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# Cyber Security Intelligence and Analytics

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Conference on Cyber Security  
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Volume 1



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Editors

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# **Foreword**

CSIA 2020 is an international conference dedicated to promoting novel theoretical and applied research advances in the interdisciplinary agenda of cyber security, particularly focusing on threat intelligence and analytics and countering cybercrime. Cyber security experts, including those in data analytics, incident response and digital forensics, need to be able to rapidly detect, analyze and defend against a diverse range of cyber threats in near real-time conditions. For example, when a significant amount of data is collected from or generated by different security monitoring solutions, intelligent and next generation big data analytical techniques are necessary to mine, interpret and extract knowledge of these (big) data. Cyber threat intelligence and analytics are among the fastest growing interdisciplinary fields of research bringing together researchers from different fields such as digital forensics, political and security studies, criminology, cyber security, big data analytics and machine learning. to detect, contain and mitigate advanced persistent threats and fight against organized cybercrimes.

The 2020 International Conference on Cyber Security Intelligence and Analytics (CSIA 2020) is held at February 28–29, 2020, in Haikou, China, building on the previous successes in Wuhu, China, (2019) is proud to be in the second consecutive conference year.

Each paper was reviewed by at least two independent experts. The conference would not have been a reality without the contributions of the authors. We sincerely thank all the authors for their valuable contributions. We would like to express our appreciation to all members of the Program Committee for their valuable efforts in the review process that helped us to guarantee the highest quality of the selected papers for the conference.

Our special thanks are due also to the editors of Springer book series “Advances in Intelligent Systems and Computing,” Thomas Ditzinger, Arumugam Deivasigamani, for their assistance throughout the publication process.

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# Contents

<b>Technical Tracks 1: Cyber Intelligence and Analytics from Different Layers of Network Space Solutions</b>	
<b>Computer Network Information Security Protection Strategy Based on Clustering Algorithms . . . . .</b>	3
Bingjie Liu	
<b>Network Communication Security Program Design Based on Wireless Router . . . . .</b>	11
Wei Miao	
<b>Network Intrusion Detection Model Based on Improved Convolutional Neural Network . . . . .</b>	18
Sile Li	
<b>Overall Layout and Security Measures of Campus Wireless Local Area Networks . . . . .</b>	25
Yixue Duan, Rui Yang, and Shaoyin Duan	
<b>Application of Computer Network Anomaly Recognition Based on Artificial Intelligence . . . . .</b>	33
Hui Xie and Li Wei	
<b>Data Security Risk and Preventive Measures of Virtual Cloud Server Based on Cloud Computing . . . . .</b>	40
Ping Xia	
<b>Computer Network Security Based on Hierarchical Evaluation Protection System . . . . .</b>	46
Dapeng Zhou and Yong Zhu	
<b>Discussion on Computer Network Security Under the Background of Big Data . . . . .</b>	53
Haiyan Jiang	

<b>Application of Virtual Local Area Network Technology in Smart Grid . . . . .</b>	59
Rui Chen, Mengqiu Yan, and Ziliang Qiu	
<b>Creative Thinking Design of Visual Communication Under Big Data . . . . .</b>	66
Yihong Zhan	
<b>Public Key Digital Authentication in Mobile Communication . . . . .</b>	72
Guofang Zhang and Quanjun Zheng	
<b>Investigation on Network Security Access Mechanism Based on Sqlserver Database . . . . .</b>	79
Huifang Xiong	
<b>Information Security Risk Assessment Based on Cloud Computing and BP Neural Network . . . . .</b>	85
Zheng Zhang	
<b>Security Technology of Wireless Sensor Network Based on IPSEC . . . . .</b>	92
Yong Zhu and Dapeng Zhou	
<b>Enterprise Internal Audit Data Network Security System in the Information Age . . . . .</b>	98
Renzao Lin and Yeping Huang	
<b>Transportation and Planning Based on Network Expansion Optimization Algorithm . . . . .</b>	104
Peng Han	
<b>Personal Information Security Risks and Legal Prevention from the Perspective of Network Security . . . . .</b>	113
Zhe Wang	
<b>The Security Protection Strategy of Computer Network Information in the Big Data Era . . . . .</b>	118
Li Wang	
<b>A Role of Law in Network Security Supervision Based on Public Internet Perspective . . . . .</b>	125
Caihong Chen	
<b>The Translation of Jiaodong's Excellent Traditional Culture Based on Computer Network . . . . .</b>	132
Xin Wang	
<b>Computer Network Database Security Management Technology Optimization Path . . . . .</b>	141
Jianrong Xi	

<b>Optimal Algorithm of Hybrid Blind Signal Real-Time Separation in Wireless Communication Networks . . . . .</b>	148
Weigang Liu	
<b>Computer Network Information Security in the Big Data Era . . . . .</b>	153
Yanli Liu	
<b>Design and Research of Metallurgical Energy Data Security Monitoring System Based on Android Platform . . . . .</b>	161
Zengxiang Liu	
<b>A Reliability Analysis Method of Multiple Components System Based on Copula Function . . . . .</b>	172
Fei Teng, Xiaoming Wang, Yuliang Li, and Wenke Hou	
<b>Method and Practice of Short Wave Long Distance Communication Link Establishment . . . . .</b>	180
Yong Guo, Guang-en Wu, Guo-Qiang Ning, and Si-min Ma	
<b>Design Information Security Management System Based on Cryptography . . . . .</b>	187
Zhou Kangle	
<b>Technical Tracks 2: Control Systems, System Integration, and Industrial Artificial Intelligence</b>	
<b>Vision Sharing Method of Network Robot Based on Deep Learning . . .</b>	197
Yang Xiao	
<b>Influence Analysis Model of Clean Energy Grid-Connected Generation to Transmission and Distribution Price . . . . .</b>	204
Ronghua Wang, Ying Du, Puyu He, Tiannan Ma, Yiming Tang, and Qian Li	
<b>Design of High Precision Frequency Meter Based on STM32H743 . . .</b>	212
Jian Huang	
<b>Centrifugal Pump Impeller Health Diagnosis Based on Improved Particle Filter and BP Neural Network . . . . .</b>	217
Hanxin Chen, Lu Fang, Dongliang Fan, and Guangyu Zhang	
<b>Simulation Analysis of Self-balancing Chassis Based on ADMAS Software . . . . .</b>	225
Liu Yang, Shunan Liu, and Li Liu	
<b>Modeling Analysis and Simulation Research of Spring-Return Plunger Pump Based on AMESim . . . . .</b>	232
Xiaoli Wang, Shunan Liu, Liu Yang, and Dehai Wang	

<b>Application Research of Business Rules Engine Management System Based on Drools . . . . .</b>	238
Bin Huang, Zheyuan He, and You Tang	
<b>Application of Self-service Analysis Tool for Data Management Application . . . . .</b>	243
Ran Ran, Zhenjiang Lei, Dapeng Zhou, Liang Bai, Yubo Liu, and Yu Xia	
<b>Intelligent Pathfinding Algorithm in Web Games . . . . .</b>	250
Hailong Huang	
<b>Design of Intelligent Manufacturing Product Identification and Detection System Based on Machine Vision . . . . .</b>	258
Shandong Zheng	
<b>Investigation on the Analysis Model of Cloud Classroom Teaching Activities of PHP Network Development Technology Based on xAPI . . . . .</b>	266
Rongxia Wang	
<b>Engineering Cost Management Strategy Based on Data Mining . . . . .</b>	273
Shuyu Shi	
<b>Upper Limb Rehabilitation Electromechanical System for Stroke Patients . . . . .</b>	283
Bo Tang, Li Jiang, Zhaowei Wang, Meng Ke, and Yanzhao Sun	
<b>Device of a Multi-functional Baby Cradle . . . . .</b>	290
Hongli Men, Hua Liu, and Lei Ma	
<b>The Exploration and Research on the Open Autonomous Learning Model of Internet Plus Initiative . . . . .</b>	296
Yexing Pan	
<b>Algorithm Design of Dynamic Question Answering System Based on Knowledge Base . . . . .</b>	303
Jingjing Jiang, JiaShun Wang, Dandan Wang, and Xue Song	
<b>K-Means Algorithm Based on Initial Cluster Center Optimization . . . . .</b>	310
Xiaolin Li and Hang Tan	
<b>Intelligent Agriculture - Agricultural Monitoring and Control Management System . . . . .</b>	317
Kaifeng Chen, Zhuo Li, Lili Ma, and You Tang	
<b>Intelligent Traffic System Path Planning Algorithm . . . . .</b>	326
Rongxia Wang	
<b>Improved Ant Colony Algorithm in Automatic Following Luggage . . . . .</b>	335
Wengao Sun	

Contents	xiii
<b>Measure, Modeling and Compensation for Wearable Exoskeleton Sitting Assist System . . . . .</b>	342
Bo Tang, Li Jiang, Yasen Yang, Chen Bai, and Yu Yao	
<b>Intelligent Kitchen Based on STC89C52RC Micro Control Unit . . . . .</b>	348
Guo Luo, XiaoFen Liang, Hui Li, CuiJing Lu, LiMin Pan, and SiWen Zhang	
<b>Method for Judging Interdisciplinary References in Literature Based on Complex Networks . . . . .</b>	354
Xiwen Zhang, Shuo Xu, and Xin An	
<b>Construction Method of Cable-Stayed Bridge Based on BIM Platform . . . . .</b>	360
Qi Wang	
<b>Tower Monitoring System Based on BeiDou Navigation Technology . . . . .</b>	367
Tieshuan Zhu	
<b>Failure Risk and Control of Nitrogen Trifluoride Tube-Bundle Container . . . . .</b>	374
Jie Tang, Mao Cheng, Wenhong Cao, and Zhangwei Ling	
<b>Construction and Exploration of Intelligent Manufacturing Training Rooms Integrated with Production . . . . .</b>	382
Lingyun Feng	
<b>An Operation Method for Uplink Science Meta Data Transmission Based on Satellite-to-Ground Large-Loop Comparison . . . . .</b>	390
Tao Xi, Jiancheng Li, Jun Wei, Heng Wang, Nengjian Tai, Hongjian Guo, Yaruixi Gao, and Shaoyu Zhang	
<b>A Brief Discussion on the Method and Key Technology of Using ZY-3 . . . . .</b>	397
Xing-hua Chi, Rui Wang, Xing-chao Yu, Ling-sha Zeng, and Yun-bi li ge Wu	
<b>Performance Improvement of the Refrigerating System in Refrigeration Storage . . . . .</b>	403
Xiaofeng Li	
<b>A Method for Attitude Guidance Law Generation Based on High Precision Space-Ground Integrated Calibration . . . . .</b>	409
Tao Xi, Jiancheng Li, Jun Wei, Heng Wang, Junfeng Li, Shuang Chen, and Dongmei Kuang	
<b>Adaptive Sliding Mode Fault Tolerant Control of Spacecraft with Actuator Effectiveness . . . . .</b>	417
Anliang Li, Henghai Fan, Shaoyu Zhang, Heng Wang, Jun Wei, Xiaobo Hui, Sicong Guo, and Qi Liu	

<b>Design of Generator Controller Based on Fuzzy Algorithm . . . . .</b>	426
Shen Jie, Shi Jianfeng, and Wang Feng	
<b>Hybrid Simulation and Vibration Analysis of Aeroengine Simulation Gearbox . . . . .</b>	432
Bai Jiankun	
<b>Kinematic Analysis of 6-DOF Parallel Robot with Multi-loop Coupling . . . . .</b>	439
Liang Yu, Peng Wang, and Zenglin Ye	
<b>Kinematic Case Verification of 6-DOF Parallel Robot . . . . .</b>	444
Liang Yu and Peng Wang	
<b>Study on a Rotor Speed Estimation Algorithm of PMSG Wind Power System . . . . .</b>	450
Xiqiang Xie	
<b>Optimal Control Strategy for Nonlinear Vibration of Beam Structures . . . . .</b>	457
Jiao Jiang, Changzheng Chen, Lei Bo, and Zhong Wang	
<b>Container Stacking Dispersion Degree and Truck Configuration Under Double Cycling Process . . . . .</b>	464
Wangsheng Liu, Pengxiang Tong, and Zhenliang Cai	
<b>Technical Tracks 3: Cloud Computing, Big Data, The Internet of Things, and Their System Intelligence</b>	
<b>Construction of Chinese Interlanguage Corpus in the Era of Big Data . . . . .</b>	473
Yali Liu	
<b>High-Quality Development of Tourism Industry Under the Trend of Cultural and Tourism Integration Based on Big Data Analysis . . . . .</b>	479
Yan Huo and Yue Wang	
<b>Distribution Information Sharing of Agricultural Products Supply-Chain in Big Data Environment . . . . .</b>	487
Xue Bai and Ning Zhai	
<b>Negative Externality of the Data Collection and Its Governing Methods . . . . .</b>	494
Ying Tang	
<b>Spillover Effect of Perceived Online Products Information Deception in the Information Age . . . . .</b>	501
Mengwei Liu, Hui Lu, Yan Cao, Xue Bai, and Rongli Xiao	

<b>Design and Implementation of Intelligent Cloud Platform Protection for Folk Art</b> . . . . .	509
Haihong Li	
<b>The Construction of Network Platform of Outdoor Sports Club</b> . . . . .	515
Bo Sun	
<b>The Construction of Off-School Practice Teaching Base for Investment Major Based on Big Data</b> . . . . .	522
Yanli Wang	
<b>Planning and Design of Transshipment Center Platform Based on Internet of Things</b> . . . . .	531
Guibin Zhang, Hongzhen Zhang, and Jirong Lv	
<b>Integrated Information System of Township Power Supply Office and Team Based on Cloud Computing</b> . . . . .	538
Dapeng Zhou, Jinghong Zhao, Ran Ran, Ying Liu, Dong Liu, and Jun Qi	
<b>Online Sales System of Sports Club Fitness Equipment Based on 5G Network</b> . . . . .	546
Chong Tian	
<b>Intelligent Environmental Art Design Course Based on Network Information Model</b> . . . . .	554
Yanlong Liu and Lei Su	
<b>Network Nature of College Students' Psychological Activities Based on Cloud Computing</b> . . . . .	562
Fei Wang	
<b>Design and Development of Intelligent Teaching System Supported by Internet of Things, VR and Cloud Computing</b> . . . . .	569
Jianlan Ren	
<b>Analysis Method of College Student Physical Education Quality Based on Big Data Analysis</b> . . . . .	576
Chuncheng Wang	
<b>Development Analysis of Government E-Government System Under the Background of Cloud Computing</b> . . . . .	582
Kaiqiang Shen	
<b>Analysis of Physical Education Quality Evaluation Model in Colleges and Universities Based on Big Data Analysis</b> . . . . .	588
Jian Wang	
<b>Yigeweisual Communication Design for Stage Decoration of Digital Media in the Context of Big Data</b> . . . . .	596
Yuelin Wu and Haixia Zhu	

<b>Education of Ideological and Political Course Under the Background of Cloud Computing.....</b>	603
Xinya Hu and Zhongyi Tang	
<b>The Application of Big Data in Urban Governance .....</b>	610
Yefei Lei	
<b>Design and Development of the Fire Sensor System of Fitness Club Based on the Internet of Things .....</b>	617
Jianhua Sun	
<b>Fitness Club Customer Body Condition Detection System Based on Internet of Things .....</b>	625
Younan Yi	
<b>Correlation Degree of Student Status Management Based on Big Data Analysis on Student Employment .....</b>	632
Haoran Dong	
<b>A Method of Resource Isolation and Security Enhancement of Container Cloud Based on Multiple Security Domains .....</b>	639
Chen Zhong and Xin Yuan	
<b>Application of Big Data in Publishing Industry .....</b>	647
Fengpeng Yi	
<b>Exploration and Practice of Teaching Reform of Computer Public Courses Under Big Data Environment .....</b>	652
Hua Zhang, Jiong Wang, and Zhengyuan Wu	
<b>Influence of Chinese English Bilingual Corpus of Traditional Chinese Medicine Prescriptions on ESP Writing Under the Background of Big Data.....</b>	658
Zheqian Su, Shulin Lian, Xing Wei, and Yongwei Shang	
<b>Research on the Application Strategy of Big Data in University Financial Management .....</b>	665
Jiaqiang Li and ZiYan Yuan	
<b>Technical Tracks 4: Machine Learning, Computer Vision, Image Processing, and Their Intelligence Applications</b>	
<b>Fuzzy Comprehensive Evaluation of Sales Decline of Automobile Industry Under the Background of Artificial Intelligence.....</b>	671
Chunjin Zhu, Li Li, and Zhenjun Shen	
<b>Countermeasures for Training Computer High-Skilled Talents in the Era of Artificial Intelligence .....</b>	680
Xinhao Sun and Yue Hao	

<b>Image Resolution Enhancement Technology Based on Deep Neural Network .....</b>	687
Ping Yu	
<b>The Effective Marketing Channels of Agricultural Products in the Artificial Intelligence Environment .....</b>	694
Chunming Liu	
<b>Construction and Application of Online Course Teaching in Intelligent Learning Environment .....</b>	702
Xiaohua Huang	
<b>Computer Aided Diagnosis of Early Breast Cancer by Multimodal Imaging .....</b>	710
Jingsi Xie	
<b>Machine Vision Based Macro Measurement System Detection .....</b>	717
Li Li, Chunjin Zhu, and Zhenjun Shen	
<b>Genetic Algorithm of the Mutual Selection Between Teachers and Students in Online Learning .....</b>	725
Jingjing Jiang, Sheng Guan, JiaShun Wang, Dandan Wang, and Xue Song	
<b>Data Mining Method of Logistics Economy Based on Neural Network Algorithm .....</b>	734
Jiacai Wang	
<b>Application of Multimedia Computer Aided Techniques in Football Teaching and Training .....</b>	741
Tingting Gou	
<b>Investigation on Art Design Assistant Method Based on Artificial Intelligence .....</b>	748
Yanyan Li	
<b>The Computer Information Technology Application of Big Data Era in Urban Planning and Design .....</b>	754
Tao Liu	
<b>Fault Detection of Club Fitness Equipment Based on Image Processing Technology .....</b>	760
Yuhao Li	
<b>Multi-objective Optimization of Construction Project Based on Multi Ant Colony Algorithm .....</b>	768
Jieyun Yang	
<b>Sports Game Management Method Based on Intelligent Computer Computing .....</b>	775
Minglai Shen	

<b>Artificial Intelligence Knowledge Transfer and Artificial Intelligence New Product Development Quality Under Knowledge Leadership . . . . .</b>	783
Jianming Zhou, Ying Liu, and Peng Zhang	
<b>Algorithm for Motion Video Based on Basketball Image . . . . .</b>	792
Wei Zou and Zhixiang Jin	
<b>Heart Rate Variability Analysis Method Based on KNN Classification . . . . .</b>	800
Jingchuan Zhao, Hongwei Zhuang, and Ling Lu	
<b>Three-Dimensional Human Motion Simulation and Video Analysis System for Physical Training . . . . .</b>	807
Wen Wei	
<b>A Regression Model of Color Value and Substance Concentration of Colored Solution Based on Lambert Beer's Law . . . . .</b>	814
Xinfang Song and Lijing Liu	
<b>A Novel Steffensen Type Method with Memory . . . . .</b>	821
Xiaofeng Wang	
<b>Author Index . . . . .</b>	827

# **Technical Tracks 1: Cyber Intelligence and Analytics from Different Layers of Network Space Solutions**



# Computer Network Information Security Protection Strategy Based on Clustering Algorithms

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**Abstract.** The information security of computer network has been threatened unprecedently recently. A more efficient and accurate method is needed to detect malicious code, but the traditional algorithm only detects malicious code to a certain extent because it uses manual feature analysis. In this paper, a malicious code feature extraction method based on particle swarm optimization K-means clustering analysis algorithm is proposed. The fitness function is used to judge the quality of the particles. After the convergence of the particle swarm optimization algorithm, the k-means algorithm is continued to perform after inheriting the global optimal position, and finally the clustering results are obtained. This paper compares the missed detection rate and accuracy of the algorithm. The results indicates that the proposed algorithm has higher accuracy and lower missed detection rate than the other two traditional clustering algorithms.

**Keywords:** Clustering algorithm · Computer network · Information security

## 1 Introduction

With most technologies depending on the growth and support of network information, information security has also become a concern. To protect computers and networks, many data mining methods have been developed for misuse [1]. With the rapid growth of malware, traditional detection methods based on features and single features become a challenging task [2].

In order to avoid attack detection technology, network intruders mostly use polymorphism mechanism to disguise attack load. Many supervised and unsupervised learning methods in machine learning and pattern recognition are used to enhance the efficiency of intrusion detection system [3, 4]. We can classify unknown malware by detecting static or dynamic behavior patterns and using machine learning technology. Lu [5, 6] proposed a method of feature extraction and detection of malicious code behavior based on semantics, which combined with semantic analysis to extract the key behaviors and dependencies of malicious code. Al-Yasee [7, 8] proposes a multi-layer hybrid intrusion detection model, which uses support vector machines and extreme learning machines to improve the detection efficiency of known and unknown attacks.

K-means is an effective clustering technology, which grouped similar data mainly by the initial centroid of clustering. Li [9] proposed a mechanism combining relational

particle swarm optimization and K-means algorithm to detect botnets. The experimental results show that this method can detect suspicious botnet members earlier than the detection application system. Bostani [10] proposes an intrusion detection method based on improved OPF algorithm, using k-means clustering algorithm as partition module to improve the performance of traditional OPF in detection rate, false alarm rate and execution time.

According to the current development direction and current situation of computer network information security, aiming at the existing troubles, this paper proposes a computer network information security protection strategy based on clustering analysis, which mainly applies particle swarm optimization K-means clustering to malicious code detection framework based on network behavior characteristics.

## 2 Method

### 2.1 Troubles in Computer Network Information Security

Protecting the information security of computer network is the most basic requirement to ensure network security. An important trouble in the application of computer network is the available protection of data information. It is necessary to ensure the integrity of network data and also to ensure that the information data in computer network is not tampered with or exposed. The trouble of information security in the computer network surrounding will continue to expand its negative impact, and it is difficult to solve it in a short time.

Network viruses are malicious program codes which have certain latency, infectivity and concealment. Viruses are increasing in number, which is one of the most important factors affecting information security in computer networks. Hacker intrusion technology is the most common security hidden danger in computer network. Hackers invade computer illegally and operate illegally, which has a great impact on users ‘information security’. All computer systems and their application software have some system vulnerabilities.

### 2.2 Cluster Analysis Technology

Clustering analysis can discover potentially significant information of data without any prior knowledge. It is a process of defining distance by using similarity between data and dividing physical or abstract object sets into multiple clusters composed of similar objects. Conventional clustering methods include:

- (1) Partition-based method: All objects are constructed into  $k$  partitions, one partition represents a single cluster, and a criterion for target partition is found.
- (2) Hierarchical clustering algorithm: first divide  $n$  data into  $n$  categories, then set a distance between classes, and then merge the data with the smallest distance to form a new category. At this time, the number of classes is  $n - 1$ , then calculate the distance between the new class and other classes, and merge the classes with similar distances, thus reducing one class after each calculation. Until finally all subclasses are aggregated into one class.

- (3) Density-based clustering: For each object in a given cluster, as long as the density of the object's nearest neighbor exceeds a certain range, the given cluster will continue to be clustered. The density of an object is defined as the number of objects near it. The density of each object must be calculated first. This clustering method can denoise data and identify clusters of arbitrary shape.

### 2.3 Improved K-Means Clustering Algorithms

Particle swarm optimization is to determine the best clustering center of clustering rather than to find the best result. It can just solve the problem that k-Means algorithm is easy to fall into local optimal solution. In this paper, a computer network information security detection algorithm combining particle swarm optimization and k-Means algorithm is proposed, which can give full play to the global optimization ability of particle swarm optimization and the fast search ability of k-Means algorithm to obtain ideal clustering results. The algorithm of this paper is as follows:

- (1) Normalization processing: normalizing eigenvalues to the range of [0, 1] by formula 1, eliminating possible inconsistent data, and performing feature normalization processing.

$$e_{new} = \frac{e_i - e_{min}}{e_{max} - e_{min}} \quad (1)$$

- (2) Remove outliers: An instance that is inconsistent with the eigenvalues of the instance behavior in the feature set is called an outlier. Some outliers which deviate greatly from all instances are removed, and then clustering analysis is carried out for the remaining instances before clustering.
- (3) Instances of Initialization Features: The improved clustering algorithm is used to randomly initialize the instances in the network behavior feature set, and each instance in the feature set is the feasible solution of malicious code detection clustering problem.
- (4) Adjusting inertia weight: Dynamic adjustment of inertia weight through formula 2, balancing the local search and global search of the algorithm.

$$\omega = \omega_{max} - \frac{\omega_{max} - \omega_{min}}{t_{max}} * t \quad (2)$$

- (5) Ensuring the diversity of the algorithm by shrinkage factor: In this paper, shrinkage factor is introduced to ensure the diversity of the particle swarm, which ensure the convergence speed of the algorithm the better.

$$V_i^t = k * (\omega * V_i^{(t-1)} + c_1 \alpha_1 (P_{max} - X_i^{(t-1)}) + c_2 \alpha_2 (G_{max} - X_i^{(t-1)})) \quad (3)$$

$$X_i^t = X_i^{(t-1)} + (1 - t/t_{max}) V_i^t \quad (4)$$

The contraction factor is expressed by K. The acceleration constants  $c_1$  and  $c_2$  bring each particle closer to the positions of  $P_{best}$  and  $G_{best}$ .  $V_i^t$  denotes the

current velocity of the  $i$ th particle,  $X_i^t$  denotes the current position of the  $i$ th particle,  $P_{best}$  is the position of the particle experiencing the best fitness, the position of the particle experiencing the best global fitness is  $G_{best}$ , the inertial weight factor is  $\omega$ ,  $\alpha_1$  and  $\alpha_2$  are random values in the range of  $[0, 1]$ , and the current iteration number is  $t$ ,  $t_{max}$  is the largest iteration number.

- (6) Formula 5 is used to calculate the quality of particles and to track the current optimal particles.

$$f = \frac{\sum_{j=1}^K \left\{ \frac{\sum_{j=1}^{P_i} Dis(c_i, y_{ij})}{P_j} \right\}}{k} \quad (5)$$

Among them,  $y_{ij}$  is the  $j$ th network behavior characteristic set of the first traffic,  $c_i$  is the first clustering center,  $Dis(c_i, y_{ij})$  is the distance between  $y_{ij}$  and  $c_i$ ,  $P_i$  is the number of data sets  $x_i$  belonging to a single cluster,  $K$  is the number of clusters.

- (7) Return to step 6 and repeat until all the particles are computed.
- (8) Get the optimal solution of the whole population and assign the nearest cluster to each particle.
- (9) Recalculating  $P_{best}$  of the current particle and  $G_{best}$  of the whole population.
- (10) Return to Step 7 and continue processing until all particles are processed.
- (11) Classify the normal data group and the abnormal data group according to the clustering results. It includes a small clustering center (normal information group) and a large clustering center (abnormal information group).

In this paper, the eigenvectors of multi-dimensional network information are constructed into a problem space. A dimension of the problem space can represent each feature rule in the feature set of the network information flow, and a point in the problem space can represent every information flow in the network. The problem space contains a large number of points, and the multi-dimensional space represents the information flow data set of the whole network.

### 3 Experimental Simulation and Experimental Data

Based on the clustering analysis of the extracted network behavior characteristics, this paper finds the host members with malicious code in the network according to the clustering results, so as to judge whether malicious code exists in the information in the computer network. In order to verify the improved k-means in this paper for information security protection mechanism in computer networks, this paper uses the following indicators to compare with other two clustering algorithms.

$$\text{Accuracy rate} = (\text{TP} + \text{TN}) / (\text{TP} + \text{FN} + \text{TN} + \text{FP})$$

$$\text{Missing detection rate} = \text{FN} / (\text{FN} + \text{TN})$$

TP represents the real class, TN represents the true negative class, FP represents the false positive class and FN represents the false negative class. If an instance is detected as a true TP-like, it is judged as a malicious client; if it is judged as a true negative TN-like after detection, it is a normal client. If the detected client is malicious but actually belongs to normal client, it is called pseudo-positive FP; if the detected client is normal but actually belongs to malicious client, it is called pseudo-negative FN.

The experimental data in this paper are all from the network traffic collected based on the computer network during the experiment. The specific data are shown in Table 1.

**Table 1.** Data flow statistics

No.	The amount of network information	The size of data packet
1	1553723	2.3G
2	1709385	2.5G
3	2028395	2.9G
4	1718293	2.4G
5	396865	0.9G

## 4 Experiments and Discussions

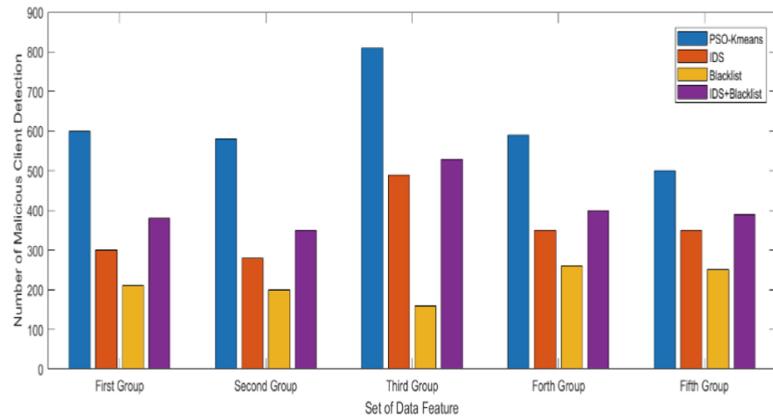
### 4.1 Experimental Process

This experiment mainly carries on the comparative analysis from two aspects: the accuracy rate of summer vacation and the missed detection rate.

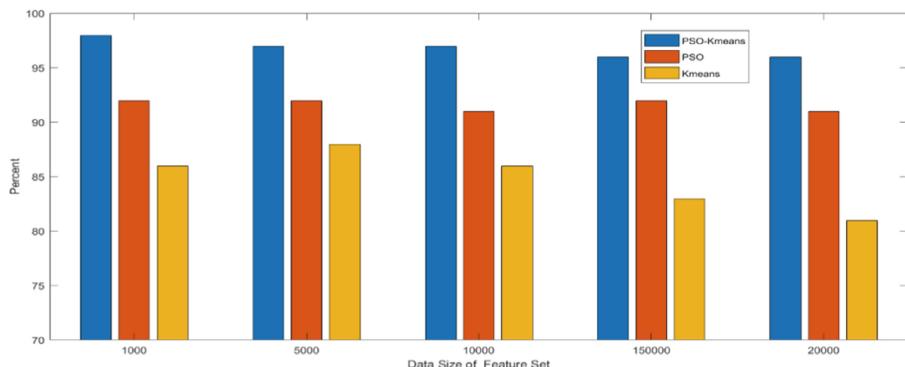
- (1) The improved K-means clustering algorithm proposed in this paper is compared with the blacklist detection mechanism, IDS, and the joint detection mechanism of IDS and blacklist. The experimental results are shown in Fig. 1.  
It can be seen that compared with other detection methods from the Fig. 1, the clustering algorithm based detection method proposed in this paper can detect more malicious clients. In the third group of data sets, the detection of malicious programs exceeds 800, which has a high detection rate of malicious code.
- (2) The accuracy comparison results are shown in Fig. 2.

Among the three contrast algorithms, the improved algorithm proposed in this paper has the highest accuracy, and the detection accuracy is basically maintained at about 97% with the increase of data volume, which is relatively stable.

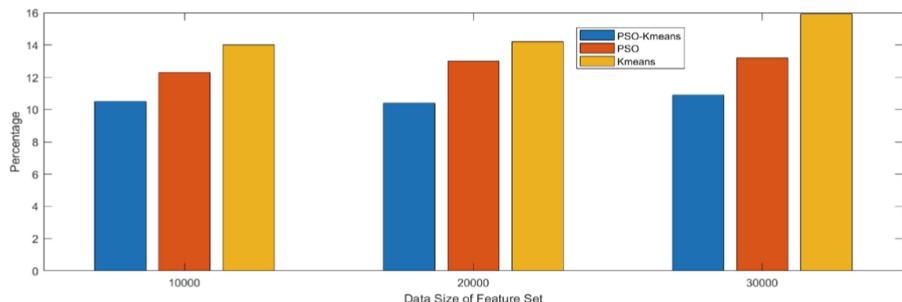
The leak detection rate of the improved algorithm proposed in this paper is less than 10%, which has a lower miss detection rate compared with the other two algorithms, and k-Means algorithm is relatively higher in these three algorithms. The leak detection rate of k-Means algorithm is even more than 16% when the amount of data exceeds 20,000, which is shown as Fig. 3.



**Fig. 1.** Number statistics of malicious client detection



**Fig. 2.** The accuracy comparison chart



**Fig. 3.** The Missing detection rate comparison chart

## 4.2 Experimental Summary

The improved clustering algorithm is compared with the other two typical clustering algorithms in the experiment. The experimental results show that the improved clustering algorithm in this paper inherits the global search ability of particle swarm optimization algorithm on the basis of maintaining the fast search ability of k-means algorithm, so the accuracy of malicious code detection has been greatly improved. The improved algorithm in this paper has the highest accuracy in detecting malicious code among the three clustering algorithms. However, this improved algorithm has the same limitation in processing large data feature sets as other two typical clustering algorithms.

## 5 Conclusion

With the rapid development of malicious attack technology, the information security of computer network has been threatened unprecedentedly. Most of the current information security protection strategies ignore the network behavior during intrusion. This paper presents an information security detection algorithm based on particle swarm optimization K-means clustering analysis. The global search ability of particle swarm optimization is used to compensate for the problem of local optimal solution of k-Means algorithm. The experimental results show that compared with the other two traditional clustering analysis algorithms, the improved clustering algorithm proposed in this paper has higher accuracy and lower miss detection rate. However, there are still some shortcomings in this paper. The method proposed in this paper is only applicable to information security detection in small computer networks, and the proposed network behavior features are limited, and all malicious code network behavior features are not extracted.

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# Network Communication Security Program Design Based on Wireless Router

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**Abstract.** The rapid development of Internet and mobile communication technology has brought great changes to people's daily production and life. At the same time, more and more users use wireless access to the Internet. In the process of wireless access, wireless router has become an essential and important equipment, and the network security of wireless router is the most important. In view of this, this paper designs a trusted network access verification system based on TCM module. Through experimental verification, it can be seen that the system designed in this paper can realize the trusted access of the router, thus greatly improving the security and credibility of the router.

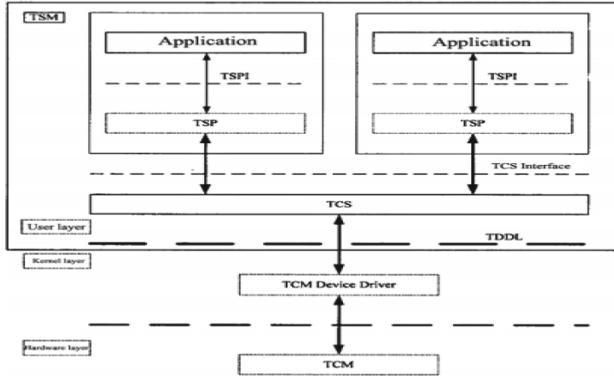
**Keywords:** Wireless router · Communication security · TCM

## 1 Introduction

TCM (Trusted Cryptography Module) is a Chinese trusted computing standard. It was launched by some IT companies within the United Nations of the National Cryptography Administration and developed on the basis of the TPM standard. TPM is developed by the Trusted Computing Group (TCG). In terms of data security, the traditional approach is based on virus protection, firewall, and intrusion detection based terminal security solutions [1, 2]. The core idea of trusted computing is to introduce a security module chip to embed it into a computer system. The TPM chip is used in the TPM standard, and the TCM chip is used in China. This can solve many problems that could not be solved before. In fact, they add a trusted third party to the computer system to ensure that a system is trusted through the metrics and constraints of the trusted third party. In China's trusted computing technology system, the core is the TCM chip, which has four main functions: symmetric/asymmetric encryption, secure storage, integrity metrics and signature authentication [3].

## 2 TCM Module Platform Structure

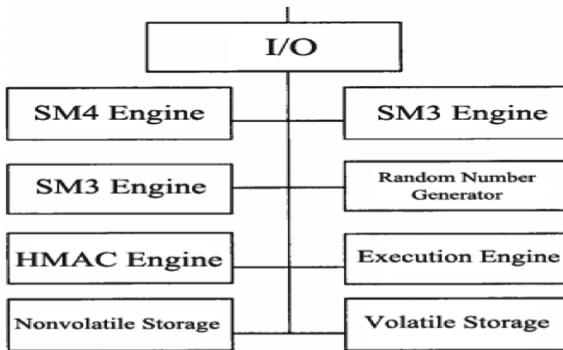
The trusted computing platform is based on TCM, but it is not composed of only one chip, but a complete architecture that integrates CPU, operating system, application software and network infrastructure. The services provided by the TPM to the upper layer application are presented through the TPM Soft Ware Stack. The structure of the TCM module is shown in Fig. 1.



**Fig. 1.** TCM module structure

## 2.1 Trusted Cryptographic Module

The Trusted Cryptographic Module (TCM) is a key component of the Trusted Computing Cryptographic Support Platform and provides independent cryptographic algorithm support. TCM is a collection of hardware and firmware that can be packaged in a stand-alone package or integrated with other types of chips using an IP core to provide TCM functionality [4]. The basic composition of the trusted cryptographic module is shown in Fig. 2.



**Fig. 2.** The basic composition of the trusted cryptographic module

## 2.2 Trusted Cryptographic Service Module (TSM)

The Trusted Cryptographic Module defines a subsystem with storage protection and execution protection that will establish a trust foundation for the computing platform and its independent computing resources will establish a strictly restricted security protection mechanism. In order to prevent TCM from becoming a performance bottleneck of the computing platform, functions that need to be protected in the subsystem

are separated from functions that need to be protected, and functions that need to be protected are executed by the main processor of the computing platform. TSM primarily provides support for the TCM infrastructure resources and consists of multiple parts, each with an interoperable interface definition. Furthermore, TSM should provide a normalized function interface [5, 6].

(1) TSM software composition

TSM is mainly composed of four parts, which are TSP, TCS, TDDL, and TDD. The application invokes the TSP function through the TSP (TCM Service Provider Interface) provided by the TSP. The TSP includes a function of encryption and decryption in addition to the TSP context management [7], and sends the application layer request to the TCS. The returned results of the TCS are processed and provided to the application.

(2) TSP SDK

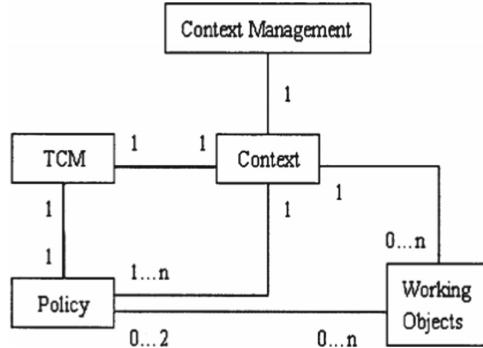
The TSM SDK provides the TCM service to the application, providing a high-level TCM function that allows the application to focus only on its own characteristics and rely on the SDK to execute the trusted functions provided by the TCM. The TSP SDK includes nine application service modules as shown in Table 1.

**Table 1.** TSP SDK application service module table

Serial number	Application service module	Description
1	Context management module	Responsible for managing information about the execution environment of TSM objects
2	Policy management module	Responsible for configuring appropriate security policies and behaviors for different user applications
3	TCM management module	Provides a function for the owner of the TCM to operate
4	Key management module	Responsible for managing TSM keys
5	Data encryption and decryption module	Responsible for associating external (e.g., user, application) data with the system (bind with the platform or PCR) or for providing external data encryption/decryption services
6	PCR operation module	Responsible for establishing the trust level of the system platform. The module provides gradient functions for selection, reading, writing and other operations of PCR
7	NV storage management module	The NV storage management module is responsible for storing attribute information in non-volatile stores of TCM
8	Hash calculation module	It provides a cryptographically secure function for digital signature operation
9	Key agreement module	Responsible for performing key exchange protocol operations

## (3) TSP applies the service module relationship

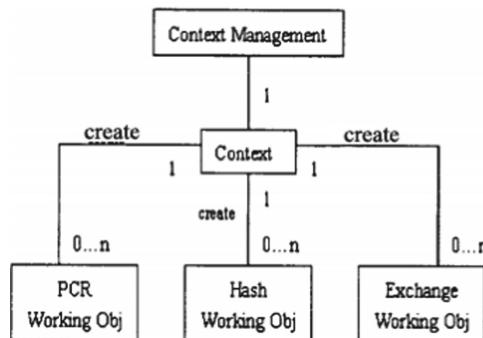
The objects in TSM can be divided into working and non-working objects according to their functions, and their relationship can be shown in Fig. 3.



**Fig. 3.** Relationships between application service modules

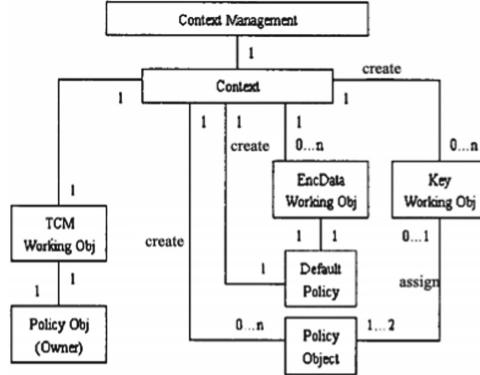
## (4) TSP work object

According to whether authorization is needed, work objects can be divided into: unauthorized work objects and authorized work objects. The relationship between unauthorized work objects can be illustrated in Fig. 4.



**Fig. 4.** Diagram of relationships between work objects without authorization

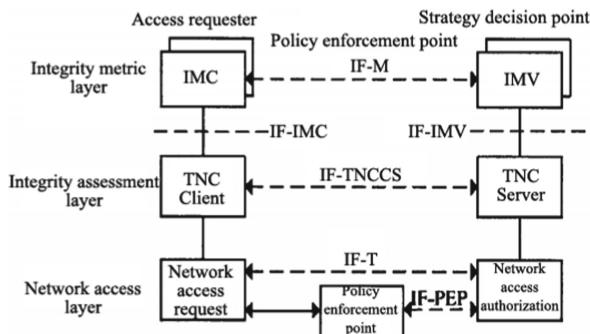
The relationship between authorized work objects can be illustrated in Fig. 5.



**Fig. 5.** Relationship diagram between authorized work objects

### 3 TCM Certification Based on 802.1X

TNC architecture is vertically divided into three levels, from bottom to top: network access layer can support traditional network connection technology; The integrity assessment layer is responsible for evaluating the integrity of all requested access network entities [8]. The integrity measurement layer is used to collect and verify information about the integrity of the requester. The relationships of three types of entities and three levels are shown in Fig. 6.



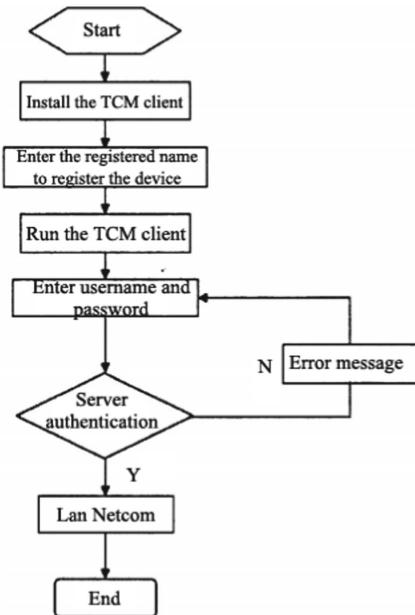
**Fig. 6.** TNC architecture

As can be seen from Fig. 6, when the terminal requests access to the network, the policy decision point (PDP) will not only carry out traditional user identity authentication for the terminal, but also verify the identity and integrity of the terminal platform according to certain policies. The policy decision point (PDP) makes the access decision after verifying the identity and platform integrity information submitted by the requesting visitor (AR). The policy executor (PEP) allows or denies requested visitor (AR) access to the network based on decisions made by the PDP.

## 4 System Test

### 4.1 Test Process

The TCM client runs the TCM client software to transmit the user name, password, device name and device information to the router in an encrypted manner. The TCM authentication server of the router decrypts the data and reads the user database information to match the user password and device information [9]. If the matching is consistent, the authentication is passed, and if the matching is inconsistent [10], the authentication failure information is returned, thereby realizing the authentication of the device. The specific test process is shown in Fig. 7.



**Fig. 7.** TCM module test flow chart

### 4.2 Test Result Analysis

By testing the TCM module server, you can log in to the PHP management interface. In user management, it is possible to add, delete, modify user information, and also upload user images. Device management saves the device registration name and encryption device information, and can be read and written by SQLite. The online status can display the current online users, and can also support the chart, indicating that PHP and SQLite are working properly. The PC running client software passes the router RADIUS service authentication, and the client displays the connection. After the authentication fails, the authentication failure prompt message is generated, indicating that the TCM module is successfully transplanted and works normally.

## 5 Conclusion

Wireless routers are one of the main modes of future Internet access. This paper first introduces the TCM module, and then proposes its platform structure. In the platform structure, the TCM and the TCM are analyzed. The TSP SDK is also given in TSM. And the division and interface of modules in the SDK. Then it is an analysis of 802.1X-based TCM authentication, including TNC architecture and 802.1X-based TNC implementation, focusing on the 802.1X-based TNC authentication process. Finally, combined with the previous analysis, the migration and implementation process of the TCM module to the wireless router is proposed. The test results show that the TCM module designed and implemented in this paper enhances the authentication function of the router and supports data encryption. It has certain guiding significance in the research field of wireless routing network communication security.

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# Network Intrusion Detection Model Based on Improved Convolutional Neural Network

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**Abstract.** Intrusion detection technology is the key technology in network security. With the diversification of means of network attacks, the traditional intrusion detection technology has gradually revealed some problems, such as poor detection performance and low adaptability. In view of the existing problems, this paper constructs an intrusion detection model based on improved convolution neural network. The convolution neural network is further studied and improved. This paper optimizes the initial weights of convolutional neural network by genetic algorithm on the problems of slow training speed and difficult convergence in the training of convolutional neural network. The experimental results show that the convergence speed of the convolution neural network optimized by genetic algorithm is faster and the feature extraction ability is strengthened. Convolution neural network based on genetic algorithm can detect various kinds of abnormal data and attack types effectively, and also has the ability to detect new attack data.

**Keywords:** Intrusion detection technology · Deep learning · Convolution neural network · Genetic algorithm

## 1 Introduction

Intrusion detection (ID) technology has become an integral part of network security [1]. With the emergence of all kinds of attack, it is difficult to guarantee network security by firewall alone. Intrusion detection is an important security gate behind the firewall. Intrusion detection technology can monitor the operation of the network in real time and respond to the abnormal data in real time. With the increasingly severe situation of network security, the traditional intrusion detection methods continue to expose the problems of low detection rate and slow detection speed.

Deep learning is a cutting-edge technology of artificial intelligence, which is developed from neural network [2]. Through layer by layer feature learning, the original data is mapped to a new feature space. Compared with the traditional neural network technology, the ability of deep learning to feature extraction is more outstanding. The combination of deep learning and intrusion detection will be the development direction of intrusion detection technology in the future [3].

In this paper, an intrusion detection model based on convolution neural network is designed, and analyze the composition of each module of the model. In order to solve the problems of slow training speed and difficult convergence in the training of

convolutional neural network, this paper applies genetic algorithm to optimize it so as to further enhance the identification ability of convolutional neural network for data characteristics. The feasibility and validity of the method are verified by experiments.

## 2 Convolution Neural Network Based on Genetic Algorithm

Based on the practical problems encountered in the training of convolution neural network, this paper applies genetic algorithm to the optimization of deep convolution neural network model to enhance the stability, improve the convergence speed of the model and the expected results [4].

For convolutional neural network, the traditional weight training method is based on some rules, and the weight is updated continuously in the network training until it meets the expectation. At present, gradient descent algorithm is very important in the training of neural network [5]. However, its initial parameters play an important role in the training of neural network. If the initial parameters are not set well, it is likely that the network will not converge, and the final performance of the network may not meet the expectations [6]. In addition, the training process of the network is the process of parameter adjustment. In this process, the selection of many parameters, such as learning rate, basically depends on personal experience to judge. If the value is not ideal, it may fall into the dilemma of network convergence. Based on these factors, this paper proposes to use genetic algorithm to optimize the weight of convolution neural network, so as to reduce the impact of these possible problems and improve the overall performance of the network model. The specific optimization process is as follows:

- (1) Encode the weight value with the pre-set encoding method;
- (2) Calculate the error function value of the sample, take the square and reciprocal of the value, and take the calculation result as the individual fitness;
- (3) For the individual with larger fitness, take the method of direct downward inheritance;
- (4) Take the crossover and mutation operation for the current population to generate the next generation of population;
- (5) Repeat the above step by step, the initial weights are also evolving through continuous iteration, and finally the individuals satisfying the requirements are generated.

## 3 Intrusion Detection Experiment Based on Genetic Convolution Neural Network

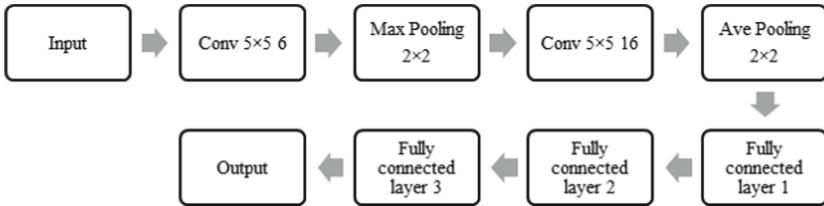
### 3.1 Chromosome Coding and Fitness Function

According to the structure of convolutional neural network, a set of weights of the network randomly generated each time is regarded as a chromosome of genetic algorithm. Because each weight takes 8-digit binary number, the binary number of chromosome is large and the calculation is complex, and the binary coding also needs

the operation of coding and decoding, which has a long running time and requires a high hardware configuration of the computer [7]. Based on this situation, this paper uses floating-point numbers to encode chromosomes, and each individual represents the weight sequence corresponding to a convolution kernel. The fitness function plays a key role in the whole process of genetic algorithm. According to the characteristics of experimental model and experimental data, the cross entropy loss function is used as the individual fitness function.

### 3.2 Experimental Model Settings

Experiments are set up to verify the effectiveness of genetic algorithm in optimizing convolution neural network model parameters and the actual effect of genetic algorithm in network training. The data set is a randomly selected subset of KDD CUP 99 data set. In KDD CUP 99 data set, each data contains 41 features, which can be divided into normal types and 39 abnormal types. 39 kinds of abnormal types can be divided into 4 categories: DOS, Probe, U2R and R2L. These four types, together with normal, constitute five types of labels, which are used as the classification basis for the validation experiment. In this paper, a total of 8000 data sets are collected by random sampling method as the data set of this experiment. The collected data sets include normal class and four types of exceptions. The data is preprocessed to meet the experimental requirements of convolutional neural network. Convolution neural network model is set to eight layers, and its specific settings are shown in Fig. 1.



**Fig. 1.** Convolution neural network model structure

The input of the network model is a fixed size numerical matrix, and then through two convolutions. The maximum lower sampling pooling layer is connected between the two convolution layers to reduce the size of the input. The second convolution layer is followed by a pooling layer, which adopts mean value down sampling and then accesses the full connection layer. Finally, softmax multiple classifiers are connected to make five classifications, namely normal and four types of exceptions.

The parameters settings of each convolution layer are as follows: number of two convolution kernels is 6, and convolution kernel size is  $5 \times 5$ . In order to deal with the variable length input, the network model uses zero filling operation to deal with the input, so as to ensure that the size of the input data characteristics meet the needs of convolution operation. The size of the zero filling expansion is 1.

The network model parameter settings are shown in Table 1:

**Table 1.** Parameter setting of convolution network model

Layer	Convolution kernel size	Number of convolution kernels	Padding	Step
<b>Conv</b>	$5 \times 5$	6	Same	1
<b>Max pooling</b>		$2 \times 2$		
<b>Conv</b>	$5 \times 5$	16	Same	1
Layer	Convolution kernel size	Number of convolution kernels	Padding	Step
<b>Ave pooling</b>		$2 \times 2$		
<b>Fully connected layer 1</b>		Number of neurons is 120		
<b>Fully connected layer 2</b>		Number of neurons is 60		
<b>Fully connected layer 3</b>		Number of neurons is 5		

### 3.3 Comparison Experiment Settings

In order to verify the optimization degree of genetic algorithm on the model, I set up a comparative experiment to analyze. Two experimental models were established: model A and model B, the experiments were carried out on these two models respectively. Both models use the convolution neural network model structure described in Sect. 3.2, the learning rate and other parameters are set to be the same. Experiments are conducted in the same hardware and software environment. In the experiments, redundant processes that may occupy additional system resources are closed to ensure that the training process of the network model is not disturbed.

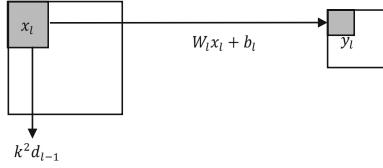
The difference between the two models:

Model A: establish the initial weight of the model through random initialization.  
 Model B: the initial weight of the model is generated by genetic algorithm and input into the model for operation.

Model A uses the random initialization method proposed in reference [8]:  
 Suppose the input operation of the convolution layer is:

$$y_l = W_l x_l + b_l \quad (1)$$

Y of formula (2–27) represents a certain value in the output characteristic graph, X is a vector, its size is  $k^2 c$ , K is the size of the kernel. The calculation diagram is shown in Fig. 2.



**Fig. 2.** Schematic diagram of formula calculation

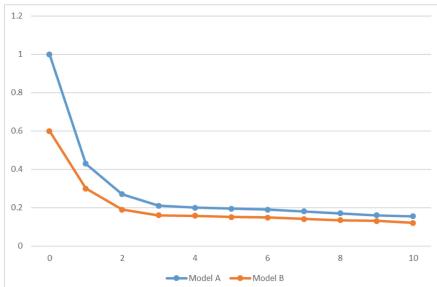
In Fig. 2, if  $n = k^2 c$ , then  $w$  is a  $(d, n)$  matrix,  $Dd$  represents the number of cores,  $d_{l-1}$  represents the number of cores in the previous layer, and  $b$  is the offset. The parameters of this layer are initialized by Gaussian sampling [9], which is different from general Gaussian sampling. Here, the standard deviation of Gaussian sampling is:

$$std = \sqrt{2/k_l^2 d_l} \quad (2)$$

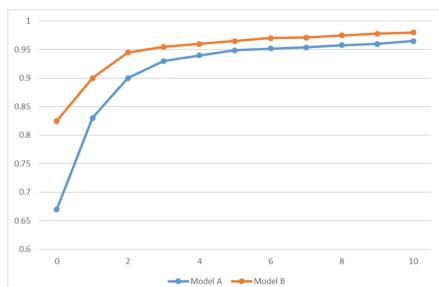
In the formula,  $l$  represents the current layer,  $k_l$  represents the size of the layer core, and  $d_l$  represents the number of layers core. This way can make the network convergence faster. For model B, the weight of the model is taken as the population, and genetic algorithm is used to find the best. First of all, we need to select the initial weights of multiple groups of model B, code the combination of each group of weights, and select, cross and mutate the chromosomes after coding, so as to generate different combinations of weights [10]. After that, the fitness of chromosome is calculated. The good fitness here means that the classification performance is higher when the weight is input into model B, and the final population is selected according to the fitness, that is, the weight combination with the best performance of model B.

### 3.4 Experimental Results and Analysis

For convolutional neural network, two main indexes should be paid attention to in multi classification task: test accuracy and loss function loss value. The convergence of the network can be judged by the change of loss value. Test accuracy is the recognition accuracy of the network model on the test set, which reflects the classification performance of



**Fig. 3.** The trend of loss value of the model



**Fig. 4.** Test accuracy trend of the model

the network model. Generally speaking, the loss value will gradually decrease with the training, the test accuracy will gradually increase, and finally tend to be stable. After 10 iterations, the loss values of the two models change as shown in Fig. 3, the test accuracy trend of the two models is shown in Fig. 4:

In the pictures, the vertical axis is the corresponding loss value and accuracy value, and the horizontal axis is the number of epochs that the training has passed. An epoch means that all samples complete a cycle. With the development of epoch, the loss value of the model shows a rapid downward trend, during which there is no gradient disappearance or gradient explosion. Compared with model B, model A's initial loss value is larger, because the initial weight of model B is more suitable for the training process of the model itself after optimization by genetic algorithm, which makes model B obtain faster convergence speed and reduces the risk of gradient disappearance. In the whole process of epoch, we can see that the test accuracy of model B is slightly higher than that of model a, and this advantage remains until the 10th epoch. Generally speaking, the process of neural network convergence is the process of parameter updating. Good initial parameters are more conducive to the model convergence in the optimal direction, so as to achieve a better state. Through the analysis of comparative experiments, the optimization effect of genetic algorithm on the performance of convolutional neural network is confirmed. The application of genetic algorithm makes the neural network model obtain better initial weights, thus speeding up the training process, reducing the risk of gradient disappearance and improving the expected accuracy [11]. The recognition accuracy of the improved convolution neural network is higher, and it has faster convergence speed and better comprehensive performance.

## 4 Conclusion

In this paper, the convolution neural network is analyzed in detail, at the same time, the idea of genetic algorithm is introduced to describe the process and application of genetic algorithm in detail. According to the problems existing in the training process of convolutional neural network, the genetic algorithm is applied to the parameter optimization of convolutional neural network, and the specific optimization process of the method is given. In order to verify the optimization effect of genetic algorithm, I designed comparative experiment on the data set, and this experiment verifies the effectiveness of the method in the application of intrusion detection.

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# Overall Layout and Security Measures of Campus Wireless Local Area Networks

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**Abstract.** Technology of wireless local area network (WLAN) has rapidly developed, and it has been more and more extensively applied. With the establishment of IEEE802.11 WLAN standard, WLAN gradually enters campus and plays an increasingly important role. This paper analyzes the requirements of Campus WLAN and puts forward the implementation plan. The scheme was designed and discussed in the aspects of network structure, business deployment, management mode and security of network. This paper prefers the techniques of two-way authentication, dynamic WEP key and session WEP key between client and authentication based on WLAN authentication to ensure the security of network. At the same time, according to the security requirements, it can be further improved by setting up authentication service and configuring other monitoring means.

**Keywords:** Campus network · Wireless LAN · Security risks · Prevention strategies

## 1 Introduction

Wireless local area networks (WLAN) refers to the application of wireless communication technology to connect computer equipment, the network system that can communicate with each other and realize the resource sharing. WLAN is a quite mature technology, the service providers at home and abroad have launched fierce market competition. Within the network coverage of operators, there are many end devices such as notebook computer, PDA (finger and palm computer), desktop computer to connect the Internet/enterprise network at high speed in a wireless way to obtain relevant information or carry out mobile office Public function. With the establishment of IEEE802.11 WLAN standard, WLAN has gradually entered the campus [1–3]. But WLAN has some defects. It is transmitted by radio waves, and buildings, vehicles, trees and other obstacles may hinder the transmission of electromagnetic waves, so its will affect the performance of the network. In addition, the transmission rate of wireless channel is much lower than that of the wired channel. The maximum of WLAN is 1GBIT/s, which is only suitable for personal terminals and small-scale network applications. Essentially, radio waves do not require the establishment of physical connection channels, for its signals are divergent. So it is theoretically easy to be

monitored any signal within the radio broadcasting range, resulting in communication information leakage and insecurity [4–8].

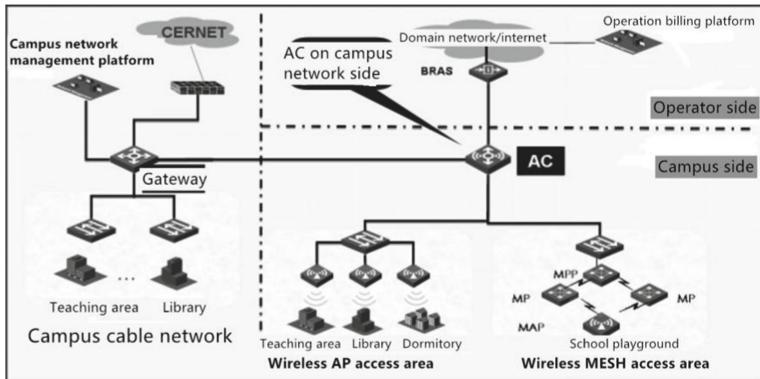
## 2 Methods and Techniques

### 2.1 Demand of Campus Network

Network in the campus involves a wide range of aspects. Whether it is indoors or outdoors, it will have a lot of impact from the campus environment, which is particularly obvious in the campus with a long history of development and simultaneous development of new and old buildings. From the aspects of investment, construction period, network maintenance and upgrading, etc., the school needs a set of plans to build campus network more quickly and better. Now most schools have built wired LAN, but with the development of the school, more and higher requirements are put forward for the existing campus network, such as the modern teaching needs, the limit on the number of ports and temporary collective activities of campus [9].

### 2.2 Network Structure and Engineering Wiring (Fig. 1)

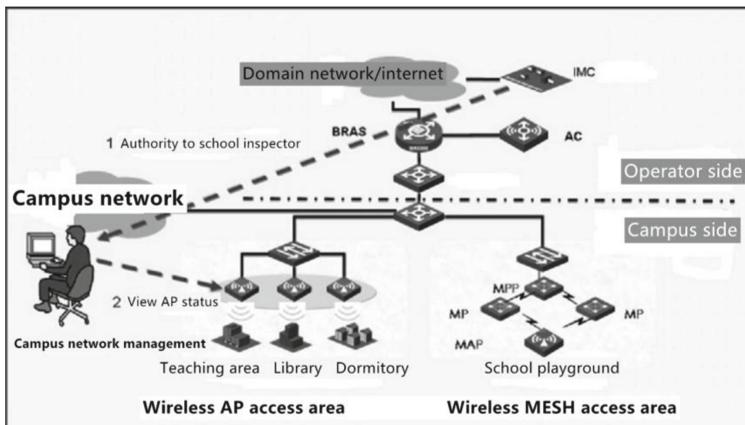
Network structures include the wireless controller + thin AP architecture, the management and control of wireless AP by the wireless controller (AC), and the encryption and decryption of wireless signal by the wireless AP. Wireless campus network was composed of two parts [9, 10]: the operator side and campus side. Indoor part: set a relatively open position, and lay the network cable and power cable in place with concealed wires; hang on the wall, and use the installation accessories provided by the equipment itself for installation; if it needs to be covered, it needs to customize the non-metal installation box; if it was hung on the ceiling, it depends on the situation of the ceiling, if the ceiling is a non-metal structure, It can be fixed in the ceiling. Anti theft should be fully considered during installation. Outdoor part: there are two wiring modes according to the equipment location. If the AP equipment is placed on the roof, the network cable and power cable are required; if the AP equipment was placed indoors and the antenna is placed outdoors, the antenna feeder was required. POE mode can be used for the power supply of AP by connected network equipment. Wireless campus network was composed of two parts: the operator side and campus side. The operator side was mainly composed of the IP network, or the internet exit provided by the operator to realize the functions of user information authentication, operation billing and operation management; the campus side was mainly composed of AC, convergence switch and wireless AP.



**Fig. 1.** Display the position of AC equipment according to data label

### 2.3 Business Deployment of the Campus Wireless Network (Fig. 2)

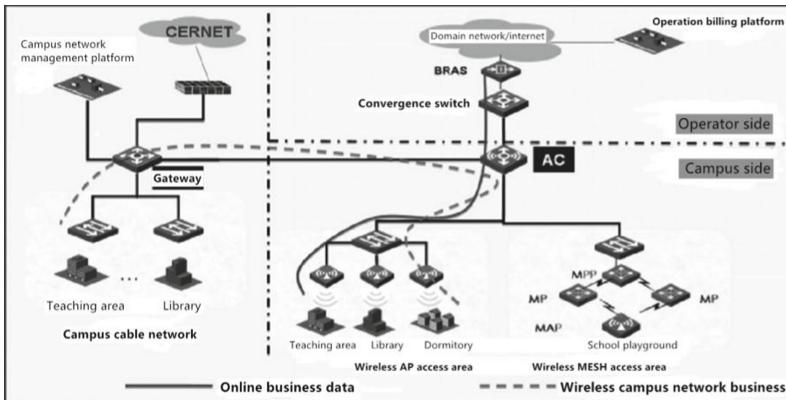
Campus internet terminal is connected to the wireless AP equipment through the wireless signal, and their data is transmitted to AC through wireless AP and convergence network. The AC equipment transmits the corresponding data to different networks according to the data label location, as the user wants to access the campus network, and the data is transmitted to the core equipment of the campus network through AC (the dotted line link); as the user thinks to access the internet through the operator's export, and AC will transfer data from the operator's export to the operator's data network or internet.



**Fig. 2.** The display data is transmitted to the core equipment of the campus network through AC

## 2.4 Management Mode of Campus Wireless Network (Fig. 3)

WLAN technology adopts the mode of wireless controller + thin AP to form the network, and the wireless controller realizes the management and control of its wireless AP. For operators with the large network scale and large number of users, they can establish a special network system to manage and maintain the network uniformly. In most cases, the operator is responsible for the management and maintenance of the network. The relevant personnel of the operator can configure and modify the equipment parameters in the network, and add, subtract and change the user's authentication information. In order to facilitate the management and control of the online behavior of teachers and students in the school, operators can provide the management personnel in the school with the authority to view the network status and user information, so as to facilitate the management and control of teachers and students in the school [9–11].



**Fig. 3.** Show unified network management and maintenance

## 3 Security of Campus WLAN

### 3.1 Common Security Risks of Campus Wireless Network

#### 3.1.1 DSSS Risks

The spread spectrum system DSSS uses a well-known 11 bit spread the spectrum sequence and can modulate one of the L4 channels specified in the standard. Since the sequence used is known in advance, the given carrier frequency of the system is fixed, and the number of possible frequencies is limited, so hackers can easily receive and hear the signal transmitted by DSSS [8, 10].

#### 3.1.2 WEP Security Vulnerability

On the MAC layer, because WLAN uses broadcast mode, if hackers break through the physical layer, they can listen to the signal, then the key to security is signal encryption technology. However, there is a security flaw in WEP technology, because the WLAN standard does not define the key management method of WEP.

### 3.1.3 Hardware Stolen

It is a common method to statically formulate the WEP key to a client. The key is either stored in the disk memory of the client or in the memory of the WLAN adapter of the client. When the client is lost or stolen, the normal user of the client will no longer have access to the MAC address and the WEP key, and the abnormal user will have these rights.

### 3.1.4 Fake Access Point

WLAN shared the key authentication uses one-way, non mutual authentication method. An access point can be authenticated a user, but a user cannot authenticate an access point. If the fake access point was placed in WLAN, it can become a platform to launch denial of service attack by “hijacking” legitimate user clients.

### 3.1.5 Other Hidden Dangers

The standard WEP can support each packet encryption function, but did not support the verification of each packet. Hackers can reconstruct the information flow from the response to known packets, so that they can send spoofing packets. One way to make up for this weakness was to change the WEP key regularly.

## 3.2 Prevention Strategies

### 3.2.1 WLAN Authentication

It is based on independent projects, such as the user name and password, which are owned and used by the user. No matter which step is running on the client, it will support two-way authentication between the client and authentication server. Using the WEP key generated dynamically by user authentication is not a static key related to the client physically, the session based WEP key is supported. At the same time, according to the level of security requirements, it should be set up authentication server and configure other monitoring means to further improve the security of the network [12–15].

### 3.2.2 Reasonable Installation of Wireless Network Equipment

It should be appropriate Effectively to isolate the electromagnetic wave coverage of wireless network and core network WLAN and the placement of AP, and to avoid exceeding the physical jurisdiction and provide wider free listening space for eavesdroppers. Starting from the network structure, the measures of network isolation and network authentication are taken to limit the range of signals, and WLAN and the important internal network are clearly distinguished. Firewall is used for security isolation between AP and the internal network, and physical isolation is used when necessary. In this way, even if WLAN has security problems, it will not immediately lead to a serious crisis of the internal network. Reasonable design and configuration of wireless network equipment to change the default SSID so that it is not easy to guess: turn off the function of regular broadcast so that the eavesdropper must use some wireless packet capture and analysis tools to restrict the access of unauthorized personnel to WLAN through the access control list by using MAC address; frequently check the AP log to find the attacker in time; activate WEP and often change WEP key or use dynamic key to avoid key reuse. Install enterprise firewall will isolate attacks

through the Internet. If conditions permit, WLAN intrusion detection system can be used for real-time analysis and monitoring to detect the illegal AP and fake client in time.

### **3.2.3 Using Static IP Address and Intrusion Detection Tool**

Using static IP address instead of dynamic IP address configured by DHCP server can prevent illegal access to wireless network through the IP address spoofing and cloning. Use human intrusion detection tools to scan and search for the illegal users regularly. Strengthen the computer security management of wireless network users: the client shall install personal firewall and anti-virus software, and update them in time; pay attention to the safe use of password or password; frequently replace the WEP key and other security measures for wireless communication. Set up the strict user password and authentication measures: to prevent illegal users from invading and using password control on the wireless network site is not necessarily limited to the wireless network. Network operating systems and servers such as Novell Netware and Microsoft Server 2003 provide built-in multi-level security services including password management. Passwords should be under strict control and changed frequently. Because WLAN users include mobile users, which tend to move their laptops around, the strict password policy is equivalent to adding a security level. It will help to confirm whether the website is being used by illegal user.

### **3.2.4 Set up Additional Third-Party Data Encryption Scheme**

Even if the signal is stolen, it is difficult to understand the content. If the data of the unit requires high security, then the unit may need to take some special measures. Finally, the highest level of security measures is to use encryption products as a whole on the network data package to be encrypted by software or hardware before being sent to the LAN. Only those sites with the correct key can recover and read these data. If a comprehensive security guarantee is needed, encryption is the best method. Some network operating systems have encryption capabilities. Third-party encryption products based on each user or server and at a lower price can also be competent, and can provide users with the best performance, quality service and technical support. Make full use of the security features provided by WLAN itself to ensure security: for example, for AP, you can do the following: change the default password, which is very simple when the device leaves the factory, and must be changed. Use encryption. Although WEP (Wired Equivalent Privacy encryption technology) has been proved to be relatively fragile, encryption is still safer than plaintext transmission. It is necessary to use MAC address to verify the client before implementing stronger authentication measures. Change SSID (service set identifier), configure AP with hiding SSID and change SNMP settings, that are the same as the precautions for wired network devices.

## 4 Summary and Prospect

At present, the wireless campus LAN has been accepted by more and more campuses in China. The wireless network technology has played a role in the distribution design of information points, as well as the network connection between buildings in the campus, and the networking of the school headquarters and the branches. In addition, the introduction of WLAN will provide an application platform for new wireless multimedia, and strengthen the construction of education information. With the further development of WLAN technology, it will replace the original wired network and become the main role of campus network, and will play an important role in more scenes and fields. But, there are some problems of WLAN security, and it is very difficult to deal with and solve. Therefore, in order to ensure the relative security of campus wireless LAN, these measures must be considered from multi-level and multi-faceted, flexibly implement a variety of security measures, and establish a diversified integrated linkage protection mechanism. However, with needs of WLAN in people's life and its applied value, WLAN security will continue to be improved and upgraded, it will become the main topic in the field.

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# Application of Computer Network Anomaly Recognition Based on Artificial Intelligence

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**Abstract.** With the continuous popularization of computer network applications, people's lifestyle has been greatly changed, and it has become an essential tool for people's daily life, which gradually affects people's daily life. However, with the continuous penetration of the network in all walks of life, the existence of various diversified network problems has also greatly affected people's normal work and development, even the network anomaly brought by various illegal attacks and hacker access issues has infringed upon people's rights and interests, and continuously affect the normal operation of the network. For this purpose, this study applies artificial intelligence to computer network anomaly diagnosis and recognition, and uses advanced artificial intelligence technology to efficiently, quickly and accurately identify anomalies and their causes in the network, and find ways to deal with them.

**Keywords:** Artificial intelligence · Recognition · Network anomaly

## 1 Introduction

With the continuous penetration of the network among people working in various industries, the massive amount of network data continues to grow, and the scale structure of the network also continues to expand, and the continuous expansion of nodes and transmission channels in the network will also lead to the increasing of abnormal probability of the network, thereby reducing the reliability of the network and causing security problems. In serious cases, it will also lead to the loss of information and the threat to property security, which will seriously affect social harmony [1]. In order to ensure the security and stability of the network and reduce the loss caused by network anomaly, it is necessary to diagnose and optimize the abnormality of the network. The purpose of this study is to apply artificial intelligence to identify the network anomaly, and further improve the diagnosis ability of network anomaly.

## 2 Current Status of Artificial Intelligence in Network Anomaly Diagnostic Applications

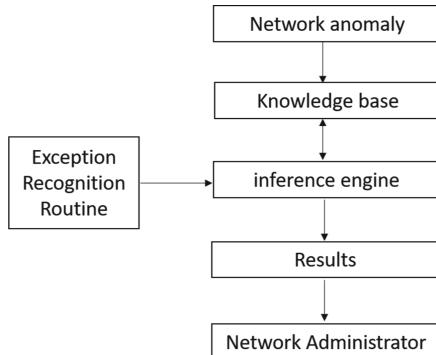
Nowadays, the role of the Internet in social development is unquestionable. When it brings convenience to work and life, also cause people distress. Once network anomaly occurs, it will affect the work progress in a small way, and it will even cause

information leakage or even property loss. Therefore, the frequent occurrence of this situation puts forward new requirements for the identification of network anomaly. However, the effect of monitoring by manpower is very limited for the huge network system. Therefore, a professional, fast and accurate network anomaly monitoring system will become the best option [2, 3]. However, currently there is no professional application for the above problems, which leads to many traditional anomalies that cannot be handled at all, while the current mature artificial intelligence technology has become the key to solving the problem.

### 3 Network Management Based on Artificial Intelligence

In this research, artificial intelligence is applied to network anomaly identification management. Although thorough intelligent identification and intelligent processing still need more continuous research, the technical feasibility of network anomaly identification has been achieved [4].

The intelligent system of this research is composed of knowledge base, inference engine, knowledge acquisition module and interpretation mechanism. Through the characteristics of real-time, compatibility, and hierarchy, the system provides targeted solutions for network anomaly identification and management (Fig. 1).



**Fig. 1.** Network anomaly process

The basic characteristic of the network is dynamic, which requires the system to have the ability to update in real time. At the same time, the causes of network anomaly are diversified. When an exception occurs, the system needs to identify the cause of the exception through the knowledge base at the first time. Therefore, the interpretation mechanism of the system is complex, and therefore a large number of instructions identifying the real-time network status, so when conducting research [5], we not only need to study how to integrate advanced artificial intelligence with the system, but also comprehensively consider the complexity of the technology implementation and the stability of the final deployment.

## 4 Analysis of Basic Characteristics of Network Anomaly

### 4.1 Hierarchy

One of the characteristics of the network is hierarchy, which covers several different levels such as data links, network hardware and software applications in different layers. The above different levels may have the possibility to occur abnormalities, so network anomaly has the hierarchy.

### 4.2 Transmissibility

There are two main types of network anomaly transmission including horizontal and vertical transmission. Horizontal transmission is that at the same level, abnormalities happen in other related structures because an abnormality first occurs. Vertical transmission is that since the correlation relationship between different levels, when an element in one level is abnormal, and then other elements in different levels become abnormal at the same time [6].

### 4.3 Correlation

The causes of network anomalies have multiple characteristics. The same anomaly may have different effects, and the same anomaly may be caused by different causes.

### 4.4 Randomness

Generally, network anomaly has no regularity, and the causes of anomalies are often random. And this just increases the difficulty of diagnosing network anomaly, and also requires stricter knowledge base. Traditional human monitoring is not only time-consuming and labor-intensive, but also the final diagnosis results are likely to be biased, so manual monitoring is difficult to meet the increasingly frequent network anomaly identification work [7].

The network diagnosis method based on artificial intelligence technology is the most efficient and achievable method at this stage. In the future, artificial intelligence network anomaly recognition will become the mainstream in this field.

## 5 Application of Network Anomaly Recognition Method Based on Artificial Intelligence

The basic idea of network anomaly recognition application design through intelligent algorithms is to use intelligent algorithms to update the network status information in real time in the knowledge base, and then carry out the detector set identified by network anomaly and use the intelligent learning capabilities of the intelligent system to update the knowledge base the network anomaly detection library is updated in real time to keep up with the problems of network anomaly [8].

The process of network anomaly identification is the reverse process of the anomaly. The cause of the anomaly and the level of the anomaly are quickly analyzed through the manifestation of the anomaly features.

There are important nodes in the identification process of artificial intelligence network anomaly as follows.

### 5.1 Information Acquisition and Processing Stage

The data generated by the hardware device during operation is the key basis for judging whether the network is abnormal. In this study, the SNMP protocol will adopt the form of actively report the device during the identification process and then obtain the network data of the hardware device in operation. During automatically extract operating data records, analyze network fault information in the extracted data and collect it as sample.

### 5.2 Related Parameter Settings

The related parameter has been settled to intelligence anomaly, it covers the period of the detector and the threshold value required starting the detection.

### 5.3 Offline Learning

Through artificial intelligence technology to improve the traditional network abnormal situation sample collection mechanism and regularly implant the relevant abnormal samples into the knowledge base. This process does not occupy network resources. The overall process of offline intelligent operation forms a comprehensive network anomaly identification comparison database at last. In order to meet the diversity and dynamic of network anomaly, the system needs to update the new network anomaly samples in time [9], so the system will continue to develop offline new samples implantation work to improve the efficiency of network anomaly identification.

### 5.4 Fault Detection and Alarm

After the above three relevant processes, it will meet the demand of basic requirements of network anomaly recognition and then a network recognition diagnosis model will be formed, it will be applied to the operation of network anomaly recognition system later and a diagnosis report will be generated for network anomaly, the reference will be provided to relevant technical personnel.

## 6 System Function Implement

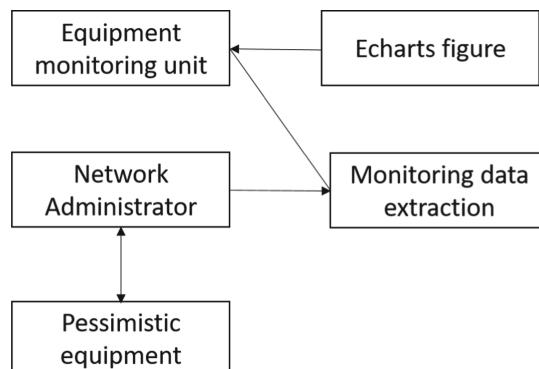
### 6.1 The Whole System Development Process

This paper analyzes and designs the network anomaly recognition system and then develops and conducts the network anomaly recognition system.

The development of various functions of the system mainly includes the development of front-end interface, the development of server-side exception identification and the development of network transmission system, and the development of front-end equipment is mainly through the front-end display page; the development of a server-side identification system mainly includes the design of restful API to meet the demands of the front-end and the development of mongo dB database; the development of transmission system is mainly aimed at the relevant agreement and information transmission of network anomaly, collect real-time data of network equipment and transfer related identification instructions [10].

## 6.2 Implementation of Equipment Monitoring Module

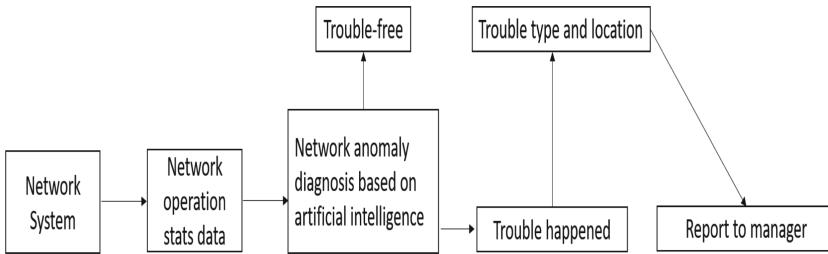
The implementation monitoring unit of the anomaly recognition system mainly monitors the relevant network equipment and systems at work in order to obtain the relevant usage data. The real-time data and relevant resources used by the network equipment during operation are stored in the database. The front-end system monitoring data and the monitoring data of the network equipment can be integrated to generate a real-time dynamic monitoring module. The specific process is shown in the figure below (Fig. 2).



**Fig. 2.** Device monitoring component implementation

## 6.3 Implementation of Network Anomaly Recognition Module Based on Artificial Intelligence

The more important thing in this research is the development of the anomaly diagnosis module for diagnosing network anomaly malfunction that occur at any time and to distinguish the types and levels of anomalies at the first time then report the anomalies to the network administrator through the front-end system to deal with abnormalities in time [5]. The following figure represents a schematic diagram of network fault diagnosis based on artificial immunity (Fig. 3).



**Fig. 3.** Network anomaly recognition based on artificial intelligence

In order to get the information of network anomaly immediately, the monitoring module needs to implement the real-time running status of the network equipment, so as to be able to obtain the running status in operation to make sure found something abnormal then report that to related department as soon as possible. Monitoring the running status of real-time network equipment is the first step in network anomaly identification [11]. After obtaining the relevant operating data of the network equipment, once the network anomaly is found, the system starts to analyze the reason of the abnormality. If the cause of failure can be directly diagnosed, it will be transmitted to the front-end interface to help the network administrator to perform the next processing and the cause of this kind of abnormality is mainly come from network equipment such as electronic wire under special conditions but unusual condition id relatively fixed.

If the abnormality cannot be judged at the first time, it shall be transferred to the artificial intelligence recognition program, extract the fault code from the recorded network data and extract the corresponding fault code from the knowledge base. If the fault code matching the network exception is identified from the knowledge base, the network exception determined by intelligence is the same as the recorded in the knowledge base and then a diagnosis report is generated [12].

## 7 Conclusion

In this study, artificial intelligence technology is introduced into network anomaly diagnosis for realizing network anomaly recognition in universities and then finds out abnormality then transfer it to the front-end real control, which is reported to the network administrator to analysis and maintenance in time.

The network anomaly recognition in this study on the basis of artificial intelligence technology, which is expected to identify network anomaly quickly and efficiently. The network maintenance efficiency of network administrators can be greatly improved through the support of front-end devices. The above front-end visual monitoring components include dashboard, figure table component, device distribution topology figure, etc. Through the design of the front-end page of the dashboard, the network administrator can view the network anomaly alarm in time, and the figure table component in the generated report can reflect the approximate time when the network anomaly occurs while the device exception can reflect the error location and the equipment affected by the fault cannot operate normally.

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# Data Security Risk and Preventive Measures of Virtual Cloud Server Based on Cloud Computing

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**Abstract.** Cloud computing is another technological revolution of the Internet. It is the product of the development of the information age, which has changed the way people use data and applications. The core idea of cloud computing is to virtualize server entities into logical servers, forming a large cloud resource pool, and providing services such as common computing, parallel processing, and shared resources. However, with the continuous development of cloud computing technology, the large amount of user and application data processed on the virtual cloud server is vulnerable to various security threats. This paper mainly analyzes the data security risks of the virtual cloud server from three aspects of data transmission, data storage, and data application, and proposes corresponding data security precautions to ensure the data security of the virtual cloud server and build a good cloud service network security environment.

**Keywords:** Cloud computing · Virtual cloud server · Data security risks · Security precautions

## 1 Introduction

Cloud computing is a commercial computing model derived from the innovative development of computer networks and communication technologies. It integrates computer network technologies such as parallel computing, grid computing, utility computing, distributed computing, load balancing, network storage, and virtualization [1]. Cloud computing is not a new web technology, but a new concept of web applications and services that rely heavily on virtualization technology to provide cloud resources and application services [2]. The core idea of cloud computing is to use virtualization technology to build a large cloud resource pool using multiple server entities or hardware resources to achieve services such as common computing, parallel processing, and shared resources. Through the services provided by cloud computing, cloud users can use a variety of terminal devices without time and space restrictions to use unlimited shared resources on the virtual cloud server [3]. However, with the continuous development of cloud computing, the massive data transmitted, stored and applied on the virtual cloud server is vulnerable to various security threats. Therefore, the research on the data security problem of the virtual cloud server is a subject worthy of further development.

## 2 Overview of Server Virtualization Technology Based on Cloud Computing

Cloud computing is another technological revolution of the Internet. It is the product of the development of the information age, which has changed the way people use data and applications. Cloud computing uses the Internet as its basic carrier and deploys a range of logical resources and software applications to the cloud via the virtualization technology, making it easy for cloud users to access and use the cloud concurrently at any time, and providing cloud users with a fee based service, services such as elastic computing and storage management.

Cloud computing uses virtualization technology to abstract server physical resources into logical resources, building large resource pools of hardware such as CPU, disk, memory, I/O devices, and so on, breaking traditional hardware physical constraints and basic network architecture, to achieve the unified allocation of resources and integrated management [4]. Under the role of virtualization technology, it can improve the resource utilization efficiency of the server, provide independent virtual cloud server resources and application support for cloud users, and achieve a high degree of integration and sharing of resources. Virtualization technology is an important means of implementing cloud computing applications, it is the core computing architecture of cloud computing, and it is also the technical foundation for the development of cloud computing [5].

## 3 Virtual Cloud Server Data Security Risk Analysis

The virtual cloud server used on the cloud platform is different from the physical server, when all data and applications are in the cloud, once there are unexpected restart failures, network failures, network attacks and denial of service problems, etc., it directly affects all the virtual systems supported by the current physical server, and only affects applications on a single server if the physical server is used. As an important application and data processing equipment, virtual cloud server can not be ignored in data security. Especially reflected in the virtual cloud server data transmission, storage, application and other major processes, there will be different degrees of data security risk.

### 3.1 Data Transmission Security Risks

In the cloud computing environment, the virtual cloud server transmits a large amount of user data and application data to cloud users through the Internet. These transmission data will regenerate and amplify the signal through the network communication infrastructure and intermediate equipment, realize the effective forwarding of the data packet, and send it to the designated target user host according to the encapsulated address. In the process of data communication, especially cloud data resources based on wireless network transmission, it is extremely susceptible to electromagnetic signal interference and data loss. It is also common for network hackers to wiretap and intercept data.

### 3.2 Data Storage Security Risks

In the cloud server, there are real-time data exchange, storage, and management services, which bear a huge data processing workload. The following data storage risks exist on the virtual cloud server:

1. The failure of the data storage facility or the attack of the virtual cloud server causes the integrity, confidentiality and availability of the stored data to be damaged, and the data cannot be used normally.
2. Because the encrypted data is difficult to query and compute on the virtual cloud server, the stored data is generally not encrypted, once the storage device or the Virtual Cloud Server is hacked, easy to cause data leakage, loss and damage [6].
3. Due to the huge amount of data on the cloud server, the cloud service providers seldom adopt the necessary fault tolerance and remote backup mechanism for the stored data in order to save system resources. Once the data is damaged and lost, this will bring serious and irreversible consequences [7].
4. Authentication mechanism directly affects the security of system data when accessing data stored on cloud server through application programming interface. In the imperfect and insecure authentication link, it is easy to be invaded and attacked by unauthorized users, which seriously affects the normal use of data.

### 3.3 Data Application Security Risks

Cloud service providers, cloud agents, cloud administrators and cloud users in the use of cloud data, due to its own reasons, will bring certain data security risks. The related users' security consciousness is not strong enough, and it is easy to overlook some security risks and system loopholes, divulge personal authorization information, and cause illegal access to cloud services and data. In addition, administrators do not have systematic professional training, professional knowledge is not strong enough, did not differentiate the system management authority, resulting in the cloud system administrators on the operation of the data center authority is too large, once administrators violate professional ethics, it is easy to occur internal attacks and information theft and other issues, seriously affect the security of cloud data.

## 4 Virtual Cloud Server Data Security Precautions

### 4.1 Improve Network Security Laws and Regulations

Due to the large number of people involved in cloud applications and data use, it is difficult to restrict and manage it from an ethical level. It is necessary for the state and the government to introduce more comprehensive network security laws and regulations to increase the crackdown on criminal activities such as illegal access to network data and hacking. In order to build a good cloud computing network security environment, it is necessary to regulate and constrain the behaviors of the participants from the national level, so that the network security behaviors can be followed and enforced strictly.

## 4.2 Improving the Awareness of Participants in Security Precautions

Cloud service providers, administrators, and cloud agents play a leading role in cloud systems as providers and managers of cloud services. In order to strengthen the security awareness of such professionals, it is necessary to carry out regular professional ethics training and professional technical guidance, and strengthen the system management, system operation and maintenance, data security, network security and personnel security and other technical training [8]. To formulate a sound system safety management system, standardize the operation procedures and methods of technical personnel, and gradually improve the level of system management of various professional and technical personnel. As users of cloud services, cloud users do not have the corresponding professional skills, but they should strengthen the awareness of network security and learn more network security skills. Do not use weak password as a password, do not easily reveal personal account and password information, do a good job of personal information security protection. Install anti-virus software on cloud devices, shut down unnecessary ports and services, perform frequent system scans and bug fixes, and regularly back up critical data.

## 4.3 Strengthen the Application of New Cloud Security Technologies and Build an Integrated Cloud Security Infrastructure

1. Application of identity authentication mechanism based on biometric technology  
Biometric technologies such as facial recognition, fingerprint recognition and Iris recognition are used to verify identity based on virtual cloud server access, and log records of login and access are kept, improved accuracy and non-repudiation of authentication. Combined with the application of CA certificate technology of Virtual Cloud Server, the strength of identity authentication of cloud server is enhanced to prevent the access of non-authorized users, so as to better guarantee the data security of cloud server.
2. Using encryption technology to realize data secure communication  
In the cloud data communication, the important information such as User Account Information, Privacy Information and system control instructions are encrypted, and the communication infrastructure is protected, or use VPN to construct virtual security channel to transmit data. Digital signature technology is used to verify the integrity, reliability and non-repudiation of information, and to ensure the security of data transmission.
3. Using the least privilege technology to realize the management of authority differentiation

According to the different roles of the virtual cloud server, each management role corresponds to different responsibilities, and the hierarchical authority management is implemented. Combined with the use of the least privilege technology, according to the actual requirements of specific operations, the system operation authority of different management roles is assigned as little as possible, and the system privilege is differentiated, so that each management role has its own responsibilities and works together. In addition, the application of the least privilege technology can also help to strictly manage the authentication mechanism, reduce the illegal

occupation and misuse of the management role account information, and reduce the damage to the data of the cloud system caused by the illegal user and illegal operation, it plays a vital role in ensuring the data security of the system.

#### 4. Deploy firewalls and intrusion detection and prevention systems

For the hacker's illegal intrusion and virus infection, we can deploy the software and hardware firewall as the first cloud server defense barrier, set the access control policy and packet filtering rules, and make the corresponding response operation according to the rules. The intrusion detection system (IDS) is used as the second security line to dynamically monitor the security of the cloud server system, and to realize situation awareness, threat monitoring, warning record, interception and cut-off, and emergency measures. Firewall and intrusion detection system complement each other to build the security infrastructure of cloud server.

#### 5. Using system redundancy design and data backup mechanism

In order to improve the reliability and stability of the virtual cloud server system and ensure the system to provide cloud service normally, the system redundancy technology is used to realize the dual hot backup or disk mirroring, which can provide backup support for the system data. When the virtual cloud server fails, the redundant configuration server replaces the failed server and quickly intervenes to provide the cloud service, thus improving the system fault-tolerance. For important system data and user data, audit and data backup can be conducted regularly to ensure the security of the original data.

### 4.4 Establishing Industry Standardized Cloud Security Supervision and Evaluation System

In order to ensure the data security of the virtual cloud server, it is necessary for the industry authority to follow the international standards, follow the national laws and regulations, and formulate a standardized, institutionalized and scientific cloud security supervision and evaluation system, standardizing the security management and sustainable development of cloud computing industry [9]. In the role of a controlled cloud security regulatory system, the participants are taken as an important regulatory object to regulate and constrain the security operations of cloud service providers, administrators, cloud agents and cloud users, building a good cloud security environment. Establish credible cloud security evaluation system, establish data security quality evaluation index, divide security quality grade, audit and evaluate data security, improve and optimize cloud data security strategy [10].

## 5 Conclusions

With the continuous development and improvement of cloud computing technology, while bringing convenience to people's work and life, the data security issues brought about cannot be ignored. This article analyzes the data security risks from the three aspects of data transmission, data storage and data application of the virtual cloud server. It is proposed to improve security laws and regulations, increase participants' security awareness, strengthen the application of new cloud security technologies, build

an industry-standard cloud security supervision and evaluation system, and do a good job of security precautions to create a good cloud network security environment.

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# Computer Network Security Based on Hierarchical Evaluation Protection System

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**Abstract.** With the continuous development of the economy and society, and the continuous improvement of Internet technology, the computer field has paid more and more attention to the use of network security technology. In fact, although network security technology has become more mature in the protection work, virus attacks have gradually matured, making network security technology more difficult in virus handling. The research purpose of this paper is to study the computer network security based on the layered evaluation protection system. This paper analyzes the characteristics of the computer network security layered protection system, studies the main technologies applied in the network security layered protection system, and combines network security The actual characteristics of protection, the design scheme of hierarchical protection evaluation system for computer network security was proposed, the hierarchical evaluation was used to establish the protection system, the computer network security was researched, and the protection system in this paper was verified through system testing. The experimental results in this paper show that the protection system based on layered evaluation in this paper has high security performance, the safety is as high as 97%. In addition, the response time in this layered protection system based on layered evaluation is short and the efficiency is higher.

**Keywords:** Hierarchical evaluation · Computer network security · Internet technology · Security protection system

## 1 Introduction

With continuous improvement and upgrading, it still cannot be completely protected. The factors affecting network security are mainly artificial and natural factors, including network viruses, internal system code writing errors, etc. Once a network security problem occurs, it will not only affect normal network work, but also cause serious losses to individuals and companies. In the process of business handling, it is necessary to use a secure payment platform to avoid the potential security hazards on the network. As a staff member, we must first identify the location of the potential hazards, then propose targeted security technology defense measures, and finally use antivirus technology. Check for viruses to ensure the safe operation of information.

Network security includes not only hardware security, but also network operation and software operation environment security.

With the continuous development of the times, people's application requirements for computers have become greater and greater, but the scope of application has become wider and wider, but the network security problems of computers have become more and more serious, which affects people's information security to varying degrees. With the continuous development of technology, the means to effectively respond to current network security issues will become more mature [1, 2]. Today's online settlement and information security are constantly updated and improved, however, because information leaks and other events often occur, consumers are concerned about online settlement and transactions. In view of this situation, it is necessary to strengthen the investigation of the operation status of the network protocol itself, and confirm whether there are loopholes and errors. There is a great need for layered inspections. The application of the computer network security layer evaluation system effectively reduces network information risks, maintains network security, eliminates security risks, and ensures the normal and stable operation of computer systems to improve network work efficiency.

The research purpose of this article is to study the computer network security based on the hierarchical evaluation protection system. This paper first introduces computer network security and its hierarchical protection system, and builds a computer network security hierarchical evaluation protection system, from the development environment, development tools to the outline design (requirements analysis and database design) is elaborated, and the detailed design and function implementation of the computer network security layered evaluation system are introduced in detail. Through the system test, the reliability of the construction system is proved.

## 2 Method

### 2.1 Computer Network Security and Layered Protection System

- (1) Network security: The so-called network security is mainly aimed at computer hardware and software. Among them, the basis of network security is personal information, data transmission, network management, personal accounts, network technology, and corporate information [3, 4]. Network security is closely related to network technology and network management. Standardization of network environment, improvement of network security technology, strengthening and optimization of network management.
- (2) Layered protection system: Nowadays, with the development of the network, the forms of network attacks have also undergone various changes. Traditional network attack defense technology is in a passive position to a certain extent and cannot prevent network attacks in a timely manner. The computer network security layered protection system is mainly composed of three parts: security assessment, security protection and security services [5, 6].

## 2.2 Characteristics of Computer Network Security and Layered Protection System

- (1) Network security and threat analysis: Computer network security is mainly aimed at hardware security and software security. The research object of network security protection is mainly data and information security [7]. Use effective network security technology to standardize the network environment, optimize network management, and establish a secure and stable network system security environment. At present, there are various ways of cyber attacks, and there are rich changes. Traditional network attack defense technology can no longer meet the needs of modern network security protection systems [8].
- (2) Characteristics analysis of computer network security layered protection system: The computer network security layer protection system guarantees the security of related components of computer information security, and implements a computer network security defense system and a security policy guarantee system [9, 10]. Computer network security strategy is an important means to ensure the high security and reliability of computer network systems. Clarify the protection limits of network security protection devices. The safety protection technologies and countermeasures adopted at the technical level are the realization of safety systems under specific conditions. The computer network security layered protection system is a complete set of comprehensive security measures [11]. Concept map of computer network security system The hierarchical evaluation and protection system of computer network security is a dynamic system that is constantly adjusted during system operation.

## 2.3 Design and Function Research of Computer Network Security Hierarchical Evaluation Protection System

- (1) System design requirements: The composition and elements of the analysis network system are complex, and the relevant technical content is high. Network system is a dynamic operating system with multiple human intervention factors. The network system is affected by many factors during its operation [12]. In the design of the computer network security hierarchical evaluation protection system, the availability, integrity, confidentiality and non-repudiation of the system must be fully considered. Usability is mainly focused on the user's own operations, enabling users to flexibly interface with the operating system [13]. When network security is threatened by multiple factors, integrity guarantees the integrity of the system. Confidentiality is based on the server/browser architecture model and uses the SSL Secure Socket Layer protocol to quickly implement user access to the WEB browser, complete server authentication accurately, and provide users with effective access control. A secure SSL channel is established between the server and the client, and the user implements a WEB128-bit key session through the SSL secure channel.

- (2) Layered design of basic network: According to the difference of network application direction, the model also has some differences in its network structure, and each index has different requirements. First, in the basic network hierarchical model, the first-level sub-indicator model includes four different sub-network indices of integrity, confidentiality, availability, and non-repudiation. From the perspective of usability, users can place tasks on the operation records and strictly follow the operation specifications. No additional software or input information is required. Just follow the steps to perform the next operation. From the perspective of integrity, the distributed computer environment is composed of different systems, including servers, host systems, and workstations, so it is more difficult to obtain complete data [14].

### 3 Experiment

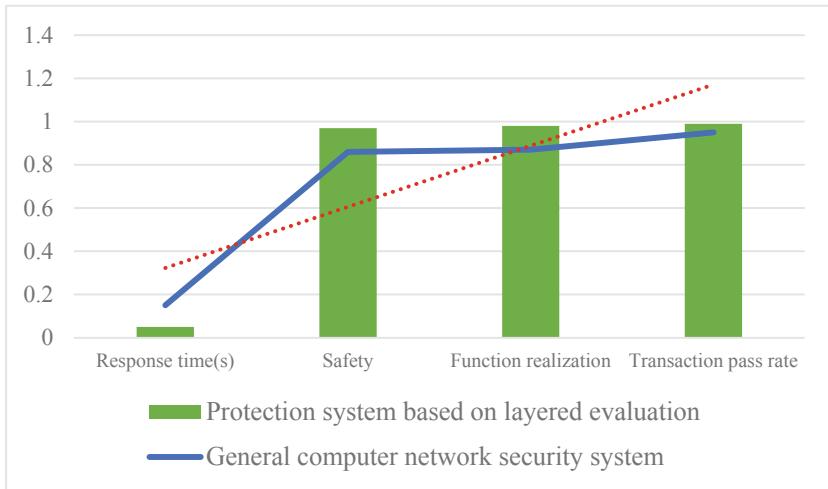
- (1) Database design: The database uses SQLserver2012. This management system can achieve effective maintenance of the database. When designing the database, the Visio database is used for data storage, and ER diagrams and database texts can be created. Inventory DDL databases. This login method requires users to perform username and Password authentication.
- (2) System test: In the system test, we completed it through the subsystem to verify whether it has the system functions in the instruction manual. In the system test, the test object is facing the entire target design of the software, including the requirements analysis system. The main purpose of the test is to select some data that is easy to find errors in the daily operation process, find out the errors and correct them.

### 4 Discussion

#### 4.1 Performance Test Analysis of Protection System Based on Hierarchical Evaluation

The performance of the protection system based on hierarchical evaluation is tested, and the test results are compared with the general computer network security system. The results are shown in Fig. 1.

From Fig. 1, we can know the performance analysis results of the protection system based on the hierarchical evaluation. Compared with the general computer network security system, the protection system in this paper has a shorter response time, higher security, and security as high as 97%. In addition, the function achieves 98%, Enough to see that the protection system in this article is safe and reliable. An effective security protection system cannot be separated from network security analysis, including virus behavior and characteristic analysis. The increasing complexity of network virus mutations and attacks makes virus defense more difficult. Only by establishing a dynamic comprehensive analysis system and finding the source of the virus can the virus file be thoroughly checked and killed.



**Fig. 1.** Performance test of protection system based on layered evaluation

#### 4.2 Usability Test of Protection System Based on Hierarchical Evaluation

The functional test is to check whether the system meets the design and development requirements. After completing the test, we found that all system modules can basically meet the development requirements. On the usability test, the test user can use it satisfactorily, which is reflected in the convenience of operation. Whether the interface is friendly. The specific test case table is shown in Table 1 below.

**Table 1.** Test case table

Number	Operation	Test result
1	Enter the home page and click “apply”	Enter the application page
2	Add existing user name, click Check user name	A prompt box appears indicating that the user name already exists
3	Add the user name that does not exist, click Check user name	Prompt user name available
4	Two user passwords are inconsistent	Prompt password is inconsistent

As can be seen from Table 1, the system's usability test passed. During the development process, after testing the website, I found that there are still some problems, mainly due to the lack of consideration in the design, including: at login, when the user logs in with the correct identity, the main page can display the user login information, however, when you switch to the function page, you will not be able to log in, and you cannot accurately identify the user permissions. You can only refresh the page to display it normally. This kind of problem occurs because the main page can

only judge whether the user is currently in a normal login state, and if it is simply calling other pages, the user completes the correct login and the other pages are not updated in time, and can only be displayed normally after actively refreshing.

## 5 Conclusion

This paper establishes a computer network security hierarchical assessment and protection system, which improves the computer network security level, thereby reducing the chance of network risks. In the process of building a computer network security and layered protection system, this paper considers technical factors, improves network technology, optimizes network security operations, and focuses on the design of system indicators. The test results show that the layered evaluation protection system constructed in this paper is safe and reliable. The research in this article will promote the continuous development of computer network technology, thereby increasing the economic benefits of enterprises and providing incentives for enterprises to participate in market competition.

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# Discussion on Computer Network Security Under the Background of Big Data

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**Abstract.** The rapid development of science and technology is gradually changing people's lifestyles, not only bringing about changes in behavior habits, but also changing and innovating their thinking patterns, which has had a tremendous impact on people's social life. However, the era of big data brings not only huge opportunities but also severe challenges to computer network security. This article starts with the potential security risks of the network in the context of the big data era, such as the lack of awareness of network security, the harm caused by hacking attacks, the harm caused by virus intrusions, the hidden dangers caused by computer network system vulnerabilities, and other security risks. Analyze the precautionary measures of computer network security.

**Keywords:** Big data · Computer · Network security

## 1 Introduction

In the context of information globalization, the rapid development of the Internet and information technology has not only brought about changes in lifestyle and behavior habits, but also changes and innovates thinking patterns, which has had a tremendous impact on people's social lives. In 2018, the number of Internet users in China reached 829 million, and each person's Internet access time reached 4 hours per day. The equipment used by Internet users to access the Internet is also constantly being upgraded. Starting from the earliest PC, mobile phones and tablets have been transferred [1]. The TV can also access the Internet.

However, in recent years, the internet and information technology have brought us convenience and brought certain threats. Cybersecurity incidents have frequently occurred, and criminals have used the Internet to engage in some bad behaviors that affect social order. Faced with the current severe cybersecurity threat situations, it is necessary to upgrade network security protection measures to effectively respond to various types of cybersecurity threats.

## 2 The Importance of Cybersecurity in the Era of Big Data

The essence of big data is to optimize the processing of information, so that the value of network information can be exerted most effectively, and multiple characteristics are reflected. First, there is so much data. Many data are not only reflected in massive

information, but also include data diversity, such as text, data, pictures, videos, software, and so on. Makes big data fully used in all aspects of social life; second, the speed and speed of data generation and processing is flexible, and the input and output of information can be upgraded to achieve remoteness; furthermore, due to the relatively low value density of large amounts of data Finally, the characteristics of the data form a huge database, which realizes data sharing and openness through the Internet technology, enabling everyone to consult and use, more information resource requirements are greatly satisfied, and provide great convenience for social life [2].

Based on the above characteristics, in order to manage these huge data under the globalization of information, to prevent information leakage or loss from bringing unnecessary trouble to our lives, to avoid security loopholes in the network to provide some hackers with the possibility of crime, data Protection is essential. This requires us to start from the hardware and software and operation links to improve the quality of data management as a whole.

### 3 Hidden Dangers of Network Security in the Era of Big Data

#### 3.1 Lack of Cybersecurity Awareness

With the widespread application of Internet technology, big data has provided unprecedented convenience for people's social life. People can access and use the information they need anytime, anywhere. They are not aware of the security risks behind this convenience, let alone pay attention to it. Moreover, major platforms need to be registered when they are used. People set the password to use the same password for easy remembering, and the password is relatively simple. This makes the account vulnerable to theft and other risks. Filled loopholes.

In addition, people will receive various spam emails when using some social information exchange documents, some of which are harmless publicity advertisements and some are destructive and offensive e-mails, which will make the mail server suffer Damage can not work properly, and even invade the system to steal important information.

#### 3.2 Harm from Hacking

Cyber hacking is one of the main hazards facing computer network databases at present. It uses special network technology to lurk in huge information and invade other network systems. It uses illegal methods to steal networks similar to governments, enterprises and individual users. System, user data resources are changed, stolen and destroyed. Nearly 50,000 websites were tampered with in July 2019, an increase from last month. There are 2,527 malicious programs in network security practice, which is huge in scale, as shown in Table 1. The typical attack methods are mainly cracking and intercepting the data during the data transmission process, destroying the transmission of the data and endangering the security of the information; or carrying out targeted damage to the target user, causing the loss of the integrity and quality of the target user information [3].

**Table 1.** Number of tampered websites and malicious programs in China from January to July in 2019

Time	2019.1	2019.2	2019.3	2019.4	2019.5	2019.6	2019.7
Number of tampered websites	1301	1192	1220	7083	19718	19743	49772
Number of malicious program events	2697	2456	2853	2544	2436	2326	2527

Data source: National Internet Emergency Center

### 3.3 The Harm Caused by Virus Invasion

Computer viruses are virtual in nature. They are artificially manufactured computer programs that invade the computer to change or even control the user's action instructions, causing great damage to the hardware and programs of the network system, and severely causing the computer system to be paralyzed. Many computer viruses currently lurk in a large amount of information in a very covert form, and the coverage of information resources is high, and the speed of transmission is fast, which facilitates the spread and spread of the virus, making the virus super-transmissive and infectious. In floppy disks and hard disks, similar to Panda Burning Virus, etc., stealing various information and business secrets of users, causing serious losses to customers. In July 2019, the CNCERT Internet Security Threat Report pointed out that in terms of network virus activities, there were more than 700,000 domestic terminals infected with network viruses, an increase from the previous month [4]. See Table 2 for details.

**Table 2.** Number of virus infection terminals in China from January to July in 2019

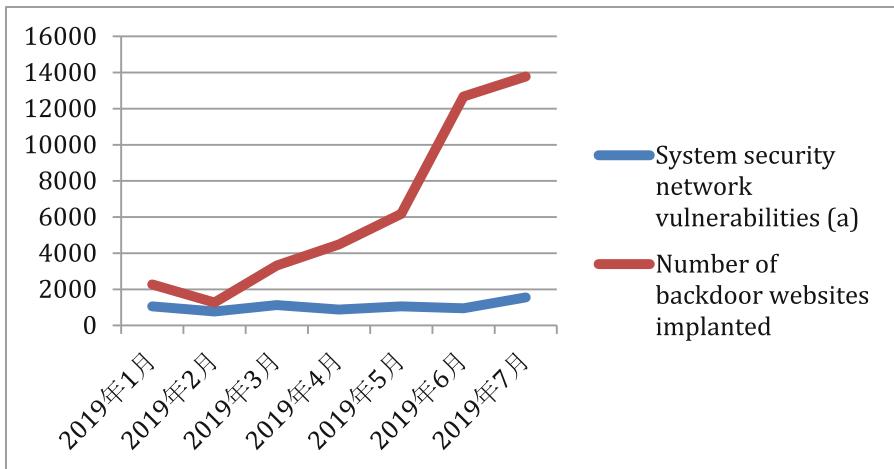
Time	2019.1	2019.2	2019.3	2019.4	2019.5	2019.6	2019.7
Number of virus infected terminals left	750,000	710,000	690,000	790,000	610,000	680,000	700,000

Data source: National Internet Emergency Center

### 3.4 Hidden Dangers Caused by Computer Network System Vulnerabilities

All areas of social life are inseparable from the support of various systems of the computer network, and the use of various types of websites and network software is built on the basis of programs. However, the design and operation of each program will not be perfect. There are more or less technical flaws and vulnerabilities. According to data collected and compiled by CNVD, the information system security vulnerabilities in July 2019 were more than 1,000, an increase of 63.2% over June, and the growth rate of high-risk vulnerabilities reached 82.8%, The vulnerabilities that can be used for remote attacks also increased by 65.2%; sometimes programmers also designed some backup programs for software or websites for convenience. In July 2019, the number of domestic websites implanted in the backdoor was 13,000 More than a thousand, an increase of 8.8% points from last month, see Fig. 1 for details. This leaves room for some criminals to make use of it, with unpredictable consequences. In addition, every person who accesses the Internet has different skills in computer network security

operations, and it is easy to ignore network threats during the installation of computer hardware and user software. Some default options have certain security risks, which are extremely destructive to the computer in the later period. The series of network operations is harmful [5].



**Fig. 1.** System security network vulnerability from January to July 2019. Data source: National Internet Emergency Center

### 3.5 Other Security Risks

In addition to the above hidden dangers, it also includes many other factors, such as the damage caused by some natural disasters such as earthquakes and fires. It is inevitable that the vulnerability of the machine itself leads to its hidden safety hazards. Or, some erroneous human operations lead to the breach of network information security [6]. For example, some calculations and instructions need to be performed in accordance with the correct steps and settings in order to be completed safely. However, because the user's operations are highly subjective, their respective operating skills are inconsistent, and they have not been systematically trained. In this case, the operation appears Mistakes are very normal. For example, when people use the Internet for socializing or shopping, it is easy for some criminals to mislead to browse illegal websites, which is also very likely to cause hidden dangers to network security.

## 4 Measures to Strengthen Network Security in the Era of Big Data

### 4.1 Improve the Protection Awareness of Network Users

Users can be reminded and educated through examples of various types of network security events, increase network security education, and set access permissions on

their own network equipment such as routers, computers, etc. to prevent others from using network equipment at will or even maliciously. Avoid using WIFI login and websites and software that involve personal privacy to prevent criminals from having the opportunity. Netizens strengthen the management of various account passwords in the use of the Internet, such as system accounts, various social accounts, online banking accounts, and mailboxes to implement safe and effective management. Accounts and passwords should be implemented in more complicated and different situations, and passwords should be lengthened and difficult to update and replaced regularly. At the same time, the security awareness of network software designers also needs to be continuously strengthened, and training and encouragement measures for cutting-edge network talents should be strengthened to provide technical support for providing a harmonious and secure network environment [7].

#### **4.2 Upgrade Firewall Technology to Enhance Monitoring Sensitivity**

The firewall technology can effectively divide the computer network from the outside world, ensure that the network can run in a normal system, and also avoid intrusions from external hackers. In view of the rapid update of network information, the upgrade of firewall technology is also crucial to ensure the effectiveness of segmentation. In addition, it is also necessary to use signature tags or statistical research techniques to track and troubleshoot network security risk information in a timely manner, so as to provide timely feedback and processing of harmful information. At the same time, the integration function of big data is used to establish an effective hacker attack model to improve the sensitivity of identifying hackers [8]. Once identified, various firewall technologies are used to isolate in time to reduce the possibility of being attacked.

#### **4.3 Improve Computer Anti-virus Capabilities**

In addition to cultivating high-quality information security personnel, in order to build a scientific, rigorous and highly specialized security system is very important. To this end, you can choose advanced anti-virus software on your computer, use genuine software, avoid clicking on unfamiliar links, and perform routine maintenance such as scanning and anti-virus on a regular and timely basis. Antivirus is the most effective measure for network security at this stage [9]. In addition, the virus is identified in time by antivirus software, and the virus is killed in the cradle. Generally, anti-virus software is required to install anti-virus software to prevent unnecessary interference between anti-virus software. Anti-virus software and anti-virus software should also be updated in a timely manner to improve the computer network security performance.

#### **4.4 Strengthen the Defense Function of the Network System**

Under the background of big data, people can enjoy the convenience of life without leaving home, but in view of the high innovation of computer applications and the existence of certain risks, the stability of their systems needs to be improved. Some good and bad products emerge endlessly. Once the performance is unstable, it is easy to cause user information leakage and the risk factor is greatly increased [10]. Therefore,

the administrators of computer network security carry out strict checks and corrections on the system, and timely repair system vulnerabilities. At the same time, the relatively important and critical information in the mass of information should be protected by some different forms of encryption technology. Modern encryption technology is constantly developing. After encryption, only the corresponding decryption algorithm can use the encrypted information normally. Thereby reducing the impact of external interference on network security [11].

#### 4.5 Other Protective Measures

Whether it is a professional computer user or a personal computer user, in addition to improving network security awareness, they also need to standardize their words and deeds, improve computer operation skills, not download unknown materials, and not only click links from unknown sources. In addition, it is necessary to standardize and guide national policies. Actively promulgate relevant laws and regulations, increase punishment, build a diversified network security management environment, and ensure the country's computer network security and stable long-term development.

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# Application of Virtual Local Area Network Technology in Smart Grid

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**Abstract.** The management of the smart grid operation process requires massive data. How to quickly, reliably transmit, process, and store these data becomes a necessary topic for effective management of the smart grid. This article mainly studies the application of virtual local area network technology in smart grid. Based on the analysis of the basic characteristics of smart grid management, this paper designs a three-layer switched virtual local area network (VLAN), which effectively divides the distributed smart grid data management system into subsystems that are not restricted by geographical locations and have clear logical communication units. In the experiments of this paper, because the client and server in the service-based VLAN are usually in the same VLAN, only about 10% of the communications that randomly occur between the VLANs need to be routed, which is basically stable at 0% to 4%. between. The VLAN based on the traditional policy decreases the routing amount as the maximum number of hosts in the same VLAN increases. It can be seen that the system in this paper can effectively reduce network congestion and improve the efficiency of smart grid data processing.

**Keywords:** Smart grid · Virtual Local Area Network · Layer 3 switching · Fault location

## 1 Introduction

With the development of social productivity, traditional grids face more and more problems in terms of energy utilization, power supply reliability, and environmental protection. To solve these problems, smart grid has become an inevitable trend of power system transformation and development. Smart grid is a new form of grid construction that is different from traditional grids. It can use advanced modern information technology, communication technology, network technology and control technology to effectively combine information and energy management to achieve distributed distribution of different energy sources. Diversified management to improve the reliability and environmental protection of power system operations. In the future, the main body of smart grid power generation will be diversified, including not only existing traditional energy sources, but also a variety of renewable energy sources, such as solar energy, wind energy, tidal energy, and biological energy. At the same time, the smart grid provides different power supply methods for different power supply subjects, so its power supply is also diversified. The changes in power supply methods and the

main body of power generation have brought about changes in the structure and management of the entire smart grid, and in particular, have put forward higher requirements for the communication methods of its internal information.

The intelligence of the smart grid is realized by various intelligent devices distributed in different areas, such as: smart sensors installed in substations, outdoor power transmission monitoring equipment, and smart meters deployed in users' homes. In addition, there are various roles of users in the smart grid system, such as: ordinary grid consumers, power company employees, equipment maintenance personnel, and security workers [1, 2]. These users have different access requirements to the devices in the grid. Therefore, the inevitable problem is the management of permissions for users with different roles and the access control of different devices [3, 4]. Because users with different roles have different device access requirements, users with different roles have different access rights. In order to prevent unauthorized attackers from trying to read and tamper with data, legitimate users, while honest, want to know the content of the transmitted data, Various complicated situations such as users holding expired authentication tickets to access equipment, a reliable authentication, authorization and access control method are very important [5, 6].

Intelligence is the intelligence of the power grid, that is, the intelligent control of the operation process of the power grid [7]. Generally speaking, the smart grid is built on the basis of an integrated, high-speed two-way communication network. The application of advanced sensing and measurement technology, advanced equipment technology, advanced control methods, and advanced decision support system technology to achieve the power grid Economic and environmentally friendly and safe to use goals [8, 9]. Virtual local area network (VLAN) is a new network form based on switching technology, which can ignore the physical location of corresponding resources and form an effective logical communication network [10]. At the same time, the virtual local area network supports two-way parallel transmission of data, which can effectively double the communication bandwidth, so it can successfully solve the communication problems caused by the diversification of subjects in the smart grid [11, 12].

## 2 Method

### 2.1 Smart Grid

Intelligence is the intelligence of the power grid (smart electricity), that is, the intelligent control of the operation process of the power grid. Generally speaking, the smart grid is built on the basis of an integrated, high-speed two-way communication network. The application of advanced sensing and measurement technology, advanced equipment technology, advanced control methods, and advanced decision support system technology to achieve the power grid Economic and environmentally friendly and safe to use goals. According to relevant national standards, the smart grid has its obvious characteristics, and its main characteristics are as follows: (1) Strong and self-healing ability. The smart grid must have real-time, online, and continuous security assessment and analysis capabilities, strong early warning and preventive control capabilities, and

automatic fault diagnosis, fault isolation, and system self-recovery capabilities. In the event of major disturbances and faults in the power grid, the power supply capacity for users can still be maintained to ensure that the power grid can still operate safely in extreme cases until the fault is eliminated; (2) The ability to be compatible and integrated. The smart grid must be broadly inclusive, can support the orderly and reasonable access of a variety of renewable energy sources and distributed power sources or microgrids, and can achieve a high degree of integration and sharing of grid information, while providing effective interaction and multiple Value-added services; (3) Economic and resource optimization capabilities. Optimize energy forms, improve energy utilization efficiency, reduce investment costs and operation and maintenance costs.

## 2.2 Virtual Local Area Network Technology

Virtual Local Area Network (Virtual Local Area Network) is an emerging technology that realizes the virtual work group by dividing the devices in the local area network logically instead of physically into network segments. In essence, VLAN technology is a logical network unit divided according to a clear goal. The specific physical locations of these units cannot be an obstacle to division, so workstations of computers in the same VLAN need not be confined to the same physical space.

VLAN is a new type of network construction method proposed to solve the broadcast problem and security of Ethernet. In traditional Ethernet, in order to determine a certain message sent by a communication node, it is necessary to play the corresponding broadcast frame to a broadcast domain in the entire network. The broadcast frame needs to pass through the switch of the entire network to reach each communication node in order to obtain the target MAC address of the broadcast frame. This will cause each switch and node to process the broadcast frame information, which takes up a lot of CPU time. At the same time, the number of broadcast frames in a network is considerable. Therefore, the working process of broadcast frames will greatly affect the efficiency of the entire network. This contradiction is even more prominent in networks with large and complex communications.

In order to solve the above problems, small switch technology can be used to limit the network size and communication complexity to a certain range, thereby reducing the number of broadcast frames, but this will also lead to some disadvantages, that is, the cost of the entire network will rise, wiring is more troublesome, maintenance is more difficult, and network flexibility is worse. A better solution is to build a VLAN on the basis of the original switched LAN. The essence of VLAN is the use of software systems to construct logical network segments, forming a group of terminal workstations with the same requirements and purposes, but with unlimited physical addresses. These workstations logically divide users into functionally independent working groups based on functions, applications, and other factors. A working group forms a broadcast domain and adds a VLAN header to the Ethernet frame to form a complete function. A logical network with reduced working range and improved communication efficiency.

Due to its reasonable structure, a complete VLAN has several advantages: (1) VLAN has a small logical range, and the range is formed based on software. It can

logically divide the port of a certain switch into a certain VLAN, and other VLANs are isolated, so you can effectively control corresponding broadcast storms; (2) improve network security, VLANs can use related software technologies to restrict user access, control the size of broadcast groups, and effectively prevent the intrusion of external users, Therefore, it has strong network security; (3) The network structure is more flexible, the composition cost is low, and the maintenance is convenient. Because VLAN is a logical network formed on the basis of the original switched LAN, software technology is used to construct a temporary workgroup network. It is extremely simple, does not need to increase hardware costs, and is flexible and convenient to maintain.

### 3 Experiment

#### 3.1 Test Environment

With the code in this article, the recompiled Linux kernel already supports sending and receiving VLAN packets. Here also needs a client tool to configure the VLAN of the network interface, vconfig is such a client configuration toolkit, the latest version is vconfig-1.9. A computer equipped with two network cards is used as a server, running a Linux operating system, and being configured to complete the routing function.

The simulation environment is a Class C subnet with 25 hosts. Integrated access equipment provides three services: Internet access, VOIP phone, and video on demand. The external server provides two services: FTP download and WEB service.

#### 3.2 Experimental Steps

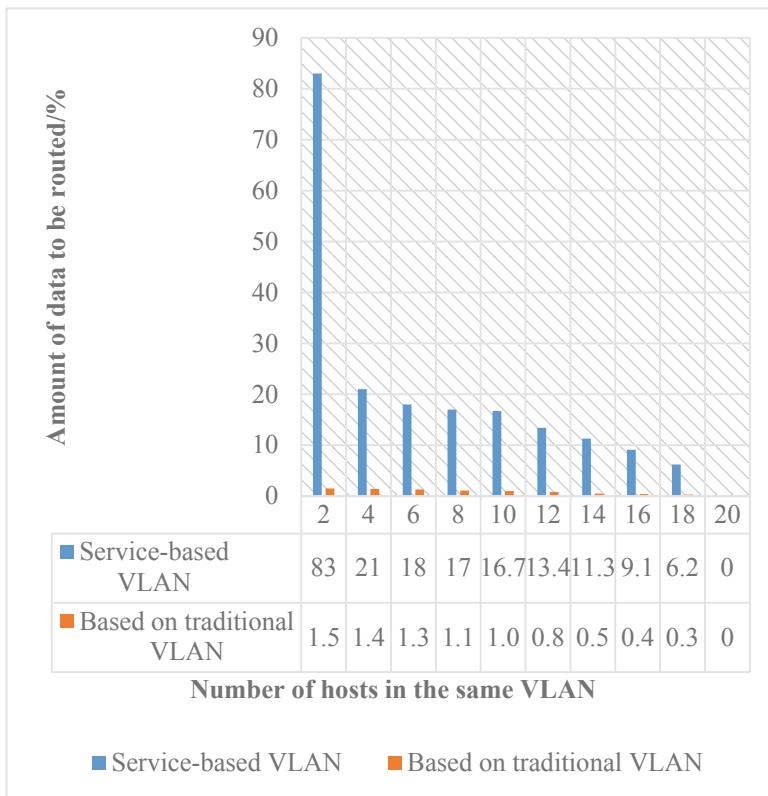
Initially, the service-based VLAN ID allocation strategy set all user PCs in the LAN to the same VLAN (Default VLAN) by default, which provides a channel for dynamic VLANID application and cancellation. The user PC on the network reads the VLAN configuration information of the workstation from the integrated access device when the service request is made, generates a correspondence table between the network application and the VLANID, and dynamically applies the VLANID for the network application of the user PC as required. With the allocation and revocation of dynamic VLANIDs, the network application-VLANID correspondence table is updated and maintained, and synchronized with the correspondence table in the storage area of the integrated access device.

- (1) First compare client-server communication. Set 90% of the network traffic as client-server communication. Each client communicates randomly with only one server at the same time. The other 10% of the traffic is randomly generated between the clients or servers. Assume that each server has an average of 5 clients.
- (2) Second, compare the end-to-end communication, the communication between service users and service providers.

## 4 Discuss

### 4.1 Experimental Application Analysis

As shown in Fig. 1, it is based on the client-server communication comparison test chart. Because the client and server are usually in the same VLAN in a service-based VLAN, only about 10% occur randomly in each VLAN Inter-communication only needs to be routed, which is basically stable between 0% and 4%. The VLAN based on the traditional policy decreases the routing amount as the maximum number of hosts in the same VLAN increases.



**Fig. 1.** Performance comparison chart of client-server model

Then compare end-to-end communication. For a local area network with a large number of end-to-end communications, the traditional VLAN grouping strategy cannot get the ideal grouping scheme. The service-based VLAN can dynamically create and withdraw new VLAN packets. For end-to-end communication, the amount of data that is routed is 0. As shown in Table 1, the communication test chart based on the end-to-end mode.

**Table 1.** Comparison chart of end-to-end performance test

Number of hosts in the same VLAN	2	4	6	8	10	12	14	16	18	20
Service-based VLAN	82.3%	67.39%	28.1%	17%	16.5%	14.1%	10.9%	7.3%	3.1%	0%
Based on traditional VLAN	3.2%	2.8%	2.5%	2.4%	2.1%	1.4%	1.1%	1.0%	0.3%	0%

It can be seen that no matter in the client-server situation or the end-to-end situation, the VLAN based on service policy has a significant effect on reducing the amount of data passing through the route. Irrelevant broadcast data is still isolated from each other at this time, and the security features of the network are not destroyed. For VLANs based on traditional policies, increasing the number of hosts in the same VLAN group reduces routing, but at the same time increases the amount of useless broadcast data received by each host, greatly reducing the network security features. These performance advantages are particularly important in this network age that emphasizes Quality of Service. The benefits to users are also obvious, such as clear image signals and stable continuous voice signals.

## 4.2 Smart Grid Structure and Data Analysis

The traditional power grid mainly relies on the energy management system EMS and the distribution network management system DMS for information management of the entire power grid. These two systems can effectively achieve data collection and control of power supply equipment, but they cannot obtain real-time information of power load in a timely manner. For the smart grid, the power supplier and the power consumer are an integral and integral part of the management system, and the change in load will have a great impact on the operation of the entire system. In order to solve the above problems, it is necessary to add a large number of sensing detection and control equipment on both the power consumer and the power supply side, and the increase of these equipment means an increase in the amount of data collected in real time, thereby forming a power generation side, a transmission and transformation side Big data group on the power side. This big data group causes the data in the smart grid to have 4 specific characteristics, which are large-scale (up to PB level) and multiple data types (structured data, unstructured data, real-time data, multimedia data, etc.). The value data density is low, the discernibility is not strong, and the processing speed is fast. In order to meet the above requirements, the information system of the smart grid should adopt a different architecture from the traditional grid. From the perspective of the power grid system, there are two cores of the entire architecture. One is data storage and decision-making; the other is data transmission. These two parts are complementary. The processing of big data cannot be separated from effective network support. This system uses virtual local area network technology to solve this problem.

## 5 Conclusion

In the control system of the smart grid, the transmission of control instructions, sensor data and system information is realized through the corresponding communication network. Therefore, the requirements for communication networks are high. Compared with the above technologies, virtual local area network has the advantages of simple system structure, strong adaptability, low cost and high reliability, which can help improve the overall control efficiency. The amount of data faced by the smart grid monitoring system is huge, so data communication becomes the key to timely monitoring during the entire system construction process. Based on the analysis of the characteristics of smart grid communication data, this paper chooses a three-layer switched virtual local area network supported by industrial Ethernet and ZigBee technology, which can effectively improve the security and stability of data communication in the monitoring system and reduce network congestion.

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# Creative Thinking Design of Visual Communication Under Big Data

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**Abstract.** With the continuous development of digitalization and informatization in the 21st century, we have ushered in the big data era. The advent of the big data era has brought about subversive changes in many fields. With the tide of the big data era, how visual communication design can more accurately and intuitively convey the information content to be expressed and can stand out among many visual communication media is the concern of every designer. Only when visual communication design is creative can the information receiver be impressed with the visual design content, so creative thinking is particularly important in visual communication design. This paper analyzes the opportunities and challenges faced by visual communication design under big data environment in detail, and puts forward several strategies for developing creative thinking in visual communication design according to the current situation.

**Keywords:** Big data · Visual communication design · Creative thinking

## 1 Introduction

With the development of science and technology and the times, the form of visual communication design is not static. With the changes of the times, the visual appreciation level of people is constantly changing and improving. If visual communication design works remain unchanged, the requirements for the visual innovation and development of people cannot be met. Therefore, creative thinking is an essential factor in visual communication design. Visual communication designers need to cultivate their own creative thinking, and use innovative ideas and innovative thinking to break through the conventional expression to design, so that the content of visual communication design has more personality and characteristics.

## 2 Concepts and Classifications of Creative Thinking in Visual Communication Design

With the continuous development of information and data, visual communication design should meet people's new requirements for visual communication design, taking the visual image of the receiver as the actual starting point. With the continuous development of science and technology, visual communication technology has gradually extended from two-dimensional planar design to three-dimensional and

four-dimensional space-time, and innovation is the foundation of visual communication design and an important condition for visual communication design to adapt to the development of the times [1]. Creative thinking can be regarded as a special expression of creativity and creative thinking. In short, creative thinking is a process of further forming by making full use of conventional elements and integrating new ideas or new combinations.

Creative thinking is divided into three ways: divergent thinking, reverse thinking and associative thinking. Divergent thinking is the diffuse state of the brain when thinking. Divergent thinking can promote designers to implement the best design scheme from multiple angles. Reverse thinking refers to thinking in the opposite way, which may break the convention and enable designers to carry out novel designs. Associative thinking refers to freestyle thinking caused by a factor. Associative thinking can reconstruct the original performance and realize innovative design.

### 3 The Important Role of Creative Thinking in Visual Communication Design

In the whole process of visual communication design, creative thinking plays a vital role. It can even be said that creative thinking is the soul of the whole design. Without creative thinking, there is no design [2]. In the whole visual communication design. Through creative thinking, a design idea is formed, which eventually evolves into a design product. In visual communication design, creative thinking is the forerunner of product evolution. In the big data era, the communication path of informatization and the communication method of digitalization are influencing people's thinking and aesthetic way through various ways. When the information receiver faces a large amount of visual information, visual fatigue will often occur. Visual communication designer can only design personalized and characteristic works to make the information receiver feel unforgettable. Therefore, creative thinking is not only the premise foundation in visual communication design, but also the key factor that determines the success of design works.

The content of visual communication design includes packaging design, corporate image design, etc. In visual communication design, attention is paid to the combination of design concepts and expression forms, and the integration of art and design. Creative thinking can break through conventional expression forms and enable designers to create works with unique styles [3]. Therefore, excellent designers need not only sharp aesthetic consciousness, but also creative thinking. When designers have creative thinking, they can enter the stage of innovative design in a very short time, so creative thinking can promote the overall efficiency of visual communication design.

## 4 Opportunities and Challenges Faced by Visual Communication Design in Big Data Era

### 4.1 Opportunities Faced by Visual Communication Design in Big Data Era

First of all, the advent of the big data era promotes the diversified development of visual communication design. The big data era provides designers with a large amount of data information, and also brings designers new creative ideas. The conventional visual communication design is mainly expressed by images. The development of big data era has promoted the formation of a rich and diversified situation in the form of visual communication design [4]. At the formal level of expression, two-dimensional text and pictures can be combined with virtual sound technology to enhance the visual and auditory sensory impression of the information receiver, which can further improve the speed and quality of information transmission in visual communication design. In addition, various forms of expression have further improved the effect of visual communication design.

Secondly, big data urges visual communication design to better meet the needs of the audience. Big data has the characteristics of authenticity and high-speed communication. The visual information department can accurately analyze the changes of people's lifestyle and rhythm of life through big data, and then extract people's needs for visual information through the analysis of these data. Designers can carry out innovative design according to the needs of the audience. On the one hand, it meets people's needs, and on the other hand, it also improves the efficiency of information transmission.

Finally, big data promotes the realization of visual communication design virtualization. Under the influence of big data, all kinds of information in our life can also be transformed into digital resources. The visual communication design can also use big data to virtualize the design elements, and the three-dimensional environment construction simulated by computer can bring more realistic and intuitive design sensory experience to the audience [5].

### 4.2 Challenges Faced by Visual Communication Design in Big Data Era

First of all, visual communication design lacks innovation and individuality in big data environment. Big data's information capacity is very large, and all kinds of information are mixed together. Designers can easily collect information through big data, among which there are many excellent works. However, the following plagiarism phenomenon is also highlighted. Many designers arbitrarily imitate or draw lessons from it, resulting in the lack of innovation and individuality in many designs, and even the appearance of vulgar taste. These low-quality designs have seriously affected people's aesthetics. The negative effects brought by big data have hindered the development of visual design and destroyed the public's aesthetics.

Secondly, the content of visual communication design in big data environment needs to be richer. The spread of big data has made the design content more and more diversified and the update speed faster, which puts forward higher requirements for

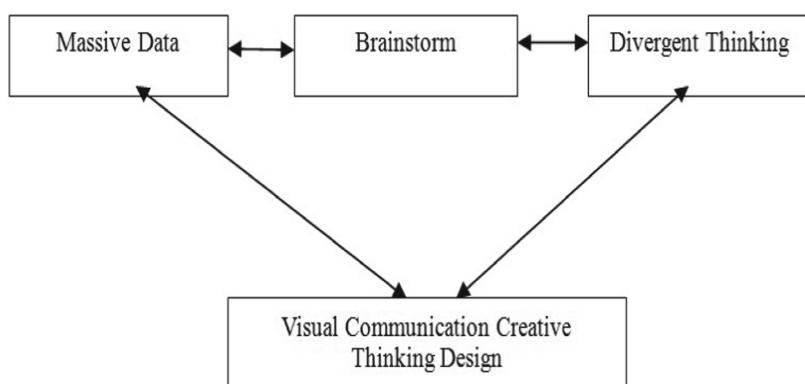
visual communication design. The conventional visual communication design can no longer meet the new requirements brought by the development of modern science and technology. Therefore, in the big data environment, visual communication design still needs continuous innovation and keeps pace with the times.

Finally, it is difficult to collect and analyze massive data in big data environment. “Making data sound” is the core of big data, and the information content of big data is very large and complex. Data plays different roles in different links in visual communication design. Therefore, it is necessary to analyze the data and allocate useless data information to other fields to maximize its value [6]. The problem in the process of data collection and analysis is that there is no direct collection channel for some data in visual communication design, which requires staff to conduct a large number of market research and analysis. However, the data and information data often obtained in this process are limited, which affects the efficiency and accuracy of data collection.

## 5 Specific Strategies of the Development of Creative Thinking in Visual Communication Design in Big Date Era

### 5.1 Make Full Use of the Advantages of Data, Strengthen the Training of Designers' Divergent Thinking

Divergent thinking has always been the most important feature in creative thinking. Divergent thinking mode can enable designers to better carry out innovative design in this process. In visual communication design, Designers realize the construction and design of visual communication design products by giving full play to their self-divergent thinking. The massive information in the big data era provides designers with more information resources and inspiration materials, improving the quality of design products, diversity of design types, and high speed of design progress [7]. In the big data era, as long as we give a keyword, we can have a large amount of data information. Designers brainstorm according to the acquired data, pictures or cases, break the conventional multi-directional thinking, and then design better visual communication works (as shown in Fig. 1).



**Fig. 1.** Visual communication creative thinking design

## 5.2 Make Use of the Diversity of Big Data to Cultivate Designers' Associative Thinking

As we all know, big data has diversified characteristics. When designers search through keywords, various text messages, pictures or cases will appear. Facing massive data and information, designers should learn to use keen observation, on this basis, through rich imagination, creative thinking design [8]. Designers need to learn how to find the internal connection between two seemingly different things, for example, associating rabbits and clothes hangers as subjects. In our conventional thinking, the two things are not linked together. Through creative thinking design of associative thinking designers, commonweal works of “protecting animals and rejecting fur” can be designed through this theme. The development of associative thinking can enable designers to carry out their brand-new associative creativity according to the relevant information of visual communication design, thus realizing the innovation of visual communication design.

## 5.3 On the Basis of Conventional Thinking, Expand the Reverse Thinking of Designers

The greatest value of visual communication design works lies in its uniqueness and innovation. Only by maintaining its uniqueness can the recipients be moved in the first place. And creativity does not come out naturally. It is based on watching and experiencing a large number of design works. In the process of visual communication design, designers can find more materials through big data for reverse thinking training. Through continuous training of visual thinking, designers can break through the conventional thinking and design distinctive works in visual communication design [9].

## 5.4 According to the Needs of the Information Age, Set up the Design Concept of Keeping Pace with the Times

Designers who want to create personalized and unique visual communication works need to have the design concept of keeping pace with the times. So how to improve the thinking concept? First of all, learning is the primary factor of one's progress. Designers can search for large amounts of data and information through the Internet. Through some cases of visual communication design, designers can absorb the essence of excellent works and stimulate their own innovative thinking. Secondly, designers can also improve their aesthetic ability by participating in and visiting various activities, thus realizing the innovation of their own design concepts. Finally, under different times background, visual communication design shows different times characteristics. Therefore, designers should make full use of the characteristics of big data high-speed transmission to keep up with the direction of the times, so as to meet the new requirements of modern people for visual communication design [10].

## 6 Conclusion

For visual communication designer, how to perfectly convey the design intent and product information is the most direct problem. The rapid development of big data does not only affect the life style of people, but also promotes their aesthetic concept. In the new era, aesthetic requirements of people are getting higher and higher, which requires designers, in visual communication design, to set up the design concept of keeping pace with the times, develop creative thinking, create unique and innovative visual communication works, and then meet the aesthetic needs of the recipients.

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# Public Key Digital Authentication in Mobile Communication

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**Abstract.** The mobile wireless terminals visit website of internet by WAP gateway, the HTML form information of website in internet will be transformed into WML form information in WAP gateway. So the WAP gateway is often the object attacked by hackers. Once the WAP was attacked, this would lead to data breach. User data leakage incident directly restricts the development of ecommerce, endangering the safety of user's personal information. In this paper, we use the public key digital fingerprint technology to protect mobile data. A new system of bidirectional identity authentication was built. The system realizes the security communication between the wireless terminal and internet server.

**Keywords:** Authentication · WPKI · Encryption

## 1 Introduction

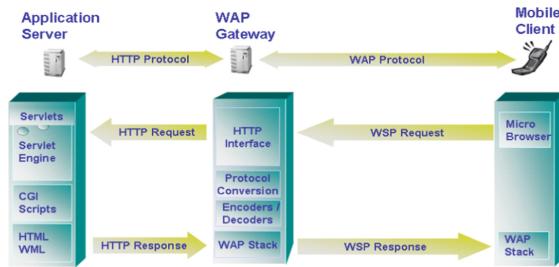
Because the data is needed to be forwarded in WAP gateway from the internet to the wireless device terminal, the wireless communication security is becoming more and more concerned. For the transmission mechanism difference between internet and wireless network, some form of encryption is needed to protect confidentiality and integrity of data. Although some encryption measures are adopted in the process of wireless communication, There are always some security defects between wireless and internet communications. The data encryption mechanism in wired network is different from that in wireless network. When the mobile wireless terminals visit website of internet by WAP gateway, the WAP gateway is often the object attacked by hackers [1]. Once the WAP was attacked, this would lead to data breach. User data leakage incident directly restricts the development of ecommerce, endangering the safety of user's personal information. How to protect communication between wireless terminal and internet server is a focus problem.

## 2 The Analysis of the WAP

### 2.1 The Application Model of the WAP

A model based on client/server has been taken in wireless application protocol. Owing to the wireless environment is optimized, many existing development tools can be used under the WAP such as web server and XML, etc. WAP client, WAP gateway and web

server of internet constitute the application structure of WAP. The WAP client can be mobile phone, tablet PC and other wireless terminal devices [2]. The WAP gateway is composed of communication operators of ISP. The content information and login service for users is provided by the web server mainly [3]. The application model of WAP like Fig. 1 shows.

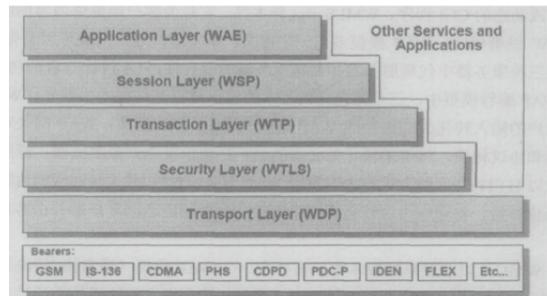


**Fig. 1.** The application model of WAP

When users access the network through mobile terminals, two environments of wireless network and wired network will be involved. So the WAP will be required to convert two different network protocols [4]. Compared with the way of processing information in wired network, it is more complex to guarantee the safety of the whole process.

## 2.2 The Protocol Stack Structure of WAP

The WAP is made up of a series of protocols. In order to be more suitable for the characteristics of wireless mobile network, these protocols has been modified and optimized. An interface was defined on each layer of WAP protocol stack [5]. These interfaces can be accessed by upper layer protocols. At the same time, these interfaces can be invoked directly by other application and services too (Fig. 2).



**Fig. 2.** The protocol stack structure of WAP

WAE includes a micro browser. The functions of the micro browser are as follows.

WML—a kind of lightweight markup language based XML design is similar with HTML.

WMLS—a simplified program scripting language that is an extension of a subset of JavaScript.

WTA—an interface which support the telephone service and programming. It provides a method of creating a telephone service with WAP.

WSP works on the layer of WTP which is safety or insecurity, it provides functions which are compressing code of HTTP/1.1 in air interface; long conversation; pending, recovering.

WTP works on data service layer. WRP is suitable for “thin” client (mobile station). WTP can run efficiently on secure or unsafe wireless datagram networks. And WTP is responsible for controlling sending and receiving data, providing reliable communication routing, ensuring no repeated receiving of data, and requiring the retransmission of lost data. Each received data packet would be confirmed [6–8].

The player of WTLS is a transport layer based security protocol. it adds support for data services, simplifies the handshake process, provides authentication services to mobile terminals and application services, and guarantees the integrity and confidentiality of data transmission between the two. WTLS is specially designed to be used in conjunction with WAP transport protocol and optimized for narrowband communication channel. WTLS has following features:

Data integrity—WTLS ensure the correctness of data transfer between terminals and applications program servers.

Confidentiality—WTLS ensure the privacy of data.

Authentication—Authentication mechanism can be used during data communication.

WDP is the base of WAP stack providing a general interface for upper protocol, running on all kinds of networks supporting different types data. Its function is to match the bottom carrier network, compensate the impact of these differences by shielding the lower communication system, so as to realize the uniform and transparent transmission of different types of network data. Because an universal interface was provided to upper layer protocol of WAP9 [9]. So the security layer, conversation layer and application layer have nothing to do with the underlying network. That is, they can work independently. These functions are achieved by enabling the transport layer to adapt the characteristics of the underlying bearer network. Under the premise of ensuring the consistency of the transaction interface and basic features, the global communication was achieved by protocol conversion of gateway.

### 3 The Main Function of PKI Is to Manage the Generation, Distribution and Verification of Secret Keys

#### 3.1 CA

CA is the ID card to prove the legal device in the internet. On the CA, there are the public key of the certificate holder, the number of certificate, the serial number of the certificate, the name of the certification authority and the signature of the certification authority. CA is organized by registration server, certificate application and audit institution, authentication center server.

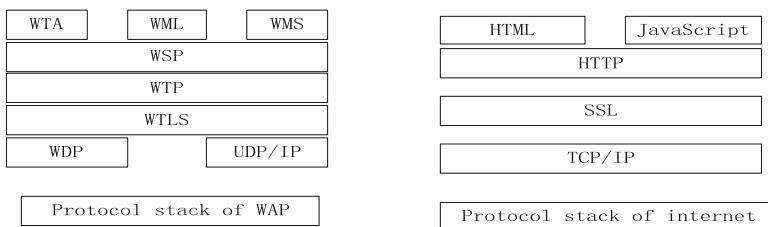
Registration server provides service of certificate application to user by web site. User can put up certificate application and write table for certificate.

Certificate application and audit institution is responsible for application and auditing of certificate.

Authentication center server is responsible for the generation and distribution of the digital certificate, and also provides the service of the management of the certificate, the generation and processing of the CRL [10].

### 4 Compare of WAP and TCP/IP

The WAP 1 stack is the extension of TCP/IP stack in wireless access. Considered the characteristics of wireless network in terms of bandwidth and reliability of transmission, the two kinds protocols stack are different in hierarchical structure. The structure of WAP protocol stack and TCP/IP protocol stack is shown below in Fig. 3.

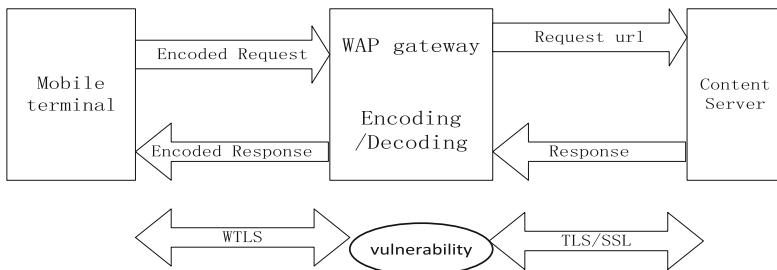


**Fig. 3.** Compare of WAP and TCP/IP

According to the comparative analysis method, the two protocols stack are researched and analyzed. The two protocols stack use hierarchical structure design. A micro browser was in the WAE, and the browser supports wireless label language, WLL is similar to HTML, is a light markup language. WLL Script is a light scripting language. They have optimized for mobile terminals. The wireless session protocol provides a unified interface for the application layer of WAP. The wired service which is similar to the TCP protocol of the transport layer of TCP/IP model. The other is a non linked service on the wireless datagram protocol WDP, which is similar to the UDP transmission. The wireless processing runs on the wireless datagram service layer,

and provides a transport lightweight protocol for “thin” customers (mobile terminals). the WTLS is based on the transport layer security protocol. WTLS is optimized for the narrow frequency channel used by mobile communications. The application program decides to use or not enable WTLS, according to the security requirements and network features of the application. The wireless datagram protocol WDP run on various types of underlying network carriers, such as GSM, CDMA, etc.

By comparative analysis, we find that the transport layer includes two protocols, TCP and UDP, which correspond to connection oriented service and disconnection service respectively in TCP/IP protocol. The transport protocol of WAP stack is only WDP, while WDP is oriented to non link. The WDP can not provide directly reliable service for the upper layer theoretically. The security layer protocol of TCP/IP is TLS, which between the application layer and the transport layer. TLS requires a reliable transport layer. This is guaranteed by the TCP protocol [11]. WTLS is a security protocol of WAP and based on TLS [12]. WTLS was optimized for narrowband channels used in mobile communications. However the WDP protocol was chosen for WAP protocols stack. However, WDP can not provide reliable services of transport layer to WTLS. Meanwhile, WDP is restricted by the resources such as wireless network bandwidth. The security protocol TLS of internet can not be directly applied to the security of wireless communications. This means that the wireless mobile data needs to be converted between two encryption mechanisms of WTLS and TLS. The data encrypted in WTLS needed to be decrypted. Before the data is needed to be encrypted with TLS in WAP gateway. That is to say, in the cache of WAP gateway, information will exist in the form of plaintext in a certain time. If the WAP gateway is controlled by hackers, the key information of user mobile banks is also not safe, which is a serious security risk. This is why we put for the scheme of remote communication based on public key digital fingerprint (Fig. 4).



**Fig. 4.** Safe vulnerability in WAP

## 5 A New System of Bidirectional Identity Authentication System

Because there is possible information leaks on the WAP gateway when data is mutual converted between TLS and WTLS. So a new protection system of WPKI solving the problem is designed (Fig. 5).

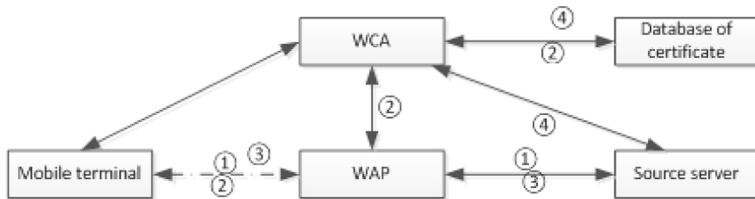


Fig. 5. Bidirectional identity authentication system

In the new protection system, the digital certificate and private key were issued to mobile terminal and source servers before communication. The transmitted data is encrypted with public key. Only the holder of the private key can decrypt the data. The internet server and the mobile terminal apply to CA for certificate when they will be in the internet. The public key was opened to all. The digital certificate was deposited database of certificate and to be queried.

The first thing is to identify identification between terminal and server of internet before communicating. ① When mobile terminal request to internet server for the service by WAP, the request requires the source server to provide certificates. Then the server provides the digital certificate of them to mobile. At the same time, the source server request the digital certificate of the mobile terminal. ② When the mobile terminal receive the digital certificate of source server, the mobile terminal will verify the certificate to CA. CA audits certificate information including the holder, term of validity, issuing agency of the digital certificate. If it is all right, the mobile terminal will be told that the digital certificate is valid. ③ On the other hand, the mobile terminal provides digital certificate to the source server. ④ Then bank server will verify the mobile terminal's certificate to CA. If it is right, both sides completed identity authentication.

The second, when the mobile terminal receives the digital certificate of the internet server, they got the public key of internet server. The data is encrypted in symmetric encryption algorithm deposited on terminal. The key is encrypted with the certificate of the internet server. The data encrypted and key encrypted were encoded and sent to internet server by WAP. The data transmitted was treated as common data. When the data arrived at the internet server, the key encrypted was decrypt firstly, then the data encrypted was decrypt using the key. Because the data encrypted can be decrypt only by the corresponding private key, so users do not have to worry about that data is revealed in WAP.

## 6 Conclusions

In this paper, we studied the architecture of WAP. A safe vulnerability was discovered in WAP compared with TCP/IP. A solution for the vulnerability is expanding PKI technology into wireless network. A new system of bidirectional identity authentication system was designed in this paper. The security communication between the wireless terminal and internet server is realized. But this requires the wireless terminal

supporting data storage and encryption. With the development of manufacturing process of intelligent terminal, the problem will be resolved in the future.

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# Investigation on Network Security Access Mechanism Based on Sqlserver Database

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**Abstract.** In recent years, the computer technology has made great progress, with the computer technology continues to mature its application scope is also gradually expanding, the computer in People's Daily life to spread. In this context, computer information data leakage and other problems, posing a threat to network security. Database and computer network security is closely related, based on this database security issues become the focus of attention. Sqlserver database developed by Microsoft is widely used in computer network because of its high performance and advanced system management. However, there are many problems in the use of the database, which threaten the security access of users. The purpose of this paper is to improve the sqlserver database and promote the improvement of network security performance by studying the network security access mechanism of sqlserver database. This paper firstly gives an overview of sqlserver database and network security, and then analyzes the problems of sqlserver database with the help of data model algorithm. On this basis, it puts forward relevant solutions, which promote the security performance of access mechanism. Experiments in this paper show that the current sqlserver database network security access mechanism has a series of problems, need to improve.

**Keywords:** Sqlserver database · Cyber security · Access mechanism · Data model

## 1 Introduction

In recent years, with the continuous development and maturity of information technology, the density of network connection has become higher and higher. Meanwhile, the connections between different networks are also relatively close. Information network has had a wide impact on people's lives. The most critical issue in information network is the security of database. At present, sqlserver database is widely used in computer network because of its high performance and advanced system management, so people pay more and more attention to the security performance of the data system. The application of the database in the computer network not only provides great convenience for data storage and query, but also effectively makes up for the shortcomings of the traditional database and promotes the further development of information technology.

In recent years, with the deepening of sqlserver database application, people also found that the system appeared a series of security problems in the application process, posing a huge threat to the security of network users' information [1]. Therefore, it is particularly important to study the security of sqlserver database. In view of a series of security problems in sqlserver database, the author thinks that the most effective way is to establish the security access mechanism of the database. Through the analysis found that a large number of existing research materials at home and abroad scholars have a rather deep study on the computer network database, security analysis of the research is mainly focused on the database, database application development, etc., on this basis, the researchers also put forward a series of policy Suggestions to solve the problem of database security [2, 3]. However, few researchers have studied the security of their databases from the perspective of security access mechanism, especially the security access mechanism of sqlserver database network. Therefore, from this point of view, there is still a large room for improvement in this study, which needs to be further studied [4].

This paper aims to improve the overall performance of the sqlserver database by studying the network security access mechanism of the sqlserver database, so as to improve the security of the database, so as to effectively protect the security interests of network users [5]. This paper firstly gives an overview of sqlserver database and network security, and then analyzes the problems of sqlserver database with the help of data model algorithm. On this basis, it puts forward relevant solutions, which promote the security performance of access mechanism. Through in-depth analysis of the sqlserver database, we can find that there are many security problems in the current sqlserver database, which pose a threat to users' interests and need to be compensated in time [6, 7]. On the one hand, the research of this paper promotes the improvement of the security performance of the database; On the one hand, it lays a certain theoretical foundation for the future research.

## 2 Method

### 2.1 Sqlserver Database and Network Security

Sqlserver database was first issued by American companies. Different from the traditional database, it is a new relational database system, showing great advantages [8]. Sqlserver database is a kind of database management system which can be extended and has high performance. Compared with the traditional information database, the database and WindowsNT computer system are integrated together. Advanced system management, high design performance, strong transaction processing capacity are the main characteristics of sqlserver database, not only so the database also supports symmetric multi-processor structure, with its own SQL language. Generally speaking, network security represents the security of computer network. Its specific meaning is that the security of relevant facilities and data in the network system will not be damaged due to some force majeure or human factors, and will always be in the state of normal operation [9, 10]. Database is closely related to network security. The research on the network security access mechanism of sqlserver database can realize the

effective analysis and query of access data, effectively ensure the analysis and management of network data, find out the problems existing in the network security access of the database and make up in time. The system establishes the data transmission channel between the client and the database and has the function of temporary network session. At the same time, the security mechanism established is mainly used to protect the transmitted information [11, 12].

## 2.2 Data Model Algorithm

The main purpose of the data model is to deepen our understanding of the sqlserver database model, which can promote us to have a more comprehensive grasp of the overall operation of the database with the help of relevant data collection, and on this basis, analyze the problems in the actual operation of the sqlserver database [13]. The error between the actual time needed to detect the database system and the perceived time is the random system equilibrium. Set the network communication A of A database, and express the actual time required for A certain part of the database data  $A \in A$  to test the database performance under the system network traffic  $x_a$  with  $t_a(x_a)$ , which is also called the detection function. The detection time is proportional to the network traffic of the system, which is consistent with the usual detection law. The continuous accumulation of detection function integral of each part is the database equilibrium objective function, whose specific formula is as follows:

$$\min Z = \sum_{a \in A} f^{xa} t_a(w) dv \quad (1)$$

Where,  $f$  represents the system flow,  $t$  represents the system detection time,  $x$  represents the serial number of each part of the system, and  $a$  represents the data number. The detection function is a direct reflection of the system detection law, which is usually a nonlinear law. By optimizing the above model, a more standard model can be obtained. The specific formula is as follows:

$$t_a(x_a) = t_a^f \left[ 1 + 0.15 \left( \frac{x_a}{C_a} \right)^4 \right] \quad (2)$$

Where,  $C_a$  represents the overall detection capability of system  $a$ . In addition, 0.15 and 4 in this model are not fixed.

## 3 Sqlserver Database Security Analysis

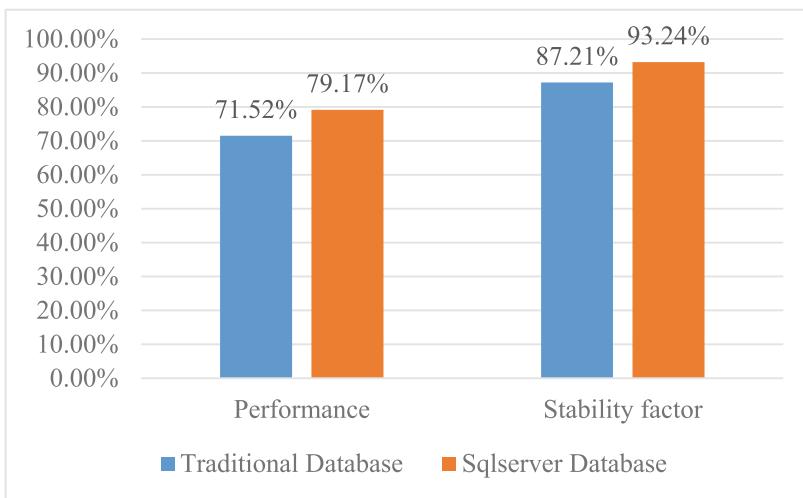
The security of the sqlserver database directly affects the security of the overall running environment of the computer. By consulting relevant information and sorting out the research data, the author finds that the main problems existing in the current sqlserver database are as follows: the database network running environment, system security and data security. First, in the use of the database and storage are to take corresponding measures, essentially a database often remember four set user access security performance boost in the form of the security mechanism is mainly consists of the following

six respectively is limited resources, audit, space, atmosphere, storage, distribution, characters, distribution, access mechanism and mode. The existence of these six security mechanisms has certain effect on the illegal access of database data. Secondly, user identity theft, data leakage and data tampering are common security environment problems of the database. Finally, the system internal illegal access and invasion is the main problem affecting the security of the database, once violated, the database will automatically start security defense. However, if the security defense value setting error, it is very easy to appear a variety of threats to sqlserver database security problems.

## 4 Discuss

### 4.1 Use Analysis of Sqlserver Database

In order to realize the essentially a deep grasp of database security problem, must use the analysis to the database, use the analysis was conducted with the aid of related computer software simulation experiment, and by essentially a database using simulation experiments, we can draw the conclusion: compared with the traditional database in the use of computer network, database used to show the bigger superiority, but is currently in use, the database security problems is significant, one of the main problem is the problem of system data security. The specific analysis data are shown in Fig. 1 and Table 1 below. The data in the chart is the result of the author's experimental arrangement.



**Fig. 1.** Comparison between traditional and sqlserver databases

**Table 1.** Sqlserver database usage data

Common problems	Probability	Dangerous degree	Difficulty coefficient
Network operating environment	25%	1.7	1.6
System security	37%	2.5	1.8
Data security	38%	3.2	2.1

\*Data came from the in-depth analysis of financial data in the experiment

It can be seen from Fig. 1 that compared with the traditional database, the sqlserver database is higher than the traditional database in terms of overall operation and stability coefficient, which reflects the advantages of the database.

## 4.2 Policies for Sqlserver Database Security Access Mechanism

### (1) Sqlserver database system internal security countermeasures

As mentioned above, sqlserver database is essentially a large-scale computer network software system, which mainly creates data by means of some key user access operations. The user is entered into the network by a specific DBA, and the database will grant specific access rights to the user after the user is detected, and the data can only be queried after the relevant rights are obtained. In this way, users can log in less with the help of the database user account, thus reducing the data damage and threat. Not only so for the database data file leakage and theft problems, this paper adopts the database encryption way to protect, the process of database encryption usually occurs in the outside of the database. Database encryption is composed of a variety of elements, including tables, records and attribute elements, these parts together constitute the encryption granularity, usually the encryption granularity and system security inversely proportional.

### (2) Sqlserver database data security countermeasures

Data security is the problem that sqlserver database must consider, ensure data security must proceed from the following several aspects: first, form the habit of backing up data, data backup mainly includes logical backup, physical backup two kinds. Logical backup is to save the data to other files with the help of relevant historical records of the database. The steps of logical backup are relatively simple. Physical backup includes online and offline backup. Physical backup is usually used to solve serious data security problems.

### (3) Sqlserver database network security countermeasures

The main component of sqlserver is TNS, which is mainly used for the connection between the database and the client and has a direct impact on the security of sqlserver database. Therefore, to ensure the security of sqlserver database, TNS security configuration must be carried out. The specific steps of configuration are as follows: firstly,

the use of network protector is detected with the help of the listener. During the security authenticator, attention must be paid to the stability of the connection between the listener and the client. Second, when a successful connection is made between the client and the listener, user data can be transferred. At the same time, the main function of the sqlserver server is to verify the identity of the network user, the user identity is determined by the server's target service case, and the final judgment directly determines the result of the session. Through this step, the security access of users is realized and the network security of the database is established.

## 5 Conclusion

In summary, the key to promote the security of sqlserver database and protect the interests of network users is to conduct network security access. Network security access mechanism provides a relatively safe network environment for network users. Currently used in the aspect of network security access database also has certain problem, the author in this article analyses the main problems and proposed the related solution strategies, the hope can give essentially a database security to provide adequate security, promoting the normal safe operation of the database, affected by the resistance and resistance factors to prevent.

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# Information Security Risk Assessment Based on Cloud Computing and BP Neural Network

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**Abstract.** With the rapid development of information technology, the risk of information security has also risen. At present, individuals, and nations attach great importance to information security issues, and information security assessment has become a necessary technical means. This paper uses cloud computing and BP neural network to use the analytic hierarchy process to evaluate the information security risk and verify the applicability of this method to information security evaluation. This paper collects and processes a large number of information security risk events, and obtains four first-level indicators that affect information security, including law, platform, user, and technology, and analyzes them with the first-level indicators. Causes, discuss them and draw relevant conclusions. The experimental results show that to reduce information security risks, related technology companies should invest heavily in technology security research, improve technology security and reliability, and the platform should consciously do a good job of protecting customer privacy and optimizing operation plans. Related departments should also introduce and Update relevant laws and regulations in a timely manner and popularize corresponding treatment methods for users who encounter security risks. Users also need to raise their own method awareness. It is also verified that the method is suitable for information security risk assessment and has good results.

**Keywords:** Cloud computing · BP neural network · Information security risk assessment · Analytic hierarchy process

## 1 Introduction

In recent years, the continuous development of information technology in China has provided excellent basic conditions for the construction of various network platforms [1]. For example, in recent years, big data has been developing more and more rapidly. Nowadays, huge amounts of data and a large number of operations have spurred the generation of big data. In order to deal with these huge data, cloud computing has also developed rapidly, and it has driven the generation and development of other technologies [2, 3].

Nowadays, with the development of these information technologies, more and more advanced technologies have been developed, but technology is a double-edged sword, which can improve people's lives on the one hand, promote human development, and on the other hand can also cause harm to people. The most prominent and

representative of today is information security risks [4]. That is, when new technologies are created, there will be related security risks. Users will inevitably leave some traces or even private information when using various devices [5, 6]. For example, payment related to people, compared with traditional commercial banking business, payment transactions carried out on the Internet are more likely to leave browsing records, and the possibility of personal information leakage is greatly increased, and criminals can steal it through some high-tech means. Get personal information. In recent years, information security incidents of various payment platforms have emerged endlessly, all revealing that there are still some loopholes in the current online payment information protection system, leading to the leakage of personal information of users, causing damage to users' personal and property rights and possible payment with third parties. The platform is contradictory. Of course, part of the reason is that the user's own awareness of information protection is weak, coupled with the difficulty of his own proof, it is impossible to pinpoint the cause of the information leakage on his own, and there are not many powers to seek channels to help him maintain his rights [7, 8].

Information security leakage is not only a weak awareness of users themselves, but also hacking technology is extremely advanced. Hackers can use big data technology and data mining technology to collect user privacy and even conduct network attacks on targets. Then there are physical equipment such as big data infrastructure. The main supporting platform of big data technology is cloud computing. Cloud computing is now developing rapidly, and the degree of processing and concentration of data transmission and collection is relatively high, which increases the risk of data security to a certain extent. The operation of big data infrastructure is easily affected [9]. Therefore, nowadays, information security is highly valued, but the related security precautions are few and vulnerable, making information security risk assessment a top priority [10]. This article evaluates information security risks using BP neural network under cloud computing platform. Because the traditional network neural algorithm has defects in the speed of data collection, and this aspect can be complemented by cloud computing, and the data can be effectively processed [11, 12].

## 2 Method

### 2.1 Cloud Computing Services

When data center problems such as resource allocation, management flexibility, resource utilization, application service quality, etc., traditional computing methods are unable to handle these problems. At this time, cloud computing technology emerged at the historic moment. Cloud computing as a kind of rapidly developing distributed computing on the Internet, it is now the result of the mixed development of computer technologies such as distributed computing, utility computing, load computing, and network storage. It integrates the network, server, storage, application software and other resources of the relevant data center, establishes a shared configurable computing resource pool, and has many basic physical facilities to provide basic support for it, making application services no longer limited to one Specific physical environments such as memory and network bandwidth set by hardware-related vendors, and users do

not need to have expertise in cloud computing, they can use cloud computing very well with little management work. With the rapid rise and development of cloud computing, it has a great impact in all walks of life, such as academia, industry, and is the focus of attention of all sectors of society.

## 2.2 BP Neural Network

BP neural network is a multi-layer feedforward network model trained by error back-propagation. It concentrates the advantages of neural networks and broadens its strengths. The essence of this neural network is actually a mathematical algorithm model obtained by understanding the structure and working principle of neuronal cells in the human brain. The algorithm uses a kind of multi-node operation to correct the data by forward prediction and error correction. The core of the algorithm is error correction. The model is generally divided into three parts: the first part can be regarded as the input layer, this part accepts external signals as input, and passes the input to the neurons in the network; the second part exists in the first layer and the second layer. This is generally called the hidden layer, and this part uses the input signal to transfer between the layers of the network; the last part is the output layer, which is the output of the data processed by the previous two layers.

## 2.3 Assess Information Security Risks

At this stage, information security risk assessment mainly refers to the process of identifying information security risks, analyzing their risks, and evaluating them. It also evaluates the security of the information security system and the actual negative losses and impacts caused by its use. The traditional information security assessment process can be divided into the following steps. First, referring to the relevant national information technology management standards, analyze the information system, grasp its asset value, existing defense measures and other known information, and find out Potential threats to information systems, hidden dangers such as vulnerabilities. Second, identify the hidden hazards found above, and determine if there are any relevant cases and treatment methods. Third, the information security risk is graded, an appropriate risk assessment algorithm is selected, and the actual situation is synthesized to form a risk assessment report and judge the possibility of a security event and its possible degree of harm. Fourth, report and summarize risk assessments.

This paper uses the 1–9 scale method to evaluate various indicators in security risk based on cloud computing and BP neural network. Assuming a set of evaluation indicators  $a_1, a_2, \dots, a_n$ , the ratio of each other is used to determine the more important value, and the following formula is used to judge:

$$A = A(a_i a_j) = (a_1 a_2 a_3 a_n) \quad (1)$$

Among them,  $i, j \in [1 \dots n]$ , in the constructed evaluation matrix,  $a_{ij}$  represents the importance scale between  $a_i$  and  $a_j$  in the network information security risk assessment system based on the evaluation matrix. The results of this judgment method are mostly

qualitative, and the 1–9 scale method needs to be introduced to set the value of each index relationship.

Then use the 1–9 scale method to calculate the importance weight of each element in the evaluation matrix. The importance of the evaluation indicators is ranked by the evaluation matrix,  $AW = \gamma W$ , where  $W$  is the vector of each indicator,  $\gamma$  is the importance weight of the judgment matrix  $A$ , and the weight formula for calculating the importance of the evaluation index in the judgment matrix is as follows:

$$\gamma_{max} = \sum_{i=1}^n \frac{(AW)}{nW_i} \quad (2)$$

Use this model to evaluate various indicators in risk.

### 3 Experiment

The first step is to use cloud computing-related platforms to collect data such as losses caused by information security risks, summarize them and find a traditional method of information security risk assessment. Query several known results and information security risk cases with detailed data in them and arrange related data to prepare for the comparison of the latter two methods.

The second step is to use cloud computing and BP neural network to process the collected data using a 1–9 scale method to obtain several information security assessment indicators. The number of indicators should not be too much, otherwise it will reduce accuracy and should not be too many make the results less representative. It is best not to exceed ten. After that, a consistency check is performed. If the consistency check is passed, the experiment is continued. If the consistency check is not passed, check whether there is a problem with the data processing. Consider changes.

The third step is to use the obtained traditional assessment methods to process the relevant data of the information risk cases that have occurred and compare the results obtained by the two methods with the standards. Make relevant charts.

The fourth step is to combine the data obtained in the first three steps, graphs, observe and explain the relevant influencing factors of information security risks, and compare the two evaluation results to obtain which one is more accurate. Then put forward relevant suggestions for the current information security risk prevention.

### 4 Discuss

#### 4.1 Information Security Risk Factors

According to the above experiments and methods, after processing the data, it can be known that the risks affecting information security are mainly composed of several indicators, which can be roughly divided into legal risks, platform risks, technical risks, and user risks. The above four indicators are defined as first-level indicators. A number

of secondary indicators are divided under the primary indicator, and then the above method is used to perform weighted operations. The results are shown in Table 1.

**Table 1.** Risk index weights at all levels

First-level indicators	Weights	Secondary indicators	Weights
Legal risks	0.277	Constraints of policies and regulations	0.602
		Normative power of the informal system	0.398
Platform risk	0.309	Operational risk	0.525
		Manipulate risk	0.475
Technical risk	0.258	Data security risks	0.391
		Authentication risk	0.375
		Information transmission risk	0.234
User risk	0.156	Personal precautionary awareness	0.358
		Ability to solve related problems	0.642

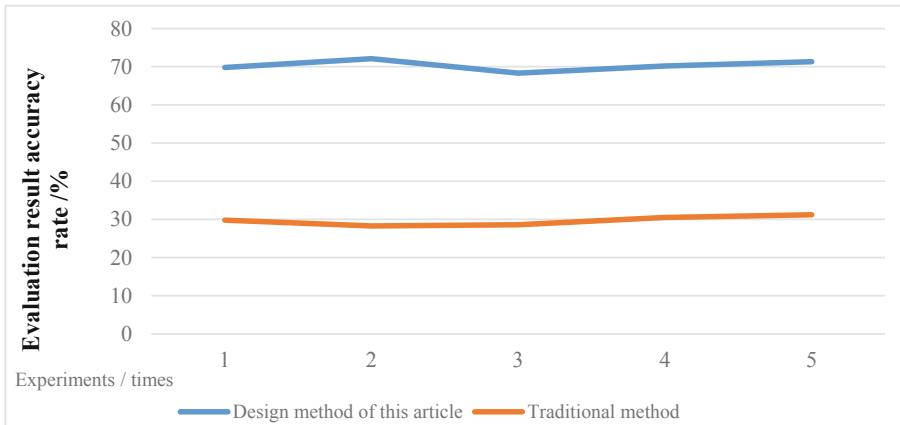
As can be seen from the table, the current information security risks are mainly caused by the platform's own security risks and technical risks, followed by legal risks, and the proportion of user risks is the smallest. However, although some users have a certain awareness of risk prevention, once Among them, I don't know how to protect my rights and interests, and I don't have the ability to solve related problems. For enterprise technology, information security risks are mainly data security risks and user authentication risks. For the platform, the operational risks and operational risks of the platform need to be taken seriously. As for legal risks, it can be seen that the binding force of policies and regulations is considerable.

## 4.2 The Design Method of This Paper and Traditional Design Method

According to the collected information on the same information security risk problem, the traditional evaluation method and the evaluation method used in this article are used to evaluate. The evaluation results are shown in Fig. 1.

## 4.3 Security Risk Prevention Recommendations

The prevention of information security risks requires the joint efforts of all parties. For relevant official agencies, more relevant prevention methods can be disseminated to allow more people to increase their awareness of prevention. At the same time, relevant policies can be introduced to strictly blame enterprises or individuals who violate laws and regulations and improve related problem solutions. For technology providers, they can invest a lot of money to improve the security of their own information products, introduce advanced technology, set up emergency handling mechanisms, and do a good job of emergency management to minimize the loss of customers and themselves in the event of a failure. Customers use this technology to respect customer privacy and establish a good reputation and image. The relevant platform should optimize the



**Fig. 1.** Comparison of evaluation results

operation mode, minimize the operational risk, protect the privacy of users and reduce the operational risk. You can also check the relevant official standards and formulate relevant guidelines that meet the requirements according to your own platform. For users, they should improve their awareness of prevention, and also have the ability or practical methods to solve related problems.

## 5 Conclusion

In summary, the current information security risks include the significant increase in the risk of personal privacy leaks, the variety and difficulty of cyber attack methods, and certain risks to physical equipment. To prevent them, it is not enough to rely on individuals or related departments. It also requires related companies, platforms and other related organizations to work together. Information security risk is a problem that is difficult to completely solve. While the relevant organizations are working hard, information security risk assessment is essential. With the development of technology, assessment methods are becoming more and more advanced, and the most important thing is fundamentally. Eliminate information security risks.

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# Security Technology of Wireless Sensor Network Based on IPSEC

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**Abstract.** With the increasing application of wireless sensor network technology in various areas of social life, the security issues it faces have become an important factor restricting its development. IPSEC is a standard framework defined by the IETF, which provides transparent security services for IP network communications. Based on the reference of the IPSEC protocol framework, this paper uses tunnel mode to perform AH and ESP security processing on data packets, and deletes the key management module. In this paper, the functions of AH and ESP are verified in the minimal.net environment. The experimental results show that the lightweight protocol based on IPSEC proposed in this paper can provide multiple pre-designed information security functions, and has passed AES and DES. Tests of commonly used encryption algorithms have concluded that the AES encryption algorithm is more suitable for IPv6 wireless sensor networks. The research results of this paper will provide a good paradigm role for solving network security.

**Keywords:** IPSEC protocol · Wireless sensor · Network security technology · Encryption algorithm

## 1 Introduction

As a new generation of technology, wireless sensor network has a wide range of applications, which also brings challenges to security management. Because the wireless sensor network environment is more complicated, the network topology is more changing, the cooperation and connection mechanisms between nodes are more fragile, coupled with their own energy limitations and limited communication capabilities, which make the possible security threats more prominent. In wireless sensor network security management, time synchronization security, routing security, positioning security, data fusion security are the main contents, and routing security is more critical. Therefore, in order to improve the security of wireless sensor networks, strengthening the risk prevention and control of routing security is an important content to ensure the safe, efficient and stable operation of wireless sensor networks.

The application of IPv6 technology to wireless sensor networks is a research direction of current wireless sensor network technologies. IPv6 has a huge address space, automatic address configuration, and a complete security protocol, IPSEC, making wireless sensor networks capable of large-scale deployment, unmanned

maintenance, and secure communication possible [1]. IPSEC is a mandatory security scheme for IPv6, so applying IPSEC protocol to wireless sensor networks is also a hot research direction [2]. Relevant literatures by carefully analyzing the structure of the IPSEC protocol and the characteristics of the wireless sensor network, it is found that the implementation of IPSEC on the wireless sensor network is feasible, and it points out that the encryption algorithm is the main factor for the performance of the application of the IPSEC protocol [3]. The research on the security technology of wireless sensor networks based on IPSEC is of great significance for solving network security problems.

Based on the Contiki operating system and the uIP protocol stack, this paper designs and implements a lightweight IPSEC protocol. The lightweight IPSEC protocol deletes the key management module, improves the implementation method of the IPSEC database, and uses tunnel mode to perform AH and ESP security processing on wireless sensor network data packets.

## 2 Method

### 2.1 IPSEC Protocol

#### (1) Structure of the IPSEC protocol

IPSEC (IPSEC Curity) is a network protocol suite developed by the IETF, which protects IP packets by encrypting and authenticating them [4]. The IPSEC protocol consists of two parts: a key exchange protocol and a protocol to protect packet flow; the former is used to establish key exchange for secure packets, and the latter includes Encapsulating Security Payload (ESP) and Authentication Header (Authentication Header, AH), used to ensure the confidentiality of data, source reliability, connectionless integrity, and anti-replay services.

The IPSEC protocol provides high-quality, interoperable, and cryptographic-based security guarantees for data transmitted over the Internet [5, 6]. The IPSEC protocol provides the following security services between specific communication parties through encryption and data source authentication:

(1) Data confidentiality: When the IPSEC sender transmits data packets through the network, the data packets are encrypted to prevent data leakage [6].

(2) Data integrity: IPSEC calculates the data packets to be sent by the sender team through a hash function or digital signature, and places the calculation results on the data packets to be sent; the receiver passes the received data. The packet recalculates the message digest and compares it with the message digest in the data packet to ensure that the number has not been tampered with during transmission [7, 8].

(3) Data source authentication: The receiving end can authenticate whether the sending end sending the IPSEC packet is legitimate.

#### (2) AH agreement and ESP agreement

The IPSEC protocol mainly includes the AH protocol and the ESP protocol. The Authentication Header Protocol (AH) provides authentication of the source of the packet and authentication of the integrity of the packet [8, 9]. The ESP protocol

can provide the security services provided by the AH protocol, as well as confidential security services, and can select the required security services according to the needs of the application.

In the IPSEC protocol, data integrity is achieved by calculating the entire packet checksum and filling the checksum into the IPSEC header [10, 11]. When the receiver receives the IP data packet, it can recalculate the checksum of the entire packet and compare it with the checksum in the data packet; if the two are the same, it means that the data packet has not been tampered with, otherwise it means that the data packet has been tampered with [12].

### (3) IPSEC related data concepts

Security policy and security association are two important concepts of IPSEC. A security policy (SP) is a policy used to specify a data flow to or from a particular host or network [13, 14]. The security association is one-way, so for a two-way communication, two SAs are needed. The security policy database and security association database are entities responsible for establishing, maintaining, and managing security policies and security associations. The key management system of IPSEC establishes, deletes, and changes the data stream processing method through the operation of security policies and security associated data.

## 2.2 Network Security Issues of Wireless Sensors

### (1) The concept of wireless sensor technology

Wireless sensor network is a technology that combines many sensor nodes through wireless communication technology to form a simple network. The data acquisition unit is a unit organization closest to the target receptor unit. This unit mainly converts the collected signals into electrical signals, such as pressure acquisition. The sensor is connected internally in a full-bridge or half-bridge manner. The change in resistance reflects the change in pressure. When the voltage is constant, the current will change to collect the corresponding pressure signal. The data transmission unit is the unit that transmits the collected signals after the data is collected. This unit is mainly a medium. The data processing unit refers to the signal that is transmitted to the inside of the sensor through a microcontroller and other related components. Signals or other signals are converted, so the processing unit is the core of the sensor, which determines the accuracy of the sensor to a certain extent. Only a good algorithm can calculate an accurate value.

### (2) Network security issues of wireless sensors

The problem of signal interference. Because the wireless sensor network is separated from the corresponding tangible transmission medium, the transmitted signal is exposed to the air and transmitted through the network. Therefore, the external environment has a great impact on the transmission of the corresponding signal. Propagates in the air, so it may interfere with the transmitted signal in the air, so it will affect the transmission of the signal. Therefore, wireless sensor networks are easily affected by the corresponding environment. In response to this problem, we should improve the wireless sensor network, develop a low-

frequency or high-frequency signal, and encode the information transmitted by it, so that the signal can be disguised.

**Security Issues.** Today's network technology development makes many previously impossible problems possible. However, the network is a double-edged sword, which has certain disadvantages, such as wireless sensor networks, which have improved people's collection methods to a certain extent. However, it also makes some criminals use the sharing of the network to intercept the collected signals during the transmission process, so the openness of their transmission has become a challenge to the security of their information.

### 3 Experiment

#### Test Environment

The test environment involves two platforms, the minimal.net environment and the TelosB node. In order to test which encryption algorithm has better security performance, this article uses actual nodes to test performance such as AES and DES.

#### Test Design and Parameters

In order to measure the performance of lightweight IPSEC on actual nodes, a node was selected. Its hardware parameters are: Atmegal284p MCU. The chip has 16 KB SRAM, 128 KB Flash. ROM and 4 KB EEPROM. The main frequency of the node chip is 8 MHz. When the IPSEC module is not loaded, the ELF file size obtained through compilation is 37 KB. After the IPSEC module is loaded, the ELF file recompiled is 44 KB. Therefore, it is known that the space required by the IPSEC module after compilation is 7 KB.

### 4 Discussion

#### 4.1 AH Protocol Function and ESP Protocol Test Analysis

The test and analysis results of AH protocol function and ESP protocol are shown in Table 1.

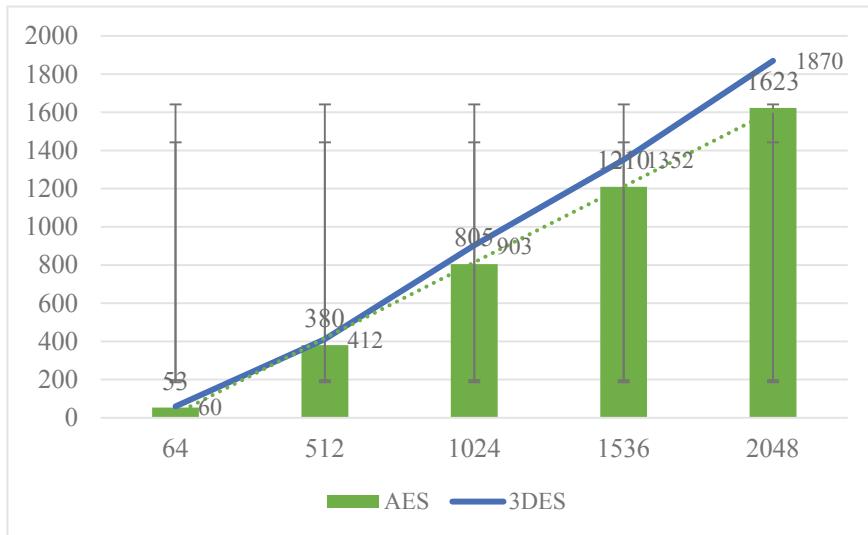
**Table 1.** AH protocol function and ESP protocol test results

AH protocol function test	Pass the test or not	ESP protocol test	Pass the test or not
Provide integrity testing for nodes	Pass the test	Packet capture test	Pass the test
Provide freshness test for nodes	Pass the test	Grab test	Pass the test
Module function implementation test	Pass the test	Functional test of SP	Pass the test

It can be known from Table 1 that the IP protocol-based wireless sensor H protocol function and ESP protocol test in this paper passed.

#### 4.2 Encryption Performance Test Analysis

The possibility of implementing IPSEC on the nodes of a wireless sensor network through verification. It is also pointed out that the biggest problem facing the application of IPSEC to wireless sensor network nodes is to find a suitable, low-power encryption algorithm. Therefore, the performance of the encryption algorithm is a bottleneck restricting the implementation of IPSEC on wireless sensor nodes. In order to test the performance of encryption algorithms such as AES and 3DES, the running time of these encryption algorithms can be compared as a scale. The results are shown in Fig. 1.



**Fig. 1.** Performance of each encryption algorithm

As can be seen from Fig. 1, AES is more efficient than 3DES, so it is suitable for use in the IPSEC protocol. As can be seen from the above structure, the IPSEC module loading operation, consumes a lot of resources to run the encryption algorithm.

### 5 Conclusion

Wireless sensor network security is an important research direction, and whether it can solve the security problem will directly affect the commercialization and large-scale application of wireless sensor networks. This article addresses this issue. It is assumed that after testing, all functions of the system have been implemented, each module is

operating normally, the cooperation between the modules is good, and it can operate normally on wireless sensor nodes. The encryption performance of AES and DES is tested. The experimental results show that AES is more suitable for wireless sensor networks in terms of energy consumption and security performance.

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# Enterprise Internal Audit Data Network Security System in the Information Age

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**Abstract.** With the development of the times, the big data has been widely applied in the management of modern enterprises, and the Internet, cloud computing, block chain, artificial intelligence, and material networking, thus bringing great challenges to the enterprise management [1]. Network security has become one of the most important risk management faced by enterprises. Internal audit cannot fully meet the requirements of the big data era. There are problems in the network security system of big data of enterprise internal audit. Enterprises need to make long-term planning, improve internal management and monitoring system, construct internal audit information platform, improve quality of personnel information. It is an urgent task for internal audit to adapt to data network security in the information age and how to identify and adjust its own role to deal with the current network risks.

**Keywords:** Information platform · Internal audit · Network security

## 1 Introduction

In 2019, Deloitte released the 11th edition of the Global Risk Management Survey, emphasizing the importance of cybersecurity, which found that 67% of respondents believed that cybersecurity would be one of the three major risks affecting an organization's business [2]. With the rapid development of big data information, big data technology has penetrated into all walks of life in society, big data has become an indispensable factor in the production and management of enterprises, internal audit of the daily management process of enterprise supervision and confirmation of the role of increasingly attention by the governance and management of Chinese enterprises. The impact of big data causes a major change in the business environment, information audit in large enterprises has developed to a certain stage, but for many small and medium-sized enterprises are still in the initial stage.

In recent years, domestic and foreign research on internal audit data network security of enterprises has been carried out and some achievements have been made, but the research on platform construction and enterprise system construction is not enough. This paper will study deeply here and put forward corresponding improvement suggestions on perfecting the network management and monitoring system of enterprise internal audit data under the big data environment.

## 2 Problems Existing in Enterprise Internal Audit Big Data Network Security System in Information Age

### 2.1 Increased Risk to the Quality of Corporate Audits

With the arrival of big data technology, the amount of information in a continuous growth state, the risk to enterprises is unprecedented [3]. Enterprises in the daily business process of the data has a certain degree of wide range and depth and a large number, in addition to the operation of data and security caused by the quality of data difficult to ensure. This is the era of big data to the quality assurance of internal audit brought great challenges. If big data technology is not used, the audit cannot obtain evidence, the audit results cannot be objective, and the audit quality cannot be guaranteed.

### 2.2 Lack of an Internal Audit Application Platform

There are more problems in the construction of audit information platform in enterprises with financial input, software development, data and network security. Enterprises do not plan in advance, do not prepare for due, platform construction is self-development or purchase ready-made information systems without reference mode. This poses a greater risk to the further development of the subsequent audit information [4].

### 2.3 Enterprise Big Data Audit Network Security Internal System Construction Is Not in Place

Internal audit in the big data environment is a new thing, enterprise management on the impact of big data technology and network security is not in place, they think that the first to build a platform, and then improve the system, resulting in a lag in system construction. Enterprise internal audit quality standards, data security, audit department management, audit system, etc. are lack of systematic system. The system is not perfect especially to network security prevention awareness is not enough, big data internal audit work will encounter many difficulties.

### 2.4 Internal Auditors' Information Skills Need to Be Improved

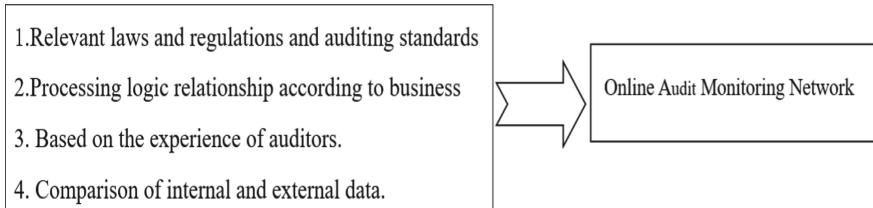
With the development of big data technology and the rise of artificial intelligence, block chain and other technologies, higher requirements are put forward for the knowledge structure of internal auditors [5]. Auditors have auditing and accounting skills, but lack a big data knowledge system. Auditors' awareness of network security is backward and they do not realize that the potential risks in the audit industry are increasing in the era of new scientific and technological background. However, there are problems in the training of talents in universities. The training of audit talents is based on the traditional mode, which only adds individual big data courses and does not arrange the skills and knowledge required for the training of information audit talents.

### 3 Solution Strategy of Internal Audit Big Data Network Security System in the Information Age

#### 3.1 Develop Long-Term Planning for Internal Audit Work in Large Data Environment

Building a good environment within the enterprise in daily work can effectively address the big data risk that the enterprise may face in future development. Establish and implement audit planning to address internal audit issues in enterprises, and specifically, enterprises can reduce risk of big data by planning methods as follows:

- (1) Strengthening of the construction of network facilities. Considering the actual situation of the enterprise, reasonable allocation of liquidity shall be made through a scientific and systematic budget, understand and control the amount of funds it needs, so that the funds are reasonably allocated. Improve the operating process of network management equipment, computer system and electronic accounting. At the same time, the computer network between the various departments of the enterprise is connected to facilitate the sharing of data information [6].
- (2) Building a network framework. In the business operation, in order to be more manageable and audited in departments, there is a need to gratify the system of the sector, thus improving information sharing among departments and effectively avoiding a range of issues that create data risks.
- (3) Formulating development strategies. From the current development situation, big data should become a inevitable trend throughout the country, and enterprises need to establish a system, scientific and perfect internal audit system for large data to establish an online audit monitoring network system (Fig. 1).



**Fig. 1.** Online audit monitoring network model [7].

#### 3.2 Construct the Information Platform for Internal Audit in Large Data Environment

From the long-term development of the enterprise, the construction of internal audit platform can implement the operation of large data technology in the specific work, and can provide efficient and easy working mode. Therefore, the construction of internal audit platform under the development of the big data age consists of two aspects:

- (1) A data network based on a unit. Establish unit data network, have a comprehensive analysis and management of financial information in enterprises, so that

the data interface is realized. This is a crucial role for the analysis of large data, strengthening linkages among various departments within the enterprise, improving efficiency and information sharing, and avoiding the large number of information that is not available.

- (2) Establishing relevant databases. When enterprises establish databases, audit data can be better used and internal auditors' analysis and collate data can be more effectively screened and obtained. There is also a need to establish audit databases to improve the efficiency of the work of the internal auditors of enterprises and to achieve interlinkages.

### **3.3 Improve Management and Control Systems in Large Data Environment**

For internal audit, the improvement of the relevant management system is essential for the final audit effectiveness, and the relevant departments can improve the following:

- (1) Large data running management requirements. Specifically, based on the way and means of implementing the data, a system of data protection related to big data is established and better data monitoring, use and collation.
- (2) Data security management system. The internal audit system has login permissions to avoid the risk of information disclosure, carefully disclose relevant data that can be shared and ensure the proper functioning of internal audit. At the same time, the government should improve the relevant legal system to further guarantee the safety of big data.
- (3) Improve the internal audit quality assurance system. Establish and improve system flexible audit system, have strong operational ability to adapt to large data technology, and control system of audit platform (Table 1).

**Table 1.** Audit content of each role of internal audit [8]

Audit subject	Audit content
System coordinator	System run safety audit
Data provider	Data source authenticity audit and compliance audit
Big data application provider	Interface security audit
Big data frame provider	Data carrier safety audit and data physical safety audit
Data consumer	Compliance audit and reverse retroactive audit

- (4) Undertake data security audits. In line with the recommendations of the Deloitte Network Security Audit, internal audit of cybersecurity needs to be strengthened in addition to the establishment of network security awareness and skills of relevant agencies, board personnel, information transparency and data security measures. This can help data information managers control the audit database operation in real time and effectively monitor the database operation and management.

### 3.4 Strengthen the Training of Informationized Internal Audit

In the large data environment, the specific requirements and methods of auditing object and audit work have also changed, and the requirements of the firm's internal auditors have changed. In traditional internal auditing, audit work was not difficult and the requirements for auditors were relatively low. Have expertise and do not require thorough knowledge of computer technology [9].

In the new situation, staff members in internal auditing of enterprises need not only have audit expertise, but also computer-related knowledge, but also have skills in computer technology and Internet technology. Traditional auditors can be trained in information technology [10].

With few personnel with both audit knowledge and computer knowledge, companies can conduct audit-related knowledge training for those interested in audits from the computer-related profession to enable them to be competent in information auditing [11].

## 4 Conclusions

Internal audit in the big data environment has become an indispensable task of enterprise management. Enterprises establish perfect auditing information platform, reduce risk, improve the quality of personnel, make internal audit work smoothly and promote the enterprise's goals. In the face of the emergence of a new and emerging thing, internal audit is not yet fully adapted, is still in the exploratory stage, lacks practical experience, and should be taken seriously by the management of the enterprise and the relevant departments of the government in the face of the impact of big data.

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# Transportation and Planning Based on Network Expansion Optimization Algorithm

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**Abstract.** The development of social economy has put forward higher and higher requirements for transportation, and the construction of transportation infrastructure has entered an important stage of rapid development. It is necessary to expand the network scale, improve the network level, and more importantly, accelerate the improvement of the network structure. Transportation network design is the most important issue in transportation planning, and it is also a hot issue in the field of transportation research. Traditional transportation network design usually ignores the uncertainty of transportation demand, which will bring risks to decision-making. When the expected traffic volume exceeds the capacity of the road network, how to choose an economical and reasonable expansion and optimization method to increase the capacity of the road network is an important issue that the transportation department needs to face. The purpose of this article is to use network capacity optimization algorithms to plan transportation. An optimization model for traffic network expansion is established, and a shortest path reconstruction and expansion cost progressive iterative algorithm is designed. The validity of the model and its algorithm can be verified, which can provide a reference for solving the optimization problem of transportation capacity expansion. Based on the maximum flow theory, a method for determining the capacity limit of the road network is proposed. In order to minimize transportation costs, a capacity optimization model is established and corresponding algorithms are designed. The experimental results show that the model and algorithm studied in this paper are effective, and the capacity expansion part of the capacity expansion optimization scheme is basically consistent with the capacity limitation part of the road network.

**Keywords:** Transportation network · Transportation network design · Capacity expansion optimization · Shortest path

## 1 Introduction

With the development of the economy and the passage of time, the capacity of the transportation network usually shows a periodical supply shortage. Therefore, how to expand and optimize the transportation network is a question worthy of attention by the transportation sector. At present, optimizing the capacity expansion of the transportation network has become an important means to improve the capacity of the transportation

network and improve the quality of transportation, but there is little research on optimization methods for capacity expansion. The study of optimization methods is of great significance for guiding practical work [1–4]. The problem of urban transportation network design is the core issue of comprehensive urban planning, and it is also the basic issue that affects the long-term stable development of the urban economy.

At present, many cities have realized the restrictions on economic development caused by transportation problems, and have begun to seek ways to alleviate urban transportation problems, and have made a series of beneficial attempts. Many cities have begun to increase investment in transport infrastructure, and many new parts of the road network have been built or rebuilt [5, 6]. Position public transportation as a major contributor to urban travel and focus on developing public transportation systems. Includes high-speed priority public transportation systems such as traffic priority strategies and light rail. Adopt advanced traffic management concepts and control methods. At present, despite the effectiveness of these measures, it is still difficult to truly alleviate the current traffic congestion situation [7–9]. In order to fundamentally alleviate current traffic contradictions, in addition to investing in infrastructure, we should also focus on advanced transportation planning theories as a guide [10, 11]. Especially in the implementation of urban transportation planning, it is necessary to start from the overall traffic situation and take into account the requirements of the city's medium and long-term development [12–14]. Formulate transportation investment reconstruction plans that are conducive to urban development. At present, with the rapid development of cities, the phenomenon of urban traffic congestion is becoming increasingly serious, and the contradiction between transportation supply and demand is becoming increasingly prominent. Relieving and preventing traffic jams has become a top priority for urban development.

First, it analyzes the network composition of the integrated transportation system, analyzes and discusses the characteristics of various transportation modes, the spatial division of integrated transportation network planning, and the choice of regional transportation network layout methods. And further clarified the content and principles of the regional comprehensive transportation network layout planning. In the comprehensive planning of the transportation network, the analysis of regional traffic distribution nodes is a prerequisite for optimizing the layout of the transportation network. The principle of selecting the basic control nodes and the importance index of the nodes in the network layout are analyzed. Based on this, in view of the shortcomings of the existing integrated transportation system and the self-adaptation and development trend of the transportation system, diversified transportation needs are used as a medium for the “mode path” of integrated transportation. This paper mainly studies the determination method of the capacity limit interval of the transportation network and the optimization method of the capacity expansion of the transportation network, and provides theoretical basis for related research.

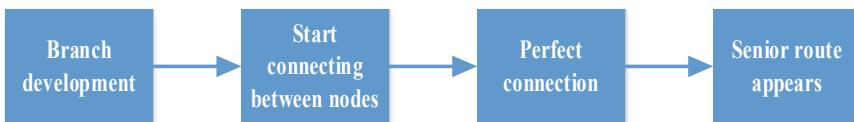
## 2 Method

### 2.1 Integrated Transportation System

A comprehensive transportation infrastructure network consists of a collection of infrastructure such as railways, highways, waterways, aviation and pipelines. These infrastructures have five modes of transportation, which are converted and connected. The physical network known as transportation is widely distributed in a region or an entire country, and becomes the basis for the socio-economic development of a region or an entire country. On this basis, through certain technical means and transportation organization methods, the operation routes, shifts, business hours, and stops of various transportation modes are reasonably arranged to form an operation network. Use advanced information technology to manage physical network facilities and monitor the operation of operational networks to form management networks. The basic elements that make up a transportation network are points and edges. Network supply and demand analysis, traffic flow analysis, network structure design and optimization of different transportation subsystems all have the common characteristics of network behavior, so graphs and network research theories and methods are often used. The network structure of various transportation systems can be described as:

$$G = (V, E) \quad (1)$$

$G$  represents the transportation network,  $V$  represents the node set, and  $E$  represents the edge set. The nodes of the integrated transportation basic network are the connection points, intersections or end points of two or more lines (such as train stations, bus stations, airports, ports, etc.). Passengers get on and off. An edge is a line infrastructure that connects adjacent nodes in various modes of transportation in a transportation network. The formation and development of integrated transportation networks have gone through a long process. The development process, characteristics and speed of transportation network systems at different development stages and various types of areas with different characteristics may vary. The transport network evolution model is shown in Fig. 1.



**Fig. 1.** Evolution of transportation network development

From a practical point of view, with the rapid growth of population and economy, transportation demand exceeds the carrying capacity of the transportation network. At the same time, the budget for reconstruction of the transport network is very limited. Therefore, it is important to study how to effectively allocate limited investment to transform the transportation network. Theoretically, the problem of transportation

network design is considered as a two-layer decision-making problem. The upper layer is the traffic manager, and the lower layer is the users on the traffic network. The upper-level traffic manager influences the routing behavior of lower-level users through the transformation of the traffic network, thereby optimizing the goals of the higher-level flow manager, and the lower-level users make selections based on the user's choice of path. Regardless of other external influences, senior traffic managers decide to maximize their effectiveness.

## 2.2 Road Network Capacity Optimization Model

For transportation networks, they can only make the most of their traffic when planning transportation or having comprehensive road condition guidance. When each traveler in the transportation network is in a self-organized state and road information cannot be efficiently transmitted in a timely manner, the maximum capacity of the road network is usually not well utilized. This is because it is assumed that the queuing information sent by the road information will not cause the decision of the road selector to change during driving. As a result, the capacity utilization of these relatively short paths is usually relatively high. At this time, even if there is capacity on other paths, the traveler does not know this information or is unwilling to choose a longer path. This prevents these remaining functions from being effectively used.

The overall idea of optimizing the expansion of transportation network capacity is to increase the network capacity at a lower cost so that the increased network capacity can meet the expected network traffic. However, the capacity expansion optimization method that only aims at the minimum cost cannot guarantee that the newly added road network traffic is distributed on the relatively shortest path, such as the shortest and secondary shortest paths from the network starting point to the destination, resulting in a newly added road network Traffic may not be fully utilized. The goal of optimizing the expansion of traffic network capacity is usually to increase the capacity of the road network at the lowest cost, so that the increased capacity of the road network can meet the expected traffic of the road network. At the same time, the optimization and optimization of the traffic network capacity is to meet the expected traffic volume. Therefore, the expanded network capacity should be equal to the expected traffic constraints of the road network. The capacity expansion optimization model established in this paper is as follows.

$$\min Z = \sum x_{ij} b_{ij} \quad (2)$$

$$\max v(f) = Q \quad (3)$$

$$\sum_j f_{ij} - \sum_j f_{ji} = \begin{cases} v(f) & i = s \\ 0 & i \neq s, i \neq t \\ -v(f) & i = t \end{cases} \quad (4)$$

Where  $x_{ij}$  is the actual energy expansion of the road segment. Where  $b_{ij}$  is the unit capacity expansion cost of the road section. Where  $Q$  is the expected flow of the road network. Where  $s$  is the source of network traffic in the road network. Where  $t$  is the

meeting point of the network flow in the road network. Find all expandable paths from the source point s to the sink point t, and calculate the length of each path and its unit expansion cost. Calculate the unit conversion capacity expansion cost of all expandable paths, and mark the path with the lowest conversion capacity expansion cost as the path that needs to be expanded in the next step. If the path with the smallest conversion capacity expansion cost obtained is greater than one, then a path with a shorter path length is selected for priority expansion.

### 3 Experiment

From several sets of planning schemes, use mathematical methods to quantitatively evaluate the advantages and disadvantages of these schemes and choose the best scheme from them. This is an evaluation of the plan. Using the qualitative planning scheme design method, multiple sets of planning schemes can be developed, and the schemes developed by different designers may be completely different. If the design of the plan is based on quantitative analysis, it will be more scientific. As far as the factors considered in its model are concerned, in theory, it can even ensure that the generated scheme itself is the best scheme, but due to the mathematical modeling at the time, it is impossible to consider all the factors related to transportation, and there are only a few. The main factors can be considered. The purpose of the evaluation is to choose the best plan or modify the existing plan or develop a new plan according to the advantages and disadvantages of the evaluation plan, so as to provide a scientific basis for the final plan decision. According to the city's existing traffic planning data and surveys of various types of population travel parameters, the current walking, cycling, road public transportation, subway, and car sharing rates are 32.35%, 13.35%, 18.38%, 20.85%, and 15.07%, respectively. Table 1 shows the ratio of trips to total trips using the Chinese method.

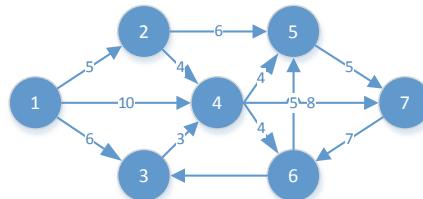
**Table 1.** Percentage of total passenger trips by passenger mode in each distance segment (%)

Distance	1	2	3	4	5	>5	Value
Walk	20.33	10.12	1.79	0.11	0	0	32.35
Bicycle	2.23	4.23	6.42	0.47	0	0	13.35
Bus	0.12	2.42	4.13	5.42	4.21	2.08	18.38
Subway	0	0.97	3.12	4.01	5.34	7.41	20.85
Trolley	0.1	0.51	4.23	5.34	5.51	6.01	15.07

This paper changes the solution of the random optimization process based on the network expansion optimization obtained by the improved path algorithm. By superimposing, deleting and replacing the network expansion optimization of different stations to obtain the optimal bus line set. At the same time, the optimal station location is determined according to the departure station of the line. Displaying the traffic routes in the form of network expansion and optimization provides a scientific and reasonable method for selecting the location of the bus station, and provides new ideas for the optimization of the transportation network.

4 Discuss

A city has a transportation network as shown in Fig. 2. As we all know, the traffic flow of this traffic network has reached the state of maximum flow 21, that is, the traffic network is in a state of congestion or even paralysis. The travel time of all sections of the road network is also the number of intervals. In networks where the travel time is the number of intervals, the calculation and determination of the shortest path are different. Some calculations of spacer numbers and comparison of spacer size must be considered. Because there is currently no generally accepted method for comparing the sizes of interval numbers, the traditional shortest path algorithm based on determining the weight is no longer applicable to the problem of the shortest number of interval numbers. An effective method needs to be redesigned to solve the shortest interval weight problem.

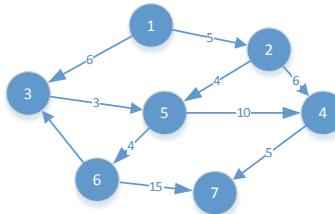


**Fig. 2.** Network maximum flow state

According to the analysis, in a certain forecast period, the traffic flow of the traffic network development trend may reach 30. According to the current state of the traffic network and the development of traffic flow, the traffic network needs to be expanded. The unit capacity expansion and reconstruction cost of each road section is shown in Table 2. Use the research content of this paper to build the optimal capacity expansion scheme.

**Table 2.** Unit Expansion costs for each section

Although the reconstruction and expansion costs of the 7 paths are the same, the two paths have the same parts. If the traffic of both paths is increased at the same time, the traffic of path 36 may exceed its original capacity. Therefore, in order to choose the way to increase the priority. Calculate the sum of unit reconstruction and expansion costs for each part of the route in Fig. 2, and then choose the larger one for improvement. Based on the largest improvement that can be achieved at this cost (i.e., 0), the traffic on path 25 is improved. The total traffic of the improved road network is 16, which has not yet reached the expected traffic of the road network. Therefore, repeating the above process to obtain a new network traffic distribution and the cost of reconstruction and expansion of its connected network is shown in Fig. 3. The network capacity of the second expansion section is increased to 1, the cost of expansion is 5, and the traffic after expansion is 17. Because the expected network traffic is less than the maximum traffic that a network extension can provide, there must be an optimal solution to this problem. Repeat the above process until the maximum traffic of the road network reaches the expected traffic of the road network. The final transportation network is shown in Fig. 3.



**Fig. 3.** The final optimized transportation network

The network expansion optimization process and the resulting expansion optimization scheme are shown in Table 3. After finishing, the final optimization plan for expanding capacity is shown in Table 3.

**Table 3.** Network expansion optimization scheme

Label	Shortest path	Length
1	1–2	5
2	1–3	15
3	1–2–4	25
4	1–3–6	45
5	1–2–5–7	25

Select the shortest path with the most stations and shortest length from the shortest path between two stations. According to this path, among the shortest paths in the remaining range, another shortest path will be filtered with the same filtering conditions.

As can be seen from Table 3, using the capacity expansion optimization algorithm proposed in this paper, the optimal solution to the problem can be obtained after 6 iterations. A total of 48 reconstruction and expansion costs were used for the reconstruction and expansion of 7 sections of the road network. The capacity of the road network increased by 5 compared with the original, reaching the expected flow of the road network.

## 5 Conclusion

The transportation network is the infrastructure of an integrated transportation system and the material basis for building an integrated transportation system. In order to make full use of the advantages and characteristics of various modes of transportation, to achieve the coordinated and sustainable development of the transportation system, to meet the requirements of passenger and cargo transportation, and to ensure the efficient operation of the integrated transportation system. And plan the layout of the integrated transportation network. The networks faced in actual planning are usually mixed, and ignoring the uncertainty of traffic demand will bring huge risks to decision-making. This article mainly studies the optimization method of traffic network expansion, establishes an optimization model with the goal of minimizing the cost of expansion, and designs an iterative method for the shortest path expansion and expansion cost calculation algorithm. The ability to optimize the problem provides method support.

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# Personal Information Security Risks and Legal Prevention from the Perspective of Network Security

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**Abstract.** In the era of big data, with the advancement of information technology and the popularization of mobile Internet, digital life has brought great convenience to people, and also brought a series of social problems. In recent years, large-scale leakages of citizens' personal information have occurred from time to time, and the citizens' rights and interests have been damaged and it is difficult to get timely relief. The leakage of personal information and data has also become an issue of increasing concern. This paper first introduces the basic overview of personal information security risks from the perspective of network security, then states the legal problems of personal information network security risks, and finally proposes corresponding countermeasures.

**Keywords:** Cyber Security · Personal information · Judicial remedies

## 1 Basic Profile of Personal Information Security Risks

On June 1, 2017, the Cyber Security Law was officially implemented, which put forward general requirements for the protection of personal information. According to the Cyber Security Law, personal information refers to various types of information recorded electronically or otherwise that can identify a natural person. This includes personal information such as the name, date of birth, ID number, phone number, and address of the natural person. In today's increasingly severe cybersecurity situation, citizens' personal information security is facing various challenges [1]. In recent years, large-scale leaks of personal information have occurred from time to time, which has brought great adverse effects to society [2]. Take Huazhu Group as an example. In August 2018, the hacking data of all the hotels under the Huazhu Group was leaked by hackers. The data breach involved the personal information and room opening records of 130 million people. These include well-known hotel brands such as Novotel, Mercure, Hanting, Grand Mercure, Jubilee, Mansion, CitiGO, Orange, All Seasons, Starway, Ibis Styles, Ibis, Elan, Hi-Tech. At that time, the hacker priced the data at 8 bitcoins. It is worth mentioning that hackers using bitcoin transactions can technically evade the tracing of judicial authorities and thus escape legal sanctions [3]. The data originated from Huazhu Group's own internal database. The dimensions, breadth, and influence of the leaked data far exceeded that of any hotel data breach. It is the most serious personal data breach in China in recent years. The scope of the leaked data

includes the following: official website registration information, check-in identification information, and hotel room opening records, which are related to personal privacy. The specific information includes ID, home address, mobile phone number, email address, ID number, login password, room number, consumption amount, check-in time, and departure time, etc. The storage capacity is more than 100G and more than 400 million records.

How big is the impact of this data breach? We can list some data. Huazhu is one of the largest hotel groups in China. According to data from the China Living website, as of September 30, 2019, China lives in 420 cities across the country and has opened 5151 hotels, including 697 directly operated stores, 4,087 managed franchise stores, and 367 franchise stores with a total of 504,414 rooms. Data breaches are not just a problem in China, they are a common problem worldwide. Many data breaches occurred in 2019, and the typical events are listed below (Table 1):

**Table 1.** Typical incidents of data breaches in 2019

Classification criteria	Event name			
Domestic	(Orvibo) IoT log leak event	Deep web vision (AI security) face data leak event	Medical PACS patient record server leak	Resume data breach
Foreign	Medical collection agency server data breach	Medical collection agency server data breach	Capital one credit history leak	Truedialog database leak

## 2 Legal Issues in Personal Information Network Security Risks

### 2.1 The Legal System for Personal Information is Insufficient

China's protection of personal information security has started late [4], and most of the relevant legal documents have been promulgated or drafted in recent years. For example, the Cyber Security Law, which was officially implemented in 2017. And the "Technical Specifications for Personal Information Security of Information Security Technology" subsequently issued. This is the first time that a national standard has provided a standard and basis for the protection of personal information [5]. It is worth mentioning that 2019 is a prolific year for personal information security regulations. Part of the file names are shown in the following table. For example, in August 2019, the National Internet Information Office issued the "Provisions on the Protection of Children's Personal Information Network," which specifies that no organization or individual may produce, publish, or disseminate information that violates the security of children's personal information [6]. It is a useful complement to the juvenile protection law. Supervising network operators at the national level to do a good job of protecting children's personal information is conducive to creating a safe network environment for

the healthy growth of children. In October 2019, the first draft of the “Provisional Measures for the Protection of Personal Financial Information (Data)” was promulgated. The bank will review the third-party institutions that provide data services, and stop cooperation with suppliers who cannot guarantee the legal source of the data.

The bill provides a legal supplement to the security of residents’ personal information at the financial level. Due to its late start, the Personal Information Protection Law is currently in the legislative plan. At present, in the relevant provisions of China’s personal information law, the law is relatively general about the leakage of personal information, how to operate after infringement, and how to remedy it, and there are problems such as poor legal operability (Table 2).

**Table 2.** Relevant laws on information security issued in 2019

Time	Legal name
May 2019	«App Illegal and Illegal Collection and Use of Personal Information Identification Method (Consultation Draft)»
June 2019	«Network Security Vulnerability Management Regulations (Consultation Draft)»
August 2019	«Children’s Personal Information Network Protection Regulations»
October 2019	«Trial Measures for the Protection of Personal Financial Information (Data)»

## 2.2 Inadequate Judicial Remedies

In judicial practice, there is a common phenomenon. After personal information is leaked or the network is damaged, it is difficult to win because of the high cost of personal rights protection.

First of all, after personal information has been leaked or infringed, the collection, storage and arrangement of evidence is heavy, which is not conducive to proof [7]. It is relatively easy to collect evidence for information leakage, but it is often difficult for network infringement to determine the source of the information leakage and find a suitable prosecution object. In the case of hacking, it is more difficult for the infringed to prove it. Second, the litigation mechanism is not conducive to defending the interests of the infringed. Information leakage incidents are often large-scale and mass damage. The infringed person is often not a single person, and the number of victims is large [8]. Because the government has not formulated a public interest litigation mechanism for the protection of personal information, this will cause many people to choose to give up their rights protection initiative after weighing the pros and cons of their rights.

Finally, the supervision mechanism is not perfect. Due to insufficient protection of personal information in our country, even government departments will condone information dissemination, trading, etc., resulting in endless types of junk advertisements. This behavior indirectly affects the security of personal information. Judicial relief is an important cornerstone of protecting the legitimate rights and interests of citizens and safeguarding social fairness and justice. Therefore, whether the design of

the judicial relief system is reasonable and sound is not only related to whether personal information can be protected by law, but also to the orderly construction of social order.

### **3 Path Construction of Personal Information Security Legal Prevention**

#### **3.1 Principles of Legal Regulation**

First, we should adhere to the principle of balanced personal information protection and reasonable use of others. Personal information is not only a personal interest, but also a social resource [9]. In the information age, the normal operation of society requires the reasonable use of citizens' personal information and the provision of corresponding services in all walks of life. For example, the subjects involved in the process of online shopping and the circulation of personal information of citizens include e-commerce companies, banks, and courier companies. In theory, their personal privacy information will be seen by numerous people. Therefore, it is an appropriate choice to ensure the convenience of people's lives, without compromising the security of personal information of citizens, and legal protection of the rights and interests of others to reasonably make personal information.

Second, we should adhere to the principle of giving priority to national security. National security means that a government can provide a stable and secure environment for the country's economic and social development. In most cases, when national interests, social public interests and citizens' personal information security rights conflict, there is no doubt that the principle of priority of national interests and social public interests should be adhered to. Citizens must tolerate a certain degree of damage at the necessary moment.

#### **3.2 Construction of Legal Norms**

First of all, the whole society should establish the rule of law in the protection of personal information of citizens. Government departments, schools, and all sectors of society should publicize the legitimacy and security of personal information rights. It is an illegal act to arbitrarily use the private information of others [10], and when this theory becomes common sense, the "Personal Information Protection Law" that is promulgated in the future may be better implemented and enforced.

Second, imitate the concept of consumer class action and introduce a public interest litigation system to provide public interest litigation support for large-scale information disclosure incidents. In recent years, information leakage incidents exposed in the society have affected a large number of people and have a large adverse impact. Individual rights protection is difficult and costly. The introduction of a public interest litigation mechanism, where a small number of people represent the infringed whole to defend their rights, can improve judicial efficiency and maintain social fairness.

Finally, improve and improve the supervision mechanism for personal information protection. On the one hand, it is possible to improve legislation at the government level and increase the number of public offices to better monitor the implementation of

personal information protection. On the other hand, the media and the people can be encouraged to monitor the implementation of personal information protection at the social level [11].

## 4 Conclusion

With the rapid development of digital economy, the infringement of citizens' rights and interests caused by the improper collection, abuse and disclosure of personal information happens from time to time. To strengthen the protection of personal information through legislation has become an inevitable requirement to protect citizens' privacy, life and property security, and regulate the healthy and orderly development of the Internet. 2019 is arguably the most important year for personal information protection. The law on the protection of personal information and the law on data security have been incorporated into the legislative plan. The state has intensified its joint investigation and punishment of the protection of personal information, especially in the financial, Internet and other industries closely related to personal information. Data leakage is one of the major events endangering data security. Looking back to 2019, large-scale data leakage incidents occurred frequently, and the situation was more severe than in previous years. How to better protect users' personal information security and privacy protection has become an urgent problem to be solved.

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# The Security Protection Strategy of Computer Network Information in the Big Data Era

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**Abstract.** With science and technology continuous development, computer network has been widespread used in all walks of life, and information technology has become a major trend in social development. With the application of computer information technology in more and more area, Chinese society has entered the era of big data networks. It not only provides a new type of scientific and technological foundation for the development of various industries, but also brings great convenience to people's lives. While the network brings convenience to people's production and life, there are also some shortcomings. The scale of network coverage is expanding day by day, the network environment is more complex, and there are many uncontrollable and uncertain factors. Because its biggest feature is openness and sharing, it brings certain challenges to computer network information technology. This article mainly focuses on the security of computer network information and protection strategies of big data. Based on the current status of computer network operations, the importance of computer security protection of network information in big data era, factors affecting computer network information security in the big data era, in the data age, three aspects of strategies to strengthen computer network information security and protection are discussed in depth in the big data age.

**Keywords:** Big data · Computers · Network information · Information security · Security protection

## 1 Introduction

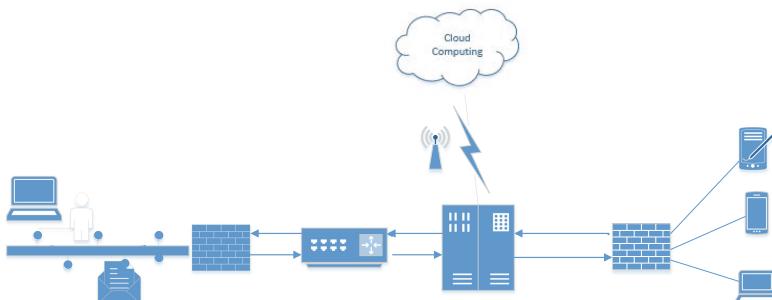
With the technology rapid development of the Internet, a huge of data and information have been generated, and human society has been in the big data era. The data era can provide more information about the development of the times for human beings, update the ideas and concepts of human beings advancing with the times, and provide convenience for human exchanges. Although there are many advantages in the big data era, it also increases the security risk of computer network [1]. Security problem risk will not only cause information data distortion, but also impact the effectiveness of human information. Therefore, in big data era, China needs to attach great importance to the computer network security. The characteristics of big data and computer network formulate a complete computer network information security management plan to avoid

information security problems, and then promote China's modern information construction process.

## 2 Basic Characteristics of the Network in Big Data Era

Big data technology is mainly to create a network platform for information sharing, which can further process and process information on the network, increase the value of information, strengthen the logical relationship between information, and provide effective and reliable data for some major decisions make sound decisions. Compared with traditional data operations, big data technology information requires advanced hardware equipment as technical support, which can achieve automation and efficient information screening [2]. The traditional data operation is just simple data software, which requires manual operation to assist, low work efficiency and low accuracy of data acquisition.

The continuous development and innovation of big data technology need to rely on a powerful information processing platform-cloud computing. Cloud computing has strong information integration and processing capabilities, can improve the utilization of information, and convert virtual data information into useful resources on the network. Communication and sharing on the information platform provides a powerful platform for big data processing information. Big data provides a platform for cloud computing development. The two are interdependent, promote each other, and develop together, as shown in Fig. 1. The cloud computing emergence has promoted the further computer information technology and the Internet development. While bringing opportunities, it is also facing more severe challenges. Especially in big data era, the network environment is more complicated, and there are some network vulnerabilities that allow criminals to take advantage [3].



**Fig. 1.** Network characteristics in the big data era

### 3 Computer Network Information Security Issues in the Big Data Era

#### 3.1 Natural Disasters

The computer's resistance to external environmental damage is very weak, so the safety of machine components is difficult to be guaranteed in the face of natural disasters or other accidents, such as water and fire threats, vibration, pollution, and lightning threats [4]. Therefore, natural disasters are included in the factors affecting the security of computer networks, because the machines themselves are vulnerable.

#### 3.2 Human Error

The display and value of computer functions cannot be separated from the user's specific operations, but human operations often have a certain degree of subjectivity, which may become a hidden danger to network information. Some users in the specific operation process because of their own weak security awareness or inadequate operation technology, resulting in large differences in the correctness of operation and setting user passwords, so human error is also a factor affecting computer network information security [5].

#### 3.3 Openness of the Network

Computer networks are not only broad in application, but also open. Although this is the advantage of computer networks, it also determines the vulnerability of computer network systems. At present, the Internet using the TCP/IP protocol does not have high security under the characteristics of openness. Therefore, the security foundation of the network itself is weak, and it is easy to fail to meet service and data requirements during the operation of lower security protocols [6]. The situation, so the factors affecting computer network security include the openness of the network.

#### 3.4 Hacking

Hacker attacks are malicious man-made behaviors. Generally, they are divided into two types. One is proactive and adopts a targeted attack method to destroy the target of the attack, causing the lack of validity and completeness of the target information; the other is passive and mainly reduces the security of the computer network by intercepting or cracking the target information [2].

#### 3.5 Spread and Theft of Spam

E-mail delivery and news propaganda are the main methods of spreading spam information. Many spam messages are mandatory to spread, in order to spread some political, commercial and religious information. The main reason for information theft in computer networks is the intrusion of spyware. Unlike spyware, which does not damage computer systems, it actively steals user information through the system,

which not only threatens the network operating environment [7]. The stability of the computer has also caused problems for the security of computer and user information. The factors affecting the security of computer network information also include the spread and theft of spam.

### 3.6 Invasion of Computer Viruses

The greater the openness of the computer network in the big data era computer virus intrusion. Once a computer virus with the characteristics of execution, storage, and concealment is loaded into the system, it will reveal its own powerful destructive, contagious and triggering nature, which seriously threatens the security of network data [8].

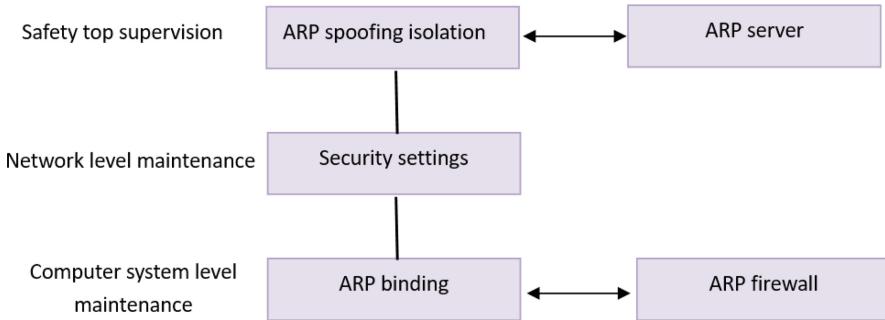
## 4 The Security Protection Strategy of Computer Network Information in the Big Data Era

### 4.1 Install Anti-virus Software, Pay Attention to Data Encryption Protection

The installation and use of anti-virus software is a computer security measure commonly used by many computer network users, which effectively avoids unnecessary computer troubles. At the same time, it is necessary to focus the security management of accounts. Different types of accounts must be encrypted and protected, especially computer system accounts, online bank accounts, and daily email accounts. Strengthen application management awareness and make account settings more complication, changing important passwords from time to time, improving the coefficient of security usage [9]. At the same time, users of computer networks should pay attention to the preservation of important data and the encryption of circulation to avoid the phenomenon of data corruption and theft. The application of data signature technology can improve the effect of encryption and further ensure the security of computer network information.

### 4.2 Strengthen Prevention Awareness to Prevent Hacking

To improve the computer network management system to prevent hacking, improve the level of automatic identification of computer systems, and effectively prevent the theft of confidential information by hackers, you can use different advanced computer technologies, such as firewall technology, computer data information inside and outside the system's isolation technology further sets up barriers to hacking and weakens the probability of successful hacking, as shown in Fig. 2. In addition, computer network administrators need to strengthen the implementation and expansion of computer data authentication technology, that is, to control the number of access to information data to further improve the use of computer network digital authentication technology and the circulation medium [10].



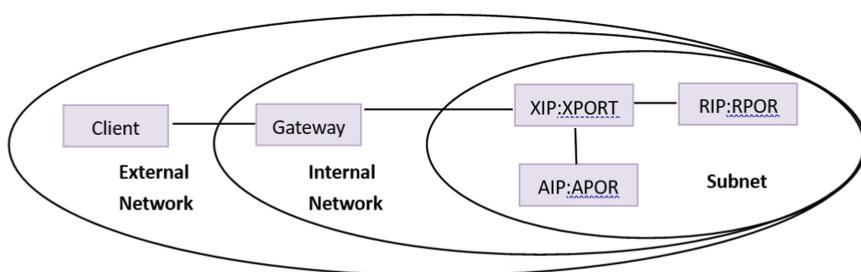
**Fig. 2.** Computer network protection system

#### 4.3 Strengthen Account Protection

The scope of online accounts is relatively broad. Common accounts can mainly include computer system accounts, e-mail accounts, and online banking accounts. In the process of security protection and management of accounts, computer users must first establish awareness of network information security protection, so that they can actively set account passwords in more complex ways, and can notice that passwords cannot be easily leaked [11].

#### 4.4 Strengthen the Scientific Application of Firewall Technology

In the big data era, the security protection of computer network information must be considered from the basic protection technology level. The application of firewall technology can effectively isolate the internal network and the external network, and establish a virtual fence between the two networks to ensure the internal network. The operation is safe and can effectively prevent the intrusion of the external network. With the application of firewall technology, it can prevent unknown intrusions and illegal attacks, and combine them with computer network security policies to improve the security of computer networks as a whole, as shown in Fig. 3. Computer network internal network security control is mainly through data information restrictions, which is an key role in the screening and isolation of hidden danger information. The application of firewall technology also adopts this method to ensure the internal network security through isolation and restriction [12].



**Fig. 3.** Computer network firewall structure

## 4.5 Data Encryption Technology

Computer network information is based on the circulation and preservation of data, and data is universal and open [9]. In the big data era, the usage of data encryption technology can realize the protection of data circulation and preservation, effectively avoid data destruction, and prevent criminals from intercepting information fragments using the network to obtain confidential information. This is an effective way to solve the current network information security problems. Among them, the data storage file encryption can prevent the data from being stolen or destroyed. The main purpose of data encryption technology is to provide encryption services for data circulation, mainly to encrypt and protect the transmission and reception ends. This technology uses line encryption and end-to-end encryption for protection, and pays more attention to the protection of data information during transmission [12]. End-to-end encryption requires encryption software to protect the data. The sender of the file uses the encryption software to encrypt the sending destination, converts the file from plain text to cipher text, and transmits it, while the receiver decrypts it with the key.

## 5 Summary

In the era of big data, information bombardment has not only facilitated people's work and study, but also caused serious security problems during the spread of data and information used by people, such as hackers and viruses. 2. Plagiarism and other forms of personal information have seriously disrupted the green and healthy network environment. If people want to continue to take advantage of the convenience and efficiency of computer networks to serve work, study, and life, they must establish a safe computer network operating environment, block hackers and viruses before they invade the network, and build network information security. Create a good internal and external environment to comprehensively protect the network information in the big data era.

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# A Role of Law in Network Security Supervision Based on Public Internet Perspective

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**Abstract.** In recent years, with the accelerated implementation of national big data development strategies, the innovation and application of big data technology have become increasingly active, generating and aggregating massive types of network data with increasing types and increasing application values, which have become key production factors for the development of the digital economy. Common network security problems include leaking user information without permission, abusing and disseminating data through the Internet, and conducting illegal transactions, etc., and there is an upward trend. Therefore, it is particularly urgent to manage network data security in the Internet industry. Network security issues are emerging one after another. This requires us to study how to prevent and respond to endless network security issues in the context of big data, and how to give full play to the legal role in network security supervision in order to face the new era of new technologies. Threats and challenges.

**Keywords:** Public internet · Network security regulation · Legal role

## 1 Introduction

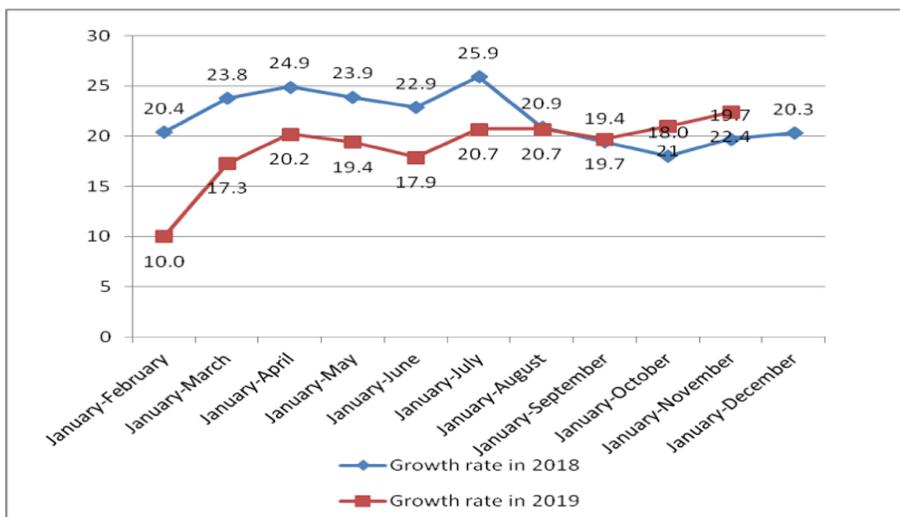
In recent years, “Internet +” has gradually been fully integrated into all areas of the economy and society, and a wide range of data on people, finances and things has been gathered, making data resources show explosive and exponential growth. As the main node for data storage and processing, the Internet data center has become a key application infrastructure for production and life in the economy and society. With the help of the Internet, emerging industries such as the sharing economy, digital payments, and cross-border e-commerce have emerged endlessly, which have promoted e-commerce, online music videos, online games and other industries and residents' lives have greatly improved, but are booming At the same time, network security issues are disturbing, seriously affecting the healthy development of various industries and the quality of life of residents. Existing network security problems such as the high number of mobile malicious programs, the occurrence of user data leaks, and cloud computing platforms have occurred one after another. Failure, its security still needs to be strengthened, extortion software wanton, network security omissions are still serious, etc. The public Internet continues to infringe on the legitimate rights and interests of users, which shows that it is imperative to maintain the network security situation firmly. The “Internet Security Law of the People's Republic of China” came out in this

context, which came into effect on June 1, 2017, to promote the healthy development of network informatization, and clearly stipulated that those who violated relevant regulations must bear corresponding legal responsibilities [1–3].

## 2 Compare the Development Trends of the Internet and Related Service Industries in 2018 and 2019

From January to November 2019, China's Internet and service industry generally maintained a stable and good development trend. Revenue continued to accelerate and profits increased somewhat. R & D investment remained high. Various Internet service businesses maintained rapid growth. Great provinces are running well. Compared with 2018, it declined from January to August, but gradually recovered and improved from September [4, 5], as shown in Fig. 1.

While Internet companies have achieved rapid development, they are also suffering from countless cases of malicious network viruses, domestic tampering with websites, domestic backdoor implantation, and phishing web pages.



**Fig. 1.** Internet and service economy operation

## 3 Network Security Threat Situation Analysis

The Ministry of Industry and Information Technology organizes the communications management bureaus, basic telecommunications companies, professional network security agencies, Internet companies, and network security companies to conduct network security threat monitoring and disposal. At the same time, the entire industry

has actively carried out related work around network security inspections in the telecommunications and Internet industries, network security guarantees for major national events, network security awareness week, and emergency response. According to the information published on the official website of the Ministry of Industry and Information Technology, the situation of network security disposal in the four quarters of 2018 is as follows:

### 3.1 Network Security Disposal in 2018

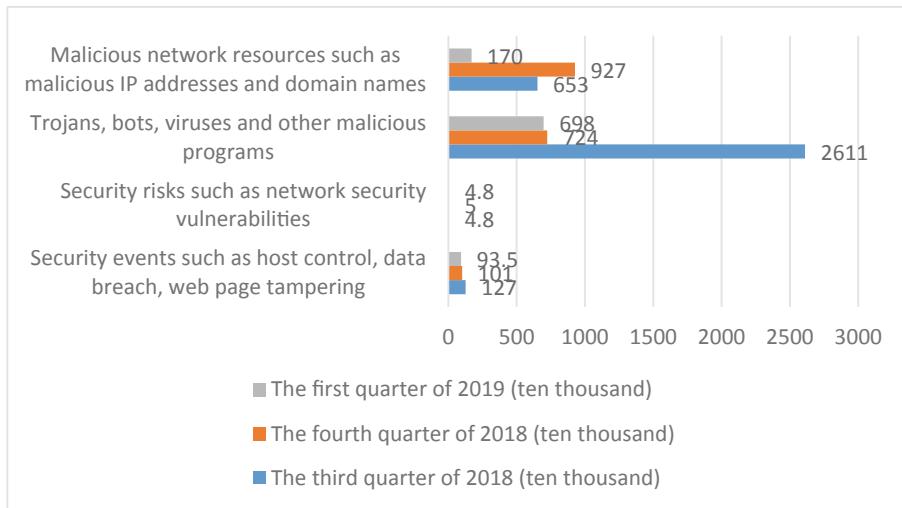
In the first quarter, we monitored about 45.41 million, network security threats, of which about 2.16 million were collected by telecommunications authorities, about 11.68 million were monitored by basic telecommunications companies, about 60,000 were monitored by professional network security agencies, and monitored by key Internet companies and network security companies. Approximately 31.51 million; in the second quarter, a total of approximately 18.41 million network security threats were monitored, of which approximately 16.83 million were monitored by basic telecommunications companies, approximately 30,000 were monitored by professional network security organizations, and approximately 30,000 were monitored by key Internet companies, domain name agencies, and network security companies. 1.55 million; in the third quarter, the industry handled approximately 33.97 million, network security threats, including approximately 6.53 million malicious network resources such as malicious IP addresses and malicious domain names, and approximately 26.11 million malicious programs such as Trojans, bots, and viruses. There are about 48,000 hidden dangers such as network security vulnerabilities, about 1.27 million security events such as host control, data leakage, and web page tampering, and about 10,000 other network security threats. In the fourth quarter, the industry handled a total of about 17.58 million network security threats (Times), including about 9.27 million (times) of malicious network resources such as malicious IP addresses, malicious domain names, Trojans, bots, etc. About 7.24 million (times) malicious programs such as viruses, about 50,000 security hazards such as network security vulnerabilities, about 1.01 million security events such as host control, data leakage, and web page tampering, and about 10,000 other network security threats [6, 7].

### 3.2 Network Security Disposal in 2019

In the first quarter, malicious programs, various phishing and fraudulent websites continued to appear. The industry handled more than 9.67 million, network security threats, including nearly 1.7 million malicious network resources such as malicious IP addresses, malicious domain names, and Trojan horses and bots. There are about 6.98 million malicious programs such as viruses and viruses, about 48,000 hidden dangers such as network security vulnerabilities, and about 935,000 security events such as host control, data leakage, and web page tampering [8].

### 3.3 Comparative Analysis of 2018–2019 Indicators

In order to calculate the consistency of the caliber, malicious network resources such as malicious IP addresses, malicious domain names, Trojans, bots, viruses and other malicious programs, network security vulnerabilities and other security risks, host control, data leakage, and web page tampering are selected. These indicators are compared, and the third and fourth quarters of 2018 and the first quarter of 2019 are compared. For details, see Fig. 2.



**Fig. 2.** Comparison of 2018–2019 indicators

It can be seen from the comparison that, among the above four indicators, the incidents of hidden dangers such as network security vulnerabilities occur the lowest, which also shows that China has been working hard to continuously record network security vulnerabilities and reduce the threat of information security vulnerabilities. Malicious programs such as Trojans, bots, viruses, backdoor, information theft, and rogue software have always been the main types of, network security threats. In the third quarter of 2018, there were 26.11 million, which ranked first among the four indicators. The second threat level is malicious network resources, such as malicious IP addresses and malicious domain names, which were greatly reduced in the first quarter of 2019. However, security events such as host control, data leakage, and web page tampering have a small impact, but they have always existed.

## 4 A Weapon to Ensure Network Security-The Network Security Law of the People's Republic of China

The Internet has been integrated into our lives and is a way of life for us, so we must manage our network security well. Now that more and more aspects of the network are involved, it is imperative to formulate relevant network laws, which is an inevitable product of the needs of social development. With the emergence of new network problems, the Internet Security Law has been continuously updated and strengthened, so as to ensure the safety of Internet users and the smooth transaction of money on many Internet platforms. Therefore, the Network Security Law is very important.

### 4.1 Significance of Implementing of the Network Security Law of the People's Republic of China

It is undeniable that before the advent of the Network Security Law, the construction of China's network security and legal system was extremely lagging behind, and network security issues could not be relied upon. As shown by the above data, the Internet in China is subject to different levels of network threats every day, and countless network attacks occur every day. If a complete network of laws and regulations is not established, the criminals will only be allowed to escape freely and wantonly. It disrupts the daily work and life of the web pages of government departments, Internet companies and the general public. In order to protect network security and the legitimate rights and interests of all relevant users, it is necessary to play a mandatory role in law. After probing and amending for a long time, the significance of the implementation of the Network Security Law is that it serves as the "basic law", building up the most basic legal framework, and gradually improving and standardizing it over time. As the "Basic Law", it mainly solves these four aspects: First, the rights and obligations of each subject are clearly specified, and all government departments, legal entities, social groups and individuals must bear responsibility; the second is to specify the basics of national network security work Thoughts and basic tasks; the third is to form conventions into laws to ensure that when there are network security problems, there are laws to follow and evidence to follow; the fourth is to establish a set of laws and regulations centering on national network security, and to prevent and reduce risks [9, 10].

### 4.2 Role of the Network Security Law of the People's Republic of China

The specific effects of this law are as follows: First, the basic provisions for the protection of personal information are clearly proposed, which is equivalent to the addition of a protective umbrella-the Personal Information Protection Law, so that subsequent related rules and standards have a higher-level law; second, it requires Internet companies of the provision of network products and services must be implemented in accordance with the law. It is not allowed to arbitrarily collect and leak user information, rely on its own industry advantages to harass users or stop providing services without notification; etc. Third, telecommunications established under the anti-terrorism law On the basis of the user's real name system, the real name system requirements for services

such as information release and instant messaging are specified, but this real name refers to “anonymous at the front desk and real name at the background” and does not affect user privacy. Fourth, it is required to publish important vulnerabilities and security incident threats in accordance with the law. The state of network security. The state has formulated regulations to stifle misleading information related to network security issued by many enterprises or institutions in the cradle. Fifth, it clarifies the law enforcement assistance obligations of network operators. This is an international Convention, and we used to rely on “red header files”; six Use legal means to eliminate illegal information posted on the Internet, and ensure the country’s Internet management system through clear legal regulations; Seventh, the establishment of infrastructure protection systems to maintain the security of key national information and require the operator to enforce mandatory Obligations, and empower the competent authorities to supervise; eight is to establish a unified monitoring and early warning, notification of threat information and emergency handling system for network security in order to eliminate the incompatibility and incompleteness of information communication among multiple departments; nine is Established a communication control system for the rapid handling of major emergencies, and strictly restricted the authority to the State Council; tenth, the network security work system was further streamlined, and the national network information department was required to coordinate and coordinate network security work and related supervision and management jobs [11, 12].

## 5 Conclusions

The security of cyberspace requires the joint maintenance of network stakeholders, including agencies, legal entities, social groups, and individuals. The “Network Security Law of the People’s Republic of China” adheres to the principle of common governance and requires measures to encourage the participation of the entire society. The public and others should do their own work, actively participate in network security governance, and resolutely resist the harmful intrusion.

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# The Translation of Jiaodong's Excellent Traditional Culture Based on Computer Network

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**Abstract.** In the 21st century, human society has entered the information age from the industrial age, and computers have penetrated into various fields. Today's world is gradually globalizing. As a bridge to spread the world's information and culture, translation is receiving more and more attention from the public. The current translation method has changed dramatically. Chinese excellent traditional culture is the national foundation of the core values of socialism. As an important part of Chinese traditional culture, Jiaodong's excellent traditional culture contains rich ideological and spiritual values, cultural and educational values. In the Internet era, how to spread excellent Chinese culture to foreign countries is particularly meaningful. Based on the computer network, this paper conducts research on cultural connotation translation.

**Keywords:** Computer network · Jiaodong Culture · Translation

## 1 Introduction

The Jiaodong Peninsula is located in the eastern part of Shandong, with its unique geographical environment and obvious military strategic position. Especially in modern times, the Jiaodong Peninsula has become a battleground among the military powers of various countries, and the Jiaodong area has also become the scorched soil of war [1].

The Jiaodong Red Culture is a culture created by the people of Jiaodong in the long-term revolutionary struggle with revolutionary philosophers and Communists. It includes revolutionary culture and advanced socialist culture. Jiaodong's red culture has a long history. It started from the new cultural trend, especially after the birth of the Chinese Communist Party [2]. It was influenced by the advanced culture of the primary stage of new democracy and socialism, and it has been rapidly inherited and developed. The Jiaodong Peninsula has rich red resources and history. There are not only revolutionary relics, memorial sites built by future generations for the revolutionary martyrs, etc., but also various forms of red revolutionary spirit inheritance and promotion activities. The red cultural spirit of the Jiaodong region is directly related to major historical processes such as the May 4th Movement, the War of Resistance Against Japan, and the War of Liberation. The red cultural spirit of Jiaodong has inspired generations of children in Jiaodong, giving them the courage to struggle and believe the

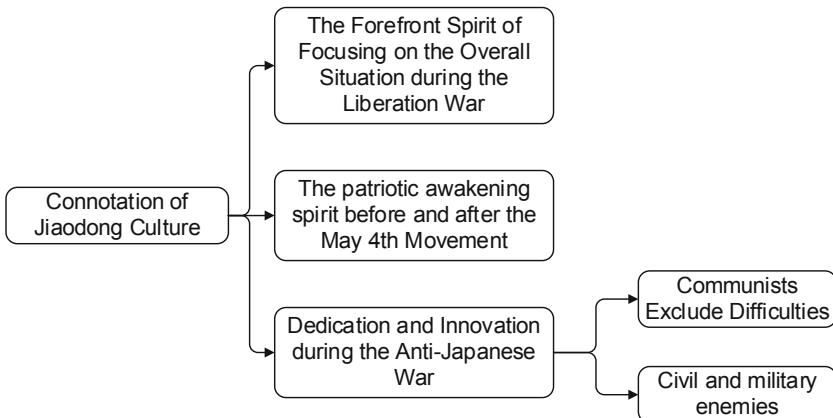
truth. Endowed with their sincere patriotism and a sense of dedication, these have formed the most powerful spiritual pillar of the Jiaodong people [3].

Jiaodong's red cultural spirit not only played an important role in the historical stories of the past, but also has practical significance in the new era, especially it has an indispensable educational role in the growth of the new generation of young people. Forgetting the past is tantamount to betrayal. The excellent red cultural spirit not only exerts great power in the old society where the sediment is rising, but in the new era it is even more worthwhile for researchers to dig deep, learn, and refine a better cultural spirit Power is injected into ideological and political education, inspiring the students' red thinking, so that learners can live in peace and empathy [4].

With the development of Internet technology and the democratization of information flow, more and more netizens are participating in the creation, sharing and consumption of information. Translation, as a powerful means of spreading cross-language and cross-cultural information, reflects new features and new features in the era of the globalized Internet. New online grassroots translation groups have sprung up, making a significant contribution to the dissemination of culture and knowledge [5]. However, in the field of translation studies in China, this mass translation phenomenon, which is closely related to people's cultural life, has not received due attention. A few studies have also focused on the analysis of the translation language style of the Internet subtitle group. As for the macro-social and cultural perspectives, there are few papers that analyze the phenomenon of collective internet translation. This thesis aims to fill the gaps in previous research, and discusses Jiaodong's excellent cultural translation methods based on computer networks and cultural translation concepts [6].

## 2 Jiaodong's Excellent Cultural Connotation

Because the geographical location of the Jiaodong Peninsula is very important, it has been a battleground for soldiers since ancient times. The outbreak of the first Opium War broke the tranquility of the Qing government's "closed door" and stimulated the economic development of the Jiaodong Peninsula [7]. At this time, the economy and trade of the Jiaodong Peninsula were active, handicrafts developed, and multiple cultures collided. In addition, Shandong people have been influenced by the Qilu culture for a long time and the spirit of "breaking through the east", which cultivates a bold personality and a strong sense of national responsibility, which makes the red culture of the Jiaodong area present a unique connotation, mainly reflecting. For the Jiaodong people's "patriotic awakening spirit", "dedication and innovation spirit" and "selfless self-supporting spirit", a variety of spirits together constitute the deep red culture of Jiaodong, as shown in Fig. 1.



**Fig. 1.** Connotation of Jiaodong Culture

## 2.1 Patriotic Awakening

From the Sino-Japanese outbreak of the Sino-Japanese War in Weihai, Shandong Province, to the invasion of Beijing by the Eight-Power Allied Forces, a lot of red wars took place in the hot land of the Jiaodong Peninsula, and a group of awakening pioneers who fought bravely like Wang Yirong and died for the country have formed the spirit of the Jiaodong Revolution. The origin of this kind of patriotic force began to be deeply rooted in the hearts of the people of Jiaodong [8]. On January 18, 1919, at the Paris Peace Conference in Paris, Japan refused to return Qingdao's sovereignty and asked the Chinese representative to sign the Treaty of Versailles [9].

The news came back to China. The indignant Shandong people took the lead to condemn, and held a special speech conference on Qingdao's cession in Jinan, Shandong, which ignited the fuse of the May 4th Movement [10].

The patriotic feeling is engraved on the bones for the people of Jiaodong. During the colonial period of Germany and Japan, they always recognized the Chinese national culture and showed rejection and resistance to the colonists. At the same time, suffering from the oppression of colonialism, the people of Jiaodong realized the fate of the country's backwardness. They believed that only by awakening and resisting could the danger of “the country be no country” could be avoided. After being influenced by the advanced western culture, some people with lofty ideals in the Jiaodong area saw the obsolescence and decay of the feudal ideas. When the country had weakened and been dominated by people, this patriotic feeling prompted the awakening and explosion of revolutionary ideas. The May 4th Movement, which was first ignited by the “awakening spirit” of the people in Jiaodong, changed the development trajectory of modern China and completely set off a prelude to the Chinese people’s anti-imperialist and anti-feudalism. Today, the May Fourth Square, one of Qingdao’s iconic landscapes, is to inherit this “awakening spirit”. The huge red torch sculpture in the square shows the cultural connotation of patriotic awakening in the red culture of Jiaodong.

## 2.2 Dedication and Innovation During the Anti-Japanese War

After the Lugou Bridge Incident, China entered a state of comprehensive resistance against Japan. Communists in the Jiaodong area do not stigmatize their mission, shoulder the national justice, carry forward the spirit of the Communists' loyalty and despise death, carry forward the consciousness of "the rise and fall of the country, the husband is responsible", "saving the nation in danger", and actively organize the people of Jiaodong to actively participate Anti-Japanese War. From the establishment of the Jiaodong Anti-Japanese Base, to the later Jiaodong Special Committee of the Communist Party of China to organize the Jiaodong people to rise up and set up the First Army of the Third Army of the People's Anti-Japanese and National Salvation Army, to become a rapid and powerful armed force in Jiaodong; The first shot of the Anti-Japanese War went to other coastal areas in the East, West, South, and North Sea, and then consolidated the firm resistance to the Japanese. Under the call of communism truth, the people of Jiaodong bravely participated in the war and were not afraid of sacrifice, leaving behind for future generations. Precious red spiritual wealth.

## 2.3 The Forefront Spirit of Focusing on the Overall Situation During the Liberation War

The Jiaodong people and the Communists united with their enemies and the military and civilians, defeated Japanese imperialism, and established a deep military and civilian situation. At the time of the liberation war, for the needs of national liberation, the land of Jiaodong constituted a strong rear of the liberation war. The people of Jiaodong actively responded to the party's call and went all out to support the liberation war. In the defense of Jiaodong, the people of Jiaodong showed unprecedented support and enthusiasm for PLA soldiers. Later, in response to the needs of the war situation, the people of Jiaodong formed a front army of more than 700,000 people, and used old and traditional transportation methods such as small and large carts, farm animals, shoulders to carry military supplies such as grain, ammunition, and clothing to the front. With the extension of the war line, this huge front army stepped out of Jiaodong, and fought with the troops in 17 provinces in North and East China. It supported dozens of famous battles, such as the Battle of Laiwu and the Battle of Menglianggu, and guaranteed "The transportation line will be smooth where the war fought," and contributed to the victory of the national liberation war. In this people's war, the Jiaodong Red Culture, with its sincere loyalty and flesh and blood, used the simplest and most powerful way to inject powerful power into the liberation of New China.

## 3 Online Acceptance of Jiaodong Culture

The rise of Chinese Jiaodong culture overseas began in the beginning of this century with foreign website forums discussing Chinese martial arts novels such as Jin Yong and Gu Long, such as the Wuxia Translations section in Spcnet. Since 2014, overseas fans have established a group of translators in China Jiaodong Culture's online platform quickly gained a large number of fan readers overseas and cultivated a large

number of overseas Chinese-English translators. Overseas people translate, read, and imitate the Chinese Jiaodong culture with high enthusiasm and speed. In the process, traditional Chinese culture has been widely disseminated, especially Confucianism, Buddhism, martial arts, and myths, and Chinese contemporary networks. Writer's literary creativity and cultural inclusion.

Using Alexa's similar site search tool and verifying them one by one, there are at least 51 overseas websites that translate Chinese online novels and at least 7 reprinted websites. These 58 websites are all in English. Germany (2), Netherlands (1), India (1), and Canada (1). Due to the limited space, this article only counts the translation of 10 overseas websites (referred to as "web translation websites") that are specialized (or major) translators of Chinese online novels in the top 100,000 websites. Translation websites are Wuxiaworld (WW), Gravitytales (GT), Radiantranslations (RT), Volarenovels (VN). Through e-mail questionnaire surveys and online surveys, the author counted the amount of Chinese web translations and the number of translation teams in these 4 overseas websites, as shown in Table 1.

**Table 1.** Translation of overseas Chinese translation websites

Site name	WW	GT	RT	VN
Translation volume	35	31	29	165
Number of translation teams	26	21	15	8

## 4 Network Translation Mode

As mentioned earlier, the English translation of the Chinese Jiaodong Culture, which was circulated overseas, was generated based on a network translation model. Jiaodong Culture writes and publishes on the Internet platform, and the translation of Jiaodong Culture is also organized and published on the Internet. This translation mode can be called "Internet translation mode". From the perspective of operation mechanism, translator background and translation strategy Explain.

### 4.1 Operating Mechanism

At present, the overseas translation platforms of China's Jiaodong Culture mainly operate through the mode of "own expense/fan donation/crowdfunding/advertising revenue-team serialized translation/editing-free reading", and a few translation platforms have begun to release originals (including Gravitytales and Wuxianation). At present, the operation of overseas translation platforms is centered on translation/editing activities. A few websites rely on self-funding support, and most rely on advertising revenue, fan sponsorship and crowdfunding to support translation/editing and website operations. The income of translators/editors is not optimistic, mainly due to translation

manuscripts and platform revenue sharing. Most translators/editors work part-time. It should be noted that since the translation of these websites was not authorized by the original authors and their contracted platforms, no translation works have been published yet.

The “translation/editing” mode in the network translation mode is different from traditional translation activities. In the network translation mode, translation works are not completed and released by individuals at one time, but are translated and published in serial form by the translation team. Through the online platform, translators can interact effectively with the target readers and even the original authors, which is conducive to improving the quality of translation and better satisfying readers’ translation needs.

## 4.2 Cultural Translation

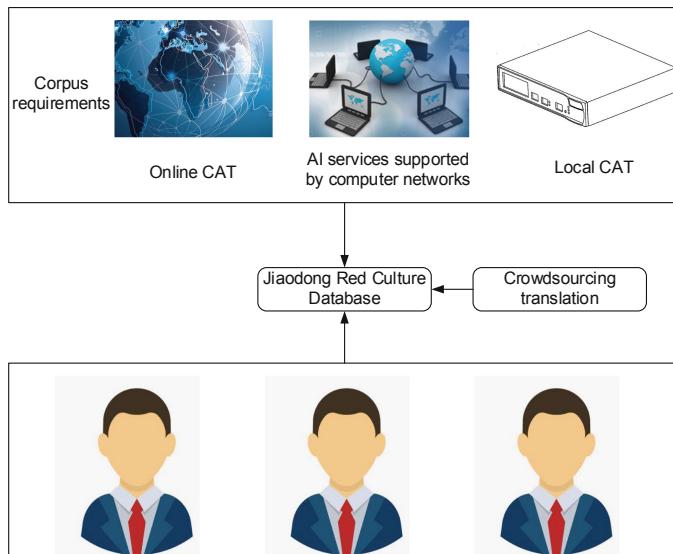
Culture and language are interdependent, and the development of culture will inevitably bring about language enrichment. The language of an era is the epitome of the social culture of this era, condensing the cultural characteristics of this era. “Every language serves culture and reflects the needs of that culture. The relationship between language and culture is the relationship between parts and the whole. Cultural forms, customs, lifestyles, etc. will be reflected in the language.” Translation, as an intercultural communication activity, is a bridge connecting two different cultures and languages. Translation is not only translation of language, but also cultural translation. In the process of translation, especially for the translation of things unique to a country, culture should be the basis and language should be the carrier. As Mr. Xu Jun said, translation is to meet the needs of culture and the needs of different groups in a certain culture.

## 4.3 Computer Network Improves Cultural Translation Ability

Bilingual ability is the basic ability and necessary condition that translators must have. Bilingual refers to source and target languages, or origin and target languages, and so on. First of all, the translator should master the basic language knowledge of translation, such as phonetics, morphology, syntax, rhetoric, textual cohesion and coherence. Secondly, it is necessary to have bilingual comprehension and text analysis capabilities, that is, the ability to reason, induct, judge, and grasp the subject matter. Thirdly, we must connect with the context and grasp the pragmatic effects and semantic choices of the language. Finally, you must have a good bilingual writing ability and communication skills. The essence of language is the symbol, the shell of thinking and culture. Linguistic symbols represent the commonalities and differences of thinking patterns and cultural patterns in different regions and different nationalities. Therefore, the deeper requirement of bilingual ability is to understand and transform culturally through the similarities and differences of surface language structures. In addition, having professional knowledge related to the subject of translation is also an important factor in the success of translation.

#### 4.4 Computer Network-Based Crowdsourcing Translation Model

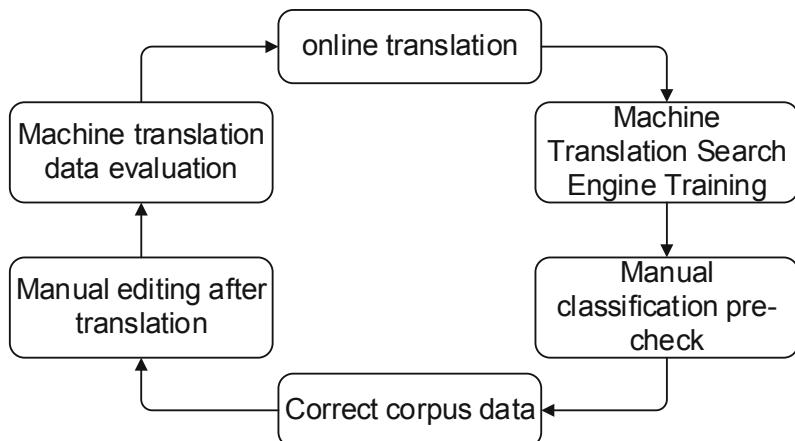
Through the introduction of crowdsourced translation, many translators and non-translators are involved in translation activities together, resulting in a large number of translation results. Since crowdsourcing translation is essentially a cooperative translation, which connects individual translators and machine translation tools, it means that both corpus requirements and corpus provision have appeared in crowdsourcing translation activities, so it is built on the organization model of crowdsourcing translation. It is possible to share corpus data. Based on its P2P corpus data store, this paper proposes a corpus data sharing platform based on crowdsourcing translation, as shown in Fig. 2.



**Fig. 2.** Computer network-based crowdsourcing translation model

#### 4.5 Collaborative Model Based on Human-Machine Cooperation

The cooperation between machine translation and human translation is an important feature of the development of translation in the new era. In the age of computer networks, pure machine translation cannot be separated from the cooperation of experts. The mode of human-machine collaboration will be an important part of the construction of big data corpora. It is the best method to pass corpus sampling, input specifications, types of errors, labeling schemes, etc., through expert review and modification, and then hand them over to machine translation, as shown in Fig. 3.



**Fig. 3.** Human-machine collaboration model

## 5 Conclusion

The core competitiveness of a region and a city is the outstanding cultural heritage that has been condensed in this region and city for a long time. The Jiaodong Peninsula is influenced by many factors such as region, culture, and economy. It has nurtured the spirit of hard work, courage, innovation, and dedication of the people of Jiaodong. The people of Jiaodong have played a pivotal role in promoting the development of modern history. The deep red imprint left a rich red cultural and spiritual heritage. Now that socialism with Chinese characteristics has entered a new era, the development of the Jiaodong Peninsula is also facing great challenges and opportunities, but no matter how the times change, the red foundation of Jiaodong cannot be lost. The people of Jiaodong must uphold this in the long-term revolutionary struggle. The accumulated spirit excavates and inherits the cultural connotation of Jiaodong, continuously improves the cultural attractiveness and competitiveness of the Jiaodong Peninsula, promotes the development of various construction undertakings with a red culture, and creates a better life for the people of Jiaodong. Participants in the Internet mass translation activities are mainly highly educated young people who disseminate cross-cultural information. The advantage is translation of multi-modal texts. It is hoped that in the near future, these characteristics can be explored more systematically and used to organize translation activities that are conducive to the external transmission of Chinese culture.

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# Computer Network Database Security Management Technology Optimization Path

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**Abstract.** Along with the progress of network technology, Internet age, the rapid expansion of electronic devices, such as computers, computer bring a lot of convenience for People's Daily lives, but at the same time the network is a double-edged sword, security problems emerge in endlessly, more and more get the attention of the people, for the network, the characteristics of openness. Therefore, the security management of computer network database has been paid more and more attention. As an important part of computer management, security management not only has a direct or indirect impact on the use of computer network, but also seriously affects the development of various fields. Therefore, this paper for the computer network database security management research, including security management characteristics security management objectives and security management technology, proposed to optimize the computer network database security management, take effective measures to provide support. It is expected that the discussion of this paper has a good reference for optimizing computer network technology and strengthening data security management in China.

**Keywords:** Computer network · Database security management · Technical optimization · Network security

## 1 Introduction

The comprehensive development and progress of computer and information Internet technology has triggered great changes in the society, and people's work, life and many fields have gradually increased their dependence on it. Computer network database is an important link to store all kinds of network information and its security concerns the vital interests of all users. Safety management technology is not perfect at present, due to the network security accidents caused by gradual growth, security risks has become increasingly diversified and complicated, therefore need to actively adopt scientific and effective security management technology, reduce the safety risk, achieve the effective control of network database, the maintenance of network security, computer is related to the development of science and technology to better serve for social progress.

The computer network database is an important network area for storing files in the process of people's life and work, and storing files in the form of data in the network facilitates the daily search [1]. At present, it has become an indispensable part of People's

Daily life and work. No matter what industry you are in, you can use the computer network database to obtain resources and also store some useful information in it [2]. It not only facilitates the search and use of follow-up resources, but also ensures the security of information resources. However, at the same time, network security issues have also brought serious impacts on cloud storage of data, and the loss and damage of data have brought benefits losses to people's lives and work [3, 4]. Therefore, higher requirements are put forward for the security of computer database, so it is of great practical significance to optimize the security management technology of computer network database [5].

This paper mainly introduces the problems encountered in the current computer database security management process, and puts forward some specific optimization measures, in order to improve the security of information.

## 2 Method

### 2.1 Characteristics of Database Security Management

Database security is in the process of database operation of safety performance, it has on the basis of the confidentiality of the new data management, can help data security communication, for all kinds of problems in the process of communication and operation, treatment and prevention measures, furthermore it is very important to the rights and interests of database users, so for a secret plan to perfect, make corresponding protection work, the important data security maintenance and strengthening management, the work is confidential to the main work [6]. To do a good job in confidentiality and security management, it is necessary to protect users' data and effectively protect their rights and interests, so as to promote better database confidentiality. The computer database network security management important characteristic also includes the integrity, because the actual use of data, will encounter a variety of problems, make the database network operation will be subject to a variety of restrictions, so to ensure the integrity of data is very important. As the Internet has penetrated every industry, computer data networks have tended to show corresponding limitations. In the process of data transmission and data storage, in order to ensure the consistency of the old and new data management formats, the integrity of Internet technology needs to be maintained in a very rigorous way [7]. With the development of the computer network by increasingly sophisticated, hackers intrusion virus implantation malignant events, so that users in the use of affected. Depth and scope of computer application is difficult to predict, so people living and working in need convenient at the same time, also have to face all kinds of problems, especially the malicious, easy to affect the use of the user experience, so for the safe operation of computer networks will happen very bad influence, it shows that for the computer network database security is very essential to [8].

## 2.2 Objectives of Network Database Security Management

### (1) Data Transmission Management

Ensure that the network database is strict enough in the actual process of data transmission [9]. This requirement applies not only to the data aspect but also to the system itself, to maintain the continuity and integrity of the data transmission, so that the public can use the data as before, so as to fully play the role of the network.

### (2) New Data Management

In the aspect of network data has a relatively special form that is new data, the new data is an indispensable part of data management, but the new data is different from the original data, whenever the input in May contain virus intrusion system, adverse effects on the network overall situation, even can bring big loss to the user, the solution of this kind of circumstance is to give the new data for testing whether safety data to enter the system, to ensure good condition of the new data to make data storage is more secure.

### (3) Data Use and Management

For data using aspects should be strict management, in People's Daily application, data reveal that the problem is very serious problem, not only involving personal privacy, moreover also can cause bigger problems, may be the chance to defraud and outlaws, may cause irreparable damage, thus, the network data management is an important link of [10].

## 3 Main Factors Threatening Computer Network Security

### 3.1 Computer System Vulnerability

Our daily use of computer is mainly composed of computer hardware and computer software, from the aspects of use were analyzed, and the hardware system and software system must be complete and safety, to provide users with a relatively safe network environment at present, our country domestic main computer system is a series of Microsoft's Windows and apple Vista of the two systems. The more powerful the computer's performance and function, the less secure it will be, because the computer network involves a wide range and field, so the possibility of hacking is also greater. The main purpose of hacker intrusion is to copy and paste the data in the computer network system or change it at will, resulting in important data being altered. The network world is complex and wide in scope, users in the use of the process can not always maintain a completely safe network environment, there is no 100% safe operating system, as long as there are system problems, there will be corresponding computer security problems, will threaten the normal use of users.

### 3.2 Virus Invasion

Virus invasion is a kind of invisible state, but it will spread to the corresponding computer system very fast, very strong destructive, to the user's overall computer

system have a destructive effect. For example, the famous “panda burn incense” virus is a virulent virus with fast transmission speed. The panda burn incense virus can invade the user’s computer system at the speed of light, destroy the data and important information, and make the whole computer system in an abnormal state. With the continuous development of network technology, the types and forms of virus invasion also become more and more, the more common forms of several viruses are script, spy, and Trojan. With the full coverage of computer network technology, people’s work and life are inseparable from the application of computer, although this brings cheap to people’s life, but also laid a foible, viruses are also widely seen in people’s life, the power of computer antivirus software can not resist a variety of virus traps. In this regard, it is necessary to increase the investment and development of anti-virus software, so that users in the use of the process of a certain security.

### 3.3 Unauthorized Access

Unauthorized access is when a visitor accesses a computer in an improper way without the user’s knowledge. Hacking is frequently used by the authorized access, the invasion of mandatory inside the user’s computer, and then to steal of internal information and data, there are some unauthorized link import way for the user’s computer virus control, make the user’s computer is in not safe under the network environment, affect the normal use of the user.

## 4 Computer Network Database Security Management Technology Optimization Measures

### 4.1 Establish the Security Management Mode

To carry out network database security management, it is necessary to establish an effective security management mode to realize the overall optimization of database resources. The computer network database includes the external system network and the internal network. Through the security management mode can provide users with a comprehensive system of network management methods and security policies, improve the security of the database. Currently using the network database security management pattern mainly includes the distributed management mode, centralized management mode, the static level management mode, through these safety management mode can realize the classification of data resources and hierarchical storage management, make different security levels of password protection scheme, realize the difference of the database security management, maintain security of network database.

### 4.2 Antivirus Technology

Computer network database facing hackers and virus invasion of security threats, once the attack, will result in the user data resource leaked out, and using the Internet, this influence will continue to expand, in 2019, a computer virus type growth data shown in Table 1.

**Table 1.** Computer virus type growth data in 2019

	Suction fee back door	Advertising programs	Backdoor virus	Deduction Trojan
July	800	800	300	310
August	1200	850	400	390
September	2500	1000	350	340
October	2100	200	600	600
November	2900	1800	700	750
December	5500	4500	1500	1300

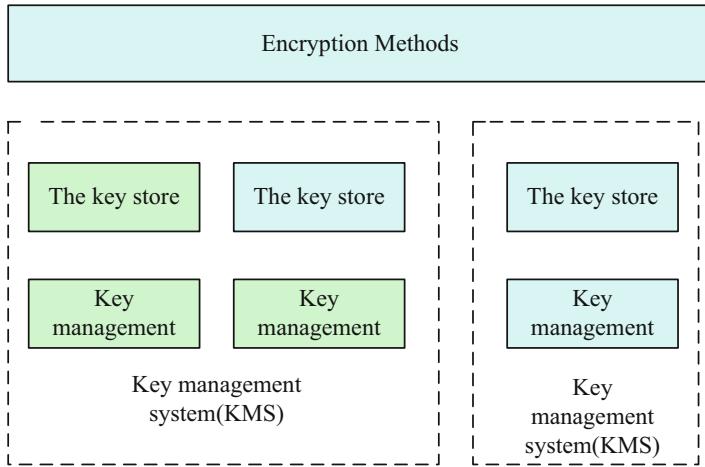
As can be seen from Table 1, the number of virus cases is gradually increasing and has a tendency to accelerate, so it is urgent to put forward effective measures for the security management of computer network database. At present, the variety of computer virus is increasing day by day, for this need comprehensive quick check kill and processing method, install the anti-virus software that has higher reliability, improve the efficiency of the virus check kill, need to carry on the second time after completing the routine anti-virus processing, improve the anti-virus disinfection. For Trojan virus, need to start popular Trojan analysis and processing system, easy to find the problem in the shortest time, combined with the Trojan system samples in the database for proper processing.

### 4.3 Storage Management and Data Backup

The computer network database can realize the effective storage and management of the database resources. The conventional login method is to set specific access rights and establish a hierarchical access system. Under the condition of no interference from external factors, this method can achieve the effect of preventing virus and hacker invasion. In view of the problem that hackers obtain data without access rights, it is necessary to conduct comprehensive systematic detection on the login system and user accounts to ensure that all logged-in users belong to authorized users of the computer database, and timely block their query activities if abnormal is found. At the same time, in order to maintain the security and stability of data resources to the greatest extent, remote copy backup is needed to avoid data loss and unrecoverable.

### 4.4 Encryption Technology

To maintain the security of computer network database, it is necessary to encrypt the system and conduct in-depth control of the computer system through specific language programs. Currently, there are three main encryption modes commonly seen in China, as shown in Fig. 1.



**Fig. 1.** Encryption mode

To prevent computer virus, encryption technology mainly adopted at present stage includes anti-replication technology, computer secret key technology, secret communication technology, etc. At the same time, the identity authentication technology can control the access rights of users, through mandatory access control, to maintain the effect of database security.

## 5 Conclusion

Computer network database security is in the process of the development of computer network security hidden danger of a technology optimization, from several aspects to strengthen work level of computer network database security plan, not only can promote the overall security of computer network, at the same time in order to better service to provide technical support for the social progress, strengthen the computer network database security is also a must to do work.

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# Optimal Algorithm of Hybrid Blind Signal Real-Time Separation in Wireless Communication Networks

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**Abstract.** Aiming at improve the signal transmission quality of wireless communication networks, blind signals need to be separated in real time. A hybrid blind signal separation algorithm based on high order statistic blind source separation under complex electromagnetic interference is proposed. The hybrid blind signal model of wireless communication network is constructed under complex electromagnetic environment interference. The fourth order cumulant is used to decompose the insensitivity of the mixed blind signal, which effectively suppresses the complex electromagnetic pulse interference. The blind separation of mixed signal is realized by using time-frequency decomposition method. The real-time separation performance of signal is realized. The proposed method brings improved blind separation ability, reduced bit error rate and enhanced communication quality of the wireless communication network.

**Keywords:** Wireless communication network · Mixed busy signal · Separation · Bit error rate

## 1 Introduction

To enhance the communication capacity of wireless communication network, the anti-jamming ability of the communication must be improved. In the case where noise environment SNR is low, it is difficult to realize real-time separation of hybrid blind signals [1]. Traditional methods are mainly aimed at the mixed blind signals in narrow band wireless communication networks with low resolution. There is no real-time separation of mixed blind signals for wideband and high-resolution wireless communication networks. When there is a strong signal and background noise interference, the performance of real-time separation performance is normally unsatisfactory. In this paper, a hybrid blind signal real-time separation algorithm based on high order statistical blind source separation under complex electromagnetic interference is proposed.

## 2 Signal Transmission Model and Signal Analysis in Wireless Communication Network

Firstly, a wireless communication network signal transmission model is constructed, which provides the background mathematical model for the algorithm design. Assuming that  $f(t)$  represents the transmitted signal, and  $r(t)$  represents the received signal, the hybrid blind signal model of wireless communication network is expressed as follows:

$$r(t) = g(t) + n(t) \quad (1)$$

Suppose the input is single frequency signal  $\cos 2\pi f_0 t$ , where  $f_0$  is the signal frequency and the first array element is the reference element, the hybrid blind signal transmission node of wireless communication network looks like a bright spot model, the point target is moving uniformly relative to the system platform, and the radial velocity is  $v$ . The output of the left beam of the hybrid blind signal model of wireless communication network is expressed as follows:

$$l(t) = \left( \sum_{m=1}^M u_m \right) \cos(2\pi f_0 t) - \left( \sum_{m=1}^M v_m \right) \sin(2\pi f_0 t) \quad (2)$$

$$u_m = \cos[2\pi f_0 \tau_m(\theta)]; v_m = \sin[2\pi f_0 \tau_m(\theta)] \quad (3)$$

In the background of electromagnetic pulse interference, the nearest antenna is chosen as the emitter output of the interference, and the angle comparison is completed, and the analog output of the hybrid blind signal approaching the real wireless communication network is completed [2].

## 3 Improved Design of Real-Time Separation Algorithm

This paper proposes a hybrid blind signal real-time separation algorithm for wireless communication networks under complex electromagnetic interference based on high order statistics blind source separation. The fractional Fourier transform (FrFT) is defined in [3]. The p-order fractional Fourier transform of function  $x(t)$  defined in t domain can be expressed as the integral expression of  $X_p(u)$  or  $F^p x(u)$ :

$$X_p(u) = F^p x(t) = F^x[x(t)] = \int_{-\infty}^{+\infty} K_p(t, u) x(t) dt \quad (4)$$

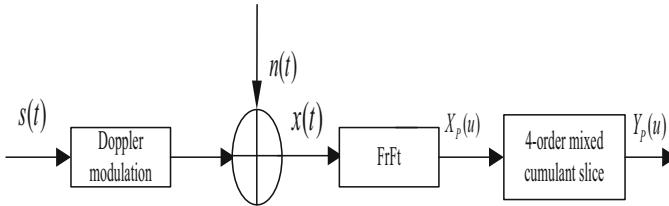
Where,  $F^x[\cdot]$  is FrFT operator, amplitude modulation component is pre-processed by residual signal filtering, the residual signal is removed after the first screening, and the IMF component satisfying the inherent mode function is extracted [4]. The  $K_p(t, u)$  is the transform kernel of FrFT, which is expressed as:

$$Y_p(u) = F^a[y(t)] = F^a[s(t) + n(t)] = F^a[s(t)] + F^a[n(t)] \quad (5)$$

The signal after fractional Fourier transform is passed through the fourth order cumulant postposition operator as follows:

$$\hat{c}_{4Y}(n, \tau) = \hat{c}_{4S}(n, \tau) + \hat{c}_{4N}(n, \tau) \quad (6)$$

By using the 4-order cumulant to decompose the insensitivity of the mixed blind signal, the complex electromagnetic pulse interference can be effectively suppressed [5]. In summary, the flow chart of the improved algorithm is shown in Fig. 1.



**Fig. 1.** Improvement of blind source separation based on high order statistics

Figure 1 shows that after the fourth order cumulant processing, the complex electromagnetic interference noise  $n(t)$  will remain the original distribution after fractional [6] Fourier transform, and the output SNR has been greatly improved compared with the original input SNR. The input SNR of the fourth order cumulant is greater than or equal to convergence condition, which can enhance the real-time separation of hybrid blind signals under complex electromagnetic interference.

## 4 Simulation

To verify the capacity of the proposed algorithm in real-time separation of hybrid blind signals in wireless communication networks, simulations are carried out by using Greco electromagnetic simulation software based on Matlab 2010 programming platform. [7–10] The transmission frequency of hybrid blind signal is  $f_0 = 20$  kHz. The gold noise of the sampled frequency  $f_s = 5f_0 = 100$  kHz,  $T = 10$  ms, and the center frequency of the color noise is 15 kHz, SNR = -10 dB. The original hybrid blind signal of the wireless communication network is obtained, as shown in Fig. 2.

Figure 2 shows the variation of BER of wireless communication network with the signal-to-noise ratio (SNR). It can be seen that the BER decreases with SNR and the BER of the proposed method has a lower BER than traditional method, indicating improved communication quality and reduced bit error rate.

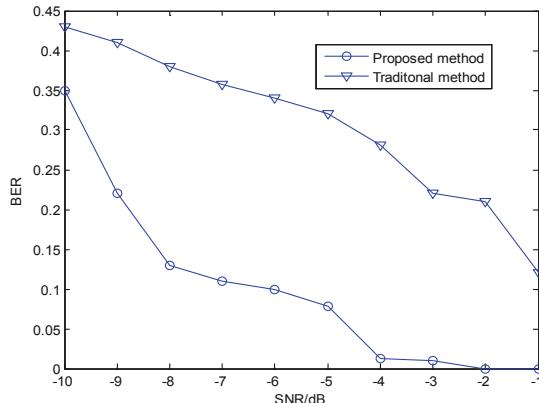


Fig. 2. BER test of wireless communication network output

## 5 Conclusions

In conclusion, a hybrid blind signal separation algorithm based on high order statistic blind source separation under complex electromagnetic interference is proposed. The hybrid blind signal model of wireless communication network is constructed. The fourth order cumulant is used to decompose the insensitivity of the mixed blind signal, which effectively suppresses the complex electromagnetic pulse interference. Simulation result shows that the proposed method brings improved blind separation ability and improved communication quality of wireless communication system.

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# Computer Network Information Security in the Big Data Era

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**Abstract.** With the continuous development of globalization, the Internet technology has achieved unprecedented rapid development. With the increasing number of intelligent network terminals, technologies such as the Internet of Things and cloud computing have been continuously applied in various fields, making the amount of Internet data appear explosive. Upgrading the Internet has gradually entered the era of big data. In order to ensure the security of data information, it is of great significance to the problems of network information security (NIS) and security development in many fields. This article details the background in the era of big data. This article clarifies the urgency and necessity of NIS control in the context of big data. It proposes three elements of the NIS control mechanism, namely network control personnel, environment and technology. The three elements are the starting point to establish a NIS control mechanism. This article starts with related control strategies and security control technologies to establish a NIS control evaluation system. The NIS control evaluation system is used to provide NIS control work. Reference standard. This paper proposes the relevant strategies for NIS control, and provides necessary suggestions for NIS work. The research results show that the research results of this paper provide help and guidance for the development of NIS work in the context of big data.

**Keywords:** Cloud computing · Control-mechanism · Informatization · Control mechanism

## 1 Introduction

With the rapid development of global informatization, the problem of network information security has become an important issue related to national security and social stability. At present, data in all areas of society is growing at an explosive rate. The advent of “big data” has profoundly changed the way data is transmitted, stored, and processed. The development of big data and related technologies has led to the transmission of massive data and information. Communication and exchanges can overcome the limitations of time and space, and people increasingly rely on databases and information systems. However, while big data brings convenience to people, it also puts forward higher requirements for network information security control. A complete network information control system and evaluation system must be established in order

to ensuring the high-speed transmission and exchange of massive data and information in information security work.

The status of the Internet in social life has been continuously improved. Human beings exchange data and information with the outside world almost all the time through the Internet. Information has become an important production resource, and the Internet has become a source and a carrier of mass information [1]. Network information is closely related to social life, so the security of network information is vital to the normal operation of social life [2]. For individuals, the interference or leakage of network information may cause violations of personal privacy information; for enterprises, network information security is related to the normal operation of the company's production and operation; for the country, NIS is national security an important part of. Therefore, NIS has become an important issue in social life, and ensuring NIS has become one of the most important tasks of information supervision departments [3]. The huge amount of big data, faster transmission speed requirements, and more effective value extraction methods make the previous management methods no longer completely suitable for NIS control in the era of big data. Therefore, based on the analysis of the characteristics of big data and the establishment of a more comprehensive NIS control mechanism based on the characteristics of network information, it is necessary to ensure greater efficiency in the transmission of large data traffic and achieve more secure network information functions. Necessary measures. Using the NIS evaluation system to improve the reliability of data security throughout the entire life cycle of network information and data can provide a more complete working standard for the systematic and scientific development of network security with high performance [4].

Therefore, the research significance of this paper lies in the analysis of the characteristics of NIS in the context of big data and the establishment of a relatively complete NIS control mechanism and evaluation system. Combining research and related theories, combined with the characteristics of big data, this paper proposes a NIS control mechanism in the context of big data, and puts forward internal guiding principles for the work of NIS in a big data environment. A relatively complete NIS control evaluation system provides new working methods and standards for network information supervision departments to carry out NIS work in the context of big data.

## 2 Proposed Method

### 2.1 Information Development in the Big Data Era

Big data refers to large-scale data based on computer technology, which cannot be efficiently and timely extracted, stored, analyzed, searched and processed using current conventional data processing methods. The node fusion applications lie in the processing and analysis of big data. The Internet of Things, mobile internet, social networking and e-commerce are the application forms of the new technology. These applications have gradually produced big data during their operation [5]. The Internet of Things, mobile internet, social networking and e-commerce are the application forms of the new technology. These applications are generating big data over time. Cloud computing provides a

computing and storage platform for these diverse and huge amounts of data. Through comprehensive data processing, analysis and management processes, the cloud platform feeds back the results of data processing to the technical application of the upper layer, which can make humans get greater social and economic value from big data [6]. Big data accelerates the pace of information technology fusion. In the process of technology integration, scientific data analysis needs also promote the formation and development of an information management innovation environment.

## 2.2 NIS Control Theory

In the principle of management, control is one of the main functions of management, and its constituent elements are divided into three aspects, namely, controller, control object, control means and tools. The establishment of the NIS control mechanism also unfolds around the constituent elements of the control function. The first aspect is the controller, that is, the administrator of NIS [7]. The second aspect is the goal of control. Resources such as personnel, finance and time are its main contents. Databases and information systems are also under control. The third aspect is control methods and tools. Management organization, principle system, regulation adjustment, and management methods are all control methods and tools. The smooth implementation of control activities requires the guarantee of organizations and principles and regulations. To realize the control activities, information must be used as a communication bridge.

The process of establishing an NIS control mechanism in a big data environment is to solve the problem of NIS, clearly identify the control objects of security precautions, organize relevant managers and staff, and scientifically and reasonably allocate work and tasks. Effectively organize personnel and allocate security investment and other factors, and set up network information security professional institutions and departments, formulate network information security rules and regulations, and ensure their practicality.

## 2.3 Problems with NIS in the Context of Big Data

### (1) Network information security incidents are on the rise

Network management equipment and software used in information networks are basically imported, which greatly weakens the security of the network. NIS supervision methods need to be improved. At present, information on the Internet is mainly managed centrally based on government regulation. Insufficient efforts have been made to exert individual monitoring and organizational monitoring. The perfect information security supervision mechanism should make use of the joint efforts of individuals, organizations, and the state to form a hierarchical system of supervision, so as to better achieve NIS [8, 9].

### (2) Weak foundation of NIS

According to the statistics published by the “China Computer News”, in all industries in China that can access the Internet, 55% of enterprises do not have firewalls, 46.9% of enterprises do not have security audit systems, and 67.2% of enterprises do not have intrusion monitoring systems. 72.3% of enterprises do not

have an automatic website recovery function. Network information has the characteristics of rapid dissemination and hidden channels. Formally due to these characteristics, the monitoring of network information also presents characteristics that are difficult to monitor. Information security management methods are gradually being expanded and improved [10]. Zhou Guoping believes: “At present, China’s social NIS awareness is relatively weak and lacks a common sense understanding of information security. This situation is extremely detrimental to ideological work under network conditions [11].”

### 3 Experiments

#### 3.1 Experimental Background

Starting from the theory of NIS control, this paper uses qualitative analysis to propose three elements of NIS control in a big data environment, and proposes a NIS control mechanism around these three elements. Through the investigation and interview of the network information supervision department, the influence of the three elements of NIS is verified through empirical analysis, and an analytic hierarchy process is used to construct a NIS control evaluation system.

#### 3.2 Test Subject

Aiming at the research hypothesis, the author designed a research questionnaire for empirical research. The questionnaire is in the form of Likert 7-level scale, and relevant questions are asked for the four variables of “network controller”, “environment”, “technology” and “NIS” in the research model. Such as the enterprise information security management department, social network information supervision department and other organizations issued questionnaires. A total of 200 questionnaires were distributed and 194 questionnaires were recovered. After excluding invalid questionnaires, a total of 185 valid questionnaires were obtained. The questionnaire recovery rate was 92.5%.

#### 3.3 Experimental Collection

This paper uses the analytic hierarchy process to calculate the weight of each indicator in the indicator system to reflect the relationship between the importance of different indicators in the evaluation system and enhance the practical operability of the evaluation system. This article adopts the expert evaluation method and conducts the evaluation based on the 1–9 scale method. Construct a judgment matrix. This article uses simplified operations of feature vectors to calculate the weight of each indicator. By issuing questionnaires to relevant experts and averaging based on valid questionnaires, a judgment matrix was constructed, and Excel software was used to find weight vectors.

The calculation method used in this article is the sum product method. The specific steps are as follows:

- (1) Normalize the elements of each column of the judgment matrix. The general terms of the elements are:

$$b_{ij} = \frac{b_{ij}}{\sum b_{ij}} \quad (i, j = 1, 2, 3, \dots, n) \quad (1)$$

- (2) The normalized judgment matrix of each column is added as rows.

$$w_i = \sum_{j=1}^n b_{ij} \quad (i, j = 1, 2, 3, \dots, n) \quad (2)$$

- (3) The vector  $w = (w_1, w_2, \dots, w_n)^T$  is the approximate solution of the required feature vector.

$$\lambda_{\max} = \sum_{i=1}^n \frac{(BW)_j}{nw_i} \quad (3)$$

- (4) Use the calculated maximum characteristic root  $\lambda_{\max}$  to calculate the consistency index C.I.

## 4 Discussion

### 4.1 Analysis of Reliability and Validity of Questionnaire Data

In this paper, structural equations are used to test the research hypothesis. The output report of the structural equation model includes the fitness index of the model. The smaller the chi-square value () value, the better the model's causal path map fits the actual data; the smaller the ratio of the chi-square to the degrees of freedom, the more suitable the model's covariance matrix is to the observed data, usually Less than 3. GFI is an adaptability index. The larger the GFI, the better the adaptability of the model. The GFI requirement is greater than 0.9, and AGFI is an adjusted fitness index, which has the same requirements as GFI; RMSEA is the root mean square and square root of the progressive residual, and the RMSEA value of the model is between 0.05 and 0.08, indicating that the model has good Adaptability. It can be seen from the table that the relevant parameters of the research hypothesis have reached the significance standard, so the research hypotheses are all valid, and the data are shown in Table 1 below.

**Table 1.** Model assumptions and parameter estimates

Suppose	Model parameter estimates				
	Non-standardized coefficient	Standard error S.E.	C.R.	P	Normalization coefficient
H1: Positive impact of network controllers	0.374	0.112	3.314	***	0.251
H2: Positive impact from environmental factors	0.221	0.084	2.765	0.005	0.231
H3: Positive impact of key technologies	0.481	0.154	3.214	0.001	0.339
Standard	-	>0	>1.96	<0.05	-

Therefore, the three elements of NIS control proposed in this article have a certain effect on NIS, and the impact of these three elements is technology, network controller, and environment. From the perspective of building a network information security control evaluation system has certain rationality, and the size of the influence coefficient can be used as a reference in establishing an evaluation index system.

#### 4.2 Evaluation System of Network Information Security Control in the Context of Big Data

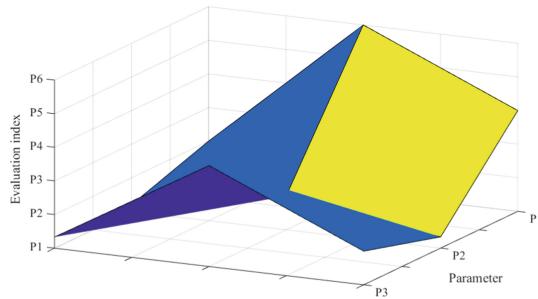
This article uses the analytic hierarchy process to calculate the weight of each indicator in the indicator system to reflect the relationship between the importance of different indicators in the evaluation system. The greater the value of the consistency index CI, the greater the degree of deviation of the judgment matrix from full consistency. The smaller the value, the closer the judgment matrix is to full consistency. For the multi-stage judgment matrix, the average random consistency index R.I. (random index) is introduced:

The data are shown in Table 2 below.

**Table 2.** Mean random consistency index R.I.

Average random consistency indicator R.I.									
N	1	2	3	4	5	6	7	8	9
R.I.	0	0	0	0.57	0.81	1.01	1.21	1.38	1.40

As shown in Table 2 above, when  $n < 3$ , the judgment matrix is completely consistent. When  $CR < 0.10$ , you can The judgment matrix is considered to be consistent; when  $CR > 0.10$ , the judgment matrix needs to be adjusted and modified to meet the consistency. The following uses the judgment matrix  $C_1 - P$  as an example to perform weight calculation. The data is shown in Fig. 1 below.



**Fig. 1.** Judgment Matrix.

After the judgment matrix is normalized and the normalized columns are averaged, the weight vector  $w = (0.106, 0.633, 0.261)$  T is obtained, and the maximum eigenvalue  $\lambda_{\max} = 3.0387$  is obtained. The weight coefficient of the NIS control evaluation system established in this paper can be the network information. Security work provides a certain guiding role. The differences in index weights can reflect the focus of work in NIS work, focus on major resources and focus on key tasks, and give full play to the guiding role of the NIS control evaluation system. From the weights of each level of indicators in the table, it can be seen that the weights of the three elements of the NIS control mechanism are technology, personnel, and environment in turn. The indicator weights identified by the expert scoring method are consistent with the data obtained from the questionnaire survey, which enhances the scientificity and credibility of this evaluation system.

## 5 Conclusions

This article focuses on the three elements of NIS control, establishes a NIS control mechanism model, and builds NIS prevention and control in the context of big data from the perspective of mutual support and cooperation between the three dimensions of network controllers, environment, and technology. The combined mechanism system provides theoretical guidance for NIS work in a big data environment. This article starts from the perspective of management and control functions and combines the practice of NIS in a big data environment. It proposes three elements of NIS control in a big data environment, namely network control personnel, environment, and technology, which lays the research foundation and theoretical support for the following. Based on the practice of NIS control in the context of big data and the research results of this article, this article proposes corresponding suggestions and strategies around the three elements of NIS in view of the current problems of NIS. The work provided help and guidance.

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# Design and Research of Metallurgical Energy Data Security Monitoring System Based on Android Platform

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**Abstract.** In the safety monitoring of Android mobile devices, the traditional security monitoring method has some problems, such as insufficient monitoring accuracy, serious energy consumption and poor stability. In view of the above problems, a security monitoring system based on Android platform is designed. For security analysis system design of Android mobile phone, through three parts, the basic framework of the security monitoring system is built, and then four modules based on the system frame work are designed to realize the monitoring of Android mobile devices. The experimental results show that the security monitoring system based on the Android platform is superior to the traditional security monitoring system.

**Keywords:** Android platform · Security monitoring · Monitoring system · System design

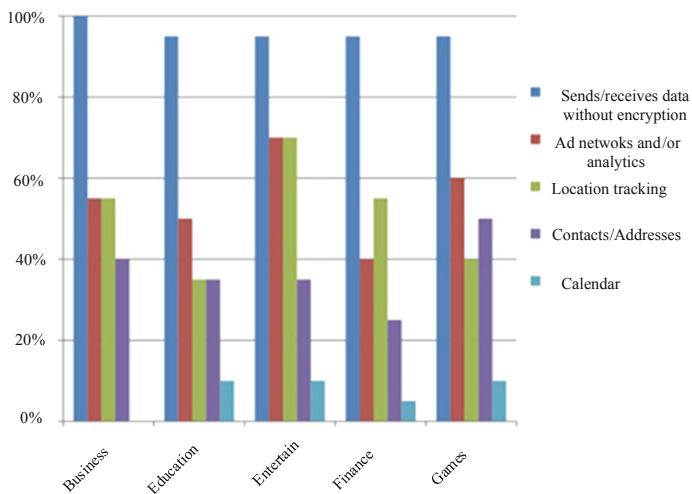
## 1 Introduction

The rapid development of mobile Internet technology brings convenience to people's life and work as well as threats to information security. The great openness of the Android system provides a platform for the spread of malicious applications. These malicious applications steal user's privacy data, carry out automatic networking, and send short message ordering services, causing huge economic losses to users [1]. On the basis of fully studying the development of Android and the security of Android application, a security monitoring system based on Android platform was designed. In this paper, the security problems of Android mobile phones were analyzed, the types of information leakage were summarized, and the Android platform was briefly expounded. The monitoring system mainly consisted of three parts, and the system structure design was completed by four modules (network intrusion monitoring module, information monitoring module, information loss module and network traffic monitoring module) [2].

## 2 Design of Security Monitoring System

### 2.1 Design Background of Security Monitoring System

The emergence of communication devices brings convenience to people, while the malicious programs hidden in it are also perplexing the user at the moment, so the security monitoring of mobile terminals has become a major topic of current research [3]. But there are many loopholes in this operation. Once accessing to the wireless network, it is easy to be monitored by illegal personnel. More than 6 billion downloaded Android applications are currently under the risk of information disclosure, and the main types of privacy data leaks are shown in Fig. 1 [4]. In this context, it has attracted wide attention from manufacturers, developers and users [5]. Therefore, it is imminent to monitor the application security from studying the network behavior and information leakage of the application.

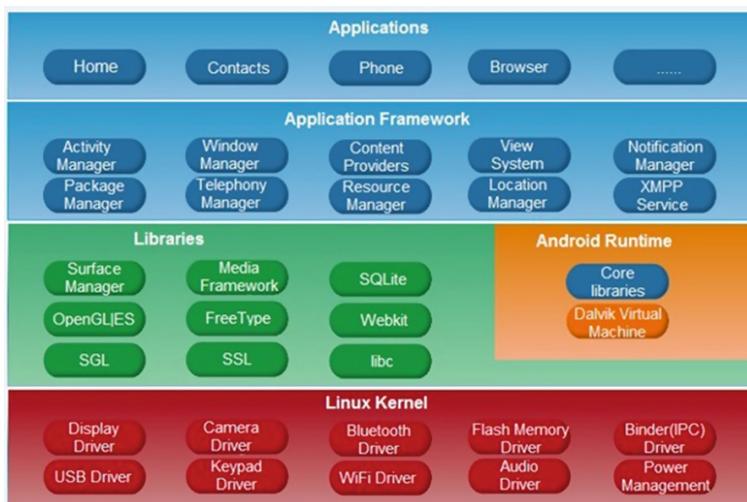


**Fig. 1.** The main types of privacy data leaks

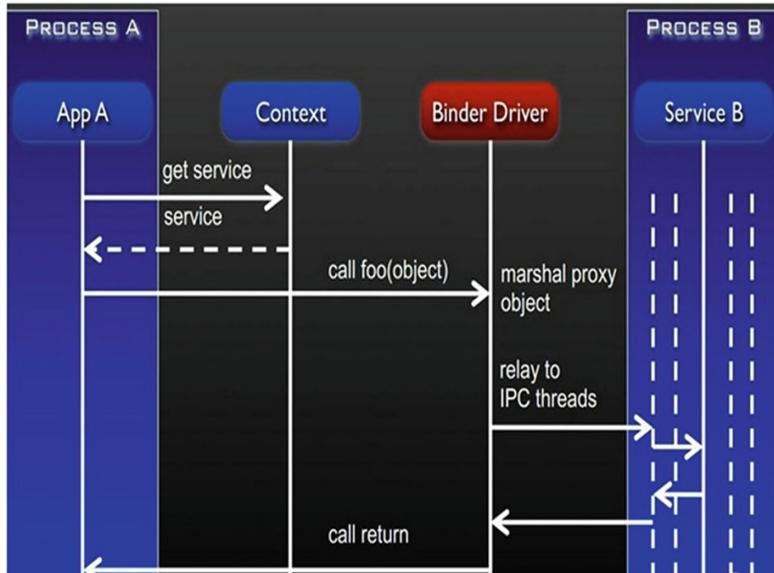
Android is a free and open source operating system based on Linux, led and developed by Google and the open mobile alliance, it is mainly used for mobile devices, such as smart phones and tablet computers [6]. It can achieve the maximum speed of application running in mobile devices. There are two main components of the Android system: the Linux kernel and the Android emulator, the secondary components are 2D and the 3D graphics engine, which can support the game development and the underlying multimedia libraries [7]. The overall architecture of the Android platform is shown in Fig. 2.

## 2.2 Security Monitoring System

The security monitoring system based on Android platform can effectively monitor the running state of the application. After the system is applied to the mobile phone, the first operation needs the user to enter the personal information. After that, the security monitoring is automatically running in the background when the mobile phone is opened, without the need for another input [8]. Figure 3 is a schematic diagram of the security monitoring system based on Android platform. In the system, iptables is used to design network intrusion monitoring, the main function of which is to monitor the running state of the application and manipulate the running application of the network operation. Once the mobile phone is stolen, the security monitoring system will immediately play its role, read the new SIM card information and send the information in the background to the security number in the way of short message. After the security number receives the message, the control instruction is sent to the mobile phone, and the mobile phone receives the corresponding control operation after receiving the instruction. Traffic detection is implemented by TrafficStats, while traffic control is implemented through iptables rule chain [6].



**Fig. 2.** The overall architecture of the Android platform

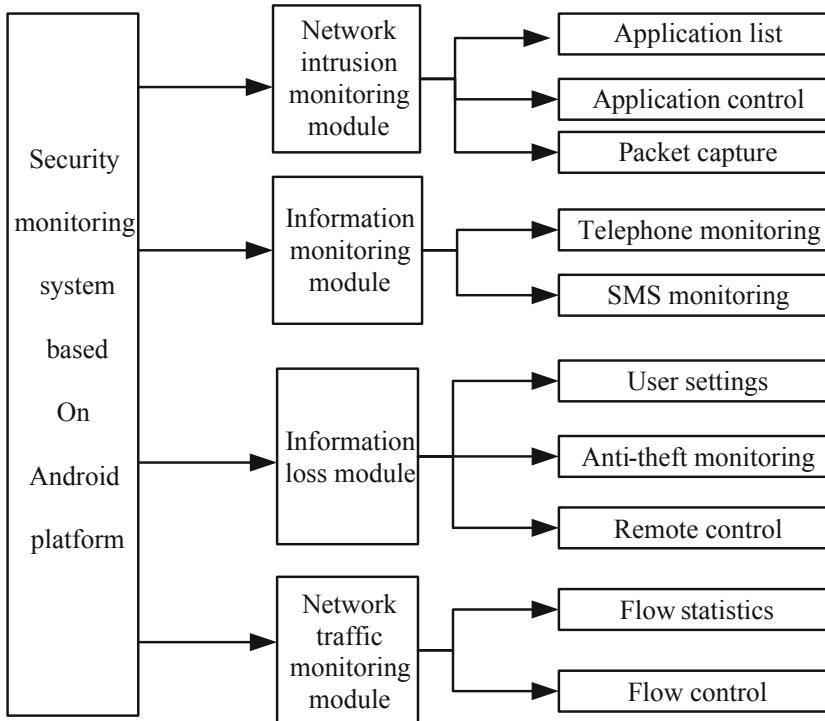


**Fig. 3.** The schematic diagram of security monitoring system based on Android platform

### 2.3 System Framework

The security monitoring system based on Android platform is mainly composed of three parts, which are the hardware equipment of security monitoring, the security monitoring system server and the Android mobile client [9], as shown in Fig. 4.

According to the composition of the above security monitoring system and the above introduction of the Android platform, a security monitoring system for Android platform's illegal intrusion is designed. After the system monitors the risk of illegal intrusion in the mobile phone, it suggests that the mobile phone users take corresponding defensive measures through alarms to form a complete security monitoring system based on the Android platform [10].



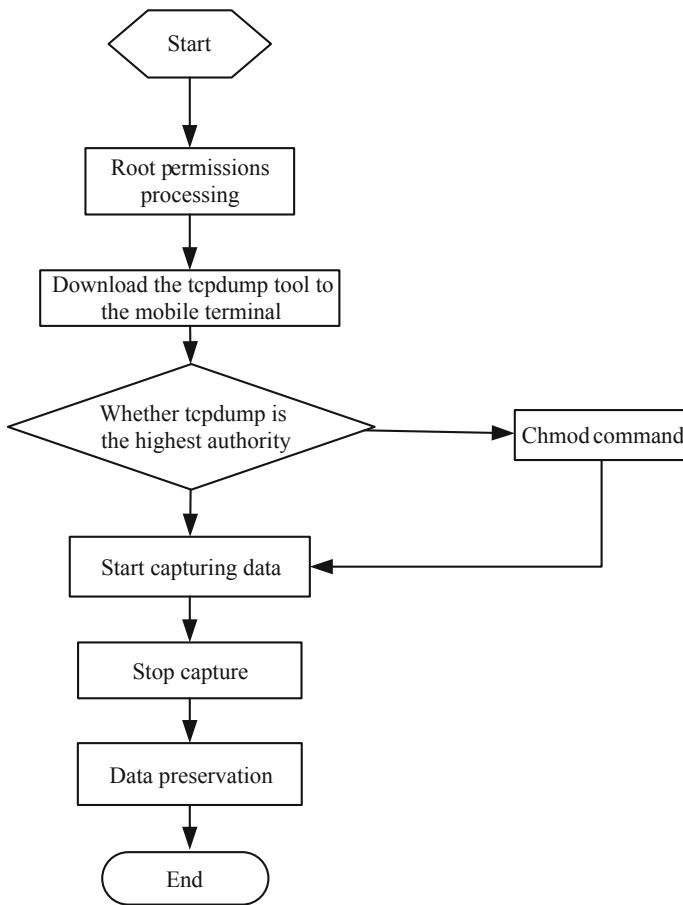
**Fig. 4.** Structure of security monitoring system based on Android platform

## 2.4 Module Design

The security monitoring of mobile phones is divided into two main types: one is the known malicious programs, for which the static detection method based on the virus feature library is used [11]. Conversely, if the match is not successful, it indicates that the application is not a malicious program. This static detection method is not only efficient, but also accurate. But for unknown malware, because there is no feature data in the virus library, it cannot be matched successfully, so this method cannot be used to detect unknown malware. Therefore, it is necessary to use another detection method – dynamic detection to identify unknown malicious programs in mobile phones [12].

### 2.4.1 Network Intrusion Monitoring Module

The main function of the network intrusion monitoring module is to monitor the behavior of the application accessing the network in the mobile device, and then control the application with the network privileges. The network intrusion monitoring module has three sub programs: application list, application control and data packet capture [13]. The first two can be implemented by means of calling the related class, while the packet capture is implemented on the basis of the packet capture tool (tcpdump). The specific process is as follows: first, the application must get the root permission of mobile phone. The flow chart captured by the packet is shown in Fig. 5.



**Fig. 5.** Flow chart of data packet capture

### 2.4.2 Information Monitoring Module

The information monitoring module is used to intercept telephone or text messages. Corresponding contacts who do not want to answer or do not want to receive text messages are added to the black list, thereby intercepting calls or short messages. In this module, there are two subroutines: telephone monitoring and SMS monitoring [14].

Telephone monitoring. Criminals charge illegal fees by making calls to users, or automatically dial a designated number by launching malicious programs to collect high fees. The concealment of making calls and answering calls is generally not as good as an SMS program, and it is easy for users to find out. Therefore, at present, there are not many malwares that use telephone programs to steal information, but they still need to be guarded to monitor phone calls and receive calls [15].

Figure 6 is a flow chart of information monitoring.

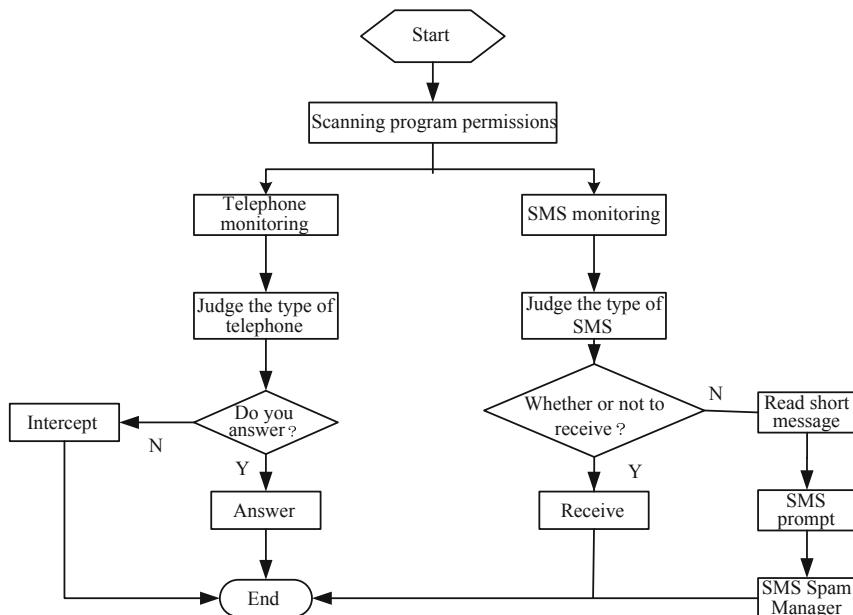


Fig. 6. Flow chart of information monitoring

## 3 Contrast Experiment

After the design of the safety monitoring system is completed, the monitoring accuracy, energy consumption and stability of the system need to be tested. The system test can detect the loopholes and errors in the system in time, make an objective assessment of the performance of the whole security monitoring system, make a correct evaluation on whether to meet the actual performance requirements and functional requirements of the system, and improve the fault tolerance and accuracy of the system, so as to prepare for the further optimization of the system performance.

### 3.1 Test Content

Three aspects of system accuracy, energy consumption and stability are tested. The system is tested on two mobile phones equipped with Android system. And two monitoring systems are installed on two completely identical mobile phones. (In mobile phone 1, traditional security monitoring system is installed, and in mobile phone 2, a security monitoring system based on Android platform is installed).

### 3.2 Test Process

The security monitoring needs to start the active defense service. After the service starts, it monitors the SMS, telephone, network, application program and performance status of two Android mobile phones in the background in real time. After everything is ready, it monitors for 1 day and then tests it.

Some of these malicious applications will send SMS in the background, some download ad programs and other malicious programs in the background, some will steal user privacy, and some will change the state of performance indicators. These malicious programs usually have at least one kind of malicious behavior.

## 3.3 Results and Analysis

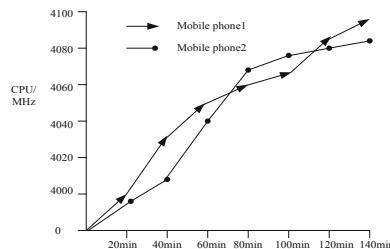
### 3.3.1 Accuracy Analysis

When the test starts, after the active defense service has been opened for a long time, the test results are statistically analyzed. The test results are as follows: in the 10 malicious programs installed before the test, five malicious programs in the virus database are detected on two mobile phones, and for the other five malicious programs which are not in the virus database, there are two malicious applications detected by the mobile phone 1, and there are three malicious applications detected by the mobile phone 2. For unknown malicious programs, the security system will prompt the user to let them determine if they are malicious programs; In the log, it can view the malicious programs detected by exception. The test results show that, for the known malicious programs, two security monitoring systems can be detected by 100%. However, for the unknown malicious programs that has been installed, 70% malicious programs can be detected by the mobile phone 1, and 80% malicious programs can be detected by the mobile phone 2. It shows that the security monitoring system based on the Android platform has achieved the expectation in accuracy detection, which can detect the known malware accurately, and the detection rate of unknown malware is very high.

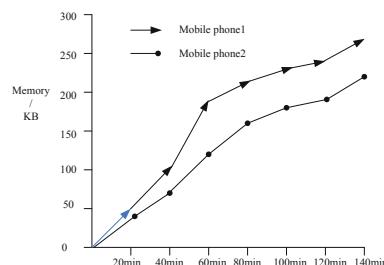
### 3.3.2 Energy Consumption Analysis

Energy consumption analysis is mainly to test the overhead generated by the operation of the security monitoring system, such as consumption of CPU, consumption of memory and consumption of electricity. A good security system does not need to consume a lot of resources, but only requires very small resources to ensure the normal operation of the equipment.

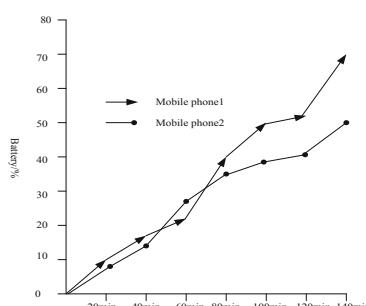
Before testing, all applications that may interfere with the test results are closed, and the usage of CPU, memory and power of two mobile phones are recorded. When testing, the security monitoring system is run to view the usage of CPU, memory and power in the security system running. In this article, the third party software is used to check the consumption of electricity and the consumption of memory in the security defense. The results are shown in Fig. 7.



(a) Consumption of CPU



(b) Consumption of memory



(c) Consumption of electricity

**Fig. 7.** Contrast analysis curve of energy consumption of mobile phone

It can be seen from the test results that when the mobile phone 2 runs on the security monitoring system based on Android platform, the consumption of CPU is only 4080 MHz, the consumption of memory is only 220 KB, and the consumption of electricity is only 50%. While when the traditional security monitoring system is run in the mobile phone, the consumption of CPU is 4100 MHz, the consumption of memory is 270 KB, and the consumption of electricity is 70%. The test results show that the energy consumption of the security monitoring system based on Android platform is small at runtime and is within acceptable range.

## 4 Conclusions

There are more and more malicious software targeting the Android platform. They steal user privacy and malicious deductions, causing serious losses to Android users. Therefore, the design and application of security monitoring system is imperative. Through the analysis of the security status and development trend of the Android system, combining the development of the theory and technology and the requirements of the performance of the monitoring system, a security monitoring system based on the Android platform is proposed in this paper, and the design of each module for the security monitoring system is realized. The system consists of hardware devices, servers and mobile clients of the security monitoring system. The designed modules include four modules: network intrusion monitoring module, information monitoring module, information loss module, and network traffic monitoring module. Finally, in order to verify the accuracy, energy dissipation and stability of the security monitoring system based on Android platform, a system test is carried out. In the test, the real malicious applications are used to attack Android mobile phones. And the test shows that the security monitoring system based on the Android platform can monitor the illegal operation steadily and accurately under the condition of low resource consumption, effectively ensuring the security of the mobile users' privacy information.

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# A Reliability Analysis Method of Multiple Components System Based on Copula Function

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**Abstract.** Through analysis the characteristics of multiple components system with tri-states, this paper builds a reliability model for the tri-states system with failure dependent, which suppose the system has three states: work, failure of safety and failure of danger. The component included in the system have two kinds of state: work or failure. The components failure behavior between components are interdependent. Through the use of copulas function, we derived the reliability index for system under different structure with the dependency of components, and obtain the mathematical formula of probability of work, failure of safety and failure of danger, mean time to failure of safety, mean time to failure of danger, which makes reliability analysis more accurate.

**Keywords:** Reliability · Safety · Copula function · Failure · System

## 1 Introduction

With continuous progress of science and technology, components of complex system become more and more, system structures also become more and more complex and component failure are independent and coupled. Accurate assessment of system reliability and appropriate maintenance measures can effectively prevent the fatal accident and improve the ability of its accompanying task [1].

Choi and Trivedi used Markov theory to study the tri-state security system in 1993 [2]. They divided the state of the system into work, safety faults and dangerous faults, and divided the system indices into reliability indices and safety indices. Bukowski and Goble use Markov theory to further study the modeling method and system availability and safety of the tri-state safety critical system, and get the important indexes of reliability: mean time to failure, failure probability [3–5]. A premise of applying Markov theory to the study of critical systems is that the life of system must obey the exponential distribution. However, many safety-critical system life distributions are not exponential in reality. The articles [6, 7] studied the reliability indices of single-component, serial and parallel systems under general distribution, which include system reliability, safety failure time distribution, hazard failure time distribution, safety failure mean time and hazard failure mean time. Based on those articles, this paper uses the copula function [8–10] to study the reliability of the tristate multi-component system with life dependency.

## 2 Problem Analysis

Aerospace systems has a very strict requirement on safety. In order to improve the safety, the system generally performs redundant design. The purpose is once the components are failure, the safety components will be alarmed and automatically switched to safe mode to prevent dangerous events. Given this, the following assumptions are made:

- (1) There are three types of status of the system, one is the normal working status, the system is in good condition and the system is running smoothly. Second, the system runs, but the components fail. Third, the system failed, and there was a fatal failure.
- (2) System is composed of a unit and each unit is comprised of two components at least. Each unit must have the working components  $X$  and safety components  $Y$ . Its life obeys general distribution  $F(x)$  and  $G(y)$  in a respective way. The life is dependent between the components. The corresponding Copulas function is  $C$  [11].
- (3) Work status: when the unit's security components and working components are normal; a safety failure status: where the unit's working components fail prior to the safety components; a dangerous failure: where the unit security components fail before the working components.
- (4) The function of the joint-life distribution  $H(x, y)$  of the working components  $X$  and safety components  $Y$  are the continuous function. The corresponding joint density distribution function of life is  $h(x, y)$  [12].

In the following, the reliability index of the unit system is deduced according to the above assumptions: system working probability distribution, safety fault distribution, dangerous fault probability distribution, safety failure mean time and hazard mean time.

## 3 Simple System Reliability

Suppose the failure time of working-components and safety components are dependent and their life distribution functions are  $F(x)$  and  $G(y)$  [12], the working components and safety components of the joint life distribution function is:

$$H(x, y) = C(F(x), G(y)) \quad (1)$$

And  $H(x, y)$  is the continuous function of  $x$   $y$ , and the corresponding joint life distribution density function is

$$h(x, y) = \frac{\partial^2 H(x, y)}{\partial x \partial y} \quad (2)$$

The system safety index is listed as:

- (1) the probability distribution function of safety failure at the moment of  $t$  is

$$P_s(t) = P(X \leq Y \leq t) = \iint_{x \leq y, 0 \leq y \leq t} h(x, y) dx dy = \int_0^t \int_0^y h(x, y) dx dy \quad (3)$$

- (2) the probability distribution of dangerous fault at the moment of  $t$

$$P_d(t) = P(X \leq Y \leq t) = \iint_{y \leq x, 0 \leq x \leq t} h(x, y) dx dy = \int_0^t \int_0^y h(x, y) dy dx \quad (4)$$

- (3) the normal working probability at the moment of  $t$  is

$$P_W(t) = 1 - P_s(t) - P_d(t) = 1 - \int_0^t \int_0^y h(x, y) dx dy - \int_0^t \int_0^x h(x, y) dy dx \quad (5)$$

- (4) the mean time before safety failure refers to expectation of the working time prior to the safety failure of the system

$$MTTF_s = E[Y|X \leq Y] = \frac{\int_0^\infty P(Y \geq t, X \leq Y) du}{P(X \leq Y)} = \frac{\int_0^\infty \int_0^\infty \int_0^y h(x, y) dx dy du}{\int_0^\infty \int_0^y h(x, y) dx dy} \quad (6)$$

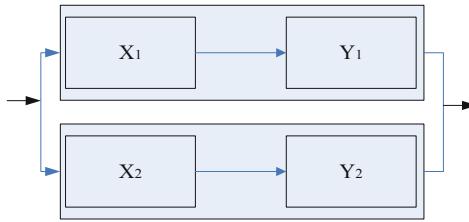
- (5) the mean time before a dangerous failure refers to the expectation of the working time prior to a dangerous failure of the system

$$MTTF_d = \frac{\int_0^\infty \int_0^\infty \int_0^x h(x, y) dy dx du}{\int_0^\infty \int_0^x h(x, y) dy dx} \quad (7)$$

## 4 Multi-components System Reliability

### 4.1 A Parallel System of Two Units Reliability and One Safety Unit

Assumes that the system is composed of two units, working component life and safety component life of unit 1 are  $X_1$  and  $Y_1$ . The life distribution are  $F_1(x)$  and  $G_1(y)$  [11]. Working component life and safety component life of unit 1 are  $X_2$  and  $Y_2$ . The life distributions are  $F_2(x)$  and  $G_2(y)$ . Assuming that the working component and safety component of unit 1 is dependent with the working component and safety component of unit 2 on life, the corresponding Copulas function is  $C_P$ , as shown in Fig. 1.



**Fig. 1.** The structure of parallel system

As shown in Fig. 1, the system is at work when any unit is working. The system is in a state of safety failure when at least one of the two units is in a state of safety failure. The system is in a state of dangerous failure when at least one of the two units is in a dangerous state of failure.

The joint life distribution function  $H_s(x_1, x_2, y_1, y_2)$  of working components  $X_1, X_2$ , and the safety components  $Y_1, Y_2$ , is a continuous function of  $x_1, x_2, y_1, y_2$ . The corresponding joint distribution density function is  $h_s(x_1, x_2, y_1, y_2)$  [13].

The joint life distribution of the system is

$$H_p(x_1, x_2, y_1, y_2) = C_p(F_1(x), F_2(x), G_1(y), G_2(y)) \quad (8)$$

$H_p(x_1, x_2, y_1, y_2)$  is a continuous function of  $x_1, x_2, y_1, y_2$ .

$$h_p(x_1, x_2, y_1, y_2) = \frac{\partial^4 C_p(F_1(x), F_2(x), G_1(y), G_2(y))}{\partial x_1 \partial x_2 \partial y_1 \partial y_2} \quad (9)$$

The reliability index of the system is [13]

(1) The probability when the system is in safety failure at the moment of  $t$  is

$$\begin{aligned} P_s^p &= P(X_1 \leq Y_1 \leq t, X_2 \leq Y_2 \leq t) + P(X_1 \leq Y_1 \leq t, Y_2 \leq X_2 \leq t) \\ &\quad + P(Y_1 \leq X_1 \leq t, X_2 \leq Y_2 \leq t) \\ &= \int_0^t \int_0^{y_2} \int_0^t \int_0^{y_1} h_p(x_1, x_2, y_1, y_2) dx_1 dy_1 dx_2 dy_2 \\ &\quad + \int_0^t \int_0^{x_2} \int_0^t \int_0^{y_1} h_p(x_1, x_2, y_1, y_2) dx_1 dy_1 dy_2 dx_2 \\ &\quad + \int_0^t \int_0^{y_2} \int_0^t \int_0^{x_1} h_p(x_1, x_2, y_1, y_2) dx_1 dy_1 dx_2 dy_2 \end{aligned} \quad (10)$$

(2) The probability when the system is in dangerous failure at the moment of  $t$  is

$$\begin{aligned} P_d^p(t) &= P(Y_1 \leq X_1 \leq t, Y_2 \leq X_2 \leq t) \\ &= \int_0^t \int_0^{x_2} \int_0^t \int_0^{x_1} h_p(x_1, x_2, y_1, y_2) dy_1 dx_1 dy_2 dx_2 \end{aligned} \quad (11)$$

(3) The probability of the system working normally at all times

$$\begin{aligned}
 P_w^p(t) &= 1 - P_s^p(t) - P_d^p(t) \\
 &= 1 - \int_0^t \int_0^{y_2} \int_0^t \int_0^{y_1} h_p(x_1, x_2, y_1, y_2) dx_1 dy_1 dx_2 dy_2 \\
 &\quad - \int_0^t \int_0^{x_2} \int_0^t \int_0^{y_1} h_p(x_1, x_2, y_1, y_2) dx_1 dy_1 dy_2 dx_2 \\
 &\quad - \int_0^t \int_0^{y_2} \int_0^t \int_0^{x_1} h_p(x_1, x_2, y_1, y_2) dx_1 dy_1 dx_2 dy_2 \\
 &\quad - \int_0^t \int_0^{x_2} \int_0^t \int_0^{x_1} h_p(x_1, x_2, y_1, y_2) dy_1 dx_1 dy_2 dx_2
 \end{aligned} \tag{12}$$

(4) The mean time prior to the safety failure is [11]

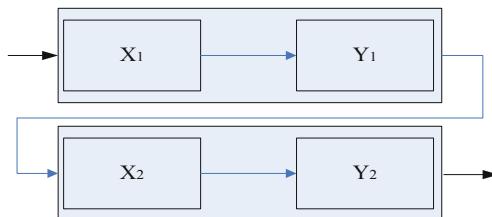
$$\begin{aligned}
 MTTF_s^p &= E[\max(Y_1, Y_2) | X_1 \leq Y_1, X_2 \leq Y_2] \\
 &= \frac{\int_0^\infty P(X_1 \leq Y_1, X_2 \leq Y_2) - P(X_1 \leq Y_1 \leq t, X_2 \leq Y_2 \leq t) dt}{P(X_1 \leq Y_1, X_2 \leq Y_2)} \\
 &= \frac{\int_0^\infty \int_0^\infty \int_0^{y_2} \int_0^{y_1} h_p(x_1, x_2, y_1, y_2) dy_1 dx_1 dy_2 dx_2 dt - \int_0^\infty \int_0^t \int_0^{y_2} \int_0^{y_1} h_p(x_1, x_2, y_1, y_2) dy_1 dx_1 dx_2 dy_2 dt}{\int_0^t \int_0^{x_2} \int_0^{x_1} h_p(x_1, x_2, y_1, y_2) dx_1 dy_1 dx_2 dy_2} \\
 &\quad \tag{13}
 \end{aligned}$$

(5) The mean time prior to the dangerous failure is [14]

$$\begin{aligned}
 MTTF_d^p &= E[\max(X_1, X_2) | Y_1 \leq X_1, Y_2 \leq X_2] \\
 &= \frac{\int_0^\infty \int_0^\infty \int_0^{x_2} \int_0^{x_1} h_p(x_1, x_2, y_1, y_2) dy_1 dx_1 dy_2 dx_2 dt - \int_0^\infty \int_0^t \int_0^{x_2} \int_0^{x_1} h_p(x_1, x_2, y_1, y_2) dy_1 dx_1 dy_2 dx_2 dt}{\int_0^\infty \int_0^{x_2} \int_0^{x_1} h_p(x_1, x_2, y_1, y_2) dy_1 dx_1 dy_2 dx_2} \\
 &\quad \tag{14}
 \end{aligned}$$

## 4.2 A Series System of Two Unit's Reliability One Safety Unit

Assumes that the system is composed of two units, working component life and safety component life of Unit 1 are  $X_1$  and  $Y_1$ . The life distributions are  $F_1(x)$  and  $G_1(y)$ . Working component life and safety component life of Unit 2 are  $X_2$  and  $Y_2$ . The life distributions are  $F_2(x)$  and  $G_2(y)$ . Assuming that the working component and safety component of Unit 1 is dependent with the working component and safety component of Unit 2 on life, the corresponding Copulas function is  $C_s$ , as shown in Fig. 2.



**Fig. 2.** The structure of series system

As shown in Fig. 2, the system is at work when both units are working. The system is in a state of safety failure when at least one of the two units is in a state of safety failure. The system is in a state of dangerous failure when at least one of the two units is in a dangerous state of failure.

The joint life distribution function  $H_s(x_1, x_2, y_1, y_2)$  of the working components  $X_1, X_2$ , and safety components  $Y_1, Y_2$ , is a continuous function of  $x_1, x_2, y_1, y_2$ . The corresponding joint distribution density function is  $h_s(x_1, x_2, y_1, y_2)$ .

The joint life distribution of the system is

$$H_s(x_1, x_2, y_1, y_2) = C_s(F_1(x), F_2(x), G_1(y), G_2(y)) \quad (15)$$

$H_p(x_1, x_2, y_1, y_2)$  is a continuous function of  $x_1, x_2, y_1, y_2$  [14]

$$h_p(x_1, x_2, y_1, y_2) = \frac{\partial^4 C_p(F_1(x), F_2(x), G_1(y), G_2(y))}{\partial x_1 \partial x_2 \partial y_1 \partial y_2} \quad (16)$$

The reliability index of the system is

- (1) The probability when the system is in safety failure at the moment of  $t$  is

$$\begin{aligned} P_s^s(t) &= P\{(X_1 \leq Y_1 \leq t) \cup (X_2 \leq Y_2 \leq t)\} - P(X_1 \leq Y_1 \leq t, Y_2 \leq X_2 \leq t) \\ &\quad + P(Y_1 \leq X_1 \leq t, X_2 \leq Y_2 \leq t) \\ &= \int_0^\infty \int_0^\infty \int_0^t \int_0^{y_1} h_s(x_1, x_2, y_1, y_2) dx_1 dy_1 dx_2 dy_2 \\ &\quad + \int_0^\infty \int_0^\infty \int_0^t \int_0^{y_2} h_s(x_1, x_2, y_1, y_2) dx_2 dy_2 dx_1 dy_1 \\ &\quad - \int_0^t \int_0^{y_2} \int_0^t \int_0^{y_1} h_s(x_1, x_2, y_1, y_2) dx_1 dy_1 dx_2 dy_2 \\ &\quad - \int_0^t \int_0^{x_2} \int_0^t \int_0^{y_1} h_s(x_1, x_2, y_1, y_2) dx_1 dy_1 dx_2 dy_2 \\ &\quad - \int_0^t \int_0^{y_2} \int_0^t \int_0^{y_1} h_s(x_1, x_2, y_1, y_2) dy_1 dx_1 dx_2 dy_2 \end{aligned} \quad (17)$$

- (2) The probability when the system is in dangerous failure at the moment of  $t$  is

$$\begin{aligned} P_d^s(t) &= P\{(X_1 \leq Y_1 \leq t) \cup (Y_2 \leq X_2 \leq t)\} \\ &= \int_0^\infty \int_0^\infty \int_0^t \int_0^{x_1} h_s(x_1, x_2, y_1, y_2) dy_1 dx_1 dx_2 dy_2 \\ &\quad + \int_0^\infty \int_0^\infty \int_0^t \int_0^{x_2} h_s(x_1, x_2, y_1, y_2) dy_2 dx_2 dx_1 dy_1 \\ &\quad - \int_0^t \int_0^{x_2} \int_0^t \int_0^{x_1} h_s(x_1, x_2, y_1, y_2) dy_1 dx_1 dy_2 dx_2 \end{aligned} \quad (18)$$

(3) The probability of the system working normally at all times

$$\begin{aligned}
 P_w^s(t) &= 1 - P_s^s(t) - P_d^s(t) \\
 &= 1 - \int_0^\infty \int_0^\infty \int_0^t \int_0^{y_1} h_s(x_1, x_2, y_1, y_2) dx_1 dy_1 dx_2 dy_2 \\
 &\quad - \int_0^\infty \int_0^\infty \int_0^t \int_0^{y_2} h_s(x_1, x_2, y_1, y_2) dx_1 dy_2 dx_1 dy_2 \\
 &\quad - \int_0^\infty \int_0^\infty \int_0^t \int_0^{x_1} h_s(x_1, x_2, y_1, y_2) dy_1 dx_1 dx_2 dy_2 \\
 &\quad - \int_0^t \int_0^{x_2} \int_0^t \int_0^{y_1} h_s(x_1, x_2, y_1, y_2) dy_2 dx_2 dy_1 dx_1 \\
 &\quad + \int_0^t \int_0^{y_2} \int_0^t \int_0^{y_1} h_s(x_1, x_2, y_1, y_2) dx_1 dy_1 dx_2 dy_2 \\
 &\quad + \int_0^t \int_0^{x_2} \int_0^t \int_0^{y_1} h_s(x_1, x_2, y_1, y_2) dx_1 dy_1 dy_2 dx_2 \\
 &\quad + \int_0^t \int_0^{y_2} \int_0^t \int_0^{x_1} h_s(x_1, x_2, y_1, y_2) dy_1 dx_1 dx_2 dy_2 \\
 &\quad + \int_0^t \int_0^{x_2} \int_0^t \int_0^{x_1} h_s(x_1, x_2, y_1, y_2) dy_1 dx_1 dy_2 dx_2
 \end{aligned} \tag{19}$$

(4) The mean time prior to the safety failure is [15, 16]

$$\begin{aligned}
 MTTF_s^s &= E[\min(Y_1, Y_2) | Y_1 \leq X_1, X_2 \leq Y_2] \\
 &= \frac{\int_0^\infty P(X_1 \leq Y_1, X_2 \leq Y_2) - P(X_1 \leq Y_1 \leq t, X_2 \leq Y_2 \leq t) dt}{P(X_1 \leq Y_1, X_2 \leq Y_2)} \\
 &= \frac{\int_0^\infty \int_0^\infty \int_0^{y_2} \int_0^{\infty} \int_0^{y_1} h_s(x_1, x_2, y_1, y_2) dx_1 dy_1 dx_2 dy_2 dt}{\int_0^\infty \int_0^{y_2} \int_0^{\infty} \int_0^{y_1} h_s(x_1, x_2, y_1, y_2) dx_1 dy_1 dx_2 dy_2}
 \end{aligned} \tag{20}$$

(5) The mean time prior to the dangerous failure is

$$\begin{aligned}
 MTTF_d^s &= E[\min(X_1, X_2) | Y_1 \leq X_1, Y_2 \leq X_2] \\
 &= \frac{\int_0^\infty \int_0^\infty \int_0^{x_2} \int_0^{\infty} \int_0^{x_1} h_s(x_1, x_2, y_1, y_2) dy_1 dx_1 dy_2 dx_2 dt}{\int_0^\infty \int_0^{x_2} \int_0^{\infty} \int_0^{x_1} h_s(x_1, x_2, y_1, y_2) dy_1 dx_1 dy_2 dx_2}
 \end{aligned} \tag{21}$$

## 5 Conclusion

In this paper, the dependence between components is considered, multi-unit system reliability model of different structures is built. The system's probability distribution of safety failure and dangerous failure, mean time of safety failure and dangerous failure are obtained through Copula function. It is very important for the system safety

prevention and maintenance. Combined with the engineering background, two kinds of basic structures: series and parallel, is considered. The corresponding accurate indices of reliability are deduced. The results show that with the increase of number of unit and complex of system, the formula will become more complicated, which is need to further explore in the future.

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# Method and Practice of Short Wave Long Distance Communication Link Establishment

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**Abstract.** Shortwave communication is one of the main means to guarantee long-distance communication, and its link establishment is a practical problem in engineering practice. Based on the analysis of the propagation mode of short wave signal, the calculation method of elevation and azimuth in the design of short wave communication link is analyzed, the relationship between the working frequency of antenna erection height is discussed, the basic thinking method of setting up short wave communication link is put forward, and it is applied in a certain communication support task, and good results are achieved. This method can be used for reference in the construction of HF communication link.

**Keywords:** Short-wave communication · Angle of pitch · Azimuth angle

## 1 Introduction

The communication quality of short wave communication is poor in long-distance communication, and even communication interruption is caused in extreme cases [1]. In short wave communication engineering practice, it is necessary to study and select the appropriate antenna erection height and determine the antenna elevation angle according to the communication distance of both sides, and calculate the optimal working frequency suitable for communication task by combining the ionosphere height, appropriate propagation mode and electronic density analysis, so as to provide support for the establishment of actual communication link. Based on the analysis of the short wave signal propagation mode, this paper puts forward the basic method of setting up the short wave long distance communication link, and carries out the practice in the communication engineering.

## 2 Short Wave Communication Link Design

The establishment of short wave communication link is to open short wave link between communication task stations. At this time, many factors need to be considered. Firstly, the signal propagation mode should be determined according to the communication distance between the two sides of communication. Secondly, the ionosphere height, electronic density and the number of sunspots should be determined according

to the ionosphere conditions, and the parameters of communication link should be calculated and designed [2, 6]. However, the design of short wave link in practical engineering, it is still necessary to consider the design and selection of station location, antenna matching and selection, transmission power size, the elevation angle, the height of the antenna, the available working frequency, the communication direction and parameters.

## 2.1 Simulation Analysis of Antenna Elevation $\Delta$ and Communication Distance

In order to get the strongest signal when the electromagnetic wave is reflected through the ionosphere to the receiving point, the elevation angle of the antenna must be adapted to the elevation angle required by the electromagnetic wave. Therefore, the radiation elevation of the antenna must be determined by the height of the ionosphere and the communication distance. According to the shape and geometry of the earth, the relationship between the antenna elevation  $\Delta$  and the communication distance and the ionosphere height is:

$$\Delta = \tan^{-1} \frac{(R + H) \cos \frac{90d}{\pi n R} - R}{(R + H) \sin \frac{90d}{\pi n R}} \quad (1)$$

Where:  $R$  is the radius of the earth, taking 6370 km;  $H$  is the height of the ionosphere, the unit is km.;  $d$  is the great circle distance from the sending point to the receiving point, in KM;  $n$  is the number of reflections of electromagnetic waves through the ionosphere, that is, the number of hops in the propagation mode [3–5].

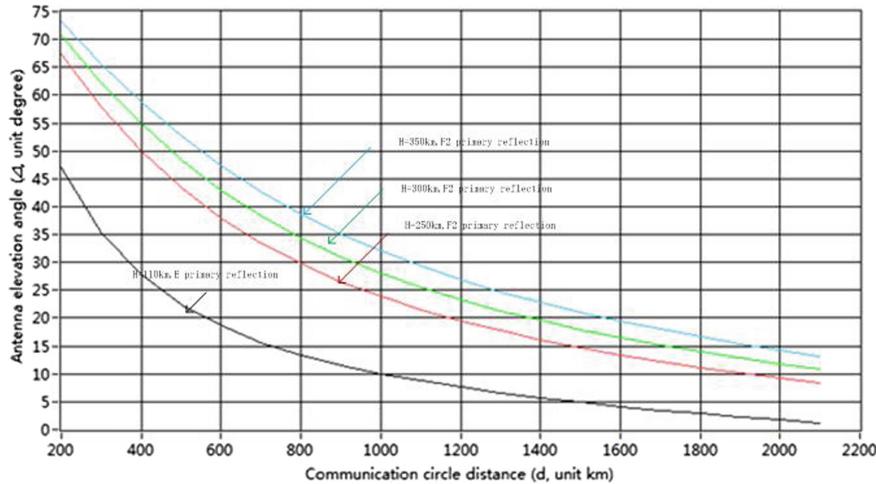
In the actual communication link establishment process, the optimal antenna elevation should be calculated and determined according to the communication distance, ionosphere height and radio wave propagation mode. In order to more intuitively and quickly establish the elevation angle of the antenna according to the communication distance and simulate formula (1), the relation curve between the radiation elevation angle of the antenna and the communication distance  $d$  is shown in Fig. 1. According to the simulation curve in the figure, the reasonable elevation angle of the antenna can be quickly selected according to the communication distance demand, which lays the foundation for the determination of the next communication antenna erection height and the optimal working frequency range.

## 2.2 Analysis and Calculation of Antenna Erection Height

The relationship between antenna elevation and antenna erection height is as follows:

$$h = \frac{\lambda}{4 \sin \Delta} \text{ (m)} \quad (2)$$

Where:  $H$  is the average erection height of the antenna, in meters;  $\lambda$  is the working wavelength, in meters;  $\Delta$  is the elevation angle of the antenna, in degrees. After the



**Fig. 1.** Relationship between antenna radiation elevation and communication distance d

antenna is erected,  $h$  will not be fixed. The antenna elevation angle  $\Delta$  changes with the working wavelength. The shorter the working wavelength is, i.e. the higher the working frequency is, the smaller the antenna elevation angle is; otherwise, the longer the working wavelength is, i.e. the lower the working frequency is, the larger the antenna elevation angle is. The change of elevation will reduce the gain coefficient of the antenna in the preset direction and weaken the signal of the receiving point [6–8].

In the process of setting up the actual communication link, the height of the antenna is often limited by the geographical location, equipment conditions and the height of the antenna support pole. Generally, the height  $h$  of the antenna is a fixed value, so the corresponding optimal working frequency can be established and the availability can be improved by the height of the antenna.

### 2.3 Analysis and Calculation of Communication Azimuth

In the long-distance communication, it is necessary to establish the communication position of both sides and calculate the azimuth angle of both sides, so that the maximum radiation direction of the antenna is consistent with that of the communication side, so as to improve the communication efficiency.

Azimuth refers to the angle between the great arc of the communication point of both sides and the north direction of the meridian, which needs to be calculated in a clockwise direction, that is, the angle from the true north line as the reference line to the communication direction in a clockwise direction, with the range of 0–360°.

According to the triangle cosine theorem of sphere, the azimuth of communication point can be calculated, and the geographic longitude and latitude information of the receiving and sending points need to be known when the computer is used. Suppose  $\lambda_T$  and  $\varphi_T$  are the longitude and latitude of the sending point respectively, and  $\lambda_R$  and  $\varphi_R$  are the longitude and latitude of the receiving point respectively, and the unit is degree,

and the values of the east longitude and north latitude are positive, the values of the south latitude are negative, and the values of the west longitude are positive [9, 10]. The calculation steps of the azimuth are as follows:

- (1) Calculate the longitude difference between the sending point and the receiving point  $\lambda_P$

$$\begin{cases} \lambda_P = \lambda_T - \lambda_R, & |\lambda_T - \lambda_R| \leq 180^\circ \\ \lambda_P = 360 + \lambda_T - \lambda_R, & (\lambda_T - \lambda_R) < 180^\circ \\ \lambda_P = (\lambda_T - \lambda_R) - 360, & (\lambda_T - \lambda_R) > 180^\circ \end{cases} \quad (3)$$

It should be noted that the difference must be the longitude of the sending point minus the receiving point.

- (2) Calculate the center angle  $b$  and the distance  $d$  of the big circle

$$b = \cos^{-1}(\sin \varphi_T \sin \varphi_R + \cos \varphi_T \cos \varphi_R \cos \lambda_P) \quad (4)$$

$$d = \frac{\pi}{180} R b \text{ (km)} \quad (5)$$

$R$  is the radius of the earth, taking 6370 km.

- (3) Calculate the azimuth  $B_{TR}$  between the sending point and the receiving point

$$\begin{cases} B_{TR} = \cos^{-1} \left( \frac{\sin \varphi_R - \sin \varphi_T \cos b}{\cos \varphi_T \sin b} \right), & \lambda_P \leq 0; \\ B_{TR} = 360^\circ - \cos^{-1} \left( \frac{\sin \varphi_R - \sin \varphi_T \cos b}{\cos \varphi_T \sin b} \right), & \lambda_P > 0; \end{cases} \quad (6)$$

- (4) Calculate the azimuth  $B_{RT}$  between the receiving point and the sending point

$$\begin{cases} B_{TR} = 360^\circ - \cos^{-1} \left( \frac{\sin \varphi_R - \sin \varphi_T \cos b}{\cos \varphi_T \sin b} \right), & \lambda_P \leq 0; \\ B_{TR} = \cos^{-1} \left( \frac{\sin \varphi_R - \sin \varphi_T \cos b}{\cos \varphi_T \sin b} \right), & \lambda_P > 0; \end{cases} \quad (7)$$

After determining the height of the antenna, the available working frequency and the communication direction, the short wave communication link can be set up according to the parameters to guarantee the communication.

### 3 Communication Support Task Practice

In May 2019, a short wave communication link from a certain area of Xi'an to a certain area of Wuhan needs to be set up in a communication exercise task. The communication equipment is a short wave 125w radio station, and the antenna is a bipolar antenna. Design communication link according to communication requirements. The preparation process of communication support is as follows:

- (1) Determine the propagation mode of short wave signal

Since the communication distance between the two places is less than 2000 km, the propagation mode is 1F,  $n = 1$ .

- (2) Determine the height range of the ionosphere

According to the weather conditions and electronic density distribution in Xi'an area, the ionosphere height is about 250–350 km, and the middle height of 300 km is the optimal value to ensure the communication task.

- (3) Determine azimuth and communication distance of large circle

The longitude of a region in Xi'an, Shaanxi Province is  $108.967^\circ$  E and  $34.077^\circ$  N, while that in Wuhan, Hubei Province is  $114.414^\circ$  E and  $30.892^\circ$  N;

When Xi'an is used as the sending station:  $\lambda_T = 108.967^\circ$ ,  $\varphi_T = 34.077^\circ$ ;

When Wuhan is used as the receiving station:  $\lambda_R = 114.414^\circ$ ,  $\varphi_R = 30.892^\circ$ ;

because of  $|\lambda_T - \lambda_R| < 180^\circ$ , it is  $\lambda_P = \lambda_T - \lambda_R = -5.447^\circ$ ; Then the center angle of the arc is:

$$b = \cos^{-1}(\sin \varphi_T \sin \varphi_R + \cos \varphi_T \cos \varphi_R \cos \lambda_P) = 5.589^\circ \quad (8)$$

The communication distance between Xi'an and Wuhan is:

$$d = \frac{\pi}{180} Rb = 621.371(\text{km}) \quad (9)$$

As a result, the azimuth of a region from Xi'an to Wuhan is calculated by formula (6):

$$B_{TR} = \cos^{-1}\left(\frac{\sin \varphi_R - \sin \varphi_T \cos b}{\cos \varphi_T \sin b}\right) = 123.243^\circ \quad (10)$$

According to formula (7), it is convenient for computer to get the azimuth of  $236.757^\circ$  from a certain area in Wuhan to a certain area in Xi'an, then both sides of communication can determine the direction of antenna installation.

- (4) calculate the optimal antenna elevation  $\Delta$

After the communication direction is determined, the rough value of antenna elevation angle can be obtained by viewing the simulation data in Fig. 1 according to the large circle communication distance. When  $h = 110$  km, the antenna elevation  $\Delta$  is about  $17.2^\circ$ , which is the reflection of layer E. according to the contingency of layer e, it will not be widely used in this support task; when  $h = 300$  km, the optimal antenna elevation  $\Delta$  is about  $41.6^\circ$ . Because of the following parameter of the ionosphere, the electronic density of F layer is not uniform, considering the maximum support requirements of communication tasks, the ionosphere height of 300 km is selected to design the communication link; in order to get more accurate antenna elevation value, formula (1) can be used to The optimal antenna elevation from Xi'an to Wuhan is  $41.9^\circ$ .

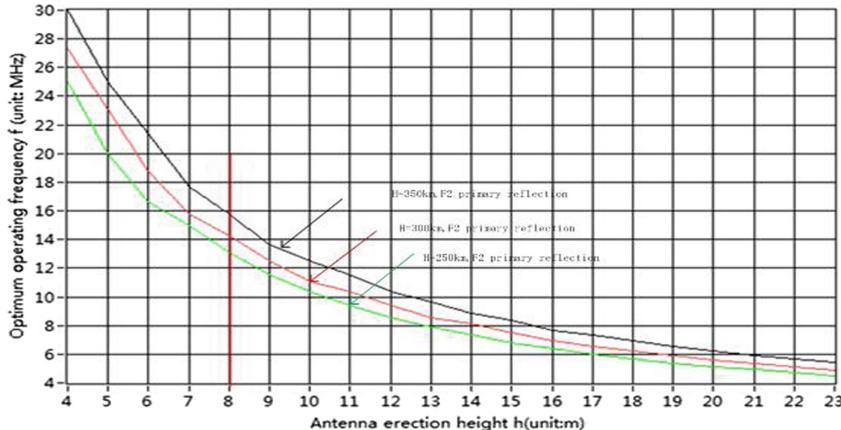
- (5) Calculate the working frequency range according to the height of antenna rack; it can be seen from Eq. (2)

$$\lambda = h \times 4 \times \sin \Delta = 8 \times 4 \times \sin(41.939^\circ) = 21.4(m) \quad (11)$$

Then the optimal working frequency can be calculated as:

$$f = \frac{c}{\lambda} = 14.018(\text{MHz}) \quad (12)$$

Where  $c$  is the speed of light  $3 \times 10^8$  m/s; It should be noted that the optimal working frequency determined here is not equal to the actual working frequency, and the actual working frequency should be a range because the ionosphere height and density are randomly changing. According to formula (2), the relationship curve between the antenna height and the working frequency can be simulated as shown in Fig. 2. From the simulation results, it can be seen that the working frequency shall be set between 13–16 MHz.



**Fig. 2.** Relationship between antenna erection height and working frequency

According to the simulation analysis results, the short wave communication link is established. The height of the antenna rack is 8 m, 14.018 MHz is selected as the constant frequency, and 20 groups of frequencies between 13–16 MHz are selected as the adaptive frequency group to carry out the communication task support. Not only the constant frequency communication is opened quickly, but also the adaptive and frequency hopping communication support tasks are completed with high quality.

## 4 Conclusions

The design of HF communication link needs the establishment of communication mode, the calculation of elevation and azimuth of communication antenna. Based on the theoretical research and the practice of communication task support, this paper gives the process and general calculation method of link opening design, which can provide reference for the actual link opening. However, due to the following parameters of HF ionosphere in engineering practice, the working frequency provided in this paper is the rate determination method can only give an optimal working frequency and a relatively reasonable working frequency range, and cannot provide the optimal working frequency in real time.

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# Design Information Security Management System Based on Cryptography

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**Abstract.** Encryption technology is the cornerstone of networked security technology. The data encryption process refers to the conversion of information into meaningless information through the encryption key and the encryption function, and the receiver restores the cipher text to the plaintext through the decryption function and decryption key. Designing an information security management system is an important information support platform for networked design. This article will focus on how to use cryptographic techniques to ensure network design information security.

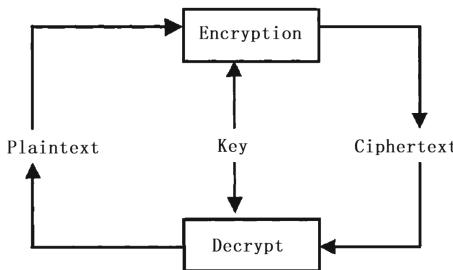
**Keywords:** Password technology · Information security · Access control

## 1 Introduction

Under normal circumstances, people refer to intelligible text as plaintext; text that converts plain text into incomprehensible form is called ciphertext; the process of converting plain text into cipher text is called encipher; it's the reverse process, that is, the process of transforming cipher text into plain text is called deCipher. The information encryption and decryption transformation process is shown in Fig. 1 below. Keyword (keyword) is some special information used for encryption and decryption. It is the key to control the plaintext and ciphertext [1, 2]. It can be numbers, words or sentences. The keys are divided into encryption keys (EncryptionKey) and decryption keys (DecryptionKey). The algorithm that performs encryption and decryption is called CipherSyetm technology.

## 2 Architecture of System

The design of the information management system ensures that in the network environment [3, 4], the correct information is delivered to the right members in the right way at the right time through certain process control. Solving the security of design information management is mainly to solve the security of product design information in storage, transmission and access control. The security architecture of the design information management system based on cryptographic technology is shown in Fig. 2:



**Fig. 1.** Information encryption, decryption transformation

Secure Design Information Management System							
Secure document management, design information transmission, etc.						Application layer	
Confidentiality      Authenticity      Integrity      Resistance      Usability							Security Services Layer
Symmetric cryptosystem, public key cryptosystem, message digest							Security mechanism layer
Public key management							Infrastructure layer

**Fig. 2.** Security architecture of design information management system based on cryptography

## 2.1 Authentication Technology

### (1) Identity authentication

The purpose of identity authentication mainly has two different aspects: to ensure the integrity of the information and to identify the true identity of the communicating counterpart [5–7].

Information verification: Information verification refers to the use of the aforementioned encryption algorithms such as secret keys, public keys, and message digests to encrypt and decrypt information, which can verify the integrity of the information. At present, the most commonly used algorithms for information integrity verification are information digest algorithms, such as MDS.

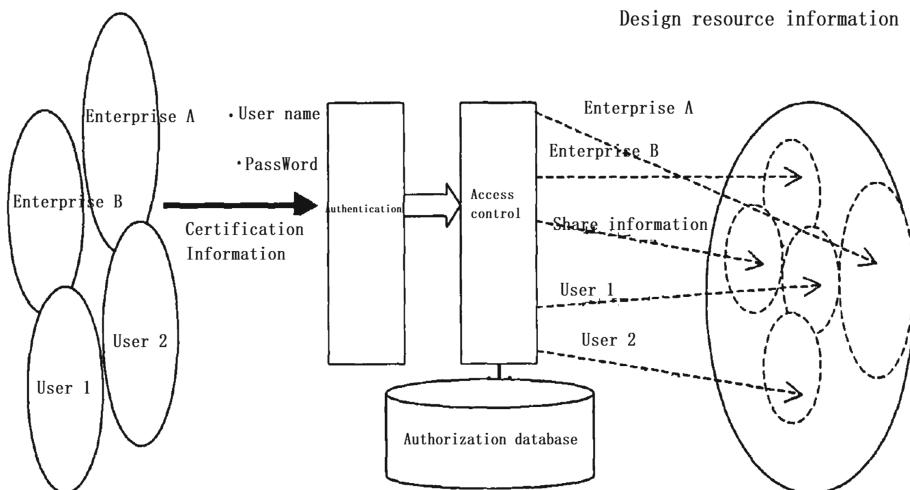
User authentication: User authentication is the process of verifying the true identity of the counterparty in communication to prevent impersonators from malicious active attacks. The common user authentication methods are:

Authentication based on shared secret key: User authentication based on shared secret key is the so-called “password-response method”. A sends a random password to B.

After receiving the password, B converts it using the shared secret key and returns the result (response) to A. A then reverse-transforms it and compares it with the original password, as if proves B's identity, otherwise it refuses to connect. Similarly, B can also perform the above identification on A.

## 2.2 Designing Information Security Access Control

The design information security access control model is to give different users different permissions to access different design information resources. The process is shown in Fig. 3.



**Fig. 3.** Designing an information access control model

### (1) Identity authentication

Use password-based authentication [3, 8, 9]. Account information is the key to user authentication. For security reasons, the account information is encrypted and stored, that is, the user's password information is encrypted. Attackers cannot read and use passwords after encryption. The encryption method can adopt the traditional encryption method and one-way function method. The encrypted account information is shown in Table 1:

**Table 1.** Encrypted account information form

User name	Encrypted password
Zhang San	@#333245rutei+!e!###
Li Si	\$%ewtwee{}—“*erte:::
Wang Wu	l) eie&&3%\$**feai@@@3eee

## (2) Access control

The design information management system uses a two-level information access control model.

The first level controls the user's connection information to the data source. Data source connection information is generally the user name and password to connect to the database or other data sources, such as our commonly used database connection information "Provider = MSDASQL; datasource. = egish; SERVER = {cgserver}; UID = sa; PWD = 1, DATABASE = egiso800 ". It is the key to ensuring information security. If an illegal user obtains this information, he can bypass the application logic and directly operate the database to obtain important design information. In addition, although different legal users have the same application logic, the operating data sources are different, and different data source connection information is needed to distinguish them. For security reasons, the data source connection information is stored encrypted.

The second level of control is to encrypt some important design information. The encryption key is passed to authorized users. Only those users who have the key can decrypt the encrypted information and access the information. The encryption granularity of the information can be the entire database, a table in the database or certain fields in the table, one or more documents, drawings and so on.

In response to the above-mentioned authentication and access control models. The password-based design information security access control implementation structure model is to set up a security agent at the middleware level of the three-level architecture (client/middleware level/database level) (the security agent (Security Agent) has user authentication and resources Access control function).

## (3) Working process

Identity authentication: When the client accesses the application server through the WEB server or directly, the application server starts the security agent, and the agent calls the account information table to verify the authentication information (user name, password) transmitted by the client.

Authorized access control: Authorized access control is mainly to achieve two-level access control of the design information management system. Now we will discuss the first level of data source connection control. The second level of control is discussed in "Secure Storage Management of Design Information" below. After the user authentication is successful, the security agent decrypts the encrypted data source connection information (the decryption method depends on the encryption method) and transmits it to the user. If the user is remotely accessed, the connection information needs to be encrypted and transmitted using the key shared by the user and the security agent or the user's public key.

### 3 Secure Transmission of Design Information

#### (1) Designing information transmission security issues

In the process of network design, there is a large amount of design information that needs to be exchanged between designers and enterprises. The design information management system must ensure the secure transmission of design information. The following first classifies and summarizes the design information, as shown in Table 2:

**Table 2.** Design information classification list

Information category	Primary coverage
Digital information	Product design index, parts material information, process parameter CAE analysis data, BOM, etc
Graphic information	D drawings, 3-D solid drawings of components, etc
Character information	Design notice, change notice, management and coordination information

For digital information and graphic information, you can encrypt the information (to ensure confidentiality and correctness) and attach the digital signature of the sender of the information (to ensure the integrity of the information). Text messages are accompanied by a digital signature from the sender of the message. After the above processing, the design information is transmitted in a secure transmission data packet.

#### ① Implementation of secure digital or graphic information packages

Digital or graphic information is encrypted using hybrid encryption (symmetric and asymmetric encryption algorithms). When the recipient of the information receives the encrypted and digitally signed information, the original information can be restored and the received information can be verified by the following steps.

##### a. Decrypt encrypted digital or graphic design data:

The information receiver uses its own RSA private key to decrypt the data encryption key (that is, the symmetric key) of this communication; then uses the decrypted data encryption key to unlock the data information of this communication;

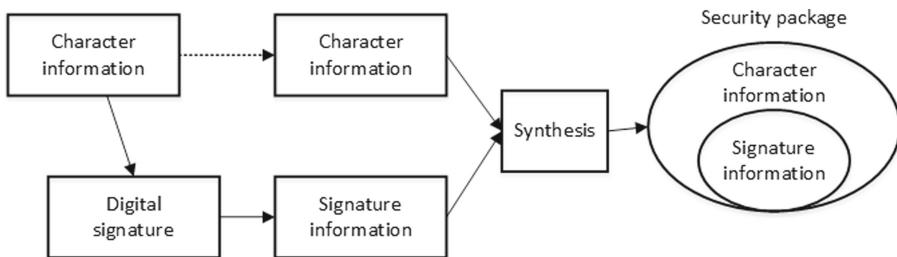
##### b. Perform MDS operation on the decrypted data information to obtain the message digest;

##### c. Use the sender's public key to decrypt the sender's digital signature to obtain a message digest;

Finally, the message digests obtained by b and c are compared. If they are equal, the design data of this communication is safe and reliable.

#### ② Realization of secure text information package

When the recipient of the message receives the digitally signed text message, the information is checked through the following steps (Fig. 4).



**Fig. 4.** Security text message package implementation process

- MDS operation on the received text information to get the message summary;
- Use the sender's public key to decrypt the sender's digital signature to obtain a message digest; compare the message digests obtained by a and b. If they are equal, the design data of this communication is safe and reliable.

## 4 Conclusions

This paper studies in detail the effects of two cryptosystems, public key cryptography and secret key cryptography, and other cryptographic technologies on information security under network environments. Based on this, a security framework structure of a design information management system based on cryptographic technology is proposed. And systematic research is carried out on the control process to ensure information security, such as secure access control of networked design information, secure transmission and storage of design information.

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## **Technical Tracks 2: Control Systems, System Integration, and Industrial Artificial Intelligence**



# Vision Sharing Method of Network Robot Based on Deep Learning

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**Abstract.** With the development of science and technology, robots are evolving from scratch, from low-level systems to high-level systems. The future of intelligent robots is towards intelligent and emotional development, and finally to achieve the goal of human-computer coexistence. Network robot is the main direction of future development. It is a robot controlled by computer network. Human-computer interaction technology, visual sharing and remote monitoring technology, data transmission and communication are the focus of their research. Therefore, the purpose of this paper is to explore the research of vision sharing method based on the theory of robotic algorithm, which leads to different thinking about the future development direction of robots. This paper will adopt the research method of concrete analysis of specific problems to make data comparison and draw conclusions. The results of this study show that as a typical representative of advanced manufacturing equipment, the network intelligent robot will have a large industrial development space and broad market prospects. At the same time, the country should draw lessons from the successful practices of foreign advanced robot industry development, formulate the development strategy and related policies of the robot industry, which is the key to the success or failure of China's robot industry development.

**Keywords:** Network robot · Vision sharing · Artificial intelligence · Human-computer cooperation

## 1 Introduction

Robot technology is in a critical period of development. It is predicted that robots will occupy all areas of life and play an active role [1, 2]. However, we need to clearly recognize that, according to the current development situation, robots are restricted by the development level of control technology, sensors and artificial intelligence, so there is still a long way to go to develop fully autonomous robots in complex time-varying environments in the short term. When a robot performs a complex control task, it can avoid the technical difficulties existing in the current robot control by incorporating human control behavior, that is, integrating human's advanced decision-making into the control task. From the perspective of human beings, the main task of robots is to meet the needs of human beings in a timely manner [3]. Man and robot can cooperate

to complete specific tasks, reduce the intensity of human work and improve the working conditions of human beings [4].

The intelligent development of robots depends on the perception of the environment information in the workspace [5]. The perception environment in visual mode is selected by many intelligent control systems [6, 7]. Visual sensors have become an effective means for robots to perceive the workspace environment because of their good information acquisition performance, and a variety of visual sensors are available, which is also a favorable condition for its wide applicability. Visual servo plays an irreplaceable role in the field of robot control. Visual servo control uses real-time visual information collected by visual sensors as feedback information of the control system, achieves non-contact acquisition of workspace information, performs servo control on specific features of the target object, and solves kinematics to complete the task of precise control. Internal core technologies involve the integration of high-speed sensor data processing, image processing, image feature information recognition and kinematics and other multi-disciplinary fields. Higher image acquisition frequency, faster graphics processing speed and faster parallel computing speed have become the driving force of wide application of visual servo. At present, scholars at home and abroad mostly use global features such as optical flow field and image moments to avoid the problem that feature information is sensitive to image noise to a certain extent, which improves the visual ability of robots and greatly facilitates the sharing of results. Robot vision sharing in our country is based on human-machine cooperation and visual servo research. The unavoidable existence of cumulative calibration errors and errors introduced by space coordinate transformation in multi-vision servo system reduces the overall accuracy of the system. Domestic research on remote control technology of network robots is relatively limited, and the research and development work in this area is mainly concentrated on the network, robot teleoperation technology in environment. Therefore, we should constantly improve the method of visual sharing, overcome technical difficulties and build competitive network robots [8, 9].

At present, intelligent robots are more and more widely used in various fields of our country, and their economic benefits are becoming increasingly obvious [10]. In order to explore the more efficient development of vision sharing technology for network robots, the combination of visual guidance and visual servo is used. In this study, we use HBVS, IBVS and Cityengine visual service systems, combine image analysis and information data analysis, objectively and truly show the trend of vision sharing technology of network robots based on artificial intelligence, and explore effective ways and innovative ways to accelerate the rationalization and sustainability of artificial intelligence.

## 2 Method

### 2.1 Core Concepts

#### (1) Network robot

Network robot is a program or script that automatically grabs the information of the World Wide Web according to certain rules. Because of the characteristics of

the Internet itself, network robots gradually break away from teleoperation robots and form independent research directions. Other names that are not commonly used are ants, automatic indexing, simulation programs or worms. With the rapid development of the network, the World Wide Web has become the carrier of a large amount of information. How to extract and utilize this information effectively has become a huge challenge. Search engines, such as traditional general search engines AltaVista, Yahoo! And Google, serve as a tool to help people retrieve information and become users' access to the World Wide Web and guide. However, these general search engines also have some limitations. In order to solve the above problems, focused crawlers emerge as the times require grabbing relevant web resources. Focus crawler is a program that automatically downloads Web pages. It selectively accesses web pages and related links on the World Wide Web to obtain the required information according to the established grabbing target.

## (2) Visual sharing method

Many changes have taken place in the current visual market, such as the communication platform, the form of the media, the age of the creator and the new technical means. The key to satisfy this new demand is to combine the new situation and achieve the promotion of visual integrated marketing with the support of technology and in-depth insight. The development trend of group vision is popularity, life, entertainment, diversification and mobile phone. The mechanism of sharing between machine vision and human vision is established, and the reference trajectory is established by identifying the angle of Eye signal. The trajectory tracking is realized by motion control, and the sharing control of service robot is realized by combining the two. Therefore, the performance of motion control will determine the ultimate effect of shared control. Visual sharing has created fruitful research results in recent years, which has aroused widespread concern in society and embodied certain social value.

## 2.2 Research Methods

The purpose of the research of network robot system is to design control methods to make the system stable and obtain good operational performance, namely transparency, under the premise of time-varying or time-invariant delay. Because of the complexity of the robot task, the environment model of its work is often unknown or uncertain, so as to share vision. Therefore, the research on the network robot system mainly focuses on stability, transparency, robustness and other issues. If the network time delay in the network robot control is divided into the following main parts: suppose the total time delay is  $T_r$ , then there are:

$$T_r = T_C + T_P + T_d + T_v \quad (1)$$

$T_c$  represents the communication delay,  $T_p$  is the execution delay,  $T_d$  is the data delay,  $T_v$  is the disturbance delay,  $T_d$  can also be expressed as  $(D_s + D_r)/V$ ,  $D_s$  and  $D_r$  are the data quantity sent and received respectively,  $V$  is the transmission speed. They aim to analyze and refine the delay time, and ultimately shorten the total delay time  $T_r$ .

by reducing the delay value of each component on the right side of the equation or the amount of data transmitted.

$$\begin{cases} (x_r - x_0)^2 + (y_r - y_0)^2 + (z_r - z_0)^2 \leq \frac{w^2}{2} \\ z_r - z_0 \leq w \end{cases} \quad (2)$$

The data density of recognition point cloud information can be measured by voxel. The default recognition density is 256 voxel, i.e.  $1000/256 = 3.9$  mm/voxel. Since gesture control information depends on the extraction of hand point cloud data, accurate segmentation of hand point cloud is particularly important. The position of palm center coordinates in hand skeletal information was studied.  $p_c(x_0, y_0, z_0)$  Locate the spatial distribution of the hand point cloud, and select the real-time point cloud to be collected on the basis of the palm coordinates. In the selection, the threshold  $w$  of the palm size is used as the standard, as shown in formula (2). The selected palm point cloud needs to further solve the palm plane. In this study, the least square fitting method is used to obtain the palm plane. The plane normal vector is the effective information for the manipulator posture control.

### 3 Experiment

For a single robot, the problem of service sequence establishment is to get the path from the starting point (that is, the video server where the robot is) to the target point (that is, the video server where the target is located). The validity of the path establishment method of the robot is verified by simulation experiments below. Assuming that there are 30 video servers in the experimental space, each video server defines its own location and its adjacent nodes and other attributes, so that each computer can be used as a multi-video server for path-building simulation experiments.

In the specific link of the experiment, many methods can be applied to such single robot planning problems, such as breadth-first, depth-first, A\* algorithm, recursive optimal search, search algorithm based on various learning, and so on. The breadth-first search has the characteristic that the optimal solution can be found as long as there is a solution to the problem. This search method checks all adjacent points before further visiting other vertices. Its disadvantage is low efficiency. Because of the small number of video servers in the workspace, breadth-first search is suitable for this kind of situation, so breadth-first search is adopted. The process of robot path establishment is also the process of service requirement sequence establishment. For multi-robots, when moving and working in the same workspace, the paths searched by the robots themselves often cross, this inevitably leads to resource competition and inefficient task execution. Especially when the number of robots and nodes increases, the optimal path of each robot will not be the global optimal path, which requires the path optimization.

## 4 Discussion

### 4.1 Visual Display of Data

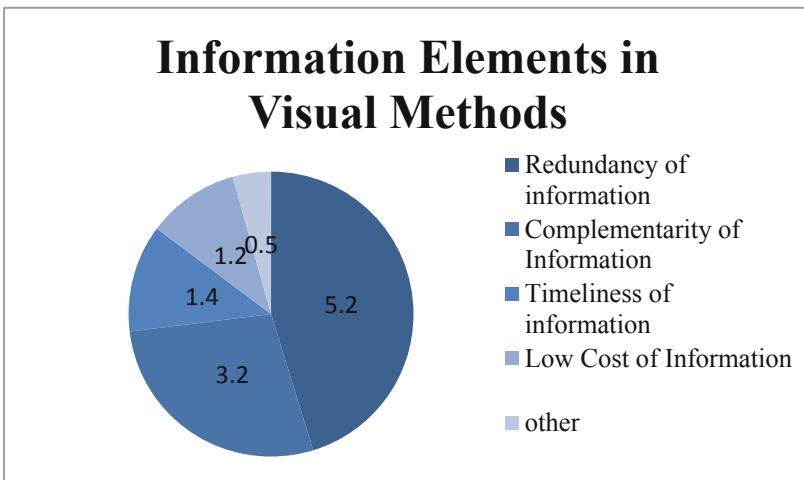
The validity of the method is verified by simulation experiments. Assuming that there are 30 video servers in the experimental space, each video server defines its own location and its adjacent nodes and other attributes, so that each computer can be used as a multi-video server for path-building simulation experiments (Table 1).

**Table 1.** Establishment of path statistics

Number of experimental groups	Video server number	Available number	Unavailable number	Available ratio	Shortest path (step)	Failure number
1	30	30	0	100	2.86	0
2	30	25	5	83.3	3.02	0
3	30	20	10	66.7	3.27	3
4	30	15	15	50.0	3.61	8
5	30	10	20	33.3	3.25	11
6	30	5	25	16.7	0	15

### 4.2 Analysis and Discussion

The visual sharing technology of network robots cannot be separated from the correct processing of information. Only by fully grasping the characteristics of the current methods, can we improve the performance better. The redundancy of visual information is that information obtained by multiple sensors (or at different times of a single sensor) can be used to describe the same characteristics of the environment. This information is redundant and has different reliability. Through the fusion processing of this information, more accurate and reliable information can be extracted. Visual information is complementary. Different kinds of sensors can provide different kinds of information for the system. The objects described by these information are different environmental characteristics, and they are complementary to each other. If a coordinate space composed of all features is defined, the information provided by each sensor belongs to only one subspace of the whole space, and the space formed by other sensors is independent of each other. Timeliness of visual information processing. In multi-sensor fusion system, the processing of each sensor is independent. The whole processing process can adopt parallel processing mechanism, so that the system has faster processing speed and can provide more timely processing results. The low cost of visual information processing. Multiple sensors can get the same amount of information as a single sensor at less cost. On the other hand, multi-sensor fusion system can reduce costs and improve the overall performance of the system (Fig. 1).



**Fig. 1.** Information elements in the visual method

## 5 Conclusion

This study shows that in today's world, the speed of information technology has been rapidly improved, and the role of big data technology is becoming increasingly prominent. With the development of science and technology, robots are evolving from scratch, from low-level systems to high-level systems. The future of intelligent robots is towards intelligent and emotional development, and finally to achieve the goal of human-computer coexistence. There are many future directions for the development of robots, such as highly intelligent emotional robots, network robots and so on. At present, the international manufacturing center is transferring to China. It has become the only way for China's industrial development to use information technology to drive industrialization and transform traditional industries with high and new technologies. As a typical representative of advanced manufacturing equipment, industrial robots will have a large space for industrial development and broad market prospects. However, we should also note that foreign robotic giants have all flooded into China, and the market competition is becoming increasingly fierce, so the future development of China's robotics industry will not be smooth. China should draw lessons from Japan's successful practices in the development of robotics industry and formulate strategies and related policies for the development of robotics industry, which is the key to the success or failure of China's robotics industry.

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# Influence Analysis Model of Clean Energy Grid-Connected Generation to Transmission and Distribution Price

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**Abstract.** The transmission cost of clean energy power generation accounts for a large proportion, so it is very important to analyze it. Based on this, this paper firstly decomposes the cost and revenue of clean energy grid connection. Secondly, based on the cost-benefit decomposition, a quantitative analysis model of the impact of clean energy grid connection cost on the transmission and distribution price (TDP) is established under the framework of the TDP accounting model. Through this model, the grid connection cost of clean energy power plants in the user's TDP can be calculated, which can promote the establishment of a more equitable transmission and distribution cost sharing system.

**Keywords:** Clean energy · Grid connection cost · Transmission and distribution price · Cost sharing

## 1 Introduction

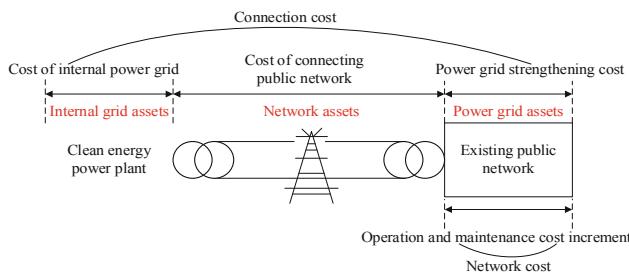
For a long time, clean energy power generation enterprises do not need to bear the cost of grid connection of clean energy [1, 2]. This will affect the healthy development of China's power market [3–5]. In the above context, it is urgent to clarify the grid connection cost for clean energy power plants in the user TDP, so as to promote the establishment of a fair transmission and distribution cost sharing system.

Based on this, this paper proposes a quantitative analysis model of the impact of clean energy grid connection cost on the TDP. Through this model, the grid connection cost of clean energy power plants in the user's TDP can be calculated, which can promote the establishment of a more equitable transmission and distribution cost sharing system.

## 2 Cost and Revenue Decomposition of Clean Energy Grid-Connected Generation

### 2.1 Cost Decomposition of Clean Energy Grid-Connected Generation

In a broad sense, the cost of clean energy grid-connected generation that power grid enterprises need to consider includes connection cost and network cost. Connection cost includes the cost of internal power grid, the cost of connecting public network and power grid strengthening cost. Network cost mainly refers to the increment of operation and maintenance cost of public network after clean energy power generation is connected to the grid [6, 7] (Fig. 1).



**Fig. 1.** Cost decomposition of clean energy grid-connected generation

#### (1) Connection cost of clean energy grid-connected generation

##### (1) The cost of internal power grid

This part of the cost is mainly composed of the construction investment cost and operation and maintenance cost of the internal grid of clean energy power plant.

##### (2) The cost of connecting public network

This cost is mainly composed of the project investment cost and the operation and maintenance cost of the clean energy power generation project connected to the public grid.

The cost of connecting the public network consists of two parts: one is the investment cost of step-up transformer near the clean energy power plant side, and the other is the investment cost of the line from the clean energy power plant to the public network. Therefore, the cost of connecting the public grid can be expressed as follows:

$$C_t^{\text{con}} = \sum_{m \in M} \sum_{i \in I} \left( P_{t,m,i} C_{t,m}^{\text{sub}} + L_{t,m,i} C_{t,m}^{\text{cab}} \right) \quad (1)$$

Where,  $t$  is the time scale variable of the year.  $m \in M$  is the voltage level variable,  $M$  is the voltage level classification set of the power grid,  $m$  subscript in the power grid side variable is  $m$  voltage level.  $i \in \{1, 2, \dots, I\}$  is the item number variable.  $C_t^{\text{con}}$  is the cost of connecting to the public network

for clean energy power plants.  $P_{t,m,i}$  is the installed capacity of clean energy grid connected project.  $C_{t,m}^{\text{sub}}$  is the unit investment of step-up substation at power plant side.  $L_{m,i}^t$  is the line length from clean energy power plant to public network.  $C_{t,m}^{\text{cab}}$  is the unit length investment of the line.

(3) Power grid strengthening cost

Power grid strengthening cost can be expressed as the cost of grid optimization and the cost of security improvement of the superior grid. The larger the installed capacity is, the higher power grid strengthening cost undertaken by the grid enterprise. Power grid strengthening cost can be expressed as:

$$C_t^{\text{int}} = \sum_{m \in M} \sum_{i \in I} P_{t,m,i} (C_t^{\text{netop}} + C_t^{\text{safe}}) \quad (2)$$

Where,  $C_t^{\text{netop}}$  is the unit optimization cost of grid structure,  $C_t^{\text{safe}}$  is the unit cost of safety improvement.

(2) Network cost of clean energy grid-connected generation

(1) Basic operation and maintenance cost of power grid

Because clean energy needs to occupy the stock of the public grid when it is connected to the public grid, the increase of the basic operation and maintenance cost of the grid caused by the connection of clean energy can be calculated.

$$C_t^{\text{om}} = \sum_{m \in M} \sum_{i \in I} O_{t,m} \frac{P_{t,m,i} T_{t,m,i}}{Q_{t,m}} \quad (3)$$

Where,  $C_t^{\text{om}}$  is the basic operation and maintenance cost of power grid caused by accessing clean energy.  $O_{t,m}$  is the operation and maintenance cost approved during the cost supervision of transmission and distribution electricity price.  $T_{t,m,i}$  is the utilization hours of clean energy power plants.  $Q_{t,m}$  is the total power transmission and distribution of this voltage level.

(2) Auxiliary service cost

Auxiliary service cost is composed of peak load regulation auxiliary service cost and standby auxiliary service cost.

$$C_t^{\text{anc}} = C_t^{\text{pit}} + C_t^{\text{sta}} \quad (4)$$

Where,  $C_t^{\text{anc}}$  represents the grid auxiliary service cost caused by clean energy grid connection.  $C_t^{\text{pit}}$  represents the auxiliary service cost of grid peak load regulation caused by clean energy grid connection.  $C_t^{\text{sta}}$  represents the standby auxiliary service cost caused by clean energy grid connection.

The cost of auxiliary services caused by the grid connection of clean energy is the difference between the auxiliary services provided by the system without access to clean energy (only for load) and the auxiliary services provided by access to clean energy (for load and clean energy).

$$C_t^{\text{pit}} = \left( C_t^{\text{pitnd}} - \sum_{s=1}^{8760} p_t^{\text{ak}} L_{t,s}^{\text{nd}} \right) - \left( C_t^{\text{pitld}} - \sum_{s=1}^{8760} p_t^{\text{ak}} L_{t,s}^{\text{ld}} \right) \quad (5)$$

Where,  $s$  is the year period number variable, the same below.  $C_t^{\text{pitnd}}$  is the auxiliary service cost of peak regulation caused by “net” load, which is the difference between the load curve and the output curve of clean energy power generation.  $p_t^{\text{ak}}$  is the benchmark feed in price corresponding to the peak load regulating unit.  $L_{t,s}^{\text{nd}}$  is the output of peaking unit caused by “net” load.  $C_t^{\text{pitld}}$  is the auxiliary service cost of peak load adjustment.  $L_{t,s}^{\text{ld}}$  is the output of peak load regulating unit caused by load.

By using the method of constant reliability, the corresponding reserve capacity of the power system after the clean energy is connected to the power system can be obtained, so as to calculate the reserve auxiliary service cost.

$$C_t^{\text{sta}} = \left( \sqrt{(\sigma_t^{\text{ld}})^2 + (\sigma_t^{\text{co}})^2} - \sigma_t^{\text{ld}} \right) \Phi^{-1} \left( 1 - \eta_{t-1}^{\text{lopl}} \right) (C_t^{\text{stain}} f_t + C_t^{\text{staov}}) \quad (6)$$

Where,  $\sigma_t^{\text{ld}}$  is the standard deviation of load forecast,  $\sigma_t^{\text{co}}$  is the standard deviation of clean energy output forecast,  $\Phi^{-1}$  is the inverse function of standard normal distribution function,  $\eta_{t-1}^{\text{lopl}}$  is the power shortage probability in the  $t-1$  year,  $C_t^{\text{stain}}$  is the unit cost of standby unit investment,  $f_t$  is the recovery sharing coefficient of standby unit investment, and  $C_t^{\text{staov}}$  is the unit operation and maintenance cost of standby unit.

### (3) Compensation cost of in-depth peak shaving service

The compensation cost of in-depth peak shaving service refers to the compensation according to the power limit when the power system cannot meet the demand of flexibility. According to the relevant documents issued by the national energy administration, this part of the compensation cost shall be borne by the grid enterprise.

$$C_t^{\text{dpit}} = \sum_{i \in I} \sum_{s=1}^{8760} p_t^{\text{dpit}} \Delta P_{t,i,s} \quad (7)$$

Where,  $C_t^{\text{dpit}}$  represents the compensation cost of deep peak shaving of clean energy,  $p_t^{\text{dpit}}$  represents the unit subsidy price of deep peak shaving of clean energy, and  $\Delta P_{t,i,s}$  represents the reduction of output of clean energy power plants.

## 2.2 Revenue Decomposition of Clean Energy Grid-Connected Generation

### (1) Income and calculation of increased power supply

After the clean energy is connected to the Internet, it will bring power supply revenue to the grid enterprises, which can be expressed as follows:

$$R_t^{ips} = p_t \sum_{m \in M} \sum_{i \in I} P_{t,m,i} T_{t,m,i} \quad (8)$$

Where,  $R_t^{ips}$  is the income from the clean energy supply increase, and  $p_{t,m}$  is the price of transmission and distribution.

## (2) Income from strengthening continuity of power grid

The improvement of power supply reliability mainly includes strengthening grid structure, eliminating potential safety hazards, strengthening distribution automation construction, etc. The direct economic benefit of this kind of project is the sum of the reduced outage loss and the reduced maintenance cost. The calculation formula is as follows:

$$R_t^{\text{int}} = \sum_{m \in M} \left( \Delta Q_{t,m}^{\text{bo}} p_{t,m} + \Delta C_{t,m}^{\text{ma}} \right) \frac{P_{t,m,i} T_{t,m,i}}{Q_{t,m}} \quad (9)$$

Where,  $R_t^{\text{int}}$  is the sustainable income brought by the grid strengthening project due to the grid connection of clean energy,  $\Delta Q_{t,m}^{\text{bo}}$  is the annual power outage loss reduction brought by the grid strengthening project, and  $\Delta C_{t,m}^{\text{ma}}$  is the annual failure maintenance cost reduction brought by the grid strengthening project.

## 3 Influence of Clean Energy Grid-Connected Generation on TDP

### 3.1 Influence Analysis of the Current TDP System in China

At present, the provincial power grid companies generally use the accounting cost method to calculate the TDP [8] (Fig. 2).

The permitted income of provincial grid companies can be expressed as follows:

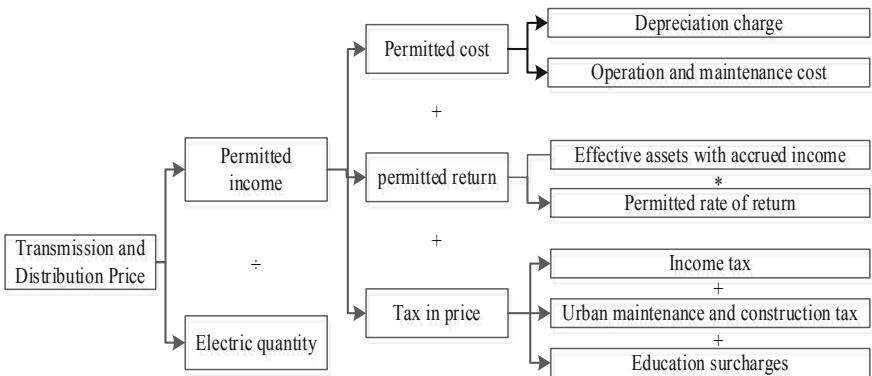
$$R_t = O_t + D_t + k_t A_t + T_t \quad (10)$$

Where,  $R_t$  represents permitted income,  $O_t$  represents depreciation charge,  $D_t$  represents operation and maintenance cost,  $A_t$  represents effective asset,  $k_t$  represents permitted rate of return, and  $T_t$  represents tax intra price.

### 3.2 Cost and Revenue Split of Clean Energy Grid-Connected Generation in Transmission and Distribution Cost

#### (1) Depreciation charge stripping of clean energy grid-connected generation

The depreciation charge reflects the consumption of fixed assets, which is condensed from the initial investment. The depreciation charge brought by clean



**Fig. 2.** Calculation model of electricity TDP

energy grid-connected generation can be determined by the ratio of its total amount to the total investment of grid. The calculation formula is as follows:

$$D_t^{\text{co}} = \frac{\sum_t^T (C_t^{\text{con}} + C_t^{\text{int}})}{\sum_t^T I_t} D_t \quad (11)$$

Where,  $D_t^{\text{co}}$  represents the depreciation cost of clean energy grid-connected generation.  $T$  is the annual set, and part of the years can be cut off for estimation, the same below.  $I_t$  is the total investment of power grid in year  $t$ .

- (2) Operation and maintenance costs stripping for clean energy grid-connected generation

The operation and maintenance cost of clean energy generation grid connection mainly considers the network cost of clean energy generation grid connection. Referring to the above, the operation and maintenance cost of public grid caused by clean energy generation grid connection can be obtained as follows:

$$O_t^{\text{co}} = C_t^{\text{om}} + C_t^{\text{anc}} + C_t^{\text{dpit}} \quad (12)$$

Where,  $O_t^{\text{co}}$  represents the operation and maintenance cost brought by clean energy grid-connected generation.

- (3) Permitted revenue stripping for clean energy grid-connected generation

In the calculation of transmission and distribution electricity price, the permitted revenue is the product of grid assets and the permitted revenue rate. Referring to the calculation method of depreciation cost, the permitted revenue brought by the grid connection of clean energy generation to the grid is obtained as follows:

$$R_t^{\text{co}} = \frac{\sum_t^T (C_t^{\text{con}} + C_t^{\text{int}})}{\sum_t^T I_t} k_t A_t \quad (13)$$

Where,  $R_t^{\text{co}}$  represents the permitted revenue brought by clean energy grid-connected generation.

### 3.3 The Influence of Clean Energy Grid-Connected Generation on TDP

Based on the ratio of stripping cost to the permitted revenue, the proportion of user side TDP can be calculated [9–11]. The calculation formula is as follows:

$$\alpha_t = \frac{D_t^{\text{co}} + O_t^{\text{co}} + R_t^{\text{co}}}{R_t} \quad (14)$$

Where,  $\alpha_t$  represents the proportion coefficient in the TDP of the user side.

## 4 Conclusions

Considering that the grid connected transmission cost of clean energy power generation accounts for a large proportion of the background, this paper conducts impact analysis of clean energy grid connected generation to TDP, and clarifies the status of grid connected cost of clean energy power plants in the user's TDP grid, so as to promote the establishment of a more equitable transmission and distribution cost sharing system.

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# Design of High Precision Frequency Meter Based on STM32H743

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**Abstract.** In engineering and experiment, it is often necessary to measure the frequency, period, duty cycle and other information of signal accurately. There are many kinds of measurement methods. In literature, the equal precision measurement method is proposed. Based on CPLD and MSP430 single chip microcomputer, the measurement of high frequency signal frequency is realized. In reference, a special chip tdc-gpx2 is used to measure the frequency of high frequency signal. In reference, the frequency measurement method of frequency shift filter is proposed, which realizes the measurement of frequency in power system and effectively removes interference.

**Keywords:** Cortex-M7 · STM32H743 · Pulse width measurement · PWM input mode

## 1 Introduction

In the conventional methods, either the hardware circuit design is complex, and it is impossible to use a microprocessor to measure the input signal, or the calculation is large, the software processing cost is high, and the accuracy cannot be guaranteed. In this paper, a new method of frequency measurement is proposed, which does not need complex hardware circuit [1–3]. Using high-performance embedded microprocessor stm32f743iit6, based on cortex-m7 architecture, it is a new high-performance ARM processor introduced by Italian French semiconductor, with the highest main frequency of 480 MHz.

## 2 Design

### 2.1 Principle

Tim8 is an advanced timer of stm32h743iit6, with the highest main frequency of 200 MHz. Besides timing and counting functions, tim8 also has the functions of input capture and output comparison [4–8]. PWM input is a special case of input capture, which can measure the duty cycle and period of input square wave. In input capture, first configure the input channel. Timer tim8 will capture IC1 and IC2 channels. When the rising edge is captured, the counter tim8 - CNT of tim8, the counter tim8 - CCR1 of IC1, and the counter tim8 - CCR2 of IC2 will be cleared at the same time, and the counting will be restarted. Tim8 - CNT automatically adds one to count in each timer

cycle. When IC2 captures the falling edge, the value of tim8 - CNT will be transmitted to Tim - CCR2 to obtain the width time value of the positive pulse width of the signal; when IC1 captures the rising edge again, the value of tim8 - CNT will be transmitted to tim8 - CCR2 to obtain the cycle value of the whole signal. At this time, the hardware will generate an interrupt, write the interrupt service program, and calculate the cycle and duty cycle. After completion, the counter tim8 - CNT, tim8 - CCR1 and tim8 - CCR2 will be cleared to prepare for the next measurement.

## 2.2 Code

First, initialize the serial port, LCD, timer, etc. After initializing the serial port, the baud rate is 115200, which transmits data with the computer. Initialize the 7-inch RGB LCD screen to display the measurement data. The timer tim8 is initialized to PWM input mode, and interrupt occurs when the rising edge is collected [9–11]. After initialization, wait for the rising edge of the input measurement signal. When the rising edge is captured, read the values of the counters tim8 - CNT, tim8 - CCR1 and tim8 - CCR2. When these values are not 0, calculate the duty cycle and period with the formulas (1), (2) and (3). Take the reciprocal of the period to get the frequency. These information can be sent to computer through serial port or displayed on LCD screen.

```
void TIM5_CH1_Cap_Init(u32 arr,u16 psc)
{
RCC->APB1LENR|=1<<3; //TIM5
RCC->AHB4ENR|=1<<0;
GPIO_Set(GPIOA,PIN0,GPIO_MODE_AF,GPIO_OTYPE_PP,GPIO_SPEED_MID,
GPIO_PUPD_PD);
GPIO_AF_Set(GPIOA,0,2); //PA0,AF2
TIM5->ARR=arr;
TIM5->PSC=psc; TIM5->CCMR1|=1<<0; //CC1S=01
TIM5->CCMR1|=0<<4; //IC1F=0000
TIM5->CCMR1|=0<<10; //IC1PS=00 TIM5->CCER|=0<<1; //CC1P=0
TIM5->CCER|=1<<0; //CC1E=1 TIM5->EGR=1<<0;
TIM5->DIER|=1<<1;
TIM5->DIER|=1<<0;
TIM5->CR1|=0x01;
MY_NVIC_Init(2,0,TIM5 IRQn,3)}
void TIM3_PWM_Init(u32 arr,u32 psc,u8 ch,u32 duty)
{
RCC->APB1LENR|=1<<1; //TIM3
RCC->AHB4ENR|=1<<2;
TIM3->ARR=arr;
switch(ch)
{
    case 1://PC6
GPIO_Set(GPIOC,PIN6,GPIO_MODE_AF,GPIO_OTYPE_PP,GPIO_SPEED_MID,
GPIO_PUPD_PU);
```

```
GPIO_AF_Set(GPIOC,6,2); //PB1,AF2
TIM3->CCMR1 |=7<<4; //OC1M[ 2:0 ]=bit[ 6:4 ] :
(Output compare 1 enable);
TIM3->CCMR1 |=1<<3;
TIM3->CCER |=1<<0; //OC4
TIM3->CCER |=1<<1; //OC4
TIM3->CR1 |=1<<7; //ARPE
TIM3->CR1 |=1<<0;
TIM3->CCR1=duty;
break;
case 2://PC7
GPIO_Set(GPIOC,PIN7,GPIO_MODE_AF,GPIO_OTYPE_PP,GPIO_SPEED_MID,
GPIO_PUPD_PU);
GPIO_AF_Set(GPIOC,7,2); //PB1,AF2
TIM3->CCMR1 |=7<<12;
TIM3->CCMR1 |=1<<11;
TIM3->CCER |=1<<4; //OC4
TIM3->CCER |=1<<5; //OC4
TIM3->CR1 |=1<<7; //ARPE
TIM3->CR1 |=1<<0; TIM3->CCR2=duty;
break;
case 3://PC8
GPIO_Set(GPIOC,PIN8,GPIO_MODE_AF,GPIO_OTYPE_PP,GPIO_SPEED_MID,
GPIO_PUPD_PU);
GPIO_AF_Set(GPIOC,8,2); //PB1,AF2
TIM3->CCMR2 |=7<<4; //CH3 PWM2
TIM3->CCMR2 |=1<<3; //CH4
TIM3->CCER |=1<<8; //OC4
TIM3->CCER |=1<<9; //OC4
TIM3->CR1 |=1<<7; //ARPE
TIM3->CR1 |=1<<0; //
TIM3->CCR3=duty;
break;
case 4://PC9
GPIO_Set(GPIOC,PIN9,GPIO_MODE_AF,GPIO_OTYPE_PP,GPIO_SPEED_MID,
GPIO_PUPD_PU);
GPIO_AF_Set(GPIOC,9,2); //PC9,AF2
TIM3->CCMR2 |=7<<12; //CH4 PWM2
TIM3->CCMR2 |=1<<11; //CH4
TIM3->CCER |=1<<12; //OC4
TIM3->CCER |=1<<13; //OC4
TIM3->CR1 |=1<<7; //ARPE
TIM3->CR1 |=1<<0; //
TIM3->CCR4=duty;
break;
```

```
}

}

void TIM5_IRQHandler(void)
{
u16 tsr;
tsr=TIM5->SR;
if((TIM5CH1_CAPTURE_STA&0X80)==0)    {
    LED0_Toggle;
    if(tsr&0X01)
    {
if(TIM5CH1_CAPTURE_STA&0X40)          {
if((TIM5CH1_CAPTURE_STA&0X3F)==0X3F)
    {
        TIM5CH1_CAPTURE_STA|=0X80;
        TIM5CH1_CAPTURE_VAL=0xFFFFFFFF;
    } else TIM5CH1_CAPTURE_STA++;
    }
}
    if(tsr&0x02) {
if(TIM5CH1_CAPTURE_STA&0X40)
    {
        TIM5CH1_CAPTURE_STA|=0X80;
        TIM5CH1_CAPTURE_VAL=TIM5->CCR1;
        TIM5->CCER=&~(1<<1); //CC1P=0
    } else {
        TIM5CH1_CAPTURE_STA=0;
        TIM5CH1_CAPTURE_VAL=0;
    }
    TIM5CH1_CAPTURE_STA|=0X40; TIM5->CR1=&~(1<<0) ; TIM5->CNT=0;
    TIM5->CCER|=1<<1; //CC1P=1
    TIM5->CCER|=1<<1; //CC1P=1 TIM5->CR1|=0x01; }
    }
}

if(TIM5CH1_CAPTURE_STA&0X80) {
temp=TIM5CH1_CAPTURE_STA&0X3F;
    temp*=0xFFFFFFFF;      temp+=TIM5CH1_CAPTURE_VAL;
    printf("HIGH:%lld us\r\n",temp);printf("Freq:%lld\r\n",1000000/
(temp*2));
    POINT_COLOR=RED;
Show_Str(0,260,200,16,"",16,0);
LCD_ShowNum(50,260,temp,4,16)LCD_ShowString(90,260,20,16,16,"us");
Show_Str(0+90+20,260,200,16,"",16,0);
    LCD_ShowNum(50+90+20,260,1000000/(temp*2),4,16);//
    LCD_ShowString(50+90+20+40,260,20,16,16,"Hz");
TIM5CH1_CAPTURE_STA=0; }
```

```

if (KEY0==0) pc6_pwm+=100;
if (KEY1==0) pc6_pwm-=100;
if (pc6_pwm<=100) pc6_pwm=1000;
TIM3->PSC=pc6_pwm;
TIM5->SR=0;
}

```

### 3 Conclusion

A new method for measuring frequency and duty cycle is proposed. The frequency of input square wave signal is measured by pulse width measurement. Due to the adoption of stm32h743iit6, the latest performance microprocessor of Italian French semiconductor company, the accuracy and range of frequency measurement are improved. The accuracy of frequency and duty cycle is as high as 99%, and the maximum square wave signal of 40 MHz can be measured.

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# Centrifugal Pump Impeller Health Diagnosis Based on Improved Particle Filter and BP Neural Network

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**Abstract.** This paper proposes an improved particle filter (PF) algorithm for the denoising of fault signals to reduce the impact of noise on the centrifugal pump impeller fault diagnosis. This method is combined with BP (back propagation) neural network to propose a trouble diagnosis method for impeller of centrifugal pump. Selecting the normal impeller and three centrifugal pumps with different fault impellers as experimental models. The improved PF algorithm is used to denoise the experimental data, then the principal component analysis (PCA) method is used for optimizing and selecting the eigenvalues. Finally, the constructed BP neural network model is used for fault identification. The accuracy of the model was verified by a four-fold cross test. In order to objectively compare the advantages of the proposed BP neural network diagnosis method based on improved PF. In this paper, the experimental results are compared with the experimental results of BP neural network based on traditional PF and particle swarm optimization particle filter (PSO-PF) algorithm. The experiment results indicate that the BP neural network diagnosis method based on the improved PF algorithm is effective for the centrifugal pump impeller fault diagnosis and has higher diagnostic accuracy. This method has certain significance for the research of centrifugal pump impeller fault diagnosis method.

**Keywords:** Fault diagnosis · Particle filter · Centrifugal pump · BP neural network · Principal component analysis

## 1 Introduction

Centrifugal pump is one of the essential equipments in industrial production and also plays an important role in the national economy. It is an important energy conversion and liquid transmission device. The impeller of the centrifugal pump is in direct contact with the fluid and the working environment is poor. In the long-term operation of the impeller, impeller wear, cavitation and other damage phenomena are most likely to occur. Once the impeller is damaged, the running time and life of the centrifugal pump are shortened, which may cause personal injury accidents or major economic losses [1]. It can be seen that the research on the fault diagnosis method of centrifugal pump impeller has important practical significance. Centrifugal pumps have a harsh working

environment and are often accompanied by abnormal vibrations and noise when the impeller fails. In order to accurately identify the fault type through the vibration signal, the signal needs to be effectively denoised to eliminate the interference of noise on the fault feature [2]. Particle filter algorithm is an effective algorithm for processing non-linear signals. It is widely applied to many fields such as fault diagnosis, navigation and positioning, wireless communication, robot positioning, visual tracking, etc., and has become a hot spot in research at home and abroad [3]. However, due to the structural problems of the algorithm itself, the algorithm has problems such as lack of particles and low computational efficiency. Combining intelligent algorithms and PF algorithms to optimize their structure is a hot topic at this stage. The combination of PSO algorithm and PF algorithm, the introduction of genetic mutation algorithm into the sampling process of PF algorithm is a typical representative of intelligent particle filter algorithm.

Principal Component Analysis (PCA) has a strong advantage in reducing the correlation between data dimensions and de-emphasis variables, and is often used to select feature variables. Liu et al. combined PCA analysis method and rough set theory to construct a new fault diagnosis method [4]. The simulation experiment of hydraulic pump fault model was carried out. The experimental results show that the accuracy of the diagnostic variables selected by the PCA after dimension reduction and decoupling is higher than that of the genetic algorithm, and the effectiveness and advantages of the diagnostic method are demonstrated. Li et al. combined a PCA algorithm with an oversampling algorithm to propose a fast oversampling PCA algorithm for the diagnosis and identification of PV array faults [5]. Experiments indicate that the method can effectively diagnose the shadow blocking and other faults of the PV array in a variable environment. BP neural network is a relatively mature technology, which has flexible network structure and strong nonlinear mapping ability. Therefore, it is widely used in pattern recognition, function approximation and state classification. Zhang et al. proposed a BP neural network prediction model using dynamically cuckoo search algorithm optimization to monitor industrial production equipment faults online [6]. Compared with traditional neural networks, the improved BP neural network has an optimal network structure, faster training convergence speed and higher precision.

In this paper, the PSO algorithm with variation operator is brought into the PF sampling process to form an improved PF algorithm, which effectively avoids the particle shortage of the algorithm and the single sample in the late sampling period, which improves the convergence speed and accuracy. The algorithm is used to denoise the vibration signals measured in the four impeller failure modes. The PCA algorithm is used for reducing and selecting the extracted time domain feature values, which greatly reduces the number of feature variables and reduces the burden of training and testing of the neural network. Finally, the BP neural network is used for identifying the fault, and the four-fold cross-validation is used for evaluating and verifying the diagnostic accuracy of the model. Therefore, a fault diagnosis method for the impeller damage of the centrifugal pump is formed.

## 2 Improved PF Algorithm

The essence of the particle filtering is based on the optimal Bayesian estimation of the Monte Carlo method [7]. The PSO algorithm with variation operation is led into the PF algorithms, and the sampling process of the PF algorithm is optimized by using the speedy and precise convergence function of the optimized PSO algorithms. All particles are moved to the optimal particle by the fitness value to ameliorate the scatter of the particle set. Therefore, the particle swarms are concentrated near the actual state, which improves the accuracy and efficiency of the filtering. The process is to introduce the newest observations into the PF sampling procedure and define the fitness function of the PSO algorithms as:

$$fit = \exp \left\{ -\frac{1}{2R_t} (Y_{new} - Y_{pred}) \right\} \quad (1)$$

Where  $R_t$  is the observed noise variance,  $Y_{new}$  and  $Y_{pred}$  are the latest and predicted observations.

The concrete step of the improved PF algorithm is:

Step 1: Initializing algorithm parameters.

At time  $k = 0$ ,  $\{x_0^i, i = 1, 2, \dots, N\}$  is sampled according to the  $P(x_0)$  distribution.

Initializing the number of groups  $N$ , Initializing the parameters of the PSO algorithm

Step 2: Optimizing the particle set sample distribution.

Using the improved particle swarm optimization algorithm to optimize the particle set in the previous step. When the termination condition of the particle swarm optimization algorithm is satisfied, then particle set  $\hat{x}_k^i$  is obtained. Otherwise return to the second step.

Step 3: Calculating the importance weight.

Sampling  $\{\hat{x}_k^i, i = 1, 2, \dots, N\}$  from  $q(x_k | x_{k-1}^i, y_k)$ . The calculation of the importance weight is:

$$\omega_k^i = \omega_{k-1}^i \frac{P(y_k | x_k^i) P(x_k^i | x_{k-1}^i)}{q(x_k^i | x_{k-1}^i, y_k)}, i = 1, 2, \dots, N \quad (2)$$

The weight normalization formula is:

$$\tilde{\omega}_k^i = \omega_k^i \sqrt{\sum_{i=1}^N \omega_k^i} \quad (3)$$

Step 4: Resampling.

According to the importance weight  $\tilde{\omega}_k^i$ , the new particle set  $\{x_0^i, i = 1, 2, \dots, N\}$  at time  $k$  is obtained by re-sampling from the set  $\{\hat{x}_k^i, i = 1, 2, \dots, N\}$ , and a new particle weight is obtained according to  $\omega_k^i = \tilde{\omega}_k^i = 1/N$ .

Step 5: Output.

Outputting state estimation sample set  $\{\tilde{x}_k^i, i = 1, 2, \dots, N\}$ , state estimation calculation formula is

$$\tilde{x}_k = \sum_{i=1}^N \omega_k^i \tilde{x}_k^i \quad (4)$$

### 3 Test System and BP Neural Network Diagnosis System

#### 3.1 Centrifugal Pump Experimental System

The Weir/Warman 3/2 CAH mud pump was used in the experiment. The model of the enclosed impeller was C2147. The impeller was 8.5 in in diameter and had 5 blades. The experiment was carried out by selecting the normal impeller S1 and three impellers S2, S3, and S4 with damage. The specific representation is shown in Table 1.

**Table 1.** Impeller failure mode

	Normal impeller	Edge damage impeller	Blade damage impeller	Perforation damage impeller
Symbol	S1	S2	S3	S4

In the experiment, the data acquisition system adopts SCXI signal conditioning system as shown in Fig. 5. The system contains 12 channels of signals, such as vibration signals, sound signals, temperature and pressure. Another Dell Inspiron 9200 laptop is used to store data. In the actual experiment, the sampling rate of the system is 9 kHz, and the sampling time is 20 s. Three three-axis vibration acceleration sensors were used in the experiment at the top of the pump, at the pump outlet, and at the top of the bearing. The working medium in this experiment was selected from clean water, and the experimental data of the four setting modes under the steady operation state of 2000 rpm were recorded respectively.

According to the Nyquist sampling analysis theorem, the upper limit of the analysis frequency is 1/2 of the sampling frequency (9000 Hz), that is, the upper limit frequency is 4500 Hz. In the experiment, the data acquisition time of each mode of the impeller was 20 s, and a total of 180,000 data points were obtained. In order to reduce the complexity of the processing and the better comparison later, the data points obtained by the four fault modes are directly denoised by the algorithm proposed in the previous section.

#### 3.2 PCA Basic Principle and Feature Value Selection

Feature extraction is the process of extracting valid information from signals. Appropriate methods and effective eigenvalues have a great impact on subsequent processing.

The vibration signal collected in this experiment is a time domain signal, which covers a large number of system status and fault information [8]. In this paper, 13 time-domain statistical indicators are extracted by time domain analysis of vibration signals. They are mean, rms, standard deviation, maximum, minimum, peak-to-peak, skewness coefficient, crest factor, kurtosis factor, margin factor, waveform indicator, kurtosis index, and pulse index. The reduction and decoupling of 13 characteristic variables are carried out by PCA, which speeds up the training and testing of BP neural network and increases the detection accuracy. The 180,000 noise-reduced data points of each state in the previous section were divided into 40 groups for analysis by a total of 4,500 data points, and a total of 160 groups were obtained. The PCA calculation principle assumes that the original data sample contains  $m$  n-dimensional feature vectors. In this paper,  $m = 13$ ,  $n = 160$ .

Due to limited space, this paper does not show the principal element contribution ratio graph and contribution table obtained after NPSO-PF, PSO-PF and PF de-noising. However, the results show that the signal after the NPSO-PF denoising treatment is analyzed by PCA to obtain the highest contribution rate of the first principal component is 99.38%, while the PF is the lowest. The cumulative contribution ratio of the first five principals is 100%. The results show that the NPSO-PF algorithm has the best noise reduction effect compared with PSO-PF and PF algorithms, and has the greatest impact on the subsequent PCA processing. The number of characteristic variables is also greatly reduced after PCA processing.

### 3.3 BP Neural Network Diagnosis System

BP neural network is a multi-layer feedforward neural network trained basic for the error back propagation algorithm, which is currently the most widely applied neural network [9]. A typical BP neural network is a forward network with no feedback or no intra-layer interconnect structure with three or more layers. BP neural networks generally use Sigmoid functions or linear functions as transfer functions.

The input layer neuron nodes amount should be the same as the number of observations of the input samples. The first five principal elements after the PCA analysis in the previous section include 100% of the feature information, so the input layer nodes amount is selected to be  $n = 5$ . Since the state mode of the four impellers is set, an amount of output layer nodes is  $m = 4$ . The formula for determining  $M$  of hidden layer nodes amount is as follows:

$$M = \sqrt{n+m} + a \quad (5)$$

Since  $a$  is a constant between [1, 9], taking  $m = 4$  and  $n = 5$  into Eq. (5) can find that the hidden layer neuron nodes of amount  $M$  is 4–12. From the 160 sets of sample data collected from the experiment, 40 groups were randomly selected as training samples. Only the neurons hidden layer nodes amount  $M$  is changed, and 40 sets of training samples are brought into the established network model space for training. The results are shown in Table 2.

**Table 2.** Network output error of different  $M$  values

M value	4	5	6	7	8	9	10	11	12
Training error	0.050	0.008	0.043	0.009	0.015	0.104	0.037	0.034	0.033

It can be seen from Table 2 that the network error is the smallest when the hidden layer nodes amount  $M = 5$ , so it is determined that the hidden layer nodes amount of the BP neural network system is 4. According to the four impeller states, the expected output of the centrifugal pump fault diagnosis system is shown in Table 3.

**Table 3.** Centrifugal pump fault diagnosis system expected output

Output layer node label	1	2	3	4
Normal status	1	0	0	0
Perforation damage state	0	1	0	0
Outer edge wear state	0	0	1	0
Blade wear state	0	0	0	1

The evaluation of the model in the verification data is commonly used for cross-validation, and the four-fold cross-validation is a kind of cross-validation [10]. The process consists of dividing the data into four parts, one for testing, and the remaining three for training the neural network. The precision of the verification is the average of the accuracy of each verification. In this paper, after denoising by three denoising algorithms, the 160 sets of sample data optimized by PCA are randomly divided into 4 parts, which are taken into the BP neural network constructed above for 4 fold cross-validation, and verified by NPSO-PF denoising. The verification results of the three algorithms after denoising are shown in Table 4.

**Table 4.** Comparison of verification results after denoising by three algorithms

Mode	Accuracy				
	First verification	Second verification	Third verification	Fourth verification	Diagnostic accuracy
NPSO-PF-BP	100%	100%	97.5%	100%	99.375%
PSO-PF-BP	100%	97.5%	95%	100%	98.125%
PF-BP	95%	92.5%	90%	100%	94.375%

The experimental results show that the vibration signals obtained by the test are denoised by NPSO-PF, PSO-PF and PF, and then brought into the PCA and PB neural network models. The three modes are used to diagnose the centrifugal pump impeller. The diagnostic accuracy is over 90%, indicating that the proposed centrifugal pump impeller fault diagnosis method is effective. The diagnostic accuracy of NPSO-PF-BP

mode is as high as 99.375%, which is 94.375% compared with traditional particle filter. It shows that the combination of the proposed algorithm and the constructed PCA-BP neural network model is more suitable for the diagnosis of centrifugal pump impeller failure.

## 4 Conclusion

In this paper, an improved PF noise reduction algorithm is proposed for the vibration signal with a lot of noise generated when the centrifugal pump impeller fails. The effectiveness of the denoising algorithm is proved by simulation experiments and set centrifugal pump failure experiments. And combined with principal component analysis and BP neural network, a centrifugal pump impeller fault diagnosis method is proposed. Through the set centrifugal pump failure experiment, the BP neural network diagnosis mode based on the improved particle filter algorithm is proved, which has higher diagnostic accuracy and is more suitable for the diagnosis of centrifugal pump impeller failure.

**Acknowledgement.** This work was supported by the Special Major Project of the Ministry of Science and Technology of Hubei Province of China (Grant No. 2016AAA056), Major project of Hubei Provincial Department of Education (Z20101501) and the National Natural Science Foundation of China (Grant 51775390).

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# Simulation Analysis of Self-balancing Chassis Based on ADMAS Software

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**Abstract.** Research and analysis a self-balancing obstacle-crossing vehicle to walk on unstructured and complex ground. In this paper, the overall design scheme is analyzed, and the innovative points of the design research are put forward. The mechanical structure of self-balancing obstacle-crossing chassis was designed, modeled and assembled by using CATIA three-dimensional drawing software. The results of the final datas show that the strength and stiffness of the model design system meet the requirements of static design. The simulation results of ADAMS show that the maximum obstacle-crossing height is 210 mm and the maximum swing angle of swing arm is 37.2°, which verifies that the data designed in this paper meets the original design requirements.

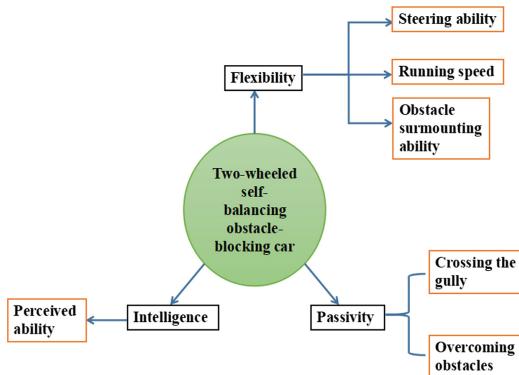
**Keywords:** Self-balancing · Obstacle surmounting · Finite element analysis · ADAMS · Simulation analysis

## 1 Introduction

The production of the two-wheel self-balancing car is the improvement of the technological level of the times and the development trend in the future. It is a convenient and quick tool for walking. It is also a subject that researchers are trying to study now. The self-balancing trolley combines technologies in many fields such as machinery, sensors, and intelligence. On this basis, the project must achieve the ability to overcome obstacles, so that the self-balancing trolley can walk on the unstructured and complicated ground, and it needs to have certain obstacle-obstacle ability. The following is a detailed study of the function of the self-balancing obstacle-obstructing chassis [1–3], as shown in Fig. 1.

Self-balancing trolley design concept: the utility model has the advantages of small volume, good portability, stable system operation and convenient operation, and more importantly, pure electric power is beneficial to the green ecological environment. This topic is based on the basic functions and design requirements of the self-balancing trolley. In order to achieve the goal of the obstacle-obscuring function, the combination of the foot-moving method and the wheel-type moving method-wheel-leg movement is adopted. This mobile solution has strong adaptability to complex road environment, and has the advantages of high efficiency, high speed and low energy consumption.

For the two-wheel self-balancing obstacle-obstructing chassis mechanical structure designed and studied in this project, the following major innovations are summarized:



**Fig. 1.** Functional planning diagram of self-balancing obstacle-crossing chassis

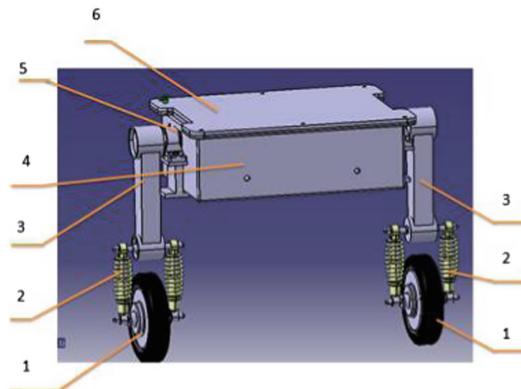
- (1) In this project, the two swing arms are independently driven by a stepper motor. Imitating the walking mode of the robot, the two swing arms can move freely in the alternate step mode, while ensuring the stability of the vehicle posture and enhancing the flexibility of the overall movement.
- (2) Adopting wheel-leg movement, The chassis can overcome obstacles of a certain height, greatly enhancing the passage of the trolley and expanding the application range.
- (3) The use of damping device, not only can greatly improve vehicle comfort, but also extend the life of the car.

## 2 Mechanical System Design

The three-dimensional model of the chassis of the self-balancing obstacle-barrier is developed and designed using CATIA software [4–6], as shown in Fig. 2. It is mainly composed of wheel, spring damping device, swing arm, box, bearing seat, bearing plate, etc.

The working principle of this project car is as follows: the body part is composed of a bearing plate 6 and a box 4, in which two motors, sensors, gyroscopes, mainboards and vehicle batteries driving the swing arm are fixedly installed. The bearing housing and the connecting frame are connected with the box body and the swing arm to ensure that the trolley runs smoothly during the movement, and does not fall back and forth. The drive wheel uses a hub motor, and the swing arm and the spring damper are driven by a small DC motor, so that the lower half is driven to raise a certain height, thereby achieving the obstacle-blocking capability.

The specific parameters of the self-balancing obstacle-obstructing chassis of this project are as follows:  $500 \text{ mm} \leq \text{car width (left and right distance)} \leq 700 \text{ mm}$ ;  $300 \text{ mm} \leq \text{Car length (front and rear distance)} \leq 400 \text{ mm}$ ; Height of chassis box from the ground  $\leq 800 \text{ mm}$ ; Vehicle weight  $\leq 35 \text{ kg}$ ; The maximum load is 100 kg;



1. Wheel 2. Spring damping device 3. Swing arm 4. Box 5. Bearing seat  
6. Bearing plate

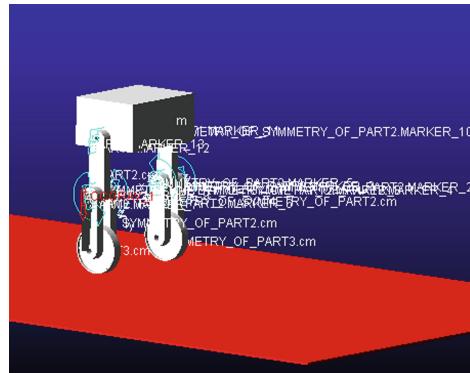
**Fig. 2.** Three-dimensional mechanical design of self-balancing obstacle-crossing chassis

The maximum swing angle of the swing arm is  $35^0$ ; The maximum obstacle crossing height is 210 mm; The average speed is 15 km/h; The highest speed car is 20 km/h.

### 3 ADMAS Simulation Analysis

First, simplify the vehicle model. The spring damping device of the original three-dimensional model chassis can be directly simplified as a connecting rod structure, which can reduce the difficulty of modeling and improve the accuracy of simulation analysis with the main parameters and motion characteristics unchanged. Then, the assembly model and part design of the CATIA software are used to build a simplified model of the whole vehicle and saved in the format of “CAT Product.”. Then open its CATIA product in Creo1.0 and save it as “x\_t” format so that it can be edited in ADAMS. Create a new model “model-1” in ADAMS, click “import” in the file drop-down menu to import the components of the “x\_t” format that have been built in Creo1.0, ADAMS will automatically determine the position of each component in a new window according to the assembled position in Creo1.0. Add the quality of each component and set constraints, as shown in Fig. 3.

Before the ADAMS motion simulation, the step function is called and interpolated according to the function of each corner in the above [7–12]. Give the relationship between the obstacle joint, the corner and time, and give the following data:



**Fig. 3.** ADAMS setup completion effect diagram

- (1) Pitch motion at the joint of the right leg.

$$\begin{aligned} & STEP(time, 0, 0, 1, od) + STEP(time, 1, 0, 2, 45d) + STEP(time, 2, 0, 3, -20d) + STEP(time, 3, 0, 4, 0d) \\ & + STEP(time, 4, 0, 5, -25d) + STEP(time, 5, 0, 6, 30d) + STEP(time, 6, 0, 7, 0d) + STEP(time, 7, 0, 8, 15d) \\ & + STEP(time, 8, 0, 9, -20d) + STEP(time, 9, 0, 10, 0d) + STEP(time, 10, 0, 11, 0d) + STEP(time, 11, 0, 12, 0d) \end{aligned}$$

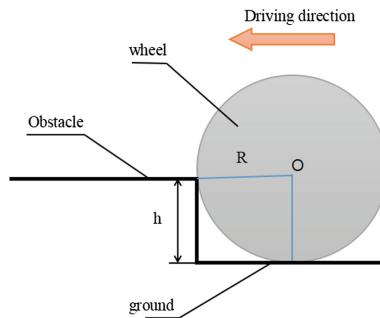
- (2) Pitch motion at the joint of the left leg.

$$STEP(time, 0, 0, 1, 0d) + STEP(time, 1, 0, 2, 0d) + STEP(time, 2, 0, 3, 0d) + STEP(time, 3, 0, 4, 0d) + \\ STEP(time, 4, 0, 5, 50d) + STEP(time, 5, 0, 6, -35d) + STEP(time, 6, 0, 7, 15d) + STEP(time, 7, 0, 8, -5d) + \\ STEP(time, 8, 0, 9, 20d) + STEP(time, 9, 0, 10, 0d) + STEP(time, 10, 0, 11, 0d) + STEP(time, 11, 0, 12, 0d)$$

The simulation analysis is based on the obstacle-obstacle system of the two-wheel self-balancing obstacle-obstacle chassis, and analyzes the movement and stress of each component of the vehicle when the obstacle is overcome. Adding an excitation to the foot wheel, simulating the vehicle with the beating of the wheel, passing obstacles and pits at a speed of 8 km/h. The height of the obstacle is 180 mm, 210 mm and the pit is -180 mm, -210 mm. There are two main situations in the whole simulation process: the vehicle is stationary and the wheel is obstructed. Since the simulation is an excitation of adding a point motion to the wheel, the excitation is a simple harmonic excitation, so the frequency of the excitation is required. The excitation frequency solving process is as follows:

Assuming that the vehicle wheel radius is  $R$ , the obstacle with a height  $h$  is crossed at a speed of  $v$ , as shown in Fig. 4. Since the vehicle speed  $v = 8 \text{ km/h} = 2.22 \text{ m/s}$ , the wheel radius  $R = 0.18 \text{ m}$ , the wheel speed  $= v/R = 12.49 \text{ rad/s}$ . When  $h = 180 \text{ mm}/210 \text{ mm}$ , the wheel can be obtained from the obstacles to the obstacles. The angles of the wheels are:

$x = 0.479 \text{ rad}/0.589 \text{ rad}$ ; Then the time required for the wheel to encounter obstacles above the obstacle is  $T/2 = 0.038 \text{ s}/0.047 \text{ s}$ ; Therefore, the period of the wheel crossing the obstacle is  $T = 0.076 \text{ s}, 0.094 \text{ s}$ ; Because there are  $2\pi/T = 26.32 \text{ pi}$ ,



**Fig. 4.** Schematic diagram of wheel obstacle crossing

21.28 pi; to simplify the excitation function expression, take  $2\pi/T = 26\pi$ , 22 pi; Therefore, the vehicle's excitation expressions over 180 mm and 210 mm can be expressed as:

Excitation expression spanning 180 mm bulge:

$$Y_1 = 10 \sin(26\pi t - 0.5\pi) + 10 \quad (1)$$

Excitation expression spanning 210 mm bulge:

$$Y_2 = 15 \sin(26\pi t - 0.5\pi) + 15 \quad (2)$$

In order to facilitate the simulation analysis, it is assumed that the vehicle passes through the process of the concave pit for the reverse process of the vehicle passing the obstacle. That is to say, the excitation expression of the vehicle crossing the pit with -180 mm and -210 mm is as follows:

Expression of pit excitation across - 180 mm depression:

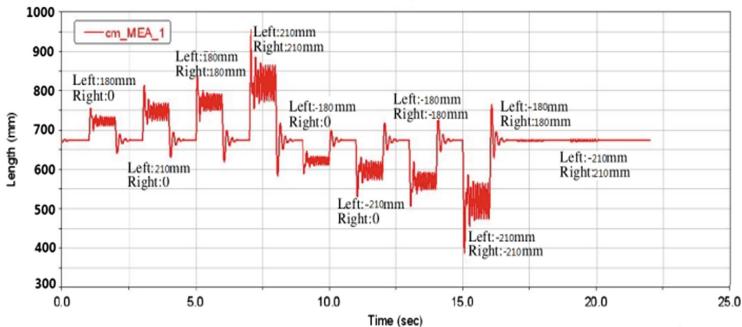
$$Y_3 = 10 \sin(26\pi t + 0.5\pi) - 10 \quad (3)$$

Expression of pit excitation across - 210 mm depression:

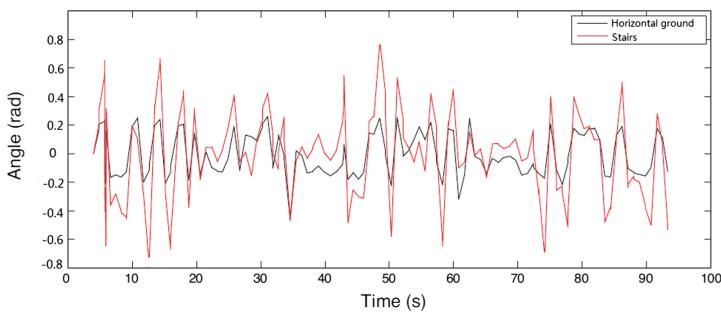
$$Y_4 = 15 \sin(26\pi t + 0.5\pi) - 15 \quad (4)$$

Because the wheel runout duration in the expression is 21 s, according to the above calculation, the minimum period of wheel excitation is 0.076 s. In order to get more accurate simulation data, the simulation step is set to 0.05 s, That is to say, the simulation time of the ADAMS software is set to 21 s, the step size is 0.05 s, and the simulation is started. The obtained data and its analysis are as follows (Fig. 5):

As shown in Fig. 6 below, it can be concluded that the swing angle of the swing arm when the self-balancing obstacle chassis walks on the horizontal ground and over the obstacle can be obtained, and the maximum swing curvature of the swing arm is



**Fig. 5.** The curve of vertical displacement of body mass center with time



**Fig. 6.** Variation curve of tilt angle of left (right) swing arm in different walking States

0.65 rad, which is converted into an angle of  $37.2^\circ$ . The maximum chassis angle of the car chassis designed by the subject is  $35^\circ$ . In summary, the experimental simulation results are in full compliance with the requirements of the motion variation law of the self-balancing obstacle-obstacle chassis study.

## 4 Conclusion

- (1) the characteristics of the traditional self balancing vehicle are analyzed, the design scheme of the self balancing obstacle crossing chassis is determined, and the three-dimensional model of the self balancing obstacle crossing chassis is established.
- (2) The results of ADMAS simulation results show that the maximum obstacle height is 210 mm and the maximum swing angle of the swing arm is  $37.2^\circ$ , which verifies the accuracy and rationality of the data results designed by this project.

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# Modeling Analysis and Simulation Research of Spring-Return Plunger Pump Based on AMESim

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**Abstract.** In this paper, the spring-resetting axial piston pump is taken as the main body of the research. Firstly, the working principle of spring-reset axial piston pump is analyzed, on the basis of theoretical analysis, constructed by hydraulic analysis software AMESim spring return type axial plunger pump, mechanical transmission volume change and flow simulation model, the three parts to spring return of plunger pump simulation model is established, and reveal the value of plunger vice dynamic circumstances has carried on the simulation analysis, at the same time set up working circuit, pump flow pressure value under different speed is discussed. The problem of low test data and high test cost is solved effectively.

**Keywords:** Plunger pump · Digital model · AMESim · Leak

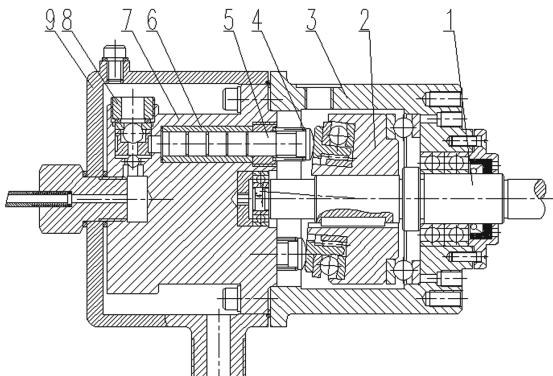
## 1 Introduction

Spring return axial piston pump is more economic power components in high pressure hydraulic system, but its hydraulic components as a single, in the actual hydraulic simulation system is difficult to get the detailed characteristics of the internal parameters and performance analysis, so the master spring return type axial piston pump under different conditions of work performance, the study of high pressure and ultrahigh pressure hydraulic technology and application has important practical significance [1–3].

## 2 Spring - Reset Plunger Pump Operating Principle

As shown in Fig. 1, the structure of spring-resetting axial piston pump is mainly composed of transmission shaft 1, swash plate assembly 2, pump shell 3, resetting spring 4, plunger 5, plunger sleeve 6, cylinder 7, distribution valve assembly 8, oil collector 9 and other components. The spring-resetting axial piston pump can be divided into rotary part, volume change part and flow distribution part according to its functions [4]. The three parts work together to ensure the stable operation of the whole system. Its basic working principle is: the plunger fits tightly to the swash plate under the action of the reset spring, when the drive shaft drives the oblique rotation, because

the change of bevel Angle between the drive shaft and the axis of the swash plate forces the plunger to make reciprocating movement in the plunger cavity of the cylinder block, thus forming a plunger reciprocating motion in the process of the change of the cavity sealing work volume, completed the continuous oil suction and drainage circulation between the oil inlet valve and the oil outlet valve [5, 6].

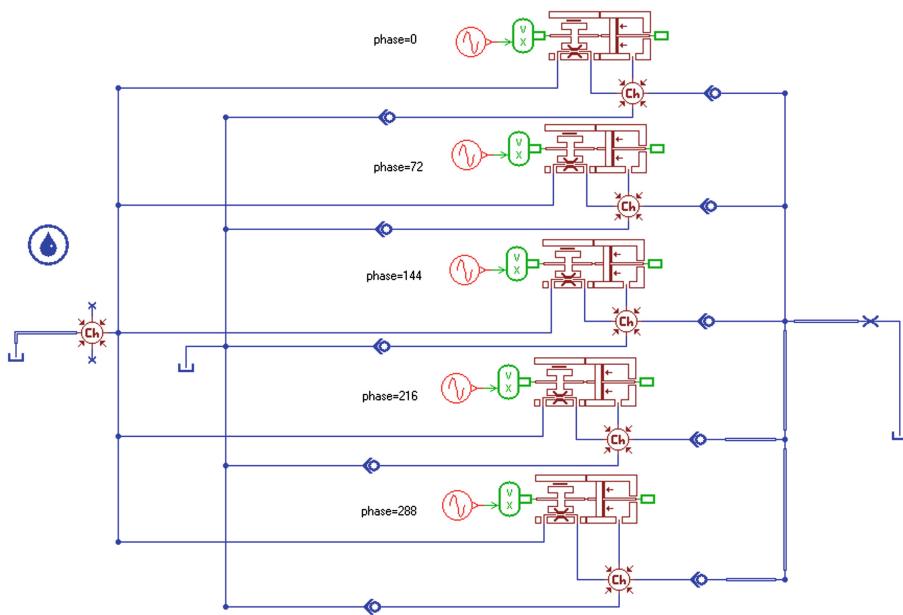


**Fig. 1.** Schematic diagram of the structure of the spring-reset axial piston pump

### 3 AMESim Simulation Model Establishment

Modeling of mechanical drive: in this paper, the signal01 icon in the AMESim control module is used to simulate the plunger movement, which is then transmitted to the plunger through the motion conversion module XVLC01 [7]. Modeling of volume change: the volume change module is composed of plunger cavity module, friction leakage module and cavity module [8]. Distribution part modeling: since the spring-reset plunger pump adopts valve distribution, the one-way valve in the AMESim hydraulic library is used to simulate the inlet valve and outlet valve of the pump [9].

The working circuit model of spring-reset plunger pump is shown in Fig. 2. It is mainly composed of control module signal01, motion conversion module XVLC01, volume leakage module baf1, plunger cavity module bap2, cavity module bhc1\_2, load throttle valve module flowcontrol01 and other icons. The simulation model is 5 plungers, which are distributed at intervals of 72°. Signal01, the control module, transfers the velocity value caused by different phase values and movement of the swashplate tilting to the motion conversion module, and the motion conversion module XVLC01 transmits the speed value and displacement value to the plunger, thus resulting in the change of the plunger chamber volume to realize the oil absorption and oil discharge of the plunger pump. The spring-reset plunger pump model, check valve, throttle valve and other models constitute the hydraulic system circuit. By adjusting the size of the throttle valve port, it can simulate the change of the hydraulic system load and establish the pressure of the system.



**Fig. 2.** Modeling model of spring-reset plunger pump

Through the above analysis and the established analysis model, we defined the parameter values of different icon modules. The main component parameters set according to the actual situation are shown in Table 1.

**Table 1.** Main component parameters

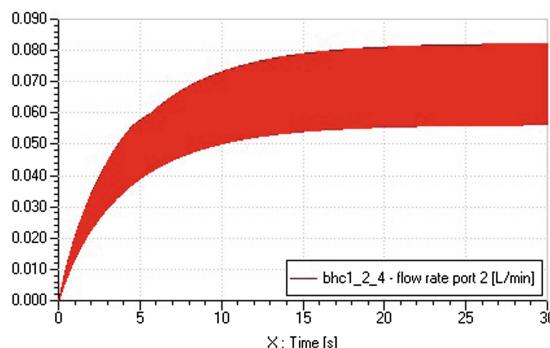
Parameter names	The parameter value	Parameter names	The parameter value
Frequency of motion function	25 Hz	Bulk elastic modulus of hydraulic oil	7000 bar
The phase angle of the motion function	phi	Kinematic viscosity of hydraulic oil	44.5 cp
Plunger diameter	12 mm	Gas viscosity	0.02 cP
Leak module gap height	0.04 mm	Gas content	0.1%
Leak module gap length	50 mm	Inlet check valve	5 L/min/bar
The oil temperature	40 °C	Outlet check valve	12 L/min/bar
Hydraulic oil density	875 kg/m <sup>3</sup>	Initial tank pressure	0.2 MPa

## 4 Simulation Analysis of Spring-Reset Plunger Pump

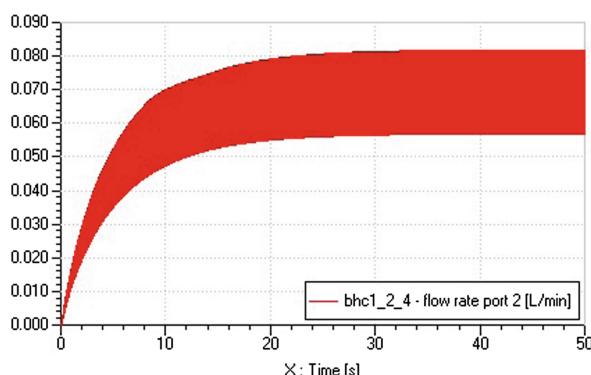
### 4.1 Leakage Analysis of Plunger Vice President

AMESim software to establish the research spring return in axial piston pump leakage model, can reflect the actual working situation axial plunger pump leakage change over time, depending on the software of the input parameters, we can learn at different axial plunger pump working system dynamic moment of internal leakage value, get the axial piston pump under different conditions of internal leakage [10].

As shown in Fig. 3, the spring-reset plunger pump has a load of 40 MPa and a speed of 1500 r/min. The leakage value in the plunger pair is stable between 0.056 L/min and 0.081 L/min, and the maximum value theoretically calculated is 0.082 L/min. As shown in Fig. 4, the leakage value in the plunger pair is stable between 0.0585 L/min and 0.082 L/min when the load constant speed is 1200 r/min, and the maximum value theoretically calculated is 0.082 L/min. A comprehensive comparison of the two figures shows that the movement velocity of the plunger has little effect on the leakage of the plunger vice President.



**Fig. 3.** Leakage flow curve of piston vice President at  $n = 1500$  r/min

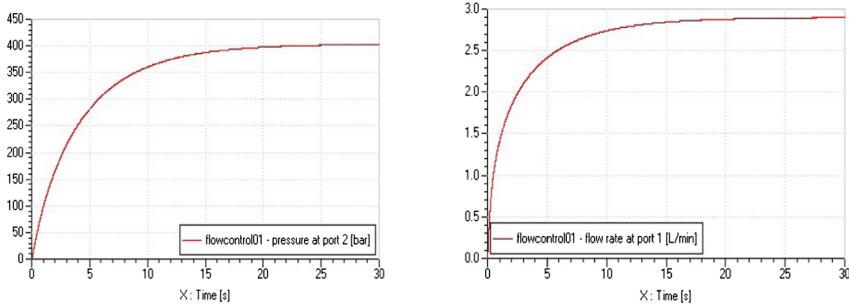


**Fig. 4.** Leakage flow curve of piston vice President at  $n = 1200$  r/min

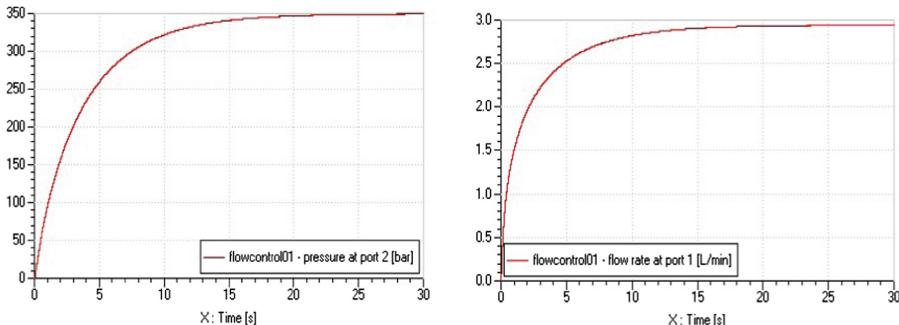
By using AMESim software in building the spring reset plunger pump circuit leakage module is added to model, can effectively simulate the plunger vice internal leakage, and the inner leakage simulation and equivalent concentric ring aperture leakage calculation of the leakage of basic consistent, so can use AMESim internal leakage of the pump plunger vice dynamic simulation, to guide the design and use of plunger pump. The leakage quantity of the plunger pump at each moment is expressed by the simulation curve.

#### 4.2 Analysis of Plunger Pump Pressure and Flow

As shown in Figs. 5 and 6, the pressure and flow at the pump outlet of the simulated spring-resetting plunger pump change with time under a rotating speed of 1500 r/min and a pressure of 40 MPa and 35 MPa.



**Fig. 5.** Pressure and flow time curves at 40 MPa



**Fig. 6.** Pressure and flow time curves at 35 MPa

As can be seen from the figure, when the pressure is 35 MPa, it takes 20 s for the plunger pump to rise from zero load to full load pressure. The actual outlet flow of the pump is 2.95 L/min, while the no-load flow of the pump is 3.23 L/min. Therefore, the volume efficiency of the pump is 91.3%. Pressure of 40 mpa, plunger pump from zero

load to full load pressure to 25 s, the real export flow pump was 2.9 L/min, and the theory of the pump flow rate was 3.23 L/min, by calculation, whether the volumetric efficiency of pump was 90%, that when the spring return plunger pump reaches ultrahigh pressure stress at work, still can satisfy the requirement of the plunger pump high volumetric efficiency.

## 5 Summarizes

In this paper, through the hydraulic analysis software AMESim, the simulation model of the spring-reset plunger pump was built, and the leakage of the plunger vice President, the movement state of the plunger pump, the pressure and flow of the plunger pump were analyzed under different working conditions, providing strong data support for understanding the operation state of the spring-reset axial plunger pump.

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# Application Research of Business Rules Engine Management System Based on Drools

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**Abstract.** This paper describes the design of a business rules engine management system based on Drools. Through the visual encapsulation of Drools, users can use a way similar to natural language to describe the originally complex, complicated and professional rules, and through the abstract configuration of business objects and parameter objects, the system can meet the business requirements of different business scenarios. In the whole life cycle management of rules, parameter table and parameter data, the system supports users to control the change of data state through three-level approval mode, so that users can conveniently carry out the configuration and management of various data in the system. At the same time, the system will record each key operation log, in order to facilitate enterprises and institutions to carry out system audit.

**Keywords:** Rule engine · Drools · Rule entire life cycle

## 1 Introduction

With the rapid development of information technology, in the fast-paced life, the needs of users and the business needs of computers also change rapidly, making many enterprises forced to frequently modify various plans and measures of the unit, and the business logic involved in each department will also change accordingly [1].

In this case, the technical staff must quickly reflect the corresponding changes in business logic into the application system of the enterprise. The emergence of a business rules engine solves the problem of computer engineers.

The business rules engine describes the logic of the business application through simple and understandable rules language, It also separates the business logic and data objects of the application system in the form of a rule file, This allows software developers to separate complex business logic from applications [2].

The application system developed based on business rules engine has the following features: The business data is stored in the system's objects, but the business logic is described in the rules language and stored in the rules file of the system. When the

business requirements of the application system change. This architectural design allows software engineers to make only changes to the system's rules file. This frees engineers from modifying the system source code and maintaining a huge configuration item.

This paper describes the design of a business rules engine management system based on Drools.

A unified system is provided for users to normalize and standardize the configuration and management of rules of different businesses, so as to facilitate users to better monitor with the system, process data of business and hit data of rules.

## 2 Technology Is Introduced

Drools is a fast forward rule matching algorithm proposed by Charles Forgy in 1979 [3]. The core idea of RETE algorithm is to retain as much information as possible in the matching process, and then use space for time to improve the execution efficiency.

The Business rules engine adopts B/S development mode on the front end. At present, in the aspect of web front end technology, the dominant languages on the browser side are respectively HTML, CSS and Javascript.

The project chooses ThinkPHP framework as the framework of system development. The ThinkPHP framework provides developers with an easy to use and convenient application template, which greatly reduces the amount of coding effort for developers, and provides reserved modules for complex code to facilitate rapid development for technicians [4].

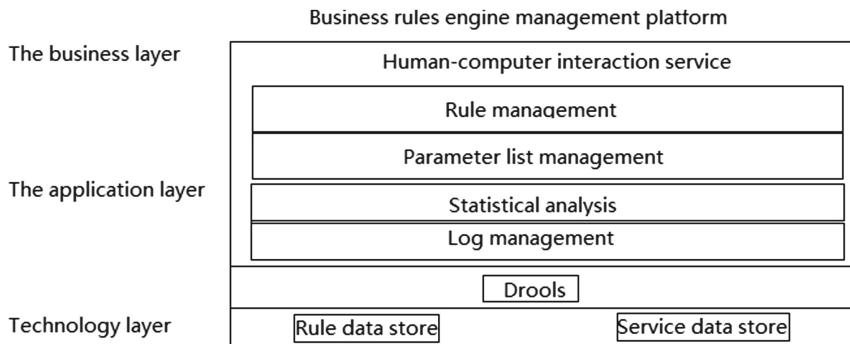
## 3 Analysis and Design of Management System

### 3.1 System Analysis

From the perspective of user demand, through investigation, we find that the business volume of various enterprises and institutions is constantly expanding, but many enterprises and institutions are also facing two difficult problems: First, how can enterprises and society respond to changes in different businesses quickly and conveniently? Second, how can companies and society effectively manage changes in business logic. Using a business rules engine has the following advantages: it separates business logic from complex code, reduces the workload and cycles of technicians, and improves the maintainability of business logic. With the continuous development of information technology, such a simple and convenient business rules engine has a good prospect.

On a technical level, JBoss Rules has shown great potential in its application at home and abroad. Not only is it an open source rules engine, but it's also fast and easy to use. Because of these advantages, our software based on Drools has become much easier and faster. In the application system, we adopted MongoDB, one of the most popular non-relational databases, and its excellent performance made MongoDB a common database.

Rule lifecycle processes include rule creation, editing, testing, rule enforcement, monitoring, and rule death. Including the whole rule engine as the core of the rule management system. With the help of the rules life-cycle control system and process, the ability of the rules engine system can be improved to provide a standardized platform for different business logic of different enterprises and institutions. Therefore, the system needs to be managed from rule creation to rule retirement, And before the rule takes effect, the user can verify the rule through a single test for syntax and simple logic. Batch testing can also be done with historical data to verify that the hit distribution of the rules is reasonable. The rule life cycle is divided into the following stages: rule creation, rule editing, rule single test, rule batch test, rule loading application, primary loading approval, secondary loading approval, rule operation monitoring, rule adjustment application, primary planting approval, secondary termination approval and rule termination. Aiming at the realization of each application of the system, according to the theory of computer, the platform is designed to reduce the coupling between the modules. See Fig. 1.



**Fig. 1.** System architecture diagram

The system is mainly divided into business data object, parameter table management, parameter data, monitoring and analysis, rule life cycle. Each module is independent and inseparable, and it depends on each other and works together to form the whole system.

### 3.2 Database Design

The E-R diagram is the entity connection diagram. It shows how entities, attributes, and entities are related to each other in a system. Because in the business rules engine system. The number of entities, the number of attributes per entity, is high, And the relationship is complicated, Therefore, this section describes the relative core E-R diagram in the system. See Fig. 2.

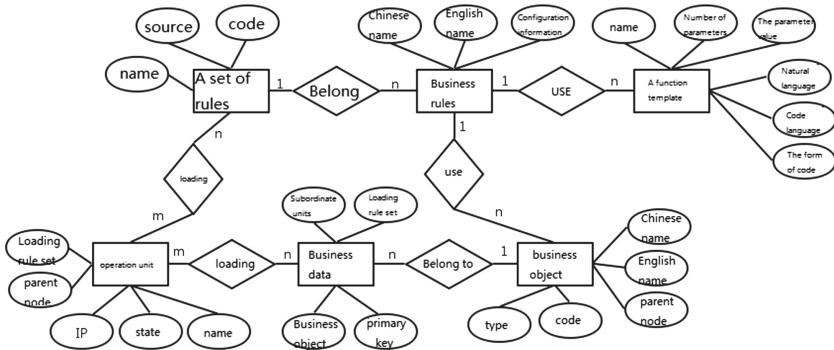


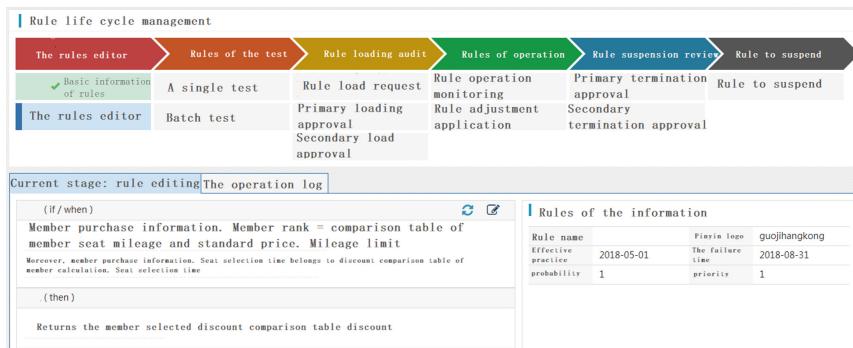
Fig. 2. E-R diagram

### 3.3 System Design

Business object management module should be provided for the processing of data to add objects and attributes of the object, as a business object management functions, we also should be for each business object and attributes of the object have add, delete, change, check operation, at the same time, we should also will object to generate Java code, and you can preview and download the Java code [5].

The business rules engine needs to convert business data objects into parameter objects, called parameter tables [6]. To better configure the rules engine, we should set up add, delete, change, check, and so on for each parameter table. In addition, in order to facilitate the authority management system of system data, it is necessary to realize the functions of the approval submission of parameter table in effect and failure, the approval of section chief and section chief, and the examination and approval log query [7].

By means of rules life cycle control system and process, improve the ability of rules engine system, so that it can provide a standardized platform for different business logic of different enterprises and institutions [8]. Therefore, the system manages the whole life cycle from rule creation to rule retirement, and before the rule takes effect, users can check the rule through single test for grammar and simple logic, and can also test the rule through historical data in batches to verify whether the rule's hit distribution is reasonable [9, 10]. The rule life cycle is divided into the following stages: rule creation, rule editing, rule single test, rule batch test, rule loading application, first-level loading approval, second-level loading approval, rule operation monitoring, rule adjustment application, first-level termination approval, second-level termination approval and rule termination. See Fig. 3.



**Fig. 3.** Rule life cycle management module implementation

## 4 Conclusion

This article describes the design process of a drools-based business rules engine management system, which provides users with a simple to understand and easy to use rule configuration function, and can manage the whole life cycle of rules.

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# Application of Self-service Analysis Tool for Data Management Application

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**Abstract.** With the advent of the era of big data, and the increasing application of big data technology, data has become one of the important assets of enterprises. Through data analysis, mining, and applications, the management level and economic benefits of the enterprise can be effectively improved. Big data management will bring challenges to the processing capabilities and data throughput of traditional database management systems and file management servers. In order to use big data more effectively and improve the science and timeliness of enterprise statistics, an application system can be constructed and rationalized. The research and development of a data management platform that supports unstructured data, faster and more accurate statistics, comprehensive management of structured data and unstructured data, is a very urgent and important task. Based on the existing self-service analysis tools, carry out research on data management, data sharing, and data application, build a professional data resource directory system, establish a hierarchical data authorization mechanism, promote data innovation and application, and create a set of data management, data sharing, and data analysis An integrated self-service analysis tool that comprehensively enhances cross-professional data sharing, integration and service capabilities, and gives full play to the value of data.

**Keywords:** Data management · Data openness · Data application · Self-service analysis

## 1 Introduction

In recent years, with the rapid development of big data-related technologies, the era of large-scale generation, sharing, and utilization of data has come. Data has become the basic national strategic resource, and big data has also risen to the national strategic level. As big data-related technologies and industries are maturing, in many cases, a single organization must perform multiple types of big data analysis work and large-capacity data storage functions at the same time [1–3]. Data will become an important strategic resource at the enterprise, social and national levels. Its detailed application will improve the level of business management, create new business models, and also promote the development of the national economy [4]. In recent years, the country has

proposed measures such as network power strategy, national big data strategy, and “Internet + Action Plan” to deeply integrate ICT and traditional industries and promote innovation in production methods and business models [5, 6]. Based on the requirements of the State Grid Corporation of China’s ubiquitous electric power IoT construction in 2019, this paper takes research on data management, data sharing, and data application based on existing self-service analysis tools based on strengthening unified data management.

In 2019, the “two sessions” of the State Grid Corporation of China (hereinafter referred to as the “State Grid Corporation of China”) put forward the strategic goal of “three types, two networks, and world-class”, and promoted the construction of the ubiquitous electric power Internet of Things as the focus of the current state grid company. In order to further solve the deficiencies in the overall construction and application of the State Grid Corporation’s system of Internet of Things in four aspects of enterprise operation, grid operation, emerging business and infrastructure, provincial grid companies use the grid as a hub to play a platform and sharing role. From the data level Starting from the dimensions of data management, open data sharing, and data application, carry out application research of various analytical tools, improve enterprise data services, application construction, and analytical computing support capabilities, form an ecosystem of cross-professional data sharing and sharing, and further deepen enterprise data The open application of resources fully taps the value of data assets and enhances the innovation and practical capabilities of grassroots units [7, 8].

China National Grid Co., Ltd. has always focused on data planning and construction, and has been committed to power informationization, smart substations, smart meters, online monitoring systems, online mobile maintenance systems, statistical measurement and control systems, and various occupations as information management systems have evolved, Is gradually evolving. Construction and application, the scale and diversity of power grid data are growing rapidly [9, 10]. Using these data to provide a scientific decision method for the development and operation control of the transmission grid is urgently necessary for the future development of the transmission grid, and it is strongly necessary to achieve self-healing, compatibility, economics, integration, and optimization of transmission The only method of network characteristics [11, 12].

## 2 Method

### 2.1 Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) is an analytical method that uses qualitative and quantitative methods to judge various influencing factors. It can solve complex decision-making problems hierarchically and systematically. For some influential factors that cannot be quantified, the metric values can be introduced through the judgment matrix given by the experts, and reasonable weights are assigned to each influential factor, which has the advantages of flexibility, simplicity, and systemicity.

The proposed analytic hierarchy process can well solve the problem that the evaluation index cannot be quantified, but in the process of analytic hierarchy process,

if there are too many evaluation indexes in a single layer, the scale of the judgment matrix will be too large, and the judgment of the judgment matrix Having consistency is more difficult when the matrix is too large. When there is a consistency problem in the judgment matrix that needs to be adjusted, the adjustment workload is relatively large and complicated, and it is difficult to ensure the consistency between the judgment matrix and human thinking. In order to solve this problem well, the fuzzy analytic hierarchy process is proposed by combining the advantages of fuzzy theory and analytic hierarchy process. The process of fuzzy AHP to solve the problem is basically the same as that of AHP, but it has made some optimizations in combination with fuzzy theory in constructing the judgment matrix and checking the consistency of the judgment matrix.

The fuzzy analytic hierarchy process has the advantages of consistent thinking when there are too many evaluation indicators and convenient adjustment when the judgment matrix is inconsistent. Therefore, the main data recognition model based on fuzzy analytic hierarchy process is selected in the railway main data recognition.

Aiming at solving the weights of fuzzy complementary judgment matrix, a general calculation formula is derived by derivation in this paper. The weight calculation formula omits many unimportant intermediate calculation links. It has the advantages of high efficiency, simplicity, and small calculation amount. It also has the characteristics of consistency and consistency based on the fuzzy consistency judgment matrix, and reasonably represents the weight of each evaluation index. Therefore, this formula is widely used in the practical solution of fuzzy complementary judgment matrix. The specific solution formula is as follows:

$$Z = \frac{\sum_{j=1}^n a_{ij} + \frac{n}{2} - 1}{n(n-1)}, (i = 1, 2, \dots, n) \quad (1)$$

According to the weighting formula (1), the weight vector of the fuzzy complementary matrix A can be solved. Setting the calculation result of the weight vector to  $Z = (Z_1, Z_2, \dots, Z_n)^T$  usually meets the formula (2).

$$\sum_i^n Z_i = 1, Z_i \geq 0 (i = 1, 2, \dots, n) \quad (2)$$

## 2.2 Self-service Analysis Tool Application

With the continuous expansion of the application scope and application depth of power grid big data technology, users in various departments and units have more extensive application requirements for cross-professional data, and have put forward higher requirements for data quality, availability, and ease of use.

The existing data management and data governance are more dependent on labor, and are carried out on demand in combination with business application requirements. The depth of research and application is insufficient, the degree of intelligence is low, and the consumption of resources and costs is high. In order to better adapt to the current development trend of the ubiquitous electric power IoT construction of State

Grid Corporation of China, an integrated, intelligent and easy-to-use self-service analysis tool can better meet the various data management and application needs of users at all levels of State Grid Corporation of China. Taking this as a starting point, this article has conducted in-depth research and discussion on how to build a self-service analysis tool that integrates data management, data sharing, and data analysis.

### 3 Experiment

Step1: Simple and easy-to-understand graphic visualization construction. When designing a data analysis tool, common chart styles are integrated. When visually designing, users only need to select the appropriate chart according to their needs, and complete the visual construction through chart dragging and data item configuration.

Step2: Intelligent data mining part. In order to allow non-professional technicians to also explore and apply data mining, the analysis tool integrates common big data algorithms and general models to streamline the model building process. Users need only have a preliminary understanding of the algorithm to quickly Complete the construction of the analysis model. In the model verification process, the user only needs to specify the input parameter range, the tool will automatically verify according to the parameter range, and finally output the results generated by different parameters, guiding the user to determine the input parameters of the analysis model based on the output results, reducing the difficulty of data mining.

Step3: Combining the requirements and development trends of the ubiquitous electric power IoT construction of the State Grid Corporation of China, through the application research of self-service analysis tools from multiple perspectives such as data management, data sharing, and data analysis, data management, data sharing, and data analysis capabilities for integration.

### 4 Discuss

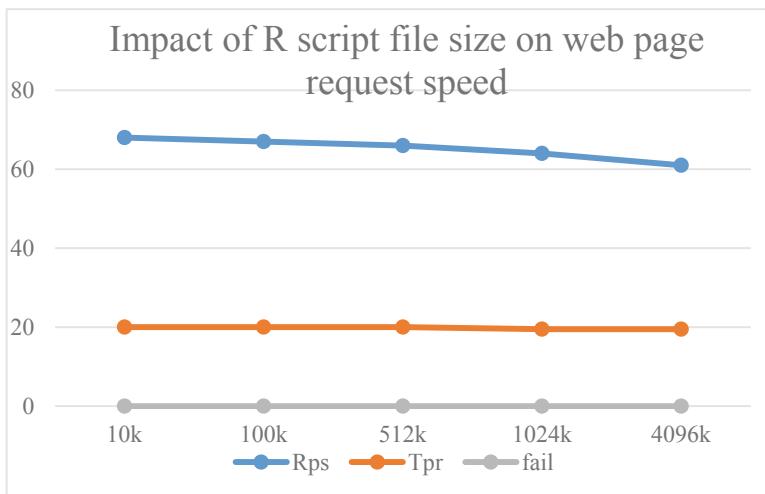
#### 4.1 Experimental Results and Analysis

In this section, the performance of the request page containing the R script and data analysis result graph for the data analysis module is shown in Table 1 from the performance of different request numbers. Where -c and -n are the parameters of the tool ab, -c is the number of requests, -n is the number of requests executed at the same time, Rps (Requests per second) throughput rate, the number of requests executed per second; Tpr (Time per request) users Average request wait time; Fail indicates the number of failed requests. It can be seen from 1 that when the number of concurrency is more than 10,000, the throughput rate will increase instead, which shows that the platform can handle high concurrency situations well.

In addition, this article also tested the number of requests based on the size of the requested R script file (10K–4M) (Fig. 1).

**Table 1.** Response schedules for different requests

Command parameter	-c 10 -n 1000	-c 30 -n 1000	-c 30 -n 3000	-c 30 -n 8000	-c 30 -n 12000	-c 30 -n 30000
Rps	14.97	17.28	17.96	17.42	71.87	17.93
Tpr	66.28	57.40	55.22	56.93	55.58	55.30
Fail	0	0	0	0	0	0

**Fig. 1.** The effect of R script file size on the speed of web page requests

## 4.2 Advantages of Self-service Analysis Tools for Data Management Applications

### (1) Integration

From the data level, the self-service analysis tools for data management applications run through the data management, governance, sharing, and application links, and realize the integration of data management, data sharing, and data applications. In terms of data management, it covers the entire process after data storage, which facilitates unified management of data and applications. In terms of data quality, an integrated self-service analysis tool can help users discover data quality problems from different perspectives, implement application-side governance, and gradually improve data quality. In terms of data sharing, it supports multi-dimensional authority management based on organizational structure, application scenarios, business systems, libraries, tables, columns, and rows. It can flexibly control the scope of data sharing and intuitively understand the application of data. In terms of data analysis, the integration of data analysis and mining has been achieved. With a tool, it not only solves the complex

problem of the visual construction process, but also reduces the entry threshold for data mining.

### (2) Intelligent

A self-service analysis tool for data management applications effectively solves the problem of difficult entry in data analysis mining. Integrating common and universal visualization charts, big data algorithms, and analysis models into dragable modules does not require users to have a deep understanding of the technology. It can infer the results and guide users to choose the appropriate algorithm model. The self-service analysis tool for data management applications is more user-friendly and intelligent from the perspective of users. Through the big data environment at the bottom of the tool, the efficiency of data processing and calculation has been greatly improved; through drag-and-drop configuration, users can easily and quickly build visual applications; through automatic verification of models, help users accurately select algorithms and models for intuitive understanding construction process of data analysis and mining. The traditional analysis tools have problems such as low data processing efficiency, complex visualization construction process, and high data mining technology requirements, which have been effectively solved by self-service analysis tools.

### (3) Convenient and easy to use

The most significant advantage of self-service analysis tools for data management applications is their ease of use. It is mainly reflected in two aspects:

The first is the convenience of the data analysis application construction process. Self-service analysis tools achieve data integration, data cleaning, data understanding, data exploration, data mining modeling, visual construction and other process integration and full coverage. Based on the data resource catalog, data is obtained and understood from a business perspective, and guided applications are used. Construction guides help users to complete each step of application construction easily and normatively.

The second is the ease of use of data analysis mining. The self-service analysis tool uses a drag-and-drop visual construction method and an intelligent data mining process, which simplifies the big data analysis and mining process. It no longer depends too much on professional skills, and is targeted at enterprise-level national users without coding. Guided, heuristic, and interactive operation modes further reduce the difficulty of tool use.

## 5 Conclusion

In summary, the self-service analysis tools for data management applications are accompanied by the widespread application of new technologies such as the “Big Cloud and Intelligent Mobile Chain”, the gradual advancement of the ubiquitous power IoT construction, and the large-scale surge in demand for big data analysis. Built to further meet user usage needs, it is a self-service intelligent analysis tool for enterprise users. It can play an important role in enterprise data management, data sharing and

data applications, and can effectively support the digital transformation of enterprises and the enhancement of the value of data assets.

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# Intelligent Pathfinding Algorithm in Web Games

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**Abstract.** In recent years, with the hardware development of the web game is getting better and better, the game graphics computing ratio decreased a lot, the traditional scene and picture effect obtained great development at the same time, players began to pay attention to the content of a video game, hope the game role behavior can more close to real people, which makes the game developers in the artificial intelligence to enhance investment in the game, and in game ai, the role of intelligent pathfinding system is always the key point of the research. Intelligent pathfinding algorithm plays A leading role in intelligent pathfinding system. At present, the most classic intelligent pathfinding algorithm used in video games is A\* (A-Star) algorithm. Many other excellent pathfinding algorithms are also developed from this algorithm. The purpose of this paper is to get rid of the limitation of having to use standard A\* algorithm functions to guide pathfinding so as to quickly find A shortest path in the map. In this paper, through A detailed study of the standard A\* algorithm, several optimization methods are proposed to improve it. Firstly, heuristic coefficients are added to the heuristic function of A\* algorithm to optimize the search for redundant paths in pathfinding process. Binary heap is used to maintain the open list in A\* algorithm. Then, the path weight in the map is optimized. The generated path is smoothed by “take the median insertion method”, and the A\* algorithm is further optimized by the zonal search method, so that it can be applied to A wider range of game map types. Finally, through the test of a simulation experiment program produced by Unity3D engine, the above methods are verified. The results of this paper show that after improving the standard intelligent pathfinding algorithm, pathfinding efficiency is higher, the range of use is wider, the player experience is better, and it can be applied in the game.

**Keywords:** Web games · Intelligent pathfinding · A-Star algorithm · Path weight

## 1 Introduction

Since the emergence of web games in the early 1960s, the web game industry has grown tremendously. Today's web games are rich in graphics, more realistic physics simulation engines, good interactivity and realistic artificial intelligence. With the rapid development of computers in today's society, web games have gradually been recognized by the society. Because of their strong interaction, they can make players feel

immersive. As an entertainment item that cannot be ignored in daily life, they have gradually become a special art form. The development of computer hardware mature, making the web game screen, the respect such as model gradually meet development bottleneck, and there is a great potential in the interactive with people, the status of artificial intelligence in the game more and more high, in the game “high intelligence”, the robot often seem to be very “smart” brings players high experience, let players feel is in and real biological interactions. The role in artificial intelligence of the game simulates the action of human, and can think simply like human, making the role in the game more intelligent. The research of game artificial intelligence should not only understand psychology, but also have enough computer knowledge, so that intelligence can be realized on the computer and other platforms. AI strategy, AI pathfinding system, AI tactical system and AI learning are common artificial intelligence in video games, among which AI pathfinding system is very important in games, especially for intelligent characters. Whether a character can find a path to a certain place, whether the path conforms to people’s thinking, etc., is a difficult function to achieve perfectly, and it also brings great challenges to game programmers.

The emergence of artificial intelligence in games began to enter the game industry in the 1970s. Game designers hope that robots in video games have certain artificial intelligence and can interact well with the characters operated by players [1]. Nature of artificial intelligence in the game code is actually the game logic, computer control, the role of the actions and decisions, completely controlled by the game program, so part of the game programmers also called artificial intelligence programming for game programming, each corresponding computerized role play will have different liquid, powered by the algorithm are different [2, 3]. Computer hardware gradually become mature, emphasizing the robots and video game players fight or cooperation, is gradually used in handling the game graphics processor screen related aspects, such as, more space to the CPU and memory to handle relevant content in the game logic, the processing and artificial intelligence in the CPU computing proportion also reached 10.3%, from 2.4% at the beginning if a game is very pay attention to the role of intelligent computer control, this proportion will be higher [4, 5]. Game artificial intelligence also adds more technologies, such as group behavior, character learning system, etc., to make robots in the game more intelligent, but also bring more pleasure to players [6].

This paper mainly improves the intelligent path-finding algorithm of artificial intelligence in the game, making the generated path more consistent with the path thought out by human [7]. This article first analyses the game and the artificial intelligence technology, aiming at some in pathfinding algorithm after several basic knowledge structure and figure of search algorithm is illustrated and the research, then the A\* algorithm is A detailed and comprehensive analysis, points out the advantages of the standard A\* algorithm and the deficiencies, on this basis, from the perspective of A few on the A\* pathfinding algorithm is proposed improvements and optimization [8, 9]. Finally, the improvements made by the A\* algorithm in this paper are compared and analyzed with the standard A\* algorithm, and it is concluded that the improved intelligent pathfinding algorithm has better efficiency and higher intelligence level [10].

## 2 Method

### 2.1 Basis of Intelligent Pathfinding Technology

#### (1) Depth-first search

The cycle of depth-first search mainly adopts the recursive idea in mathematics, and its main flow is: first visit the first vertex a, then visit the node b adjacent to the first node after processing, and then take the node c adjacent to the b node again after the visit of the b node is completed, ... Until the visited node m has no adjacent nodes, it will go back to the node n above m to continue the search. The whole process is completed by recursion. When all nodes are visited, the search is completed [11].

In web games, the scene is a gaming environment that is similar to the real world in which people live, while a character walking in a map is essentially moving in a two-dimensional or three-dimensional coordinate world. In order to realize walking in the game map similar to human walking in reality, the map in the game should be simulated into reality [12]. Current maps of the majority of the game is divided to a lot of small grid, when the character ready to move from one position to another position, the game program by had written a good path finding algorithm to calculate the appropriate path, and then control characters along the path, the corresponding grid displacement step by step until the destination smoothly [13].

#### (2) Breadth first search

Breadth first search is called width first search. Different from depth first search, the search order is different from depth search. Breadth first search USES queue to schedule access order. The search process is as follows: the first node a of the graph is taken, and its adjacent nodes b and e are inserted into queue Q. After the search of node a is completed, the first node b of the queue is taken from queue Q, and the adjacent node c of node b is inserted into queue Q. At this point, the nodes in queue Q are successively e and c. When the access of node b is completed, continue to take the first node e of the queue squadron, and insert the adjacent nodes f, g and h of node e into queue Q successively. In this way, the cycle continues until the search stops when queue Q is empty.

It can be seen from the search order that in breadth-first search, when the adjacent nodes of a node are inserted into the queue, different methods will lead to great differences in the order of the final access. How to select is also the flexibility of breadth-first search.

### 2.2 Improved Intelligent Pathfinding Algorithm

The standard A\* algorithm requires two tables, the open list and the closed list, to maintain vertex information during the path search, and most of the time is spent maintaining the open list. There are four things to do in the open list: find the smallest vertex, insert adjacent nodes, remove nodes to search for, and replace nodes that are highly valued. According to finding the path in the scene map of the web game, the

most frequently used operation is the search operation, so choosing a fast data structure in the case of low operation time has become the core of the optimization algorithm.

After optimizing the A\* algorithm, the program can find an optimal path in less time, while the characters in the game will start moving after receiving a feasible path. However, the path calculated by the path-finding algorithm A\* does not take into account the thinking mode of people, so the trajectory taken by the character is linear, and walking at multiple corners is in the form of straight walking and straight turning.

In the computer field, specialized research on curves and surfaces has been developed into a part of computer graphics and graphics. In the optimization of folded linear maps, the most common method is to optimize with Bezier curves, which are defined as:

$$P(t) = \sum_{i=0}^n P_i BEZ_{i,n}(t), \quad t \in [0, 1] \quad (1)$$

Where,  $P_i$  represents the point under control, while discounted  $P(t)$  is polygon.  $BEZ_{i,n}$  is a basic function, expressed as:

$$BEZ_{i,n}(t) = C_i^n t^i (1-t)^{n-i}, \quad t \in [0, 1] \quad (2)$$

For the sake of analysis, the corners of the function route are obvious, just to illustrate the principle, while the actual map shows small, gentle, and more continuous polyline paths.

### 3 Experiment

#### 3.1 Experimental Environment Deployment

In the pathfinding process of web games, from the conceptual design to the actual completion, it needs to go through the process of sketch design, original drawing, map terrain production, scene element production in the map, scene element placement, rendering, etc., and each of these items requires a lot of time. After the completion of the game map, for 3D games, character production, collision system, character animation and so on are also a huge project.

#### 3.2 Experiment Implementation

The simulation experiment program adopts 2D production mode. The map in the scene is a plane of image attributes, which is divided into a rectangular grid of  $30 \times 30$  by crisscrossed lines. Each grid represents a unit of movement, and the coordinates are distributed from  $(0, 0)$  to  $(29, 29)$ . In this simulation experiment, a total of three pathfinding algorithms including Dijkstra algorithm, the regional search method and the improved intelligent path-finding algorithm were selected to participate in the experimental evaluation.

Then some pathfinding algorithm of simulation test, first choose the type of good map, the system will automatically generate a map with obstacle Blocks, after using the keyboard shift key sets the starting point on the map, Esc setting target, use the left mouse button to add or delete a weight of Block, 1 finally click on the corresponding path search algorithm. After pathfinding, the program will display the corresponding data results in the text box on the left of the test interface.

## 4 Discuss

### 4.1 Experimental Simulation Results

Among the three groups of experiments, 10 path searches were conducted for each group, and the starting point and target point of each search were different. After each pathfinding, the total pathfinding length and the time consumed by the search path are recorded, and the corresponding comparison conclusions are drawn by analyzing the two data. The simulation results of the three basic path search algorithms after data processing in the simulation experiment are shown in Table 1 below.

**Table 1.** Data table of experimental simulation results

	Dijkstra algorithm		Zonal search method		Intelligent pathfinding algorithm	
	Path length d	Path time t (ms)	Path length d	Path time t (ms)	Path length d	Path time t (ms)
First time	18.26	0.743	20.66	0.106	18.53	0.352
Second time	19.35	0.735	24.93	0.327	22.84	0.642
Third time	22.43	1.342	21.83	0.335	31.94	1.093
Fourth time	9.85	0.309	17.49	0.783	9.57	0.847
Fifth time	22.95	1.181	25.53	0.624	12.56	0.145
Sixth time	19.15	0.636	9.45	1.035	16.37	0.742
Seventh time	10.21	0.752	12.37	0.258	21.64	1.357
Eighth time	35.51	1.468	31.73	0.834	28.89	0.537
Ninth time	27.78	0.892	25.92	0.476	32.57	0.296
Tenth time	31.42	1.283	18.75	0.782	30.53	0.698

As can be seen from the table, in the three single path-finding algorithms, the path length is different, and the path-finding time is different. When the length of the path increases, the pathfinding time decreases, because the positions of the starting point and the target point change before each test, and the reason for the existence of Blocks. First, the experimental path length of the three pathfinding algorithms is compared. For convenience, the search path length of the three algorithms is compared by using a bar chart, as shown in Fig. 1 below.

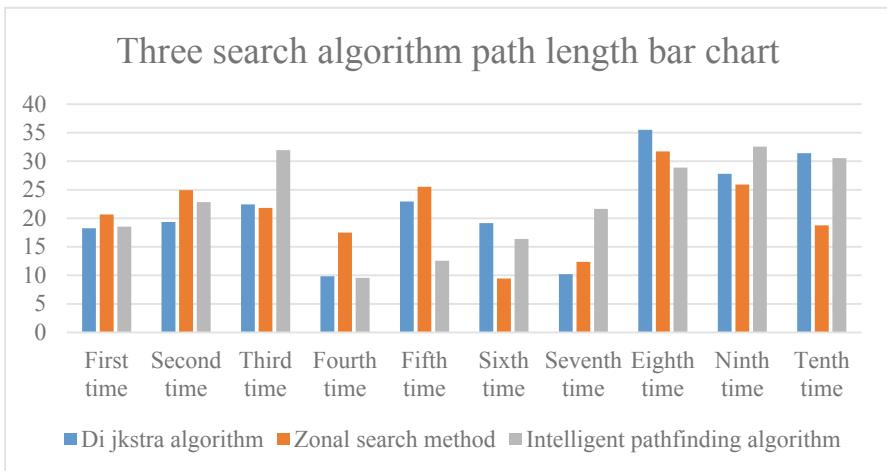
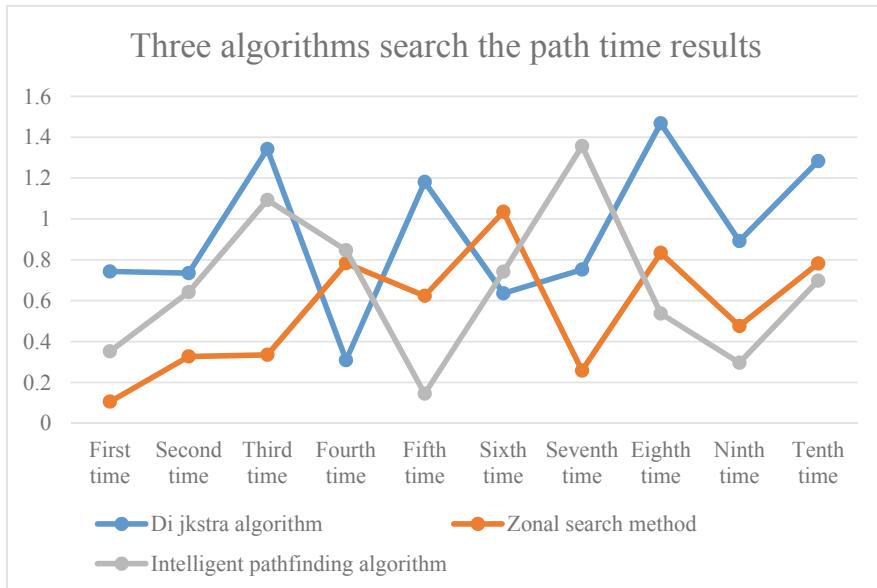


Fig. 1. Bar chart of path length of three search algorithms

## 4.2 Analysis of the Best Pathfinding Algorithm

Through the combination of the above and table can be seen that, for most of the test group in the data path length, Dijkstra algorithm with subregional search approach to measure the basic equal path length  $d$ , and the improved intelligence pathfinding algorithm to measure  $d$  is longer than the above two algorithms of  $d$ , this shows that the improved intelligence pathfinding algorithm to find the path to the shortest path, the tiny difference between  $d$  because the error of the calculation of diagonal distance, and the improved intelligent pathfinding algorithm to search out the path of the generally large than the former two algorithms detect. After comparing the length of the path, data analysis was conducted on the time taken by the three algorithms to search the path. The path-finding time of each of the ten groups of data was extracted from Table 1, and then a linear graph was made, as shown in Fig. 2 below.

It can be clearly seen from the figure that the path-finding time of Dijkstra algorithm is longer, the time calculated by the zonal search algorithm is smaller, on average one third of that of Dijkstra algorithm, while the pathfinding time of the improved intelligent pathfinding algorithm is between the above two algorithms. The start and end points are reset for each test, so the polyline floats up and down. Pathfinding data comparing the above three kinds of algorithm, can calculate the intelligent pathfinding algorithm can improve the search efficiency than Dijkstra algorithm with high efficiency by 52.6%, 63.2% higher than the score method of search algorithm, it shows that using the improved intelligent pathfinding algorithm efficiency is very high, so the comprehensive search speed and path length, the improved intelligence pathfinding algorithm in searching the shortest path on the effect is very obvious.



**Fig. 2.** Results of the time taken by the three algorithms to search the path

## 5 Conclusion

With the increasing demands of players on all aspects of web games, adding artificial intelligence pathfinding technology into web games has become a necessary part of the survival of web games. Whether web games can find their way intelligently and find a path from the beginning to the end point on the map more intelligently has become an important indicator of how interactive a web game is with players. The results of this paper show that the improved intelligent path-finding algorithm proposed in this paper is more efficient and applicable than the traditional path-finding algorithm.

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# Design of Intelligent Manufacturing Product Identification and Detection System Based on Machine Vision

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**Abstract.** With the advent of the Industry 4.0 era, the development of smart factories and smart manufacturing industries has become the consensus of all countries. The intelligent manufacturing process is very complicated and usually consists of multiple links, each of which is completed by one or more intelligent manufacturing equipment. The environment perception and intelligent control technology of intelligent manufacturing equipment are the fundamental guarantee of adaptability, high precision and intelligent operation. It is also a technical problem that must be solved first in the development of intelligent manufacturing equipment. Based on the above background, the purpose of this article is the design of an intelligent manufacturing product recognition and detection system based on machine vision. In the context of the transition to intelligent manufacturing production mode, this paper proposes a method to directly generate matching templates using 3D models of cloud products. Second, this paper studies and compares various preprocessing algorithms such as image filtering and edge detection to determine bilateral filtering and Canny Edge detection performs image preprocessing, and then extracts contours from the processed binary image. Finally, based on the aforementioned theoretical research, a visual detection platform is built, and several products produced are matched with cloud storage data through experiments. The algorithm in this paper can meet the classification requirements of small and medium batches and customized products in flexible production lines, and realize the matching of actual product and cloud product model data.

**Keywords:** Machine vision · Intelligent manufacturing · Image processing · Product identification

## 1 Introduction

The development of manufacturing industry in a country is the focus of a country's work, because manufacturing industry is not only the foundation of a country's national economic development, but also a reflection of the country's overall comprehensive strength [1]. In recent years, with the continuous advancement of the information technology revolution, the emerging industrial revolution that it spawned is also booming. In order to seize the development opportunities in emerging industries,

developed countries such as Europe and the United States have proposed plans to promote the development of local manufacturing industries. In order to stabilize the position of domestic manufacturing industry in the new round of industrial technological revolution [2]. With the continuous advancement of the transformation of manufacturing technology, manufacturing enterprises that have developed rapidly have realized the reform of factory automation, and used machine vision to quickly locate and classify products in the transformation of production lines, instead of manual labor applied in traditional manufacturing. Inspection to solve the problems of low production efficiency, facing rising labor costs and hidden dangers to workers' health [3]. However, after the realization of automation, the company's production mode is still driven production, that is, a small variety, large-volume production mode. In order to develop towards intelligent manufacturing and realize the requirements for multi-variety, small-batch, and personalized production of products under the intelligent manufacturing model, the production model of manufacturing enterprises is facing the challenge of shifting from the push-type production method to the intelligent manufacturing method of mass customization [4]. The visual inspection technology used in existing automated production lines intelligently recognizes and classifies products of a small variety, which has been unable to meet the needs of multi-variety detection and identification of industrial production line products under the intelligent manufacturing model [5, 6].

In this strategic plan for the development of China's manufacturing industry, intelligent manufacturing is the main goal of the development of China's manufacturing industry. In the place occupied by the peak of the new technological revolution, and then reached the goal of catching up with advanced manufacturing technology in developed countries or even surpassing it [7, 8]. In the intelligent manufacturing production mode, product diversity increases, and the recognition after product production is completed is much more difficult than the recognition under the push-type production method [9]. In order to solve the identification of multi-variety, small-batch customized products, and even single-piece customized products, a flexible production line that realizes type detection of mixed production of products, under this background, the "cloud manufacturing" production model was proposed [10]. Users can customize products in the cloud and upload data to the cloud. In this case, due to the variety of products produced by the industrial production line, in order to obtain the specific data of the product, image acquisition, that is, machine vision technology, is used to collect data and match it with cloud data. Therefore, this article will propose an improved template matching method to identify products, and build a visual inspection platform to achieve the matching of multiple types of production artifacts and cloud data at the assembly station, so as to obtain product categories and specific parameters [11]. In summary, the recognition and detection based on machine vision still has great research significance and application value in the current wave of manufacturing reform.

Manufacturing industry is an important cornerstone of the national economy. Countries have formulated national-level plans, and actively promoted the upgrading of domestic manufacturing technology, and gradually moved closer to the intelligent manufacturing production model. However, the production mode in the intelligent manufacturing environment and the traditional production mode have different

requirements for the flexibility of the product production line. Therefore, this article focuses on the factory production environment under intelligent manufacturing, with small batches and personalized production as the starting point, and flexible manufacturing in the mixed flow shop as the goal to achieve multi-category, small batch products and cloud data in the intelligent manufacturing process.

## 2 Method

### 2.1 Image Filtering Method

Image filtering is simply to suppress or remove interference information under the prerequisite of retaining the feature information in the original image to the greatest extent. Before the image is processed, noise and other interferences will affect the extraction of interesting features in the image. The purpose of image filtering is to eliminate these noises as much as possible, and to assist in the extraction of information of interest in the image, so as to achieve the important feature information (such as contours, edges) of the image can not be damaged, so that the filtered image is more clear. Filters are divided into linear filtering and non-linear filtering according to different methods.

#### (1) Box filtering and mean filtering

Box filtering, also known as box filtering, is a linear filtering technique. The idea of this method is derived from the principles and ideas of integrated images. In the fast solution of the integral image, the sum difference operation of the corner points corresponding to the matrix pixels is used instead of the sum operation between the matrix pixels. The key to the realization of square filtering is the initialization of the square filter kernel template. Each value in the template stores the pixels and values in the neighborhood of the pixel. When solving the pixel sum in a rectangular block, you only need to access the corresponding area. The sum stored in the position can complete the calculation.

#### (2) Median filtering

The median filtering method is a non-linear smoothing filtering technique. This filtering method processes the pixel values of all pixel positions in the 8 neighborhoods of the selected pixel position and takes the intermediate value instead of the pixel value of the selected position. This method greatly reduces the effect of isolated noise points in the image by selecting the pixel intermediate value, so it has a good filtering effect in removing pulse noise and salt and pepper noise. In addition, while filtering the noise, It will not damage the edges of the image information and make it better protected. The advantage of this kind of pixel boundary line protection cannot be achieved by the linear filtering method. In addition, the median filtering algorithm is relatively simple. Although the processing time is longer than the average filtering method, the performance of filtering the noise is better.

#### (3) Gaussian filtering

Gaussian filtering is a kind of linear Gaussian filtering that can effectively eliminate and suppress noise, and is an important image preprocessing method.

Gaussian filtering is the weighted average of graphics. This method has the following specific operations: first construct a discrete Gaussian convolution kernel of  $(2k + 1) \times (2k + 1)$  dimensions, as shown in Eq. (1); then use the kernel function. The image is convolutionally discretized to obtain the value of the discrete points after the convolution operation. Finally, the weighted average of the selected discrete points and the discrete points in the neighborhood is used to achieve Gaussian filtering.

$$H_{i,j} = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{(i-k-1)^2 + (j-k-1)^2}{2\pi\sigma^2}\right) \quad (1)$$

## 2.2 Contour Feature Description Based on Fourier Transform

After the contour is correctly extracted, the contour needs to be analyzed and processed to extract favorable features for post-processing. The method of classifying contours has different classifications according to different rules. The earliest method for analyzing contours is a classification method based on a sequence of contour boundary points. The classification methods of contour descriptors are divided into: the use of boundary information and the use of contour region information: area-based contour feature description method, contour sequence-based feature description method. In addition, whether contour-based and contour-based feature description methods are aimed at contour global or contour local, can be divided into local description and global description.

The Fourier feature operator feature is a contour feature description method based on the transform domain. In order to avoid the influence of the initial point, direction, scale and other contents of the contour on the Fourier descriptor operator, the Fourier feature operator will be normalized below deal with.

$$z(n) = \frac{1}{N} \sum_{k=0}^{n-1} Z(k) \exp\left(\frac{j2\pi kn}{N}\right), (0 \leq n \leq N - 1) \quad (2)$$

The energy of the Fourier coefficient has the characteristics of low-frequency concentration. Therefore, in actual use, we usually only retain the first  $n$  terms of the Fourier coefficient to approximate the contour curve of the object, that is, the low-frequency coefficient of Fourier includes the contour The overall shape information of the curve, and the information described by the high-frequency coefficient is the detail part of the contour curve of the object. Generally speaking, the fewer the coefficients of the Fourier descriptor are selected, the greater the recognition robustness, but the discrimination accuracy during recognition will be reduced; on the other hand, when too many Fourier coefficients are retained, Although the degree of discrimination of contours is enhanced, the sensitivity to noise is also increased.

### 3 Experiment

Step1: Firstly analyze the STL file of the cloud 3D model of the product that needs to be produced. By analyzing and processing the 3D model data, and using OpenGL to display and match the template, it is a multi-type product for the later stage. Provide a reference template for recognition, pre-process the image of the target product, and compare the pre-processing methods to select a pre-processing method that has a good processing effect; and use a contour extraction algorithm, and perform contour extraction on the generated template and the object of interest So as to lay the foundation for subsequent research.

Step2: Secondly, research on contour feature description and classification method. After contour extraction, in order to accelerate the speed of contour matching recognition, it is necessary to select representative points on the contour as feature points. Then the Fourier transform is performed on the selected feature points, and the Fourier feature descriptors are used to describe the contour features. In addition, the similarity measurement method is compared, and a similarity measurement method suitable for combining with the Fourier descriptor is selected as a judgment basis for contour recognition.

Step3: After the Fourier feature descriptor is performed on the contour extracted from the template library, the corresponding Fourier descriptor operator is extracted according to the collected user cloud customized product images, and the product features are compared with the cloud model data features. Test product images for classification prediction, and then verify and analyze the feasibility of the algorithm proposed by this research.

### 4 Discuss

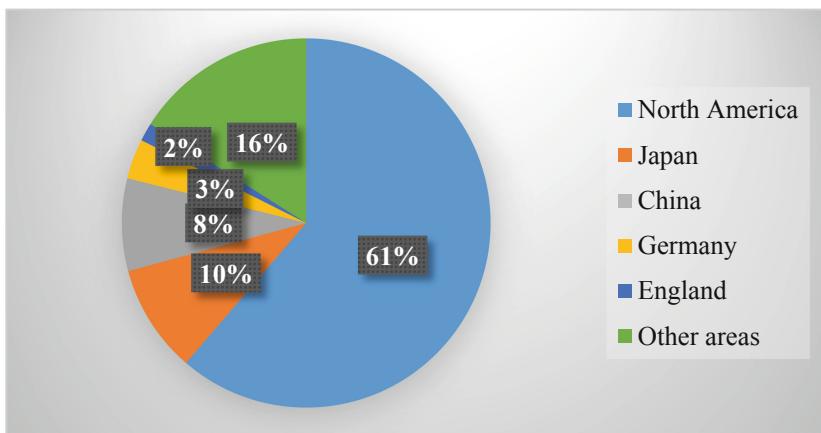
#### 4.1 Analysis of Experimental Results

After training to get the Model required for classification, read the model data feature file that needs to be predicted, and use the predict function Predict to predict the product type of the entered features. By performing 10 tests on 5 products collected, the average detection accuracy is 97%, and the average classification time is 1.8 ms, as shown in Table 1.

**Table 1.** Product test results

Number of experiments	1	2	3	4	5	6	7	8	9	10	Average
Correct rate (%)	100	100	100	90	100	90	100	100	100	90	97
Time (ms)	1	2	1	2	2	1	2	1	2	2	1.8

According to the big data survey, this article finds that in terms of regions, machine vision is mainly distributed in the United States, Germany, Japan, China and other countries. Although China's machine vision industry started late, it has developed rapidly and has become the world's third largest machine vision market after the United States and Japan. The specific data is shown in Fig. 1.



**Fig. 1.** Regional distribution of the global machine vision market

It can be seen from Fig. 1 that China's machine vision started in the 1980s. Before 2006, the application of domestic machine vision products was mainly concentrated in foreign-funded manufacturing enterprises, with a small scale. The domestic machine vision market started in 2011, and the industry is currently in a period of rapid development, with a large space for development.

## 4.2 System Performance Test

This system implements precision automation operations and high-precision quality inspection in practical applications. In order to analyze its specific performance, this article mainly detects the system from the aspects of loading and unloading operation accuracy, defect detection accuracy, pallet detection accuracy, and real-time performance. Performance analysis.

In loading and unloading operations, the accuracy of the operation mainly depends on the resolution of the three-dimensional positioning of the target, and the resolution mainly depends on the imaging system and the target detection algorithm. During loading and unloading, the resolution of the camera used is  $2048 \times 1536$ , and the maximum imaging area is about  $35 \times 28 \text{ cm}^2$ . Therefore, the minimum resolution of the imaging system at each imaging position is about 0.17 mm. Using the target recognition and pose measurement method proposed in this paper, the positioning error is less than 3 pixels, so the operating accuracy of the entire device is about 0.5 mm.

At the defect inspection station, although the detection is different for different inspection tasks, in all cases, the detection accuracy rate of unqualified products is greater than 99.2%, and the detection accuracy rate of all products is greater than 99.4%. In the palletizing link, the accuracy of palletizing detection and recognition is greater than 99.97%, and the resolution of palletizing thickness measurement using line scanning imaging system is about 0.2 mm.

The real-time performance of this system mainly depends on the complexity and fineness of the operation. The workpiece inspection operation, under the condition that the manipulator and the arm are running at full speed, the entire operation process can be completed in 10 s, and the longest processing time of a single image processing process is 2 s. In most cases, the system can meet the needs of intelligent manufacturing automation operations.

Based on the research of machine vision detection and recognition algorithms at each station, the detailed design and implementation of machine vision detection and control system for intelligent manufacturing equipment are introduced. According to the requirements of high-speed, high-precision and high-adaptive operation, this system uses a six-degree-of-freedom industrial robot as a precision operation mechanism, and uses an intelligent imaging system to measure the posture of the work object in real time. Based on the hardware selection, this article introduces the coordinated working principle and communication scheme of the entire device, and analyzes the specific implementation of the loading and unloading operations in detail. Based on the hardware design, the detailed implementation of the machine vision pose detection software module in loading and unloading operations is analyzed in detail, as well as the modular image processing flow design scheme used for different tasks. The developed machine vision quality detection and control system has the characteristics of high adaptability, high operation and detection accuracy, and strong real-time performance. The core algorithms can be popularized and applied to many fields of intelligent manufacturing.

## 5 Conclusion

The intelligent production mode in the intelligent manufacturing environment requires that we can provide customers with customized products with personalized needs, and then realize large-scale personalized and customized flexible production. However, the company's production method is a large-scale, standardized push-type production method. The vision technology used in its production line cannot meet the demand for product diversity under intelligent manufacturing conditions. Aiming at this problem, this paper proposes a method and method for matching multi-variety, small-batch customized products with cloud data in the intelligent manufacturing process. This paper proposes a method to directly generate a matching template by using the CAD model of the target object, researches the image preprocessing method, researches the image filtering method, edge detection algorithm, and determines the selection of bilateral filtering method and Canny edge detection operator. The contour feature description method based on Fourier transform is researched and a vision system detection platform is set up.

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# Investigation on the Analysis Model of Cloud Classroom Teaching Activities of PHP Network Development Technology Based on xAPI

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**Abstract.** With the continuous proposal of “Internet + education”, educational informationization has made rapid development in China, and information technology is playing an increasingly important role in the development of China’s education. In order to promote the further improvement of education level, cloud classroom has been developed. In essence, cloud classroom is a kind of public education service system, which realizes the network sharing of education resources with the help of information technology and belongs to a comprehensive virtual network learning community. As for the actual development of cloud classroom, on the one hand, cloud classroom and education are moving towards deep integration step by step; on the other hand, many problems are exposed in the process of cloud classroom and teaching integration. The purpose of this paper is to promote the further development and application of cloud classroom by constructing and studying the analysis model of cloud classroom teaching activities. This paper firstly gives a brief overview of relevant core concepts such as cloud classroom, xAPI and PHP network development, and then combines the existing research data with the actual situation of current development of cloud classroom. Finally, with the help of cloud area algorithm, it carries out testing experiments on the cloud classroom teaching activity model. The experimental results show that the xap-based analysis model of cloud classroom teaching activities of PHP network development technology proposed in this paper is reliable and can record and analyze the whole process of cloud classroom teaching activities in detail.

**Keywords:** Cloud classroom · Teaching activities · Analysis model · Web development

## 1 Introduction

With the advent of information age and the continuous development of information network technology, the traditional teaching mode has been unable to adapt to the needs of education development, reflecting the backwardness. At present, network technology plays an important role in teachers’ daily teaching and becomes an indispensable auxiliary tool. In education and teaching, virtual classroom is introduced on a large scale, and cloud classroom emerges as The Times require. Cloud classroom is the

inevitable requirement of education progress, which realizes the sharing and exchange of learning resources, breaks the space-time limitation of teaching and learning, especially plays an important role in the organization of teaching activities, and promotes the continuous progress of teaching. Based on the extensive application of cloud classroom and the deepening of education reform, the society attaches more and more importance to the teaching quality, so the research focus of education and teaching has gradually shifted to the organization and development of teaching activities.

At present, in order to promote the improvement of education and teaching quality, domestic and foreign scholars have conducted in-depth research on teaching activities [1]. This article at the beginning of the study also looked at a lot of research data, on the basis of research data analysis and processing, we can find the current foreign scholars on the research of the teaching activities are mainly concentrated in the following aspects, respectively is the study of the essence of teaching activities, teaching tools and the use of the teaching activities of a whole evaluation and so on; In addition, domestic and foreign scholars have also defined teaching activities differently [2, 3]. Domestic research on teaching activities mainly focuses on the definition of teaching activities, the design of teaching activities, factors affecting teaching activities and evaluation of teaching activities. Few studies have put teaching activities into the information environment for research, and even fewer research on the analysis of teaching activities based on cloud classroom [4]. Therefore, from this point of view, there is still a big theoretical gap in the study of this aspect, which requires a more in-depth analysis and research.

In order to deeply explore the problems existing in the application of cloud classroom in teaching activities, promote the improvement of application efficiency of cloud classroom, and thus realize the in-depth application of cloud classroom in teaching, this paper builds an analysis model of cloud classroom teaching activities on the basis of xAPI [5, 6]. This paper firstly gives a brief overview of relevant core concepts such as cloud classroom, xAPI and PHP network development, and then combines the existing research data with the actual situation of current development of cloud classroom. Finally, with the help of cloud area algorithm, it carries out testing experiments on the cloud classroom teaching activity model. Test experiments show that this model is conducive to in-depth analysis of cloud classroom application and has reliability [7, 8]. The research in this paper not only promotes the further application and development of cloud classroom, but also lays a certain theoretical foundation for future related researches [9].

## 2 Method

### 2.1 Core Concepts

Cloud classroom is a new educational mechanism emerging under the background of the rapid development of the Internet. It carries out online teaching with the help of network information technology, featuring convenience, efficiency and real-time interaction. Cloud classroom breaks through the time-space limitation of traditional teaching and realizes the rapid dissemination and sharing of learning resources. It is a

comprehensive online learning mode. Under the cloud classroom teaching mode, the organic combination of face-to-face teaching and online learning is realized. Students are able to conduct online learning selectively according to their actual situation, and change from passive to active. xAPI is essentially a learning technical specification, which enables flexible tracking of learning experiences in different learning environments [10, 11] even if the learning content cannot be determined. Compared with traditional learning technologies, xAPI shows great advantages, such as flexible data interchange, multiple types of learning data, and so on. In addition, the learning technology pays more attention to teaching and learning data, and pays less attention to the teaching content. With the help of this technology, the limitation of traditional learning system management can be broken. PHP network development based on xAPI is a convenient network development language. The use of this network development has effectively reduced the use cost and greatly improved the development speed, which is the inevitable result of the rapid development of the current network development. The biggest advantage of PHP network development technology is that it ADAPTS to the most advanced interactive network development and application mode. Applying this network development technology to the construction of cloud classroom teaching activity analysis model is conducive to reducing the complexity of model construction [12, 13].

## 2.2 Cloud Area Algorithm

The cloud area is mainly used to represent the main tendency of teaching activities in the cloud classroom. The larger the cloud area is, the more dominant the teaching interaction is in the cloud classroom. The radius size of each cloud slice is the final score of various teaching activities determines the size of the cloud area, but the final score of each teaching activity is determined by the z-score of each score data, and the initial score, average score and standard deviation directly affect the z-score. In general, the smaller the score of cloud classroom teaching activities is, the larger the standard deviation is, and the relationship between the two is inversely proportional. Therefore, the analysis of the score of teaching activities can be obtained by evaluating the standard deviation. The specific calculation formula is as follows:

$$Z_i = \frac{x_i - \bar{x}}{S_x} \quad (1)$$

Where S represents the cloud area and x represents the specific activities of the cloud classroom. I represents a sequence of cloud classroom activities. Here, the arithmetic square root of variance is taken as the standard deviation, which can directly reflect the degree of data aggregation. In general, the degree of data concentration is also inversely proportional to the standard deviation. On this basis, the cloud area is evaluated. The specific calculation formula of cloud area is as follows:

$$S_x = \sqrt{\frac{1}{N} (x_i - \bar{x})^2} \quad (2)$$

### 3 Test Experiment of Cloud Classroom Teaching Activity Model

The xAPI cloud classroom teaching activity model testing experiment is conducted to explore the reliability of the model proposed in this paper by virtue of in-depth analysis and research on the model, so as to help teachers and students better carry out cloud classroom teaching activities. This paper takes the cloud classroom teaching activity model as the main experimental object. The experimental materials of cloud classroom teaching activity are mainly the wuhan online cloud classroom teaching cases, and all of them are excellent teaching cases. The purpose of selecting excellent teaching cases is to ensure the integration of cloud classroom and advanced teaching concepts. In this experiment, in order to avoid interference from other factors, three different subjects were selected as case experiment materials, namely junior high school Chinese, mathematics and English. Finally, excellent cases of cloud classroom in these three subjects were determined as sample data of the test experiment. After determining the relevant class cases of cloud classroom teaching activities, the data of class cases should be collected. The teaching time of each class case is 45 min. At last, the teaching activities of cloud classroom examples are discussed and analyzed. Firstly, the overall analysis and discussion are carried out, and then the partial analysis and discussion are carried out to make the analysis of class examples comprehensive.

## 4 Discuss

### 4.1 Construction of Cloud Classroom Teaching Activity Model

Through consulting relevant data and analysis, we can put the cloud roughly divided into the following nine categories, classroom teaching activities are the teachers' teaching activities, teachers and students exchange activities, group work, role playing activities, group activity, in-class practice activities, competition, cooperation, inquiry activity and practice simulation activities. Comparing these activities together, it is easy to find that these nine types of teaching activities contain some common elements, mainly the implementor, content, object activity result and other common elements. Xap-based PHP network development technology with the help of related activity language, that is, the triplet activity model “” basically includes all teaching activities. So, according to the PHP web development technology based on xAPI proposed language to construct the cloud classroom teaching activities of the specific model, the model is as follows: the Activity = <Actor, Verb, Object, Timestamp>.

In this model, Actor represents the Actor and controller of the activity, that is, teachers and students who participate in the cloud classroom teaching activities. Verb refers to a series of actions taken by the Verb implementers, such as teaching content, etc. Object represents the main Object of the activity, mainly refers to the specific activities or personnel involved in the cloud classroom teaching activities, and can also refer to the specific teaching content. Generally speaking, the content of activity objects is relatively broad. Timestamp represents the time required to implement teaching activities in the cloud classroom. For the nine types of teaching activities mentioned

above, each activity corresponds to a different model. The specific model is shown in Table 1 below, and the data in the table is the result of the author's experimental arrangement.

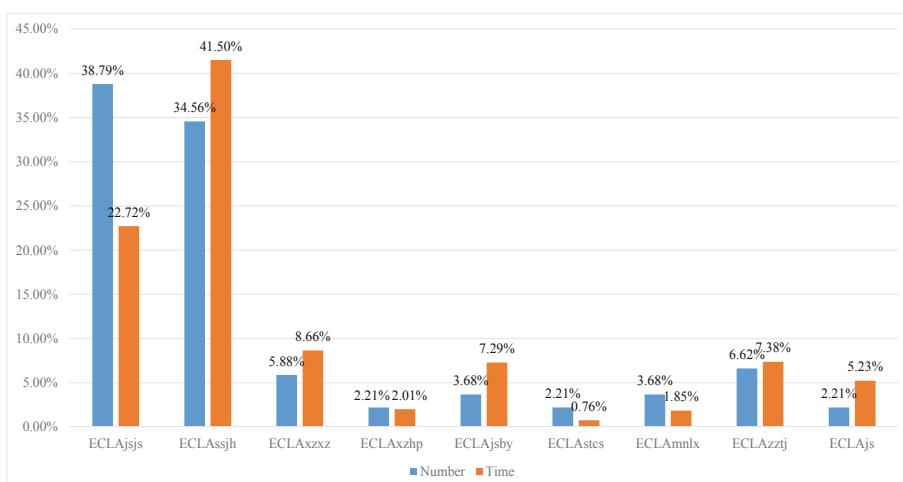
**Table 1.** Construction models of xAPI for different cloud classroom teaching activities

Serial number	Cloud classroom teaching activities	xAPI model
1	Teachers teach teaching activities	ECLA <sub>JSJS</sub>
2	Interactive teaching activities between teachers and students	ECLA <sub>ssjh</sub>
3	Group collaborative teaching activities	ECLA <sub>xzxz</sub>
4	Group evaluation of teaching activities	ECLA <sub>xzhp</sub>
5	Role-playing teaching activities	ECLA <sub>jsby</sub>
6	In-class testing teaching activities	ECLA <sub>stcs</sub>
7	Practice teaching activities	ECLA <sub>mnlx</sub>
8	Independent research teaching activities	ECLA <sub>zztj</sub>
9	Competition teaching activities	ECLA <sub>js</sub>

\*Data came from the in-depth analysis of financial data in the experiment

## 4.2 Verification of Cloud Classroom Teaching Activity Model

Based on the test and verification of the model proposed in this paper, excellent teaching cases of three subjects on wuhan cloud classroom platform were selected with the help of the analysis method of cloud classroom teaching video. According to the cloud classroom teaching activity model of PHP network development technology based on xAPI in this paper, teaching video data of a certain subject and a certain period of time were recorded. The specific data are shown in Fig. 1 below, which is the result of the author's experimental arrangement.



**Fig. 1.** Comparison of recorded data of different cloud classroom teaching activities

According to the data in Fig. 1, we can see that the model proposed in this paper records the corresponding data of various activities, which indicates that the model built in this paper can record the whole process of cloud classroom teaching activities in detail, reflecting the reliability of the xAPI-based PHP network development technology cloud classroom teaching activity model. In addition, on the basis of this model, we also have a deep understanding of the rules and characteristics of teaching activities in different subjects.

## 5 Conclusion

The construction of the model is a key step in the analysis and evaluation of cloud classroom teaching activities, which is of great significance to the improvement of cloud classroom teaching activities. A good model can provide scientific and reliable evaluation and analysis methods for teaching activities. In this paper, the model of cloud classroom teaching activities built based on xAPI PHP network development technology is proved to be reliable and conducive to the further development of cloud classroom teaching activities. However, there are some problems in this model, which need to be further adjusted according to the actual situation. The construction of the model is a long and complicated process.

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# Engineering Cost Management Strategy Based on Data Mining

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**Abstract.** With the deepening of national informatization work and the reform of construction cost management, accelerating the construction of information on construction costs has become an inevitable trend to achieve sustainable development in the field of construction costs. As the core part of construction cost information, the price of construction materials is increasingly affected by concerned by the relevant departments of engineering cost management, the engineering cost management agencies of each province and city have established engineering cost information networks to regularly publish the information price of engineering materials as a reference basis for the valuation of all parties in the construction project. However, through research, it was found that the information price of engineering materials released by the government deviated seriously from the actual market price, which led to inaccurate project valuation, which caused many problems and construction disputes in the management of construction market. This paper studies the research of engineering cost management strategy based on data mining technology. This article takes the material price in the engineering cost as the research object, and uses the normalized data to train the BP network through data analysis. An optimization method is used to improve the training efficiency, and the early termination method is used to improve the network generalization ability. Divided into 4 groups, of which 96 records were used as training set, 64 were used as test set, and the error range was between 0.005.

**Keywords:** Data mining technology · Engineering cost management · Information collection · Market management

## 1 Introduction

With the advancement of national informationization work and the reform process of construction cost management, the construction cost informationization has gradually become the main goal of construction cost management reform. With the advancement of the Ministry of Housing and Urban-Rural Development and the Housing and Urban Construction Committee, the current project cost informationization work has achieved good results, but there is still a long way to go to truly promote the healthy and sustainable development of the construction industry. At present, the problem of inaccurate engineering cost information is particularly prominent, and it has been highly concerned by relevant national departments. Since 2010, relevant state departments have successively issued policy guidelines on the development of construction

cost informationization, effectively promoting and standardizing the development of construction cost informationization work, thereby improving the level of construction cost informationization in China and the quality of information release on construction cost. The state attaches great importance to the informationization of engineering cost, and issued a number of documents and guidance to strengthen the informationization of engineering cost. The Ministry of Housing and Urban-Rural Development issued “Several Opinions on Doing a Good Job in the Information Management of Construction Project Costs” in May 2011 and September 2014 (Build Standard and Letter [2011] No. 46) and “On Further Promoting Reform of Project Cost Management” Guiding Opinions (Jian Biao [2014] No. 142), requires cost management departments at all levels to strengthen the construction of construction cost information platform, proposed that by 2020, complete the construction of the national construction cost database, establish a standard system of construction cost information, and break The island of construction cost information lays the foundation for cost information data sharing, carries out the accumulation of construction cost basic data, and improves public service capabilities. In September 2017, the Ministry of Housing and Urban-Rural Development further formulated the “Opinions on Strengthening and Improving the Supervision of Construction Costs” (Jianbiao [2017] No. 209), which proposed to jointly compile and share the valuation basis, build a fair market platform, and require projects at all levels The cost management institution improves the mechanism for releasing labor, material and machinery price information in the region and industry, improves the timeliness and accuracy of information release, and provides information support for the entire process of investment control and engineering cost supervision of construction projects.

With information technology as a way to develop advanced productivity, the management of engineering costs also faces inevitable opportunities and challenges [1]. Therefore, accelerating the informationization of engineering costs has become an inevitable trend to achieve sustainable development in the field of engineering costs [2]. At present, China's level of understanding of construction cost management is still very low, not enough attention has been paid to the collection, analysis and processing of basic expenditure data, and an appropriate data management system has not been established, which is far from advanced external management systems [3]. Based on a variety of factors, engineering cost awareness is an urgent task that should be highly valued by the cost management department and supported by advanced technologies such as information technology and network technology. Use scientific data analysis and processing technology to develop engineering technology. The collection and processing of pricing data, the creation of a smart engineering cost data platform, and a powerful framework for cost management reforms [4, 5].

Based on the traditional engineering material price information collection channels, this article adds information source channels, and replaces the traditional simple and backward data processing methods with more scientific data processing methods. The innovation points mainly include the following two points. (1) Collecting engineering material price information through multiple channels to improve the validity of the original data The traditional engineering material price information source channels are relatively limited, mainly from quotations from cooperative material suppliers, the number of data samples obtained is small, and the predicted value of material prices is

obtained Lack of effectiveness. Therefore, on the basis of the original source of material price information, this article adds two sources of information sources: project settlement record price and bid price of engineering project transaction information. Improve the validity of the original data. In addition, due to the different coding systems of engineering materials from different source channels, the collected information lacks a unified standard. This article uses the attribute standardization method to establish a standardized product unit for each material, thereby establishing a standardized SPU material database for subsequent data mining processing. Foundation. (2) The use of scientific data processing methods to improve the accuracy of material predictions found that the current data processing methods of collected material price information by engineering cost information websites established by engineering cost management agencies in provinces and cities are relatively backward, and more simple Weighted average, can not make full use of accumulated historical data. This paper uses data mining technology. First, the data in the established database is preprocessed. After three steps of target data selection, data cleaning, and data transformation, a high-quality data sequence that meets data mining is obtained. The data mining prediction model is used to obtain the predicted price of the engineering material. Finally, the output value of the output is judged by relative deviation, and the scientific and reasonable information price of the sub-engineering material is obtained. This process mainly uses the exponential smoothing model to give different weights to the data in different periods. It can make full use of historical data and pay attention to data that has a large impact in the near future. Compared with traditional data processing methods, the output prediction value is closer to the actual market value.

## 2 Method

### 2.1 Commonly Used Data Mining Methods

Data mining technology is an emerging technology for solving a large amount of data. It is a comprehensive interdisciplinary discipline covering a wide range of fields, including database technology, artificial intelligence, mathematical statistics, visualization, parallel computing and other fields. Common data mining methods and models are as follows [6].

#### (1) Statistical methods

Traditional sampling techniques, Bayesian methods, regression analysis and other theories are widely used in data mining processes. In complex statistical processes, models such as factor analysis and time series analysis are also effectively used.

#### (2) Decision tree method

Decision tree methods are often used for data classification functions. It is a method classification that approaches an objective function of different values and adjusts the pattern from the root node to some leaf nodes. The knot describes a test of one property of the sample. Each branch of the knot corresponds to a possible value for the attribute. Select an attribute and lower the branch corresponding to the attribute value for the given example.

### (3) Neural network technology

Neural network technology is a non-linear dynamic system that can simulate human brain thinking. It has the functions of data storage, autonomous learning, knowledge verification and optimization calculation. Adaptive capabilities can complement more complex data analysis.

### (4) Rough set theory

Rough set theory is a theory of data analysis and processing. Split database attributes into condition attributes and result attributes. The pairs in the database are subcategories of different attribute values for each attribute, and then the conditional attributes are subdivided. The upper and lower convergence between the subset and the subset of result attributes is used to create decision rules that can analyze and process fuzzy or uncertain data without prior information [7].

## 2.2 Project Cost Prediction Model

The description of each project includes a number of attributes such as the characteristics of the engineering base, design parameters, and technical and economic indicators. The number of attributes has been reduced to a few through the aforementioned preliminary attribute screening, attribute reduction, and other methods. Considering the size of the database and runtime issues, these attributes cannot be used to build a fuzzy neural network. The aforementioned algorithm further optimizes the attributes. The goal is to find the smallest attribute subset that can represent the original attribute set on the basis of retaining the original data information to the greatest extent possible. In power line engineering, historical data mostly appears in the form of numerical attributes. If a Bayesian classifier is to be used, continuous attribute values must be discretized. This will produce a contradiction. The number of discrete discrepancies will be small and the information will be lost. However, the large number of discretes will lead to too long calculation time and too many branches of the decision tree, which ultimately makes it difficult to achieve the purpose of optimizing attributes. Therefore, this paper adopts an improved Bayesian classifier as the evaluation and heuristic function to avoid the discretization of continuous values [8].

When the attribute is a continuous value, the kernel density estimation is used to calculate the posterior probability, and Eq. (1) becomes:

$$p(X|C_j) = (n_{C_j}h)^{-1} \sum_{X:C(X)=C_j} K\left(\frac{X - \mu_j}{h}\right) \quad (1)$$

Among them,  $h = \sigma$  is called the bandwidth of the kernel density,  $n_{C_j}$  is the number of samples in the category  $C_j$  and  $K = g(X, 0, 1)$  is defined as a non-negative function.

Take it into the above formula, and get the posterior probability calculation formula of the improved Bayesian classification algorithm:

$$p(X|C_j) = \frac{1}{n_{C_j}} \sum_i g(X, 0, 1) \quad (2)$$

Among them,  $g(X, 0, 1) = \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}}$  is a Gaussian density function with a mean of 0 and a variance of 1.

When using the improved Bayesian classifier, a discrete attribute is also required as the final classification attribute. Considering that the numerical distribution of the two attributes of “voltage level” and “conductor cross section” in power line engineering construction is relatively scattered, So these two attributes are discrete as classification attributes. Run the algorithm with these two attributes as category attributes, respectively, and take the intersection of the two calculation results as the final optimal subset. When the “voltage level” is used as the classification attribute, there are two types, that is, “voltage” and “voltage”. When folding cross-validation is used as the evaluation function, the data in it is used as training data, and the remaining data is used as test data. The algorithm selects attributes [9].

## (2) K-means clustering algorithm

Clustering is an unsupervised pattern recognition method that divides data records into a series of meaningful subsets according to the principle of maximum similarity within classes and minimum similarity between classes. K-means clustering is a classic clustering algorithm, which takes the sum of squared errors as the objective function [10]. There are n samples ( $x_1, x_2 \dots x_n$ ), which are divided into k categories ( $C_1, C_2, \dots, C_k$ ), and the average value of each category is ( $m_1, m_2 \dots m_k$ ). Then the squared error sum expression is:

$$J = \sum_{k=1}^K \sum_{i=1}^{N_k} \|x_i - m_k\|^2 \quad (3)$$

Among them,  $\|\cdot\|$  is a norm expression, commonly used norms are distance functions, and  $N_k$  is the number of samples in the  $k$ th class.

There are many K-means methods, and they may differ in strategies such as the selection of initial clustering centers, the measurement of similarity, and the calculation of clustering averages. The first problem is the selection of the initial clustering center. The selection of the initial value has a large impact on the data clustering result. It is obviously difficult to randomly select the initial clustering center to meet the requirements. In order to find a more suitable initial value, a repeated clustering is set. The number of classes. An initial clustering center is randomly selected for each clustering. Finally, a clustering result that minimizes the sum of squares within the class is returned. The clustering center at this time is selected as the initial center value.

For different data types and structures, different distance functions can be selected as the object similarity measure. The commonly used method is based on Euclidean distance. In the historical data of power engineering construction, when the line is long, the absolute values of its corresponding car distance, manpower distance, and number of poles and towers will be higher. If a measurement method based on Euclidean distance is used, the line will be The length attribute has a higher weight in the clustering process, and the clustering result tends to reflect the length of the line. Obviously, this similarity metric will lead to multiple correlations of indexing, resulting in overlapping information, and one-sided emphasis on the importance of certain

variables. This is not the way we want to cluster. For this reason, the vector angle cosine metric is used as similarity. Metrics for sexuality. The vector angle cosine metric takes each record as a vector, and the attribute value as the coordinate of each dimension of the vector. It judges the similarity between the projects by measuring the similarity relationship of the vector habits and the changes of the elements inside the vector. The form of the cosine lying away is:

$$d(x, y) = \frac{\sum_{i=1}^n x_i y_i}{\sqrt{\sum_{i=1}^n x_i^2 \sum_{i=1}^n y_i^2}} \quad (4)$$

Among them,  $x_i$  and  $y_i$  are the i-th attribute of projects X and Y [11].

### 3 Experiment

The collection of engineering cost information is the centralization and integration of materials price information resources in order to better grasp and use them. It is the basic stage of the construction of material price information and the key to improving the accuracy of engineering material information prices. To grasp the timeliness and comprehensiveness of the collected information. The research at this stage is mainly divided into two parts. The first is to summarize the optional engineering material price information source channels based on literature identification and practical application research. Then, by analyzing the advantages and disadvantages of various source channels and according to the principles of material price information source channel selection, The available engineering material price information source channels were screened, and material price information from different channels was collected step by step. The second is to use the attribute standardization method to establish standardized product units for various engineering materials, and to establish engineering material price information from different source channels. Correspondence relationship forms a standardized SPU material database, which provides a data foundation for subsequent data mining analysis.

After the diversified collection of material price information and the establishment of a standardized database, how to make good use of the data in the database is the key problem to be solved in this process. Data mining is a process of discovering knowledge to facilitate decision-making. This research uses data mining technology to conduct in-depth mining and analysis of material price information. The process is mainly divided into three stages: data preprocessing, data mining, and reasonable judgment of output data. The realization of data mining is a gradual process. A slight error in one of the three steps of data mining will cause errors in the final result. Therefore, every step of the data mining process should be dealt with seriously.

## 4 Discuss

### 4.1 Experimental Results and Analysis

In order to verify the performance of the model, “unit static investment” and “unit dynamic investment” are selected here as the output attributes, and the input attributes are selected according to the purpose of review and analysis to select some indicators related to the design attributes. 130 records were selected to establish the network. The input and output data are shown in Tables 1 and 2. The hidden layer transfer function is a differentiable hyperbolic tangent function. Because the transfer function needs to be differentiated in the sensitivity calculation process, it must ensure its differentiability. The output layer transfer function is purein. Before the data is input into the network, the input and output data are normalized respectively, and the number of neurons is set to obtain the normalized coefficient matrix. The normalized data is used to train the BP network, an optimization method is used to improve the training efficiency, and the early termination method is used to improve the network generalization ability. 140 data are divided into 4 groups, of which 96 records are used as the training set, and 32 are used. As the test set, 32 are used as the verification set. The mean square error of the training results is shown in Fig. 1. It can be seen that the errors of the training set, the verification set, and the test set all decrease synchronously, indicating that a certain degree of accuracy and generalization ability have been achieved by training the network. The sensitivity matrix can be calculated by reading the hidden layer neuron weights, the output layer neuron weights, and the hidden layer neuron bias matrix on the trained BP network.

**Table 1.** Input attribute set

Serial number	Section	Terrain coefficient	Number of corners	Average pitch	Manpower distance	Car distance
1	300	3	10	350.2	0.7	21
2	157	3	10	333.33	1.3	7
3	300	3	10	289.23	0.32	6
4	187	3	10	320	0.4	8
.....						
130	188	3	4	288.65	0.4	12

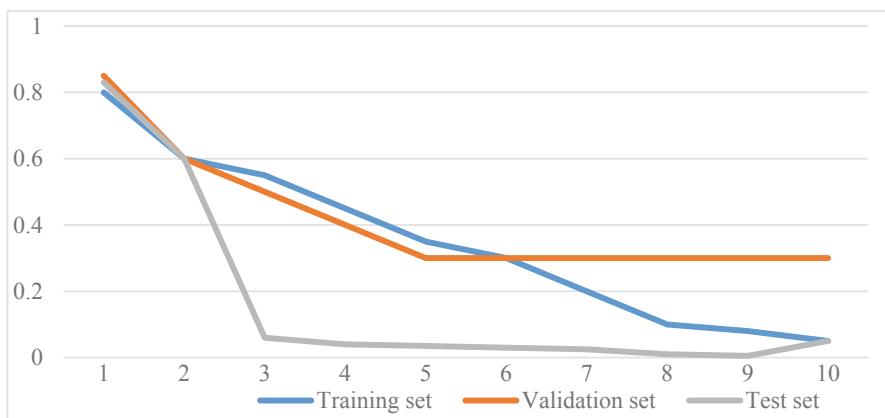
### 4.2 Precautions for Application of Data Mining Technology in Engineering Cost Management

#### (1) Preprocessing the original data

In the process of using data processing technology, the raw data is usually pre-processed, and then the available data is used to select calculation methods and calculation models for different research purposes. Preprocessing of the raw data is necessary, and in the next stage, it is related to the selection and implementation of various

**Table 2.** Output attribute set

Serial number	Unit static investment 10,000 yuan/km	Unit dynamic investment 10,000 yuan/km
1	110	113.66
2	79.55	82.45
3	75.55	78.15
4	33.55	33.50
5	75.89	75.55
.....		
130	43.66	45.77

**Fig. 1.** Error curve of BP network

analysis methods. The preliminary processing of high-quality raw data can easily classify huge data, quickly detect abnormal data, reduce unnecessary problems in the future, ensure accurate data retrieval and improve future productivity.

### (2) Ensuring that the data source is large enough

Because the data requirements for data retrieval are diverse, different research objectives have different requirements for the authenticity, health, intervention, and format of the data. The size of the data source will have a significant impact on the results of the data acquisition. Therefore, the data source must be rich and diverse, so that the information collected during the data creation process can meet various research needs.

### (3) Prerequisites and conditions for applying data

Because the data collected through data extraction are relative, the research results and model parameters are not suitable for all data. The application of data collection has certain limitations and is strictly restricted and controlled. The area of interest is also very limited. It is necessary to thoroughly review the data obtained during the

application of data processing techniques in order to make the most effective use of valid information and to conduct various research and calculation model calculations.

#### (4) Regular form of data mining technology

As data processing technology is constantly being updated, data retrieval rules must be up-to-date and appropriate adjustments should be made when new data is added. Multivariate data processing technology can effectively process real-time data, help users collect new data in a timely manner, and integrate new data to improve research results, enhance research results and increase research results in a timely manner.

## 5 Conclusion

With the rapid development of the Chinese economy, there is still a lot of room for engineering cost management, and engineering cost management is facing huge market pressure. Therefore, it is important to learn how to manage engineering costs. The improvement of engineering cost management system cannot be separated from the application of advanced technology. Combined with data mining technology, it can effectively improve the efficiency of project cost management, optimize the quality of project cost management, make the project cost management work more smoothly, and achieve the purpose of enhancing market competitiveness. At present, the advancement of the project cost informationization process is To realize the inevitable trend of sustainable development in the field of engineering cost, the price information of engineering materials is one of its core contents, and the quality of the release of information price must be highly valued, so as to provide scientific and accurate price basis for all parties in the engineering cost construction. Therefore, this article takes engineering material price information as the research object. Aiming at the problem of single source data channels and backward data analysis and processing methods for the current engineering material price information, it proposes a diverse collection of engineering material price information and reviews the collected information. Establish a standardized material database, and then use data mining technology to conduct in-depth mining and analysis of the data in the database, and build a scientific and reasonable material price prediction model, so as to obtain high-quality, high-level engineering material release prices.

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# Upper Limb Rehabilitation Electromechanical System for Stroke Patients

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**Abstract.** The mechanical and electrical system of upper limb rehabilitation is a kind of medical equipment which relies on the aid of machine to help stroke patients to carry out upper limb activity training. Many stroke patients can not move independently, which greatly limits their lives. In this paper, we have learned the etiology and symptoms of stroke patients, scientifically formulated their training methods and movements, and fully considered the safety and practicability of the equipment, and used relatively light materials as far as possible. For stroke patients to provide a safe, comfortable, effective upper limb wearable exoskeleton machine, can be anytime and anywhere rehabilitation training, simple appearance, low cost, suitable for stroke patients to use, to help them recover. Realize the independence of movement.

**Keywords:** Upper limb rehabilitation · Wearable exoskeleton · 3D modeling

## 1 Introduction

Today, with the continuous improvement of the people's living standards, the national economic ability is increasing day by day, so they have paid unprecedented attention to all aspects of life, especially in terms of healthy life, and people have paid more attention to related issues than before. According to relevant health institutions, The survey shows that China's number one mortality disease is now stroke (stroke), and it is also the number one cause of disability in adults, and its incidence has already far exceeded other types of diseases in China [1]. Stroke is caused by the inability of blood to flow into the brain [1]. In recent years, there are more and more patients, those who can survive and say goodbye to the ability to move only seven of ten, it brought a heavy burden on the family. Modern medicine shows that limb training can play a more active role in patients' rehabilitation. The human upper limbs engage in various complex and delicate activities, which have a huge impact on people's normal life. In European and American countries, doctors usually treat stroke patients undergo one-on-one rehabilitation treatment to help them restore motor function [1]. However, there are many people in our country who have suffered a lot of strokes, so that every patient accepts this rehabilitation, to be honest quite hard, so many patients missed the best

treatment time, left a regret. So, electromechanical systems for upper limb rehabilitation of stroke patients should be timely.

Because the upper limbs are special and flexible, and they are relatively lightweight. There are also more muscle groups, and the muscle shape is small and slender. Thanks to these characteristics, the upper limbs are also very flexible, so the upper limbs can complete many complex movements and achieve various Function [2]. For patients in the middle stage, they have a certain ability to move, for this, they should increase the range and intensity of the activity to help them recover better. In the late stage patients, we can improve in the mid-term movements, but after all, they are still patients, so there is a limited increase, and the range should not be too large. Patients who can take care of themselves in the later stages do not need to use exoskeletons, so even if it is the action with the highest activity intensity, it should not be too aggressive. The user is safe first and must not cause secondary injuries.

## 2 Mechanical Structure Design of the Extremity Exoskeleton Robot

As we all know, the eight systems together constitute the large system of the human body. The eight systems have different functions and different functions, and together form the higher life body of humans. Each part is extremely important. For a normal person, these systems are not lacking, it is an important part of maintaining life and even life. The main system involved in this design is the upper limb skeletal system and muscle system, they are units composed of many tissues that can exercise specific structures.

According to relevant data, the weight of one arm of an adult accounts for about 5% of the total weight [3, 4]. the joint to The distance between any point of the arm is x, then the following inference process:

$$M = \int_0^L F dx \quad (1)$$

$$\int_0^L mg dx \quad (2)$$

Assuming the arms are the same length anywhere, the unit mass is s:

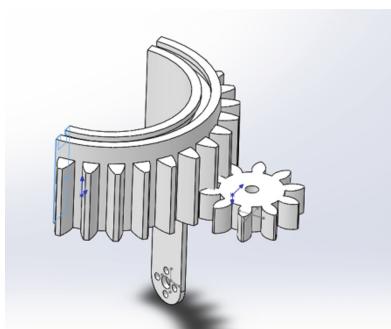
$$\int_0^L SX g dx \quad (3)$$

For this formula, S and g are both constants, and there are:

$$M = \frac{1}{2} S g X^2 |_0^L \quad (4)$$

Select SUPER300 servo, the maximum output torque is  $300 \text{ kg} \cdot \text{cm}$ , support PWM pulse 1–2 ms marked servo signal control, working mode can reach  $360^\circ$ , adjustable speed [5, 6].

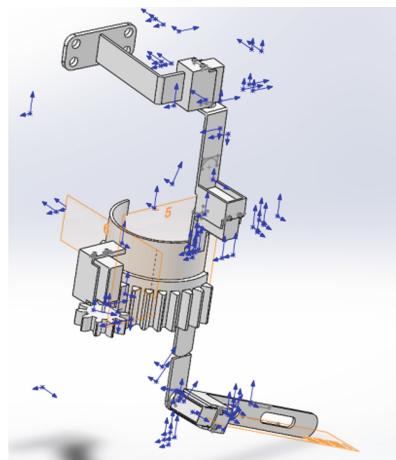
It is necessary to change the direction and speed of the power output by the servo. In the mechanical industry, there are various methods of transmission. The most common are gear transmission, chain transmission, worm gear transmission, spline transmission and other schemes. Among them, the most widely used should be the gear transmission mechanism, which can be used to transmit motion and power between any axis, and has a wide range of power transmission, accurate transmission ratio, high efficiency, long life, etc. [7, 8]. It is very suitable for this exoskeleton design. So in this design, I decided to use a spur gear transmission for parallel axes, as shown in Fig. 1, to achieve the internal and external rotation of the joint.



**Fig. 1.** Gear transmission

Therefore, in order to ensure correct transmission, the maximum center distance should be 88.4 mm, and the final center distance of this design is 82.5 mm.

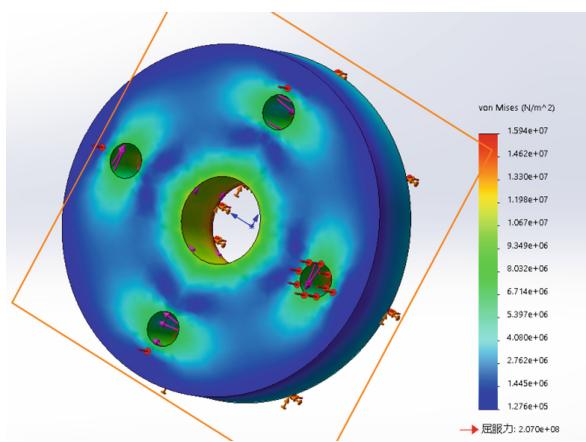
Use the selected screws and washers to connect the output shaft of the steering gear to the steering wheel through the larger hole in the center of the steering wheel, and then connect the steering wheel and exoskeleton through the four evenly distributed holes around the steering wheel. The mechanism is connected, so that the steering gear is connected to the steering wheel and the steering wheel is connected to the exoskeleton, and the power transmission is completed. In addition, the specifications of these four sets of screws are also the same, and the benefits of doing so are many, for example, it can let the line of action of the transverse load be perpendicular to the axis of the screw and pass through the axisymmetric center of the screw group. When the screw enters the thread to complete the connection, the load of each screw is exactly the same under the action of the lateral load  $F$ . This greatly increases the stability and reliability of the connection (Fig. 2).



**Fig. 2.** Assembly drawing

### 3 Simulation of Main Components

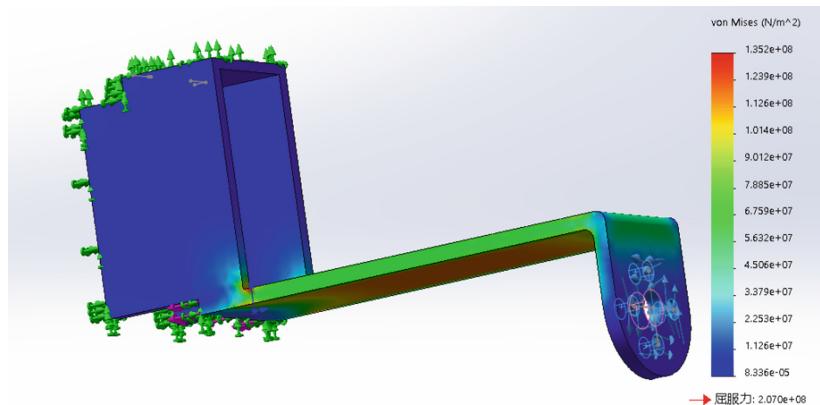
Take the steering wheel as an example. The steering wheel is used as an intermediate part between the steering gear and the parts. It has a light weight status and its quality requirements are very high. Firstly, it is subject to the force of the mutual squeeze between the parts. He was subjected to the shear force of the screw, but these forces were not very large and relatively small. The specific simulation is shown in Fig. 3:



**Fig. 3.** Finite element analysis of steering wheel

The simulation shows that the maximum stress on this part is  $1.594e + 7 \text{ N/m}^2$ , which is far less than the material's yield stress of  $2.070e + 8 \text{ N/m}^2$ .

The next joint of the upper limbs is directly connected to the steering wheel by screws and bears the flexion and extension movements of the forearm. Therefore, this piece of stress is also the largest in the entire mechanism. Impact on him, so the structural strength requirements of this piece are relatively strict, and its simulation is shown in Fig. 4:

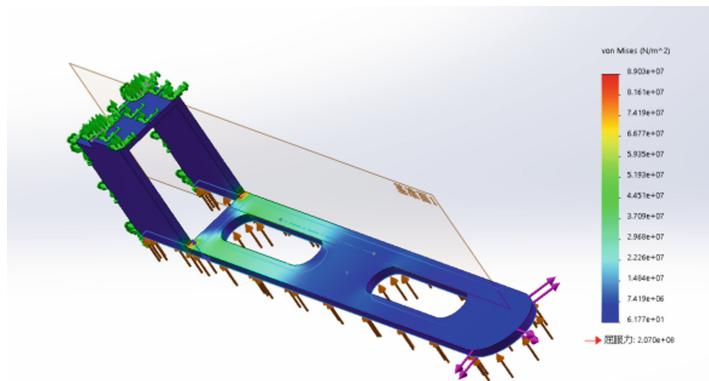


**Fig. 4.** Finite element analysis of upper limbs

This part of the force is relatively large, up to  $1.352e8 \text{ N/m}^2$ , which is still less than the yield stress of the material, so it is qualified.

When it comes to the gear part, the role of this part is mainly to complete the internal and external rotation function of the arm. Because this part has very high wear requirements, and the rail mechanism must withstand the mass of most arms, the strength requirements of this part are also the highest in all designs. Therefore, unlike other parts, I do not intend to use aluminum alloy materials here, and use 45 steel directly to strengthen the structural strength. For the forearm part, we assume that the user concentrates all the mass of the forearm on the forearm exoskeleton, plus the mass of the arm when it naturally sags, the result is shown in Fig. 5:

It can be seen that the maximum stress is  $8.903e7 \text{ N/m}^2$ , which is much smaller than the yield force of the material. In summary, the simulation results of each part meet the requirements for use, and some far exceed the requirements, and generally meet the requirements.



**Fig. 5.** Finite element analysis of the forearm

## 4 Conclusion

The development speed of all aspects of our country is obvious to all. We will usher in a new era. In this new era, our living standard is destined to reach an unprecedented height, which cannot be separated from the hard work of workers from all walks of life. Wearable exoskeleton equipment is also produced from time to time to help stroke patients in need improve their lives and help them recover. Although this design is based on many schemes of previous researchers, it is also a part of self breakthrough for me to transform what I have learned into actual labor achievements. Through the analysis of human skeleton and muscle group, combined with the actual situation of our own, we have clearly defined the movement mode of the upper limb of the human body, and after a little optimization, we have adopted the driving scheme of the steering gear, which greatly reduces the complexity of the structure and has a clear design idea. By using gear transmission skillfully, the output force of the steering gear is transformed into the force to drive the inner and outer rotation of the arm, and the gear and the arm ring of the fixed arm are designed as a whole, which increases the integration of the whole set of equipment, reduces unnecessary design, and greatly simplifies the cost and structure. Different rehabilitation programs have been adopted for different levels of patients, which are purposeful and targeted, more safe and reliable, and suitable for different groups of people.

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# Device of a Multi-functional Baby Cradle

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**Abstract.** Designed a multi-functional, without being limited by the place the baby anti-theft cradle, for baby cradle on the market at present the current situation of the intelligent level is not high, and the baby smart anti-theft system based on RFID technology by the workplace environment limit problem. This baby cradle by STC12C5A60S2, with temperature sensor, weighing sensor, rain sensors, ultrasonic module, audio playback function module, voice detection module and other kinds of sensors and set up the Bluetooth communication network and mature GPRS network, implements the domain bed temperature, weight survey, baby anti-theft, wetting the bed to remind, baby cradle anti-theft, female voice coax function such as sleep, at the same time can be controlled by APP. Through performance test, the results show that the cribs can effectively reduce the nursing pressure of parents, and it has the promotion significance.

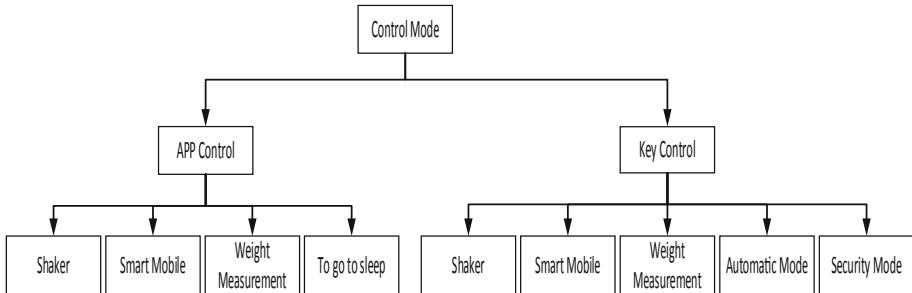
**Keywords:** Sensor · Multi-functional · Guardianship

## 1 Overall Design

Cribs are beds for infants and toddlers. They come in a variety of styles, and the functions and prices are also very different. Safety and practicality are always the primary principles for selecting cribs [1, 2]. In addition to the traditional crib, the crib structure on the market has different functions, giving consumers more choices and experiences. When the baby is asleep and sleeping, the caregiver usually causes the baby to fall asleep by shaking the crib and playing the baby song [3]. After the baby is asleep, the caregiver needs to look after him from time to time, and change the diaper bed when he is crying. And then continue to repeat the doze process, Put pressure on parents. Especially in the middle of the night, young parents are overwhelmed. In order to alleviate the stress of young parents, we designed this multi-functional baby shaker.

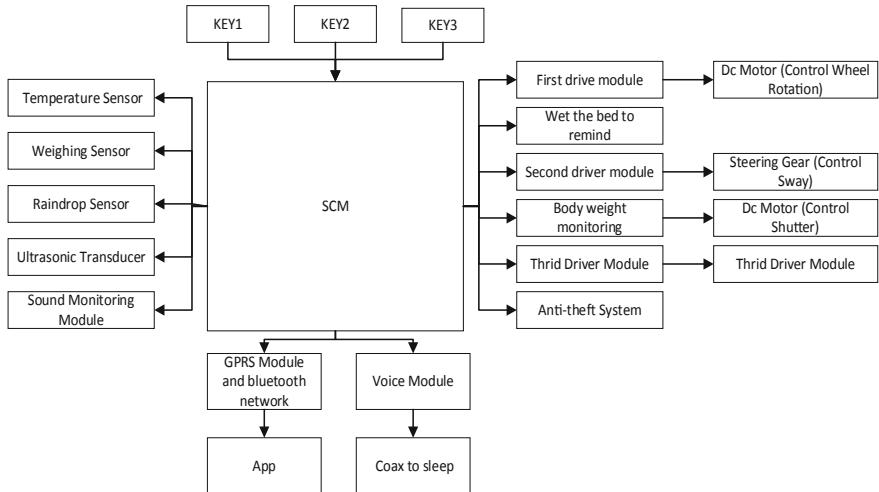
As shown in Fig. 1, the overall function flow chart of the shaker can be controlled by the mobile phone app and the control buttons on the shaker [4]. After entering the safe mode, the function of the baby anti-theft and the baby shaker can be realized. Entering the automatic mode, the function of bedwetting detection and coax sleep detection.

As shown in Fig. 2, STC12C5A60S2 is the main control chip, through DS18B20, raindrop sensor, weighing sensor module, ultrasonic ranging sensor module, sound detection sensor module and other sensors and modules and build Bluetooth



**Fig. 1.** Overall function flow chart

communication Network and mature GPRS network, realize intelligent mobile, bed-wetting reminder, smart shaker, weight detection, baby anti-theft, crib anti-theft [5], bed temperature control, maternal sleep, etc. We can be accessed through APP and shake Control button control on the bed.



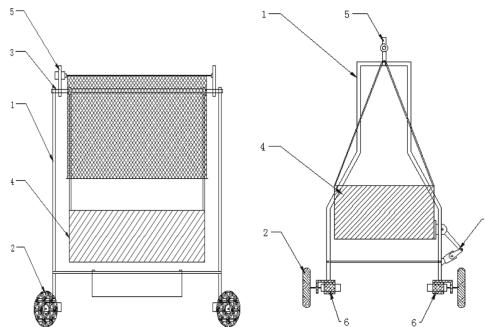
**Fig. 2.** Function control block diagram

## 2 Design of Key Mechanical Component

### 2.1 Shaker Overall Mechanical

As shown in Fig. 3, it is a front view and a left view of the overall structure of the shaker: including a shaker frame 1, four wheels 2 are arranged at the bottom of the frame, and a cross bar 3 is arranged on the top of the shaker frame 1, the crossbar There is a swinging bed 4 and a roller blind device 5 is also arranged on the crossbar. 1 The

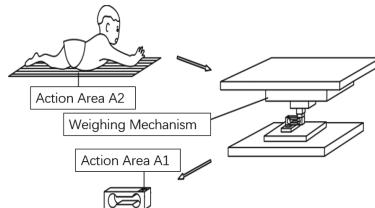
main control box is hung on the bottom beam, 6 is the drive motor of the wheel, and 7 is the shaker device.



**Fig. 3.** Shaker mechanical structure

## 2.2 Mechanical Design of Weighing Sensing Mechanism

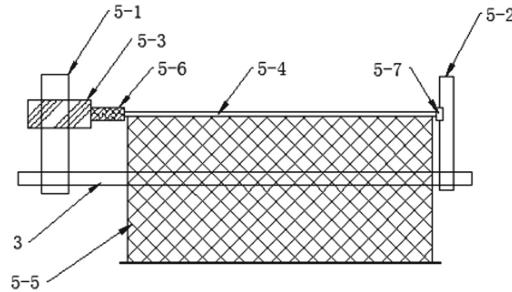
As shown in Fig. 4, since the force area A1 of the cantilever beam load cell itself is small, and the gravity  $g$  of the baby to be measured has a large area A2, it is used in the shape of a bucket archin an ancient building [6]. The model is designed to transfer the weight  $m$  of the infant to be measured by reducing the area of the force until the gravity  $mg$  that needs to be measured acts within the range of the load cell.



**Fig. 4.** Schematic diagram of weighing sensor

## 2.3 Temperature Control Roller Blind Device

As shown in Fig. 5, the roller blind device 5 includes a motor bracket 5-1, a bearing bracket 5-2, a motor 5-3, a roller blind shaft 5-4, and a roller blind 5-5. The motor bracket and the bearing bracket are fixed on the crossbar 3, and the motor is fixedly disposed on the motor bracket in the lateral direction. The output shaft of the motor is connected to one end of the roller blind shaft through the coupling 5-6, and the roller blind shaft is horizontally and horizontally arranged, and the roller blind shaft is horizontally disposed. The other end is fixed on the bearing bracket through the bearing 5-7, and the rolling shaft is rotated by the motor to realize the folding and lowering of the roller blind to realize the bed temperature control [7, 8].

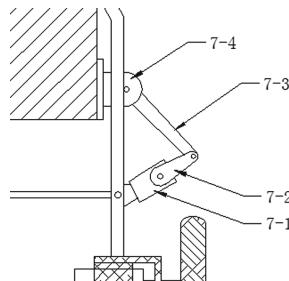


**Fig. 5.** Mechanical structure of the roller blind device

## 2.4 Shaker Device

### 2.4.1 Mechanical Structure of the Shaker Device

An oscillating driving device 7 for driving the swinging bed 4 is arranged between the bottom of the swinging bed 4 and the frame 1 so that the swinging bed can be swung around the crossbar 3. As shown in Fig. 6, the oscillating driving device 7 includes a steering gear 7-1. Rocker arm 7-2, connecting rod 7-3 and hinged support 7-4. The steering gear is fixed on the frame 1. One end of the rocker arm is fixed to the steering output shaft, and the other end is connected to the end of the connecting rod 7-3. Hinged, the other end of the connecting rod 7-3 is hinged with the hinged support 7-4, the hinged support is fixed with the swinging bed 4, the steering gear 7-1 drives the rocker arm to rotate, and the rocker arm drives the swinging bed around the crossbar through the connecting rod swing.



**Fig. 6.** Mechanical structure of the shaker device

### 2.4.2 Working Principle of the Shaker Device

The shaker function can be realized by using the mobile phone app and the buttons on the shaker. For example, if the button is used, the shake time must be set before the shaker, and the time is set to 4 files, corresponding to 1–4 min respectively [9]. If using APP, you do not need to set the shake time in advance, but you need to connect Bluetooth, enter the mobile phone app shaker interface, press the “start shaker”, the shaker will automatically swing, press the “stop shaker”, the shaker will stop Shake and restore the initial position. In the automatic mode, if the sound detection sensor module

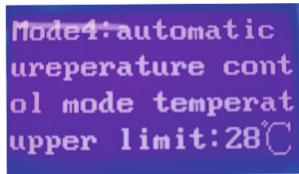
detects the crying of the baby, first shake the bed for 3 s (the time can be set by itself), and stop the shaker when the baby is no longer crying, otherwise An alarm will be sent to inform the parents to deal with it [10].

### 3 Part of the Performance Experiment

#### 3.1 Experimental Process

##### 3.1.1 Bed Area Temperature Control Function Test

When testing this function, press the button to select the mode four automatic mode. Firstly, the room temperature is 28 °C measured by the thermometer, and the maximum alarm temperature set by the shaker is 26 °C. At this time, the motor is rotating the roller blind, as shown in Fig. 7.



**Fig. 7.** Automatic mode interface

##### 3.1.2 Baby Anti-theft Function Test

As shown in Fig. 8, put a simulated baby model into the shaker, press the button to select mode 5 outdoor safety mode, remove the baby after 20 s, and see the display 12864 display content, and receive the call after 8 s. Shown as display 12864 alarm display interface and mobile phone call page.



**Fig. 8.** Child off the bed alert display and mobile phone call page

#### 3.2 Conclusion and Analysis

Through the actual test results of some functions of the shaker, we can see that the functions tested can be achieved and the performance is good, although the

implementation of each function needs to be controlled by the selection mode, it is also because of the function between the functions. The indirect connection makes for each other's functions to work properly without affecting each other. The shaker now has the function of real-time monitoring of the baby's physiological state, improving the monitoring efficiency, reducing the artificial care, improving the quality of the nursing baby, and creating a good growth environment for the baby.

## 4 Conclusion

The following innovative points in the basic intelligent shaker function: (1) After the security mode is locked, if someone tries to take the baby away or steal the baby shaker, the shaker will use the GPRS technology in the network to automatically make a call to the guardian's mobile phone and issue an alarm. (2) When the temperature around the shaker is higher or lower than the set temperature, the shaker will give an alarm reminder, and the temperature control curtain will automatically roll up or put down to prevent the baby from catching a cold. (3) There are two control modes, one is to use the mobile phone app to realize all functions, the other is to use the key switch to realize all functions, the operation mode can be set according to the actual situation.

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# The Exploration and Research on the Open Autonomous Learning Model of Internet Plus Initiative

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**Abstract.** This paper mainly discusses the independent learning model based on Internet plus initiative of college students. This learning model is an interactive link between teachers, students and knowledge in a virtual digital space. It is a link between teacher and student, teacher and knowledge, students and knowledge, students and students, knowledge and knowledge. In the meantime, the interactive relationship is the main element of the space, and the activation of these elements is the students' way of accepting knowledge, learning state and effect, and the method of teachers' virtual teaching. While the influence of space dynamics will also promote the birth of a new learning platform, students can also choose a more comfortable environment for learning to make this intuitive teaching environment well applied.

**Keywords:** Learning model · Autonomous learning · Link

## 1 Introduction

Twenty-first Century is the era of information explosion, people can not live without the Internet, computers and mobile phones which have penetrated into every corner of people's life, online office, learning, conference, entertainment, games, chat, search, online banking, electronic payment, GPS positioning, and so on, to bring people a very rich and colorful life.

For a group of freshmen who are the most receptive to new things, college students are quick to accept new things and highly adaptable. With the help of the Internet and the new learning electronic equipment, in the Internet + open virtual reality space, students can gather knowledge and entertainment on an integrated network to excavate huge amounts of data and fun.

## 2 Learning Model of College Students at Home and Abroad

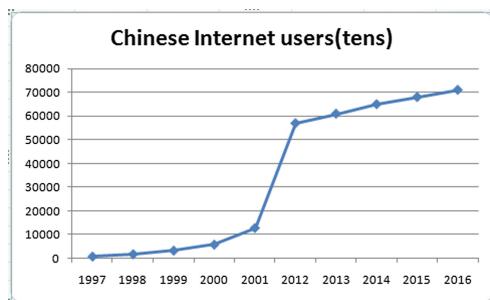
The most advanced mobile science in China was put forward in 2000, the researchers began to study the theory of autonomous learning from then on. In 2001, the Ministry of Education approved the first laboratory of autonomous learning in the laboratory of the modern education center of Peking University, which led the Tsinghua University

and Beijing Normal University to carry out research on autonomous learning projects. In 2006, the mobile Internet information platform and SMS platform provided educational resources, technological innovation and other educational services to the recipient.

Wireless Andrew of Carnegie Mellon University started a series of mobile teaching practice projects in 1994, achieving remarkable results in a period of time. The supplier provided e-Learning and extended it to the m-Learning field, and quickly was launched into the market, which became the innovation education of the industry organization. The research of mobile equipment abroad is also early. The Alan Kay research group of American computer scientist put forward the concept of Dynabook in the PARC study (portable computing with the mobile function of the battery, which configures a variety of software [1]. “In order to provide a good service platform for the learners, the joint Palm company has a program named Palm Education Pioneers Project (the PDA and computer of the company). Later, with the continuous promotion of network computing and mobile communication 2G, 3G, 4G technology, the market is out of the market. Many powerful mobile devices are now available.

According to the latest statistics in July 2017, China has 1 billion 304 million mobile phone users, nearly 90% of whom use mobile phones, ranking the first in the world, and 646 million of them are 4G users. As of June 2016, there were 710 million Internet users in China, and 656 million of users using mobile Internet access, and the number of users using mobile Internet has increased to 92.5% [2].

According to the “report on the status quo of independent learning in China” published by Skillsoft in 2015, the feasibility, use and challenges of autonomous learning in China are analyzed. 95% of the respondents said that self-study benefited them, and 74% believed that autonomous learning could help them acquire new knowledge and new skills. 54% of the users expressed their preference for the content of self-study. Now the number of mobile phone users in China is close to 1 billion 300 million, that is, nearly 90% of people are using mobile phones. The data of 2013 summer homework which was conducted by Baidu showed that 32% of students were asking questions by mobile phones, 200% higher than last year, and the number of mobile phone questions in 2014 is expected to exceed 60% and will increase year by year. There are about 37 million 420 thousand college students in China in 2016, about 37 million 420 thousand college students in various colleges and universities in China, about 37 million 950 thousand college students in various colleges and universities in 2017 [3, 4]. From the survey of Baidu, it can be seen that the use of autonomous learning has increased year by year, and the other related learning type APP is similar. Nowadays, the popularity of mobile Internet is more conducive to the development of autonomous learning, and has created an interconnected platform for autonomous learning, and the potential of autonomous learning is huge (Fig. 1).



**Fig. 1.** Each year Chinese netizens refer to the graph

### 3 The Multidimensional Analysis of the Open Autonomous Learning Model with the Guidance of Internet Plus Initiative

#### 3.1 Characteristics of Autonomous Learning Model

Reproduction of simulated learning scenarios: learners break the restrictions of time and space, they can study joyfully at any time and anywhere. Large data brings resources sharing learning and enjoyment: using the Internet platform, taking advantage of various mobile terminals for selective learning, enjoying the sharing of resources, and also having pleasant interactive learning. The upgrading of technology promotes the growing population of learners: the organic structure of mobile devices and Internet provides learners with a wide learning space. And the trend of this kind of learning is growing.

#### 3.2 Factors Restricting the Model of Autonomous Learning

There are also some shortcomings in autonomous learning. The first one is the limitation of knowledge field. The content of knowledge is different from the same subject. Second, mobile devices are affected by external factors, such as the main storage capacity, the disturbance of the external environment, and the network bandwidth, which cause the low emotion in the learning process. Learners' learning efficiency is low, learning content is limited, and the evaluation of learning effect is more difficult.

#### 3.3 The Group Analysis of Autonomous Learning Model

The first is that the learning group is limited by age, geography and time, and the demand is uncertain. The knowledge domain of learning is uncertain [5]. Therefore, users, potential users, and peripheral users are three basic groups of users in the outer circle, but the classification of the 3 groups is not fixed, but in constant conversion and addition according to the function of the system and extension. Therefore, we should choose local diffusion method and small range location in user group processing.

### 3.4 The Research on Independent Learning Model Equipment

The equipment that supports random autonomous learning is called autonomous learning equipment. With the rapid development of science and technology, the learning equipment is constantly changing the birthday crescent. At the same time, various new learning products have emerged as the time requires. It is a bridge between the learners and the learning environment to communicate with each other. In the process of learning, it has its cognitive and logical judgment and storage function, and it is easy to carry and carry on the infinite network data transmission without the limitation of place and time.

Nowadays, there are various types of learning equipment for college students, such as smart phones, IPD, tablet computers, learning dictionaries, etc. Because of the wide coverage of modern mobile communication, mobile phone technology is also very mature, large screen, high resolution, good sound quality, light volume, unimpeded 4G network, 100 megabytes bandwidth, easy access to web pages and video, so the mobile phone is the preferred device for students.

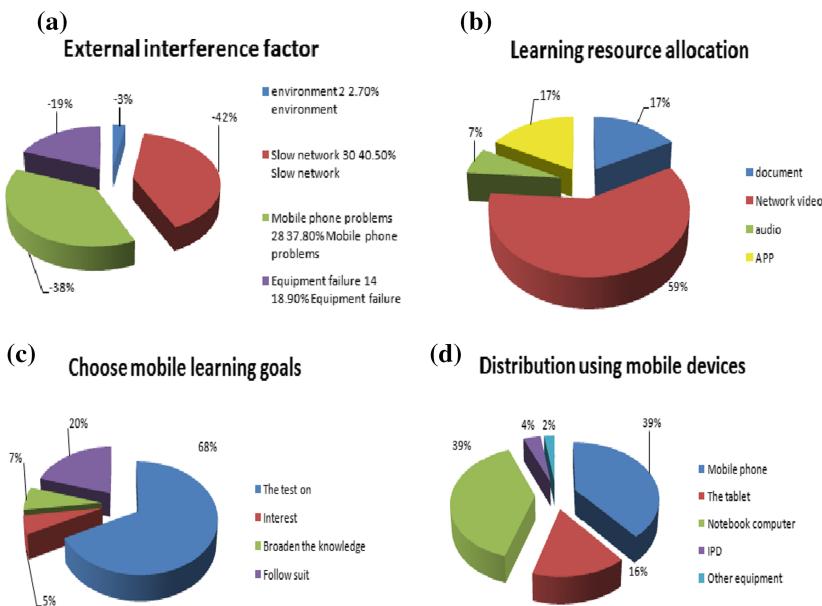
## 4 The Analysis of the Results of Multi-style Questionnaire

We can discuss the students' acceptance of autonomous learning through the questionnaire, on their specific requirements of the mobile devices that they uses, the requirements of learning resources, and the factors that affect the self-learning factors of college students.

The study was conducted by the students of Agriculture Science And Technology College, which were investigated by the PPS sampling survey method. The subjects were major, sophomore, junior and senior students, including electronic information science and technology, computing science and technology, network engineering, electrical and automation, chemistry, English, gardening, A total of 74 students, including Chinese medicine, animal medicine, biotechnology and accounting, were sampled. The following four aspects are intercepted to analyze college students' autonomous learning habits: one affects college students' autonomous learning factors (Fig. 2a); two is college students' demand for autonomous learning resources (Fig. 2b); three is the choice of mobile devices to influence learning efficiency analysis (Fig. 2c); four is the purpose of students' use of autonomous learning (Fig. 2d).

### 4.1 An Analysis of the Factors Affecting the Autonomous Learning of College Students

In the way of learning, college students generally use Internet to search engines and borrowing books or online video teaching, so 40% students think that the slow speed of the Internet is the main factor; and the 38% students consider the mobile phone problem (the screen is small, the quality of the screen causes visual fatigue), and 19% students think that the use of mobile devices failure (memory is small or equipment outdated) will affect learning. Only 3% of students hold the belief that the external environment is also affected. At the same time, the habit of independent learning is



**Fig. 2.** Questionnaire results analysis table

different among the students of different majors. Most majors use the highest proportion of vocabulary translation classes. For the students of liberal arts, the proportion of APP and borrowing books is large, and the students of science and engineering specializes in the use of professional technical tools (video teaching and software download) [6–8]. The effect is different from day to day, because the emphasis is different, but the students of science and engineering are relatively efficient, because the students of science and engineering have a higher concentration.

Freshmen and sophomores choose to do more online translation and audio teaching, because they have to take part in CET-4&CET6, and their autonomous learning helps to listen, speak and read, and the most obvious is vocabulary translation. The training and learning of the section mainly examines the ability to solve problems independently, so they will use all the time to learn, and they tend to study independently (using PC terminal to choose video) and solve problems in time. At this time, they do not focus on the examination, but focus on solving the problem.

#### 4.2 An Analysis of College Students' Demand for Autonomous Learning Resources

According to the data, it can be found that college students generally use Internet search engines and borrow books or online video teaching, 59% students choose network video teaching, 17% students search engines and borrowing books through Internet, 17% use APP to learn, 7% students use walking time to listen to audio, but these are not absolute, like watching online video, and with relevant learning materials.

### 4.3 The Analysis of the Learning Efficiency that Was Influenced by the Selection of Mobile Devices

In the questionnaire, each student has mobile phone according to own family conditions, 39% students choose the mobile phones and notebook computers, 19% students choose tablet computer, and 2% choose other devices. The first machine can be studied at anytime and anywhere, but the students who are using mobile phones, notebook computers, and other social software such as WeChat or QQ, are easy to distract their attention which may cause the problem of lacking their concentration. APPs of learning types can not meet the requirements of students' communicating in their daily lives and with teachers. At the same time, the learning software for some practical and strong professional learning can not meet the actual needs of the students, and the efficiency of autonomous learning is generally considered not high.

### 4.4 An Analysis of the Purpose of Autonomous Learning

From the data of the above analysis, it can be concluded that the main use of mobile applications for college students is to deal with the exam. 64% of application is to deal with the exam, followed by 5% of interests, 7% of widening knowledge, and only 20% for the application of the casual entertainment and the edification function. Music APP is related. The increase in the frequency of college students occurs mainly in the case of problems or before the exam, and 47.52% students will also use APP to learn when they meet some of the boring lectures or activities of which is up to 64%. Thus, it can be seen that the use of mobile devices for college students is mainly for the use of the examination, which provides a development direction for the designers of developing APPs of learning types [9, 10].

### 4.5 The Analysis of Other Factors

With the purpose of Fully investigating the problems and requirements of College Students' transfer learning. We take fully consideration from the perspective of users through questionnaires. For example, to increase the attraction of the students for the learning system, and to add the catering telephone and address, the page is more convenient, the UI is more exquisite, and the user can greatly improve the use efficiency. Therefore, we can create a more suitable learning platform for the vast number of users from the perspective of users.

## 5 Problems in the Open Learning Model

Due to the limitations of mobile devices and the current trend of educational reform, the promotion of autonomous learning is lagging behind. And today's various manufacturers and education and training institutions have been involved, because they have a strong backing and strong strength of the R & D team, so the current autonomous learning equipment and functions are limited to these manufacturers and education and training institutions.

This open way of learning has changed the traditional way to acquire knowledge and interchangeably in space. It not only improves the students' interest in learning, but also improves the professional level of the teachers. At the same time, it also promotes the optimization of the online resources under the line of the educational institutions. The key is to drive the development of the third party electronic industry. But there is still a lot of problems in the study of autonomous learning. Students' own learning efficiency, hardware updates, etc., but with the reduction of the future wireless mobile equipment and communication costs, the improvement of hardware and the continuous improvement of the software platform, a large number of service providers have been used to promote it. It is believed that in the near future, autonomous learning will soon be extended to various institutions and other educational institutions.

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# Algorithm Design of Dynamic Question Answering System Based on Knowledge Base

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**Abstract.** This paper presents an ongoing study of the structure and operation of a dynamic question answering system. The main result of this paper is to use architecture to master more intelligent answers. This system is designed for the natural language process in the open domain of knowledge base of HowNet on the basis of knowledge base. Natural language processing can get better results. At the same time, the system has the ability of learning through the update of database. The purpose of this system is to improve the search speed and search the answers accurately. This paper improves the algorithm from three aspects. In text clustering, the new ant tree algorithm is used to replace the original k-means algorithm to accelerate the clustering. When decomposing keywords, we combine classic algorithm and knowledge base of HowNet to understand natural language with high precision. When we do the answer extraction, we should consider the necessary factors to improve the old algorithm. By testing the prototype of the dynamic question answering system, the improved algorithm is proved to be effective.

**Keywords:** Dynamic question answering system · New ant tree algorithm · Natural language · Answer extraction

## 1 Introduction

In the early stage of network development, what search engine presents is to provide an online search platform, which is really convenient for users. But with the rapid development of Internet technology and information technology, the explosive growth of online information has brought some problems to search engines. So the traditional search engine seems to be difficult to meet the needs of users. The question answering system in this paper is put forward under such conditions, and it seems to be a more accurate and fast way to obtain information. Design concept, operation principle and expectation are different from the current keyword search, which is a high level of information retrieval [1, 2]. However, Q & A system can never replace traditional online search. To some extent, this is just the development of search engine, which can understand natural language and facilitate users to obtain information through more friendly interactive programs. This will revolutionize the way people get information from computers and the Internet, which has important theoretical and practical value.

## 2 Proposed Architecture

### 2.1 Dynamic Question Answering System

The traditional Q & A system starts from the user, the user asks questions, puts them into the system. Compared with the traditional Q & A system, two steps are added:

- (1) After the answer is returned to the key user, let the user make a satisfaction evaluation. If yes, we store the question and answer into the database matching the question and answer. If no is selected, we return the question to the manual answer, which we call user 2.

In fact, in our system, there are two groups of users who deal with different information. At the same time, there are two groups of information in our system. One group is the question, the other is the answer. User 1 enters the question into the system and gets the answer. User 2 enters the answer into the system and then gets the question.

- (2) After the manual answer, we will send the answer to user 1 again to let the user evaluate again. If yes, store the result. If no, repeat step 2 again.

### 2.2 Main Algorithm Based on Knowledge Base of HowNet

HowNet is a knowledge base that explains the relationship between concepts and the relationship between their attributes in Chinese and English. HowNet divides the concepts of all words in the objective world into four categories, namely entity, event, attribute and attribute value. The original semantic elements are used to explain the concept.

Knowledge database markup language (KDML) is used to describe the definition of a concept in HowNet. KDML uses def semantic pattern to define a concept. Def describes the semantic properties of words and phrases in detail [3].

## 3 Natural Language Processing

### (a) OPEN NLP

In the dynamic question answering system, we choose NLP tool package to build the natural language processing process. The Apache Open NLP is a machine learning toolkit for natural language processing. It contains many kinds of natural language processing components based on Java. The analysis focuses on the five core components of NLP, namely, tokenization, word segmentation, part of speech tagging, sentence segmentation and parsing. Open NLP is a uniform package based on machine learning, that is, maximum entropy (me). The principle of the maximum entropy of any fact set is to select all the models that conform to the fact and to be as uniform as possible. Every Open NLP tool requires a me model. In order to test the Open NLP component we considered, two main biomedical corpora, genia corpus and pennbio i.e. corpus, will be adopted [4]. It contains the most detailed relevant annotation for syntactic analysis in the biomedical field. We will cross test all corpus tools in two corpora.

(b) Shallow Parsing

Shallow parsing is a kind of formalized description, which reflects the meaning of a sentence by its syntactic structure and the meaning of each word in the sentence. The functions of shallow semantic analysis of question answering system are mainly embodied in: semantic disambiguation, syntactic ambiguity and semantic relations [5].

(c) Problem Classification

Problem classification refers to defining a set of classes according to a certain classification standard, then judging the categories of problems according to a certain calculation and assigning the problems to a certain set. From a mathematical point of view, problem classification is a mapping process, mapping unclassified problems to existing categories. This mapping process can be one-to-one or one to many, because problems are often connected to many classifications. The classification method used in this paper uses the combination of question words and question focus to classify, and defines the following eight categories of questions, which is shown in Table 1.

**Table 1.** Problem classification

Question classification	Question words examples	Expected answers	Examples
About people	Who	Name	Who put forward evolutionism?
About location	Where	Location	Where host the 2020 Summer Olympic Games?
About time	When	Time	When is the first time that human landed on the moon?
About number	How much	Number	What's the area of Taiwan?
About definition	What	Explain	What means artificial intelligence?
About method	How	Explain	How to look energetic every day?
About reason	Why	Explain	Why does bird flu happen?
Other	...	Complex	What brands of famous clothes are there in the world?

## 4 Algorithm Improvement

(a) Cluster Analysis

In the open field question answering system, especially in the enterprise, there is a large amount of data in the knowledge database. In the question answering system, we call these texts questions and answers. With the passage of time and the real-time update of the database, the data will grow rapidly. As a result, the phenomenon of information overload will often occur.

(b) New ant tree algorithm

In this Q & A system, we improve the traditional clustering algorithm. We combine k-means algorithm with ant tree algorithm. The new improved algorithm is ant-tree algorithm based on K-means algorithm. Major improvements will be explained in detail in this section. Ensure the initial sequence of ants connected to the root; we want ants connected to the root to be closer to the cluster core. Therefore, a silhouette coefficient is proposed, which combines similarity and dissimilarity. For individuals:

$$S_i = \frac{b_i - a_i}{\max(a_i, b_i)} (-1 \leq S_i \leq 1) \quad (1)$$

$a_i:d_i$  and the mean difference of other members in the same group,  $b_i:d_i$  and the difference mean of the closest group members. Overall:

$$S_k = \frac{1}{n} \sum_{i=1}^n S_i \quad (2)$$

k: Number of clustering groups,  $S_k$ : silhouette factor. Calculate the mean value of silhouette Technology:

- (1) K-means clustering algorithm gets the initial clustering group, and the number of groups is K.
- (2) Create an array to store the cluster values. The size of the array should be k elements. Each element represents some cluster groups, and store the side shadow factor values of each group in descending order.
- (3) Select the first ant of each group, and then transform it into a single node ant tree.
- (4) Iterate until the array is empty [6, 7].

### i. Similarity of knowledge base based on HowNet

According to the traditional algorithm, the similarity of words is  $\text{Sim}(w_1, w_2)$ , which is related to the distance between words  $\text{Dis}(w_1, w_2)$ .

$w_1, w_2$ : word 1, 2

$$\text{Sim}(w_1, w_2) = \frac{a}{\text{Dis}(w_1, w_2) + a} \quad (3)$$

a: Adjustable parameters

We use the algorithm based on HowNet database to calculate the similarity after clustering:

First, introduce some definitions:

Similarity between words

w1: word

w1i: It contains n concepts S11 ... S1n

w2j: contains n concepts, S21 ... S2m

$$Sim(w_1, w_2) = \max Sim(w_{1i}, w_{2j}), i = 1 \dots n, j = 1 \dots m \quad (4)$$

Sentence similarity:

Weighted average algorithm.

Establish matrix R (m, n): sentence a has m words, sentence B has n words.

Similarity between ab: the sum of similarity between two words in the matrix

$$S = \sum_{i=1, j=1}^{m, n} R_{ij}(mn) \quad (5)$$

Text feature extraction:

The text t contains P sentences. Establish a matrix RPP similar to R,

$$M_p = \sum_{i=1}^P S_{pi} \quad (6)$$

Finally, we choose the highest value of  $M_p$  as the text feature.

## ii. Similarity test results

Now let's test some sentences and paragraphs with algorithms. Similarity Estimation Results is shown in Table 2.

**Table 2.** Similarity estimation results

R	Beijing	Shanghai	Are	Two	Big	City
They	0.04444	0.04444	0.074074	0.074074	0.04444	0.04444
Both	0.07333	0.07333	0.068254	0.048971	0.86111	0.8
Belong	0.04444	0.04444	0.285714	0.074074	0.04444	0.04444
China	0.90741	0.90741	0.655026	0.047462	0.65503	0.64074

S Beijing and Shanghai are two big cities	Beijing and Shanghai are two big cities	Beijing is in the north and Shanghai is in the south	They both belong to China
Beijing and Shanghai are two big cities	1	0.262653	0.32505
Beijing is in the north and Shanghai is in the south	0.262653	1	0.218664
They both belong to China	0.32505	0.218664	1

	Beijing and Shanghai are two big cities	Beijing is in the north and Shanghai is in the south	They both belong to China
$M_p$	1.587703	1.481517	1.543714

(c) Keyword Extension

Suppose the number of keywords in the problem is  $m$ , where the number of extended keywords is  $n$ ,  $t$  is a positive integer, and the initial value is 0. It is known that  $m \geq n \geq 0$  [8].

According to the input problem, through problem analysis and synonym query, the values of  $M$  and  $N$  are obtained.

(d) Answer Extraction

Considering the defects of traditional VSM algorithm, we take the following factors into account:

The order of keywords, the distance between keywords, the length of questions and answers.

Next, we will show the advanced VSM algorithm in detail.

Answer: a (vector)

$n$ : Number of words

$a_j$ : the number of times  $J$  appears in a

$Q$ : Problem (vector)

Cosine: the correlation between questions and answers

## 5 Q & A System Test

Based on the previous research and existing environment, the Q & A system will be evaluated from the following aspects.

(1) Experiments to verify the accuracy of problem classification

In the stage of understanding questions, if there are errors in the analysis of question types, the answer extraction will also be incorrect. Therefore, first of all, test the accuracy of problem type recognition, and compare with the general problem classification method. The general problem of classification method is to extract the question words to get the type of recognition results [9].

(2) Experiment of testing keyword expansion results

This experiment is to complete the extraction of simple segmentation and general problem keywords, then retrieve relevant documents, in addition to completing keyword expansion, and then you will get results through Google search.

(3) Test of semantic role annotation results

Three common evaluation indexes are used to test the results of semantic role tagging. Precision (P), recall rate R and degree F. The calculation is as follows:

$P =$  mark the correct semantic block and the total number of semantic blocks marked.

$R =$  mark correct semantics quickly, the total number of special envoy corpus and the total number of semantic blocks.

After analysis and statistics, we get some factors that affect the accuracy of the system, which have nothing to do with the performance of the system itself, but cannot be avoided. One is user input error. The system may not be able to analyze the problem

due to the wrong type input by the user. The other is search online. The main problem of network search analysis algorithm is that after Google search domain engine searches some keywords, the keywords on the feedback page are not marked red, so it will cause the consequence that the named entity recognition module cannot be identified [10, 11].

## 6 Conclusions

This paper focuses on the description of QA system prototype framework and three new algorithms of each component in the framework. It also provides a deeper insight and Analysis on information retrieval and problem understanding in QA system. In addition, through the test part of the prototype system, it can be concluded that the method proposed in this paper is proved to be reasonable and practical with theoretical basis.

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# K-Means Algorithm Based on Initial Cluster Center Optimization

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**Abstract.** K-means algorithm is a kind of algorithm with higher frequency at present, but with the continuous research, this algorithm gradually exposes some defects in practical application, which is manifested in the choice of random and sensitive noise points, which is difficult. Get accurate and reliable clustering solutions. Aiming at this kind of defect, a K-means algorithm based on the distance density of noise points is proposed. Specifically, it uses the effect of density and distance on the cluster center to perform weighted analysis and prediction of the randomness of its data. Processing, based on the determination of data weights, further introduce the “minimum and maximum principle”, which can automatically select the initial clustering center and determine the number of clustering centers. The research results show that this new algorithm can meet the expected requirements, which can not only ensure the accuracy and reliability of the optimization results from the source, but also help people to conduct a more comprehensive and rigorous analysis of the data.

**Keywords:** K-means algorithm · Distance density · Cluster center

## 1 Introduction

Cluster analysis technology is one of the important basic research topics in the current data mining technology. The so-called clustering refers to putting data objects with high similarity according to the attributes of the input records themselves and the relationship between each other. A cluster analysis technique that tries to place other data objects with high dissimilarity in different clusters in a cluster at the same time. The algorithm is the most representative type of machine learning algorithm. A large number of practical studies have clearly confirmed that this algorithm combines multiple advantages into one, with simple operation and reliable results.

In the original K-means method, the initial cluster is usually randomly selected. Obviously, this randomness will lead to unstable clustering results. To solve this problem, many K-means initialization methods have been proposed. For example, [1] proposes an improved K-means algorithm based on dissimilarity, and selects the initial centroid based on the Huffman tree composed of the dissimilarity matrix. Literature [2]

proposed a method using reverse nearest neighbor (RNN) search to select the initial centroid. Reference [3] combined the data density distribution and kd-tree to select the initial centroid. Literature [4] selected the initial clustering center based on the sample spatial distribution information, the size of the variance of each data sample, and the average distance between samples. Literature [5] proposed the idea of selecting initial clustering centers based on the idea of global optimization. The algorithm obtained k initial clustering centers by running the K-means algorithm multiple times. However, due to the large computational cost and time cost of selecting the initial centroid, a fast global K-means clustering algorithm is proposed in the literature, which improves the method of selecting the initial center and shortens the clustering time. Based on the algorithm proposed in [6], this paper studies the problem of further improving the efficiency of the clustering algorithm, and proposes an efficient K-means algorithm based on the initial clustering center optimization. Some of the information is used in the next iteration to reduce part of the calculation and improve the efficiency of algorithm execution.

## 2 Related Definitions

### 2.1 Document Representation

In this subject research, after considering and comprehensive analysis in various aspects, the author chose the vector space model. Reference [7] introduced the vector space model.

$$b_i = (\omega_1(b_i), \omega_2(b_i), \dots, \omega_j(b_i), \dots, \omega_n(b_i)) \quad (1)$$

$\omega_j(b_i)$  Reflects the frequency and weight of the j-th high-frequency feature term, In this design, the author chooses the TF-IDF which is currently favored by the industry to obtain the feature item weight, reference [8] mentioned the use of TF-IDF. However, high-frequency features will have an adverse effect on low- and medium-frequency features. In order to effectively reduce this effect, the model needs to be normalized. The calculated formula for the weight of the feature term can be expressed as

$$\omega_j(b_i) = \frac{tf_j(b_i) \ln(N/n_j + 0.01)}{\sqrt{\sum_{j=1}^n tf_j(b_i)^2 \ln^2(N/n_j + 0.01)}} \quad (2)$$

### 2.2 Document Similarity

For a document, its similarity can be expressed as

$$similarity(b_i, b_j) \quad (3)$$

The cosine can be used to determine the angle between the two vectors. If the inner product is zero, it means that they are orthogonal to each other and the two documents are not similar. Its evaluation formula can be expressed as

$$\cos \theta_{ij} = \frac{\sum_{k=1}^n b_{ik} b_{jk}}{\sqrt{\sum_{k=1}^n b_{ik}^2} \times \sqrt{\sum_{k=1}^n b_{jk}^2}} \quad (4)$$

Among them,  $b_{ik}$  and  $b_{jk}$  represent the weights of the k-th feature terms of documents  $b_i$  and  $b_j$ , respectively.

### 2.3 Objective Convergence Function

The K-means target convergence function can be determined by

$$E = \sum_{i=1}^k \sum_{x \in c_j} |x - m_i|^2 \quad (5)$$

When performing a clustering operation, the final convergence value of E is usually dynamic. As long as the floating change of E is significantly reduced, and it hovers steadily in a certain interval, this indicates that reliable clustering results will be obtained, and there is no need to do anything.

Among them,  $E$  represents the sum of squared errors, and  $x$  is the average value of all the clustering documents of  $c_j$  in the clustering cluster.

### 2.4 Document Distance

In the generated document set  $BL$ , the document distance  $b$  reflects the degree of relevance between it and other documents, and is usually evaluated by the following formula

$$distance(b) = \sum_{x \in BL} similarity(x, b) / N_{BL} \quad (6)$$

The above parameters are explained in detail. The denominator reflects the total number of documents, and the numerator reflects the sum of the relevance of the target document to other documents.

### 2.5 Core Document

If the density of document  $b$  is greater than or equal to the threshold  $refSimilarity$ , the document is defined as the core document.

Objectively speaking, using the density of outliers can not only directly obtain the core documents based on noise, but also effectively overcome the shortcomings and deficiencies of the local optimal solution. In practice, people are more inclined to disprove the method: if the outlier has a large noise. It is regarded as a very important core document and has no similarity to other documents. It is learned through function calculations that the density of documents with noisy points is basically close to 0.

Obviously, this violates the definition standard of core documents. Therefore, a document with noisy points cannot be selected as the core document.

### 3 Related Algorithms

#### 3.1 K-Means Algorithm

The advantages of the K-means algorithm are described in [9], including simple operation, wide search range, and powerful computing functions. Even if it is applied to local cluster analysis of large data sets, it can still provide reliable and fast calculation speeds. Accurate analysis results. Next, the author will focus on the following detailed description of the operation steps of this algorithm

Step 1: Use k values to set k initial cluster centers.

Step 2: Calculate the distance between each object and the center, and make a unified distribution according to the nearest principle.

Step 3: Calculate the average of each cluster and treat it as an independent new cluster center.

Step 4: If the termination requirements are met, the calculation will be stopped immediately, otherwise the operation will be repeated and step 2 will be repeated.

#### 3.2 Cluster Selection Algorithm for Initial Clustering Based on Distance and Density

A DBSCAN algorithm proposed in [10] is an algorithm that is currently used more frequently. Its biggest feature is to calculate the density as an object. Specifically, it subdivides clusters of areas that reach a certain density level, and searches for various shapes through database retrieval. Clusters, and efficiently organize these clusters, thereby generating a large collection with density as the correlation. The author was inspired by this algorithm and proposed a new Initial Center algorithm. First, all core document objects must be retrieved, and then K weakest similar core documents are filtered out, and this is used as the initial cluster center. Proceed as follows

Step 1: Take the specific document set blogList as the object, determine the correlation K between two random documents through formula calculation, and import the obtained result into the matrix docSimilarity.

Step 2: With docSimilarity as the starting point, the average value of the similarity of the documents is determined through formula calculation, and the documents higher than the density threshold are selected, and a new set coreDocs is generated by inductive integration.

Step 3: Define the first core document in the coreDocs set as the first initial clustering center point center, then clear this document from the coreDocs set, set the count variable to nk = 1, and consider center [1] as the latest clustering center point.

Step 4: Completely and comprehensively search the existing core documents in the coreDocs collection, and select the document with the lowest relevance to the latest clustering center point, and define it as the next initial clustering center point, and also import it to centers, And then clear this document from the coreDocs collection.

Step 5: Update the current cluster center point, and make  $nk = nk + 1$ , return to Step 4.

Step 6: Follow the above two steps to perform a loop operation until the value of  $nk = K$ , generate centers, and finally end.

### 3.3 Improved K-Means Clustering Algorithm

The first step uses the center selection algorithm proposed in [11] to generate the first cluster center, the idea of center point selection according to [12]. The second step uses the conventional K-means algorithm to re-calculate the center point of the cluster, and repeats the operation around this step until the cluster center point tends to Stable, so you can get the most suitable bidding data clusters.

Given the bidding information file  $blogList = \{b_1, b_2, \dots, b_n\}$ , the initial cluster center point set is initialized, and the cluster  $clusters = \{clu_1, clu_2, \dots, clu_K\}$  is initialized, where  $K$  is the number of clusters.

The operation process can be detailed as follows

Step 1: Determine the correlation between document  $b_i$  and the initial cluster center document; and import  $b_i$  into clusters according to the nearest principle.

Step 2: Find the initial clustering center again, until the value does not change, you can update  $centers' = \{c'_1, c'_2, \dots, c'_K\}$ , and clear all the documents stored in clusters for the next clustering.

Step 3: Repeat iteration Step1 and Step2 until E converges.

Step 4: Output result.

## 4 Experimental Results and Analysis

### 4.1 Data Set

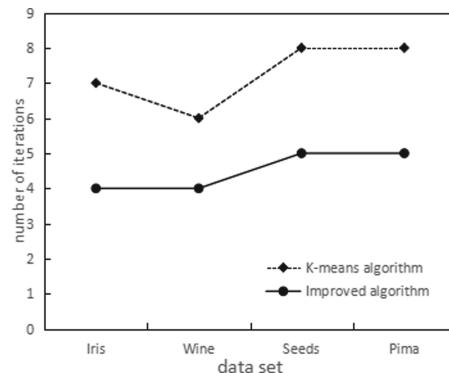
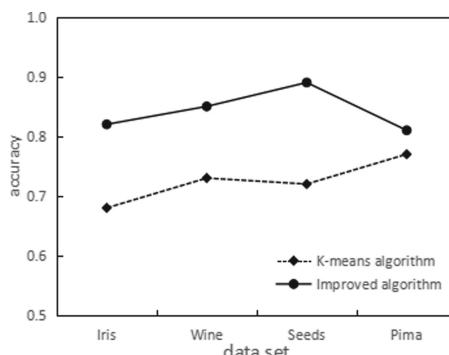
In order to verify the effectiveness of the improved algorithm in selecting the initial clustering center, a UCI dataset was selected to test the performance of the clustering algorithm. UCI is a database for machine learning proposed by the University of California. It is a commonly used standard test data set. The experimental data set has clear classifications, so you can directly observe the quality of clustering. Experiments were performed on the four data sets of Iris, Wine, Seeds, and Pima. The number of iterations and accuracy were used as performance indicators, and compared with the traditional K-means algorithm and the improved algorithm in this paper (Table 1).

**Table 1.** Dataset description

Dataset	Number of samples	Number of features	Number of categories
Iris	200	4	3
Wine	180	12	3
Seeds	621	22	3
Pima	328	6	3

## 4.2 Experimental Results

Different features in the data set often have different dimensions, and this situation will affect the final classification effect. In order to eliminate the dimensional influence between the indicators, the data is preprocessed by normalization, so that each feature is in the same order of magnitude and participates in the algorithm's execution reasonably. Specifically, the Min-Max Scaling method is used.

**Fig. 1.** Number of iterations**Fig. 2.** Accuracy

During the experiment, it was found that the selection of the initial clustering centers of the K-means algorithm has a certain randomness, resulting in unstable accuracy and the number of iterations. It can be seen from Figs. 1 and 2 that the improved algorithm proposed in this paper has the optimal number of iterations and accuracy on the data set. It can be seen that the improved algorithm can achieve better clustering when processing low-dimensional and high-dimensional data Effect and efficiency.

## 5 Conclusions

To sum up, in this subject research, the author relied on professional algorithms to expand and upgrade traditional algorithms, and proposed a feasible method that can accurately and efficiently select clustering centers, ensuring the clustering results from the source. Reliability and authenticity. Compared with traditional algorithms, the advantages of the improved algorithm are not only reflected in the accuracy of the clustering results, but also improve the operating efficiency of the algorithm. Experimental verification has been performed on the UCI data set. Results and validity in clustering time.

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# Intelligent Agriculture - Agricultural Monitoring and Control Management System

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**Abstract.** In the past, agricultural production was affected by changes in the farming environment and the weather, and production conditions were also changeable. However, with the continuous development of society, the continuous progress of science and technology, the accumulation of means of subsistence, human beings have a new definition of agriculture, and intelligent agriculture will become the development trend of agricultural production in the future. Intelligent agriculture refers to the detection of various important influencing factors in agricultural production, connecting various information through the network, so as to realize the intelligent management, remote monitoring and resource sharing of these factors, improve production and scientific management and control. With the development of the Internet of things (IoT) technology and the great changes in the mobile application market, the present life has gradually developed into a mobile-centered, intelligent and diversified life. People can monitor the status of the field, remotely manage and control the light or water anytime and anywhere through their mobile devices or the Internet. Under this large industry background, in order to expand the application of Internet of things technology in intelligent agriculture and explore the core technology of Internet of things, relying on its three-terminal framework technology: sensor, server and application, the project of “Intelligent agriculture - agricultural monitoring and control management system” based on C/S framework is designed and implemented.

**Keywords:** Internet of things technology · Greenhouse · Intelligent control

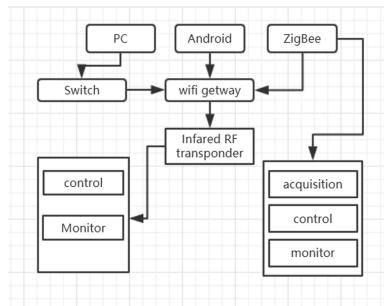
## 1 Function Introduction

### 1.1 Function Overview

The agricultural monitoring and control management system mainly realizes the management and monitoring functions of the field conditions. It is mainly composed of three parts, namely the sensing end, the server end and the application end. The sensing end is composed of ZigBee wireless communication system, infrared radio frequency

central control, various sensors and controllers, forming a wireless transmission control network [1], receiving control commands and return data from the application end. Its main functions include data collection, electrical control and alarm monitoring. In the data collection, sensor data such as temperature and humidity, light intensity can be collected. Electrical control can control lights, sockets, electric curtains, irrigation equipment, etc. Alarm monitoring mainly includes fire alarm, leakage detection and other functions. The main function of the server is to establish the WiFi server, respond to the command request from the application, parse the request data, and send the requested operation to the sensor through the serial port. Then process the data of the sensor side and send the data to the application side to realize the transfer service [2].

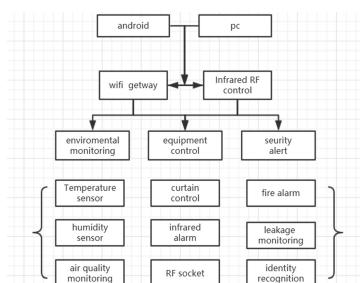
The application side adopts C/S system architecture, and realizes remote control and monitoring of intelligent agriculture through the control interface on the server. The system structure is shown in the following figure (Fig. 1):



**Fig. 1.** System structure

## 1.2 Functional Classification

See Fig. 2.



**Fig. 2.** Functional classification

### 1.3 Functional Description

- (1) Environmental monitoring  
Collecting the environmental data collected by the smart sensor and transmitting it to the mobile client for display, mainly including the following three types.
- (2) Temperature monitoring  
The temperature of the environment is collected by the temperature sensor and transmitted to the mobile client for display after data processing [3].
- (3) Humidity monitoring  
The humidity of the environment is collected by the humidity sensor and transmitted to the mobile client for display after data processing.
- (4) Air quality monitoring  
The ambient air quality is collected by the PM 2.5 sensor and transmitted to the mobile client for display after data processing.
- (5) Electrical control
- (6) Curtain control  
The relay switch on the child node is controlled by the Zigbee wireless network to control the electric curtain.
- (7) Infrared alarm  
The remote control operation of the infrared alarm is carried out through the infrared central control repeater, including the functions of device on/off, voice mode switching, volume adjustment, music selection and broadcasting, and alarm.
- (8) RF socket  
The RF central control transponder is used to operate the RF socket remotely, and turn on or off the socket power.
- (9) Security alarm
- (10) Fire alarm  
Fire alarms on the child nodes are monitored through the Zigbee wireless network. In case of fire, the mobile client and the Zigbee child nodes will alarm automatically at the same time [4].
- (11) Leakage detection  
The water leakage alarms on the child nodes are monitored through the Zigbee wireless network. When the water pipe leakage is detected, the mobile client and the Zigbee child nodes will alarm automatically at the same time.
- (12) RFID identification  
The RFID sensors on the child nodes are queried through the Zigbee wireless network. When the user swipes the card, the IC card code will be directly transmitted to the mobile client for processing.
- (13) Video surveillance  
The video data stream is collected in real time through the webcam and transmitted to the mobile client, which is convenient for users to call the camera to view the monitored environment.

## 1.4 Performance Requirements

The system shall meet the following performance requirements:

(1) Data accuracy

Environmental temperature, humidity, air quality and other information can be queried through the mobile client.

The accuracy of the numerical value is required to be accurate to one decimal place, but when it is displayed, the collected data will be rounded [5].

The frequency of spontaneous data or polling of Zigbee child nodes cannot exceed 7.5 s.

(2) Time characteristic

As the system is a real-time display mode, it requires that the data displayed by the mobile client be updated every 3 to 5 s.

Video surveillance playback requires short delay, smooth video display, as clear a picture as possible and a small memory footprint.

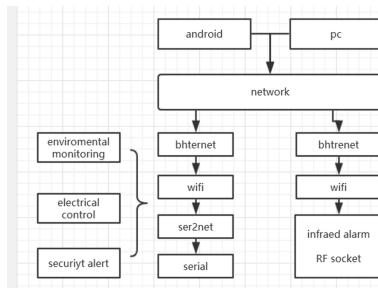
(3) Applicability

It can collect other similar sensor data, such as pressure sensor data, smoke sensor data, light intensity sensor data, etc. [6].

## 2 System Framework Diagram and System Flow Chart

### 2.1 System Framework Diagram

The system framework of the agricultural monitoring and control management system is divided into three levels, from top to bottom: Android application layer, central control service layer and wireless sensor layer. The system block diagram is as follows (Fig. 3):



**Fig. 3.** System framework diagram

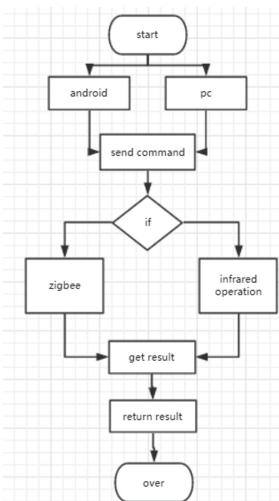
### 2.2 System Flow Chart

System executing flow of the agricultural monitoring and control management system:

- (1) The Android application layer responds to the command request sent from the mobile client.

- (2) The Android application layer parses the command request and judges the Zigbee operation command or the infrared central control operation command.
- (3) In case of Zigbee operation command, it will continue to judge the data acquisition command or device control command [7].
- (4) In case of Zigbee data acquisition command, it will acquire the sensor acquisition data of the specified child node.
- (5) In case of Zigbee device control command, it will control the device of the specified child node.
- (6) In case of infrared central control operation command, it will transmit remote control code value through the infrared central control to control the device.
- (7) The Android application layer obtains the collected data or returns the result, and returns it to the user interface for display [8].

The system flow chart is as follows (Fig. 4):



**Fig. 4.** System flow chart

### 3 Wireless Sensor Layer

#### 3.1 System Description

The wireless sensor layer is divided into the Zigbee sensor layer and the infrared sensor layer.

The Zigbee sensor layer consists of the wireless network composed of Zigbee coordinators and Zigbee controllers, and smart sensors embedded in a Zigbee data acquisition device. Each Zigbee controller corresponds to a group of sensor devices [9].

The Zigbee coordinator acts as a router in the wireless network. Its upper layer is connected to the central control service system. It receives commands sent by central control from the serial port and broadcasts them to the Zigbee network, so that device

nodes can receive the commands. On the other hand, it receives the operation result data returned by the device node from ZigBee network and sends it back to the central control service system through the serial port [10].

The Zigbee controller monitors the command request on the network, matches the operation request belonging to itself according to the device node number, and executes the corresponding device operation according to the command: data collection and electrical control, then obtains the return data or device status of the smart sensor, and sends it back to the coordinator through the Zigbee network again.

## 4 Hardware Interface

### 4.1 Embedded Hardware Platform

Castwise-Z7 embedded all-programmable application development training platform adopts Xilinx Zynq-7000 AP SoC chip Z-7020 (XC7Z20-1CLG400) as the core processor of the training platform, which adopts ARM-Cortex™-A9 dual core and Artix™-7 FPGA architecture, and Its FPGA programmable logic function makes the whole system have rich expandable ability. The processor contains ARM dual core Cortex™-A9 processor and supports NEON™ Processing/FPU Engines, which has powerful audio and video processing capabilities. The processor provides a variety of peripheral device I/O interfaces, such as USB, SPI, SDIO, CAN, UART, and I2C [11].

### 4.2 Sensor Expansion Module

The module contains the following sensors:

Light intensity sensor (measurement range 1–70000 lx, accuracy 1 lx)

Digital temperature sensor (measurement range  $-55^{\circ}\text{C}$ – $+125^{\circ}\text{C}$ , measurement accuracy as low as  $0.0625^{\circ}\text{C}$ )

Temperature and humidity sensor (humidity measuring range 20–90% RH, accuracy  $\pm 5\%$  RH, temperature measuring range  $0$ – $50^{\circ}\text{C}$ , accuracy  $\pm 2^{\circ}\text{C}$ )

Pulse humidity sensor (measuring range 20–95% RH, accuracy  $\pm 5\%$  RH) [12]

### 4.3 WiFi Gateway of Agricultural Monitoring and Control Management System

The WiFi gateway of agricultural monitoring and control management system is a WiFi development platform based on the RT5350 wireless network module. The development board consists of two parts, Zigbee (cc2530) and RT5350. The Zigbee part is consistent with the common node: all IO ports, four sensor sockets, one OLED interface, one program download port, three keys (two function keys and one reset key) and one USB serial debugging port are led out. The USB port of the RT5350 can be used for external USB flash drive, USB camera and other devices. The 8 IO ports of the RT5350 are led out, and the user can program and control them as required. The two network ports of the RT5350 are led out, which can be programmed as WAN port or LAN port. The serial port 1 of the RT5350 is led out, this serial port is used for the

debugging information output of the RT5350 and the console command input. The two debugging ports (wifi and Zigbee) on the backplane use super-strong USB ports, which are durable, plug-in resistant and not easy to damage. The serial port 2 of the RT5350 is led out, which can be connected to Zigbee (serial port transparent transmission) or the USB serial port on the backplane (debug RT5350 serial port 2) [13].

The development board can choose both internal and external antennas, including Zigbee and RT5350.

#### 4.4 Infrared RF Central Control

Infrared RF central control is a central control transponder which receives the commands from the mobile phone clients and forwards them to infrared/RF remote control signals. It adopts 315 MHz wireless radio frequency technology, has the learning and memory function of infrared/radio frequency signals, and can learn and memorize intelligent products of multiple infrared devices. The devices can be self-organized to realize unlimited signal extension. It has built-in high-power infrared transmitting tube, the transmitting angle is 360° with no dead angle forwarding, covering every corner of the room. Combined with the smart home host [14] can remotely control home appliances such as the TV, air conditioning, audio, DVD, set-top box, refrigerator, washing machine, electric curtain through mobile terminal apps such as mobile phones and tablet computers, and can also cooperate with the host to set multiple scene modes to realize real-time remote control and combined control [15].

### 5 Conclusion

The main objective of the smart project is to meet people's demand for scientific management of agricultural production, improve the yield and quality of agricultural products, so that people can more easily manage and control the field environment. This paper systematically expounds the architecture, design principles, software and hardware platform of the concept of the Internet of things, and designs the front-end Android application layer, platform layer and background processing module in detail. Among them, the front-end Android application layer uses Java language to write APK application program to realize the main functions of indoor environment monitoring, video monitoring, security alarm, irrigation equipment control, etc.; the platform layer coordinates the Android application layer and the background processing module to implement command receiving and sending and data transmission functions; the background processing module collects and displays environmental monitoring information, control and call each functional module through ZigBee wireless communication technology, infrared radio frequency technology and Linux device driver. The implementation of this system can enable users to connect with the server through the mobile phone client and perform operations such as real-time query and control of environmental parameters. With the development of Internet of things technology, the system will have a great development space.

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# Intelligent Traffic System Path Planning Algorithm

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**Abstract.** With the rapid development of economy and the continuous progress of science and technology, people's material living standard has been significantly improved. The number of cars in China has exceeded 250 million. Along with it, the construction structure of road traffic network becomes more and more complicated, road congestion becomes more and more serious, and safety accidents occur frequently. The root cause is that related traffic facilities have been unable to keep up with the pace of vehicle growth year by year. In this context, the purpose of this paper is to propose a traffic path planning algorithm that can optimize urban traffic and reduce congestion and safety accidents, so as to achieve reasonable distribution of traffic flow. In terms of research methods, this paper uses ant colony algorithm, and fit in the latest traffic information and technology, realized in the road traffic network planning out a optimal path from start to finish, make in the process of route planning, combine the search speed and precision, so as to reduce the purpose of residence time on the road. The simulation results show that the ant colony algorithm can effectively obtain the optimal path, and for different departure times, the estimated travel time obtained by planning is also different, and can effectively improve the overall operating efficiency of the system.

**Keywords:** Intelligent transportation system · Path planning · Ant colony algorithm · Optimal path

## 1 Introduction

The total number of motor vehicles in China reached 250 million in 2018, ranking first in the world for four consecutive years. While maintaining a high increment of the possession, it is accompanied by a series of traffic, especially in big cities. Traffic jam and traffic safety have become major problems in China's transportation field. In the past several years the measures do have a good result, but since entering the new century, the development of metropolitan centers unprecedented, plus the limitation of geographical environment and land use of urban decline, this approach to ease traffic pressure is no longer difficult to play a bigger role, and can only rely on advanced technology and management strategy to make the urban traffic system more intelligent.

In human history, the research on intelligent transportation system began in the 1970s, but it has been stagnating due to the restriction of technology [1]. After the 1990s, with the development of various information technologies entering a mature

stage, the research on intelligent transportation started to get on the right track [2]. International research on intelligent transportation is mainly represented by the United States and Japan. Their research focuses are also different, but their overall goals are the same [3]. The research focus of the United States is to realize the intelligence level of transportation through the construction of intelligent transportation network and framework, and the research results obtained have also been recognized and referenced by researchers in other countries [4, 5]. The Japanese government attaches the greatest importance to intelligent transportation. Compared with the research focus of the United States, Japan realizes the optimization of urban transportation through the development of intelligent transportation [6]. The research on intelligent transportation planning in China started relatively late, and the relevant research center was established in 2000, which formally entered the research field [7]. Moreover, the research results are mostly simple publishing and sorting of traffic data, without realizing in-depth mining and providing auxiliary strategic Suggestions based on these traffic data. Therefore, the research in the field of intelligent transportation in China is still in its infancy [8–10].

In this paper, classical ant colony algorithm is not only used as the heuristic formula, but also the algorithm's pheromone allocation rules are improved to reevaluate the weight proportion of the algorithm [11]. After the end of each cycle, the length of the path is compared and arranged in the order from short to long, so that in the early search process of optimal path planning, the search focuses on speed, while in the later search process, the search focuses on accuracy. In this paper, a time-dependent road network model considering information such as steering delay is established. After discussing the theoretical basis of the model, it also discusses the calculation of time-dependent section weight and time-dependent steering delay time, and introduces the maximum-minimum ant system to limit the occurrence of too many or too few pheromones and prevent the local optimal solution.

## 2 Method

### 2.1 Ant Colony Algorithm

In nature, foraging colonies can find the shortest path between food and the nest at any time and without prompting. And can find the new optimal path adaptively according to the change of environment. As ants search for food, they release a special substance called pheromones in the path they take. Over time, these pheromones gradually evaporate. For later ants, the probability of choosing a particular path is proportional to the concentration of pheromones in that path. The more ants in a path, the greater the concentration of pheromones in that path, and the greater the probability that subsequent ants will choose that path. The more ants on the path, the higher the concentration of pheromones, which attracts more ants, forming a positive feedback mechanism through which the colony can eventually discover the shortest path.

## 2.2 Mathematical Model of Ant Colony Algorithm

In the process of modeling actual ant colonies, it is necessary to solve the modeling problem of ant individuals in ant colonies and the problem of pheromone updating mechanism. Although a single ant can construct a feasible solution to the problem, the optimal or suboptimal solution of the problem to be optimized can be found through the cooperation between individual ants, and pheromone is the medium for mutual cooperation among ants. The basic model of ant colony algorithm is given.

There are  $n$  cities and the number of ants is  $m$ . At time  $t$ , the probability of ant  $k$  transferring from city  $i$  to city  $j$   $p_{ij}^k(t)$  can be calculated by the following formula:

$$p_{ij}^k(t) = \begin{cases} \frac{[\tau_{ij}(t)]^\alpha \cdot [\eta_{ij}(t)]^\beta}{\sum_{s \in J_k(i)} [\tau_{is}(t)]^\alpha \cdot [\eta_{is}(t)]^\beta}, & j \in J_k(i) \\ 0, & \text{other} \end{cases} \quad (1)$$

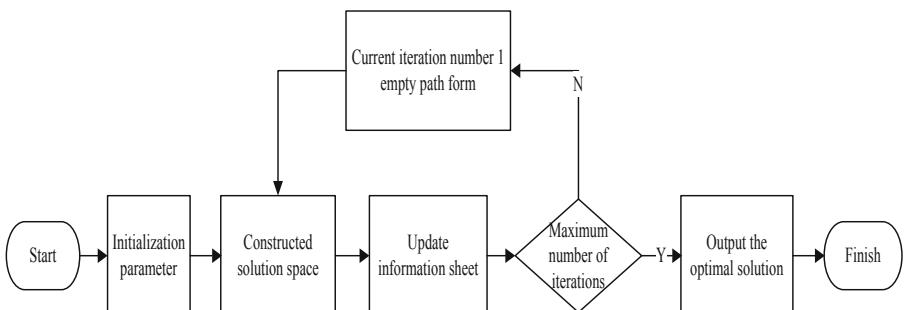
Existing cities  $i$  and  $j$  set a taboo table for each ant to record the cities it has passed through. The first position in the taboo table is the city where the ant was at the initial moment. When all the cities are added to the taboo table, it means that the ant has walked all the cities. If all ants complete a journey at time  $(t, t + n)$ , then the pheromone content between city  $i$  and city  $j$  at time  $t + n$  needs to be updated in real time, namely:

$$\tau_{ij}(t + n) = (1 - \rho) \cdot \tau_{ij}(t) + \Delta\tau_{ij}, \quad 0 < \rho < 1 \quad (2)$$

$$\Delta\tau_{ij} = \sum_{k=1}^m \Delta\tau_{ij}^k \quad (3)$$

Where,  $\Delta\tau_{ij}^k$  represents the concentration of pheromone released by the  $K$ th ant on the path of city  $i$  and city  $j$ .  $\rho$  represents the volatility of pheromones. By analyzing the above formula, it can be seen that the higher the pheromone content of path  $i$  and  $j$ , the greater the probability of the ant to choose the path, and the greater the distance between path  $i, j$ , the smaller the heuristic factor.

## 2.3 Ant Colony Algorithm Flow



**Fig. 1.** Flow chart of ant colony algorithm

The flow of ant colony algorithm mainly consists of initializing parameter variables, constructing solution space, updating information table and judging termination, as shown in Fig. 1.

The operation of parameter initialization and default value setting of iteration times. To construct the solution space, each ant is randomly placed at different starting points, and the distance of the next city to be visited is calculated until all the ants have visited all the cities. Updating pheromone is to update the pheromone concentration on the city connection path by the optimal solution recorded. The termination of the judgment is the execution of the record table that clears the path of the ant and returns to the step of constructing the solution space, otherwise the optimal solution will be directly output.

## 2.4 Road Network Model

To carry out optimal path planning for urban road traffic network in reality, it needs characteristic information from node location, geometric length of road segment, travel time of road segment and other aspects, and corresponding quantitative description data. At the same time, quantitative description of these information will generate a large number of data, how to organize these data reasonably, so as to express the prototype of the road network accurately, comprehensively and with little redundancy, we need to study the road network model and its corresponding data storage structure.

To simulate and abstract the real road network, the corresponding network simulation diagram should be established, and the optimal path should be selected through a comprehensive study of the algorithm by combining the examples of the diagram. A paradigm for constructing a network model:

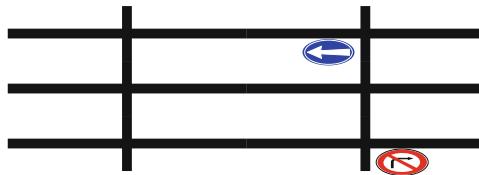
$$\begin{cases} G = (V, E, W) \\ V = \{v_i | i = 1, 2, \dots, n - 1\} \\ E = \{\langle v_i, v_y \rangle | v_i, v_y \in V\} \\ W = \{w_{ij} | \langle v_i, v_j \rangle \in E\} \end{cases} \quad (4)$$

Where,  $V$  represents the set of nodes;  $E$  represents the set of sections;  $W$  represents the weight set of section, and its attribute value can also be selected according to different optimization objectives. If the dynamic travel time is taken as the road resistance, then the optimal path planning algorithm can make the optimal path planning based on the real-time traffic information obtained. The average travel time of the section is:

$$t = t_0 [1 + \alpha(q/c)^\beta] \quad (5)$$

Where,  $t$  represents the actual time required to pass the section,  $t_0$  represents the actual time, and cents are the model parameters.

Generally, the traffic information in the relative direction of the same section of a specific urban road traffic network is different. Although the normal form model expands the storage capacity of the road network, it cannot fully restore the real-time and accurate information of the road network, and these factors cannot be avoided in the process of planning the optimal path. Otherwise, there may be a serious mismatch between the planned route and the actual road network. Based on this requirement, it is necessary to simulate a graphical road network. The simple road network model simulated in this paper is shown in Fig. 2 below.



**Fig. 2.** Simple road network model diagram

### 3 Experiment

In order to determine the updating strategy of the weight coefficient and introduce the most appropriate weight coefficient into the ant colony algorithm to improve the algorithm, it is necessary to redefine the search heuristic function of the high road network. The key to update the weight coefficient is to determine the exact value of the evaluation function in each time node, which can be used to search the path in the early stage by increasing the weight coefficient, so as to improve the operation efficiency.

In the later process of path search, in order to ensure that the search accuracy is not lost in the faster search speed, we also need to set the upper and lower thresholds for the precise values. If any two nodes in the road network are respectively o and d, then the optimal path from o to d is searched as follows:

- Step1. Load the road network data and initialize the road network.
- Step2. Obtain the hierarchy of the road network in which nodes o and d are located. If all nodes are in the high-rise road network, then the ant colony algorithm is directly used to calculate the shortest path p, and the algorithm ends; Other cases are transferred to Step3.
- Step3. Ant colony algorithm is adopted to find the nearest node in the network from the lower level to the higher level as the new starting point and ending point, denoted as o' and d' respectively. The path from o to o' is p1, and the path from d to d' is p2.
- Step4. In the high-rise road network, the improved path planning algorithm is adopted to calculate the shortest path p3 from o' to d'.
- Step5. Combine the optimal path of p1 + p2 + p3, and the algorithm ends.

## 4 Discuss

### 4.1 Simulation Results

In order to verify the effectiveness of the improved algorithm proposed in this paper, combined with the map model drawn according to the actual needs of this study, an intelligent traffic system path planning system is built. Several pairs of starting point and ending point, namely o node and d node, are randomly selected from the electronic map, and the optimal path is calculated by a-star algorithm and ant colony algorithm respectively and displayed in the electronic map. The comparison parameters of the experimental results mainly include: number of search nodes, number of actual path nodes, search duration, actual road parameters, actual journey, search efficiency and proportion of excellent sections. The comparison results are shown in Table 1 below.

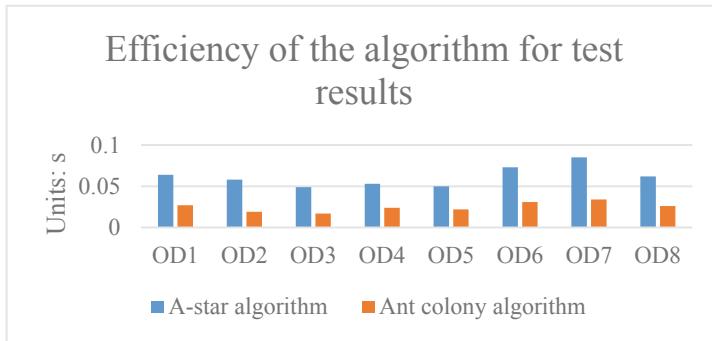
**Table 1.** Comparison results of algorithm effectiveness

	A-star algorithm	Ant colony algorithm
Number of nodes searched	65	57
Actual number of path nodes	42	42
Search duration (us)	42673	45933
Actual road parameters (m)	5460	5460
Actual travel (s)	953	690
Search efficiency (%)	56%	82%
Proportion of excellent sections (%)	27%	46%

It is not difficult to find from Table 1 that the test results of a-star algorithm and ant colony algorithm are basically equivalent in three aspects: the number of nodes searched, the number of nodes in the actual path and the search time. However, there are significant differences in actual road parameters, actual trips, search efficiency and proportion of excellent road segments. Compared with the a-star algorithm, the actual journey of the ant colony algorithm is significantly shorter, which means that the time on the way is shortened. It can be seen that the improved intelligent traffic system path planning algorithm has ideal effectiveness.

### 4.2 Comparison and Analysis of Algorithm Efficiency

In order to detect the improved the efficiency of route planning algorithm of intelligent transportation system, choose to traffic pressure smaller time period as A test period, from the map random excerpts from the eight od path in the network, respectively, with A - Star algorithm and ant colony algorithm to calculate the time required to run each od path, the 8 groups of the results of the computation time are shown in Fig. 3 below.

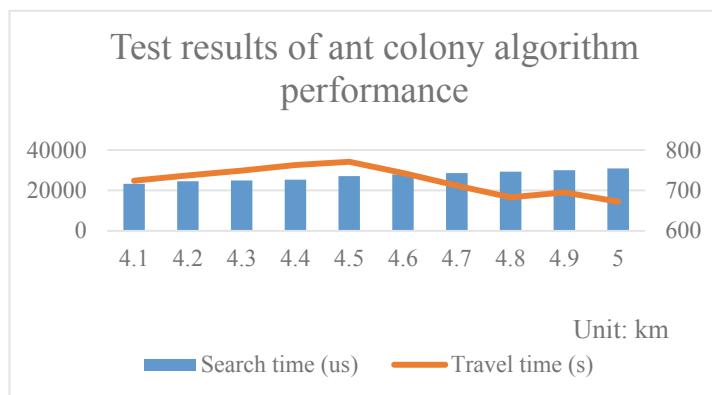


**Fig. 3.** Detection results of algorithm efficiency

It can be found from Fig. 3 that the time-dependent a-star algorithm is obviously inferior to the ant colony algorithm in computing time. The reason is that in the whole path planning process, a-star algorithm needs to call the static algorithm several times to carry out multiple path planning, while the ant colony algorithm has already considered the traffic condition at the time of arriving at each road segment in advance when conducting route analysis, and only needs to directly calculate the shortest path. Therefore, ant colony algorithm is helpful to reduce the number of planning times, and the algorithm efficiency is obviously better than a-star algorithm.

#### 4.3 Analysis of Ant Colony Algorithm Performance

Orthogonal experiment is used to test the performance of ant colony algorithm. A 5 km urban road was selected for the test, and the search time and travel time of the current road section were recorded from a distance of 4,000 m, at intervals of 0.1 km. The experimental results are shown in Fig. 4 below.



**Fig. 4.** Test results of aco performance

As can be seen from Fig. 4, before the initial 4.4 km, the search time of the ant colony algorithm did not perform well, but in the path after 4.4 km, the advantage performance of the ant colony algorithm began to emerge. At the beginning of data recording, the algorithm needs to perform multiple calculations at the high and low road layer, so a lot of search time will be wasted at the starting point. However, as the performance of the algorithm becomes more stable, its effect will become better.

## 5 Conclusion

This paper considers the complexity of urban traffic network in its development, as well as the disadvantages such as lack of control of transit time and restriction of diversion in previous research results, and thus establishes a time-dependent road network model. In this study, the time factor is also introduced into the evaluation function of the path planning algorithm of the intelligent transportation system, so the time-dependent ant colony algorithm is developed. The simulation results confirm the effectiveness and excellent efficiency of the algorithm, which indicates that the proposed algorithm is helpful to improve the efficiency of travelers.

Due to the limitations of various factors, this study also has some deficiencies, mainly manifested in the following two points. First, the production scope of electronic network map is relatively small. Due to the difficulty problem, the latest road condition information is not retrieved from relevant departments. Second, the optimal path planning in this paper is mainly based on relevant historical traffic data. If real-time traffic data can be combined or obtained, the value of simulation experiment will be higher. In the following research, the above two shortcomings can also be regarded as the breakthrough point, so as to carry out more valuable research.

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# Improved Ant Colony Algorithm in Automatic Following Luggage

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**Abstract.** At present, many people, especially when going out to study, work, and travel, cannot do without suitcases. The luggage compartment can integrate some essential items into one space. If there is less luggage, it is more convenient to bring a suitcase out, but when there is more luggage and the suitcase is relatively large, it is a burden for the user. The heavy luggage not only consumes the user's physical strength, but also may being overweight makes it difficult to go through security. In recent years, some suitcases that can automatically follow the user have appeared on the market, which is relatively convenient. However, there are also some problems, such as encountering obstacles that may slow down the action, slow down the user's rhythm, and become stuck due to uneven road surfaces and other issues. The purpose of this paper is to optimize the optimal path selection of the luggage, so that the luggage can quickly find the shortest way to reach the target under complicated road conditions. This paper improves the ant colony algorithm and uses it in the luggage auto-following system. The adaptive adjustment of the volatility coefficient  $p$  is used to solve the problem of slow convergence speed and easy fall into the local optimal solution of the algorithm during operation. Lattice model uses different algorithms for the same luggage to perform experiments in the same road conditions, and calculate, record the path length and the corresponding number of iterations obtained from the experiment and compare them. Experimental results show that the improved algorithm is superior to traditional algorithms. In the improved algorithm results, the optimal path length and the corresponding number of iterations are smaller than those obtained by traditional algorithms, especially the number of iterations is much smaller than that obtained by traditional algorithms. Obviously, the improved algorithm in this paper can be used to automatically follow the luggage and enhance its performance to some extent.

**Keywords:** Ant colony optimization · Auto follow · Trolley luggage · Optimal path length

## 1 Introduction

With the widening social exchanges and the rapid development of transportation and tourism, travel has become an important part of people's work and life. However, luggage has become a burden on people to a certain extent. Although the current luggage design market types are diverse, the design homogeneity is serious and basically not intelligent [1]. At present, most of the suitcases on the market are weak in

functional expansion. In the design, in addition to meeting the basic functions of the luggage carrying luggage items, there is no other functional expansion. Moreover, many luggage design brands have neglected the investment of the product to a certain extent, resulting in the lack of bright spots in the design of most luggage products. At the same time, many similar products lack humanization and intelligent design in the design details, leading to the product has many design pain points in usage, which brings a lot of inconvenience to customers. In recent years, the auto-follow luggage has appeared on the market. The auto-follow luggage can be automatically pulled without human hands. It can automatically adjust the current luggage speed and position according to the relative position of the traveler. Since then, it has made travel easy, enjoyable, and in line with the times [2, 3]. However, the current auto-following luggage technology is only a preliminary development, and the technology is not yet mature. There are many problems such as failure to follow the owner smoothly in complex terrain and may even slow down the owner's speed. The luggage using infrared sensing technology has certain requirements for light. If it is in a dark environment, the owner cannot be accurately identified and even the environmental judgment is prone to errors. To some extent, human assistance is still needed [4, 5].

Huang Min's team based on the optimization of the original continuous space when researching the continuous space optimization problem, and proposed an improved ant colony algorithm to solve the continuous space optimization problem, thereby overcoming the disadvantage of ant colony algorithm long search time [6]. It also introduces functions that change with the number of iterations to improve the convergence speed of the improved ant colony algorithm, and the improved ant colony algorithm based on the information distribution function has better convergence performance [7]. It can be seen that the ant colony algorithm can effectively enhance the intelligence of the automatic follow luggage, which can be used for the research and development of automatic follow luggage [8–10]. However, the ant colony algorithm has some shortcomings, so that if it is used to automatically follow the suitcase, it is necessary to upgrade the technology. Therefore, it is necessary to improve the ant colony algorithm in accordance with the situation of the suitcase.

In this paper, an adaptive adjustment of the volatility coefficient  $p$  is mainly used in the ant colony algorithm, and then it is tested by the grid method and the results are compared with the traditional algorithm. Finally, some suggestions are made for the development of automatic follow-up luggage.

## 2 Method

### 2.1 Automatically Follow Luggage

At the current stage, the auto-following trunk is mainly composed of electronic components such as a control chip, a sensor, a power supply, a wireless serial port module, and a DC motor driver. The main capability of the sensor is to detect the surrounding environment, such as ups and downs, surrounding people, vehicles, obstacles and other road conditions. At present, mainstream sensors are ultrasonic sensors, laser sensors, and the like. The wireless serial port is mainly integrated with a wireless data

transmission module, which can modify various parameters such as serial port speed, transmit power, and radio frequency rate. At the same time, it has the characteristics of small volume and wide voltage operation and long transmission distance. The DC motor driver and power supply are mainly used to provide energy and drive for the luggage. The choice of DC motor driver and power supply is different for different luggage. For large luggage with more loads, higher power DC motor driver and power supply is often used [11]. The main core of auto-following luggage is sensors and related technologies, especially positioning technology. Currently, the sensor positioning technologies of commercial auto-following luggage are mostly based on ultrasonic positioning technology and positioning technology based on visual sensors.

The two most commonly used methods of ultrasonic positioning technology are the reflective ranging method and the direct ranging method. Among them, the reflective ranging method generally determines the position of the object through a multilateral positioning algorithm [12]. The system composition of reflection ranging method includes: main rangefinder and several receivers, where the main rangefinder is placed on the target and the receiver is fixed in the environment. During positioning, an ultrasonic signal of the same frequency is transmitted to one of the receivers, and then it is reflected and transmitted to the main rangefinder. The time between the echo and the transmitted wave is calculated by different position. The difference between the direct-type ranging method and the reflective positioning technology is that the direct-type ranging method separates the transmitting function and receiving function of ultrasonic waves. Ultrasonic positioning has obvious advantages and disadvantages, the advantages are simple structure and high overall positioning accuracy, but ultrasonic has some disadvantages such as poor anti-interference ability, unable to achieve accurate positioning and high cost in complex environments. Vision sensor-based identification and positioning technology has better positioning accuracy in complex environments than ultrasonic positioning technology. This technology mainly collects target images through one or more cameras or image sensors. Single-purpose vision positioning and identification technology mainly is to obtain the characteristic information of the surrounding environment after processing the image information. Then, the feature information is matched with the template, and then the position information of the target is obtained by the related algorithm. Multi-eye is to obtain the image of the same target from different angles through multiple image sensors, and process multiple images, such as processing operations such as matching, segmentation and subtraction, and finally obtain the target position information. The disadvantages are that stereo matching is difficult and the real-time performance is poor. In addition to the disadvantages of sensor positioning technology, the following path selection of luggage is also a problem, and it is necessary to optimize the selection plan of its motion path, which can be optimized by improved ant colony algorithm.

## 2.2 Ant Colony Optimization

Path planning is an important technology in the automatic research and development of luggage-related technologies. It is to plan an optimal or near-optimal collision-free path from the start to the end in a space with obstacles according to certain standards. In solving path planning, ant colony algorithm as a heuristic global optimization

algorithm in evolutionary algorithm has strong robustness, easy integration with other algorithms, fast speed, high accuracy, and can quickly find the optimal solution. Compared with other algorithms, it has significant advantages, but its shortcomings are also obvious, that is, it has a slow convergence speed and is easily trapped in a local optimum. Therefore, it is necessary to optimize it. The ant colony algorithm will be affected by many factors during the operation. This paper uses adaptive adjustment of the volatility coefficient  $p$  to solve the problems of slow convergence speed and easy fall into the local optimal solution during the operation. When the volatility coefficient  $p$  is set to be relatively large, the chance that the previous ant's path is selected again will increase, and if it is too small, the global search ability will be improved, leading to a decrease in convergence speed. Therefore, the parameter  $p$  is set to the maximum value at the initial time. Although the search path is likely to be selected again in the past, positive information feedback plays a dominant role. In this paper, the parameter  $p_{\min}$  is set to 0.05, and the adaptive adjustment formula of  $p$  is as follows:

$$p(t) = \begin{cases} C * p_{t-1} & C * p_{t-1} \geq P_{\min} \\ p_{\min} & \text{Other} \end{cases} \quad (1)$$

### 3 Experiment

#### 3.1 Experimental Object

This article aims at optimizing the choice of the path of automatically following luggage, combined with the current pursuit of intelligence in various devices, and the trouble of carrying luggage when traveling abroad. The ant colony algorithm is improved so that it can be applied to the automatic following luggage, and to some extent, some problems such as following errors of the luggage are solved.

#### 3.2 Experimental Method

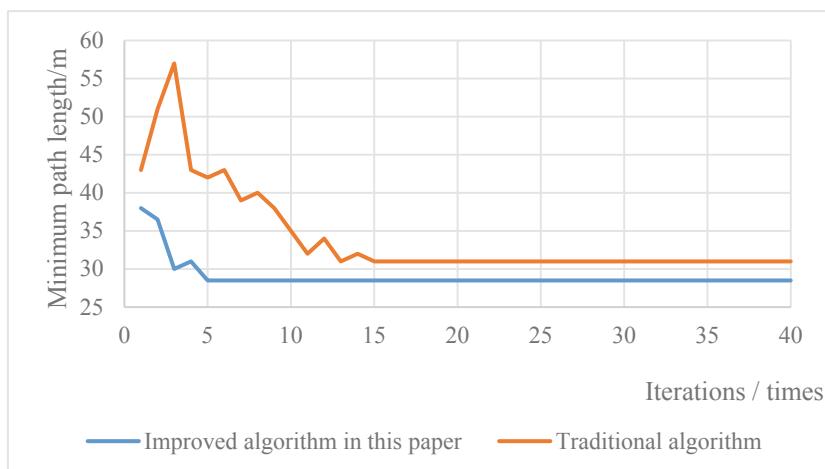
This paper uses grid method to compare the improved algorithm and traditional ant colony algorithm. First, use the grid method to assume that the area near the luggage area is a region G composed of a black and white grid. The black grid is an obstacle, marked as 1, and the white grid is marked as 0. This area marks the grid in order from left to right and from top to bottom, and is labeled 1, 2, 3, 4, ..., N, where each number represents a grid, the origin of the coordinates is set at the lower left of the grid space, from left to right is defined as the positive direction of the X axis, and from bottom to top is defined as the positive direction of the Y axis. The length of the grid is defined as the unit length, thereby establishing a two-dimensional coordinate plane XOY. In this area, U-shaped obstacles can be added to increase the complexity of the terrain. Then, in order to simplify the practical problem and ensure the safety of the movement, each obstacle is expanded, and the width of the expansion is the radius of the luggage, so that the luggage can be regarded as a mass point during simulation. For the same suitcase and under the same environment, the improved ant colony algorithm and

traditional ant colony algorithm of this article were used to record the data of the suitcase from the start point to the end point. The data is then analyzed. Draw experimental conclusions and propose corresponding solutions to some other shortcomings of the luggage.

## 4 Discussion

### 4.1 Comparison of Convergence of Two Algorithms

According to the above experimental steps, relevant important data such as the number of iterations, the minimum path length, and the optimal path length are obtained. These data are arranged, and the comparison between the number of iterations and the data of the minimum path length is shown in Fig. 1:



**Fig. 1.** Convergence comparison of the two algorithms

It can be seen from Fig. 1 that the traditional ant colony algorithm is still caught in a local optimum, and the optimal solution is found after 20 iterations. This paper introduces an adaptive parameter adjustment strategy to accelerate convergence in the early stage. With a small initial value, by introducing a turning angle, the superiority of the number of turns in this algorithm is very obvious, and the path is smoother. The optimal path is found after only 6 times.

### 4.2 Algorithm Optimal Solution Comparison

The multiple sets of data are comprehensively processed to obtain the optimal path length of each algorithm, and the optimal path length of the two algorithms and their corresponding iteration times are compared, as shown in Table 1:

**Table 1.** Comparison of experimental results

Algorithm	Optimal path length/m	Iterations/times
Traditional ant colony algorithm	30.26	51
Improved algorithm in this paper	29.49	22

As can be seen from Table 1, the improved algorithm in this paper is not only less than the traditional algorithm in the number of iterations, but also the optimal path length found by this method is slightly shorter than the traditional algorithm. However, through the comparative analysis of the above simulation experiments, it is obvious that the traditional ant colony algorithm has slow convergence speed and is easy to fall into local optimal solutions. The improved ant colony algorithm proposed in this paper effectively solves these problems. In the initial stage of the improved algorithm, the data is updated by dynamically adjusting the parameter  $p$ , which improves the optimization ability of the algorithm, accelerates the convergence speed of the algorithm, and quickly finds the optimal path. And when encountering U-shaped obstacles, it can quickly avoid and continue to find the optimal path. Obviously, this algorithm is superior to traditional algorithms.

#### 4.3 Suggestions for the Future Development of Automatically Following Luggage

At present, in addition to the optimal path selection problem, there are also other problems with the current automatic follow-up luggage. For example, different luggage may be used depending on the amount of luggage. Therefore, the luggage can be added with a retractable function. Pull out the second and third sections of the box, and the box design can use light and durable materials, which not only greatly increases the available space of the luggage, but also does not increase the burden of the body due to the increase in materials and increase in the number of consumers, while improving the cost performance, reducing the economic burden for consumers. At present, the auto-following luggage on the market basically does not have the ability to climb stairs. To this end, things such as crawlers can be installed on the back or bottom of the luggage to help them climb the stairs. When a staircase is detected in front, it will automatically switch up the stairs. The luggage compartment can also be set to a semi-automatic mode, that is, when the user is not assured that the luggage compartment is behind him and wants to manually pull the luggage, he can automatically switch to manual mode. In the manual mode, the luggage compartment will adjust the power according to the user's speed and road conditions. Reduce the burden on users. There is a function that is essential, that is, the positioning function. Users can check the location of the suitcase through the relevant APP or applet on the mobile phone to prevent loss.

## 5 Conclusions

Aiming at problems such as the slow convergence speed and easy fall into the local optimal solution of automatic following luggage in path planning, this paper improves the ant colony algorithm and applies it to the automatic following luggage, and proves it experimentally by using the fence method. This algorithm is better than the traditional ant colony algorithm. It shows that the algorithm is helpful for the development and innovation of automatically following luggage. At the same time, some suggestions for the intelligent development of luggage are proposed. It has the functions of more intelligent stairs and automatic customer staircase, as well as improving the customer experience.

**Acknowledgements.** Youth Project Funded by Xi'an Traffic Engineering Institute: System of Self Following Trunk Based on Arduino (Program No. 19KY-37).

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# Measure, Modeling and Compensation for Wearable Exoskeleton Sitting Assist System

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**Abstract.** The wearable exoskeleton robot adjusts the sitting posture of the person through mechanical structure, helping people to reduce some unnecessary diseases caused by poor sitting posture. It is mainly suitable for people who are already hunchback or who have not yet hunched. The purpose is to adjust the sitting posture to improve the hunchback and prevent the occurrence of hunchback. Wearable exoskeleton sitting assist is a sitting adjustment device designed for people who are not sitting in a standard position. The main purpose of this design is to correct the sitting posture of the seated person or to prevent the spine from bending back due to the sitting posture. This topic is designed to meet the human body's artificial spinal structure by learning the characteristics of the spine and hunchback, and to learn and summarize the existing similar products. Use solidworks to model the external bone structure in three dimensions to determine the feasibility of the organization. Mechanical analysis of each mechanical structure is carried out to ensure the safety of the mechanism. Finally, use Arduino to control its equipment, write programs, and complete the design of the entire device.

**Keywords:** Exoskeleton robot · Microcomputer control · Sitting adjustment · 3D modeling

## 1 Introduction

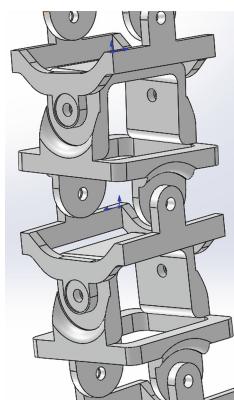
With the rapid development of modern science and technology, human life style has changed a lot. Human beings basically bid farewell to the era of manual labor, and then came the era of electronic technology and mechanical industry as the core. Human travel is no longer by walking, but by car. Human life is not limited to real life, but also can be leisure or work in the Internet world [1]. These advances in science and technology bring convenience to human beings, but also bring some disadvantages of life. One of the most common is that people gradually form the habit of “bow head”, “chest” and other bad sitting posture. At present, there are more and more “hunchbacks” in [2] society. This is especially true for people who sit for a long time. Because of the common phenomenon, we all think that this kind of hunchback has little impact on people, and it will make your spine more labor-saving. But the fact is that for a long

time in this kind of hunchback will lead to various diseases, especially the diseases of lumbar vertebrae and cervical vertebrae. This can lead to long-term back pain, limited activity, and even dizziness, chest and rib pain, turning over difficulties. Therefore, we usually need to correct our sitting posture and keep our heads up and chest up. But with the passage of time, people's bad habits are hard to change [3]. Moreover, due to the fast pace of modern life and the great pressure of life, if people spend a lot of time to go to the hospital to specifically correct their sitting posture, it may be unwillingness of many modern people. So we naturally think of wearable sitting AIDS.

At first, this kind of wearable device appeared in all kinds of science fiction movies. These wearable robots are mainly used to perform some arduous tasks to prevent human body from being damaged in the harsh environment. Others are used to help people walk faster, run faster, jump higher or increase the strength of adults. At present, although these wearable robots have been studied for many years, they have not been widely used in society due to technical reasons. In conclusion, it is very necessary and promising to develop a wearable sit assist system. If you can design a wearable exoskeleton sitting assistant product and this product has the function of automatically judging sitting posture and automatically adjusting sitting posture [4, 5]. This can not only reduce the occurrence of diseases such as thoracic hunchback, cervical spondylosis and lumbar spondylosis, so as to improve the living standard of human beings, but also enable people who have suffered from lumbar spine damage to do so [6, 7]. This has greatly improved the quality of life of these people.

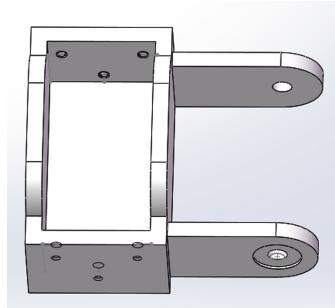
## 2 Design of Artificial Spine Structure

Because there are 33 vertebrae, we designed the 12 vertebrae of the thoracic vertebrae into 5 vertebrae, considering the simplification of complex problems and the comfort of users Joints as shown in Fig. 1. The range of motion of each joint is much larger than the range of motion of the actual human body, [8, 9] so as to avoid the obstruction of the normal daily action of the user due to the small range of motion of the artificial spine [10]. According to the length of human spine, the length of the five segments we designed is about 30 cm.



**Fig. 1.** Structure of thoracic joint

We didn't design so many degrees of freedom for the design of the cervical vertebra, because the first part that is easy to bend according to the above analysis is the joint of the cervical vertebra and the thoracic vertebra. So we use a steering gear at the junction to adjust the hump here. The structure of installing the steering gear is shown in Fig. 2. The size of the rudder shell just matches the size of the steering gear.



**Fig. 2.** Mounting shell of steering gear at cervical spine

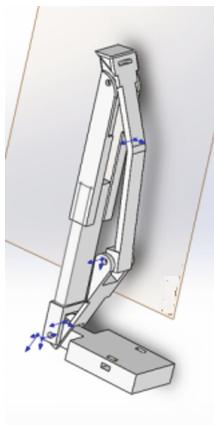
We designed a rigid and adjustable length structure at the upper cervical spine of the steering gear case to serve as the cervical spine. This spine structure does not need to fit with the human spine, but only plays a pulling role on the spine. Therefore, this structure is designed as a relatively simple rod to pull the cervical spine for reduction.

### 3 Seat Function Mechanical Structure Design

Walking is one of the most common movements in people's daily life, but for some special workers, they stand for a long time, so if a wearable lower limb structure is added on the basis of sitting posture assistance, when people want to rest, they only need to make a sitting position, this lower limb structure can be used as a seat, which will solve the rest problem of such workers. Of course, it can also be used by ordinary people to facilitate people's rest.

The two indexes of light structure and comfortable wearing are the core elements of the design of lower extremity seat function. This requires that the exoskeleton designed by us not only have the flexibility of movement, but also meet the matching degree of human lower limb joints. In the design of the lower limb exoskeleton, we should meet the kinematic requirements of the human body, try to make the walking height of the mechanical structure fit the walking height of the human body, and try to expand the range of motion of each joint of the normal human body. In order to ensure the user's comfort in use and the synchronization between human body and exoskeleton robot, theoretically, we should make sure that the exoskeleton lower limb robot we designed should completely duplicate the human joints, and should design the exoskeleton with the same degree of freedom as the human joints. Referring to the relevant data, the human anatomy and biomechanics related human body academic papers show that the

lower limb joints can be abstracted from the complex human biomechanical model into three joints of the lower limb, namely, the hip joint, the knee joint and the ankle joint (Fig. 3).



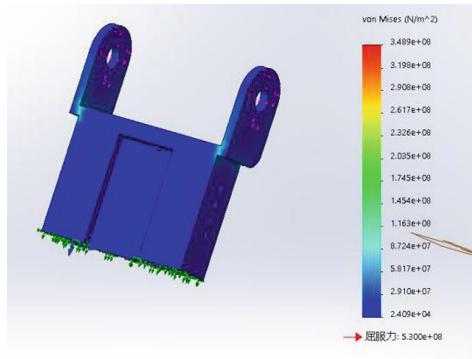
**Fig. 3.** Leg seat function

The two inertial detection units described in this paper are gyroscopes, which are installed on the center line behind the body. The angle between cervical vertebra and horizontal line was detected by gyroscope, and the angle between thoracic vertebra and horizontal line was detected. Calculating the size of  $\angle OAB$  and angle  $\theta$  according to the following formula to determine whether the sitting posture is correct.

1. Calculate the  $\angle OAB = \Pi - \Pi + \beta$  in the initial state
2. Calculate the initial state  $X_b = L_1 \cdot \cos\alpha + L_2 \cdot \cos\beta$  and the initial state
3.  $L_{ob} = \sqrt{L_1^2 + L_2^2 - 2 \cdot L_1 \cdot L_2 \cdot \cos(\pi - \alpha + \beta)}$  As a result  $L_{ob} \cdot \cos\theta = X_b$ , in the initial state  $\theta = \cos^{-1} \frac{X_b}{L_{ob}} = \cos^{-1} \frac{L_1 \cdot \cos\alpha + L_2 \cdot \cos\beta}{\sqrt{L_1^2 + L_2^2 - 2 \cdot L_1 \cdot L_2 \cdot \cos(\pi - \alpha + \beta)}}$
4. After these data are calculated by the calculation module, the two inertial detection units detect the change of these data at any time and compare with the initial data to know whether the sitting posture changes.

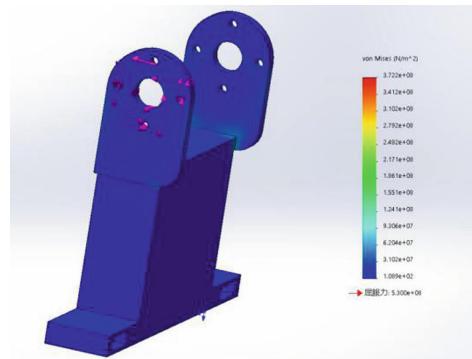
#### 4 Structural Analysis of the Upper Spine

The function of the upper spine structure is to pull the cervical vertebra back to the normal position through the drive of the steering gear when the user is sitting in an irregular position. That is, the cervical spine segment of the anti spinal structure described above. After the above analysis, here is the multiple points of spine deformation, so install multi-level adjustment here. The stress analysis diagram of its structure is shown in Fig. 4.



**Fig. 4.** Upper spine analysis

After analysis, we know that it takes 5 N to pull the spine. In order to ensure safety, we apply 10 N force, which can meet the demand. The function of the lower spine structure is similar to that of the upper spine structure. Through the above analysis, we know that when the lumbar spine is bent, the connection between the thoracic spine and the lumbar spine is the most likely position to be bent. The stress analysis of the lower spine structure is shown in Fig. 5.



**Fig. 5.** Analysis of the lower spine structure

From our analysis, we know that the angle between pulling lumbar vertebrae and thoracic vertebrae needs 5 N force. For the sake of safety, we apply 10 N force, obviously, to meet the requirements.

## 5 Conclusion

In this paper, we design the mechanical structure of irregular adjustment of spine bending and sitting posture, the mechanical structure design of leg wearing seat, the design of sitting posture detection and control. Through the analysis and research of the

human spine, looking up the relevant data, we come to a conclusion that the bending and hunchback of the human spine mainly occurs in two places. First, it occurs at the junction of the cervical vertebra and the thoracic vertebra. Second, it occurs at the junction of the thoracic and lumbar vertebrae. In view of the bending of these two places, we designed an anti spine structure to adjust the back caused by the bending of the spine. Before adjusting, we first need to know how much the spine is bent here, so as to judge how much we should adjust it. So we designed a set of methods to detect sitting posture. This method is based on the Arduino control of the gyroscope to detect the angle of the sitting posture detection method. This method is unique in that it can be worn with you. This design also designed the leg seat structure, that is, imitating the main freedom of human leg joints, to design a structure with supporting structure can be used as a seat.

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# Intelligent Kitchen Based on STC89C52RC Micro Control Unit

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**Abstract.** A smart kitchen system taking STC89C52RC as the Micro Control Unit (MCU) and regarding Keil uVision 4, DXP2004, as the assistant design software is studied in this paper. This system is composed of temperature and humidity sensor, flame sensor, buzzer, relay, combustible gas sensor, photosensitive sensor, NRF24L01 wireless communication module, and liquid crystal display module. This design can detect the illumination intensity, temperature and humidity, combustible gas concentration, and flame brightness of the kitchen in real-time and display its numerical value on the LCD screen. This system not only can be used for monitoring the environmental safety of the kitchen but can also be used for monitoring the environment of rental houses.

**Keywords:** STC89C52RC · Intelligent kitchen · Monitor · Sensors

## 1 Introduction

For the past few years, the frequency of explosion as well as fire accidents caused by gas leakage has become higher and higher. Under this situation, the intelligent kitchen safety detection system came into being [1]. The existing technology has a significant disadvantage that the environmental data collected is insufficient for accurately judging whether a safety accident occurs or not. The main reason is that the sensors of the existing system are not complete enough, and the second reason is that they can't make extinguishing measures in time, thus causing high losses. Because of this shortcoming, the system proposed in this paper uses four sensors to collect data, including a combustible gas sensor, flame sensor, photosensitive sensor, and temperature and humidity sensor [2]. The system will compare the collected data with the set values, and then determine the result of gas leakage or fire. If these data exceed the set limit, the system will alarm by a buzzer and open a ventilating fan to make the air can circulate by a relay to prevent the expansion of safety accidents. The wireless communication module of the system, which sends the collected data to the PC in real-time, is convenient for users to view real-time information about the kitchen remotely.

## 2 System Framework

An intelligent kitchen safety monitoring system realizes risk perception, processing, and transmitting the information. The system mainly uses the STC89C52RC Micro Control Unit, combustible gas sensor (MQ-2), temperature and humidity sensor (DHT11), flame sensor, light sensor, NRF24L01 wireless communication module and LCD1602 display screen [3].

### 2.1 Micro Control Unit (MCU)

The MCU STC89C52RC used in the system is an 8-bit high-performance single-chip computer [7]. It contains 8-bit central processing unit, 512-byte inside data storage (RAM), 8K on-chip procedure memorizer (ROM), 32 tow-way input/output (I/O) ports, three 16-bit timer/counter and five two-stage interrupt structures, one full-duplex serial communication port, and on-chip clock oscillation circuitry. STC89C52RC MCU has high-performance stability, strong anti-interference ability, and affordable price.

### 2.2 Flammable Gas Sensor (MQ-2)

The flammable gas sensor (MQ-2) used as a gas monitoring function is a high-performance and inexpensive sensor. Many different kinds of combustible gases can be detected by this sensor. Sensor with the kitchen the conductivity of the increases with increasing the concentration of combustible gas in the air. Electrical conductivity is converted by a conversion circuit to the attention of combustible gases in the kitchen air [9]. When the level of flammable gas reaches a certain threshold, the buzzer will alarm. Concurrently, the ventilating fan starts to work to disperse the combustible gas and reduce the concentration of the combustible gas.

### 2.3 Temperature and Humidity Sensor (DHT11)

DHT11 is a digital signal output of the temperature and humidity compound sensor alignment. It adopts exclusive digital module acquisition, temperature technology, and humidity sensing technology to ensure that the system has high dependability and good long-term stability. The temperature and humidity sensor (DHT11) consists of a resistive moisture sensor and an NTC temperature measuring element [4]. Its humidity accuracy is  $\pm 5\%$  RH and temperature is  $\pm 2^{\circ}\text{C}$ . What's more, its humidity layer is 20–90% RH, and the temperature range is 0–50  $^{\circ}\text{C}$ . It has the advantages of high quality, quick response, strong anti-interference ability, and affordable.

### 2.4 Light Sensor

The light sensor used in this system makes use of photosensitive elements to transform optical signals to electrical signals. Its working principle is the internal photoelectric effect. Photosensitive resistor uses the photoelectric effect of semiconductors to change the intensity of incident light into the magnitude of resistance. The power of the

incident light is inversely proportional to the size of the opposition. Photosensitive sensors have the characteristics of non-contact, fast response, and reliability [2].

## 2.5 Flame Sensor

The system uses an infrared receiving sensor to detect the real-time flame size of the kitchen. The sensor can convert the variation of infrared light intensity into the variety of current, and reflect the change of value in the range of 0–255 through A/D converter. Kitchen the more infrared light, as shown in the PC value is small; The infrared light weaker of the kitchen, the higher the numerical [8]. When the flame sensor detects a flame, it will trigger the buzzer.

## 2.6 NRF24L01 Wireless Communication Module

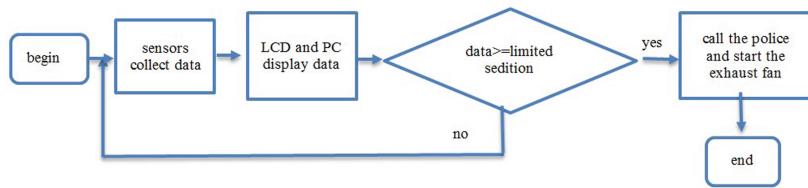
The wireless communication module of this system is based on the NRF24L01 chip, which is an RF transceiver chip working in the ISM band of 2.4–2.5 GHz. Besides, the power consumption of semiconductors is deficient [5]. The design is energy-saving and convenient. The system can send the collected data to the PC through the NRF24L01 wireless communication module. Also, the user also can view the real-time data on the PC.

## 2.7 LCD1602 Module

LCD1602 is a dot-matrix liquid crystal module used to display letters, numbers, symbols, and so on. It is composed of a few 5 \* 7 or 5 \* 11 dot-matrix character bits. Each dot matrix character bit can show a character, between each bit has a dot space interval, and between each line also has space, which takes effect on character spacing and line spacing. The reason it is very suitable for portable and quiet power test equipment is that it has the advantages of micro power consumption, small size, rich display content, ultra-thin, and lightweight. In this system, the LCD1602 display screen is connected with MCU by the 8-wire network, and the data collected by four sensors are displayed on the screen separately.

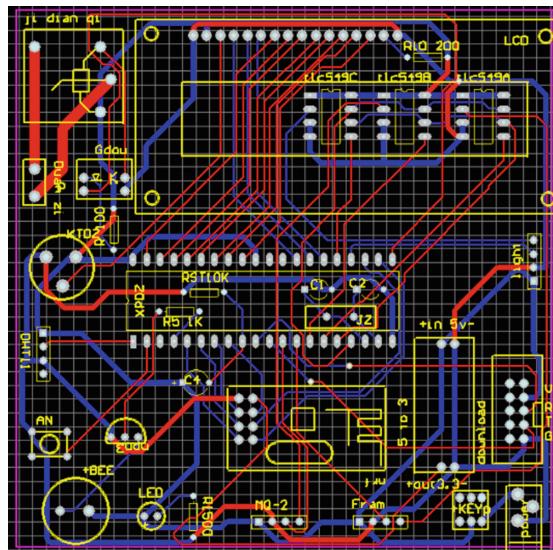
## 3 System Flow

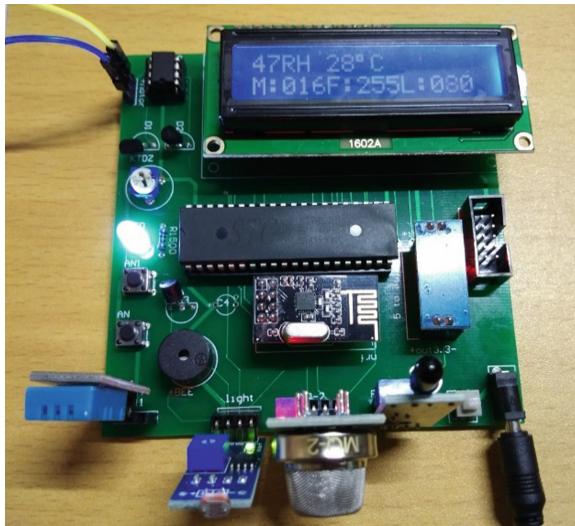
The flow chart of the system is as shown in Fig. 1. When this system starts to work, the serial port, interruption, LCD1602 display screen, and various sensors will be initialized. After initialization, the MCU sends the start signal to each sensor. Each sensor receives the signal and starts to work according to its working sequence. It collects physical information and converts physical information of nature into a digital signal through sensors. The digital signal is transmitted to the LCD1602 through I/O port. At the same time, the data is synchronously displayed to PC through the NRF24L01 wireless communication module. If the numerical value of the combustible gas sensor (MQ-2) reaches or exceeds the limit, the buzzer will alarm. A while, the relay on, and the ventilating fan are turned on and delayed for some time. If the whole system is out of power, it will end.

**Fig. 1.** System flow chart

### 3.1 System Testing

The hex file generated in the Keil uVision, four compiler system will be burned into STC89C52RC. Figure 2 is the PCB figure of this system. Figure 3 is a real figure of the intelligent kitchen system when it works. After several tests, the LCD1602 display screen of the system can typically show the data gathered by four sensors. As shown in Fig. 4, via the NRF24L01 module, the users can view the data in real-time on the PC side [6].

**Fig. 2.** PCB layout



**Fig. 3.** Picture of intelligent kitchen



**Fig. 4.** Test rendering

#### 4 Summary

This paper devises an intelligent kitchen system based on the STC89C52RC as well as the NRF24L01 wireless communication module. With the help of Keil uVision 4, DXP2004, and other software, the system realizes timely detection of brightness, temperature and humidity, smoke concentration, and flame brightness in the kitchen. And LCD1602 display screen displays the collected data. When the level of combustible gas in the kitchen exceeds the preset limit, the system can react immediately. If the user leaves the kitchen, the user can also view the kitchen situation on the PC side in real-time, which ensures the flexibility of the system. Meanwhile, the single-chip computer controls the relay to open a ventilating fan to discharge the gas, which provides the safety of users and embodies the humanized design of the system. The hardware modules of the system are independent of each other and can work well

together. The whole system design has the characteristics of simple operation, convenient maintenance, and high practical value. More importantly, the system can monitor kitchen safety anytime and anywhere.

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# Method for Judging Interdisciplinary References in Literature Based on Complex Networks

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**Abstract.** The arrival of information age provides a platform for the development of academic field. Knowledge exchanges between disciplines are becoming more frequent, boundaries are gradually blurred, interdisciplinary has become an inevitable trend. In the field of Scientometrics, it has become a new hotspot to study the interdisciplinarity of specific documents by identifying the subject characteristics of references. However, facing a massive academic documents, how to identify the subject characteristics of references quickly and accurately still restricts the development of related research. In this paper, we use the reference data in the field of Gene Editing of 2015 from Web of Science core database, with the help of the indicators of complex network link prediction, five features are selected. Base on this, a non-linear Support Vector Machine classification model is constructed to judge the interdisciplinarity of citation. Finally, the F1 value obtained by 5 fold cross-validation is 0.63, which indicates that the indicators can distinguish the academic citation from the interdisciplinary citation.

**Keywords:** Citation analysis · Interdisciplinary · SVM

## 1 Introduction

The development of disciplines and the continuous advancement of technology lead to the fact that problems cannot be solved by a single discipline alone. Increasingly, the phenomenon of cross-disciplinary integration has promoted major scientific discoveries and the emergence of emerging disciplines. Interdisciplinary research will become a basic trend in the development of contemporary disciplines [1]. At present, scholars use interdisciplinary to measure the degree of knowledge transfer between disciplines, generally from the perspective of authors and citations [2]. However, due to the fact that different institutions have not unified their departments, there is a big deviation in judging from author aspect.

Relatively speaking, citation data is easy to obtain and subject positioning is accurate, which can better reflect the beginning and end of knowledge flow [1, 3, 4]. Previously, scholars generally located their disciplines by consulting the journals to

which citations belonged, which had problems of low economic and time efficiency. In view of this, this article aims to propose a classification model that can automatically determine whether a citation is interdisciplinary. The selection of classification indicators refers to some features of citation network link prediction.

## 2 Indicator Selection and Method

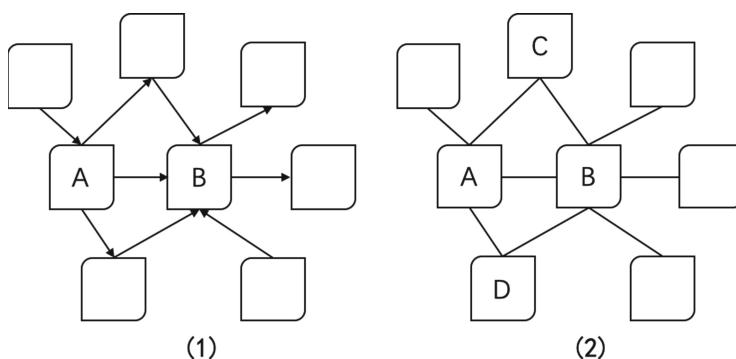
In this paper, interdisciplinary citation determination is transformed into citation classification. The information of nodes from citation network is easy to obtain and the citation relationship hardly changes once it is generated [5]. Considering the difference between the original intention of interdisciplinary citations and academic citations, this paper selects nine classification indicators in the link prediction similarity index based on local information, which are divided into two aspects: topology and node attributes.

## 3 Topological Indicators

- (1) *Common Neighbor*: two nodes with more common neighbors are more similar, and they are more inclined to connect the edges [6].
- (2) *Link based Jaccard Coefficient*: defined as the intersection size divided by the union size, expressed as follows:

$$J_{\text{link}}(\text{from}, \text{to}) = \frac{|L_{\text{from}} \cap L_{\text{to}}|}{|L_{\text{from}} \cup L_{\text{to}}|}$$

where  $L_x$  represents the link set (Citation set) of the original paper X. In the example of Fig. 1, the link based Jaccard coefficient for links (A, B) is  $2/6 = 0.33$ .



**Fig. 1.** Example of interdisciplinary citation network

- (3) *Betweenness Centrality*: It indicates the degree that a node is located in the path between other nodes, and also be interpreted as measuring the impact of nodes on network information transmission. Papers with greater intermediary centrality are considered to explore unknown innovation points [7].
- (4) *Node Difference in Degree*: degree is one of the important attributes of the network topology. Nodes with large degree are located in important positions of the network.

## 4 Attribute Indicators

- (5) *Whether Keywords Appear*: only a small part of keywords in interdisciplinary citations may be similar to the original keywords. In the article, it is more appropriate to set the index link this.
- (6) *Publication Year*: the difference between the citation publication period and the cited period can reflect the difference in citations at different stages of the “life cycle”, which generally shows a trend of rising first and then falling [8].
- (7) *Disciplinary Attributes*: differences between disciplinary attributes originate from the speed of development and the degree of knowledge fusion, which will be presented in the paper.
- (8) *Frequency of Cited Papers*: The number of cited papers reflects their relevance and core level. Researchers are usually more inclined to high cited papers [9].
- (9) *Interdisciplinary Appeal*: defined as the number of authors newly added to the field, the formula is expressed as follows [10]:

$$X_f = \frac{n_{i+4} - n_i}{c_i}$$

among them, the number of unique authors of the paper published in the field f from the beginning to the  $t_i$  year and the  $t_{i+4}$  year are  $n_i$  and  $n_{i+4}$  respectively. The number of papers published in the domain f in the time window  $(t_i - t_{i+4})$  year is  $c_i$ .

## 5 Method

Hasan et al. (2006) compared the classification performance of multiple supervised learning models and found that the Support Vector Machine (SVM) model can achieve better results [11]. SVM model is suitable for high-dimensional citation prediction and the resulting model has high prediction accuracy. This paper chooses a non-linear SVM model to solve the high-dimensional citation interdisciplinary determination problem.

## 6 Data and Experiment

### 6.1 Gene Editing

Gene Editing (GE) is a strategic emerging discipline that currently has a wide range of applications in agriculture, biomedicine, and other fields [12]. Recent years, the research results in this field have been remarkable, the interdisciplinary interaction is strong, the output of papers is moderate, and bibliographic data is available, which has interdisciplinary research value.

### 6.2 Data Acquisition and Processing

The bibliographic data in this article is collected from the core database of Web of Science. The data retrieval formula is: “TS = (gene edit \*) OR TS = (crisp) OR TS = (clustered regularly interspaced short palindromic repeats)”; language is limited to English; file types include articles, conference papers, and reviews; publication year is 2015. As a result, the number of papers was 1,544, with 49,667 nodes and 78,653 edges. Using the Web of Science classification system, the disciplines of paper and citation journals are marked respectively, and the citations are divided into the same discipline citation and interdisciplinary citation. According to statistics, the logarithms of academic citations and interdisciplinary citations are 18,476 and 60,177.

### 6.3 Indicator Filtering and Dataset Partition

Considering the judgment indicators mentioned in previous section and the acquisition of data in GE field, this article screens the final indicators. This article collected only one year of citation data, after trial calculation, the values of *Common Neighbor* and *Link based Jaccard Coefficient* were close to 0 with no discrimination. *Whether Keywords Appear* may have polysemy, which was difficult to avoid; *Interdisciplinary Appeal* was related to the author’s name, and the data processing involved name disambiguation [13], which was not our point. The index of interdisciplinary determination of citations in the GE field was finally selected as the following five items: *Betweenness Centrality* (‘bet\_cen’), *Node Difference in Degree* (‘degree’), *Publication Year* (‘dif\_year’), *Disciplinary Attributes* (‘per\_sub’) and *Frequency of Cited Papers* (‘num’).

We use Networkx package and MYSQL to calculate the indicators. Among them, *Disciplinary Attributes* is the proportion of interdisciplinary citations; *Frequency of Cited Papers* is the number of citations based on the dataset, for example: citation A was cited two times in the data set, and the years were 2012 and 2014, then its variable is set to 0 and 1.

After calculating indicators, we applied the LIBSVM software package [14] for subsequent work, including data normalization. For the imbalance problem in the dataset (18,476 in the same subject and 60,177 in the interdisciplinary), we need to weight two types in parameter selection, model training, and prediction. If all citations are set to “1”, then academic citation ratio is “0.2335” and the interdisciplinary citation ratio is “0.7665”. Therefore, they are weighted 0.7665 and 0.2335 respectively. In this article, the interdisciplinary and academic citations are set to +1, -1, and the ratio of training set to test set is 80% and 20%.

## 7 Results and Discussion

This article uses Precision, Recall, and F1 values to evaluate the results. In order to obtain a more robust result, a 5-fold cross-validation is performed, the macro average, micro average, and variance are obtained, the results are as follows (Table 1):

**Table 1.** Empirical analysis results

	Precision	Recall	F1
Group 1	0.7787	0.7228	0.7497
Group 2	0.8030	0.4896	0.6083
Group 3	0.7968	0.4808	0.5998
Group 4	0.7928	0.4763	0.5951
Group 5	0.7904	0.4774	0.5953
Macro-average	0.7923	0.5294	0.6296
Micro-average	0.7911	0.5292	0.6342
Variance	0.0001	0.0094	0.0036

The cross-validation results show that the macro-average and micro-average of the three evaluation indicators with little difference, precision is 0.79, recall is 0.53, and F1 is 0.63. All the variance are less than 0.01, indicating that 5-fold cross-validation result is stable.

Among above, indicators have different contributions to the classifier. This paper uses the stepwise elimination method to explore the impact of each index on the classification effect. Therefore, based on the group1 of data, additional training to eliminate all indicators is added. The final result is as follows, where  $\Delta$ Precision,  $\Delta$ Recall, and  $\Delta$ F1 represent the difference between the value after deleting an indicator and the results of all indicators (Table 2).

**Table 2.** Results of gradual elimination of indicators

	Precision	$\Delta$ Precision	Recall	$\Delta$ Recall	F1	$\Delta$ F1
All indicators	0.7787	—	0.7228	—	0.7497	—
Remove ‘bet_cen’	0.7735	-0.0052	0.7213	-0.0016	0.7465	-0.0033
Remove ‘degree’	0.7725	-0.0062	0.7175	-0.0053	0.7440	-0.0057
Remove ‘dif_year’	0.7667	-0.0121	0.7291	0.0063	0.7474	-0.0023
Remove ‘num’	0.7737	-0.0050	0.7230	0.0002	0.7475	-0.0022
Remove ‘per_sub’	0.7811	0.0024	0.9332	0.2104	0.8504	0.1007

In general, the Precision changes relatively small, only when the “per sub” is removed, there is an upward trend; Recall changes greatly, and when the “per sub” is removed, the Recall rate increased by 0.2104, which may be the major reason for the F1 value changes.

Throughout the above results, the *Disciplinary Attributes* is the most sensitive to the classifier and it plays a negative role in the interdisciplinary determination of citations. This paper only uses the number of papers in the dataset as statistics when calculating this indicator, which lacks representativeness and accuracy. This may be one of the reasons for the negative impact of the indicator. In addition, this indicator has a negative impact on the classification index system of bibliographic data in the GE field of 2015, which does not mean that it has a negative result on other fields or more comprehensive datasets. In the future, it is necessary to apply datasets in different fields and different spans for verification.

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# Construction Method of Cable-Stayed Bridge Based on BIM Platform

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**Abstract.** The modern bridge design concept is more and more advanced, the structure is more and more complex, the modeling requirements are higher and higher. The traditional bridge construction ideas and methods can not meet the needs of modern bridge construction. The emergence of BIM has provided new concepts and technologies for the construction of modern Bridges, and the benefits of informatization, industrialization and intellectualization of construction projects have been gradually highlighted. The purpose of this paper is to apply BIM technology to the life cycle management of bridge engineering, greatly reduce the work intensity of designers, analyze and guide the construction process of Bridges, improve the safety of bridge operation, and truly reflect the huge economic and social benefits brought by BIM technology to bridge engineering. The research method of this paper is to apply BIM technology to the construction, operation, maintenance and management of steel box laminated beam cable-stayed bridge based on Revit, a general BIM software. Combined with the experimental research of bridge engineering, the BIM core modeling software Revit was applied to build the three-dimensional model of bridge structure, and the collision inspection of components in the basic components of the bridge, the accurate engineering quantity statistics of bridge construction materials and the two-dimensional plane plan were conducted in combination with its built-in functions. The experimental results show that this method can demonstrate how BIM technology is applied to the design and construction stage of cable-stayed bridge project as well as the operation and maintenance management stage, which reflects the visualization, parameterization, optimization, mapping, information completeness and integration of BIM technology.

**Keywords:** BIM technology · Cable-stayed bridge design · Engineering informatization · 3D model

## 1 Introduction

At present, the construction industry has completed a series of advanced design concepts, complex structure modeling, high technology content, high use requirements, construction difficulty, the world attention to the major projects. However, the current economic growth of the construction industry is still extensive growth at the cost of energy consumption. These problems, to some extent, restrict the development of the construction industry. The traditional production concept and production mode of the

construction industry must be changed to meet the requirements of the future sustainable development of the construction industry. As an emerging technology in the field of construction engineering, Building Information Model (BIM) is the core technology to realize the BLM concept. The emergence of BIM technology will greatly reduce various forms of waste in the construction industry through innovative information technology and production methods. Its application will bring revolutionary changes to the production mode and production concept of the construction industry, is a comprehensive application of high and new information technology to the transformation of the traditional construction industry is a major change.

According to the data reviewed at present, the construction control of foreign cable-stayed Bridges is mainly carried out around long-span cable-stayed Bridges, suspension Bridges and continuous rigid frames, while the research on construction control methods and technologies of concrete-filled steel tube arch Bridges is very few, which may be due to the fact that such Bridges are rarely built abroad [1, 2]. The third version of BIM specification in the United States has some important ideas, such as how to conduct information conversion, secondary development application level, project classification, usage standards in different regions of the United States, and 3d model and construction standards [3]. In 2004, the BIM concept entered China, but the development form of BIM always showed a lukewarm state. During the 11th five-year plan period, the ministry of housing and urban-rural development started an in-depth study on BIM technology [4]. In December 2016, the ministry of housing and urban-rural development officially issued the relevant standards for building information models, which were officially implemented on July 1, 2017. This represents the beginning of standardization and standardization of BIM technology in China [5].

Based on the characteristics of cable-stayed bridge engineering, this paper explores the application framework and advantages of BIM technology in different stages of the whole life cycle of engineering, providing scientific reference for the depth of modeling [6]. When the appropriate model accuracy is determined, project participants can extract model data suitable for the accuracy of the project stage in the model as expected [7]. Cable-stayed bridge of BIM technology was applied to the construction and operation maintenance and management, combined with engineering experiment research, the application of BIM core Revit modeling software to establish three-dimensional model of the structure of the bridge, bridge and combined with its own function in basic components of collision check, bridge construction material artifacts precise quantities of statistics and the 2D floor plan [8]. The experimental results show that this method can demonstrate how BIM technology is applied to the design and construction stage of cable-stayed bridge project as well as the operation and maintenance management stage, demonstrating the visualization, parameterization, optimization, mapping, information completeness and integration of BIM technology [9, 10]. The specification specifies the model depth of different components at large length, which also indicates that the standardization of BIM model depth can facilitate the management of BIM application [11].

## 2 Method

### 2.1 Revit Parameterized Design Method

Revit is a BIM core modeling software that can be parameterized and designed. Most of its pixels have various parameters, and the geometry and properties of the pixels can be controlled by modifying parameter values [12]. Family is the basic unit of Revit software parameterization, through which the parametric design of bridge BIM model is realized [13]. Used to define the attribute of component there are many kinds of parameters, in the case of bridge pile caps, which contains the clan name, clan type of pile cap, pile caps, including material, size, 3D position in the definition of the values of these parameters also have a lot of kinds, such as: digital type, material type, text type, type, such as geometry model, Boolean algorithm by modifying the parameters of pile caps is clan can according to the parameter value of geometric properties of the geometric properties of the corresponding change. Family type parameters appear in the type properties dialog box, but instance parameters appear in the family metadata properties dialog box. A family type attribute is a common attribute used to define a class of primitives, and an instance attribute is a property used to define a certain primitive. Family type parameters will be common attributes of the kind of primitive binding linkage, facilitates the management of the parameters, then by the family type instances of bridge box girder are generated by the type parameter, the family just change one instance of the parameter values, all of the same type of box girder bridge in the project instance parameter value will be modified, suitable for general attribute parameter definition.

### 2.2 Damage Identification Method

From the beginning of operation to the end of life, the bridge structure is understood as a bridge structure in a broad sense because of the influence of the structure itself and various external factors. From the micro perspective, it can be considered that the original mass, stiffness and damping of the structure have been changed, while from the macro perspective, it is directly reflected in the safety status of the structure. After the structure is damaged, its mass, stiffness, damping and other characteristic parameters will change, which are reflected in the natural frequency, mode of vibration and strain mode of the structure. Therefore, mainly from these aspects to judge the damage degree and location of the structure. It is considered that the stiffness of the structure will change at the later stage of damage. Although the change is local and dispersed, it will make the natural frequency of the structure change. Later, in the process of using, people continue to improve this method and get used in the actual project. Frequency variation and static test data can be used to identify the damage location and extent of a fixed beam. Combined with the statistical method, the damage in the steel cantilever plate is determined by the change of natural vibration frequency of the structure. Relevant experts put forward the strain mode as an index of structural damage identification. It is considered that when some or all members of the structure are damaged, the original equilibrium state will be changed in order to obtain a new equilibrium state, which is literally the redistribution of force. This change quantity is obtained through

the strain mode, and the damage degree and position will be judged according to the size of the change quantity.

### 3 Experiment

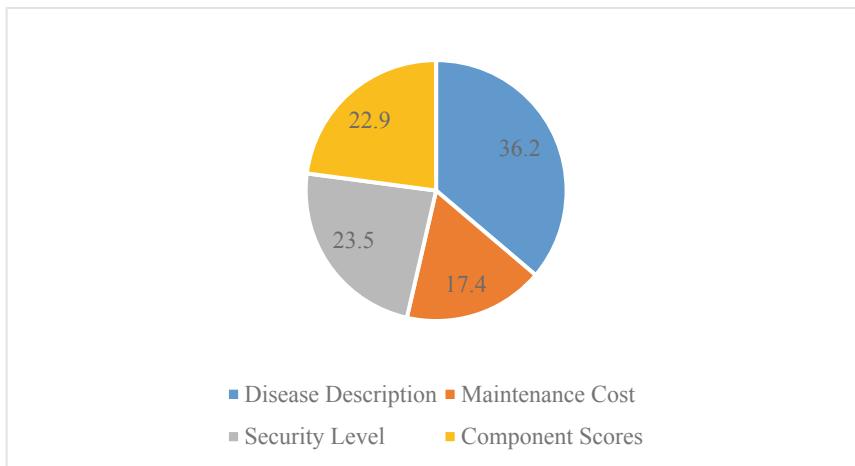
The experiment of this paper is the modeling application of BIM platform based on paper plate technology in the construction of cable-stayed bridge. This is because it is difficult for the technical leader to describe the construction plan at the complex joints of the bridge components and the relative positions of the components and components in the space. By comparing the three-dimensional technology disclosure with the paper version technology disclosure, we can find that the three-dimensional technology disclosure is more vivid and vivid, which can make the current bridge site construction personnel more deeply understand the difficulties in the construction. At the same time, the three-dimensional technology disclosure can improve the quality of the bridge project and ensure the site safety of the construction personnel. The 3D visualization technical clarificaiton will be able to make the order of the work of the construction preparation stage, construction stage and construction stage of concrete curing after the completion of work through image realistically animated demo program presents in front of construction personnel, these animated demonstration project to replace the traditional text, graphics, and tables of contents, make construction personnel more accurately understand the design intent of bridge designer, at the same time, the animation demo program to facilitate the construction and design personnel communication and exchanges. Through BIM technology, relevant construction simulation software is used to combine the construction information model of the bridge with the construction schedule to form a 4D-bim model with spatial and temporal information, which can perfectly solve the above problems. The model can express the construction process of bridge engineering directly and accurately.

## 4 Discuss

### 4.1 Analysis of BIM Platform Function Realization

From the analysis of the content and business of bridge maintenance management, its object is the main body of the bridge to ensure the safety state of the bridge, and the safety state of the whole bridge is determined by the state of each member of the bridge. Therefore, in bridge operation and maintenance management, the general inspection is accurate to the level of components. In other words, bridge components are the most basic unit of bridge operation and maintenance management. Therefore, as long as the safety state of each component is determined, the overall safety state of the bridge can be basically guaranteed. One of the tasks of bridge operation and maintenance management is to accurately describe the safety status of components so as to determine the overall safety status of Bridges. In the BIM platform, the geometric model has various attributes. Therefore, based on the data characteristics of the operation stage and the function setting of each module of BIM in the operation and

management stage, it is necessary to design the attribute parameters of BIM model components. According to the analysis, model attributes should clearly contain four types of information, including identity information, type information, management type information and component security information. The identity information includes the identification ID of the component in the software. Component name; The type information contains the category of the component; Management information includes maintenance date, maintenance personnel and other information; Safety information includes component damage description, component technical condition score, sensor parameters, etc. Based on the above identity information, the function realization of BIM platform is analyzed, and the proportion of attribute parameters of BIM model components can be obtained as shown in Fig. 1 below.



**Fig. 1.** Proportion diagram of each attribute parameter of BIM model component

#### 4.2 Effect Test Based on BIM Operation and Maintenance Management Platform

The bim-based bridge engineering information management platform is a huge project integrating multi-specialty and multi-aspect technology. The central task of this project is for the safety of the bridge structure information and damage the structure of the state, and in bridge structure safety state evaluation module and bridge after the initial state of bridge safety information compared, to develop a scientific and effective maintenance plan, so as to ensure the safety of Bridges to run smoothly and meet people's demand for transportation. Therefore, we can decompose the bridge engineering information management platform of BIM into three parts: "data collection and transmission", "data storage" and "data analysis". Data acquisition and transmission: namely, the use of sensors, manual inspection and wireless transmission system to collect and transmit the safety information of the bridge structure, providing the most basic information for the assessment of the safety status of the bridge structure.

Data storage: build bridge information database by using cloud platform. The database mainly stores the drawings and written materials of the bridge project in the planning stage, design stage and construction stage, as well as the structural status information, structural damage information and maintenance records in the bridge operation and maintenance stage. Through the analysis of the collected information, relevant evaluation values can be obtained, such as positive red warning, negative yellow warning and other indicators. Through the analysis of relevant evaluation values, the effect test based on BIM operation and maintenance management platform can be obtained. The result of effect test is shown in Table 1 below.

**Table 1.** Results of effect test and analysis based on BIM operation and maintenance management platform

Number	Current value	Positive red alert	Positive yellow alert	Negative red alert	Negative yellow alert
1	-10.2	200	180	-200	-180
2	-8.3	164	159	-164	-159
3	-9.7	182	172	-182	-172
4	-12.3	223	201	-223	-201

## 5 Conclusion

In the operation and maintenance management system, the basic information of cable-stayed bridge is the fundamental basis. Using data collected by sensors and manual inspections as the basis; Bridge safety information analysis and output as the key, the three complement each other, one is indispensable. At the same time, through the comparison with the traditional bridge engineering operation and maintenance management mode, it is found that the bim-based bridge operation and maintenance management system has a variety of intelligent advantages. This paper makes use of the features of BIM technology visualization and information integration, combines theoretical calculation with BIM technology, provides theoretical calculation and visualization guidance for some difficult problems in cable-stayed bridge construction, and provides efficient and feasible BIM functional module design for bridge operation, maintenance and management.

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# Tower Monitoring System Based on BeiDou Navigation Technology

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**Abstract.** With the development of the railway, the railway mobile communication has transitioned from a wireless train system to a GSM-R digital mobile communication system, and large number of communication towers have been built along the railway. Due to the principle of frequency band coverage of railway mobile communication system, the distance between communication tower and railway line is usually very close. The safety of communication tower plays an important role in the safe and stable operation of railway. This article analyzes the mainstream tower monitoring system technology from the perspective of railway safety production. Based on BeiDou navigation technology, the design and research of the tower monitoring system is carried out. The tower monitoring system combined with BeiDou navigation technology can comprehensively conduct railway communication towers. Real-time monitoring effectively guarantees the safety of railway transportation.

**Keywords:** BeiDou navigation technology · Tower monitoring · Monitoring system

## 1 Introduction

The current tower monitoring system is mainly applied to towers on power transmission lines, and there are similar buildings or bridges in weather monitoring towers, border monitoring towers and other fields [1, 2]. The monitoring of communication towers is mostly based on the power transmission tower detection system equipment [3, 4]. Modified, there is no complete detection system for communication towers. The mainstream tower monitoring system is mainly based on sensors or satellite positioning systems [5–7].

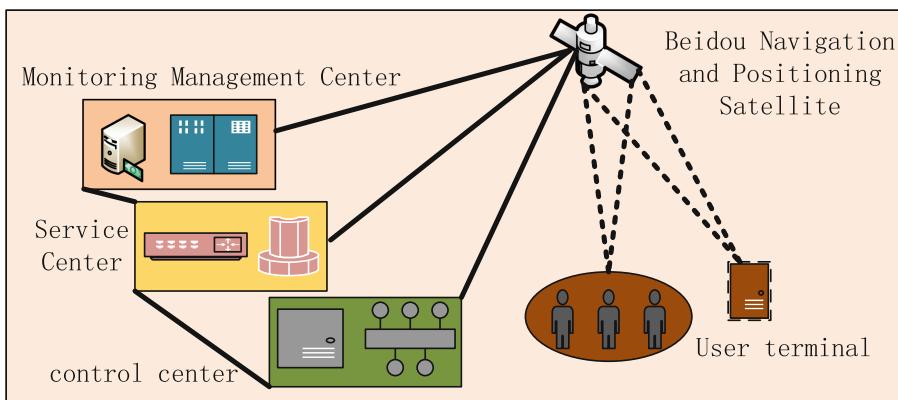
BeiDou navigation system is a global satellite navigation system with China's independent rights [8–10]. It has stable navigation, precise positioning and timing functions, and is widely used in defense, industry, agriculture and environmental protection. The railway communication tower is an important infrastructure of the wireless communication system along the railway. The trouble-free operation of the tower is of great significance to ensure the wireless signal coverage along the railway, smooth communication, the safety of surrounding residents, and the safety of railway transportation [11, 12]. Most of the railway communication towers are large steel structures, which have been used for a long time in the harsh environment of the field. Many components have

problems of deformation, corrosion and loosening, which are prone to the risk of structural damage, tilt and even collapse, which threatens the safe transportation of railways. At present, the manual monitoring, laser positioning and gyroscope are mostly adopted for the safety monitoring of railway communication towers [13].

The cost of inspection is high, and the accuracy and stability of current monitoring equipment are not high. In order to improve the monitoring technology of beidou navigation system and ensure the security and reliability of tower monitoring system based on Deidou navigation technology, it can provide extremely accurate positioning information for the tower monitoring system and provide a strong guarantee for the condition monitoring of the tower.

## 2 BeiDou Navigation Technology

Satellite navigation systems are global public resources, and multi-system compatibility and interoperability have become a development trend. China always upholds and practices the development concept of “China’s Beidou, world’s Beidou, and first-class Beidou”, serves the “Belt and Road” construction and development, and actively promotes international cooperation in the Beidou system. Hand in hand with other satellite navigation systems, and work with various countries, regions and international organizations to jointly promote the development of global satellite navigation, so that the Beidou system can better serve the world and benefit mankind.



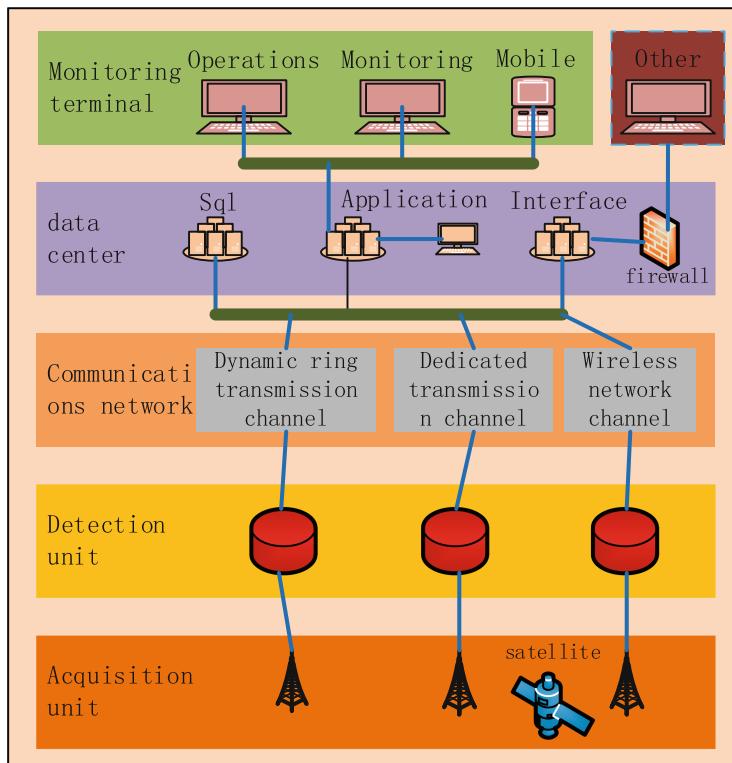
**Fig. 1.** BeiDou satellite navigation and positioning system

The beidou satellite navigation system may be composed of three parts: the first part is the space part, the second part is the ground part, and the third part is the user part. The satellite navigation system has the following functions: regional navigation, positioning and timing, positioning accuracy is 10 m, the speed of measurement accuracy is 0.2 m/s and timing accuracy is 10 ns. Beidou satellite navigation system is one of the four core suppliers of global satellite navigation, with 39 satellites in orbit. Since the end of 2017, Beidou phase III project has entered the stage of ultra-high density launch. Beidou officially provides RNSs services to the world, with 39 satellites

in orbit. Another 5–7 satellites will be launched in 2019, and after 2–4 satellites are launched in 2020, the construction of Beidou global system will be completed completely. Beidou satellite navigation and positioning system is shown in Fig. 1.

### 3 Application of Iron Tower Monitoring System Technology Based on BeiDou Navigation Technology

According to the “Technical Conditions of Railway Communication Tower Monitoring System”, the basic structure of the tower monitoring system includes acquisition units, monitoring units, monitoring centers, and monitoring terminals. The acquisition unit is generally installed on the tower to achieve the collection of tower state parameters and environmental parameters, including the tower’s horizontal displacement, verticality and foundation settlement, antenna pitch angle, wind speed and direction. The monitoring unit is usually installed in the base station or repeater room. The sensor sends the collected data to the monitoring unit in a wired or wireless manner. The monitoring unit can analyze the collected data and transmit the analyzed data to the monitoring center through a wired or wireless channel. The monitoring center analyzes, sorts, stores, processes, and outputs the monitoring data, and finally displays it to the operation and maintenance personnel by the monitoring terminal. The basic structure of the tower monitoring system is shown in Fig. 2.



**Fig. 2.** Overall structure of the tower monitoring system

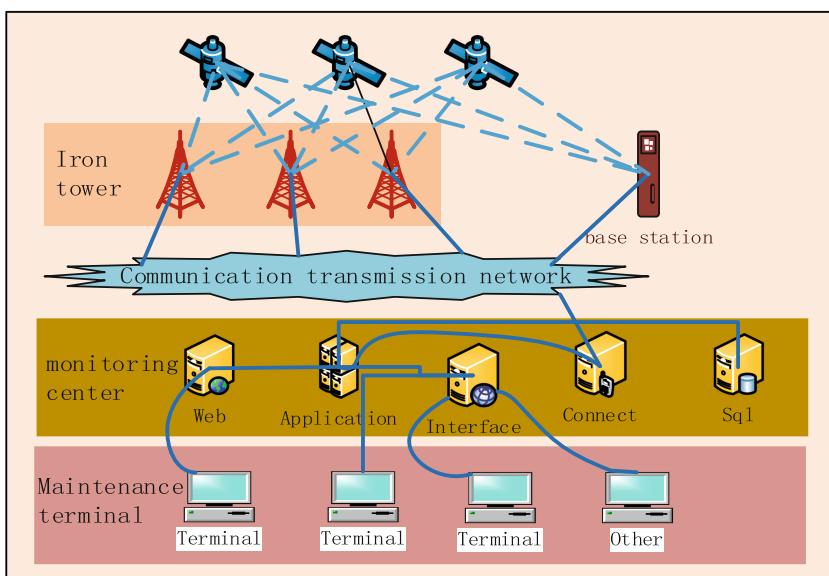
The following describes the tower monitoring system based on satellite positioning system:

### (1) System principle

Real-time Kinematics carrier phase difference technique is used to process the observed carrier phase difference between two measuring stations in real time. This technique is mainly used to calculate the carrier phase difference collected by the test station and the carrier phase difference received by the receiver and calculate the coordinates. This is a new common GPS measurement method, which can obtain real-time positioning accuracy of centimeter scale. Based on this technology, the tower can be accurately positioned and observed in real time, and its displacement status and attitude information can be obtained.

### (2) System composition

The tower monitoring system based on RTK technology is usually divided into four levels of structure, consisting of a monitoring station, a reference station, a monitoring center, and a maintenance terminal. The reference station is installed in a place where the geographic coordinates are known and relatively stable. It is mainly responsible for locating the geographic coordinates of the point and sharing it with the surrounding monitoring stations through the communication transmission network. The monitoring station is installed at the iron tower and mainly locates the satellite positioning system. Point location, and receive the position information shared by the base station, monitor the tower site attitude information. The monitoring center is composed of monitoring center server, database server and other equipment, and calculates the precise position coordinates based on the differential positioning algorithm. The monitoring data is analyzed, stored and displayed, and the state of the tower is pre-warned. The system structure is shown in Fig. 3.



**Fig. 3.** Tower monitoring system based on satellite positioning system

### (3) Monitoring station

The monitoring station equipment is mainly composed of satellite receivers and dedicated measuring antennas. It is powered by solar power or wired power. It is installed on the top of the tower and the base of the tower. It is connected to the reference station through a communication transmission network. This information is monitored in real time, compared with the information received by the base station, and finally sent to the monitoring center.

### (4) Reference station

The base station equipment is also composed of a satellite receiver and a dedicated measurement antenna. It is powered by solar power or wired power and is equipped with a UPS uninterruptible power supply. It is generally set on a relatively stable ground with known geographic coordinates. The reference station generally provides location information to monitoring stations within 20 km for comparison, and transmits the information to the monitoring center.

### (5) Monitoring center and maintenance terminal

The settings and functions of the monitoring center and maintenance terminal are basically the same as the sensor-based tower monitoring system. By comparing the position information of the monitoring station with the reference station to which it belongs, the inclination, displacement, and settlement of the tower can be monitored in real time, and an alarm message is issued when the tower status is abnormal.

## 4 Research and Analysis of Tower Monitoring System Based on BeiDou Navigation Technology

At present, the most widely used US GPS global satellite positioning system, due to the out-of-service conditions of satellites, has caused the accuracy of positioning information to decline, which has caused a lot of obstacles for the operation of such systems as towers monitoring high-precision positioning information. With the steady construction of China's independent BeiDou satellite navigation system, BeiDou navigation system provides a strong guarantee for the tower monitoring system. At the same time, the short message function of BeiDou navigation system is not available in other satellite navigation systems.

This makes BeiDou navigation based. The data transmission between the stations of the system's tower monitoring system can be achieved without relying on an external communication transmission network, and only by the short message function of the BeiDou navigation system. However, the reference and monitoring stations in the system can only monitor the inclination, displacement, and settlement of the tower in real time through changes in position information, and the tower still has structural safety hazards such as structural aging and loose bolts before these conditions occur. Cannot be detected by the system.

A single technical foundation cannot completely and accurately monitor the condition of the tower. At present, comprehensive tower monitoring systems have begun to appear in some fields. Combining the high-precision BeiDou satellite navigation system with various sensors such as vibration and weather, it is possible to perform real-

time and comprehensive monitoring of towers from different angles. Combine analysis to reduce false alarm rate and improve system operation efficiency. With the rapid development of China's railways today, efficient tower monitoring systems can effectively guarantee the safety and stability of communication towers along the railway, and can greatly promote the safety of railway transportation.

## 5 Conclusion

During the large-scale construction of railway communication towers, especially in areas with frequent geological disasters and poor maintenance environments, in order to eliminate the hidden dangers of tower safety in time, avoid dangerous accidents such as tilt and collapse, and accumulate basic data such as foundation settlement and tower maintenance, It is very necessary to build a communication tower monitoring system. As the displacement, deformation and foundation settlement of the communication tower are a development process from gradual change to sudden change, it is necessary to rely on precise monitoring methods and appropriate technical methods for long-term continuous monitoring. With the comprehensive deepening and expansion of new technologies such as cloud computing, big data and mobile Internet in various fields of Railway, a variety of monitoring technologies are likely to be applied to tower monitoring. The big data formed after the monitoring of the tower reflects the foundation condition of the area where the tower is located in real time, which not only helps to ensure transportation safety and improve transportation efficiency, provides a scientific basis for operation and maintenance, but also provides reliable data for the design and construction of surrounding projects. Avoid risks in advance and reduce possible disaster losses.

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# Failure Risk and Control of Nitrogen Trifluoride Tube-Bundle Container

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**Abstract.** Due to the rapid development of Chinese semiconductor industry and the expansion of chip manufacturing capacity, the storage and transportation of electronic special gas in ordinary gas cylinders has been unable to meet the demand. High pressure liquefied gas tube-bundle container is a better solution. Since 2017, Chinese machine manufacturer has started to be approved cautiously to manufacture high pressure liquefied gas tube-bundle container, including nitrogen trifluoride. But objectively speaking, the domestic regulations and standards about special equipment do not support the tube-bundle container containing high pressure liquefied gas. It is very important to identify the failure risk accurately. Through the analysis of the supervision mode and failure mode of high pressure liquefied gas tube-bundle container, six possible failure modes, including fatigue failure, ductile failure, brittle failure, corrosion failure, leakage failure and frame structure failure, were proposed. The corresponding risk control measures are studied, and relevant Suggestions are given to ensure the safety of tube-bundle container.

**Keywords:** Tube-bundle container · Large volume seamless steel cylinders · Nitrogen trifluoride · Risk assessment

## 1 Introduction

The safety of storage and transportation of gas is always an important issue. Thanks to the rapid development of the semiconductor industry in China, the electronic specialty gas industry has also achieved considerable development. In fact, the storage and transportation of electronic special gas in ordinary gas cylinders has been unable to adapt to the rapid expansion of production capacity of enterprises in the semiconductor industry [1]. Therefore, Chinese market quickly generated a large number of demands for liquefied gas tube-bundle container. Some experience has been accumulated in the manufacturing and using of large volume seamless gas cylinder, long-tube trailer and tube-bundle container [2–5]. However, Long tube trailer, tube bundle container is only suitable for filling compressed gas medium, that is, does not contain liquefied gas, which is explicitly stipulated in TSG R0005-2011 Supervision Regulation on Safety Technology for Transportable Pressure Vessel [6] (hereinafter referred to as

“Regulation on Transportable Pressure Vessel”) in China. Therefore, the design, manufacture, inspection, filling and use of high pressure liquefied gas tube-bundle container including nitrogen trifluoride are very special. Its failure risk and control measures should arouse sufficient attention.

## 2 Regulatory Model in China

As a transportable pressure vessel, high pressure liquefied gas tube-bundle container is subject to the supervision and management of the national law named as Special Equipment Safety Law. At the same time, it should comply with the relevant administrative regulations of the department of special equipment safety supervision and the requirements of safety technical specifications including “Regulation on Transportable Pressure Vessel”. All liquefied gas tube-bundles containers used in China were imported from abroad before 2017. After 2017, based on the rapid development of manufacturing technique on tube-bundles containers, especially the rapid progress of grinding technology, several manufacturing firms were approved to produce them through the technical review by the department of national special equipment safety supervision. High pressure liquefied gas tube-bundle container which made in China is mainly used for the storage and transportation of electronic special gas, mainly covering nitrogen trifluoride, silane, nitrous oxide, anhydrous hydrogen chloride, carbon tetrafluoride, sulfur hexafluoride in the industry. It should be pointed out that the manufacture of high pressure liquefied gas tube-bundle container is still belong to “one case one discussion”, which requires each manufacturing unit to pass the technical review and administrative permission before trial production and trial use. There is no national standard, and the industry standard or group standard are still in the process of formulation. At present, each manufacturing firm adopts the enterprise standard that has been reviewed and filed [7]. In addition to the special equipment manufacturing license issued by the market supervision department, the manufacturing firm shall obtain the license stipulated by the transportation department if participating in the maritime transportation.

## 3 Typical Product and Properties

High pressure liquefied gas-bundle container also belongs to the multi-unit gas container (MEGCS) defined in the International Maritime Dangerous Goods Code [8], which is composed of four parts: frame, large-volume seamless steel gas cylinder, piping system and pneumatic control system. The common nitrogen trifluoride (NF<sub>3</sub>) tube-bundle container is made of large volume seamless steel gas cylinders, with material 4130X, outer diameter 559 mm, design wall thickness 13.7 mm, and nominal operating pressure 16.6 MPa, and it is formed by 8 or 12 tubes usually. The technical characteristics of typical products are shown in Table 1.

Nitrogen trifluoride [9], boiling point at standard atmospheric pressure is  $-129.06\text{ }^{\circ}\text{C}$ , critical temperature is  $-39.3\text{ }^{\circ}\text{C}$ , critical pressure is 4.53 MPa, liquid density is  $1.204\text{ g/cm}^3$  at  $25\text{ }^{\circ}\text{C}$ . Its physical properties are shown as follows: it is liquefied gas under high pressure. Pure nitrogen trifluoride is colorless and odorless at room temperature and atmospheric pressure. While mixed with certain impurities, it has a mildew smell. Gases or vapors are heavier than air and may accumulate in confined spaces, especially in low-lying areas. Its chemical characteristics are shown as follows: nitrogen trifluoride supports combustion, as a strong oxidant. Nitrogen trifluoride can burn if it is heated or contact with flame, electric spark, organic matter and so on. If nitrogen trifluoride contact with combustibles will have a violent reaction, and even causing combustion explosion.

**Table 1.** Technical characteristics of typical nitrogen trifluoride tube-bundle container

Item name parameter	
Nominal operating pressure	16.6 MPa
Filling medium	Nitrogen trifluoride (NF3)
Environment temperature	$-40\text{--}60\text{ }^{\circ}\text{C}$
Specification of gas cylinder	$\Phi 559 \times 13.7 \times 5480\text{ mm}$
Test pressure of Pipeline	27.7 MPa
Cylinder volume	1100 L
Leakage pressure	16.6 MPa
Filling ratio	0.56 kg/L
Empty container weight	17000 kg
Maximum charge per bottle	616 kg
Rated quality	30480 kg
Cylinder number	12
Stacking weight	192000 kg
Gross capacity	$13.2\text{ m}^3$
Design service life	20 years
Outside dimensions	$6058 \times 2438 \times 1980\text{ mm}$
Mode of transport	Road and sea transportation
Connector specification	CGA DISS 640

High purity nitrogen trifluoride, as a fine etching gas, is widely used in the electronics industry and solar photovoltaic industry, especially in integrated circuit manufacturing, which has excellent etching rate and selectivity, leaving no residue on the etching surface.

## 4 Failure Mode

In the process of type test, filling, transportation and unloading, Nitrogen trifluoride tube-bundle container mainly bears the following loads: operating internal pressure, dynamic load, fatigue load, temperature gradient force, testing load. The main failure modes include fatigue failure, ductile failure, brittle failure, corrosion failure, leakage failure and frame structure failure.

### 4.1 Fatigue Failure Mode

Fatigue failure is mainly caused by cylinder fatigue after a certain period under the action of cyclic change of operating pressure and temperature, which may be leaking before explosion. Under the action of alternating stress, slippage, crack of grain boundary and crack of inclusions and matrix plane occur between crystals in internal high-stress zone. Micro-crack initiation and expansion, in a certain period and under a certain stress, fatigue failure may occur, once serious leakage of nitrogen trifluoride, will cause serious consequences.

### 4.2 Ductile Failure Mode

Ductile fracture failure is mainly caused by mechanical damage, thickness thinning, internal overpressure and other factors, that cause the internal stress of the cylinder to reach or approach the tensile strength of the material. Once the strength insufficient and failure damage occurs, nitrogen trifluoride spread quickly, and mixed with air into an explosive mixture, in case of open fire or spark, which could easy to cause explosion.

### 4.3 Brittle Failure Mode

Brittle fracture failure is mainly due to the material embrittlement and other factors, resulting fracture in a small amount of deformation of the cylinder body, and the stress inside the container wall is much lower than the material tensile strength. Fracture occurs when  $KI$  is larger than  $KIC$  of the material. Once brittle fracture occurs, it is very easy to cause malignant explosion accidents under normal operating parameters, and the consequences will be unimaginable.

### 4.4 Corrosion Failure Mode

Metal materials of nitrogen trifluoride tube-bundle container may be corroded and destroyed by the action of internal and external medium, resulting in the thinning of the equipment wall. Although the corrosion failure develop slowly, the corrosion develops to a certain extent may cause leakage or even detonation. It mainly occurs in the inner and outer walls of gas cylinders and pipe fittings in pipelines. The inner wall corrosion is mainly related to the filling medium, while the outer wall corrosion is mainly related to the service environment. The impurity in nitrogen trifluoride that does not meet the standard, especially the excessive water content, will accelerate the corrosion of the tube-bundle container, posing a serious threat to the safety of the equipment.

Meanwhile, the peeling off of the external paint will also cause water corrosion of the equipment in the environment.

#### 4.5 Leakage Failure Mode

Leakage failure is mainly caused by the leakage of nitrogen trifluoride medium due to insufficient sealing or penetrating cracks, which mainly occurs in the connection between the gas cylinder and the end plug, valves, welding points and other external pipeline systems. Improper selection of thread connection between bottle mouth and bottle stopper or crevice corrosion will lead to leakage failure.

#### 4.6 Frame Structure Failure Mode

The failure of frame structure refers to the repeated impact of collision or vibration during the transportation of tube bundle container, which leads to excessive deformation of the frame structure or even material fracture. As a result, the cylinder rotates or moves, which will distort or even break the pipeline. The failure of frame structure will result in the instability of equipment structure, pipeline damage or leakage, which will cause serious consequences [10].

### 5 Risk Control Measures

Risk control of nitrogen trifluoride tube-bundle container mainly aims at above-mentioned failure modes that may occur in the process of manufacturing and using, in order to ensure the safe operation of tube-bundle container in its designed service life. The following risk control measures are mainly adopted.

#### 5.1 Fatigue Failure Control

First of all, it is very important to reduce the actual stress of dangerous parts. When there are defects, rough surface and stress concentration on the cylinder surface, crack initiation and propagation will be accelerated. Therefore, stress concentration should be avoided as far as possible in manufacturing. After spinning, the cylinder body and the outside of cylinder shoulder, as well as the cylinder shoulder and neck should be smooth and smooth. And obvious gap scratch, folding, crack or off-shoulder phenomenon should not be allowed to exist, so as to improve the surface smoothness of the cylinder body, prevent surface scratch and avoid surface defects or soft spots. In the second place, the cylinder body needs to undergo proper quenching and tempering heat treatment to obtain good comprehensive mechanical properties, which can effectively improve the fatigue resistance. In addition, the fatigue test cycle times of the cylinder body with the same outer diameter and thickness should reach at least 15,000 times. Last but not the least, the surface should be strengthened by shot peening. Surface strengthening can produce high residual compressive stress on the surface of the cylinder, which could delay or inhibit the initiation of fatigue crack on the surface.

## 5.2 Ductile Failure Control

Firstly, the actual minimum thickness of the new cylinder must be greater than or equal to the design wall thickness. The manufacturing firm shall fully consider the manufacturing tolerance of the steel pipe when purchasing the raw material and the thickness thinning in the product process. Secondly, it should strictly control the overpressure operation of the container, and strictly control the filling medium and filling capacity. Finally, it is very important to have regular internal and external inspection, and pay attention to wall thickness during service period.

## 5.3 Brittle Failure Control

First, the service temperature of nitrogen trifluoride tube-bundle container should not be lower than the non-plastic transition temperature of the material and not lower than the low limit of the design temperature. Second, the mechanical properties of cylinder after heat treatment are in accordance with the design requirements, especially the yield strength ratio, elongation and impact absorption energy. Third, reduce the stress concentration, the inner corner of cylinder mouth and the bottom diameter of the thread should be rounded, and to be strictly controlled according to the design. The manufacturing quality of the inner and outer surface shall be strictly controlled. Mechanical damage shall not exist. Sharp steel seal shall not be used for marking. Last, filling nitrogen trifluoride cannot be mixed with other medium, which should meet the corresponding standards of nitrogen trifluoride, together with regular internal and external inspection.

## 5.4 Corrosion Failure Control

Firstly, pay attention to the chemical composition of raw material of cylinder: phosphorus content should be less than 0.015%, while sulfur content should be less than 0.010%. Secondly, the actual tensile strength of the cylinder after heat treatment shall not exceed 880 MPa, and the actual yield strength ratio shall not exceed 0.86. The seamless steel tube and cylinder should be non-destructive tested by ultrasonic wave and magnetic powder. There should be no folds, delamination, cracks or other defects. Thirdly, the roughness Ra of the inner surface of the cylinder after grinding should be no more than  $0.8 \mu$ . After vacuum replacement, the water content in cylinder and pipeline should be less than 2 ppmV to avoid the corrosion of the inner wall caused by water. The outer wall of cylinder is sprayed with epoxy amino baking primer and acrylic amino baking topcoat after shot peening. The total dry film thickness of the paint is more than  $150 \mu$ , which meets the corrosion resistance requirements of normal service environment. Lastly, tubes, fittings and valves shall be made of S30603 which can be compatible with nitrogen trifluoride. The roughness Ra of inner and outer surface of pipes and fittings shall be  $0.25 \mu$ .

### 5.5 Leakage Failure Control

First of all, the cylinder should be tested for static balance before installation to ensure the lowest center of gravity. Fixing hoop and radial pin are arranged axially to prevent cylinder from axial movement and circumferential rotation in use. In the second place, the pipeline adopts flexible structure to avoid the influence of temperature stress. The pipeline is supported to prevent damage of sealing surface caused by mechanical vibration. The pipeline adopts the converge-wires to minimize contact points and reduce the possibility of leakage. In the third place, the sealing of gas cylinder and the end plug adopts radial sealing of two O-type fluorine rubber (FKM) sealing rings and end face sealing of PTFE sealing ring. The root valve and the branch pipeline adopt full-penetration butt welding structure. Last but not the least, the overall air tightness test is conducted with mixture of helium and nitrogen (90% nitrogen +10% helium) according to the nominal working pressure before delivery. The leakage rate should meet the requirements of the design document (the leakage rate should generally be no more than  $1 \times 10^{-7} \text{ Pa} \cdot \text{m}^3/\text{s}$ ).

### 5.6 Frame Structure Failure Control

Firstly, the frame should be selected Q345E and other appropriate materials, to ensure sufficient toughness reserves at  $-40^\circ\text{C}$  and the strength under normal operation. Secondly, Frame type test should be achieved according to GB/T 16563-2017 series 1 “Freight Containers Specification and Testing Tank Containers for Liquids, Gases and Pressurized Dry Bulk” [11], including stacking, hanging top, hanging bottom, longitudinal bolting, internal longitudinal bolting, internal transverse bolting, transverse rigidity, longitudinal rigidity, etc. Those only participate in road transport shall comply with the requirements of appendix E1.4 of “Regulation on Transportable Pressure Vessel”.

## 6 Conclusion and Suggestion

Nitrogen trifluoride high pressure liquefied gas tube-bundle container as a special equipment that needs “three new” technical review and administrative permission by the national department of special equipment safety supervision before trial production, its failure modes and control measures should be given special attention. The design and manufacturing firm must uphold the main responsibility of product quality and safety, to strengthen source control and comprehensively in accordance with the enterprise standard and process documents that have been reviewed and registered. The user and the filling firm shall operate strictly in accordance with the operating instructions and relevant specifications, make emergency plans and safety drills, and eliminate illegal operations. The inspection firm shall carry out periodic inspection and supervision inspection according to regulations to eliminate potential safety hazards timely. Supervisory department should urge relevant units to fulfill their main responsibilities, implement the registration of high pressure liquefied gas tube-bundle

container, strengthen the in-process and ex-post supervision of license-issuing firms and intensify law enforcement.

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# Construction and Exploration of Intelligent Manufacturing Training Rooms Integrated with Production

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**Abstract.** The *Made in China 2025* strategy puts forward the goal of building China a manufacturing power. To meet the demand for high-quality technical and skilled talents, in this paper, an intelligent manufacturing training room for the cultivation of intelligent manufacturing professionals in higher vocational colleges is constructed. It is proposed that the intelligent manufacturing training room should have the characteristics of exhibition, teaching and scientific research. Taking these characteristics as the basic construction concept, the layout of the training room is designed; the construction scheme and the construction mode are elaborated in detail. Practice has proved that the intelligent manufacturing training rooms can serve the teaching, researching and talent training in higher vocational colleges, and plays a positive role in promoting the school development, improving teachers' scientific research ability and enhancing students' practical ability. It can provide reference for the construction of similar training rooms in other colleges and universities.

**Keywords:** Integration of production · Study and research · Intelligent manufacturing · Industry 4.0 · Construction of training room · Higher vocational colleges

## 1 Introduction

The proposal of “industry 4.0” has inspired a new round of technological revolution in the manufacturing industry. Based on our own national conditions, China proposes the “made in China 2025” strategy and vigorously promotes the upgrading of manufacturing industry [1]. The transformation and development from traditional manufacturing to intelligent manufacturing are in line with the strategic direction of the times, and is also the only way for China to occupy the high point of the manufacturing industry strength and realize the manufacturing power [2]. As the main body outputting application talents of manufacturing technology, it is imperative for higher vocational colleges to build intelligent manufacturing training rooms to help the cultivation of high-end talents. This paper focuses on the construction of the intelligent manufacturing training room in our institute, and conducts research and practical exploration from aspects of the construction concept, the layout design, the construction scheme

and the construction mode, so as to provide useful reference for the construction of related training rooms in similar colleges and universities.

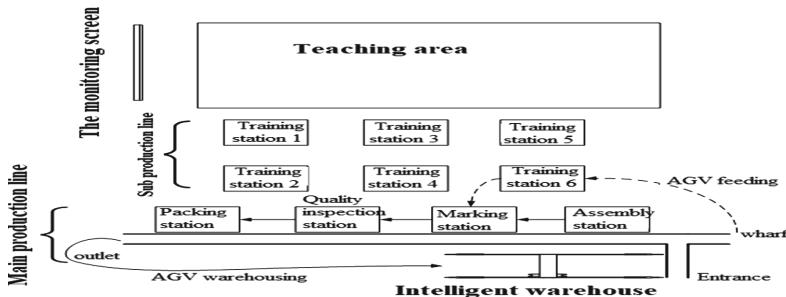
## 2 Exploration of the Construction Concept

The intelligent manufacturing training room in colleges and universities should be able to reflect the characteristics of intelligent manufacturing technology, and deeply integrate information technology, intelligent technology and equipment manufacturing process technology [3]. The intelligent manufacturing training rooms represented by literature [4–6] build single automatic demonstration production lines covering a number of intelligent manufacturing technology elements, generally including a number of physical work stations such as the three-dimensional warehouse, the object conveying system, the processing station, the assembly station and the detection station as well as management information systems such as ERP and MES. They can demonstrate technologies related to intelligent manufacturing in the process of producing objects. The advantages are good production display effects as well as intelligent processing and production environment provided for scientific research in colleges and universities. The disadvantages are high construction costs, the large floor area, and difficulties in practical teaching due to different equipment in each work station. The intelligent manufacturing training rooms represented by literature [7–9] are equipped with intelligent manufacturing training platforms, which generally have a desktop type small production line, including the PLC, the robot, the machine vision, the conveyor belt, the sensor, the frequency converter, the motor and other equipment, which can realize all-round practical training of production and manufacturing links. These rooms have some advantages. The cost of the training platform is low; it is convenient to carry out practical teaching after purchasing multiple sets of equipment. The disadvantages include lacking complete production and application scenarios, poor display effects, and difficulties in meeting the scientific research needs of teachers.

Based on the advantages and disadvantages of the above two schemes, in order to give full play to the benefits of the training room, the construction of intelligent manufacturing training room in higher vocational colleges needs to take three factors into account. First, the room should be a window for the school to display and a technical reference for surrounding enterprises to carry out equipment innovation. Second, the room is a teaching platform for students to improve intelligent manufacturing skills and abilities [10]. Third, the room is the platform of teachers' scientific research and various achievements. With the basic construction concepts of "displaying characteristics, teaching characteristics and scientific research characteristics", our institute began to prepare for the construction of intelligent manufacturing training room in 2018, striving to build a training room with the leading and demonstration effect in domestic higher vocational colleges.

### 3 Layout of the Training Room

The construction area of the training room is 300 m<sup>2</sup>. In order to make full use of the site, a layout plan consisting of four parts, namely the main production line of intelligent manufacturing (hereinafter referred to as the main line), the sub production line of intelligent manufacturing (hereinafter referred to as the sub line), the large monitoring screen and the teaching area (shown in Fig. 1) is formed. The interface of each functional area is clear. It has the characteristics of production, teaching and scientific research. The main line is an automatic demonstration production line including several technical elements of intelligent manufacturing, which mainly embodies the production display function of the training room. The sub line is a number of training stations, which can not only participate in the production of products and complete certain processes of production, but also can be used to carry out experiments and training. The materials are transferred between the main line and the sub line through AGV trolleys. The teaching area is equipped with teaching equipment such as desks, chairs and desktops for theoretical teaching. The monitoring screen can be used as the interface of MES system monitoring in the training room and display the current production status of the ring production line, and used as the display screen in the teaching area.



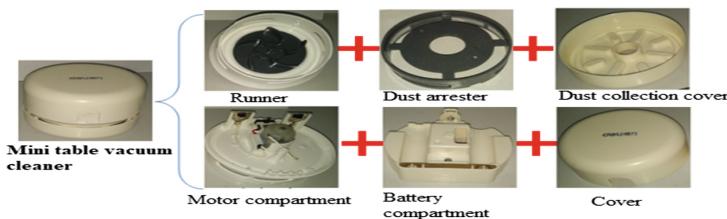
**Fig. 1.** Layout of the main and sub production lines in the training room.

### 4 Training Room Construction Plan

#### 4.1 Selection of Production Objects

Because of its flexibility, the intelligent factory can produce personalized products on a large scale. The production objects of the main line of the intelligent manufacturing training room should be able to reflect the characteristics of flexible production and personalized customization. It is also the display production line of higher vocational colleges; we need to comprehensively consider the processing and assembly difficulty, the display effect, the purchase difficulty, the cost of raw materials, the maintenance convenience and other factors. Finally, the object is determined as a mini desktop cleaner (shown in Fig. 2). The production object has a variety of colors. It can be marked by the laser; it can reflect the diversity and customized features of the products.

At the same time, as the extension application product of core components of the motor, it is consistent with the connotation and characteristics of our institute.



**Fig. 2.** Production objects and components.

#### 4.2 Hardware Composition and Operation Mode

Figure 3 is the main production line of the intelligent manufacturing training room. Taking the mini desktop vacuum cleaner as the production object, it is composed of the intelligent warehouse, the assembly workstation, the marking workstation, the quality inspection workstation, the cartooning workstation, the material conveying line, the AGV transfer trolleys and so on. It integrates information and communication technologies such as MES, RFID, the industrial Ethernet and fieldbus, and realizes online customized order through intelligent cloud technology. It can realize the interconnection of products in demand, production, supply and other links, and display the key application technologies of products in the intelligent manufacturing process.



**Fig. 3.** Main production line of the intelligent manufacturing training room.

The operation process of the main line is as follows. First, the user scans the code and places an order through the terminal equipment such as mobile phone, selects the color and quantity of the product in the order interface, and writes the personalized characters or patterns. After the MES system receives the network order, it generates each execution command, in which the raw material components are taken out from the intelligent warehouse by the high-speed stacker and placed on the material tray. Then the material tray carrying the raw material components starts to flow along the main line from the entrance of the transmission line. First, it passes through the assembly station. There is an ABB YUMI double arm robot in the station, which simulates the

human hands to assemble the six components of the mini desktop vacuum cleaner (the motor compartment, the battery compartment, the runner, the dust arrester, the top cover and the dust collection cover, as shown in Fig. 3). Next, at the marking station, a laser marking machine marks individual characters and patterns on the top cover. Afterwards, a SCARA robot in the quality inspection station picks up the marked products for visual inspection and functional inspection. Finally, the qualified products are transferred to the packing station for outer packing; the AGV trolley is informed to transport the finished products back to the intelligent warehouse from the outlet of the transmission line.

According to the beat time of each work station, it is found that the assembly station takes the longest time, which is the “bottleneck” of the whole production line. Therefore, the production function of each training station of the sub line (as shown in Fig. 4) becomes the product assembly line to improve the production efficiency. The training station is equipped with the ABB IRB120 six axes industrial robot, the Siemens S7-1200 PLC, the Cognex vision system, the AC servo system, the frequency converter and other equipment. When the main line production task is heavy, the MES system will dispatch AGV trolleys to transfer the ex warehouse raw material components from the wharf to each workstation of the auxiliary line. After the components are assembled by the robot, they will be transported back to the main line marking station via AGV trolleys for subsequent process flow. In addition, the training workstation also has the function of experimental training, which can be used in the teaching of multiple courses. Because it is a set of equipment with the same structure, it can meet the needs of the whole class to carry out experimental training.



**Fig. 4.** Communication between the training workstation and the equipment room.

Each workstation in the training room is controlled by a PLC. All work station units are interconnected through the industrial Ethernet, the industrial wireless network or the industrial bus technology, and are connected with the MES system of the training room. The system architecture is shown in Fig. 5. In the application of teaching, we can gradually train students' abilities of operation, fault detection and maintenance, problem analysis and solution, as well as comprehensive innovation from the easy to the difficult and complicated.

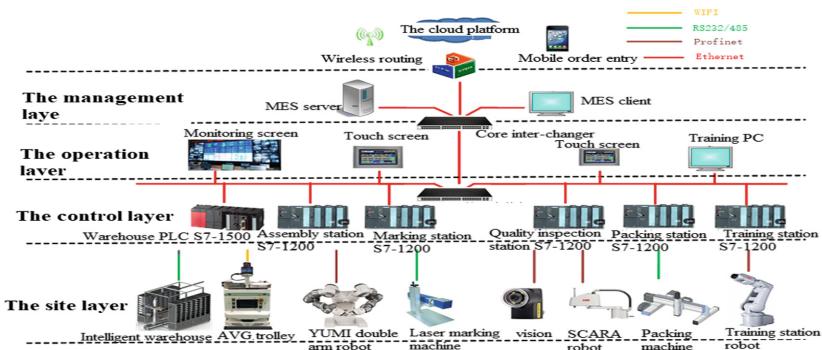


Fig. 5. Framework of the intelligent manufacturing training room.

#### 4.3 MES System in the Training Room

The MES system is the core system of intelligent manufacturing. Based on the framework of intelligent factory, the MES system of training room is designed and developed to control the whole production process and realize the traceability of the whole production process. Production data are mainly displayed in the form of boards in the large monitoring screen of the training room, including information of output, yield, storage status, energy consumption and so on. In order to facilitate the use and maintenance of the training room, the MES system also integrates the big data analysis function of the training room, makes statistical analysis on problems and defects found in the use of the training room, and provides data support for the continuous optimization of the teaching management, as well as the equipment and consumables management of the training room.

#### 4.4 Construction of Teaching Resources

The training room integrates advanced technologies such as PLC, the industrial robot, the machine vision, the AC servo, the sensor, RFID, the intelligent storage, AGV and the industrial Internet of things; it can carry out experimental teaching of industrial robot, the machine vision, the programmable controller, the AC servo and the frequency conversion technology. Guided by the needs of the industry, with typical projects as the carrier, combined with the talent training objectives and curriculum standards of the school in mechatronics, electrical automation, industrial robot technology and other majors, the online and offline integrated teaching resources are developed. The teaching resources cover teaching materials, experimental training instructions, teaching videos, courseware, question banks, micro courses, engineering cases and other forms. Students can scan code to access the supporting online digital resources of self-learning.

#### 4.5 Construction of Environment and Culture

In addition to the construction of software and hardware, the ceiling installation, the floor paint painting and other decorations which are suitable for the overall color of the equipment create a good environment for the training room. At the same time, contents of intelligent manufacturing and technology are displayed indoors through hanging cultural display boards on professional construction, the system specification, professional qualities, characteristic innovation and application cases on the wall. Visitors and learners can experience the vitality brought by the environmental culture [11].

### 5 Construction Mode

The intelligent manufacturing training room is constructed by our school and enterprises; teachers, enterprise engineers and students participate in the whole process of construction. The school is responsible for the layout design and scheme construction of the training room by a project team composed of professional leaders and key teachers. The enterprise is responsible for decoration engineering, the equipment procurement and installation, and the overall debugging of software and hardware systems. The school and enterprise cooperate to complete the customized development of control system and production control software. In the construction process, the installation, wiring and debugging of the equipment are arranged in the training room under construction. 15 students of the “modern apprentice system” are both college students and enterprise employees. Under the guidance of professional teachers and enterprise engineers, they complete the installation and debugging of the training room together. Through the co-construction mode of “school, enterprise and student”, all kinds of unexpected problems in the construction process can be solved through real-time communication; the construction quality and progress can be guaranteed. Through the construction of intelligent manufacturing training room, teachers not only improve their scientific research ability, master the cutting-edge technology of the subject, but also help students get engineering practice training in the school, and greatly improve their technical skills.

### 6 Conclusion

Since the construction of the training room in early 2018, preliminary achievements have been made in social services, scientific researches and innovation, as well as practical training and teaching. At present, the training room has received more than 100 visits from enterprises or similar colleges and universities, undertaken 6 national and provincial training programs for secondary and higher vocational schools in Guangdong Province, and trained 189 teachers in technologies related to intelligent manufacturing. Relying on the construction of the training room, the scientific research output of our professional teachers has been significantly improved. In 2018, our college has obtained 4 key scientific research platforms and scientific research projects, applied for 3 patents for invention, authorized 6 patents for utility models, compiled and published 2 teaching materials, and won the first prize in Guangdong Vocational

College Teaching Ability Competition. The students who participated in the construction won two first prizes in the 2018 Guangdong Challenge Cup, one second prize and two third prizes in the National Skills Competition for College Students. At present, the utilization rate of the training room is high, and it has been used in the practical teaching of AC servo and frequency conversion technology, the industrial robot programming and application, as well as machine vision and other courses.

The integration of production, teaching and research intelligent manufacturing training room has a relatively ideal social service ability. It not only provides students with an advanced teaching environment of intelligent manufacturing production, but also provides teachers with a scientific research platform to improve their own technical abilities and professional levels. It has the characteristics of production displaying, teaching as well as scientific research. It has become an important base for promoting the growth of teachers and students, and promoting the development of our school. In the process of construction, some actions and methods can be used for reference in the construction of similar training rooms in relevant colleges and universities.

**Acknowledgements.** This paper is supported by the Foundation for Provincial Key Platforms and Major Scientific Research Projects in Universities and Colleges of Guangdong Province. The Project Number is 2018GXJK309.

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# An Operation Method for Uplink Science Meta Data Transmission Based on Satellite-to-Ground Large-Loop Comparison

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**Abstract.** The distribution of satellite-to-ground secret key is an important experiment for some Science experiments satellite. To finish the secret key distribution experiment, it is necessary for the satellite and ground to interact and cooperate with each other to complete information exchange for uplink and downlink science meta data transmission for 8 times in 24 h. In view of the strict constraint to ground system, the requirement of high reliability, particularly the new challenge to ground system that uplink science meta data transmission function is required, this paper put forward an operation method for uplink science meta data transmission based on satellite-to-ground large-loop comparison to effectively cooperate with the secret key distribution experiment, designed the information interface between systems and accomplished the scientific experiment task quickly and efficiently by optimizing the experiment flow.

**Keywords:** Science experiments satellite · Key distribution · Satellite-to-ground large-loop · Uplink science Meta data transmission operation

## 1 Introduction

Space science is of great significance to the implementation of innovation-driven development strategy for China in account of its frontier, tendency, expansiveness and urgency for development. Therefore, the quantum science experimental satellite, be known as Mozi, is specially planned during the 12th Five-Year Plan by Space Pilot Project of Chinese Academy of Sciences. The program aims to establish a platform for satellite-to-ground long-distance quantum science experiments and complete large-scale quantum science experiments in space on this platform to achieve a breakthrough in fundamental physics research of quantum mechanics and a series of internationally famous scientific achievements.

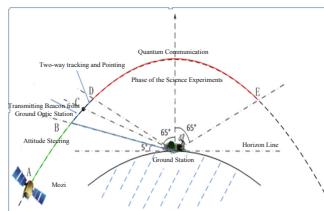
Mozi carries out quantum key distribution, quantum entanglement distribution and quantum teleportation experiments in orbit [3, 10, 11]. The quantum secret key distribution experiment requires the satellite and ground to cooperate with each other to complete information exchange for uplink and downlink science meta data transmission for 8 times in 24 h to extract effective quantum key, so it has strict constraint on satellite-to-ground timeliness, high reliability requirement and the greatest technical

difficulty. Furthermore, it is a new challenge for the flight mission control center to operate uplink science Meta data transmission in high code rate.

In order to solve the problem of high-timeliness constraint and uplink science meta data transmission operation in quantum secret key distribution experiment, this paper put forward an operation method for uplink science meta data transmission based on satellite-to-ground large-loop comparison to effectively cooperate with the quantum secret key distribution experiment, designed the information interface between systems and accomplished the scientific experiment task quickly and efficiently by optimizing the experiment flow.

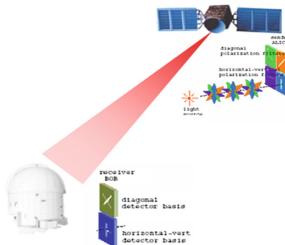
## 2 Experiment of Quantum Key Distribution

When the satellite enters the range of  $5^\circ$ – $25^\circ$  elevation angle of the ground station, Mozi will establish the satellite-to-ground quantum channel [4]. Otherwise, Mozi will establish a two-way information channel when the satellite enters the range of  $25^\circ$ – $155^\circ$  elevation angle of the ground station, seen as Fig. 1, and the satellite will keep high precision synchronization of time with the ground. Firstly, the payload on Mozi emits a decoy state quantum signal and the ground selects the base vector randomly to detect the quantum signal. Then, the ground station uplink the data transmission, including the uplink signal measurement time and the base vector information, and Mozi downlink the matched correct base vector information and the forming initial code of time information [5, 9]. After the satellite and ground complete the error correction and privacy amplification of initial code, will finally get the desired secret key. The Schematic flow of the secret key distribution experiment is shown in Fig. 2.



**Fig. 1.** The schematic map of satellite-to-ground communication

The Science Application Center, shorted as SAC, receives the science Meta data transmitted by Mozi to extract the quantum secret key information, generates the data file to be uplinked and give it to the Flight Control Center, shorted as FCC. Then, FCC sends the data file to the Ground Station Equipment, shorted as GSE, and the data is injected into Mozi through data transmission channel by GSE [6–8, 12] when the satellite enter the transit arc and the satellite feedback the correctness of the scientific data reception. At the same time, the satellite processes the ground quantum key, extracts quantum information again, outputs downlink science Meta data and sent it to SAC. Repeating this operation for 8 times and we will finally get the quantum secret key.



**Fig. 2.** The schematic flow of the quantum key distribution experiment

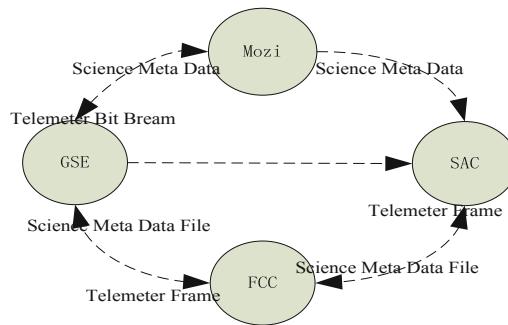
### 3 Operation Method for Uplink Science Meta Data Transmission Based on Satellite-to-Ground Large-Loop Comparison

The experiment of quantum secret key distribution requires the close cooperation of SAC, FCC, the Ground Station and Mozi to ensure that uplink and downlink data transmission can be finished for 8 times in 24 h to extract the effective quantum secret key. Considering the information interface between FCC and the Ground Station and the reliability of information transmission between FCC and SAC, this paper designed an operation method for uplink science meta data transmission based on satellite-to-ground large-loop comparison to ensure finishing the Satellite-to-ground integration of information exchange the quickly and efficiently. Besides, we designed a science Meta data file interaction interface and an interface for communicating the processed results of satellite uplink science Meta data between SAC and FCC. Furthermore, we defined the control command between FCC and the Ground Station to realize the quick capture and information injection of Mozi by ground station. Figure 3 shows the information flow of satellite-to-ground large-loop uplink science Meta data transmission operation.

#### 3.1 Upstream Data File Confirmation Interface

The data of uplink data transmission is generated by SAC and sent to FCC. FCC forwards the uplink data file to the data transmission baseband. After receiving the data file, the data base tape checks the correctness of the file format and returns the data file to FCC to confirm whether the data file is received correctly. Then, FCC notifies SAC after receiving the state feedback message. If the data file is not received correctly, SAC needs to send the data file again.

SAC and FCC use FTP transmitting data. FCC uses File Exchange Protocol sending data files to data transmission baseband. Data transmission baseband of the ground station uses Packet Data Exchange Protocol sending the feedback state information to FCC. The transmission confirmation interface of uplink data transmission data file is shown in Fig. 4.



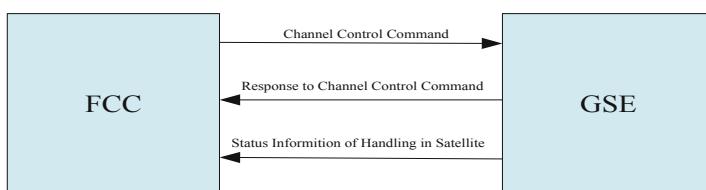
**Fig. 3.** The information flow of satellite-to-ground large-loop uplink science data transmission operation



**Fig. 4.** The transmission confirmation interface of uplink data transmission data file

### 3.2 The Interaction Information Between FCC and the Telemetry, Tracking and Control and Data Transmission Equipment (TT&CDTE)

In order to ensure that the operation of uplink science Meta data transmission is finished within the constraint time, FCC designs the information used for interacting with the TT&CDTE. It mainly includes the channel control command information from FCC to TT&CDTE, including the beginning of the uplink data transmission carrier scan, the stop of the carrier scanning, the added filling frame, the added effective data etc., the control command response information from TT&CDTE to FCC, such as the notification carrier scanning has begun, and the satellite status information, providing the information of satellite data transmission carrier lock, frame synchronization, etc. These control command, response information and satellite status information interface all use packet data exchange protocol for transmittion. The information interaction interface between FCC and TT&CDTE is shown in Fig. 5.



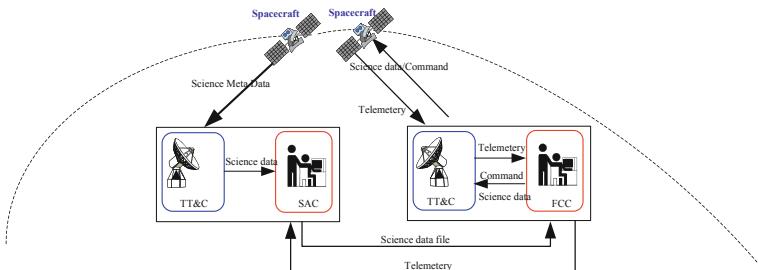
**Fig. 5.** The information interaction interface between FCC and TT&CDTE

### 3.3 The Interaction Information Between FCC and SAC

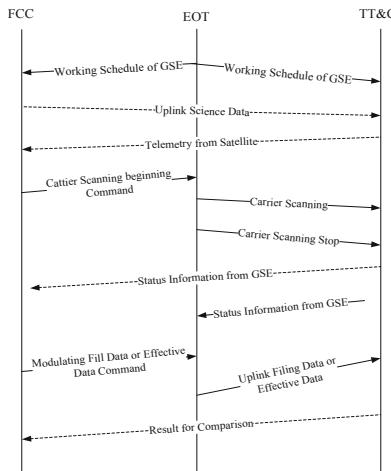
After FCC controls TT&CDTE completing the data injection of uplink science Meta data, it will transmit the telemetry information from satellite to SAC. Then, SAC determines the correctness of satellite receiving and processing uplink science Meta data transmission through processing the telemetry information.

## 4 Uplink Science Meta Data Operation Process

When Mozi enters the range of telemetering, tracking and control arc, the equipment operation terminal, shorted as EOT, which is deployed in the FCC, Firstly controls TT&CDTE to carry on data transmission carrier wave scanning of the satellite and uplinks some filling frame information for satellite subsequently. Then, when Mozi locks up the uplink science Meta data transmission carrier wave, it will feedback the locking state of carrier wave and feedback the bit synchronization information state to FCC in telemetry information. After FCC determines the synchronization of satellite data frame, it will control TT&CDTE sending the pre-prepared science data to the satellite. After receiving and processing the science data, the satellite will feedback the receiving and processing results of the science data in the downlink telemetry information, and FCC will forward the telemetry to SAC. Finally, SAC will interpret the implementation effect of this uplink science Meta data transmission operation. The realization and operation process of uplink science Meta data transmission operation are shown in Figs. 6 and 7.



**Fig. 6.** The realization process of quantum secret key distribution experiment



**Fig. 7.** The realization process of uplink science Meta data transmission operation

## 5 Applications and Conclusion

Since Mozi launched in August 2016, FCC, cooperating with the SAC and the science research group, has adopted the method designed in this paper more than once to carry out the experiments of secret key distribution [1] and intercontinental quantum communication network [2] based on the science experiment satellite, which completely finished all scheduled experiments, meanwhile that also verified the correctness of the method proposed in this paper and the validity of the experiment flow.

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# A Brief Discussion on the Method and Key Technology of Using ZY-3

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**Abstract.** Digital orthography (DOM) is an important 4D mapping product. In this paper, according to the characteristics of ZY-3 satellite image, the technical process of making orthophoto image based on ZY-3 satellite image is designed, the key technology of orthophoto image making and the quality inspection method are introduced, and the useful exploration of making orthophoto image of the area without measurement control points is carried out.

**Keywords:** ZY-3 · The DOM · Image fusion · Image Mosaic · The key technology

## 1 The Introduction

Digital orthographic image (DOM) is an important 4D mapping product, which is obtained after digital differential correction, image fusion, image Mosaic and other processes for aerial and satellite images using digital elevation model (DEM). Numbers are projective like figure compared with the traditional topographic map, has rich information, intuitive, real cycle short, etc., and more readable and has been widely applied in the investigation of land and resources, environmental monitoring, energy exploration, disaster relief and the urban construction and other fields, in the national economic construction and national defense construction has played an important role in [1].

Based on the resource # 3 (ZY-3) satellite images, for example, in the absence of field measurement control points to participate in, through to the traditional digital orthogonal projection like figure method to carry on the improvement and optimization, design based on ZY-3 satellite images of the technical scheme of orthogonal projection like figure, further improves the production results of orthogonal projection like quality and work efficiency, no field measurement control points for the region's orthogonal projection like figure database construction has carried on the beneficial exploration.

## 2 Overview of ZY-3 Satellite Images

ZY-3 satellite is China's first civil surveying and mapping satellite. It was launched in Taiyuan, Shanxi Province on January 9, 2012. It is a linear push-sweep optical satellite, with a sun-synchronous circular orbit and an orbital height of 505.984 km. The satellite is equipped with three-line array panchromatic cameras and multi-spectral cameras, front-view cameras and rear-view cameras. The wavelength range of the front-view cameras and rear-view cameras is 0.5–0.8 μm, the spatial resolution is 3.5 m, and the width is 52 km. The wavelength range of the front camera is 0.5–0.8 μm, the spatial resolution is 2.1 m, the width is 51 km. The wavelength range of the front multispectral camera is blue (0.45–0.52 μm), green (0.52–0.59 μm), red (0.63–0.69 μm) and near-infrared (0.77–0.89 μm), with a spatial resolution of 6 m and a width of 51 km [2].

ZY-3 satellite can simultaneously take forward, front and rear ground photos and obtain three-dimensional information of the ground, playing an important role in land and resources census, geological disaster monitoring, environmental protection, urban planning, energy exploration, emergency and disaster relief and other aspects. ZY-3 satellite is equipped with three-wire array stereoscopic imaging function, and the control-free measurement technology adopted by it can meet the mapping needs of 1:50,000 topographic maps without the need of field measurement control points, which is of great significance in serving national economic construction and national defense construction.

## 3 The Production Process of ZY-3 Satellite Orthophoto Image

The production process of ZY-3 satellite orthophoto image map mainly includes: original image preprocessing, aerial triangulation, DEM production, image correction, image fusion, image Mosaic cutting, quality inspection and result submission. In the absence of field measurement control points, aerial triangulation and image correction are different from the production methods of conventional satellite images. Therefore, scientific planning should be made in advance to ensure the smooth completion of the task.

### 3.1 Preprocessing of the Original Image

Prior to the mission, the original satellite images were examined and preprocessed. Check the overlap rate and cloud coverage of the image. The partial cloud coverage of the single image should not exceed 5% of the total area, the total cloud coverage should not exceed 15%, and important features should not be covered. The pretreatment of thin cloud and mist can be carried out by image processing software such as Photoshop and PCI, and better processing can be achieved without loss of image resolution and pixels. The color difference between the images of the same band is smaller, while the color difference between the images of different bands is larger. It is necessary to use software to carry out unified color mixing to ensure clear texture, uniform tone and moderate contrast of all images [3].

### 3.2 Aerial Triangulation

In the absence of field survey control points, the aerial triangulation method of the satellite image of resource 3 is different from the conventional triad encryption method. Through the use of VirtuoZo photometry workstation, the front and rear images of ZY-3 satellite are firstly imported to generate a three-dimensional model of the monoculture image, and the accuracy of the image itself is tested. Then, all the images are connected and a stereo model is generated by free adjustment of area network. Finally, relevant elevation point or other control point data are used to test the accuracy of the results to ensure that the quality of the results reaches the standard [4].

### 3.3 DEM Production

Affected by the tilt of the image and the fluctuation of the ground, the image point produces tilt error and projection error during the shooting of the satellite image, resulting in the inconsistency of the scale of each part of the image, which needs to be corrected by digital elevation model (DEM). The quality of DEM directly affects the effect of geometric correction, and high quality DEM data is the key to the quality of DOM results. DEM can be obtained in three ways: first, 1:50,000 scale DEM is provided free of charge on the Internet. Its advantages are cost-free, short cycle, but its disadvantages are poor accuracy, low current performance, and the error in some areas is up to 100 m. Secondly, contour lines are first collected manually and then DEM is automatically generated by contour lines, which has the advantages of high accuracy and accurate position, but the disadvantages are long cycle and high cost. Third, VirtuoZo software is used to automatically generate DEM through image matching results and then manually modify individual regions. This method has low cost, short cycle and high accuracy, and is an important way to obtain high-quality DEM data.

### 3.4 Image Correction

The purpose of image correction is to correct the central projection image into the vertical projection image, generally using the digital differential correction method supported by DEM [5]. It is recommended to use the Canadian software PCI Geomatica to process the orthography of the resource 3 satellite in the area without field measurement control points. It is the most efficient and accurate remote sensing image processing software in the current image processing software. It can quickly provide strict orbit model for the newly launched satellite. By selecting rational function model, the image's own \*.RPC parameter file was imported, and panchromatic orthophoto image was obtained by using DEM data to correct panchromatic image.

### 3.5 Image Fusion

Resources three satellite images fusion is based on correct good panchromatic satellite images as control, selection of the same name on the panchromatic image and multi-spectral image points for registration, the fusion image has higher spectral information and color information at the same time, the spatial detail, ability is good, get sharpening

edge features, rich texture information, more conducive to improve remote sensing solutions like [6]. Pansharpen fusion method in PCI software can improve the sharpness of the image, make the texture more obvious, reduce the degree of color deviation of the image after fusion, and reduce a certain amount of work for the process of uniform light and color in the later stage.

### 3.6 Image Mosaic

Image Mosaic is the Mosaic of multiple images according to the information of position coordinates to obtain the whole image of the measured area. When the image is concatenated with the same track, the error is small, while when the image is concatenated with the different track, the error is large. The difficulty of image stitching in the same period is small, while the difficulty of image stitching in different periods is large. Therefore, the limit of edge stitching accuracy should be stipulated. While ensuring the accuracy and quality, it should not affect the use of images.

## 4 The Key Technique of Making Orthography

### 4.1 Pretreatment of Thin Cloud and Mist

Cloud is composed of water molecules, air molecules, suspended particles and other components in the air, with uneven distribution and high reflectivity. In the process of taking images, the satellite is easy to be blocked by clouds, which affects the quality of the image of the original resource no. 3 satellite. Can use PCI Geomatica atmospheric analysis modules of software, can automatically set to identify parameters, achieve rapid extraction of cloud area, also can use other image editing software, by enhancing the image contrast and wavelet decomposition and operation way, improve the original spectral satellite image information, reduce the thin mist effect to the feature of shade on image.

### 4.2 Edit Image Matching Results

DEM can be generated automatically by using the image matching module of VirtuoZo software, but the accuracy of DEM data generated automatically is lower, and the errors of ridge, valley, shadow and other areas are larger, so the matching results need to be edited manually to obtain high-quality DEM data. The texture features of reservoirs and lakes are not obvious, and there will be many mismatching points. The matching effect of ridge and gully is also poor. In serious cases, the trend of ridge and gully will be changed. For the areas with large height difference, such as steep cliffs and overpasses, the severe smoothing algorithm should be selected to reduce the deformation of ground features.

### 4.3 Edit Mosaics

Image Mosaic is the Mosaic of multiple single - field orthography images according to geographic coordinates. Due to the different shooting angles of different airstrips [7],

the errors caused by air triangulation cannot be completely eliminated. During image Mosaic, the stitching and dislocation of part of the image boundary region will occur. Can use software to make the image first automatic stitching, then human editors stitching line, edit the stitching line to extension along the boundary between feature, cannot be directly through the object, if there must be through the object, not through the vertically, to choose the right point of view, try to reduce the features of deformation degree, ensure that image feature complete and true.

#### 4.4 The Technique of Equalizing Light and Color

Uniform color is the key to ensure the quality of orthography. Due to the interference of shooting time, different tracks and other factors, the colors of the images are inconsistent, which needs to be processed by means of uniform light and color. The traditional uniform color work is manually processed by photoshop and other image processing software, with high cost, low efficiency and poor quality. PCI software, easy to puzzle and other orthographic image processing software, own a better uniform light uniform color module. Firstly, a standard image is selected as the reference template to automatically homogenize all images. Then select a part of the image inspection, color difference value contrast is too large image, to analyze whether the water area caused by too large, can let the water in the overall uniform color do not participate in the calculation, reduce the impact of water color on the image calculation. After the treatment of even light and even color, the orthophoto image has real color, clear texture, rich spectral information and even tone.

#### 4.5 Image Patch

In orthography production, the distortion of Bridges and tall buildings is common, which needs to be repaired using raw satellite imagery. Traditional image repair is to open the original satellite image in photoshop, cut the image of the deformed area, and directly repair to the orthography, which takes a long time and has poor accuracy. Easy puzzles (EPT) software professional image repair module [8], first on the orthogonal projection as to determine the deformation area, the software will automatically filter the best alternative images, then triangulation geometric correction, ensure the position precision of image for repair, finally automatically repair replacement deformation area, and to replace the image and the original orthogonal projection as the color difference between adjustment, to ensure the color transition nature, tonal and consistent.

### 5 Quality Inspection of Orthography

The quality inspection of orthography includes: file format inspection, drawing inspection, precision inspection and edge inspection. 1. File format check: the submitted image location information is in \*.TFW format. 2. Surface check: mainly check whether the overall tone of the image is consistent, whether the brightness and contrast are moderate, and whether there are obvious stitching traces; 3. Accuracy check: open the topographic map editing software, superposition the vector data and orthographic

image registration, check the data alignment, and analyze the error value and error source [9]; 4. Edge check: it is mainly carried out along the Mosaic line to check whether the image texture on both sides of the Mosaic line is consistent, whether the tone and shadow are properly handled, and whether there is any obvious dislocation. 5. Tone check: extract 20 orthophoto of the test area, select the area for the test area southeast, northwest, southwest, northeast and center of five areas of sample map, Mosaic synthesis image, easy to check the overall tone, contrast, brightness deviation.

## 6 Conclusion

ZY-3 satellite image adopts the controlling-point measurement technology, which can obtain image information on a global scale, which is of great significance to the country's political, economic and national defense fields. As an important digital mapping product, the orthophoto image of ZY-3 satellite provides important data support for the acquisition of basic global geographic information data in China. With the rapid development of computer technology and sensor technology, orthophoto products will have higher and higher resolution and accuracy, and will be applied and developed in more fields [10].

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# Performance Improvement of the Refrigerating System in Refrigeration Storage

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**Abstract.** A cold storage is a food cold storage for storage of perishable foods. The refrigeration effect of the cold storage does not meet the expected requirements. It is necessary to carry out operation and debugging to find out the reasons for the unsatisfactory cooling effect, and finally achieve the expected cooling effect. In this paper, a detailed debugging program is developed for the cold storage, and the operation and debugging are performed to find out the reason, and finally the ideal cooling effect is achieved.

**Keywords:** Cold storage · Refrigeration system · Performance transformation · Cooling effect

## 1 Introduction

A cold storage is a food cold storage for storing perishable foods. The basic requirements of the food cold storage are to maximize the quality of the food and reduce the dry consumption of the food in the cold storage. According to the nature of cold storage, the cold storage belongs to the distributed cold storage, which is characterized by large refrigeration capacity, small freezing capacity and various food types. After the cold storage was put into use, it was found that the cooling effect did not meet the expected requirements, and it was necessary to carry out operation and debugging to find out the cause of the unsatisfactory cooling effect, and finally achieve the expected cooling effect.

## 2 Project Profile

The cold storage has five warehouses with an area of 864 m<sup>2</sup>. There are three freezer rooms with the total area of 648 m<sup>2</sup>, and a freezing room with an area of 72 m<sup>2</sup>. The freezing capacity of this cold storage is 10 t for 24 h.

## 2.1 Refrigerating Capacity

After calculation, the total mechanical load of the refrigerator is 162 KW, the cooling equipment load is 180 KW. The total mechanical load of the freezing room is 76 KW, and the cooling equipment load is 95 KW. The total mechanical load is 238 kW.

## 2.2 System Division

The refrigeration system of the cold storage uses R717 (ammonia) as the refrigerant, and the design pressure of the pipeline is 2.5 MPa. The evaporating temperature of the refrigerating room is  $-30^{\circ}\text{C}$  and the freezes temperature is  $-35^{\circ}\text{C}$ . Since the two evaporating temperatures are similar, they are combined into a  $-35^{\circ}\text{C}$  system, and the temperature adjustment can be controlled by a valve. The condensing temperature during normal operation is  $+38^{\circ}\text{C}$ .

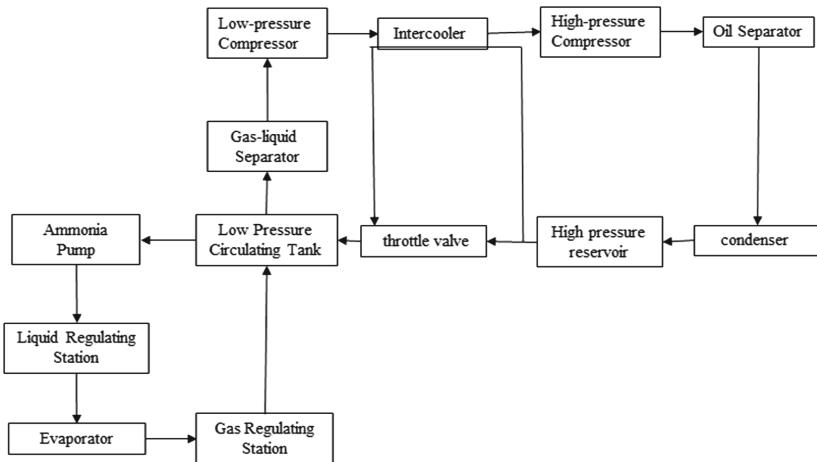
## 2.3 Introduction of the Refrigeration Process

Cold storage refrigeration system has equipment room system and warehouse system. The four processes of the refrigeration cycle: compression, condensation, expansion, and evaporation. Only the evaporation process is completed in the warehouse and the other three processes are all completed in the equipment room, so the refrigeration room is an important part of the cold storage.

The refrigeration system adopts the form of forced pumping of the ammonia pump. The compressor is a screw compressor with an economizer. The compressor has a good oil cooling device, and the exhaust temperature is much lower than that of the piston type. The use of such compressors in refrigerators is becoming more and more widespread.

The general flow of the system is as follows (as shown in Fig. 1). The low-temperature and low-pressure return gas is compressed by the compressor and becomes high-temperature and high-pressure ammonia. Afterwards the ammonia vapor enters the oil separator to separate the lubricating oil. The ammonia vapor then enters the evaporative condenser for heat exchange with air and water. After heat exchange, the condensed low-temperature and high-pressure ammonia liquid first enters the high-pressure liquid storage tank, then enters the intermediate cooler for re-cooling, and then passes through the throttle valve to reduce the pressure and then enters the low-pressure circulation barrel. At this time, the ammonia liquid is the low-temperature and low-pressure ammonia liquid which can be used to continues to refrigerate. The ammonia liquid is pumped to the liquid regulating station through the liquid outlet valve, enters the warehouse exhaust pipe through the pipeline valve of the regulating station, absorbs heat and vaporizes in the exhaust pipe. The ammonia gas through the gas regulating station first returning to the low pressure circulation tank, then the wet steam is separated and left in the low pressure circulation tank, and the dry saturated steam is sucked by the compressor through the return pipe to continue the above cycle.

The cooling method of the warehouse system is natural convection with the air, and the cooling equipment adopts a smooth U-shaped top tube. The liquid supply mode is the lower supply last return type. The liquid supply mode is relatively easy to be



**Fig. 1.** System schematic of the refrigeration storage

uniform, and a multi-channel evaporator with a header can be used to simplify the liquid separation device and save the valve for regulating the flow rate. The relative position of the liquid mode evaporator and the low-pressure circulation barrel is not limited, and the applicability is strong.

### 3 Debugging Process

#### 3.1 Preparation Before Debugging

1. Before commissioning the system, first test conditions are set up. The data collectors and sensors system for testing related data are built by purchasing related materials.
2. After the installation of the system pipeline is completed, the system pressure test is first carried out with compressed air, then the system sewage discharge and vacuum pumping experiments are carried out, and the vacuum is preferably performed in several steps to balance the system. After the system is tested and vacuumed, a small amount of ammonia can be used for leak test. The ammonia test leak can be tested with phenolphthalein test paper. If the system is found to have leakage, the system must be pumped out of the ammonia and can be repaired after being connected to the atmosphere. It is strictly forbidden to repair welding in the case of ammonia in the system [1–3].
3. Ammonia system equipment and pipelines are insulated only after the above test pressure test is qualified, and then paints of different colors are applied on the outer wall or insulation layer of the pipeline and equipment to distinguish the types of pipelines and to show the flow direction of the medium in the pipeline.
4. The compressor must also be commissioned before commissioning to verify the assembly quality and running performance of the machine and prepare for the commissioning work.

The test run of the compressor is divided into empty test run and load test run. The purpose of the empty test run is to make the moving parts get running through the operation, check whether the oil system is tight and unblocked or not, whether the oil pressure and oil temperature are normal or not. Whether the operate sound is abnormal or not. After all the normal operation for 4 h, the empty vehicle test run can be ended and the load vehicle test run can be completed. That is to enter the system debugging process.

### 3.2 System Debugging

1. System commissioning and load operation, system ammonia addition, and cold storage cooling are carrying out simultaneously. The ammonia should be added to the system segment by segment and room by room, and firstly be added a small amount of ammonia. If there is leakage, the ammonia in the equipment or pipe section should be exhausted first, and it should be separated from other parts. After the atmosphere is connected, it will be repaired. Until the entire system does not leak, it can be used for ammonia irrigation. After the completion of the ammonia filling, the compressors shall be subjected to load test operation one by one. The last continuous operation time of each unit shall not be less than 24 h, and the cumulative operation time of each unit shall not be less than 48 h. After the system load test operation is normal, the acceptance shall be submitted.
2. During the commissioning process, always pay attention to the pressure and temperature indication of the main unit display and the pressure and liquid level indication of each equipment. If the indicated value exceeds the allowable range, the relevant valve should be adjusted in time. When the high pressure liquid storage device is working normally, the inlet valve, the outlet valve, the pressure equalization valve, the pressure gauge valve, the liquid level indicator valve, and the safety valve are all open, and the oil discharge valve and the air release valve are closed, which is only open when draining or releasing air.
3. The pressure of the high-pressure liquid storage tank should not exceed 1.5 Mpa. If this value is exceeded, the cause should be found out in time. The liquid in the barrel is normal at 30%–80%. If the liquid level is too high, it is easy to malfunction, and the liquid level is too low not to ensure normal liquid supply. If the liquid level is too high and prevents normal circulation, the liquid can be sent to a cold storage tank or a drain tank for storage [4]. During operation, the liquid level in the low-pressure circulating drum should be kept at about 1/3 of the height of the barrel. Always pay attention to the liquid level of the liquid level indicator. If the liquid level is too high, the compressor will have a wet stroke. And if the liquid level may be too low, the ammonia pump cannot supply liquid normally.
4. In the ammonia pump forced liquid supply system, the operation status of the ammonia pump is very important, which directly affects the cooling of the cooling pipe and the cold storage. Before opening the ammonia pump, first open the liquid supply valve of the low-pressure circulation barrel and the inlet valve of the ammonia pump, so that the ammonia pump is filled with ammonia liquid, and then the outlet valve of the ammonia pump is turned on. When the ammonia pump is

running normally, the pointer of the pressure gauge is stable, the current does not exceed the specified amperage, and the sound of the relatively heavy liquid is sent. If the pressure and current drop, the pointer swings indefinitely, and the ammonia pump emits a sharp unloaded sound, It is very likely that the ammonia pump has insufficient liquid supply, and measures should be taken in time to ensure the normal operation of the ammonia pump. When stopping the pump, first close the liquid supply valve of the low-pressure circulation barrel and the ammonia pump inlet valve, cut off the current, and close the outlet valve, otherwise the liquid will come back to cause the ammonia pump to reverse, open the suction valve, and remove the gas in the ammonia pump. Then close this valve.

5. During the operation of the system, air release is a relatively frequent operation. Before commissioning, the system should be emptied. Due to restrictions on equipment, technology, operation, etc., it is inevitable that there will be residual air. The valves of low-voltage equipment will also have air infiltration in the tight places, and the air will be added when the system adding ammonia. It is also easy to enter the system. The air entering the system mainly accumulates in the condenser and the high-pressure liquid storage tank along with the circulation of the refrigerant. Excessive air in the condenser will reduce the coefficient of heat transfer coefficient of the condenser, which causes the condensation pressure and temperature to rise, the gas volume of the compressor to reduce, the power consumption to increase, and the cooling efficiency to lower. Therefore, when there is air in the system, it should be released in time.

## 4 Debugging Results

According to the regulations, in order to make the moisture in the civil construction of the warehouse in the cooling process, and avoid damage to the building, it is necessary to slowly and gradually cool down, so that the moisture inside the building gradually volatilizes outward during the cooling process. Generally speaking, when the room temperature is above +2 °C, the temperature is lowered by 3–5 °C every day; when the room temperature is lowered to +2 °C, it should be kept for 3–5 days, so that Make the free water in the structure of the building as far as possible, to achieve as much dryness as possible; when the temperature is below +2 °C, the temperature is allowed to cool 4–5 °C per day [5].

Combined with the actual situation of the cold storage, the cold storage has been built for a long time, most of the water in the storage has evaporated, and because owner is anxious to put into use, the cooling time is tight, so the cooling process is not strictly in accordance with the design requirements, and the cooling rate is slightly big. It is also because of this fact that the main engine is in full-load operation for most of the time, and the exhaust pressure is high. The problem is that the main unit display oil temperature gauge is damaged due to the high voltage supplied by the power system, and the manufacturer has come to replace it.

As the temperature of the reservoir gradually decreases, the exhaust pressure gradually returns to normal. Finally, the cooling requirements were met at the time specified by owner, and the equipment was operating normally.

## 5 Conclusion

A cold storage is a food cold storage for storing perishable foods. The basic requirements of the food cold storage are to maximize the quality of the food and reduce the dry consumption of the food in the cold storage. After the cold storage was put into use, it was found that the cooling effect did not meet the expected requirements. After research and development, the detailed debugging program was developed and the operation and debugging were carried out in the paper. It was found that the cold storage was not in accordance with the cooling requirements of the cold storage because it was eager to put into use. The main engine was in full load operation for a long time, the exhaust pressure was high, and the voltage was high, which cause damage to the main unit display oil temperature gauge. After the replacement is completed, it is gradually reduced according to the cooling requirements of the cold storage, and finally the normal operation, the cooling effect also achieves the expected effect.

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# A Method for Attitude Guidance Law Generation Based on High Precision Space-Ground Integrated Calibration

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**Abstract.** The quantum satellites in-orbit mainly perform scientific experiments of space-ground high speed quantum key distribution, quantum entanglement distribution and quantum teleportation. All the experiments mentioned above require accurate space-ground calibration, which accomplish attitude maneuver and alignment between optic axis of satellite payload and ground optical station. According to the pointing accuracy demand of quantum key distribution, the paper proposes an attitude guidance law with the quaternion algorithm, based on magnetometer and double-vector attitude determination algorithm and in-orbit satellite attitude pointing mode. The paper carries out the numerical simulation of attitude pointing precision between optic axis and ground station from the orbit determination error point of view. The results prove that the proposed algorithm of the attitude guidance law can provide accurate calibration and achieve the attitude stabilization pointing precisely.

**Keywords:** Quantum satellites · Space-Ground integrated calibration experiment · Attitude maneuver · Attitude guidance law

## 1 Introduction

In order to validate the completeness of quantum theory and obtain significant breakthroughs in quantum basic experiments, the leading space science project of Chinese Academy of Sciences (CAS) planned the quantum science experimental satellite in 2010. The research will be performed including the experiment of satellite-ground high speed quantum key distribution, satellite-ground quantum entanglement distribution and ground-satellite quantum teleportation. The experiments above need to accomplish the attitude maneuver so that the precise calibration can be achieved. On the basis of in-depth research on “double/multiple vector” attitude determination algorithm and multi-sensors information fusion attitude determination algorithm generated from broad Kalman filter algorithm, as well as combining with the analysis of satellite attitude sensors and satellite in-orbit mode along with the payload optical axis angle, the single station pointing guidance law is designed, the numerical simulation of attitude guidance law is conducted and the simulation result according to the errors of orbit determination is analyzed.

## 2 Satellite Attitude Estimation Algorithm

### 2.1 Star Sensor and Gyro Attitude Determination Algorithm

The star sensor directly measures the attitude, and the approximate attitude angular velocity can be obtained by the difference equations [1, 3]. The gyroscopes directly measures the angular velocity of the inertial system, and the attitude angle can be obtained by the integrals [5, 6, 10]. The extended Kalman filter is adopted by the combination of star sensor and gyroscope. The accuracy of the attitude determination can be greatly improved with the mutual correction.

#### 2.1.1 Attitude Quaternion Calculation with Angular Velocity Integration

The satellite attitude quaternion is concluded as follow based on the angular velocity:

$$q_{k+1} = e^{\frac{1}{2}\Omega(\bar{\omega}_k)\Delta t} q_k \approx \left( I + \frac{1}{2}\Delta t\Omega(\bar{\omega}_k) + \frac{1}{4}\frac{\Delta t^2\Omega(\bar{\omega}_k)^2}{2!} + \frac{1}{8}\frac{\Delta t^3\Omega(\bar{\omega}_k)^3}{3!} \right) q_k \quad (1)$$

#### 2.1.2 Angular Velocity Calculation with Difference of Attitude Quaternion

The satellite three-axis angular velocity is concluded as follow based on the attitude quaternion output [2, 4]:

$$\begin{bmatrix} \bar{\omega}_x \\ \bar{\omega}_y \\ \bar{\omega}_z \end{bmatrix} = \frac{2}{\Delta t} \begin{bmatrix} q_{4,k} & -q_{3,k} & q_{2,k} \\ q_{3,k} & q_{4,k} & -q_{1,k} \\ -q_{2,k} & q_{1,k} & q_{4,k} \end{bmatrix}^{-1} \begin{bmatrix} q_{1,k+1} - q_{1,k} \\ q_{2,k+1} - q_{2,k} \\ q_{3,k+1} - q_{3,k} \end{bmatrix} \quad (2)$$

#### 2.1.3 Star Sensor and Gyro Extended Kalman Filter Algorithm

The high accuracy of attitude determination is achieved by designing Kalman filter with using star sensor and gyroscope. The algorithm is as follow [9, 11]:

##### (1) Pre-estimation of attitude

Filtering state selection: three-axis attitude angle and constant drift error of three-axis gyro

$$\begin{cases} \hat{b}_{k+1} = \hat{b}_{k/k} \\ \hat{\omega}_{k+1} = \omega_{gy,k+1} - \hat{b}_{k+1/k} \\ \hat{q}_{bi,k+1} = [I \cos(\theta_{k+1}/2) + \Omega(\hat{\omega}_{k+1})/|\hat{\omega}_{k+1}| \sin(\theta_{k+1}/2)] \hat{q}_{k/k} \end{cases} \quad (3)$$

where,  $\theta_k = |\hat{\omega}_{k+1}| \Delta t$

##### (2) Calculation of filtering observed quantity

Quaternion  $q_{bi,st,k+1}$  measured by star sensor can be calculated based on quaternion  $q_{bs}$  and star sensor output  $q_{si,k+1}$

$$q_{bi\_st,k+1} = q_{si,k+1} \otimes q_{bs} \quad (4)$$

Calculate  $\delta q_{k+1}$  by  $q_{bi\_s,k+1}$  and  $\hat{q}_{bi,k+1}$

$$\delta q_{k+1} = \hat{q}_{bi,k+1/k}^{-1} \otimes q_{bi\_st,k+1} \quad (5)$$

Filtering observed quantity  $Y_{k+1}$  is the vector part  $\delta q_{v,k+1}$  of  $\delta q_{k+1}$

### (3) Calculation of Kalman filter in state deviation

$$P_{k+1/k} = \Phi_{k+1,k} P_{k/k} \Phi_{k+1,k}^T + \Gamma_{k+1,k} Q_{k+1} \Gamma_{k+1,k}^T \quad (6)$$

$$K_{k+1} = P_{k+1/k} H_{k+1}^T (H_{k+1} P_{k+1/k} H_{k+1}^T + R_{k+1})^{-1} \quad (7)$$

$$P_{k+1/k+1} = (I_{6 \times 6} - K_{k+1} H_{k+1}) P_{k+1/k+1} (I_{6 \times 6} - K_{k+1} H_{k+1})^T + K_{k+1} H_{k+1} K_{k+1}^T \quad (8)$$

$$\hat{X}_{k+1/k+1} = K_{k+1} Y_{k+1} \quad (9)$$

Attitude correction

$$\hat{q}_{bi,k+1/k+1} = \hat{q}_{bi,k+1/k} \otimes \left[ \frac{\delta \hat{q}_{biv,k+1/k+1}}{\sqrt{1 - |\delta \hat{q}_{biv,k+1/k+1}|^2}} \right] \quad (10)$$

$$\hat{b}_{k+1/k+1} = \hat{b}_{k+1/k} + \delta \hat{b}_{k+1/k+1} \quad (11)$$

## 2.2 Single/Double Vector Attitude Determination Algorithm

Using the combination of magnetometer and sun sensor to estimate satellite attitude through vector attitude determination algorithm when the star sensor fails or fails to meet the working condition.

### 2.2.1 Magnetometer and Sun Sensor Double Vector Attitude Determination Algorithm

The prior array A of satellite three-axis attitude can be achieved by using the mature double vector attitude determination FORM algorithm, based on solar vector  $S_b$  and magnetic vector  $B_b$  measured by sun sensor and magnetometer along with solar vector  $S_o$  and magnetic vector  $B_o$  in orbit system obtained from solar calendar model and geomagnetic field model. The algorithm is as follow [2]:

$$R_1 = S_o, R_2 = \frac{S_o \times B_o}{\|S_o \times B_o\|}, R_3 = R_1 \times R_2 \quad (12)$$

$$S_1 = S_b, S_2 = \frac{S_b \times B_b}{\|S_b \times B_b\|}, S_3 = S_1 \times S_2 \quad (13)$$

$$M_R = [R_1 \ R_2 \ R_3] \quad (14)$$

$$M_S = [S_1 \ S_2 \ S_3] \quad (15)$$

$$\mathbf{A} = M_S \cdot M_R^{-1} = M_S \cdot M_R^T \quad (16)$$

### 2.2.2 Single Magnetometer Attitude Determination Algorithm

When the satellite enters into the earth shadow area, the solar vector cannot be observed, only the information of magnetometer can be used to determine the pitch angle  $\theta$ . Setting the vector of the orbital geomagnetic field to  $\vec{B}_o$ , the magnetic field vector measured by the magnetometer is:

$$(\vec{B})_B = \begin{vmatrix} B_{xb} \\ B_{yb} \\ B_{zb} \end{vmatrix} = R_{bo} \cdot \vec{B}_o = R(\theta) \cdot R(\varphi) \cdot R(\psi) \cdot \vec{B}_o \quad (17)$$

Where,

$$R_{bo} = \begin{vmatrix} \cos(\theta) & 0 & -\sin(\theta) \\ 0 & 1 & 0 \\ \sin(\theta) & 0 & \cos(\theta) \end{vmatrix} \begin{vmatrix} 1 & 0 & 0 \\ 0 & \cos(\varphi) & \sin(\varphi) \\ 0 & -\sin(\varphi) & \cos(\varphi) \end{vmatrix} \begin{vmatrix} \cos(\psi) & \sin(\psi) & 0 \\ -\sin(\psi) & \cos(\psi) & 0 \\ 0 & 0 & 1 \end{vmatrix} \quad (18)$$

During the short time, as  $\psi \approx 0$ ,  $\varphi \approx 0$ , the pitch angle can be obtained as follow:

$$\theta_m = \arctan 2[B_{xO}B_{zB} - B_{zO}B_{xB}, \ B_{zO}B_{zB} + B_{xO}B_{xB}] \quad (19)$$

## 3 Calculation of Guidance Law

We need to carry out the satellite attitude maneuver according to current working mode before all the in-orbit optical experiments being performed by the quantum satellite. The expected three-axis attitude angle and attitude angular velocity, i.e., the data of attitude guidance law are processed and up-injected so that the optic axis of satellite payload and the ground optical station can be calibrated precisely, for example the quantum key distribution experiment.

The algorithm for attitude guidance law for a single ground station is planned as follow [7, 8],

Step1. The description of the satellite vector in the orbital coordinate system when satellite points to the geometer is obtained from the satellite position vector in the J2000 coordinate system:

$$\overrightarrow{\mathbf{O}_s \mathbf{O}_{eo}} = \mathbf{A}_{oi}(-\mathbf{R}_i) \quad (20)$$

Step2. The vector of the ground station in J2000 coordinate system is transferred from the WGS84 coordinate system through coordinate transfer.

$$\begin{pmatrix} R_{Fix} \\ R_{Fiy} \\ R_{Fiz} \end{pmatrix} = R_4^T \times R_3^T \times R_2^T \times R_1^T \times \begin{pmatrix} x \\ y \\ z \end{pmatrix} \quad (21)$$

Where,  $R_4^T, R_3^T, R_2^T, R_1^T$  respectively are the precession, mutation, earth rotation, and transposed matrix of pole shift matrix; (x, y, z) is the rectangular coordinate in the WGS84 coordinate system, which can be obtained from the calculation of the longitude, latitude and elevation of the ground station:

$$\mathbf{R}_{Fi} = [R_{Fix} \quad R_{Fiy} \quad R_{Fiz}]^T \quad (22)$$

Step3. The ground station vector is transferred to the satellite orbital coordinate system from J2000 coordinate system:

$$\overrightarrow{\mathbf{O}_e \mathbf{F}_o} = \mathbf{A}_{oi} \mathbf{R}_{Fi} \quad (23)$$

Step4. In the orbital coordinate system, the satellite pointing vector to ground station can be gained from as follow

$$\overrightarrow{\mathbf{O}_s \mathbf{F}_o} = \overrightarrow{\mathbf{O}_s \mathbf{O}_{eo}} + \overrightarrow{\mathbf{O}_e \mathbf{F}_o} \quad (24)$$

Step5. In the orbital coordinate system, the vector of the optical axis of key distributor is gained from as follow:

$$\overrightarrow{\mathbf{O}_s \mathbf{G}_o} = \mathbf{A}_{bo}^T \overrightarrow{\mathbf{O}_s \mathbf{G}_b} \quad (25)$$

When calculating the expected satellite attitude guidance law,

$$\overrightarrow{\mathbf{O}_s \mathbf{G}_o} = \overrightarrow{\mathbf{O}_s \mathbf{G}_b} \quad (26)$$

Step6. The expected attitude matrix:

$$\mathbf{A}_{qo} = \begin{bmatrix} \mathbf{A}_{qox} \\ \mathbf{A}_{qoy} \\ \mathbf{A}_{qoz} \end{bmatrix} = \begin{bmatrix} ((\overrightarrow{\mathbf{O}_s \mathbf{F}_o} \times ([1 \quad 0 \quad 0]^T)) \times \overrightarrow{\mathbf{O}_s \mathbf{F}_o})^T \\ (\overrightarrow{\mathbf{O}_s \mathbf{F}_o} \times ([1 \quad 0 \quad 0]^T))^T \\ \overrightarrow{\mathbf{O}_s \mathbf{F}_o}^T \end{bmatrix} \quad (27)$$

The unit matrix is obtained from the normalization of the row vector of attitude matrix.

Step7.  $u\mathbf{Q}_{op}$  is obtained from the expected attitude matrix.

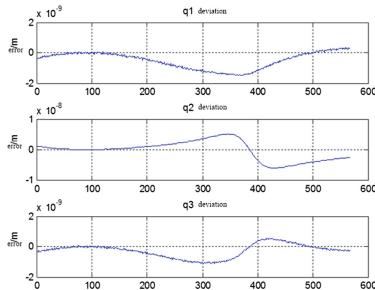
$$\begin{cases} q_4 = \frac{1}{2} \sqrt{\text{tr}\mathbf{A}_{qo} + 1} \\ q_1 = [(\mathbf{A}_{qo})_{23} - (\mathbf{A}_{qo})_{32}] / (4q_4) \\ q_2 = [(\mathbf{A}_{qo})_{31} - (\mathbf{A}_{qo})_{13}] / (4q_4) \\ q_3 = [(\mathbf{A}_{qo})_{12} - (\mathbf{A}_{qo})_{21}] / (4q_4) \end{cases} \quad (28)$$

Taking the vector part of  $u\mathbf{Q}_{op}$ , which is considered as the guidance law quaternion, as the input guidance law.

## 4 Numerical Simulation and Result Analysis

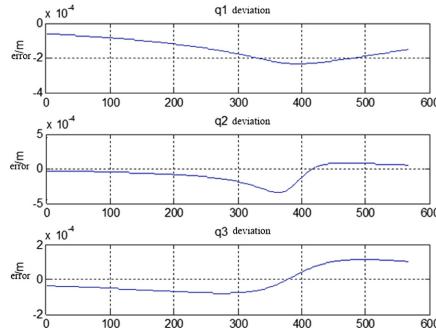
According to the guidance law calculation method, the guidance law attitude quaternion is calculated based on the given attitude mode along with the relative position of satellite and optical experiment station during the scientific experiment. Therefore, the accuracy of guidance law calculation is composed of track extrapolation accuracy and the calculation of guidance law attitude quaternion.

Taking the calculation result of the guidance law of satellite of round 26 at Nanshan Station as an example, according to the same position of both satellite and observation station, the result deviation of the calculated guidance law is less than  $1.0 \times 10^{-8}$ , compared with the calculation results of the satellite manufacturer. As shown in Fig. 1.



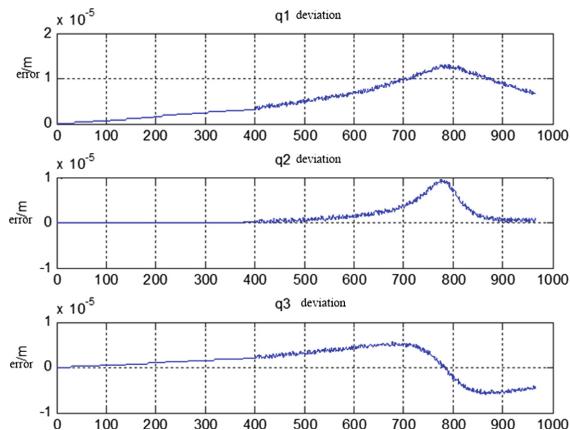
**Fig. 1.** Guidance law deviation of the same position

According to the calculation requirement that the deviation of 12-h satellite extrapolation limits in 500 m, the guidance law quaternion calculation deviation is less than  $4.0 \times 10^{-4}$  by taking the 500 m position deviation of satellite as an example, as shown in Fig. 2.



**Fig. 2.** Attitude quaternion deviation

In order to ensure the experimental effect and improve the accuracy of guidance law calculation, the modified orbit elements in the proximity of scientific time at the optical station can be used the deviation between the guidance law quaternion calculation in round 26 and the actual result is less than  $2.0 \times 10^{-5}$ . As shown below (Fig. 3):



**Fig. 3.** Attitude quaternion deviation in round 26

## 5 Conclusion

According to the requirements of scientific experiments on quantum key distribution, the attitude estimation and attitude maneuver algorithm before the quantum science optical experiment are taken into consideration. Combined with the satellite attitude mode in orbit as well as the installation angle of satellite payload axis and other factors, the data of quantum satellite attitude adjustment guidance law is generated from numerical simulation. The simulation results prove that the output data of the generated guidance law can meet the demand of the station pointing accuracy of the quantum satellite.

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# Adaptive Sliding Mode Fault Tolerant Control of Spacecraft with Actuator Effectiveness

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**Abstract.** Under the extensive application of the spacecraft, an adaptive sliding mode fault tolerant controller is proposed for a spacecraft with the actuator effectiveness and external disturbance. In this approach, the attitude fault-tolerant control scheme based on the sliding mode control theory is design to achieve fault-tolerant control and external disturbance rejection. Then, considering the unknown parameters problem of the actuator and disturbance, adaptive methods is introduced to real-time estimate the unknown parameters, which improve the robustness and practicality of the controller. Finally, the stability of the proposed controller is proved based on the Lyapunov theory and the simulation results show the method with strong fault tolerance for spacecraft actuator failure.

**Keywords:** Actuator effectiveness · Control constraint · Fault tolerant control · Adaptive sliding mode control

## 1 Introduction

As the spacecraft are gradually applied in the civil and commercial fields, it is higher request for the security, reliability, high accuracy of the spacecraft control system independent operation, especially under the condition of actuator failure and sensor failure. The high precision of autonomous fault-tolerant control technology is particularly important for the spacecraft to complete the mission, perceive the space and increase damage efficiency. However, the spacecraft long-term operation in weightlessness, high and low temperature, strong radiation and other adverse environment, mechanical or electrical components of aging, wear and other inherent factors will inevitably cause the failure of the actuator, output control torque is limited, resulting in the control system accuracy, stability and other performance decline, or even collapse [1, 2]. In view of these problems, many scholars have carried on the extensive and depth research about how to complete the control task, especially the spacecraft fault-tolerant control problem.

One class of robust nonlinear control methods, such as  $H\infty$  control, adaptive control, fuzzy control and sliding mode control, are widely used in the state fault-tolerant control of spacecraft attitude [3–9]. Zou et al. [1] designed a passive fault-tolerant controller by

using adaptive control technology after considered the uncertain rotational inertia and saturated control input of the formation spacecraft, and it realized the tracking control of the spacecraft time-varying reference attitude without any fault diagnosis information. Boskovic et al. [2] designed a controller to realize attitude robust control used adaptive technology to estimate the fault value for flight control system with actuator failure and external interference. Godard et al. [3] designed the controller to achieve satellite formation control based on the sliding mode control theory. However, the actuator fault was only simulated and analyzed, and the stability analysis of the closed-loop system was not proved. To solve this problem, Varma et al. [4] designed a sliding mode fault-tolerant attitude controller to ensure that the satellite could achieve high-precision tracking control of the desired attitude in the case of actuator failure. Lee et al. [5] designed an observer used the iterative technique to estimate the total amplitude of actuator failures and interferences, and designed a fault-tolerant controller based on this estimate to realize the operation of large angle attitude maneuver. Noumi et al. [6] adopted the control moment gyro as the actuator and designed the manipulation rate to achieve high precision and high agility attitude control of the satellite, which ensured that the system has a certain fault-tolerant ability. In order to realize fault-tolerant control for multiple faults, Chandrasekar et al. [7] proposed an intelligent attitude control method based on adaptive control theory, which could realize attitude high-precision control in the case of installation deviation and fault of the actuator. In practical application, Ruiter et al. [8] proposed an attitude control strategy only using magnetic torque to solve the problem of JC2Sat-FF satellite actuator failure. For Cassini deep space detector, Macalaet et al. American JPL laboratory demonstrated the feasibility of designing a hybrid attitude controller with only two reaction flywheels or thrusters to complete the given mission in the case of actuators failure. Considering the model uncertainty and thruster failure in spacecraft docking, Li et al. [9] proposed an autonomous fault-tolerant control method based on Lyapunov stability theory and genetic algorithm.

On the basis of the above research results, the common modes have shortages of switch fault handling method relies heavily on the ground support, weak capacity for independent operation, timeliness is not strong and so on, this paper researched the design problem of autonomous attitude fault-tolerant control system for the unpredictable exceptions and failures of the spacecraft during a mission. This research aimed to solve the high precision and stability control problem of spacecraft under the conditions of actuator failures, input saturation, model parameter uncertainty and unknown disturbance. The research results will provide a reference for the failure rescue of Chinese future space combat platform or spacecraft and the rapid mobile reconnaissance.

## 2 Spacecraft Mathematical Model

Considering rigid body spacecraft, its attitude dynamic equation is

$$\mathbf{I}\dot{\boldsymbol{\omega}} + \boldsymbol{\omega}^{\times}\mathbf{I}\boldsymbol{\omega} = \mathbf{u} + \mathbf{d} \quad (1)$$

where  $\mathbf{I} \in \Re^{3 \times 3}$  is the rotation inertia matrix of the spacecraft;  $\boldsymbol{\omega} = [\omega_x \ \omega_y \ \omega_z]^T$  is the projection of attitude angular velocity of body coordinate system relative to inertial coordinate system in this system;  $\mathbf{u} \in \Re^3$  is the output control torque generated by the actuator;  $\mathbf{d} \in \Re^3$  is the external interference moment. The symbol “ $\times$ ” is the adjoint matrix of the vector, defined as

$$\boldsymbol{\omega}^\times = \begin{bmatrix} 0 & -\omega_z & \omega_y \\ \omega_z & 0 & -\omega_x \\ -\omega_y & \omega_x & 0 \end{bmatrix} \quad (2)$$

According to the 3-1-2 rotation sequence, the three rotation angles of the spacecraft body coordinate system and the inertial reference system are defined as yaw angle  $\psi$ , rolling angle  $\phi$  and pitch angle  $\theta$ . Let  $\boldsymbol{\alpha} = [\psi \ \phi \ \theta]^T$  is the attitude angle of the spacecraft, then the attitude kinematics equation of the spacecraft is

$$\dot{\boldsymbol{\alpha}} = \boldsymbol{\Xi}(\boldsymbol{\alpha})\boldsymbol{\omega} \quad (3)$$

where

$$\boldsymbol{\Xi}(\boldsymbol{\alpha}) = \frac{1}{\cos \phi} \begin{bmatrix} -\sin \theta & 0 & \cos \theta \\ -\cos \theta \cos \phi & 0 & \sin \theta \cos \phi \\ -\sin \theta \sin \phi & \cos \phi & \cos \theta \sin \phi \end{bmatrix} \quad (4)$$

If the partial failure of actuator is considered and the failure model is built into a form of product factor, then in the case of partial failure of actuator, the dynamic equation of spacecraft is

$$\mathbf{I}\dot{\boldsymbol{\omega}} + \boldsymbol{\omega}^\times \mathbf{I}\boldsymbol{\omega} = \mathbf{E}(t)\mathbf{u} + \mathbf{d} \quad (5)$$

where,  $\mathbf{E}(t) = \text{diag}(e_1(t) \ e_2(t) \ e_3(t))$  is the effective factor of the actuator, and  $e_i \in [0 \ 1]$ ,  $i = 1, 2, 3$ , state 0 represents the actuator is complete failure, state 1 represents normal operation, and the remaining states represent partial failure of the actuator. The formula can be rewritten as

$$\mathbf{I}\dot{\boldsymbol{\omega}} + \boldsymbol{\omega}^\times \mathbf{I}\boldsymbol{\omega} = \mathbf{u} - \Delta \mathbf{E} \mathbf{u} + \mathbf{d} \quad (6)$$

where  $\Delta \mathbf{E} = \text{diag}(1 - e_1(t) \ 1 - e_2(t) \ 1 - e_3(t))$  is the failure factor of the actuator, then  $\|\Delta \mathbf{E}\| \leq 1$ , let  $\gamma = \|\Delta \mathbf{E}\|$ .

During the operation of the spacecraft, it is assumed that the system meets the following conditions:

Assume 1: The inertia matrix is positive definite;

Assume 2: The disturbing torque  $\mathbf{d}$  is bounded, that is, it satisfies  $\|\mathbf{d}\| \leq d_{\max}$ , where  $\|\cdot\|$  is the vector taking 2 norm,  $d_{\max}$  is the upper bound of the disturbing torque.

Therefore, the attitude autonomous fault-tolerant control problem of the spacecraft can be described. After considering the cases of the actuator is failure, parameters are uncertainty, external has interference and so on, the appropriate control law  $u$  should be designed under the conditions of assume 1 and 2 to make the system meet the requirements of  $\alpha \rightarrow 0$  and  $\omega \rightarrow 0$  when  $t \rightarrow \infty$ .

### 3 Adaptive Sliding Mode Fault-Tolerant Controller Design

According to the theory of sliding mode control, the surface of sliding mode is selected as  $s = \omega + k\alpha r$ , where  $k \in \mathbb{R}^3$ .

For the spacecraft control system with limited control, uncertain parameters and external interference, under the conditions of assume 1 and assume 2, assuming that the failure of the system actuator is unknown, the following adaptive sliding mode fault-tolerant controller is designed

$$\begin{aligned} u &= \omega^\times I\omega - \Xi^T P\alpha - D\omega - \Gamma(t) \frac{\omega}{\|\omega\|} - \hat{d}_{\max} \frac{s}{\|s\|} \\ \Gamma(t) &= -\xi + \hat{\varphi}\xi \\ \dot{\hat{\varphi}} &= c_1\xi\|\omega\| \\ \hat{d}_{\max} &= c_0\|s\| \end{aligned} \quad (7)$$

where  $\xi = \|\omega^\times I\omega - \Xi^T P\alpha - D\omega\| + \hat{d}_{\max} + \varepsilon_0$ ,  $\varphi = 1/(1-\gamma)$ ,  $\hat{\varphi}$  is the estimated value of  $\varphi$ ,  $c_1$  is the positive constant.

**Proof:** Select the Lyapunov function  $V = \frac{1}{2}\alpha^T P\alpha + \frac{1}{2}\omega^T I\omega + \frac{1-\gamma}{2c_1}\tilde{\varphi}^2 + \frac{1}{2c_0}\tilde{d}_{\max}^2$ , where  $\tilde{\varphi} = \varphi - \hat{\varphi}$ , take the derivative to formula (5) (9), it can be get that

$$\begin{aligned} \dot{V} &= \alpha^T P\dot{\alpha} + \omega^T I\dot{\omega} - \frac{1-\gamma}{c_1}\tilde{\varphi}\hat{\varphi} - \frac{1}{c_0}\tilde{d}_{\max}\hat{d}_{\max} \\ &\leq \omega^T(-\Delta Eu - \Gamma \frac{\omega}{\|\omega\|}) - \frac{1-\gamma}{c_1}\tilde{\varphi}\hat{\varphi} \\ &= -\omega^T \Delta Eu + (1-\hat{\varphi})\xi\|\omega\| - \frac{1-\gamma}{c_1}\tilde{\varphi}\hat{\varphi} \\ &\leq \gamma\|\omega^T\|(-\varepsilon_0 + \hat{\varphi}\xi) + (1-\hat{\varphi})\xi\|\omega\| - (1-\gamma)\xi\tilde{\varphi}\|\omega\| \\ &= -\varepsilon_0\gamma\|\omega^T\| + [1 - (1-\gamma)\hat{\varphi}]\xi\|\omega\| - (1-\gamma)\xi\tilde{\varphi}\|\omega\| \\ &= -\varepsilon_0\gamma\|\omega^T\| \leq 0 \end{aligned} \quad (8)$$

The spacecraft control system is asymptotically stable under the influence of control rate.

Considering the limited output amplitude characteristic of the actuator, saturation function  $\text{sat}(u)$  is used to replace the control input  $u$ . Meanwhile, in order to reduce the

chattering problem of the control system, linear function  $\mathbf{x}/(\|\mathbf{x}\| + \varepsilon)$  is applied to approximate the nonlinear function, and the system and control law are rewritten as

$$\begin{aligned} I_0\dot{\omega} + \omega^\times I\omega &= Esat(u) + d \\ u &= \omega^\times I\omega - \Xi^T P\alpha - D\omega - \Gamma \frac{\omega}{\|\omega\| + \varepsilon_1} - \hat{d}_{\max} \frac{s}{\|s\| + \varepsilon_2} \end{aligned} \quad (9)$$

$$\text{where } sat(u) = \begin{cases} u & |u| < u_{\max} \\ u_{\max} sgn(u) & |u| \geq u_{\max} \end{cases} \quad (10)$$

The  $u_{\max}$  is the saturated value of the control output,  $\varepsilon_1$  and  $\varepsilon_2$  are the positive constants. In order to ensure the approximation effect,  $\varepsilon_1$  and  $\varepsilon_2$  are generally smaller.

## 4 Numerical Simulation and Analysis

In order to verify the effectiveness of the method, an adaptive sliding-mode fault-tolerant controller is applied to a spacecraft simulation [10–12], the rotation inertia

matrix of the spacecraft is  $I = \begin{bmatrix} 22.1 & -1.3 & 2.2 \\ -1.3 & 17.8 & 1.1 \\ 2.2 & 1.1 & 20.3 \end{bmatrix}$ , the external disturbance

moment is  $d = A_0 \begin{bmatrix} 3 \cos(\omega_0 t) + 1 \\ 1.5 \sin(\omega_0 t) + 3 \cos(\omega_0 t) \\ 3 \sin(\omega_0 t) + 1 \end{bmatrix}$ , where  $A_0$  is the amplitude of the

external interference torque, and  $\omega_0$  is the orbital angular velocity of the spacecraft.

The main simulation parameters of the controller are shown in Table 1.

**Table 1.** The main simulation parameters of the controller

Item name	Parameter value
Initial parameter	$\mathbf{x}_0 = [8.0 \ -12.0 \ 8.0]^T / (\circ)$ ; $\omega_0 = [-5.0 \ 5.0 \ -5.0]^T / (\circ/s)$ ; $\hat{\phi}_0 = 0$ , $\hat{d}_{\max,0} = 0 / (\text{N} \cdot \text{m})$ ; step = 0.001 s
Disturbance parameter	$A_0 = 2.5e - 4 / (\text{N} \cdot \text{m})$ ; $\omega_0 = 7.2722e - 5 / (\text{rad/s})$
Controller parameter	$K = 6.0 \text{ E3}$ , $P = 1.25 \text{ E3}$ ; $D = 12.0 \text{ E3}$ ; $u_{\max} = 0.5 / (\text{N} \cdot \text{m})$ ; $c_0 = 7.1e - 6$ , $c_1 = 0.3$ ; $\varepsilon_0 = \varepsilon_1 = \varepsilon_2 = 1.0e - 5$

Under the conditions of the above initial value, the external interference, parameter change and the following two conditions are considered for the system simulation.

Case 1: Safety mode, the actuator works well without failure.

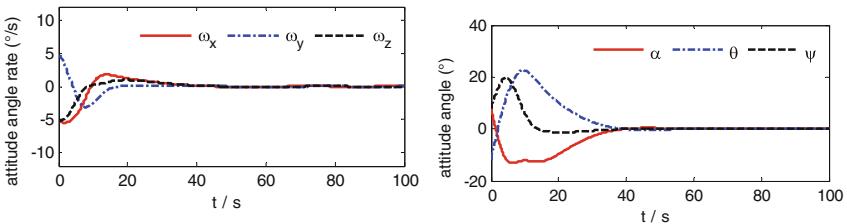
Case 2: Fault mode, the actuator has a known fault, partial failure, resulting in a constant fault. The moment deviation and parameter uncertainty of the actuator are considered, and let

$$E = \begin{bmatrix} e_1(t) = 0.85 + 0.15 \sin(t) & | t > 4s \\ e_2(t) = 0.6 + 0.07 \sin(0.2t) & | t > 3s \\ e_3(t) = 0.6 & | t > 5s \end{bmatrix} \quad (11)$$

According to the above three cases, the control rate is used to simulate the spacecraft control system, and the results are as follows.

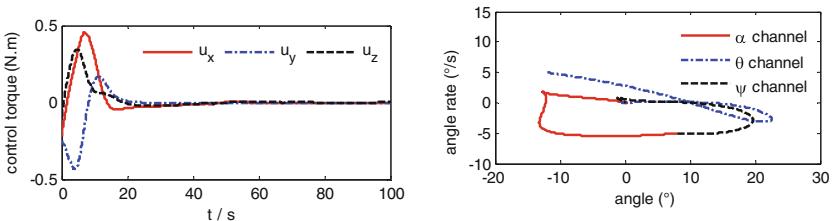
#### 4.1 Safe Mode

In the safe mode (case 1), the actuator works normally. Using the action of control rate (11), the response of the attitude angle, the angular rate, the control torque and the phase spacecraft of the trajectory movement are shown in Figs. 1, 2, and the estimated upper limit of the external interference is shown in Fig. 3.

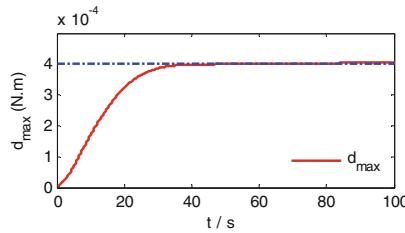


**Fig. 1.** Attitude Angle and angular rate response in case 1

As can be seen from the simulation results, the attitude control system of the spacecraft reached stability in the 60 s, the control accuracy is better than  $1.0 \times 10^{-4}$  °, and the maneuvering acceleration of the spacecraft is higher than  $0.16^{\circ}/s^2$  using the action of the designed controller.



**Fig. 2.** The control torque (left) and the phase trajectory of triaxial attitude (right) in case 1

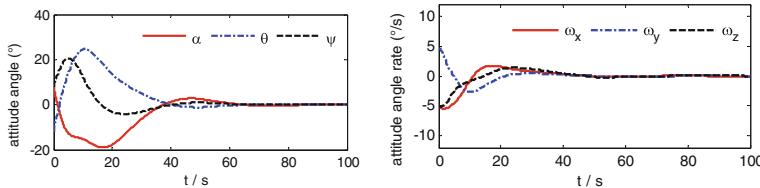


**Fig. 3.** The last estimate curve of external interference in case 1

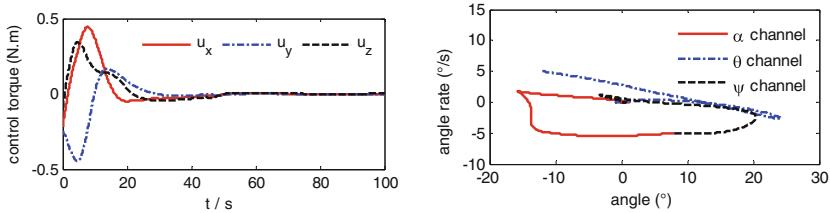
From the above simulation results, it can be see the chattering caused by the sliding mode control is effectively suppressed during the control process, the pitch, yaw and rolling channels movement of the spacecraft is stable, and the upper limit of system interference is effectively estimated.

#### 4.2 Failure Mode

In order to verify the effectiveness and feasibility of the designed controller with the same initial conditions and controller parameters, the simulation analysis is carried out considering the failure mode. The Fig. 4 shows the response of the corresponding variable controlled under the case 2.



**Fig. 4.** The attitude angle and angular rate response in case 2



**Fig. 5.** The control torque (left) and the phase trajectory of triaxial attitude (right) in case 2

As can be seen from the Fig. 5, the attitude angle and the control process are stable under the control system with the minor fault mode, and the stability time was less than 70 s and the accuracy was not less than  $1.0 \times 10^{-3}$ . The attitude control system has good robustness and stability.

In a word, the designed adaptive sliding-mode fault-tolerant controller has good performance both in the safe mode and in the fault modes, which can meet the requirements of the spacecraft control system. In particular, it has good robust fault-tolerant capability in the fault mode.

## 5 Conclusion and Prospect

A class of fault-tolerant control scheme based on the sliding mode theory and the adaptive theory is designed to solve the uncertainty problems of the actuator-fault parameter and disturbance. The stability of the control system is proved theoretically. Simulation results verified the feasibility and effectiveness of the proposed method with good robustness to the partial failure of the actuator of the spacecraft, which has high engineering practical value.

The follow-up work will be to study the unknown inertia parameters of the spacecraft, installation deviation of the actuator, fault-tolerant control allocation and other aspects.

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# Design of Generator Controller Based on Fuzzy Algorithm

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**Abstract.** In order to solve the anti-interference of generator excitation, this paper establishes PID controller of generator excitation and small signal mathematical model of single machine infinite system, combines the advantages of PID and linear multivariable controller, and uses fuzzy controller for coordinated control, so as to enhance the anti-interference of the system and increase the robust stability of the system. The simulation results show that the designed controller has good control effect.

**Keywords:** Generator excitation · Fuzzy control · Linear multivariable control · Coordinated control

## 1 Introduction

The stability of power system operation is the basic requirement of power system safe operation. Generator excitation control is one of the most economical and effective technical means to improve the stability of power system [1–3]. It has excellent voltage regulation accuracy. Linear multivariable optimal control has better dynamic performance; robustness and adaptability because it considers the synthesis of multiple control objectives of power system and adopts optimal design. Firstly, because the design is based on the approximate linearization model at the balance point, when the system is far away from the designed balance point or in the transient process caused by large interference, it can not guarantee that the system has good control characteristics, the robustness to the change of the operation point of the system can not be guaranteed. Fuzzy control is a kind of intelligent control. When artificial intelligence is applied to excitation control, it does not need the precise mathematical model of the controlled object. Its control effect is determined by the control rules and its adaptability to the changes of system operation, so it has strong robustness. In this paper, the advantages of PID and linear multivariable controller are combined, and fuzzy controller [4–6] is used for coordinated control to enhance the anti-interference and robust stability of the system. The simulation results show that the designed controller has good control effect [7, 8].

## 2 Mathematical Model of Single Machine System

In order to establish the state space equation of transmission system linearization and linearize the representation of electromagnetic power, we can get

$$\Delta P_e = S_E \Delta \delta + R_E \Delta E_q \quad (1)$$

where

$$\begin{aligned} S_E &= \frac{E_q V_s}{x_{d\Sigma}} \cos \delta + V_s^2 \frac{x_{d\Sigma} - x_{q\Sigma}}{x_{d\Sigma} x_{q\Sigma}} \cos 2\delta; S'_E = \frac{E'_q V_s}{x'_{d\Sigma}} \cos \delta + V_s^2 \frac{x'_{d\Sigma} - x'_{q\Sigma}}{x'_{d\Sigma} x_{q\Sigma}} \cos 2\delta \\ R_E &= \frac{V_s}{x_{d\Sigma}} \sin \delta; R'_E = \frac{V_s}{x'_{d\Sigma}} \sin \delta. \end{aligned}$$

We can also express the deviation of electromagnetic power as a function of the deviation of operation angle  $\Delta \delta$  and the deviation of generator terminal voltage  $\Delta V_t$ , and then we can get

$$\Delta P_e = S_v \Delta \delta + R_v \Delta V_t \quad (2)$$

where  $S_v = S_E - R_v \frac{\partial V_t}{\partial \delta}$ ,  $R_v = R_E / \partial V_t / \partial E_q$ ,

So the state equation of the small signal model of the system is in the form of the following fourth order, that is, the state equation of the system is:

$$\begin{bmatrix} \Delta P_e \\ \Delta \omega \\ \Delta U_t \\ \Delta E_f \end{bmatrix} = \begin{bmatrix} \frac{S_E - S_V}{T'_d S_v} & S_E & \frac{S_E R_V}{T'_d S_v} & \frac{R_E}{T_{d0}} \\ -\frac{\omega_u}{H} & -\frac{D}{H} & 0 & 0 \\ \frac{S_E - S_V}{T'_d R_v S_v} & \frac{S_E - S_V}{R_v} & \frac{S_E}{T'_d S_v} & \frac{R_E'}{T_{d0} R_v} \\ 0 & 0 & 0 & -\frac{1}{T_e} \end{bmatrix} = \begin{bmatrix} \Delta P_e \\ \Delta \omega \\ \Delta V_t \\ \Delta E_f \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ \frac{1}{T_e} \end{bmatrix} \Delta V_R \quad (3)$$

$$\begin{bmatrix} \Delta P_e \\ \Delta \omega \\ \Delta U_t \end{bmatrix} = \begin{bmatrix} \frac{S_E - S_V}{T'_d S_v} & S'_E & \frac{S_E R_V}{T'_d S_v} \\ -\frac{\omega_u}{H} & -\frac{D}{H} & 0 \\ \frac{S_E - S_V}{T_d R_v S_v} & \frac{S_E - S_V}{R_v} & \frac{S_E}{T'_d S_v} \end{bmatrix} = \begin{bmatrix} \Delta P_e \\ \Delta \omega \\ \Delta V_t \end{bmatrix} + \begin{bmatrix} \frac{R_E}{T_{d0}} \\ 0 \\ \frac{R_E'}{T_{d0} R_v} \end{bmatrix} \Delta E_f \quad (4)$$

where  $P_e$  is the electromagnetic work of the generator;  $\omega$  is the angular speed of the rotor;  $V_t$  is generator terminal voltage;  $V_R$  is the output voltage of voltage regulator;  $E_f$  is the generator excitation winding voltage;  $T_e$  is the excitation time;  $T'_d$  is the d-axis short circuit transient time constant;  $T_{d0}$  is the excitation winding time constant;  $H$  is the unit inertia time constant.

If the generator adopts the thyristor excitation system, the excitation time  $T_e \approx 0$ , then the control quantity  $U$  is the generator excitation winding voltage  $\Delta E_f$ , so the system state equation degenerates into the following three order form:

For (4), we can write the standard form of equation of state.

### 3 Design of Fuzzy Controller

The fuzzy controller designed in this paper uses the excellent voltage regulation characteristics of PID excitation controller as the main channel of excitation regulation, uses the multivariable controller designed by linear optimal control theory as the additional excitation regulation channel, and dynamically coordinates the action weight of voltage regulation channel and additional regulation channel through the fuzzy controller.

- (1) Define the fuzzy subset of each fuzzy variable

Input and output variable word set

The input of system are  $\Delta V_t, \Delta P_e, \Delta \omega$ , we use “big, medium, small, zero” to describe the input and output variables of the fuzzy controller. It is expressed in English letters as {0, PS, PM, PB}. Output  $K_1$  and  $K_2$  are the dynamic action weights of the two control channels, without negative value requirements, taken as: {zero, positive small, positive small, positive small medium, positive middle, positive middle large, positive large}. It is expressed in English letters as {0, PSS, PS, PSM, PM, PMB, PB}. In order to ensure that the fuzzy set can cover the domain well, according to the principle that the number of elements in the fuzzy set domain is more than two times of the total number of fuzzy language word sets, we take the fuzzy subsets of variables  $\Delta V_t, \Delta P_e, \Delta \omega$  as {0, 1, 2, 3, 4, 5, 6, 7}. The fields of output variables 12K and K fuzzy subsets are {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13}

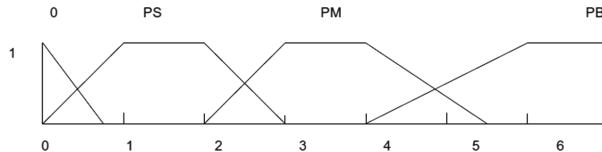
- (2) Quantification of input and output variables

According to regulations, the allowable deviation of normal operation voltage is 10%. Here, take the domain of voltage deviation  $\Delta V_t$  at generator end as  $[-0.1, 0.1]$ . If  $\Delta V_t > 0.1$  or  $\Delta V_t < -0.1$ , treat as 0.1 and -0.1 respectively. Take the theoretical domain of active power deviation  $\Delta P_e$  as  $[-0.02, 0.02]$ , if  $\Delta P_e > 0.02$  or  $\Delta P_e < -0.02$ , treat as 0.02 and -0.02 respectively. Take the electric angular velocity deviation  $\Delta \omega$  of generator rotor as  $[-0.015, 0.015]$ , if  $\Delta \omega > 0.015$  or  $\Delta \omega < -0.015$ , treat as 0.015 and -0.015 respectively. All the above variables are unit values. The output variables of the fuzzy control module, i.e. the weight coefficient  $K_1$  of the voltage regulation channel and the weight coefficient  $K_2$  of the additional excitation regulation channel, are taken as [0, 1.5].

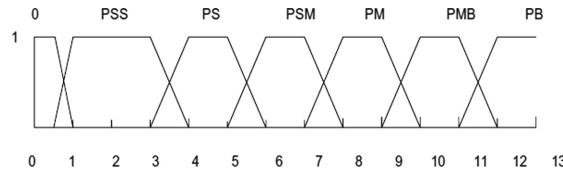
The input and output variables are converted into discrete values according to formula (5) and then rounded.

$$x' = \frac{1}{b-a} \left( x - \frac{a+b}{2} \right) \quad (5)$$

- (3) Establishment of membership function of fuzzy set: membership function of input and output variables is shown in Figs. 1 and 2.



**Fig. 1.** Membership function of input variable



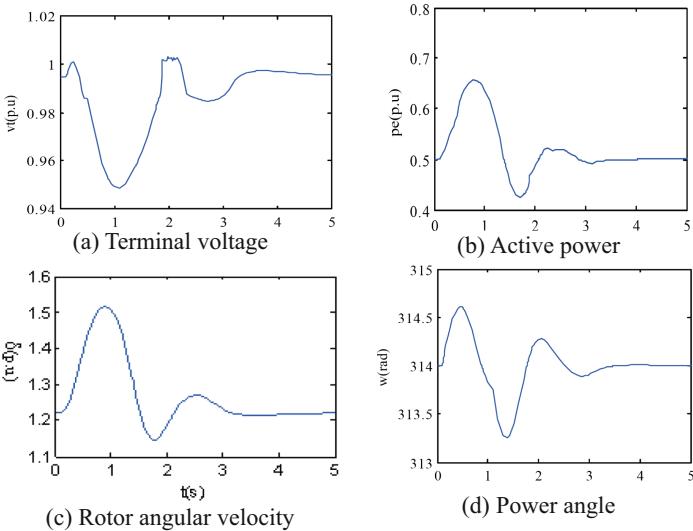
**Fig. 2.** Membership function of output variable

(4) Establishing the coordinated control rules of fuzzy controller

In the actual operation, when there is a large disturbance, such as a short circuit, the voltage deviation is large, the main task of the controller is to eliminate the voltage error as soon as possible to ensure the stability of the voltage. In case of small disturbance, the voltage deviation is small, and the main task of the controller is to suppress the system oscillation. Ensure the stability of the system. The main task of the controller is to increase the damping of the system and calm down the oscillation as soon as possible. Therefore, the adjustment effect of additional control should be increased. In the short time of large disturbance, due to the large voltage fluctuation and large deviation, for the sake of system safety, the key point of control at this time should be to recover the generator terminal voltage to the required range as soon as possible. In order to ensure that the output of additional control channel does not affect the voltage regulation of generator, the voltage regulation channel should play a major role, and the output of additional control channel should be limited. In the dynamic process after large disturbance, when the voltage returns to the safe range, the key point of the control should be to provide damping for the system, so that the oscillation will subside as soon as possible, and at this time, the additional control channel should play a role.

#### 4 Simulation Analysis

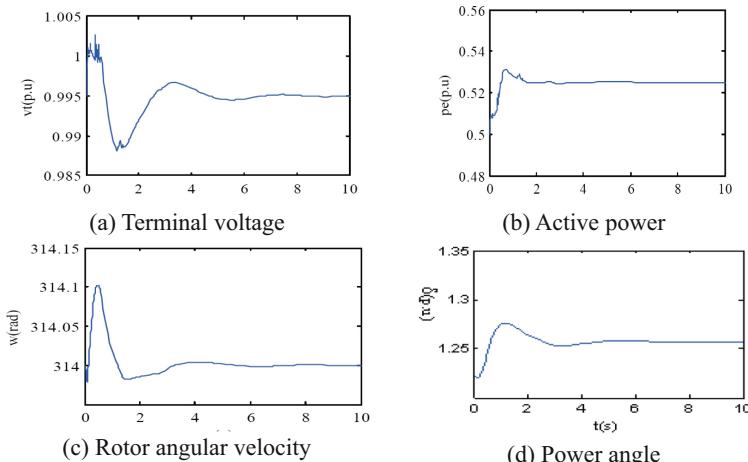
By using the fuzzy control toolbox in MATLAB, the fuzzy control model is established through the fuzzy inference system editor, membership function editor and fuzzy rule editor, and the designed fuzzy controller is transferred into Simulink. The fuzzy controller outputs different weights to PID and linear multivariable controller to coordinate the control. In the Fig. 4, the static small disturbance, static small disturbance and transient large disturbance are simulated.



**Fig. 3.** Static small disturbance 1 simulation under the action of fuzzy coordinated controller

- (1) Static small disturbance 1, the mechanical power  $P_m$  of generator end increases from 0.5 to 0.6 in 0.1 s, and  $P_m$  recovers to 0.5 in 1.1 s (Fig. 3).

Through the simulation, the  $V_t$  with the multivariable feedback controller acting alone fluctuates more than 10%, but it has a very fast damping effect on the active power, rotor angular velocity and power angle. When the PID controller works alone, it can adjust the voltage quickly and the voltage fluctuates little within the specified range, but its damping effect on the active power, rotor angular velocity and power angle is very weak. The fuzzy coordinated controller can not only ensure the accuracy of voltage regulation, but also improve the damping of active power and rotor angular speed. The effect is better than the former two. The system can be stable in 3 s.



**Fig. 4.** Static small disturbance 2 simulation under the action of fuzzy coordinated controller

- (2) Static small disturbance 2, the mechanical power  $P_m$  of generator end increases from 0.5 to 0.525 in 0.1 s, and remains unchanged after 1.1 s.

Through simulation, after the step increase of mechanical power, the fuzzy coordinated controller can adjust the voltage to the set value well, and the active power, rotor angular velocity and power angle can be stabilized within 3–4 s after the disturbance.

## 5 Conclusions

In this paper, a fuzzy PID controller is designed. Through simulation, it can be seen that the fuzzy controller has good control performance. The fuzzy controller can ensure the accuracy of voltage regulation. When the step mechanical power is disturbed, the voltage can be adjusted at the set value. At the same time, the overshoot of terminal voltage and active power is also significantly reduced. The fuzzy coordinated control mode not only improves the transient stability of the system, but also Moreover, the regulation accuracy of the voltage is guaranteed, and it has good robustness.

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# Hybrid Simulation and Vibration Analysis of Aeroengine Simulation Gearbox

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**Abstract.** Based on the theory of plate and shell, the rationality of shell element in building thin-walled structure is proved by the method of model comparison and test verification, and the general method of model verification is put forward. First of all, a series of gearbox models with different thickness diameter ratio  $\gamma$  are established for calculation and comparison. The results show that the shell element can better simulate the gearbox structure in the range of  $0.014 < \gamma < 0.037$ . According to this, the shell element is used in ANSYS to establish the simulation gearbox model for modal analysis. In order to further verify the reliability of the model, the modal test is carried out for the simulation gearbox. The test results are in good agreement with the finite element analysis results by verifying the natural frequency and the modal mode confidence.

**Keywords:** Aero-engine case · Thin wall cylinder · Finite element analysis · Model verification

## 1 Introduction

The vibration of aeroengine has always been an important part in the development and design of engine. This research has become a special subject [1–3]. The gearbox can be simplified into a thin-walled cylinder by neglecting the irregular structures such as mounting edge, hole and accessory. In the theory of plate and shell, the research on thin-walled cylinder structure is mature. In recent years, there have been many articles about the modal analysis of thin-walled cylinder structures, which have calculated the response under different boundary conditions, and some have adopted new and more accurate test verification methods [4–6].

At present, the research on the vibration of aeroengine case in foreign countries is mainly based on finite element analysis and test verification [3, 7], and there are similar methods [8, 9] in domestic research, but there is still a lack of reliable methods and processes in model verification.

In this paper, the unique hybrid simulation technology of LMS virtual lab is used to calculate and analyze the vibration characteristics of aeroengine simulation gearbox. The mixed model and the corresponding mode of the simulation gearbox are established, and the modal test of the simulation gearbox is carried out.

## 2 Analytical Solution and Finite Element Analysis of Thin-Walled Cylinder Mode

The final simplified model of the gearbox is thin-walled cylinder, so its mode can be calculated according to the theory of plate and shell. In the theory of plate and shell, the general formula of natural frequency of vibration mode of cylindrical shell is

$$f = \frac{\Omega}{R} \sqrt{\frac{E}{\rho(1 - \mu^2)}} \quad (1)$$

where  $f$  is natural frequency;  $\Omega$  is frequency coefficient;  $R$  is the average radius of the cylinder;  $E$  is the modulus of elasticity;  $\rho$  is the density of the material;  $\mu$  is the Poisson's ratio. Let  $u$ ,  $v$  and  $\omega$  be the displacements of any element in axial, circumferential and radial directions respectively. The boundary condition of thin-walled cylinder is  $u = v = \omega = 0$ . Where  $z$  is the axial coordinate of the cylinder,  $l$  is the length of the cylinder, and  $M$  is the bending moment.

$$\begin{aligned} & 2\Omega^3 - \Omega^2[2 + (3 - \mu)(p^2 + m^2) + 2k(p^2 + m^2)^2] + \Omega[2(1 - \mu^2)p^2 + (1 - \mu)(p^2 + m^2)(p^2 + m^2 + 1)] \\ & + (3 - \mu)k(p^2 + m^2)^3] - (1 - \mu)(1 - \mu^2)p^4 - (1 - \mu)k(p^2 + m^2)^4 + (1 - \mu)k\{2[\mu p^6 + 3p^4m^2 + (4 - \mu) \\ & p^2m^4 + m^6] - 2(2 - \mu)p^2m^2 - m^4\} = 0 \end{aligned} \quad (2)$$

where  $p = n\pi R/l$ ;  $k = h^2/(12R^2)$ ,  $h$  is cylinder wall thickness;  $m$  and  $n$  are the circumferential wave number and the axial half wave number of cylinder vibration respectively. In addition, the dynamic characteristics of thin-walled cylinder with different thickness and radius are different, so we introduce the concept of thickness radius ratio  $\gamma$ .

$$\gamma = h/R \quad (3)$$

In the finite element analysis software, a thin-walled cylinder model with thickness diameter ratio of  $\gamma = 0.003/0.107 = 0.028$  is established with solid45 and shell63

**Table 1.** Comparison of natural frequency analysis results

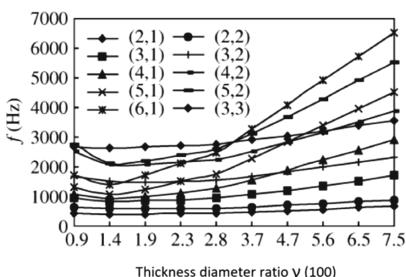
Modality ( $m, n$ )	Analytical solution (Hz)	Results of finite element analysis (Hz)		Error (%)	
		SHELL63 units	SOLID45 units	SHELL63 units	SOLID45 units
(2, 1)	1997	2459	2512	23.15	25.81
(3, 1)	1254	1723	1795	37.44	43.182
(4, 1)	1213	1516	1605	25.01	32.349
(5, 1)	1617	1762	1892	8.979	17.019
(6, 1)	2250	2315	2513	2.894	11.694
(4, 2)	2519	2419	2926	3.957	16.172
(5, 2)	2430	2613	2869	7.516	18.049

elements respectively for modal analysis. The comparison between the analysis results and the above theoretical solutions is shown in Table 1, and the theoretical solutions are calculated with formula (1) and formula (2).

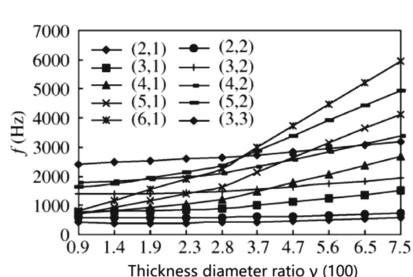
It can be seen from Table 1 that the analysis results based on shell63 are closer to the analytical solution given in reference [2] than those based on solid45. Therefore, when the thickness diameter ratio  $\gamma = 0.028$ , shell 63 element can better simulate the thin-walled cylinder structure. The model parameters are: the outer diameter  $r$  of the gearbox, the outer diameter  $r$  of the mounting edge, the length  $L$  and the material properties refer to Table 2. The wall thickness  $h$  of the gearbox varies from 1 mm to 8 mm, and the mounting edge thickness  $H = h + 2$ .

**Table 2.** Gearbox parameters and test parameters

Casing parameters		Test parameters	
Casing material	1Cr18Ni9Ti	Sampling frequency	12.8 kHz
Thickness of casing wall $h$ (mm)	3	Channel number	2
Thickness of mounting edge $H$ (mm)	5	Sample size	4 pieces
Casing outer wall radius $R$ (mm)	107	Sampling points	4096
Outer radius of mounting edge $r$ (mm)	122	Analysis points	4096
Casing length $l$ (mm)	250	Average mode	Linear average
Modulus of elasticity $E$ (GPa)	184	Average times	The 4 time
Material density $\rho$ (kg/m <sup>3</sup> )	7920	FFT block size	1024
Quality $m$ (g)	4792	Programmable amplification	1 times
Poisson's ratio	0.24	Trigger mode	Signal trigger
Unit type	SHELL63	Trigger level	20%
Unit number	1344	Window type	Excitation signal: force window
Constraint state	Freedom - freedom		Response signal: exponential window



**Fig. 1.**  $f$ - $\gamma$  curve based on SOLID45 element



**Fig. 2.**  $f$ - $\gamma$  curve based on SHELL63 element

Two different elements are used to establish the gearbox model, and the modal frequencies of each order vary with the thickness diameter ratio. The analysis results are shown in Figs. 1 and 2. It can be seen that when  $0.014 < \gamma < 0.037$ , the results of the two kinds of unit analysis are the closest, and when  $\gamma < 0.014$  or  $\gamma > 0.037$ . Especially when  $\gamma < 0.014$ , the calculation result of solid element is significantly higher than that of shell element, which is due to the fact that there is less one rotational degree of freedom for solid element node than shell element node, and the former error is higher than the latter at this time; while when  $\gamma > 0.037$ , because there is more than one rotational degree of freedom for shell element, the natural frequency is lower, and the calculation error of shell element is larger at this time.

### 3 Model Validation

- (1) Convergence analysis. In the finite element model, in order to meet the requirements of completeness, continuity and coordination of the trial function, convergence verification is needed. It can be seen from Fig. 3 that when the number of elements is close to 1000, the calculation results have reached the convergence state.

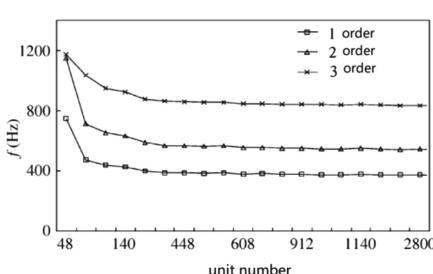


Fig. 3. Convergence verification

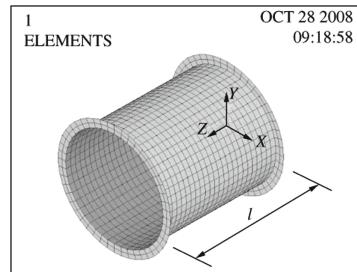


Fig. 4. Finite element model of box

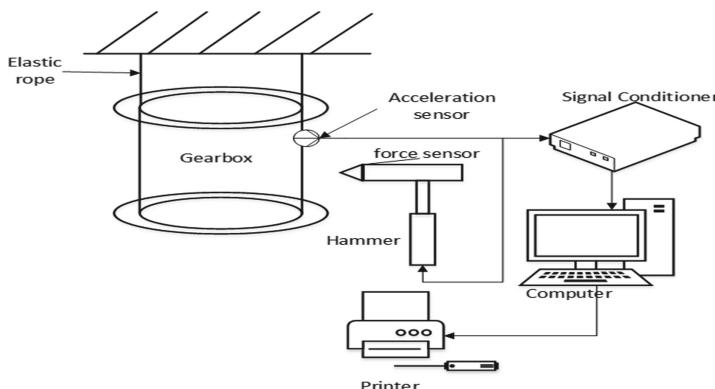


Fig. 5. Schematic diagram of analog gearbox modal test system

- (2) Finite element analysis. Finally, we need to verify the model of the engine case. The shell 63 element can be used to build an engine gearbox model for modal analysis. The finite element model is shown in Fig. 4, and the parameters of the gearbox are shown in Table 2.
- (3) Test verification. In Sect. 2, the finite element software is used to analyze the simulation gearbox, and the final test is needed to verify. The modal test system required for the test is shown in Fig. 5, and the test parameters are shown in Table 2. The gearbox is hung on the crossbar with soft rope to form a free hanging state. The force hammer is connected to channel 1 (CH01) of the signal conditioner through the wire, and the acceleration sensor is connected to channel 2 (CH02) of the signal conditioner through the wire and the charge amplifier.
- (4) Result analysis. In this test, the real frequency curve of FRF and PWR of 84 test points of the gearbox are collectively averaged, and the real frequency curve of FRF and PWR are obtained. According to the test data, the vibration pattern of each stage of the gearbox can be drawn, only the first four modes are listed.

**Table 3.** Natural frequency and damping ratio of analog gearbox

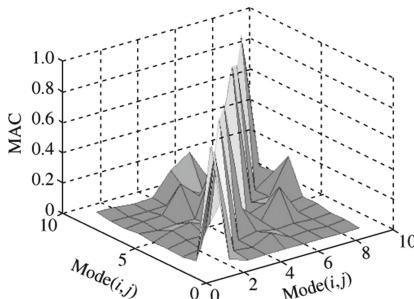
Order	Modality (m, n)	Natural frequency (Hz)			Error (%)		Damping ratio ( $\zeta$ )
		Test result	SHELL63	SOLID45	SHELL63	SOLID45	
1	(2, 1)	412.0	417.9	438.9	1.43	6.53	1.76
2	(2, 2)	587.5	586.8	615.8	-0.12	4.82	1.06
3	(3, 1)	912.2	911.1	966.0	-0.12	5.90	1.30
4	(4, 1)	1262	1209	1317	-4.20	4.36	0.50
5	(3, 2)	1472	1472	1575	0.00	7.00	0.85
6	(5, 1)	1725	1646	1889	-4.58	9.51	0.36
7	(4, 2)	2149	2119	2306	-1.40	7.31	0.27
8	(6, 1)	2387	2280	2773	-4.48	16.17	4.84
9	(5, 2)	2525	2425	2745	-3.96	8.71	0.35

It can be seen from Table 3 that the test mode is visually consistent with the finite element mode. It can be seen from Table 4 that there are errors in the test results and the finite element analysis results, and the shell element is closer to the test results than the solid element. The matrix of modal assurance criterion (MAC) of test mode and finite element mode (subject to shell element) is shown in Table 5. If  $\varphi_{iA}$  and  $\varphi_{jT}$  are the calculated first mode vector and the tested J mode vector respectively, then MAC matrix can be expressed as

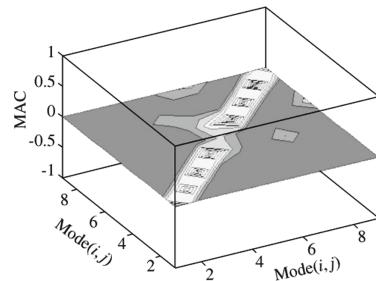
$$MAC_{i,j} = \frac{(\varphi_{iA}^T \varphi_{jT})^2}{(\varphi_{iA}^T \varphi_{jA})(\varphi_{jT}^T \varphi_{jT})} \quad (4)$$

MAC is located between 0 and 1, equal to 0 means that two modal vectors are orthogonal; the closer the diagonal element is to 1, the higher the degree of agreement between the experimental mode and the calculated mode is. It can be seen that, in addition to the low correlation between the results of (3, 2) order calculation and the modal shape of the test, the obvious correlation degree of other orders is relatively high. It can be concluded that the shell 63 element is effective in building a complex thin-walled structure model.

Figures 6 and 7 are the three-dimensional and plane graphs of the mode confidence degree. The bright part indicates the high mode coincidence degree, on the contrary, the worse the coincidence degree. It can be seen from the figure that the higher part of the confidence is concentrated on the diagonal, indicating that the test mode is in good agreement with the finite element mode.



**Fig. 6.** Three dimensional diagram of mode correlation confidence



**Fig. 7.** Plan of mode correlation confidence

## 4 Conclusions

This process can lay a foundation for the final realization of the full simulation design of engine structure. (1) When the thickness diameter ratio is  $0.014 < \gamma < 0.037$ , the analysis results of shell element and solid element are the closest. When  $\gamma < 0.014$  or  $\gamma > 0.037$ , the deviation of analysis frequency results gradually increases, and the shell element is always lower than the solid element. Especially when  $\gamma < 0.014$ , the calculation results of shell element are obviously lower than that of solid element, and the calculation error of solid element is larger, while when  $\gamma > 0.037$ , the calculation error of shell element is larger. (2) in addition to the thickness diameter ratio  $\gamma$ , the length ratio of the thin-walled tube structure is also an important factor affecting the selection of elements and the establishment of the model. Further research is needed for good engineering application.

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# Kinematic Analysis of 6-DOF Parallel Robot with Multi-loop Coupling

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**Abstract.** A multi-loop coupled 6-DOF parallel robot with 3-RSS-PRSS branch type is designed. The kinematics model of the robot is established by vector method, and the kinematics equation is solved. The robot designed not only has the high-speed movement characteristic of DELTA robot, but also has the flexibility characteristic of 6-DOF series robot. The research method of its kinematics position relationship provides reference for kinematics analysis of the same type of robot.

**Keywords:** Parallel robot · Configuration design · Kinematic analysis

## 1 Introduction

Nowadays, robot is an important tool to improve product chain and reduce manufacturing cost. According to the statistics of literature [1], in recent years, industrial robots are widely used in a series of industries such as automobile, 3C, electronics, metal products, plastics and chemicals, food, beverage and tobacco. The traditional 3-DOF parallel robot does not have large rotation angles in all directions, and the 6-DOF serial robot has relatively slow speed and low accuracy. Therefore, it is very urgent to design a parallel robot which can change the position and attitude of the operated object at the same time. In order to realize robot control, kinematics research is necessary. The kinematics research of parallel mechanism mainly includes position relation, work-space, singularity, velocity and kinematics performance [2]. Many scholars at home and abroad have made a lot of research and made breakthrough progress [3–11]. Due to the complexity and redundancy of the multi-loop coupling parallel mechanism, the position vector equation established is a non-linear equation group, and the iterative algorithm of the analytical equation is complex, so it is difficult to get the analytical solutions of all positions. Therefore, in the engineering application, for the high-speed parallel mechanism with strong motion coupling, the forward kinematics analysis generally adopts the numerical method. Because the inverse kinematics of parallel mechanism is simpler than the forward kinematics, the analytical method is more convenient. A 6-DOF multi-loop coupling parallel robot is designed and its kinematics is analyzed. The inverse kinematics position equation of the robot is established by

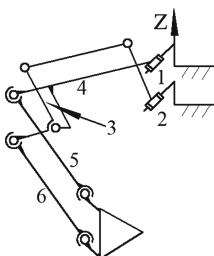
vector method. The Newton iterative method, which is commonly used in numerical method, is used to get the numerical solution of the robot's forward kinematics quickly and accurately.

## 2 Configuration Design

Based on the principle of unconstrained branch chain selection, the 3-RSS-RSS coupling branch chain mechanism is used as the branch chain structure of the robot. In order to improve the rigidity of the branch chain, the driving arm 2 is coupled to the driving arm 1. Due to the heavy weight of servo motor and planetary reducer, this design will lead to the excessive inertia of robot drive arm 1, so it is necessary to transfer the drive device of drive arm 2 to the frame. In order not to destroy the designed branch chain coupling structure, a parallel four-bar mechanism is added to the driving arm 2 by using the equivalent transmission effect of parallelogram, so that the driving device of the driving arm 2 is transferred to the frame in the coaxial position with the driving arm 1. The modified coupling branch chain is shown in Fig. 1, and the type is RSS-PRSS branch chain. Respectively design the corresponding three-dimensional model of the branch chain, as shown in Fig. 2; combine three identical branches in parallel into a multi ring coupling 6-DOF robot, as shown in Fig. 3.

## 3 Kinematic Analysis of Mechanism

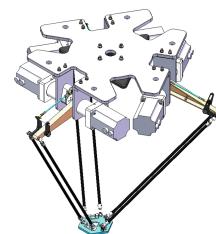
The coordinate systems of the static platform and the dynamic platform of the parallel mechanism are established respectively. The static coordinate system OXAYAZA is established on the static platform, and the origin O of the coordinate system is established at the center of the tangent circle in the static platform, so that the YA axis is vertical to A2D2, and the ZA axis is vertical to the static platform. The origin U of the UXBYBZB coordinate system of the moving platform is established at the center of the tangent circle in the moving platform, the YB axis is perpendicular to N1N2, and the ZA axis is vertical to the moving platform, as shown in Fig. 4.



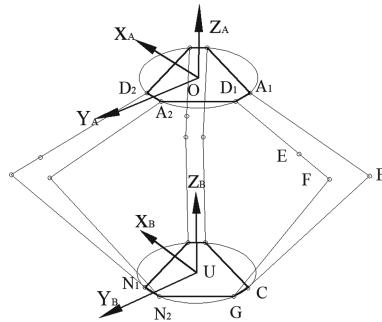
**Fig. 1.** Branch chain structure after modification



**Fig. 2.** Branched chain 3D model



**Fig. 3.** Robot 3D model



**Fig. 4.** Schematic diagram of mechanism coordinates

The structure of coupling branch chain is analyzed. The connecting rod A<sub>1</sub>B is the boom of driving arm 1, and the angle u<sub>1</sub> between A<sub>1</sub>B and the static platform plane is the boom driving angle. D<sub>1</sub>E is the equivalent link of drive arm 2, and it always parallel to link A<sub>1</sub>B. The connecting rod EF is equivalent to the jib of the driving arm 1, and the angle U<sub>4</sub> between EF and the plane of the static platform is the driving angle of the jib. Connecting rod BC and connecting rod FG are driven arms of drive arm 1 and drive arm 2 respectively. The other two coupling chains have the same structure as the coupling chain, and the corresponding driving angles are u<sub>2</sub>, u<sub>5</sub>, u<sub>3</sub> and u<sub>6</sub>.

#### 4 Inverse Solution of Mechanism Position

The inverse solution of mechanism position is to find the angle of driving joint (u<sub>1</sub>, u<sub>2</sub>, u<sub>3</sub>, u<sub>4</sub>, u<sub>5</sub>, u<sub>6</sub>) from the known position and pose of robot end actuator (X, Y, Z,  $\alpha$ ,  $\beta$ ,  $\gamma$ ). The inverse kinematics equation of the robot is established by vector method.

Vector representation of the equation of motion of the arm's branch chain.

$$\overrightarrow{BC} = \overrightarrow{OC} - \overrightarrow{OA}_1 - \overrightarrow{A_1B} \quad (1)$$

Vector representation of the equation of motion of the branch chain of the jib.

$$\overrightarrow{FG} = \overrightarrow{UG} - \overrightarrow{OD}_1 - \overrightarrow{D_1E} - \overrightarrow{EF} \quad (2)$$

Reduce the vector  $\overrightarrow{BC}$  in formula (1).

$$F_1 = \left| \overrightarrow{BC} \right|^2 - \left( \overrightarrow{OC} - \overrightarrow{OA} - \overrightarrow{AB} \right)^T \left( \overrightarrow{OC} - \overrightarrow{OA} - \overrightarrow{AB} \right) \quad (3)$$

Reduce the vector  $\overrightarrow{FG}$  in formula (2).

$$F_4 = \left| \overrightarrow{FG} \right|^2 - \left( \overrightarrow{O_{UG}} - \overrightarrow{OD} - \overrightarrow{DE} - \overrightarrow{EF} \right)^T \left( \overrightarrow{O_{UG}} - \overrightarrow{OD} - \overrightarrow{DE} - \overrightarrow{EF} \right) \quad (4)$$

The other two branches are the same, and six nonlinear equations can be obtained as follows.

$$F_i = 0 (i = 1, 2, 3, 4, 5, 6) \quad (5)$$

The vector  $\overrightarrow{OU}$  is expressed in the static coordinate system.

$$\overrightarrow{O_{UC}} = R * \overrightarrow{UC} + \overrightarrow{OU} \quad (6)$$

In formula,  $R = R_Z * R_Y * R_X$ ,  $\overrightarrow{OU} = [X \ Y \ Z]^T$ ,  $R_X = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \alpha & -\sin \alpha \\ 0 & \sin \alpha & \cos \alpha \end{bmatrix}$ ,

$$R_Y = \begin{bmatrix} \cos \beta & 0 & \sin \beta \\ 0 & 1 & 0 \\ -\sin \beta & 0 & \cos \beta \end{bmatrix}, R_Z = \begin{bmatrix} \cos \gamma & -\sin \gamma & 0 \\ \sin \gamma & \cos \gamma & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

All known parameters are substituted into Eq. (5), and the general formula of  $u_1 \ u_2 \ u_3 \ u_4 \ u_5 \ u_6$  are solved.

$$u_i = f(X, Y, Z, \alpha, \beta, \gamma) (i = 1, 2, 3, 4, 5, 6) \quad (7)$$

## 5 Positive Solution of Mechanism Position

The meaning of the positive solution of mechanism position is that the angle of the driving joint of the robot is known to solve the pose of the moving end. The forward kinematics equation of the mechanism designed in this paper is six coupled nonlinear equations, so it is difficult to get the analytical solution. In order to facilitate the robot control, the numerical solution is adopted.

The Newton iterative method of nonlinear equations is used for the designed mechanism, and the formula is as follows.

$$P^{(K+1)} = P^{(K)} - \left[ F'(P^{(K)}) \right]^{-1} F(P^{(K)}), k = 0, 1, \dots \quad (8)$$

Vector function is  $F = (F_1, F_2, F_3, F_4, F_5, F_6)^T$ . The Jacobian matrix of vector function F is

$$F' = \begin{bmatrix} \frac{\partial F_1}{\partial X} & \frac{\partial F_1}{\partial Y} & \frac{\partial F_1}{\partial Z} & \frac{\partial F_1}{\partial \alpha} & \frac{\partial F_1}{\partial \beta} & \frac{\partial F_1}{\partial \gamma} \\ \frac{\partial F_2}{\partial X} & \frac{\partial F_2}{\partial Y} & \frac{\partial F_2}{\partial Z} & \frac{\partial F_2}{\partial \alpha} & \frac{\partial F_2}{\partial \beta} & \frac{\partial F_2}{\partial \gamma} \\ \frac{\partial F_3}{\partial X} & \frac{\partial F_3}{\partial Y} & \frac{\partial F_3}{\partial Z} & \frac{\partial F_3}{\partial \alpha} & \frac{\partial F_3}{\partial \beta} & \frac{\partial F_3}{\partial \gamma} \\ \frac{\partial F_4}{\partial X} & \frac{\partial F_4}{\partial Y} & \frac{\partial F_4}{\partial Z} & \frac{\partial F_4}{\partial \alpha} & \frac{\partial F_4}{\partial \beta} & \frac{\partial F_4}{\partial \gamma} \\ \frac{\partial F_5}{\partial X} & \frac{\partial F_5}{\partial Y} & \frac{\partial F_5}{\partial Z} & \frac{\partial F_5}{\partial \alpha} & \frac{\partial F_5}{\partial \beta} & \frac{\partial F_5}{\partial \gamma} \\ \frac{\partial F_6}{\partial X} & \frac{\partial F_6}{\partial Y} & \frac{\partial F_6}{\partial Z} & \frac{\partial F_6}{\partial \alpha} & \frac{\partial F_6}{\partial \beta} & \frac{\partial F_6}{\partial \gamma} \end{bmatrix} \quad (9)$$

The input driving angle is  $u_1 u_2 u_3 u_4 u_5 u_6$ . By using Eq. (8) to calculate the positive solution of the mechanism, the pose of the moving platform can be obtained.

## 6 Summary

A multi-loop coupled 6-DOF parallel robot with 3-RSS-PRSS branch type is designed and its kinematics is analyzed by different methods. In the operation space of the mechanism, the reference is provided for the kinematic analysis of the non singular position of similar mechanisms.

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# Kinematic Case Verification of 6-DOF Parallel Robot

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**Abstract.** A 6-DOF parallel robot with 3-rss-prss is designed. The kinematic model of the robot is established by vector method, and the analytical method is improved after the case verification of 3D sketch by SolidWorks, which improves the accuracy of kinematic calculation and provides reference for kinematic analysis of the same type of robot.

**Keywords:** Parallel robot · Configuration design · Case verification

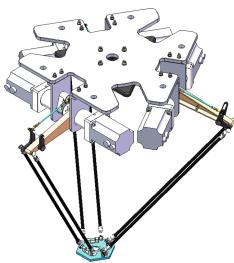
## 1 Introduction

Nowadays, robot is an important tool to improve product chain and reduce manufacturing cost. According to the statistics of literature [1], in recent years, industrial robots are widely used in a series of industries such as automobile, 3C, electronics, metal products, plastics and chemicals, food, beverage and tobacco. The traditional 3-DOF parallel robot does not have large rotation angles in all directions, and the 6-DOF serial robot has relatively slow speed and low accuracy. Therefore, it is very urgent to design a parallel robot which can change the position and attitude of the operated object at the same time. In order to realize robot control, kinematics research is necessary. The kinematics research of parallel mechanism mainly includes position relation, work-space, singularity, velocity and kinematics performance [2]. Many scholars at home and abroad have made a lot of research and made breakthrough progress [3–7].

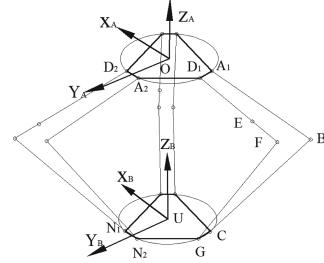
## 2 Design and Kinematic Analysis of Mechanism

Based on the principle of unconstrained branch chain selection, the 3-RSS-RSS coupling branch chain mechanism is used as the branch chain structure of the robot. As shown in Fig. 1. The coordinate systems of the static platform and the dynamic platform of the parallel mechanism are established respectively. The static coordinate system OXAYAZA is established on the static platform, and the origin O of the coordinate system is established at the center of the tangent circle in the static platform, so that the YA axis is vertical to A2D2, and the ZA axis is vertical to the static platform. The origin U of the UXBYBZB coordinate system of the moving platform is established at the center of the tangent circle in the moving platform, the YB axis is perpendicular to N1N2, and the ZA axis is vertical to the moving platform, as shown in Fig. 2.

The structure of coupling branch chain is analyzed. The connecting rod A1B is the boom of driving arm 1, and the angle  $u_1$  between A1B and the static platform plane is the boom driving angle. D1E is the equivalent link of drive arm 2, and it always parallel to link A1B. The connecting rod EF is equivalent to the jib of the driving arm 1, and the angle  $U_4$  between EF and the plane of the static platform is the driving angle of the jib. Connecting rod BC and connecting rod FG are driven arms of drive arm 1 and drive arm 2 respectively. The other two coupling chains have the same structure as the coupling chain, and the corresponding driving angles are  $u_2, u_5, u_3, u_6$ .



**Fig. 1.** Robot 3D model



**Fig. 2.** Schematic diagram of mechanism coordinates

### 3 Inverse Solution and Positive Solution of Mechanism Position

The inverse solution of mechanism position is to find the angle of driving joint ( $u_1, u_2, u_3, u_4, u_5, u_6$ ) from the known position and pose of robot end actuator ( $X, Y, Z, \alpha, \beta, \gamma$ ). The inverse kinematics equation of the robot is established by vector method.

The positive solution of mechanism position, that is to say, the angle of the driving joint of the robot is known to solve the pose of the moving end. The forward kinematics equation of the mechanism designed in this paper is six coupled nonlinear equations, so it is difficult to get the analytical solution. In order to facilitate the robot control, the numerical solution is adopted.

In the era of classical control theory and modern control theory, it is difficult to describe some systems which are difficult to be described by general physical and chemical laws. There are many influencing factors, and there are cross-coupling systems among them. The establishment of their models is very complex. Some production processes lack appropriate testing means, or testing devices cannot enter the tested area, which makes it impossible to establish systems.

### 4 Case Verification

The driving joint points on the static platform of the multi-loop coupling 6-DOF parallel robot are connected with the origin of the static coordinate system, and rotate clockwise from OA1 to OD1. The included angles with the X axis of the static

coordinate system are (16.5043, 33.4336, 136.5043, 153.4336, 256.5043, 273.4336) respectively. The connection position of each spherical pair on the moving platform is connected with the origin of the moving coordinate system. It rotates clockwise from UC to UG, and the included angle with the X axis of the moving coordinate system is (-9.2881, 69.2881110.7119189.2881230.7119309.2881). The angle between the length of pole A1B, d<sub>1e</sub> and EF projected to the static platform and the X axis of the static coordinate system is 30°. The angle between the three lengths of the other two coupling chains and the static coordinate system is 150° and 270° in the clockwise direction. See Table 1 for other relevant motion parameters.

**Table 1.** Kinematic parameters of mechanism

Code of member	Length	Angle with static platform
OA <sub>1</sub>	308	0
A <sub>1</sub> B	340	u <sub>1</sub>
BC	1032	
UC	71	0
OD <sub>1</sub>	300	0
D <sub>1</sub> E	280	u <sub>1</sub>
EF	60	u <sub>4</sub>
FG	1032	
UG	71	0

In order to judge whether the kinematic position relationship of the mechanism deduced is reasonable, four groups of examples are selected for verification.

Example 1, the input end pose is P1 = [X = 200; Y = -160; Z = -1000;  $\alpha$  = 0;  $\beta$  = 0;  $\gamma$  = 0];

Example 2, the input end pose is P2 = [X = -300; Y = 260; Z = -1100;  $\alpha$  = 0;  $\beta$  = 0;  $\gamma$  = 0];

Example 3, the input end pose is P3 = [X = 300; Y = 260; Z = -1100;  $\alpha$  = 25;  $\beta$  = 0;  $\gamma$  = 0];

Example 4, the input end pose is P4 = [X = 300; Y = 260; Z = -1100;  $\alpha$  = 25;  $\beta$  = 15;  $\gamma$  = 13];

## 5 Verification of Inverse Solution and Improvement of Solution

Four groups of examples are substituted into the inverse kinematics equation by MATLAB numerical calculation to obtain the inverse solution data. Use SolidWorks to build 3D sketch for data verification, and the data comparison results are shown in Table 2.

**Table 2.** The calculation results of inverse solution and the verification value before improvement.

Angle of joint	Example 1		Example 2		Example 3		Example 4	
	Calculated value	Verified value						
$u_1$	4.1640	4.1640	80.4351	80.4351	36.7988	36.7988	41.2610	41.2610
$u_2$	35.6724	35.6724	41.3698	41.3698	86.7983	86.7983	85.8388	85.8388
$u_3$	43.3167	43.3167	25.8507	25.8507	25.1297	25.1297	23.7396	23.7396
$u_4$	4.1640	4.1640	80.4351	80.4351	84.4614	77.1412	60.4157	58.3115
$u_5$	35.6724	35.6724	41.3698	41.3698	58.2066	55.4542	44.5052	41.3180
$u_6$	43.3167	43.3167	25.8507	25.8507	25.1297	25.1297	40.3053	38.0252

According to the data comparison between example 1 and example 2 in Table 2, When there is only position change and no attitude change, the accuracy of general formula  $u_i$  can meet the requirements; According to the data comparison between example 3 and example 4, it can be determined that when there is attitude change, the accuracy of three boom driving angles  $u_1 u_2 u_3$  can meet the requirements, and the error of the driving angle  $u_4 u_5 u_6$  of the three jibs is large, which indicates that the error of the general formula of  $u_i$  can not meet the accuracy requirements. The analysis is willing to find that the small arm of the mechanism is coupled to the big arm, and the movement of the big arm has a certain impact on the small arm, so it is unreasonable to reduce the  $u_4 u_5 u_6$  in the equation of small arm branch chain in the method of solving  $u_1 u_2 u_3$ . Therefore, when we solve the general formula of  $u_4 u_5 u_6$ , we keep  $u_1 u_2 u_3$  in the equation. After solving the value of  $u_1 u_2 u_3$ , the value should be substituted into the general equation of  $u_4 u_5 u_6$ . Again, the above four examples are used for verification, and the data comparison table is shown in Table 3.

**Table 3.** The improved inverse solution and the verified value.

Angle of joint	Example 1		Example 2		Example 3		Example 4	
	Calculated value	Verified value						
$u_1$	4.1640	4.1640	80.4351	80.4351	36.7988	36.7988	41.2610	41.2610
$u_2$	35.6724	35.6724	41.3698	41.3698	86.7983	86.7983	85.8388	85.8388
$u_3$	43.3167	43.3167	25.8507	25.8507	25.1297	25.1297	23.7396	23.7396
$u_4$	4.1639	4.1640	80.4351	80.4351	77.1409	77.1412	58.3115	58.3115
$u_5$	35.6724	35.6724	41.3698	41.3698	55.4543	55.4542	41.3179	41.3180
$u_6$	43.3165	43.3167	25.8510	25.8507	25.1297	25.1297	38.0252	38.0252

Compared with the calculated and verified values in Table 3, when the end position and attitude of the mechanism are changed, the calculation results are correct and the accuracy can meet the requirements. That is to say, any point outside the singular position can be selected in the operation space of the mechanism and the correct result can be calculated quickly by this method.

## 6 Positive Solution Verification

According to the above mathematical model of positive solution of position and the selected Newton iterative algorithm of positive solution, the above four examples are also used to input the joint angle calculated in the inverse solution, so as to calculate the end position and attitude. The final calculation results are listed in Table 4.

**Table 4.** Calculation results of positive solution.

Number of iterations	Example 1	Example 2	Example 3	Example 4
$P^{(0)}$	[100, 130, -1038, 0, 0, 0]	[100, 130, -1038, 0, 0, 0]	[100, 130, -1038, 0, 0, 0]	[100, 130, -1038, 0, 0, 0]
$P^{(1)}$	[210, -167.7, -1054.3, 0, 0, 0]	[-322.9, 281.6, -1215, 0, 0, 0]	[307.6, 260.4, -1139.5, 30.4, 0, 0]	[298.3, 261.8, -1141.2, 29.8, 15.1, 10]
$P^{(2)}$	[200.3, -160.2, -1001.6, 0, 0, 0]	[-301.3, 261.2, -1106.6, 0, 0, 0]	[300.2, 260, -1100.9, 25.2, 0, 0]	[300.4, 260, -1100.9, 25.3, 15, 13.1]
$P^{(3)}$	[200, -160, -1000, 0, 0, 0]	[-300, 260, -1100, 0, 0, 0]	[300, 260, -1100, 25, 0, 0]	[300, 260, -1100, 25, 15, 13]
$P^{(4)}$	[200, -160, -1000, 0, 0, 0]	[-300, 260, -1100, 0, 0, 0]	[300, 260, -1100, 25, 0, 0]	[300, 260, -1100, 25, 15, 13]

From Table 4, it can be concluded that when the initial value is [100, 130, -1038, 0, 0, 0], the data calculated by Newton iteration method are compared with the input  $P_1$ ,  $P_2$ ,  $P_3$  and  $P_4$  in the example in the inverse solution, it can be seen that the calculation results converge quickly, the data are correct and the accuracy is high, which can meet the requirements. It shows that selecting any point outside the singular position in the operating space of the mechanism can use this method to calculate the correct result and converge quickly.

## 7 Summary

A multi-loop coupled 6-DOF parallel robot with 3-RSS-PRSS branch type is designed and its kinematics is analyzed by different methods. Based on the 3D sketch of robot established by SolidWorks, the calculation result is verified, and the solution of inverse kinematics equation is improved, which improves the calculation accuracy of inverse kinematics obviously. In the operation space of the mechanism, the reference is provided for the kinematic analysis of the non singular position of similar mechanisms.

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# Study on a Rotor Speed Estimation Algorithm of PMSG Wind Power System

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**Abstract.** A rotor speed estimation algorithm in a direct vector controlled permanent magnet synchronous generator wind energy conversion system is proposed. The method is based on a simple equation obtained from stator voltage and current. Stator flux information required by the speed estimator is obtained using the stator voltage equation by implementing a programmable low pass filter. The constant gain recursive least squares algorithm is adopted. Then, the rotor position obtained based on the proposed method are used in the rotor-flux oriented vector control of PMSG. The simulation result shows that the control strategy realizes maximum power point tracking control, which verifies the validity and feasibility of the theoretical model and control strategy.

**Keywords:** Permanent magnet synchronous generator · Speed estimation · Wind energy conversion systems · Sensorless control · Maximum power point tracking control

## 1 Introduction

Wind power generation system mainly consists of constant speed and constant frequency wind power generation system and variable speed and constant frequency wind power generation system. The latter uses permanent magnet synchronous generator, which can achieve the maximum wind energy capture in a wide range of wind speed changes, has high power density, and does not need gearbox, slip ring and excitation device [1] with simple structure and high reliability, which is the main trend of future wind power generation technology development One of.

The uncertainty of wind energy and the characteristics of wind turbine make the output power of wind turbine fluctuate with the change of wind speed. In order to improve the utilization efficiency of wind energy and capture wind energy to the greatest extent, it is necessary to make the wind turbine run at the optimal speed at any wind speed. Therefore, high-precision wind speed detection and speed detection are required, but the reliability of system operation is also reduced. In addition, the air flow around the wind turbine is greatly disturbed by the blades, so it is difficult to accurately measure the current effective wind speed [2]. At the same time, the accurate measurement of stator current and stator voltage can be used for speed estimation, so there is no need for speed measurement. At present, scholars at home and abroad have done a lot of research on direct drive PMSG speed sensorless vector control. There are two mature methods to estimate the position and speed of PMSM: high frequency signal

injection method and back EMF method. The former uses the salient pole effect of the motor with strong robustness, especially suitable for zero speed starting and low-speed operation, but only suitable for the motor with salient pole effect, and the injected high-frequency signal will make the motor loss, torque fluctuation and noise larger, and the dynamic performance of the motor worse; the latter starts from the measurement of the motor's generating potential, the algorithm is relatively simple, but because of the low The back EMF value of the motor at speed is small, and it is easy to be affected by the measurement error of the system, so the effect is not ideal [3, 4]. In addition, the control strategy of introducing software phase-locked loop is proposed in reference [5], through which the speed of wind turbine can be obtained, but the accuracy of phase locking is affected by some harmonic components in the output voltage signal of generator. In reference [6, 7], an extended Kalman filter algorithm is proposed. However, due to the large amount of calculation, high-precision digital signal processor is needed to realize real-time control, which is not suitable for engineering. In addition to the method based on mathematical model, the rotor speed can also be estimated based on the theory of artificial intelligence.

In this paper, a speed estimation vector control algorithm is proposed for PMSG variable speed wind power generation system without speed sensor. Through simple stator flux model to estimate the speed of wind turbine, the speed of wind turbine can be obtained without measuring device. By controlling the electromagnetic power of direct drive permanent magnet wind turbine, the speed of wind turbine can be indirectly controlled to track the best power curve of wind turbine Capture of maximum wind energy. In this paper, the parameters estimation algorithm of recursive least square method is used for real-time on-line identification, and the real-time identified speed is applied to PMSG rotor position estimation and rotor field oriented vector control. In order to improve the performance of stator flux estimation, PLPF is designed based on stator voltage model.

## 2 Control Method Design

### 2.1 Stator Flux Estimation

PMSM stator voltage equation  $\vec{v}_s = R_s \vec{i}_s + \frac{d \vec{\psi}_s}{dt}$ , Using PLPF [3], the estimated stator flux is

$$\widehat{\vec{\psi}}_s = \left( \frac{\vec{v}_s - R_s \vec{i}_s}{s + \omega_e} \cdot \frac{\sqrt{\hat{\omega}_e^2 + \omega_e^2}}{|\hat{\omega}_e|} e^{-j\epsilon_1} \right) \quad (1)$$

In style:  $\epsilon_1 = \tan^{-1}(\hat{\omega}_e / (k|\hat{\omega}_e|))$  is the phase compensation angle;  $\hat{\omega}_e = [\hat{\psi}_{s\alpha}(v_{s\beta} - R_s i_{s\beta}) - \hat{\psi}_{s\beta}(v_{s\alpha} - R_s i_{s\alpha})] / |\hat{\vec{\psi}}_s|^2$  is the estimated synchronous angular frequency; the gain error can be compensated by multiplying the compensation coefficient

$G = \sqrt{\hat{\omega} + \omega} / |\hat{\omega}_e|$ . The phase angle compensation can be multiplied by the compensation coefficient  $P = e^{-j\epsilon_1}$  for compensation;  $\omega_c$  is the cut-off frequency of LPF,  $\omega_c = \frac{\hat{\omega}_e}{k}$ , select the appropriate  $k$  value to obtain the best performance of the system.

## 2.2 Rotor Speed Estimation

The rotor speed can be estimated. But the numerator of the fraction of the vector  $\vec{\psi}_s = L_s \vec{i}_s$  is equal to 0 at the phase angle  $\xi = 45^\circ + n90^\circ$  ( $n = 0, 1, 2, \dots$ ), and the denominator of the fraction is equal to  $\xi = n90^\circ$  at the phase angle  $o$ . In order to estimate the rotor speed, the least square method is used.

$$s \left\{ (\hat{\psi}_{s\beta} - L_s i_{s\beta})^2 - (\hat{\psi}_{s\alpha} - L_s i_{s\alpha})^2 \right\} = 4 \left( \hat{\psi}_{s\alpha} - L_s i_{s\alpha} \right) \left( \hat{\psi}_{s\beta} - L_s i_{s\beta} \right) \hat{\omega} \quad (2)$$

According to the extreme value theorem, the mathematical expression of the least square method with forgetting factor can be deduced as follows:

$$\hat{\omega}(k) = \hat{\omega}(k-1) + D(k) \{y(k) - x(k)\hat{\omega}(k-1)\} \quad (3)$$

$$D(k) = P(k-1)x(k)\{\lambda + P(k-1)(x(k))^2\}^{-1} \quad (4)$$

$$P(k) = P(k-1)\{1 - D(k)x(k)\}\lambda^{-1} \quad (5)$$

In style:  $\lambda$  is the forgetting factor,  $0 < \lambda < 1$ . The smaller the forgetting factor is, the stronger the tracking ability of the algorithm is, but the greater the fluctuation of the parameter estimation is; and the larger the forgetting factor is, the weaker the tracking time-varying parameter ability of the algorithm is, resulting in the result unable to converge. When  $\lambda = 1$ , the forgetting factor least square method degenerates into the ordinary least square method. The convergence and stability of parameter estimation should be considered in the selection of forgetting factor.

Trace of fixed value  $P$  matrix

$$\text{tr}[P(k)] = \text{tr}[P(0)] = \gamma > 0 \quad (6)$$

Because the recurrence matrix  $P$  is a single element matrix, that is to say  $P(k) = P(0) = \gamma$ . Substituting formula (10) and formula (11) can get:

$$\lambda = 1 - P(0)(x(k))^2 \quad (7)$$

Also because of  $0 < \lambda < 1$ , Eq. (13) can be simplified by the first order approximation

$$\lambda = 1/(1 + P(0)(x(k))^2) \quad (8)$$

The expression of the simplified recursive least square estimation of constant gain is

$$\hat{\omega}(k) = \hat{\omega}(k-1) + D(k)\{y(k) - x(k)\hat{\omega}(k-1)\} \quad (9)$$

$$D(k) = P(0)x(k)\{1 + P(0)(x(k))^2\}^{-1} \quad (10)$$

### 2.3 Control Strategy of Generator Side Converter

According to the orientation of rotor magnetic field, the mathematical model of PMSG in synchronous rotating coordinate system can be obtained as follows

$$u_{sd} = R_s i_{sd} + L_s \frac{di_{sd}}{dt} - \omega l_s i_{sq} \quad (11)$$

$$u_{sq} = R_s i_{sq} + L_s \frac{di_{sq}}{dt} + \omega l_s i_{sd} + \omega \psi_r \quad (12)$$

In style:  $u_{sd}$ ,  $u_{sq}$  is the direct of stator voltage and cross axis component;  $L_s$  is the surface type PMSM direct and quadrature axis inductance;  $i_d$ ,  $i_q$  is the direct and quadrature axis component of stator current;  $\omega$  is the electrical angular speed of rotor rotation;  $\psi_r$  is the motor flux.

There is coupling between d-axis and q-axis variables, which makes it difficult to design the controller, so feedforward decoupling control strategy is adopted.

When the PMSM operates stably and the stator resistance voltage drop is ignored, the voltage equation can be simplified as

$$v_{cd} = -L_s \omega i_{sq} \quad (13)$$

$$v_{cd} = L_s \omega i_{sd} + \omega \psi_r \quad (14)$$

The vector control of the side converter is shown in Fig. 2. The vector double closed-loop control technology is adopted. The outer loop is a speed loop, and its speed reference value is given by the maximum power point tracking algorithm. The electromagnetic torque of the generator is adjusted so that the actual speed tracking this reference speed can capture the maximum wind energy. The reference speed is compared with the speed estimated by the estimation algorithm, and the deviation value is sent to the PI regulator to output the reference value of the active current; the inner loop realizes the closed-loop control of D and Q current respectively, and the error signal is adjusted by PI and added with the respective decoupling compensation term to obtain the reference voltage of the converter on the machine side, so as to carry out SVPWM modulation. Set d-axis reference current according to unit power factor control (Fig. 1).

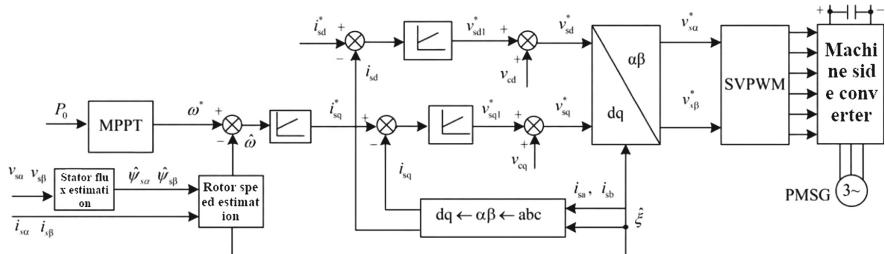


Fig. 1. Machine side converter control system

### 3 Simulation Result

In order to verify the feasibility of the control strategy proposed in this paper, Matlab/Simulink is used for simulation. The PMSG direct drive variable speed wind power generation system without wind speed and rotor speed sensor is established. In the figure, the machine side  $i_{sd} = 0$  is used to obtain the rated flux, and the network side  $i_q = 0$  is used to obtain the unit power factor. PMSG simulation parameters: DC bus voltage 400 V, armature winding AC-DC shaft inductance  $L_d = L_q$  is 4 MH, winding resistance of each phase 0.9 Ω, motor pole pairs 18, motor rated voltage 200 V, rated current 11.6a, rated power 2 kW, rated speed 200 r/min.

There are two kinds of wind speed curves used in the simulation. One kind of curve is shown in Fig. 2(a). Ideal wind is adopted, with the maximum wind speed of 9 m/s

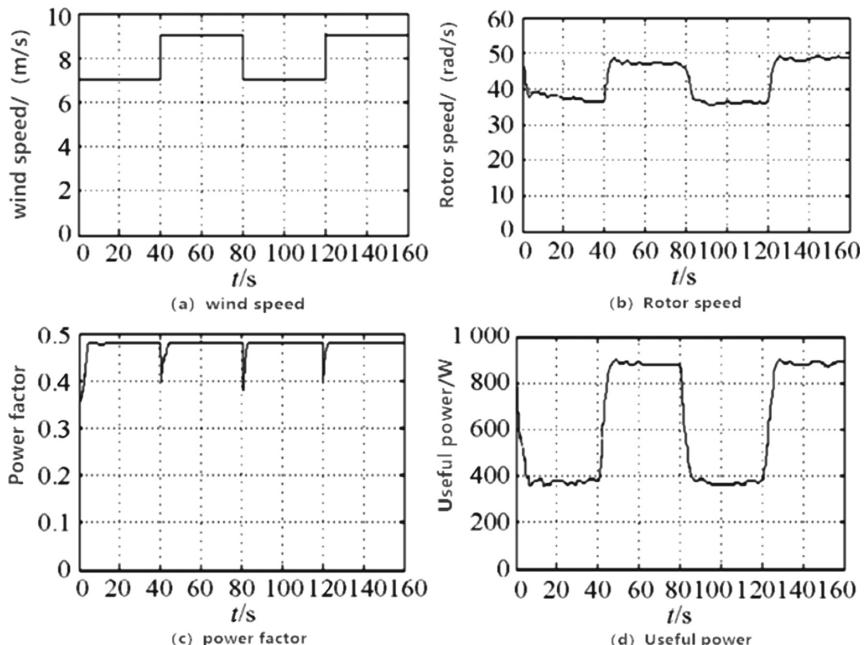
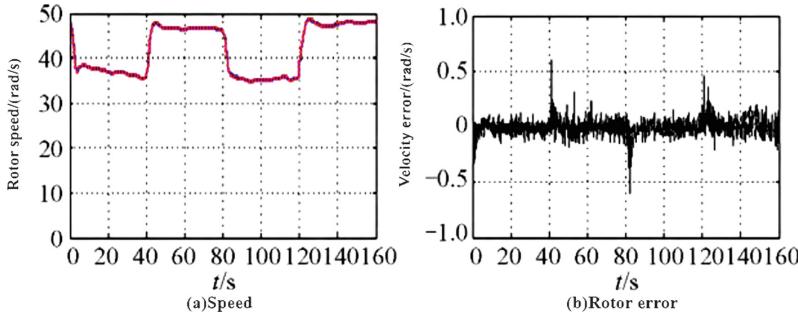


Fig. 2. Simulation results of PMSG with rectangular wind

and the minimum wind speed of 7 m/s. the rotor speed, power factor and active power output of the control system using the sensorless rotor estimation algorithm are shown in Fig. 2(b) (c) (d) respectively. For the convenience of comparison, Fig. 2(a) shows the corresponding rotor speed and the estimated rotor speed simulation curve. The dotted line in the figure represents the estimated rotor speed, and the real line represents the actual rotor speed; Fig. 2(b) shows the speed error curve of both.



**Fig. 3.** Speed estimation for rectangular wind speed profile

It can be seen from the figure that the maximum error of estimated wind speed and actual wind speed is 0.64 rad/s, and the control effect is very good.

Figure 3(a) shows the natural wind speed curve, and the rotor speed, power factor and active power output of the control system using the sensorless rotor estimation algorithm are shown in Fig. 3(b) (c) (d), respectively. For the convenience of comparison, Fig. 3(a) shows the corresponding rotor speed and the estimated rotor speed simulation curve. The dotted line in the figure represents the estimated rotor speed, and the real line represents the actual rotor speed; Fig. 3(b) shows the speed error curve of both.

## 4 Conclusions

In this paper, the rotor speed estimation method of PMSG wind power generation system is studied. The maximum power tracking of wind power can be realized without measuring wind speed and wind turbine speed. The algorithm is derived from simple stator flux equation, and the stator flux estimation is based on the design of programmable low-pass device based on the stator voltage model, and the recursive least square algorithm of forgetting factor is used to identify the speed in real time. In this paper, the mathematical model of the system is established, the design of the system is carried out in detail, and the simulation is carried out to verify the correctness and feasibility of the algorithm.

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# Optimal Control Strategy for Nonlinear Vibration of Beam Structures

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**Abstract.** Beam structure is the most basic component or component in construction engineering. The research on beam structure is not only of great theoretical and engineering significance, but also can provide some reference for the study of plate and complex structure. In addition, the beam structure is also considered as the solidification model of the pipeline, and the in-depth study of the beam structure is helpful to solve the pipeline problem. Therefore, this paper takes the cantilever structure as an example to study its non-linear vibration system, and puts forward the corresponding optimal control strategy.

**Keywords:** Beam structure · Non-linear vibration · Optimal control · Strategy research

## 1 Introduction

The dynamic system in engineering contains many complex non-linear factors, but these non-linear factors are often simplified into linear factors and set up in linear systems, which are used as simplified models for various theoretical and simulation calculations [1, 2]. Under special circumstances, these neglected non-linear factors will bring serious errors and errors to the project [3]. In addition, in linear analysis, the change of linear damping coefficient under the influence of harmonic excitation is unique; however, in the nonlinear dynamic system, the phenomenon of multi-solution and multi-frequency vibration will occur under the action of harmonic excitation [4–6]. Therefore, the study of non-linear systems is of great significance for practical engineering. In recent years, beam structures have been widely used in engineering fields, such as civil engineering, aerospace and machinery. In practice, these beam structures will be stimulated by external forces, resulting in a large scale of continuous non-linear vibration, which will inevitably have a serious impact on the normal work of the structure, and even fatigue damage in serious cases. Therefore, it is necessary to optimize the control of non-linear vibration of beam structure. At present, scholars' research on the non-linearity of beam structures mainly focuses on the calculation

of non-linear response, bifurcation and chaotic characteristics, the construction of non-linear dynamic model and the stability analysis of motion [7–9].

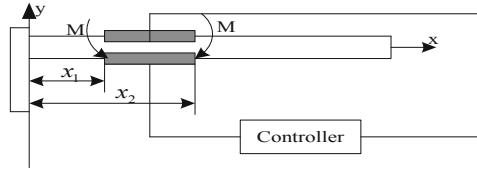
With the in-depth study of non-linear dynamic systems, optimal control has become the key content of contemporary control theory research. The main content of the research is to find the optimal control strategy for the performance of the nonlinear vibration control system in order to obtain the maximum or minimum value under certain constraints, which is the basic condition and synthesis method for the optimization of the performance of the nonlinear vibration control system. Simply speaking, we can find an optimal combination of feedback control gain parameters from a nonlinear dynamic system, and then design a control scheme to make the nonlinear vibration of the whole system reach the optimal performance index when it changes from one initial state to another specified target state. At present, the optimal control theory has been widely applied to the seismic control of beam structures. Chen Zhen et al. chose piezoelectric energy material cantilever beam as the object of study, and established the actuation equation and piezoelectric sensor equation of intelligent cantilever beam. The optimal vibration control problem of piezoelectric intelligent beam was studied by combining genetic algorithm with linear quadratic optimal control method [10]. In this study, the suspension beam under piezoelectric control is taken as the research object, and the dynamic vibration reduction system model with non-linear effect is established. The control voltage and the system deflection are expanded with small parameters. The perturbation method is used to transform the calculus equation from non-linearity to linearity. Finally, the state space equations of the vibration reduction system are derived. A hierarchical optimal control method is used to control the vibration reduction system of the suspension beam. The specific results are as follows.

## 2 Modeling

As shown in Fig. 1, a piezoelectric controlled suspension system is used. Piezoelectric sensor is attached to the surface of the beam, which will deform with the vibration of the beam. According to the principle of piezoelectric effect, the piezoelectric signal will be generated with the deformation of the piezoelectric plate. The signal is used as the signal of the controller to control the vibration of the piezoelectric beam actively [11]. The optimal control of the suspension beam is achieved by pasting the piezoelectric actuator on the bottom. Its voltage source mainly consists of two parts: active control voltage and output voltage of piezoelectric sensor. Vibration control is carried out by superimposing two kinds of voltage. When the beam is bent, the piezoelectric sheet of the upper layer will bend along with the beam. The bending center angle is:

$$\Delta\theta = \alpha^{*'}(x_2, t) - \alpha^{*'}(x_1, t) \quad (1)$$

Among them,  $\alpha^*$  refers to the bending deflection, and the position coordinates of the two ends of the piezoelectric sheet are expressed by  $x_1$  and  $x_2$ , respectively. The time parameter is expressed in  $t$ . If the thickness of the piezoelectric plate is neglected, the strain along the length direction of the piezoelectric sensor is as follows:



**Fig. 1.** Models of piezoelectric control suspension system

$$\beta = \frac{h}{c} [a^{*'}(x_2, t) - a^{*'}(x_1, t)] \quad (2)$$

Among them,  $\beta$  refers to the strain of piezoelectric sensor (along the length direction),  $h$  refers to the thickness of 1/2 beam, and  $c$  refers to the length of pressure sensor. According to the piezoelectric equation, the electric pressure of the piezoelectric sensor due to the deformation of the length direction is obtained.

$$V(t) = S_p [a^{\phi'}(x_2, t) - a^{\phi'}(x_1, t)] \quad (3)$$

Among them,  $s_p = \frac{b(2h + \delta_{pe})g_{31}}{2C_s}$ ,  $b$  refers to the beam width, the thickness of piezoelectric sensor is expressed by  $\delta_{pe}$ , the piezoelectric constant  $g_{31}$ , and the capacitance of piezoelectric sensor is expressed by  $C_s$ . When the active control voltage and the piezoelectric sensor voltage are superimposed, the couple moment will be generated in the lower driver:

$$R = bd_{31}E_{pe}(2h + \delta_{pe})/2 \quad (4)$$

Among them,  $u$  refers to the active control voltage acting on the controller,  $H$  is a step function, coefficient:  $R = bd_{31}E_{pe}(2h + \delta_{pe})/2$ ,  $E_{pe}$  is the elastic modulus of piezoelectric sheet,  $d_{31}$  is the piezoelectric constant. The force acting on the piezoelectric control system is as follows:

$$r = \frac{l^3}{EI} R, S = S_p r \quad (5)$$

Among them,  $r = \frac{l^3}{EI} R, S = S_p r$ ,  $I$  is the moment of inertia of the cross section and  $K$  is the proportional coefficient.

### 3 Establishment of State Space Equation

Firstly, the decimal parameter  $\kappa$  is introduced, then the equation is:

$$\ddot{\alpha} + \alpha''' + \frac{1}{2}\kappa \left[ \alpha' \int_1^\xi \int_0^\xi (\dot{\alpha}'^2 + \alpha' \ddot{\alpha}') d\xi d\zeta \right]' + \kappa [\alpha'(\alpha' \alpha'')']' = p(\xi, t) + f(\xi) e^{j\Omega t} \quad (6)$$

Among them, the transverse bending deflection of the beam and the expansion of the control voltage on the beam are as follows:

$$u(t) = \sum_{j=0}^{\infty} K^j u_j(t) \quad (7)$$

$$u(t) = \sum_{j=0}^{\infty} K^j u_j(t) \quad (8)$$

The deflection solutions are obtained by substituting (7) and (8) into equation

$$M(x, t) = R[u + V(t)][H(x - x_1) - H(x - x_2)] \quad (9)$$

### 4 Optimal Control of Linear Equations

The optimal control design of linear equation is based on the optimal controller of state space technology. The linear system of the system model of the beam structure is obtained through the state space [12]. Among them, the purpose of designing the optimal regulator output is to find the vector  $U$  of the optimal control voltage, so as to minimize the quadratic performance index; its objective function is the quadratic function of the control input and the object state.

$$J_j = \frac{1}{2} \int_{t_0}^{t_f} \left[ z_j^T(t) Q_j z_j(t) + u_j^T(t) P_j u_j(t) \right] dt \quad (10)$$

$j = 0, 1, \dots$

The performance index of the optimal control corresponding to the perturbation equation of order  $J$  is expressed by  $J_j$ .  $Q_j$  is used to represent the semi-positive definite state weight matrix corresponding to the perturbation equation of order  $j$ , and  $P_j$  is used to represent the positive definite control input weight matrix corresponding to the perturbation equation of order  $J$ . The initial state time and the final state time are expressed by  $t_0$  and  $t_f$ , respectively.

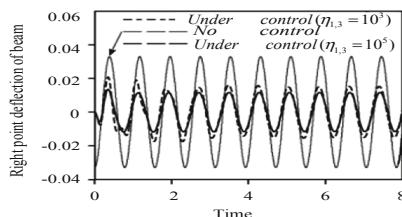
$$Q_J = \eta_j \begin{bmatrix} a_{j1}^2 & 0 & \wedge & 0 \\ 0 & a_{j1}^2 & \wedge & 0 \\ \wedge & \wedge & \wedge & \wedge \\ 0 & a_{j1}^2 & \wedge & 0 \end{bmatrix}, P_j = \gamma_j I \quad (11)$$

Among them,  $\eta_j$  is the adjustment coefficient of the state weight matrix corresponding to the perturbation equation of order  $j$ , and  $\gamma_j$  is the adjustment coefficient of the control input weight matrix corresponding to the perturbation equation of order  $J$ . Specific operation is: under the continuous response of computer simulation closed-loop system, repeated trial calculation can be carried out, when the control requirements of the control system are met, the calculation can be terminated.

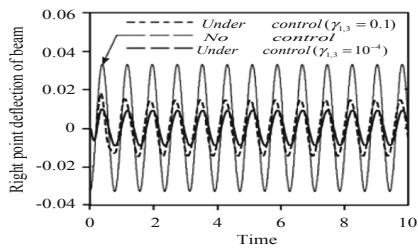
## 5 Examples of Numerical Simulation

A simulation example of piezoelectric cantilever vibration reduction system is designed according to Fig. 1. Material of base beam: aluminium material. Parameters:  $l = 600$  mm,  $b = 20$  mm,  $h = 1.4$  mm,  $E = 60$  GPa, piezoelectric material: PZT piezoelectric ceramics. The parameters of two piezoelectric actuators are  $l_{pe} = 30$  mm,  $\delta_{pe} = 0.2$  mm,  $E_{pe} = 50$  GPa,  $d_{31} = 1.80 \times 10 - 10$  m/V,  $C_s = 36$  pF. The concentrated force acting on the midpoint is expressed by the external load  $F = 39\delta(x - 0.15)$  e jot N.  $x_1$  and  $x_2$  represent the position parameters of the piezoelectric actuator ( $x_1 = 50$  mm,  $x_2 = 250$  mm);  $\kappa$  is a small parameter of the non-linear equation with a numerical value of 0.2.

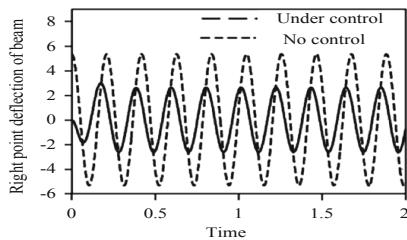
The results of simulation are obtained by two-order perturbation solution. Firstly, the optimal control formula of each order perturbation equation is to take the first and second order modes for the next calculation (the second order perturbation excitation term only takes the first term). Secondly, the steady-state analytical solution is used to calculate the uncontrolled solution, and the Runge-Kutta algorithm is used to calculate the controllable solution. For the sake of concise representation, all physical quantities are dimensionless. The actual displacement value and dimensionless value are calculated by  $x = l\xi$ . The relationship between actual frequency and dimensionless frequency is expressed by  $\alpha = \Omega\sqrt{ml^4/EI}$ . The simulation results are shown in Figs. 2, 3, 4, 5 and 6. By introducing the optimal control  $u_j$ , the vibration reduction amplitude of the beam structure vibration reduction system is well controlled.



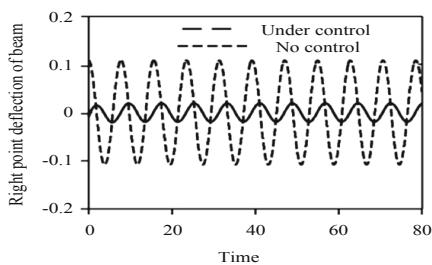
**Fig. 2.** Phase response diagram of endpoint displacement of beam ( $\gamma_1, 3 = 0.2, \Omega = 9$ )



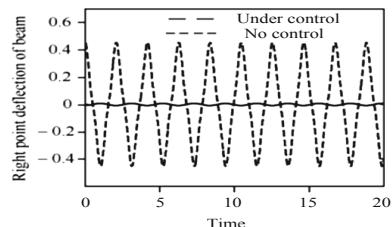
**Fig. 3.** Phase response diagram of endpoint displacement of beam ( $\eta_1, 3 = 0.2$ ,  $\Omega = 9$ )



**Fig. 4.** Displacement response (right end of beam) ( $\eta_1, 3 = 103$ ,  $\gamma_1, 3 = 10 - 4$ ,  $\Omega = 20$ )



**Fig. 5.** Displacement response (right end of beam) ( $\eta_1, 3 = 104$ ,  $\gamma_1, 3 = 10 - 3$ ,  $\Omega = 0.9$ )



**Fig. 6.** Displacement response (right end of beam) ( $\eta_1, 3 = 103$ ,  $\gamma_1, 3 = 10-4$ ,  $\Omega = 4$ )

From the above results, it can be seen that when  $\gamma_j$  and  $\Omega$  are unchanged, the effect of vibration reduction will be enhanced with the increase of  $\eta_j$ ; when  $\eta_j$  and  $\Omega$  are unchanged, the effect of vibration reduction will be weakened with the increase of  $\gamma_j$ ; when  $\gamma_j$  and  $\eta_j$  are unchanged, it can be seen from Figs. 4 to 5 that the vibration reduction system of beam structure not only has a good effect on high-frequency excitation, but also has a good effect on low-frequency excitation. The test results in Fig. 6 show that the system also has a good shock absorption effect for the vibration of the driving force.

## 6 Conclusion

In summary, the parameters of the whole beam structure vibration reduction system are optimized by deducing the formula, and the optimal control effect is obtained. According to the results of the simulation, it is proved that the vibration reduction system of the beam structure can well deal with the excitation of various frequencies.

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# Container Stacking Dispersion Degree and Truck Configuration Under Double Cycling Process

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**Abstract.** The new loading and unloading technology of double cycling is beginning to be used in ports, because it can improve the loading and unloading efficiency at container terminal. However, in the published articles, there is no research on the dispersion degree of stacking and the allocation of trucks. This paper first define the dispersion degree, then proposes a evaluation model, which considered comprehensively the ship's loading and unloading time and the cost of the quay crane, container truck and yard crane. And a simulation model by FlexTerm software is established to simulate a quay crane's working process with different dispersion degree and truck configuration. Finally the experiment shows that the best dispersion is 1 and the number of trucks is 6 for one quay crane in double cycling process.

**Keywords:** Double cycling · Dispersion degree · Truck configuration

## 1 Introduction

When the container terminal conducts quay crane dual cycling, the loading and unloading efficiency is greatly improved and higher requirements are put forward for the operation efficiency of the container yard. However, two factors have to be considered: the first factor is the dispersion degree of container stacking, that is, the number of container stacking in the horizontal direction. When the dispersion degree is small, that is, the stacking number is small, the container truck is easy to be blocked in the critical path during the transportation of containers, which increases the running time of the container truck. On the other hand, the work efficiency of the yard crane has a significant impact on the overall work efficiency. When the dispersion degree is large and the stacking number is large, the single container truck transportation path increases, and more container trucks and yard crane need to be equipped, which increases the cost and time of container ships in loading and unloading operations. The second factor is the number of equipped container trucks. When the number of container trucks is too small, it cannot meet the requirements of loading and unloading and affects the efficiency. However, when equipped with too many trucks, the efficiency of some container trucks is low and the cost is increased. So it is necessary to research the

best match dispersion degree and number of container trucks under double cycle process based on comprehensive trade-off in operation time and operation cost.

The remainder of the paper is organized as follows. In the next section, we review the related research. Section 3 provides a mathematics evaluation model, which is based on the characteristics of the double cycling process. Section 4 carries out simulation experiments and compares various schemes using previous evaluation model. And conclusions are given in Sect. 5.

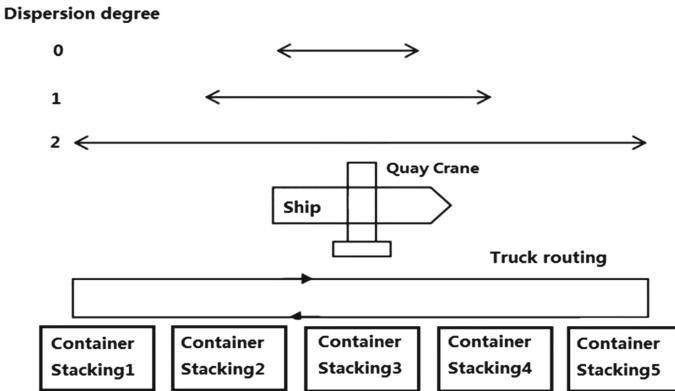
## 2 Literature Review

As to the researches about double cycling, experts and scholars mainly focus on the improvement of demonstration efficiency [1], the optimization of loading and unloading operation sequence [2–4], scheduling and comprehensive optimization [5–7]. Liu Qin et al. proposed the stacking strategy of the same vessel with the same yard-bay position. The exported containers are located at the side of the bay position near the wharf, while the imported containers are located at the rear, which can be found in literature [8]. However, its research focuses on the use of simulation technology to study the selection of equipment in the yard. Zhang Xiaoju, Zeng Qingcheng and Yang Zhongzhen proposed the mixed storage strategy in [9], which was the same as in the literature [8], but their paper focuses on the simultaneous loading and unloading scheduling problem of the same container under the mixed storage strategy. By optimizing the order of loading the export containers, the number of double-cycle operations of the yard cranes is increased. In the literature [10], they focused on the effect of the stacking strategy. The experiment showed that the use of the layout strategy in the double-cycle process greatly shortened the driving distance of the trucks, which reduced the demand of the required trucks and the operation time of the yard cranes by 16% and 26% respectively.

In the published articles, there is no research on the dispersion degree of stacking and the allocation of trucks. Dispersion degree of stacking refers to the straight-line distance between the outputting point of the container yard and the center of the operation point after the ship berths. In particular, outputting point represents the storage location of the container yard. Generally, the center of the ship berthing berth is taken as the operation center. Generally speaking, when the dispersion degree of the container stacking is 0, the import and export containers loaded and unloaded by the ship are stacked in the same container stacking. When the dispersion degree of the container stacking is 1, the import and export containers are distributed in the three adjacent container stacking, and when the dispersion degree of the container stacking is 2, the corresponding containers are distributed in the five adjacent container stacking, as shown in Fig. 1.

## 3 Evaluation Model

First let us define some symbol:  $\alpha$ -weight coefficient of loading and unloading operations time;  $\beta$ -weight coefficient of loading and unloading operations cost;  $\theta$ -the



**Fig. 1.** Dispersion degree of container stacking in the storage yard

dimensionless value of handling time;  $\delta$ -The dimensionless value of handling cost;  $d$ -container dispersion degree ( $d = 1, 2, \dots, D$ );  $T_{di}$ -the total loading and unloading time when the dispersion degree is  $d$  and number of container trucks arranged is  $i$ ;  $F_{di}$ -the total operation cost when the dispersion degree is  $d$  and number of container trucks arranged is  $i$ ;  $F_k, F_i, F_j$ -quay crane, container truck and yard crane expense;  $c_k^1, c_i^1, c_j^1$ -unit time operation cost of quay crane, container truck and yard crane;  $c_k^2, c_i^2, c_j^2$ -unit time waiting cost of quay crane, container truck and yard crane;  $T_k^1, T_i^1, T_j^1$ -operation time of quay crane, container truck and yard crane;  $T_k^2, T_i^2, T_j^2$ -quay crane, container truck and yard crane waiting time.

The objective function is as follows:

$$f = \min(\alpha\theta + \beta\delta) \quad (1)$$

Among them:

$$\theta = \frac{T_{di}}{\max[T_{di}]} \quad (2)$$

$$\delta = \frac{F_{di}}{\max[F_{di}]} \quad (3)$$

$$F_{di} = F_k + F_i + F_j \quad (4)$$

$$F_k = c_k^1 \cdot T_k^1 + c_k^2 \cdot T_k^2 \quad (5)$$

$$F_i = \sum_{i=1}^I (c_i^1 \cdot T_i^1 + c_i^2 \cdot T_i^2) \quad (6)$$

$$F_j = \sum_{j=1}^J (c_j^1 \cdot T_j^1 + c_j^2 \cdot T_j^2) \quad (7)$$

$$\alpha + \beta = 1 \quad (8)$$

(1) is the objective function, and represents the minimum value weighted sum of the ship's loading and unloading time and the cost of the quay crane, container truck and yard crane after dimensionless; (2) and (3) represent the dimensionless handling time and cost; (4) means under the condition of dispersion degree is d, container truck number is i, the total cost of container loading and unloading is equal to the sum cost of quay-crane operation, container truck operation and yard crane operation; (5) means that the cost of quay crane is equal to the sum of the operation cost per unit time of quay crane times the quay crane's operation time and the waiting cost per unit time of quay crane times the quay crane's waiting time; (6) means that the cost of container truck is equal to the sum of the operation cost per unit time of container truck times the container truck's operation time and the waiting cost per unit time of container truck times the container truck's waiting time; (7) means that the cost of yard crane is equal to the sum of the operation cost per unit time of yard crane times the yard crane's operation time and the waiting cost per unit time of yard crane times the yard crane's waiting time; (8) is the weight coefficient constraint of operation time and the cost, the sum of them is 1.

## 4 Case Study

Using Flexterm software version 2.7.0 to build the simulation model for the different dispersity of container stacking and the number of trucks. Relevant parameters are set as follows:

- (1) the berthing time of the ship is 45 min, preparation time is 10 min;
- (2) the speed of quay crane is 2 m/s at the front of wharf, and the average handling speed of container is 40 move/h, i.e. the average time of loading and unloading is 1.5 min/move, and the specific handling efficiency obeys the irregular distribution of trigonometric function.
- (3) a container stacking in the container yard contains 30 shells, and the stacking height is 4 layers. The moving speed of the yard crane is 3 m/s, and the average handling speed of the container is 25 move/h, that is, the average time of loading and unloading is 2.4 min/move, and the specific handling efficiency obeys the irregular distribution of the trigonometric function.
- (4) the operation speed of the truck collector in the model is 5 m/s, ignoring the speed change in the process of starting and decelerating.
- (5) The number of containers to be loaded and unloaded in the model is 300.

By referring to relevant literature and the field research on the container terminal, the unit time work and waiting costs of the quay crane, yard crane, container truck are shown in Table 1.

**Table 1.** Quay crane, yard crane container truck work and waiting unit time cost

	Trucks	Quay cranes	Yard crane
Work cost per unit time (RMB/hour)	99.1	504.2	189.3
Wait cost per unit time (RMB/hour)	81.1	304.2	129.3

It is set that the container terminal attaches equal importance to the loading and unloading time and the cost, so the value of  $\alpha$  and  $\beta$  is 0.5. The value of objective function of the scheme with different trucks quantity when the dispersion degree is 0, 1 and 2 are shown in Table 2.

**Table 2.** Values of objective function with different degrees of dispersion and number of trucks

Dispersion degree	Trucks quantity		
	0	1	2
1	0.630	0.924	0.965
2	0.320	0.511	0.531
3	0.272	0.356	0.312
4	0.275	0.286	0.297
5	0.292	0.276	0.299
6	—	0.271	0.297
7	—	0.279	0.304
8	—	0.286	0.311
9	—	0.293	0.318

When the dispersion degree is 0, the optimal number of trucks equipped is 3, and The value of target function is 0.272; when the dispersion degree is 1 and 2, the optimal number of trucks is 6, and the objective function is 0.271 and 0.297 respectively. Therefore, under the condition of synchronous loading and unloading with shellfish, the optimal distribution dispersion degree of container stacking in the container yard is 1, and the optimal number of collector trucks is 6.

## 5 Conclusions

In this paper, FlexTerm software is used to establish the simulation model. The operational data of the relevant mechanical equipment obtained by running model, were substituted into the evaluation model established in the third part, then evaluated the best match dispersion degree and number of trucks. From the results of the experiment, the best combination is one quay crane, the corresponding dispersion is 1, and the number of trucks is 6 in double cycling process at the container terminal.

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# **Technical Tracks 3: Cloud Computing, Big Data, The Internet of Things, and Their System Intelligence**



# Construction of Chinese Interlanguage Corpus in the Era of Big Data

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**Abstract.** Under the background of the new era, Chinese language teaching has attracted much attention. Among them, the development of Chinese international education is faster and faster. Few teachers and students stand in a macro perspective, based on the actual conditions of Chinese International Education and teaching, and conduct in-depth analysis and Research on the current situation and form of teaching in this field. The knowledge of Chinese interlanguage corpus is seriously lacking.

Although our country has built a domestic interlanguage corpus, most of the knowledge and content have some obstacles and difficulties in application, and there is a certain gap between the quality and level of the substance and the objectives of the previous work. It is difficult to conduct comprehensive analysis and research from an interdisciplinary perspective, which provides a certain basis for the construction of learners' historical corpus.

Compared with other corpora, the construction of interlanguage corpora is more complex and diverse, with obvious nonlinear and dynamic characteristics. In the process of practical operation, every staff member needs to combine theoretical analysis with practical research to understand the essential requirements of the construction of Chinese interlanguage corpus under the background of big data era. It is also necessary to build a perfect management system based on different working principles such as historicity, universality, authenticity, barrier free sharing in and out of class, interdisciplinary and all media.

**Keywords:** Big data era · Chinese interlanguage · Corpus construction

## 1 Introduction

The content and form involved in the construction of Chinese interlanguage corpus are relatively complex, among which the selection of the content is the most important. Only to ensure the scientificity, rationality and reliability of the content of the article can we build a perfect Chinese interlanguage corpus.

At present, under the background of big data era, the development of Chinese International Education in our country is faster and faster. How to realize the perfect integration between classroom teaching and students' teaching content is an important issue to be considered in the education field. In order to improve the quality and efficiency of teaching and realize the optimal allocation and utilization of educational resources, many schools have begun to make full use of modern multimedia teaching

tools to constantly reflect the comprehensive soft power of our country, among which the application of new technology has attracted much attention. In the process of globalization, the content and form of Chinese international education have changed to some extent [1].

The current research conclusions do not meet the requirements of the development of the times. At the same time, it is difficult to provide more support and basis for the real Chinese intermediary corpus. Chinese international education faces many difficulties and obstacles in the process of practical operation, which cannot guarantee education. The adequacy and effectiveness of resources, the quality and level of classroom teaching are not optimistic [2].

## 2 Problems in Chinese Interlanguage Corpus

The construction of Chinese interlanguage corpus is a long-term process, which can not be accomplished overnight. The existing research model and theory can not lay a solid theoretical foundation for the implementation of this work, so it is difficult to avoid many problems and obstacles [3]. In addition, most of the interlanguage corpora are mainly based on the study of the second language, lack of real and reliable data sources, and can only take the simple records of speech products as the main body, which can not achieve the successful application of the research content form of the second language corpus. Among them, the rational design of the raw material database is particularly critical. The academic and theoretical circles take big data as the analysis object and focus, and deeply interpret the problems existing in the construction process of Chinese interlanguage corpus, including the following points [4].

### 2.1 Lack of High-Quality and Authentic Spoken Language Corpus Resources

The key to the effective transmission and expression of real corpus is the core and focus of the construction of spoken corpus. Many academic circles have built a systematic and perfect interlanguage corpus. Most of the corpus content can be uploaded by themselves and shared free of charge, but other spoken corpus is difficult to play its due role and advantages [5]. At the same time, the content of the material is insufficient and the scale is relatively small, which is difficult to meet the research requirements of teachers. In addition, the scope of the study is relatively limited. It is directly based on the analysis of the literal meaning of words, and lacks the real and objective video corpus and non-verbal behavior records. Therefore, it is unable to point out the way and direction for the later education guidance and theoretical research.

### 2.2 Lack of Interdisciplinary Perspective in Corpus Construction

Interdisciplinary research is the principle of corpus construction. At present, corpus construction lacks certain theoretical basis and core. Pedagogy, communication, culture, psychology, sociology and other knowledge play a key role in the construction of Chinese interlanguage corpus. The content of written language corpus materials is

relatively simple, and there is no in-depth interpretation of multiple communicative competence, one-way communicative competence, educational background and social identity. Therefore, it is difficult to avoid the impact of external uncertainty factors, and can not better reflect the internal logical relationship between interdisciplinary and guidance value. The quality of Chinese interlanguage corpus construction is not optimistic, which leads to the waste of some research resources.

### 2.3 Limitations of Data Sources

First of all, under the background of big data age, the content and external environment of the construction of Chinese interlanguage corpus are very complex, and the number of real corpus is low, only the Chinese and learners' oral corpus sponsored by Beijing Language and Culture University. Secondly, from a more macro point of view, the comprehensive construction of corpus is relatively small, which is directly based on the collection of oral answers, most of which involve some composition answers at the same time. This kind of small-scale interlanguage corpus can not provide guidance for later education and teaching, and it is difficult to reflect the learning conditions and characteristics of different stages and different learners. Finally, in the process of constructing the corpus of Chinese interlanguage, Asian scholars are the main body of the corpus, which does not involve the substantive corpus and specific content of other countries' Chinese learning languages, so it is difficult to better reflect the depth and guiding value of this study [6].

### 2.4 Lack of History Corpus Course for Building Learners

Historical corpus takes the study of historical stages as the starting point and starting point to describe the language learning situation of different scholars in different stages. Corpus can provide some basis and guidance for this research. For the dynamic composition corpus, most of them are based on the income of composition papers. Meanwhile, the Chinese level of the students participating in the examination is relatively high, and the number of existing corpus is relatively limited, so it is difficult to focus on the specific characteristics and development laws of the language, so the guidance and value are very limited.

## 3 Characteristics of Chinese Interlanguage Corpus in the Era of Big Data

In the process of constructing interlanguage corpus, participants need to understand the essence and concept of the system construction, extract its characteristics and advantages, so as to be more targeted. In the process of language communication, big data is mainly based on the study of complete language communication, of which the construction of interlanguage corpus and Chinese sentences is the most important. Big data can break through the limitation of time and space. Large quantity, high speed and uncertainty are the important characteristics of big data. If Chinese interlanguage corpus is built on this basis, learners must take the corpus learning analysis of different

stages and different historical periods as the basis and premise. Social network and Web text data collection is the most important [7]. Although the essential rules are relatively simple, some are systematic, some are overlapping, but most of them are the result of causality, so the analysis of language environment and development stage is particularly critical.

In the era of big data, the construction of Chinese interlanguage corpus has the characteristics of non-linear and complex dynamics. The key variables in the construction of Chinese interlanguage corpus are the social background corpus, the language elements, the cultural background education, the multiple communication ability, the religious belief and the educational background. In the analysis and research of these variables, it is necessary to build a relatively complete network word organization system, understand the internal and external relations between different factors, and analyze the correlation between indirect and direct relations [4]. As an important channel of information input, vision and hearing are the most important. In addition, taste, smell and touch may also produce certain information input.

Therefore, in the process of building a corpus of Chinese interlanguage, we must pay attention to the mobilization of multiple senses, understand the dynamic process of language communication, analyze the substantial changes of concepts, and build a perfect perceptual system. Among them, the world's senses are the core and focus. In the process of communication and interaction with the environment, personal sensory mobilization is particularly critical to language acquisition [8]. Before understanding external information, a certain sense will play a core role, and vision is often the most critical. Vision can effectively break through the shortcomings of language expression and pay attention to the real state in the process of information input. When different senses are in different positions, first of all, they need to replay repeatedly, pay attention to the speaker and the substantive requirements of spoken language, actively respond to the participants, understand the communicative intention of the communicator, and better reflect the communication mode and process between them.

## 4 The Construction of Chinese Interlanguage Corpus in the Era of Big Data

Under the background of big data era, the content and form of the construction of Chinese interlanguage corpus have changed to some extent. In order to ensure the quality and efficiency of the construction, we need to adhere to certain principles of construction. The first principle is the word network technology, which is mainly based on the thinking not included in the traditional vocabulary, specifically involving the existing network of network vocabulary, catchwords, network terms, network languages and different network words. Through the in-depth analysis of the connotation and shape of different words and the study of simple mining and analysis of Chinese keywords, make full use of keyword analysis and mining function to achieve effective definition and ensure the rationality of Chinese corpus construction. In addition, for the construction of Chinese interlanguage corpus, keyword mining website, trend keyword, comparative keyword and related keyword are the most important components. Learners can make full use of modern tools to achieve efficient construction and

research, so as to achieve targeted and ensure the optimal allocation and utilization of construction resources [9]. In addition, the research in the field of corpus and second language acquisition is also very important. Every participant must understand the variable factors of learners' language and the negative effects of psycholinguistic factors and situations, actively realize the organic combination of different texts, fully reflect the characteristics of social linguistics and the core requirements of Chinese Interlanguage Corpus design [10].

The nonlinear finite feature is also an important feature of the construction of interlanguage corpus, which will directly affect the different variables of the construction of interlanguage corpus. From the above correlation analysis, we can see that in the process of building this corpus, most of the variables are relatively complex, at the same time, it is not a simple superposition as the main body, but interaction and common influence, showing a dynamic interaction [11]. The corpus data does not need to be prioritized and prioritized as the main body, but focuses on the essence of language observation, analyzes the real conditions in public and private occasions, and pays attention to various abnormal changes and natural environment. Among them, modern teaching equipment, teaching resources, cultural environment, social environment and natural environment will have a certain impact on the contribution of corpus. In addition, there are many unpredictability and randomness in learners' learning psychology and learning state [12]. In the process of realizing the balanced development of different variables, we need to understand the essential causes of various behavior mutations and analyze the important influence of individual behavior. At present, some scholars take the survey of corpus contributors and learners' comprehensive situation as the main body to analyze the motivation, learning ability, language level, age characteristics and learning needs of corpus contributors, which can better promote the efficient construction of Chinese language intermediary in corpus under the background of big data era [13].

## 5 Conclusion

If the corpus is built on the basis of big data thinking, it is necessary to understand the shortcomings brought by traditional concepts, constantly challenge the current construction methods and concepts, deeply analyze and study the scale, quantity and depth of the corpus, and better reflect the role and characteristics of this information technology through the rational application of big data To ensure the stable construction and development of international Chinese education.

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# High-Quality Development of Tourism Industry Under the Trend of Cultural and Tourism Integration Based on Big Data Analysis

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**Abstract.** The era of big data makes it inevitable for the traditional tourism industry to integrate cultural and tourism, and at the same time, it also provides new momentum and infinite possibilities for the high-quality development of the tourism industry. First of all, applying big data to the cultural and tourism industry can solve some problems in the cultural and tourism industry, such as: resources are hard to replace, experience is hard to copy, demand is hard to predict, etc. It is also possible to reconstruct the supply chain and ecology of cultural tourism industry, so that cultural tourism resources can be fully developed and a new world of cultural tourism development can be explored. Secondly, the inclusion of big data in the cultural tourism industry will make the integrated innovation and development of cultural tourism more promising and more favored by tourists. Finally, cultural tourism integration should give full play to the advantages of big data, and combine local development characteristics and local customs to build a platform where “culture speaks for itself”. With the combination of science and technology elements, accurately depict the user portrait of tourists, comprehensively understand the real needs of tourists, and then combine the tourists’ interests with product development and profits, so as to expand and strengthen the cultural tourism industry, and thereby improve the high-quality development of tourism. This paper mainly USES content analysis method and data visualization method to discuss and analyze the integration trend of culture and tourism, hoping to promote the high-quality development of tourism industry.

**Keywords:** Big data · Integration of culture and tourism · Content analysis method · Tourism industry

## 1 Introduction

In the 40 years since the reform and opening up in 1978, China’s tourism industry has made great progress from the unilateral focus on inbound tourism, to the simultaneous development of inbound tourism and domestic tourism, to the three pillars of domestic tourism, inbound tourism and outbound tourism [1, 2]. According to statistics, the number of inbound tourists in 2017 was 139 million, 77 times that of 1978. Domestic

tourists reached 5 billion person-times, 14.5 times that of 1991 [3]. In 2017, the number of outbound tourists reached 129 million, and the outbound tourism consumption reached \$115.29 billion [4]. These data show that people pay more and more attention to traveling and expect to relax and feel happy during the trip. How to improve the high-quality and innovative development of tourism is the problem we need to solve now [5]. In recent years, the country has made great efforts to develop the cultural industry and accelerated the integration of cultural industry and tourism industry, and the cultural tourism industry has achieved good development results [6].

With the development of China's tourism industry from sightseeing to in-depth tourism, the consumption structure of tourists is constantly changing and their consumption demands are becoming more and more diversified [7]. In this context, the tourism industry needs to continuously integrate with cultural elements, science and technology in a deeper degree, in order to continuously meet tourists' demands for in-depth tourism and experience tourism [8]. As is known to all, the integration and development of cultural tourism industry and big data has become an important means to promote the upgrading, functional restructuring and value innovation of traditional culture and tourism industry [9]. The development of cultural and tourism industry has three main backgrounds: first, tourism has become the normal and rigid demand of life. With the reform and opening up, the major contradiction in China has changed fundamentally, which urges us to better meet the people's increasing needs in all aspects, and tourism's comprehensive contribution to GDP increases year by year. Second, the integration of culture and tourism opens a new era of tourism. In March 2018, the Ministry of Culture and Tourism was officially launched, highlighting the cultural attributes of tourism. Third, the macro-economy is complex and severe. Especially in 2018, China's economic development is faced with many difficulties, such as the impact of economic periodicity and structural changes, and increased uncertainties in the international environment. By 2019, the uncertainties of domestic and foreign economic development will be even higher [10]. The three backgrounds also reflect that the integration of culture and tourism needs to be combined with big data in order to achieve better innovative development and provide strong support for China's economic development [11]. At present, there are still many problems in the development of China's tourism, especially on the supply side. The only way to promote the transformation of tourism development is to launch distinctive and high-quality cultural and tourism products from the supply side [12, 13].

In this paper, combining with related data analysis the tour industry trend of the development of tourism, using the method of content analysis and data visualization to deep analysis of the data, find the tourists pay most attention to what aspects of the tour industry, to find out the related factors to promote the development of tourism industry with high quality, provide feasible Suggestions for the development of the tourism industry of high quality [14, 15].

## 2 Method

### 2.1 Content Analysis

Content analysis method, also known as text analysis method, is an objective and systematic quantitative description of scattered explicit content or literature. This method has three characteristics: first, systematic. That is to say, unified or systematic standards should be adopted to choose and reject the content to ensure the consistency of the analyzed content, and the analysis method should not be changed at will. Second, objectivity. That is, the analysis must be carried out according to clearly established rules, which means that different people can get the same information from the same thing. Third, quantitative, refers to the use of statistical methods to calculate the frequency of the occurrence of related words and the frequency of calculation, and the use of Numbers or charts to show the results of our statistics and calculation.

In this paper, first of all, the review data of tourists were collected from ctrip. After relevant processing of the data, the content analysis method was used to analyze the data. In this paper, ROSTCM6 is mainly used for data preprocessing and word frequency statistical analysis, and the words with higher occurrence frequency are classified and analyzed. The classified analysis is mainly based on the factors that affect the high-quality development of tourism industry. This study mainly divides the high-frequency words into three categories: public service, science and technology and ecological environment. The classified analysis will help us find the information that can best support the study in this paper, and finally explain the information to get the important factors that affect the high-quality development of tourism industry under the trend of cultural and tourism integration.

### 2.2 Data Visualization

Data visualization is the process of converting our data into appropriate visualizations and then presenting information that might be hidden in the data directly to people. The advantages of data visualization are as follows: first, the visualization has various forms, which can present the data in a more intuitive way and make the data more objective and convincing. Second, the combination of data visualization and data analysis provides convenience for users. Third, data visualization has diversity and powerful expressiveness, which helps us understand information and dig out deep information.

In this paper, the processed data are visualized and analyzed, mainly in the form of combined charts, so that the data can be presented more intuitively, and the data can be understood more conveniently and intuitively, and meanwhile, the credibility of the research in this paper is enhanced. Using the histogram and linear combination chart way figure together, main said word frequency histogram, the linear graph mainly said the words appear frequency as a percentage of the frequency of all words, in the composite chart we can see each word clearly appears the frequency and the corresponding proportion, which can determine the focus of tourists on tourism, from these concerns to specific analysis factors to promote the development of tourism industry

with high quality. The data visualization method can reduce the burden of our research and provide reliable information support.

### 3 Experiment

With a high degree of freedom and little interference from external factors, online speech is highly authentic, time-efficient and abundant, which provides a large amount of data support for researches in related fields of tourism. In this paper, the crawler software (octopus) is finally used to crawl 150 pieces of data from ctrip, which will be taken as the original data of the experiment. The criteria were: comments or travel notes in the last three years; Clear point of view, relatively complete process, there is more comprehensive information; Words with strong emotions, a strong desire to pour out, express the travel experience.

First, copy and paste the selected text content into notepad and save it in “. TXT” format, so as to facilitate the subsequent use of word frequency analysis software to process it. Secondly, the use of ROSTCM6 software file “. TXT” word segmentation processing, get the file “. TXT - word segmentation”. Again, ROSTCM6 software was used to conduct text processing on the newly generated files, delete meaningless words like “one belt”, “one road” and “we”, and add these unnecessary words to the filter word list. The next step is the classification of synonyms. The freedom of online text writing is very high. Due to the tourists’ own writing habits, special spoken expressions and the use of some online expressions, it is necessary to integrate and process words with the same meaning. ROSTCM6 text replacement and supplement tool is used to unify words with the same semantic meaning into one word, such as “beautiful” and “good-looking” into “beautiful”, which can improve the accuracy of word frequency analysis. Finally, data visualization platform is used to visualize the processed data, and the results of high-frequency vocabulary analysis are obtained.

### 4 Discussion

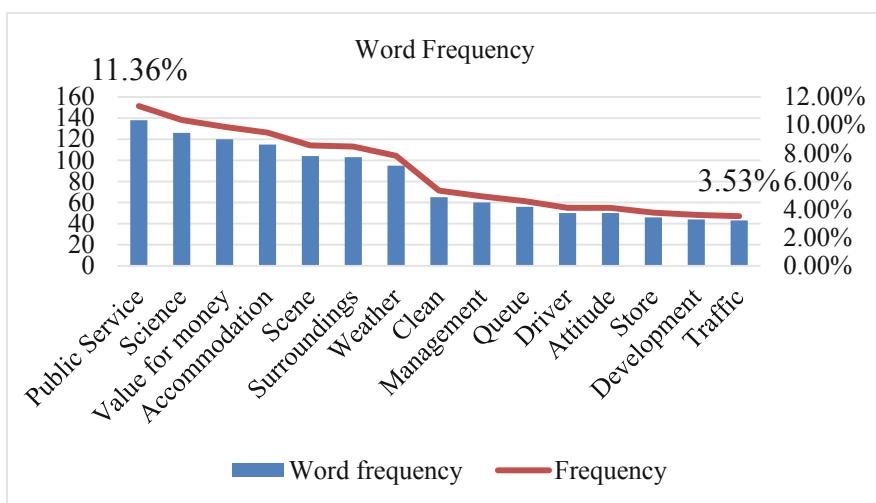
#### 4.1 Experimental Results

The high-frequency words in the network text can objectively reflect the tourists’ direct impression on the tourist destination. They represent the things that tourists pay most attention to in the process of travel and are also the image card of the tourist destination. By using ROSTCM6 software to analyze high-frequency words in preprocessed documents, 212 meaningful words were obtained with a vocabulary frequency of 500, and 20 typical high-frequency words were screened. The analysis results of high-frequency words are shown in Table 1. Meanwhile, the first 15 high-frequency words are selected for word frequency analysis, as shown in Fig. 1.

As can be seen from Table 1 and Fig. 1, tourists are most concerned about public services, technological integration and ecological environment. Strengthening the construction of public cultural service system can promote the high-quality development of public cultural services, meet the requirements of the continuous improvement

**Table 1.** High frequency characteristic words

High frequency word	Word frequency	High frequency word	Word frequency
Public service	138	Charge	40
Science	126	Green	39
Value for money	120	Rubbish	38
Accommodation	115	Localize	35
Scene	104	Fun	30
Surroundings	103	Time	30
Weather	95	Temperature	25
Clean	65	Almost	20
Management	60	Regret	15
Queue	56	Bus	14
Driver	50	Light breeze	10
Attitude	50	Lucky	8
Store	46	Feature	6
Development	44	Problem	6
Traffic	43	Air	6

**Fig. 1.** Vocabulary frequency distribution

of mass cultural consumption quality, and enhance people's sense of happiness and acquisition, and enhance cultural confidence. The degree of integration of science and technology refers to the integration of culture and tourism industry with science and technology. Whether it is combined with AR, VR and other technologies to increase tourists' experience, mobility, depth and quality. Ecological environment refers to the surrounding environment, smell and temperature of the tourism industry base, which directly affects the willingness of tourists to travel.

## 4.2 Analysis of Influencing Factors and Countermeasures

From Sect. 4.1, we can learn that the three main factors that affect the development of tourism are the construction of public cultural services, the application of science and technology, and the ecological environment of cultural tourism industry base.

### (1) Strengthening public cultural services

We can improve the breadth and depth of the construction of public cultural service system and the quality of public cultural service from three dimensions: first, we can enhance the tourism service functions of public service facilities such as museums, memorial halls, art galleries and cultural centers (hereinafter referred to as “four museums”), so as to provide more high-quality cultural experience places for the public. Second, strengthen the application of science and technology in public cultural services, enhance the level of wisdom and experience of public culture, and improve the utilization rate of public cultural services. Third, with the integration of cultural and tourism as the driving force, we will drive the development of grassroots cultural personnel and cultural undertakings in ethnic minority areas.

### (2) Strengthen the application of science and technology in cultural and tourism industry

We will strengthen the application of the Internet, mobile Internet and digital technologies in cultural and tourism industry bases and institutions, and raise the level of digitalization and intelligentization of the cultural and tourism industry. For example, the construction of our country's tourism archives. Digitalization can not only better preserve the immediate state of cultural relics, but also make more cultural relics that are not convenient for regular exhibition to be perceived and understood by the public in various forms such as pictures, video and texts, so as to improve the cultural transmission value of cultural relics. The application of science and technology in cultural tourism industry can not only improve the online reservation function of cultural facilities and places and facilitate the cultural consumption behavior of the public, but also need to make use of AR, VR and other technologies to design the content of online and offline cultural experience, so that culture can be more accessible and perceived, instead of being “cold”.

### (3) Protect the ecological environment of cultural tourism industry base

The sustainable development of tourism is inseparable from a good ecological environment. The carrying capacity of ecological environment determines the sustainable development of tourism to a large extent. It is extremely urgent to protect the ecological environment of cultural tourism industry base. To protect the ecological environment of cultural tourism industry base, we can start from the following three aspects: first, to enhance the environmental protection awareness of tourists and residents; second, to do a good job in environmental protection of cultural tourism industry base by setting up more trash cans or environmental protection signs; third, to strengthen the punishment of environmental damage. Protecting the ecological environment of cultural tourism industry base can not only increase the number of tourists in cultural tourism base and promote the high-quality development of tourism, but also contribute to the construction of resource-conserving and environment-friendly society.

## 5 Conclusion

In the era of big data, to promote the tourism development under the trend of integrating culture and tourism, it is not only necessary to combine scientific and technological means to improve tourists' travel experience, but also to strengthen the construction of public cultural services in the tourism industry base, and to pay more attention to the construction of ecological environment around the tourism industry base. We should pay attention to the recycling and treatment of garbage, strengthen environmental education, and improve the environmental protection awareness of residents and tourists. Efforts should be made to build a green and environmentally friendly civilized environment and bring people better travel experience, so as to promote the high-quality and innovative development of China's tourism industry and strive to make the cultural tourism industry bigger and stronger.

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# Distribution Information Sharing of Agricultural Products Supply-Chain in Big Data Environment

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**Abstract.** China has vigorously promoted the integration of agricultural products Supply-Chain (SC), developed online and offline agricultural products models by using Internet technology, and effectively improved the management level and circulation efficiency of fresh agricultural products SC in combination with the development. In the report of the 19th National Congress of the Communist Party of China on the implementation of the strategy of rural revitalization, it is proposed to “improve the service system of agricultural socialization and realize the organic connection between small farmers and the development of modern agriculture”. China put forward the action guide for solving this contradiction, taking the deep integration of SC, Internet and Internet of things as the path, network sharing and intelligent cooperation, and promoting the structural reform of the supply side of agricultural and rural areas. The aim of this paper is to explore the research on the distribution information sharing of agricultural products SC, so as to cause different thinking in the integration of big data with agriculture and SC. In this paper, we will use the research method of specific analysis to compare the data and come to a conclusion. The results of this study show that SC is an organizational form which is oriented to meet the personalized needs of customers, aims to improve quality and efficiency, integrates external resources, and realizes efficient collaboration in the whole process of products. In the context of economic, the practical application ability of big data is constantly improved, and higher hopes and objectives for agricultural product SC are put forward.

**Keywords:** Big data · Agricultural products · Network sharing · Supply-Chain

## 1 Introduction

The SC of agricultural products takes agricultural products as the medium of SC, through systematically grasping the logistics and business flow in the SC, from the resource procurement, production and processing to the final consumption process of agricultural products, and integrates the connected network chain structure [1–3]. As a new economic model, sharing economy refers to a form in which the owners of goods temporarily exchange the right to use idle resources to strangers. Its core and essence is the integration of offline idle resources [4].

We have entered the era of modern enterprises will produce large quantities of data in any link of the business process. If these massive data can be timely and accurately classified and reasonably used in the process of online marketing, the effect of enterprise online marketing can be significantly improved [5, 6]. E-commerce enterprises can use big-data and Internet platform to analyze the consumption habits, historical browsing and purchasing records, personal preferences, personal information of associated customers and potential customers in detail, and conduct in-depth mining [7]. Predict the future market development direction and deeply understand the real needs of customers, so as to carry out precise marketing and personalized recommendation for customers with different needs [8]. Different from the traditional business model, the operating subject of the sharing economy does not own trading goods and services. It operates completely in the mode of asset light and disintermediates in the form of asset light. In the sharing economy, everyone is the organization, mainly in the form of P2P. The existing research mainly focuses on the promotion and application of intangible resources sharing in the SC, while the most important field of tangible resources in the sharing economy is rarely discussed [9–11]. Generally speaking, there are few researches on the combination of SC and big-data, and only a few of them stay at the theoretical level. There is no literature about big data as a big environment to consider its impact on the specific issues of SC. On the basis of combing the current situation, this paper compares the development of domestic and foreign agricultural product SC sharing, and puts forward a new sharing agricultural product SC model [12].

With the continuous achievements of China's reform and opening up, the economy is booming, and people's living standards are also increasing. From the initial focus on quantity to meet food and clothing to the focus on quality and safety to pursue health, from the focus on a few types of agricultural products to the focus on multi-level, multi-standard differentiated agricultural products [13–15]. This research enriches the results can provide scientific decision-making theoretical methods.

## 2 Method

### 2.1 Core Concepts

#### (1) Big data

In today's information age, data, as the basic resource of people's communication, naturally becomes the source of people's cultural value. Big data is firstly collected in a wide and diversified way, and then distributed computing architecture is adopted to conduct data processing and integration analysis. A large number of high-speed, diverse and valuable features of big-data have emerged. In the virtual network world, we extract valuable information from a large amount, and then extract its value from effective information. Big-data is mainly used in all aspects today by its users' accurate positioning for the required information groups, point-to-point accurate services, and understanding the preferences of target customers and habits of high-quality marketing. Although it has experienced suspicion and criticism in the process of using, it was

accepted by the public and survived in the cruel Internet competition, and it is getting better and better, bringing considerable benefits to enterprises.

## (2) Agricultural product SC

SC is the concentrated embodiment of the integration of the current economic model, which links agricultural producers, distributors and end consumers into a whole functional network structure. Around the core enterprises, from the place where the materials are produced to the intermediate semi-finished products to the final products, the products are finally delivered to the consumers through transportation, storage, distribution, sales, etc., and the whole industry is combined by using the circulation route of goods and integrating transportation resources.

## 2.2 Research Methods

The first is literature research. Through reading the relevant literature, the specific content of SC change and the changes it brings to information sharing. Through the research and collation of a large number of relevant references at home and abroad, the importance and necessity of studying SC information sharing under a new background of the era of big-data are fully recognized, which is the cornerstone of the paper research. Based on the comparative analysis of the existing mode of information sharing, the existing problems of the mode are summarized. On this basis, a new mode adapted to the new environment is constructed, and the composition of the mode is described in detail. In this industrial chain, different types of enterprises will be affected by upstream and downstream enterprises to different degrees. When upstream enterprises choose to share or not to share information, the benefits are as follows:

$$E_a^X = y(\pi_1 + \pi_2 \beta_2 \gamma_2) + (1 - y)(\pi_1 - C_1) \quad (1)$$

$$E_a^{(1-x)} = y\pi_1 + (1 - y)\pi_1 = \pi_1 \quad (2)$$

Among them, set the sharing variable x, not sharing as (1-x), according to the game between the two sides, the average interest rate difference of downstream enterprises is 12%. The third is quantitative research. When analyzing the benefits of SC information sharing for enterprise inventory level, total cost and satisfaction rate under big data environment, set up relevant variables and parameters, build mathematical model, and conduct quantitative research and analysis with mathematical methods.

## 3 Experiment

### 3.1 Experimental Data Source

In this study, 150 agricultural products processing companies were randomly selected for investigation. These companies are located in different regions, different product types and different levels of enterprises. The selection of these research objects is mainly based on the factors of company development level, combination of technology

application, cooperation at home and abroad and economic factors. The comprehensive consideration of these factors is conducive to the representativeness and typicality of experimental data.

### 3.2 Experiment Implementation

Compared with foreign countries that implement the SC of agricultural products better, there is still a certain gap in China, mainly because of the differences in the organization of agricultural production and operation and the organization form of industrial chain. In the course of investigation, it is found that the geographical advantage of the plain makes most of the developed countries produce in a centralized way, and the production bases are equipped with professional processing lines, which can effectively integrate and maximize the SC resources. But our country has always been based on the family decentralized management, the efficiency is relatively low, through the development of recent years, gradually to the direction of intensive and professional development. Through literature review, we know that foreign market economy is developed, there is a complete system of production and sales, but the system construction of our country is not complete. Through the comparison, it is found that the good policy environment support of foreign countries provides an effective guarantee for the further development of its agricultural product SC. At present, China is in the process of catching up. Recently, foreign consulting companies revealed in their investigation reports that most enterprises have great expectations, but in fact, many enterprises have difficulties in the application process. 97% of executives reported that they fully realized the benefits to their SC, but only 17% announced that they had implemented big-data analysis in one or more SC functional modules.

## 4 Discussion

### 4.1 Data Visualization

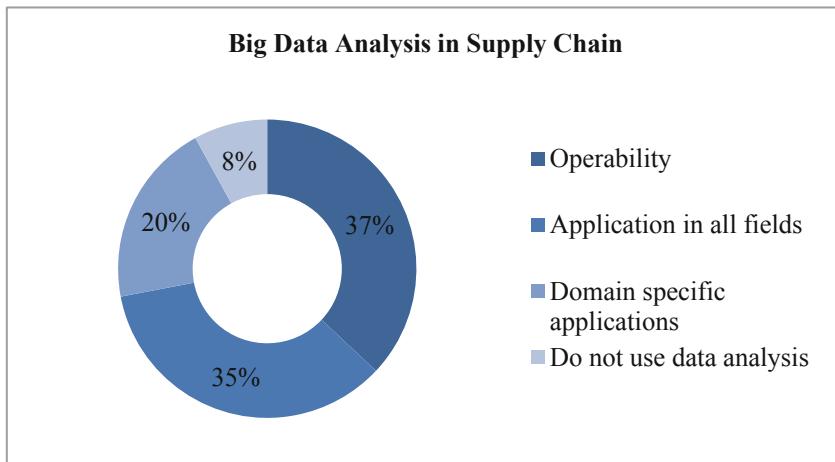
In the questionnaire survey, a total of 100 questionnaires were sent out, 85 of which were recovered, 82 of which were valid, the effective recovery rate was 82%, and the experimental results were valid. The basic information of the respondents is shown in Table 1.

**Table 1.** Shared resources of agricultural product SC

Link	Content	Shareable intangible resources	Shareable tangible resources	Application rate
Upper reaches	Plant	Technology, information	Equipment, plant, machine and vehicle	25%
Middle reaches	Processing and manufacturing	Production process		40%
Downstream	Circulation link	Product, channel and market		32%

## 4.2 Analysis and Discussion

One of the challenges of SC in big data environment is storage. In the big data environment, the data grows explosively every day. It is very difficult for the traditional enterprise database to store such a large amount of complex data. Even if it can barely be stored, the speed of access and operation is also worrying. The emergence of cloud computing in big data environment solves this big problem for enterprises. Cloud computing provides powerful tools and ways, necessary storage space and access channels for big data. With the tide of big data, many enterprises use big data related services to make profits. IBM, HP and other enterprises providing software and solution services seize the development potential of big data and provide many related services by using big data. As the third-party software provider of big data information sharing platform, these enterprises can not only trust in hardware equipment, but also trust in management and service level. Big data information sharing platform is the core of information sharing mode. It includes network security layer, data transformation layer, cloud storage layer and service layer. The network security layer mainly includes unified authentication system and monitoring system. Unified authentication system is an access control system based on role assignment. The data conversion layer is mainly to extract the relevant data in the database and transform the data information model constructed in the previous section into useful information that can be understood for the access of users with relevant permissions. Cloud storage layer is mainly used to store huge amount of data, which includes three big databases: shared information database, consumer database based on big data analysis. The service layer mainly provides evaluation services, personalized services, charging services, access services, upload and download services. The evaluation system is mainly a system that each information sharing subject in the SC has enjoyed the information sharing platform and fed back its relevant services (Fig. 1).



**Fig. 1.** Current situation of applying big data analysis in agricultural product SC

## 5 Conclusion

According to the results of the survey and empirical research, we can see that the most influential factors of information sharing in agricultural SC are the structure of SC, the sharing channels, the comprehensive ability of enterprises, and the reputation of enterprises. In other words, if the enterprise wants to better realize information sharing and open up a new road for the development of the enterprise, it needs to do a good job in the selection of SC. In the selection of enterprises, we can select the most suitable partners according to the order above.

The shared agricultural product SC refers to taking sustainable development as the principle, taking agricultural products as the core, taking the optimization of resource allocation and the integration of SC as the ultimate goal, integrating all economic resources in the agricultural product SC, and then re matching resources through the sharing form, forming a complete and intensive SC mode, and increasing the number of enterprises through the creation of sharing mechanism. The cooperation degree of the upstream and downstream entities in the SC improves the final efficiency. The SC mode of sharing agricultural products needs from each link of upstream, midstream and downstream. We need to integrate idle resources to improve the efficiency and revenue of each link of the SC. First, the integration of a single link, such as the integration and reuse of idle land resources in the upstream link of planting, the sharing of planting technology and machinery, the sharing of processing production lines, processing technology and other resources in the midstream link and the sharing of marketing knowledge in the downstream channel. Secondly, from the perspective of the whole SC, integrate the upstream, middle and downstream logistics resources to improve the circulation efficiency of the SC, and form a three-dimensional shared agricultural product SC structure.

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# Negative Externality of the Data Collection and Its Governing Methods

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**Abstract.** In this paper, we aim at finding out the mechanism of the negative externality of governance in the process of data collection. In the big data age, data collection is the key link of data value mining. Using “public” and “externality” of public economics theory to carry out empirical analysis, on the one hand, the technology innovation produced by data collection brings huge positive externalities, but at the same time the Temptation of potential data set, may bring about the excessive behavior of value mining, which may cause the negative externalities that endanger the privacy of citizens. In order to make data collection and use of compliance reasonable, the author intends to design the system arrangement of “negative externality internalization” from the aspects of externality marketization and public management mode: (1) To establish industry data Alliance or data benefit community, and then design data security protocol and restriction, which need to be placed on the agenda, (2) the responsibility of negative externalities should be shifted to the data set users, and the relief responsibility of the government as trustee should be clarified through the design of legal system. All of the above are used to circumvent the potential social costs above private costs.

**Keywords:** Data collection · Negative externality · Governance mechanism

## 1 Introduction

Nowadays, it has been receiving growing attention of the collection and management of “big data”, not only within the information technology field, but more broadly in social apply, including government and business arenas [1]. The Government has achieved effective social governance by means of effective data collection and processing, and business innovation in various fields has created a large number of new patterns based on data [2]. As business and governments use technology to better identify and track their customers and citizens, there is tension between a corporation’s desire for economic growth and the consumers’ desire for privacy [3]. As more consumer and organization information is digitized and collected for data analytics, the potential for cyberthreats and cyberattacks also increases [4]. We need to reinforce the management of the internet industry and strictly regulate personal data collection of the government [5]. Insight into the nature of the data, found that the data set in the

creation of value, at the same time the data set caused by the negative externalities [6]. It is important to think about suitable, acceptable, and sustainable governance mechanism. How to solve these public problem is our research objectives from public economic perspectives.

## 2 Data Collection

**Data.** Data is the result of quantifying and documenting the objective world [7]. It's believed that the data has the high growth rate value the symbol by the information technology records, reads, analyzes and reorganizes. Ubiquitous terminals began to collect more and more data. Everything can be transformed into a data form. It can even be said that wherever you go, you will leave "footprints". The basic unit of this footprint is the data stored in non-organism and other intelligent technical records. By means of data, we can collect and compute the existence of physical and intangible material, and analyze it, and then use it around a specific purpose.

**Data Collection.** In the field of information research, scholars have the same potential to understand the relationship between data and information: information is the manifestation of relational data. Its essence lies in the data collection, completes the relational of the data, then produces has the actual presentation, the judgment, the forecast significance information. The data itself is meaningless, is raw information, and is the basis and premise of information. Data means that one can use it, and the machine can be analyzed, reorganized, and played a greater role. Data collection makes data relational and form a certain practical value of the information sets, around a specific target, through assembly, imputation and analysis of data, by certain analytical tools and algorithms.

**The Value of Data Collection.** Data is a new resource with high growth rate value. It will not be used less, only use more and more. Its value can be changed from basic use to potential use. It can be reused, many people at the same time, and other data integration to use together, resulting in new value and utility. The mining of these values requires continuous data collection. Amazon collects shopping data, not just to get instant purchases, but more importantly to prepare for future data analysis and reuse. So the value of data lies in the value mining after data collection. Most of the data value comes from the second-level use, that is, the use and mining of potential value, the extension of the whole lifecycle of data, and the continuous extension of the data collection.

## 3 The Essence of Data Collection Is a Public Issue

To get the second-level use of data value or even more, it requires as much data as possible. This raises the public nature of the data collection. The problem of public nature is mainly a problem which is not or will not be solved by a particular interest community, which is related to the interests of each community member and is not willing to be resolved by individual subjects [8].

The public nature originates from: first, it is that the public nature embodies the multiple personal interests related to form the specific benefit community, in which the people are subject to the influence of an event or phenomenon and become the stakeholders of the event. The rapid expansion of data has involved the expansion of data groups in the interest community. We may face become “data”, which means every moment of our words and deeds potential to be recorded. Because the data in the computer can be analyzed, the rendering of human society more real, increased the panorama of the object world, more granular analysis, the resulting data objects to the value of people more closely.

Second, in the face of the interaction or influence of the community, the individual members of the benefit community are based on individual limitations, unwilling or unable to solve the common problems involving all alone. Only resorting to collective action can transcend individual or individual rationality and form the ability to solve problems. Facing of impact of massive data, a single person’s ability and rational limitations, more and more show a sense of powerlessness. The greater the gap between demand and capacity, the greater the “public” nature of public data is.

## 4 Analysis of Externality of Data Collection

### 4.1 Externality

Externalities happen in people’s interactions. In some cases, the actions of an individual or an enterprise can bring (no compensation) benefits to others, which are called externalities. This influence often leads to inconsistencies between private cost and social costs, private interests and social interests. As long as there is externality, the market equilibrium is inefficient.

According to the influence of externality, the social cost is increased or the social benefit is increased, and the externality can be divided into positive externalities and negative externalities. Positive externalities tend to become inadequate because private costs are higher than social costs and private costs are not compensated for, and when private costs are lower than social costs, private costs do not have to incur additional social costs and become oversupply. On the one hand, we should encourage positive externalities to flourish, and more importantly, we must overcome the harm of negative externalities.

### 4.2 Analysis of Externality of Data Collection

With the wide existence of sensors and intelligent terminals, the data is still large-scale fission, human activities, natural environment changes in the state of industrial machinery, the city’s life will be widely recorded, the future of each group of data collection reuse, have the potential for externality. Excavating this externality will bring great opportunity for scientific research, economic development and social governance, but at the same time the negative externality of data set may crisis national security and citizen privacy.

### 4.3 Positive Externalities of Data Collection

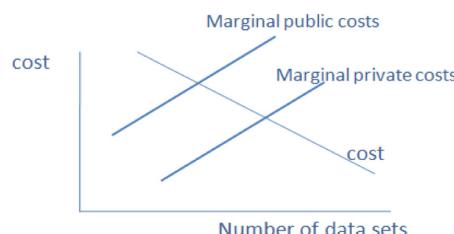
Adam Smith thought, “The natural economic system (market economy) is not only good, and it is out of Providence, because in them, the natural effort of each person to improve his or her situation can be guided by an invisible hand to try to achieve a purpose that is not what he intended to achieve, namely” in the pursuit of his own interests, Also often promotes the interests of society” (Smith 1776). Well explained the root of the development of market economy. An ordinary individual who makes “self-interest” for his own benefit may also benefit others or society as a whole, and the beneficiaries need not pay for it.

The maximum value of a data set is embodied in the release and excavation of positive externalities. The role of data may well be beyond the imagination of its original collectors, it is also entirely possible to exceed the purpose of the original information system design that the same set of data can produce different values and effects in different dimensions, and if we can constantly discover and exploit new dimensions, the energy and value of the data will be magnified. The outbreak of adult influenza can be predicted through hospital data mining.

In data positive externality mining, businesses in the business sector are inherently sensitive and are also expected to maximize data externalities. Many enterprises are flocking to data construction, and begin to build their own data collection kingdom around the data. The important reason for Alibaba’s growth and expansion is that it uses the “Externality of data Sets”. Its Taobao, TMall, Alipay, business-to-business and other internet platform, gathered a large number of market transaction information and payment data for its follow-up business data value added to lay a good foundation.

### 4.4 Negative Externalities of Data Collection

Data sets, especially the potential value of data set utilization of second-level “temptation”, the immeasurable potential personal interest brought by the behavioral subject of data value mining has a powerful incentive to its behavior, but few people consider and take responsibility for the impact and cost of data collection on individuals and society. The result is that the private cost of the data set is less than the social cost and the negative externality of the data collection is produced. The existence of negative externalities means that to achieve market equilibrium will be excessive production (Fig. 1).



**Fig. 1.** Excessive production with negative externalities ( $Q_M$ : market equilibrium,  $Q_E$ : effective level of output)

The most important effect of negative externalities is: data security and privacy exposure, which brings about potential personal property security risk. Data conflicts occur at the crawl stage of the data. On the surface, the data conflict is business interests conflict only between Huawei and WeChat, however, any data conflict is not a “private issue” between enterprises, national law and management should establish a series of “public norms” for data sharing, privacy boundaries, big data security and other aspects, to ensure that China’s big data service develops in a healthy competition of the ecological environment. As more and more things are being computerized, the first thing policymakers do is get bigger and more data. All kinds of companies, without our knowledge, gather all the data of our daily life, and share the data and our unknown use. In just one month, several global vicious events have erupted as a result of data problems. In 2017, Equifax report that data breach that revealed the sensitive privacy information of 143 million Americans [9]. More than 50 million of Facebook’s user information (which implied user behavior patterns, personality traits, values, growth experience) was leaked. The user’s data security and information privacy are victims. There is huge imagination space in the collection, storage and utilization of large data.

On the one hand, the protection and use of data in the country is still messy, underground production has no bottom line, internet companies are acting on self-discipline. According to reports, that numbers of workers involved in underground production have more than 1.5 million, the market size of hundreds of billions CNY [10]. On the other hand, large companies with data are in dire need of power to deliver data, and companies are more concerned about whether they can stand at a strategic high point in the future. The data collection began to carry on large-scale, the friction between enterprise and user, enterprise and enterprise obviously intensified. On the one hand, enterprises find ways to obtain user data; on the other hand, the data competition between enterprises is intensified. In 2017, Shun Fung and “Cai niao” war, focus on consumer privacy data.

## 5 Research on the Governance for Negative Externalities of Data Collection

The existence of externalities often requires some kind of intervention to achieve efficiency. The existence of negative externality proves the failure of the market. The traditional externality theory holds that even if the market fails, there may be a “government failure” in direct government control, which will directly reduce the positive externalities of data collection if the data is controlled. So we go back to the problem itself to find the solution, and the key and fundamental to managing the data collection is to ensure that the data collection is used rationally and in compliance.

## 5.1 Solutions Based on the Market

**The Establishment of Industry Data Alliances.** Clear property rights can solve the problem of negative externality, but there is a great controversy about the definition of the property right of data. To produce a data, the participants mainly have the record side and the recorded party. Data is valuable only if it is faithful to the subject being recorded, while the recording party spends a great deal of money on the collection and collation of data. The problem of data ownership in the data set is precisely due to the relevance between the record side and the recorded party, which is still being discussed in the legal circles today. When property rights are not easily defined, can we refer to “oil beds without clear property rights, where owners of oil wells are often lumped together to make their production a whole (unitize)”, and fishermen who use the same waters can also be lumped together to design mutually acceptable protocol limits to prevent overfishing. Data collection governance can refer to this model, through the establishment of Industry data Federation, design data security protocols and constraints to prevent the misuse of data sets.

**Internalization of Externalities.** By forming an adequate scale of economic units, the results of any action can occur within a specific unit, thus enabling the internalization of externalities. In the data set governance, if there is a data interest community, or the establishment of cooperation and condominium associations, we jointly decide the negative externalities of the impact of the problem in some form or approach to solve. If someone becomes a potential hitchhiker, then it must be done by resorting to the law to ensure the implementation of the terms of the Consortium agreement.

## 5.2 Public Sector Solutions

**The Method of Controlling Externality.** The public supervision may require that the liability party be turned to the data user by the individual permission. Traditional privacy norms emphasize that “own information, the decision of their own”, the processing of information on their own hands, which is the core principle of privacy norms. In reality the expression is the formulation system of “informing and permitting”. In the new age of data, because the value of the data is largely reflected in future uses, the initial “inform and permit” does not guarantee the risk of future estimates of intended use. In the large data age, we need to set up a new privacy protection model, more focused on the data collection and users for their behavior, rather than simply the initial acquisition of user consent. In this model, regulators need to determine the relevant rules: to establish a “right to forget”, to limit the time of personal information storage and processing, to eliminate the fear of permanent memory, content, the provision of data obfuscation, different privacy requirements and responsibilities.

**The Use of Legal Systems.** The competition for data sets in various fields will persist until new cooperation and rules are created. Before the market mechanism is able to effectively complete the optimal configuration, and when property rights are not fully defined, the legal system can prevent the emergence of externalities. The right position and rights of billions of users in the data set should be our focus. The solution of this

public issue also depends on the design of the legal system. June 1, 2016, China's two network security laws and regulations, the illegal acquisition, sale of personal information on the minimum of 50 items can be identified as "serious circumstances", to achieve the standard of punishment. In three months, Beijing Haidian police cracked more than 30 related cases. As a "trustee" of the public interest, the Government has the right to prosecute the damage caused by the data privacy traffic. In the legal system design, the prevention because the transaction cost is too high, cannot solve the externality problem through the judicial procedure. The rampant underground market is closely related to the lack of regulation. Even before the hundreds of billions of data transactions, due to the lack of judicial interpretation, the case cannot go to the proceedings, often no result in the end.

## 6 Conclusions

Facing the negative externality of the data collection, we can design the system arrangement of "negative externality internalization" through externality marketization and the change of public management mode to avoid the situation that the latent social cost is higher than the private cost.

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# Spillover Effect of Perceived Online Products Information Deception in the Information Age

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**Abstract.** This study is aiming to explore the mediating mechanism and regulating variables of the spillover effects of perceived deception in the context of continuous online product information presentation. Through experiments and empirical test, the following conclusions are drawn: (1) Perceived deception has negative spillover effects in online environment; (2) Trust plays a mediating role in the negative spillover effect of perceived deception. (3) Cognitive effort plays a regulatory role in the spillover effects' direction of perceived deception. Specifically, perceived deception has negative spillover effect in conditions with low cognitive effort. In contrast, perceived deception has positive spillover effect in conditions with high cognitive effort. (4) Perceived substitutability plays a mediating role in the positive effects of perceived deception.

**Keywords:** Product information · Perceived deception · Spillover effect · Cognitive effort · Purchase intention

## 1 Introduction

Online shopping has been developing rapidly. Meanwhile, the Internet is considered as a hotbed of Deception [1]. Previous studies have shown that consumers are most concerned about product information when they shop online, and misrepresentation of product information is also one of the most common forms of online fraud [1, 2]. Therefore, it is necessary to investigate the perceived online products information systematically. This paper tries to answer the following questions in the context of continuous presentation of online products information: (1) Whether perceived deception has spillover effect in online shopping environment? (2) How does the spillover effect happened? (3) when will the negative spillover effect of consumers' perceived online products information be restrained? Can consumers' perceived online products information have a positive effect?

## 2 Literature Review and Hypothesis

### 2.1 Perceived Deception and Purchase Intention

The priming effect suggests that the information stimulus presented previously may positively or negatively influence the follow-up tasks. When online products information is presented continuously, the previously presented product information will have a priming effect on the subsequently presented product information. According to the theory of assimilation effect, if the previously presented product information causes consumers to make a judgment of perceived deception, then consumers' judgment on the subsequent product information will also be consistent with it, that is to say, there is "deception" in the subsequent product information. According to the existing literature, once consumers perceive deception when search product information, it will significantly reduce consumers' purchase intention [3].

Therefore, this paper deduces that the higher the perceived deception degree of the previously presented product information, the higher the perceived deception degree of the subsequent presented product information, and then the lower the purchase intention of products in the subsequent presented product information, that is, there is a negative spillover effect of perceived deception.

Thus, we propose hypothesis 1:

H1: consumers' perceived deception of online products information has a negative spillover effect.

### 2.2 The Intermediary Role of Trust

Previous studies have shown that product information is an important antecedent of trust when shopping online [4]. Perceived deception caused by online product information will significantly reduce consumer trust [5–7]. Previous literature also shows that there is a positive correlation between consumer's trust belief and behavior intention. Consumers are more willing to buy goods from merchants they trust [8].

Therefore, this paper proposes hypothesis 2:

H2: trust plays an intermediary role in the negative spillover effect of perceived online products information deception.

### 2.3 The Moderating Effect of Cognitive Effort

Martin [9] pointed out that cognitive effort can affect the occurrence of assimilation and contrast effects. When the individual cognitive effort is high, there is contrast effect; when the individual cognitive effort is low, there is assimilation effect [10]. Therefore, this paper puts forward hypothesis 3:

H3: cognitive effort regulates the spillover effect of perceived deception.

H3a: under the condition of low cognitive effort, consumers' perceived deception has assimilation effect and negative spillover effect happens;

H3b: under the condition of high cognitive effort, consumers' perceived deception has a comparative effect and positive spillover effect happens.

## 2.4 The Intermediary Role of Perceived Substitutability

There are two aspects of perceived substitutability, one is the alternative of substitute, the other is the attraction of substitute. When shopping online, moving from one business to another is almost free and effortless, so the alternative is high. As for the attractiveness of substitute, on the premise of comparative effect, if consumers get perceived deception from previously searched businesses, they will be more inclined to think that the subsequent product information is nondeceptive and positive, so they will feel more attractiveness from the subsequent products.

Therefore, Hypothesis 4 is proposed:

H4: perceived substitutability plays an intermediary role in the contrast effect. That is, under the condition of high cognitive effort, consumers' perceived deception has a positive impact on the purchase intention of subsequent products through the intermediary role of perceived substitutability.

## 3 Method and Results

### 3.1 Pre-experiment

Based on the research of Xiao and Benbasat [1], this paper uses three different ways to manipulate perceived deception: falsification, concealment and equivocation. In the pre experiment, 190 subjects completed the questionnaire, and finally 185 valid samples (average age 19.86, female 62.26%) were obtained, including 57 valid samples in group A, 64 valid samples in group B and 64 valid samples in group C. The results of t test are shown in Table 1, and the three manipulation methods have been verified to be effective in the pre experiment.

**Table 1.** The results of T-test

Pre-experiment		Experiment A (Falsification)	Experiment B (Concealment)	Experiment C (Equivocation)
Mean	High perceived deception	5.040	5.361	5.300
	Low perceived deception	4.135	4.638	4.176
T-test: sig.		0.001**	0.005**	0.000***

Through pre-experiment, the manipulation of independent variables is proved to be effective. On this basis, this paper will test the spillover effect of consumer perceived deception through five experiments. The specific experimental design is shown in Table 2.

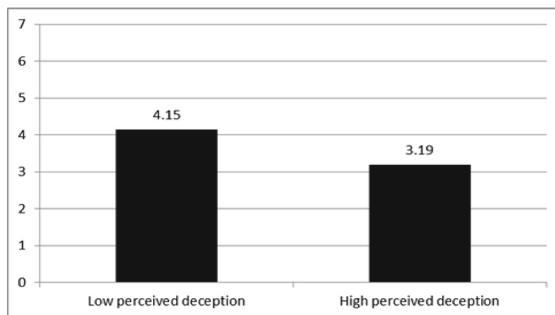
**Table 2.** Summary of experiments

Experiment	Objective	Product	Perceived deception	Cognitive effort
1	H1, H2	Search product	Falsification	–
2	H2	Experience product	Falsification	Scale measurement
3	H3, H4	Search product	Concealment	Cognitive ability
4	H3, H4	Search product	Equivocation	Cognitive motivation

### 3.2 Experiment 1

The objective of this experiment was to explore whether there was a spillover effect when product information was continuously presented online, and how the spillover effect occurred. Sixty-eight undergraduate student subjects were randomly assigned to one of two conditions (perceived deception: low VS. high).

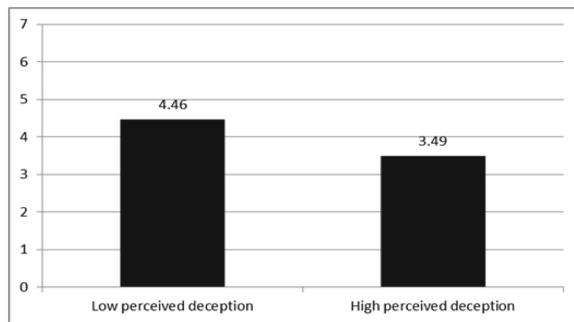
The results of t-test suggested perceived deception was appropriately manipulated ( $M_{high} = 5.64$ ,  $M_{low} = 3.83$ ,  $P < 0.001$ ). It's showed that the average score of purchase intention of low perceived deception group was 4.15, and that of high perceived deception group was 3.19. There was significant difference between the two groups ( $P < 0.001$ ), so hypothesis 1 was supported (Fig. 1).

**Fig. 1.** Variance results of experiment 1

According to Preacher and Hayes (2004) and Hayes (2009), the bootstrap method was used to check mediating effect. The results showed that trust played a mediating role in the spillover effect of perceived deception (LLCI = -0.2650, ULCI = -0.0048). Thus, hypothesis 2 was also supported.

### 3.3 Experiment 2

The main purpose of this experiment was to examine the mediating mechanism of emotion. Seventy-four undergraduate student subjects were randomly assigned to one of two conditions (low perceived deception VS. high perceived deception) (Fig. 2).



**Fig. 2.** Variance results of experiment 2

Perceived deception was appropriately manipulated ( $M_{high} = 5.41$ ,  $M_{low} = 3.64$ ,  $P < 0.001$ ). Mean value of purchase intention of low perception deception group was 4.46; while that of high perception deception group was 3.49. The result showed that the difference between the two groups was significant ( $P < 0.001$ ), so hypothesis 1 was supported.

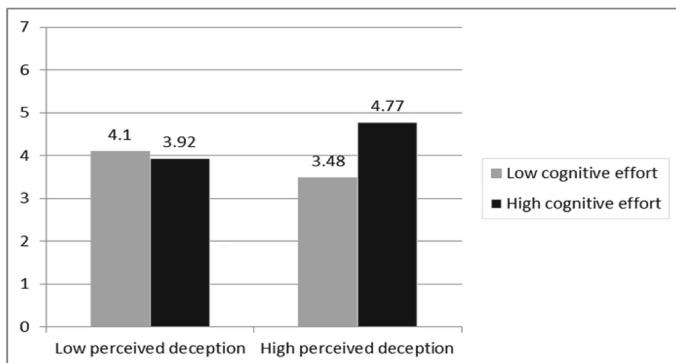
A mediating test showed that the mediating effect of trust was significant ( $LLCI = -0.3437$ ,  $ULCI = -0.0104$ ); the mediating effect of emotion was not significant ( $LLCI = -0.2869$ ,  $ULCI = 0.0241$ ). Therefore, the possibility of emotion as an intermediary variable could be excluded.

### 3.4 Experiment 3

According to Martin [9], this experiment manipulated cognitive effort through cognitive ability. The objectives of this experiment were as follows: (1) to further verify the regulatory role of cognitive effort; (2) to explore the mediating role of perceived substitutability in the positive effect of perceived deception. One hundred thirty-six subjects were randomly assigned to one of four conditions of a 2 (perceived deception: low VS. high)  $\times$  2 (cognitive effort: low VS. high) between-subjects design.

The results of t-test showed that perceived deception was manipulated appropriately ( $M_{high} = 5.11$ ,  $M_{low} = 4.104$ ,  $P < 0.001$ ), and cognitive effort was also appropriately manipulated ( $M_{high} = 5.26$ ,  $M_{low} = 3.67$ ,  $P < 0.001$ ). The main effect of perceived deception was not significant ( $P > 0.05$ ), while the main effect of cognitive effort was significant ( $P < 0.05$ ), and the interaction between cognitive effort and perceived deception was significant ( $P = 0.001$ ) (Fig. 3).

Under the condition of low cognitive effort, the results of this experiment were the same as those of experiment 1 ( $M_{high} = 3.48$ ,  $M_{low} = 4.1$ ,  $P < 0.05$ ). Under the condition of high cognitive effort, the results were completely opposite to those under the condition of low cognitive effort ( $M_{high} = 4.77$ ,  $M_{low} = 3.92$ ,  $P < 0.05$ ). Thus, cognitive effort played a moderating role in the effect of perceived deception on purchase intention, and Hypothesis 3 was supported.



**Fig. 3.** Variance results of experiment 3

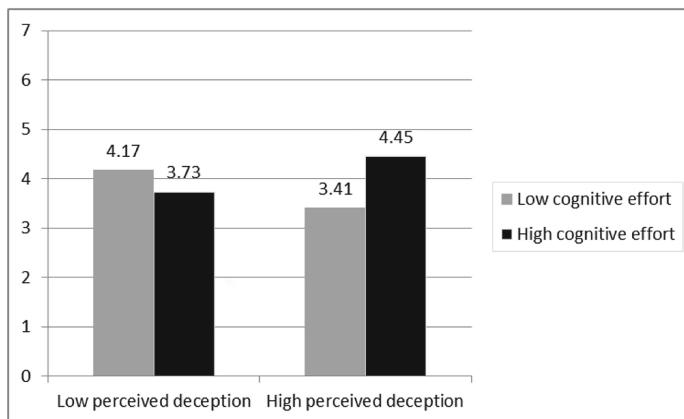
A mediating test showed that the mediating effect of trust was significant ( $LLCI = -0.5259$ ,  $ULCI = -0.1108$ ) and that of perceived substitutability was not significant ( $LLCI = -0.0083$ ,  $ULCI = 0.1317$ ) when the level of consumer's cognitive effort was low. Under the condition of high cognitive effort, the mediating effect of perceived substitutability was significant ( $LLCI = 0.0896$ ,  $ULCI = 0.4900$ ), and that of trust was not significant ( $LLCI = -0.1996$ ,  $ULCI = 0.1124$ ). The results showed that cognitive effort had a significant moderating effect on the spillover effect of perceived online products information deception, and perceived substitutability played an intermediary role in the positive spillover effect of perceived deception.

### 3.5 Experiment 4

This experiment manipulated cognitive effort through cognitive motivation. One hundred thirty-two subjects were randomly assigned to one of four conditions of a 2 (perceived deception: low VS. high)  $\times$  2 (cognitive effort: low VS. high) between-subjects design.

It's showed that perceived deception was manipulated appropriately ( $M_{high} = 5.097$ ,  $M_{low} = 4.12$ ,  $P < 0.001$ ), and cognitive effort was also appropriately manipulated ( $M_{high} = 5.39$ ,  $M_{low} = 3.86$ ,  $P < 0.001$ ). The main effect of perceived deception was not significant ( $P > 0.05$ ), while the main effect of cognitive effort was significant ( $P < 0.05$ ). Besides, the interaction of this two variables was significant ( $P = 0.001$ ) (Fig. 4).

When the level of cognitive effort is low, mean value of purchase intention of low perception deception group was 4.17, while that of high perception deception group was 3.73. The result showed that the difference between the two groups was significant ( $P < 0.05$ ). When the level of cognitive effort is high, the results were completely opposite to those under the condition of low cognitive effort ( $M_{high} = 4.45$ ,  $M_{low} = 3.73$ ,  $P < 0.05$ ). Obviously, cognitive effort played a moderating role in the spillover effect of perceived deception. So hypothesis 3 was supported again.



**Fig. 4.** Variance results of experiment 4

Under the condition of low cognitive effort, the mediating effect of trust was tested to be significant ( $LLCI = -0.3517$ ,  $ULCI = -0.0473$ ) and that of perceived substitutability was not significant ( $LLCI = -0.1257$ ,  $ULCI = 0.0647$ ). When the level of consumer's cognitive effort was high, the mediating effect of perceived substitutability was significant ( $LLCI = 0.0384$ ,  $ULCI = 0.3891$ ), and that of trust was not significant ( $LLCI = -0.1257$ ,  $ULCI = 0.0647$ ). Thus, cognitive effort had a significant moderating effect on the spillover effect of perceived online products information deception, and perceived substitutability played an intermediary role in the positive spillover effect of perceived deception.

## 4 Conclusions

This paper investigates the spillover effect of perceived deception in online shopping environment through a pre-experiment and four experiments, and draws the following conclusions: (1) There is a negative spillover effect of perceived deception in online shopping environment; (2) Trust plays an intermediary role in the negative spillover effect of perceived deception; (3) Cognitive effort plays a regulatory role in the spillover effects' direction of perceived deception; (4) Perceived substitutability plays an intermediary role in the positive effect of consumer perceived deception.

There are a number of theoretical contributions of this study. First, this paper explores consumers' perceived deception in the context of continuous online products information presentation, which improves the previous literature. Second, this study finds that consumers' perceived online products information deception may also have a positive impact, which enriching the outcome variables of perceived deception. Third, this paper extends the spillover effect of perceived deception from offline setting to online setting, which is a useful supplement to the previous research.

Future research may focus on the antecedents of perceived online product information deception, or compare perceived online product information deception between online setting and offline setting.

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# Design and Implementation of Intelligent Cloud Platform Protection for Folk Art

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**Abstract.** With the wide application of information technology, network technology and digital technology in modern society, digital service has been deeply applied in people's daily life. Beyond doubt, folk art is also influenced by information technology towards the direction of developing digital and intelligence gradually. The emergence of big data and cloud computing not only brings challenges to folk art, but also makes it face so many opportunities. Folk art intelligent cloud platform design can not only promote the further development and dissemination of folk art, but also help to improve the user experience. However, with the extensive application of cloud platform, the security of cloud services is also come up with higher requirements. Starting from the current situation of folk art in the information age, this paper discusses the great significance of cloud platform to the development of folk art, and from the current security issues and influencing factors of cloud platform, designs the intelligent cloud platform protection of folk art.

**Keywords:** Folk art · Cloud platform · Protection · Design

## 1 Introduction

In recent years, the emerging technologies represented by big data and cloud computing have developed rapidly. In the information age, the traditional folk art mainly develops towards the direction of digital resources. Through efficient information dissemination, folk art can develop and spread better. Therefore, the key to the preservation and development of folk art is to build a safe and reliable folk art intelligent platform. Through the design and implementation of the folk art intelligent platform protection, the folk art can be better developed in the information age. The realization of protection and design through the folk art intelligent platform promotes the better development of folk art in the information age.

## 2 The Current Situation of Folk Art in the Information Age

Computer is one of the most advanced scientific inventions in the 20th century, not only it brings great changes to the mode of production, but also affects the change of people's life style. For instance, the emergence of mobile phones has totally changed the way people communicate. In the modern era of rapid development of information,

let “tradition” shuttle in “modern”, let “folk” be popular in “city” [1]. Digitalization and informatization can enforce folk art and regional culture to spread more widely it also provide inspiration for creators with the extensive information resources of cloud platform.

Folk art, which condenses strong local flavor, it reflects the traditional culture in a region. For instance, paper cutting in Northeast China is full of rich Manchu customs and has unique historical value. With the advent of network and information age, people’s ideas are influenced by Western civilization. Modern young people don’t pay as much attention to traditional folk art as before. Therefore, folk art tends to be marginalized. With the continuous development of information technology and digital technology, a good painting or paper-cut can be copied in large quantities in the form of digital painting or digital sculpture. This rapid change also makes folk art’s works more weak in national flavor. On the other hand, the development of information technology makes the regional differences smaller and leads to homogenization.

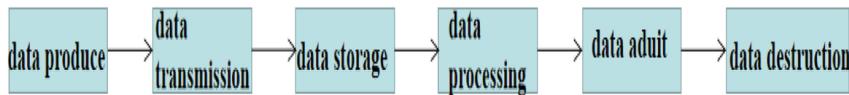
Even though the information age brings great challenges, but it also brings development opportunities. Folk art should be well inherited and developed as an art resource. Folk art’s inheritance methods are spread by words and deeds or by graphic records. However, because lack of market an times changes, there are few crafts handed down by these methods. Therefore, the use of information and digital methods to save folk art’s data is not only a good preservation of folk art resources, but also convenient for people to search works quickly. However, the traditional methods of information collection, recording and storage have been unable to meet the requirements of modern large-scale, high-quality and efficient protection [2]. Therefore, through cloud technology, the protection and inheritance of folk art resources can be achieved and more people can understand the local regional culture.

### 3 Security Problems and Influencing Factors of Cloud Platform

#### 3.1 Data Security Problems in Cloud Platform

Cloud platform is based on “cloud computing”, it is a network service platform. However, there are still some technical loopholes “cloud computing” technology in the current situation, so it may bring some potential dangers to the data security of cloud platform. Data security has been the focus of computer information management all the time, but also the problem makes people worry about, cloud platform data security is the same. From the perspective of data life cycle, the data security of cloud platform includes the aspects as follows: data generation, data transmission, data storage, data processing, data audit and data destruction (Fig. 1). Data security problems may occur in the whole data life cycle. Cloud platform provides the storage function for users. Users put their local data into the “cloud” through the Internet, which leads to the storage of data resources with a lot of user information in the cloud [3]. In recent years, “cloud attack” has also occurred frequently, which has attracted people’s attention.

System reasons can also leads to data loss. There is a close relationship between the computer and the storage and processing of user data on the cloud platform, so if there



**Fig. 1.** Data security for cloud platform

is a problem in the computer itself, it will cause the data loss of the cloud platform. For example, when the device has been implanted virus, the cloud services accessed by the device are more likely to be damaged, so the protection of the device is also crucial.

### 3.2 Virtualization Technology May Cause Security Risks

The virtual technology is the key of “cloud computing”. Due to the virtualization technology is totally dependent on the system hardware, when there is a problem happened in the system, the virtual machine will face the risk of total collapse [4]. During the same time, the sharing of computer resources will be deployed on the same physical server, so data isolation between different virtual machines should be done well. If an illegal user obtains the permission of the virtual machine, he can access the information on other virtual machines thus causing the leakage of data resources.

### 3.3 Cloud Privacy Protection Issues

The Cloud platform is in a virtualized dynamic environment, so the privacy of users is also threatened. In order to achieve resource sharing and maximize utilization on the cloud platform, users share technology with underlying resources through multiplexing or multi-tenant technology. This will cause some malicious users to attack through virtual machines and steal users. Confidential information or privacy [5]. On the other hand, cloud computing managers may use their rights to occupy or use users' information without their permission.

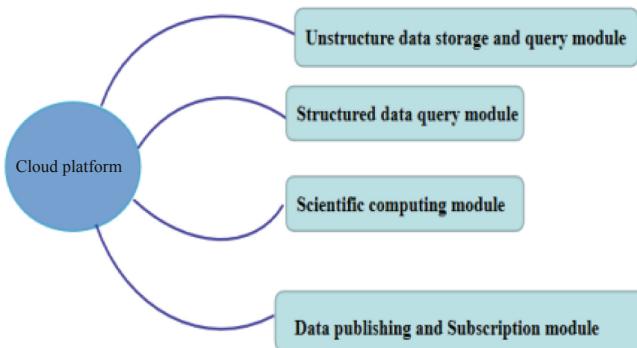
Above all, there are three security factors that we find affecting the cloud platform include: users, networks, and devices. At first, it refers to security issues, people seem to consider malicious actors only, but in fact, the unintentional behavior of some users may also lead to security issues, even if they do not realize [6]. Secondly, the network factor is the most easily overlooked. However, the internet seems to be the weakest link. Wireless networks are advanced at this age. People often want to find the fastest way to connect to the network, but they ignore the security issues of the network. Finally, the equipment factor. When the device is implanted with virus or occupied by an illegal program, it will threaten the security of the cloud platform.

## 4 Design and Implementation of Folk Art Intelligent Cloud Platform Protection

The safe operation of folk art intelligent cloud platform always aims to ensure the safety of user information, folk art intelligent cloud platform should provide security protection for users accessing art resources and ensure the normal operation and safety of cloud platform, folk art intelligent cloud platform protection design can be divided into the following aspects: first, the security of users accessing folk art cloud resources includes user authentication, access control resource isolation and folk art resource protection. Second, the security of cloud platform itself, including network security, host computer and data security threats should be defended. Third, the security access of different levels of users and their rights management. Fourth, the security of platform data exchange.

### 4.1 Design of Cloud Platform System Architecture

In the process of using the cloud platform, users hope that they can make full use of the openness of the cloud platform to discover more folk art resources, but they do not want to let their information be disclosed to the cloud then they need to consider Protection of private information, through the encryption of information to prevent criminals or some cloud server providers from stealing data. Moreover, it is necessary to ensure the user information security and the ease of use of user operations. According to the application of cloud platform, cloud platform is divided into four modules: unstructured data storage and query module, structured data query module, scientific computing module, data publishing and subscription module (as shown in Fig. 2). The design of these four modules is relatively independent and can provide users with privacy protection in different applications.



**Fig. 2.** Application module of cloud platform

At first, the design of unstructured data storage and query module adopts MRSE technology, which enables users to query or manage private files through multi keyword sorting search while encrypting files, and ensures its security in the process of

transmission and query [7]. Secondly, structured data query module is also divided into two roles: uploader and querier. The data uploader encrypts the data and uploads it to the cloud service, while the querier needs to query the cloud service and download it to the local for decryption to obtain the plaintext information. The design of this module is based on independent third-party auditors TRA and public-key homogeneous linear authentication HLA technology, which enables information to be stored on the cloud without leaking sensitive information. Thirdly, the scientific computing module can enable users to protect the specific content of user computing from being leaked while using the affluent computing resources of cloud computing.

Finally, the data publishing and subscription module mainly solves the problem of protecting information and privacy of users when information is released. This module implements security protection of information and data of information publishers and subscribers by using Paillier homomorphic encryption algorithm.

## 4.2 Design and Implementation of Information Resource Protection

First of all, firewall technology has great use value in network security. It can establish a security protection barrier between the external and internal network to guarantee the security in the network construction [8]. In the connection between cloud platform service and Internet, firewall plays a role of security. In the protection design of information resources, firewall technology plays a role in analysis restriction and isolation function. Through the management of access rights to cloud platform, security access and rights management of different users can be achieved. If some users want to access the folk art resources, they cannot enter into the core database of cloud platform without permission. Secondly, the data encryption technology is used to realize the data encryption of cloud platform and then to control the data visitors in order to reduce the risk of data theft.

## 4.3 Design of Vulnerability Defense in Virtualization Layer

The foundation of cloud platform is virtualization technology, in other words the security of virtualization layer plays a key role in the protection of cloud platform. First, the scalability and agility of network infrastructure are improved by using SDN and nfv [9]. Through the visualization of virtual network, managers can clearly understand the structure of virtual network in the cloud environment and its changes.

## 4.4 Design for Intrusion Detection

Cloud platform attaches importance to data security, but also can not ignore the monitoring of cloud platform network. Through the application of intrusion detection technology, illegal elements or hackers can be hindered from entering it by making use of network vulnerabilities. Intrusion detection technology can shield illegal IDS in time [10]. For the information security of cloud platform, the intrusion detection system is used to handle the situation that unauthorized users call information in the platform.

## 5 Conclusion

In the new era of the rapid development of network technology, the construction of digital network security refers to a long-term work. In the cloud era, the network is more complex than before, so the security issues are also more tough. Improving the security prevention capabilities of the folk art intelligent cloud platform through the use of technology continuously, on the one hand, it not only helps to make sure the user's information security, but also enhance the folk art to develop and inherit better.

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# The Construction of Network Platform of Outdoor Sports Club

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**Abstract.** In recent years, the development of sports in China, the importance of sports activities is also increasing. At the same time, with the improvement of social and economic level, people's overall living standards have also improved significantly. People have higher requirements for physical and mental health. In this situation, outdoor sports activities gradually enter people's lives. As a new industry, outdoor sports clubs are developing vigorously, and have a growing influence on people's lives. The growing number of members of outdoor sports clubs has left them with a lot of information to process. At the moment, however, outdoor sports clubs cannot cope with the complexity of information. Therefore, it is particularly important to build a network platform for outdoor sports clubs and process information resources with the help of network technology to realize the orderly development of outdoor sports clubs. Based on a brief overview of outdoor sports and outdoor sports clubs, this paper sets up the network platform module of outdoor sports clubs with the help of Kohonen network algorithm, and puts forward the construction strategy of network platform of outdoor sports clubs.

**Keywords:** Outdoor sports · Outdoor sports clubs · Network platform · Kohonen algorithm

## 1 Introduction

With the continuous development of social and economic level and the improvement of people's life, people pay more and more attention to the healthy development of body and mind. Under the background of the vigorous development of sports in China, outdoor sports and outdoor sports clubs gradually emerge, playing an important role in people's lives [1, 2]. The so-called outdoor sports is to use leisure time to carry out relevant sports with the help of natural environment. These sports are risky and challenging to some extent, and aim to improve physical and mental health and meet the needs of leisure [3]. Outdoor sports activities take into account the dual needs of people's leisure and exercise, has been widely welcomed by people. At present, the number of members of outdoor sports clubs is increasing, and the increase in the number of members is accompanied by the increasingly prominent conflicts among members, which results in that the club cannot provide high-quality services for each member, and the service level cannot fully meet the requirements of members, which makes the activity enthusiasm of club members frustrated [4, 5]. The solution of this

problem is directly related to the normal operation of outdoor sports clubs and is also the key to the sustainable development of outdoor sports clubs. With the rapid development of information technology, it provides a good way to solve this problem [6]. Network information technology can quickly process various information data and has been widely used in various fields, and outdoor sports clubs have also begun to apply information technology [7]. Based on information technology, the construction of a network platform for outdoor sports clubs can better solve various contradictions in the operation of clubs, promote the good development of outdoor sports clubs, and have a profound impact on the progress and development of outdoor sports [8, 9].

Based on the current development situation of outdoor sports clubs, it is of great practical significance to discuss and construct the network platform of outdoor sports clubs [10]. At present, domestic and foreign scholars have conducted a series of in-depth studies on outdoor sports and outdoor sports clubs. Relevant studies mainly focus on the following aspects: research on the development of outdoor sports and outdoor sports clubs, strategy research on improving the operation of outdoor sports clubs, etc. [11, 12]. However, there are few researches on the construction of network platform for outdoor sports clubs based on network information technology. From this perspective, there are still some theoretical gaps in this study [13].

In order to fill this theoretical gap, on the basis of a simple overview of outdoor sports and outdoor sports clubs, this paper sets up the network platform module of outdoor sports clubs with the help of Kohonen network algorithm, and proposes the construction strategy of network platform of outdoor sports clubs on this basis [14, 15]. On the one hand, it is beneficial to the development of outdoor sports and outdoor sports clubs. On the other hand, it provides some reference for the future research.

## 2 Method

### 2.1 Outdoor Sports

At present, scholars at home and abroad have not reached a unified conclusion about the concept of outdoor sports, so the concept of outdoor sports is not clear enough. Through consulting the data, it can be found that different scholars often define outdoor sports from different perspectives. In this paper, on the basis of reviewing a large number of literatures, the related concepts are integrated and finally defined. Outdoor sports is to use leisure time with the help of the natural environment to carry out related sports, these sports with a certain adventure and challenge, and to improve physical and mental health and meet the needs of leisure for the purpose. Mass sports, leisure sports and emerging sports are the three main attributes of outdoor sports. The characteristics of outdoor sports mainly include the following three aspects: first, sports events as the main media; Secondly, sports venues and rules are more flexible, with the natural environment as the main place for activities; Third, outdoor sports are more challenging, with a certain degree of leisure.

Outdoor sports club is a kind of organization form of outdoor sports activities. According to the classification of types can be divided into professional and amateur, comprehensive and unitary, aggregation and relaxation club and so on. Outdoor sports clubs mainly have the following characteristics: first, the organizational form is membership; Second, strictly ensure the safety of members, take the team leader responsibility system; Third, the ability to deal with emergencies; Fourth, combine with network technology to organize outdoor sports activities.

## 2.2 Kohonen Network Algorithm

With the help of Kohonen network algorithm, its output can be analyzed and mastered, which can not only judge the pattern category represented by the output network nodes, but also control the data in the network area to obtain the relevant characteristics of relevant data. Therefore, the network algorithm based on Kohonen can deeply process and analyze the data of the network platform of outdoor sports clubs, especially in the optimization of club membership and management. The main purpose of the optimization of the division of labor among club management members is to arrange related affairs on the network platform according to the abilities of different members. The difference ( $D_{ij}$ ) between the management requirements of the network platform and the ability of the management members of the selected club members is as follows:

$$D_{ij} = \sum |ai - bj| \quad (1)$$

Where, input personnel is the club manager, network platform equipment is the output neuron, and the node weight contained in its neighborhood is represented by  $bj$ . The purpose of optimizing the club's network platform management is to minimize the maintenance cost of the network platform. The purpose of management optimization is to minimize equipment maintenance costs. The expenditure plan of maintenance funds in category  $y$  is selected. The annual expenditure for maintenance items in category  $x$  of the club's network platform is called  $O_{xy}$ . The specific calculation formula is as follows:

$$O_{xy} = cx \times dy \quad (2)$$

## 3 Idea of Network Platform Construction for Outdoor Sports Clubs

The construction of outdoor sports club platform can provide club members with more abundant outdoor sports resources, meet the diversified needs of different club members, and provide a more convenient way for mutual coke oven and cooperation among club members. In order to make the outdoor sports club platform better serve the club members must adhere to the correct network platform construction idea. First, adhere to the club member-based, oriented to the needs of all club members and network platform construction, so that the personalized needs of members at different levels can be met; Secondly, the construction of the network platform should conform to the purpose

of sports activities, maximize the physical and mental health of club members, and achieve good sports effects; Thirdly, the network platform of outdoor sports clubs should be both instructive and interactive, which can not only promote mutual communication among members but also realize the orderly management and guidance of club members. Fourth, the construction of club network platform should be guided by advanced design ideas and clearly reflect the characteristics of the construction of club network platform in The Times, so as to enable more people to participate in sports club activities.

## 4 Discuss

### 4.1 Building Blocks of Outdoor Sports Club Network Platform

#### 4.1.1 Information Resource Module

The information resource module is a key part of the network platform of outdoor sports clubs and a module for information processing of the network platform. The establishment of this module can help club members to inquire and detect the information of various outdoor activities, and can effectively promote the publicity and organization of outdoor sports activities. The information resource module mainly contains the following contents: relevant rules and regulations of outdoor sports club, outdoor sports activity arrangement, club member information update and related information at home and abroad. Information resources involve all aspects. Through the integration of information resources, the club members' sports vision can be expanded to the maximum extent and the personalized sports needs of club members can be satisfied to the maximum extent.

#### 4.1.2 Interactive Module

The outdoor sports club provides a good platform for the outdoor sports activities of various groups. In order to facilitate the communication between different members of the club and promote the activities, the construction of interaction modules must be considered during the construction of the network platform of outdoor sports clubs. This module mainly includes the following aspects: first, the information exchange part of outdoor sports activities; Second, club members message forum; Third, the network survey part. Through the establishment of the interaction module, different members of the club can communicate and interact with the help of the information platform, so that the club can have an in-depth understanding of people's sports needs and habits, and adjust sports or from them.

#### 4.1.3 User Management Module

The user module mainly aims at the management of application personnel related to the platform, including members of outdoor sports club and background management personnel of the network platform. Because this module involves the personal information of different users and is related to the normal operation of the network platform;

Therefore, it is necessary to strengthen the security and confidentiality of the module data, carry out regular network environment testing and data management. Therefore, when setting up the user management module, the visitor rights should be set, and the browsing and operation rights should be layered according to different levels.

## 4.2 Suggestions on the Construction of Network Platform for Outdoor Sports Clubs

In view of the current development status of outdoor sports clubs, the following Suggestions are put forward for the construction of the network platform of outdoor sports clubs. Secondly, the main purpose of building the club network platform is to provide daily management services for outdoor sports clubs, which puts forward higher requirements for the flexibility of the network platform. Therefore, each outdoor sports club should build an appropriate outdoor sports club network platform according to its different types and actual conditions. Third, as mentioned above, outdoor sports clubs are membership-based organizations that serve club members and meet their actual needs. Therefore, the construction of outdoor club network platform must take the club members as the core and the text as the construction purpose.

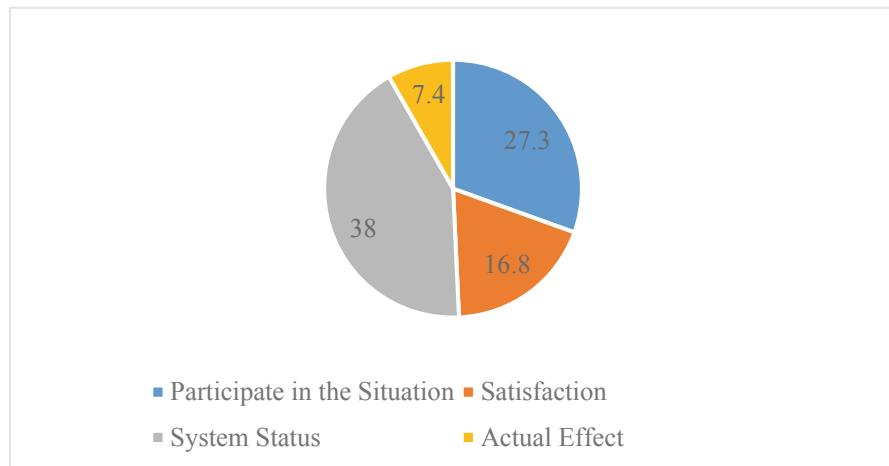
## 4.3 Platform Test

Judge a network platform has always been the measure of the overall situation of user experience, in order to verify the performance of this system, this paper studies the comprehensive account of the participation status, outdoor sports club members satisfaction, cultural background factors, such as the quality of the system factor to establish different types of members to be the use of different levels, and to the experience of members of the club by 40%, 30%, 20%, 10% of the grade weight with the help of Kohonen network algorithm to the comprehensive building of network platform test, the test results in the following Table 1, as shown in Fig. 1, the chart data is the sorting result.

**Table 1.** Test results of the system from different indicators

	Value	Mark	Score proportion	Score
Participate in the situation	1	95	40%	38
Satisfaction	5	91	30%	27.3
System status	10	84	20%	16.8
Actual effect	15	74	10%	7.4
<b>Final score</b>				<b>89.5</b>

Data came from the in-depth analysis of financial data in the experiment



**Fig. 1.** Statistical results of network platform scores

As can be seen from the data in Table 1 and Fig. 1, the test results show that apart from the difficulty of adapting to the network platform partly due to club members' own factors, the evaluation of the network level of outdoor sports club members and relevant management personnel is generally satisfactory, which verifies the feasibility of the system.

## 5 Conclusion

To sum up, the construction of outdoor sports network platform involves many aspects, including information, interaction and user network modules, and its construction is a long-term project. It is necessary to make unremitting efforts, combine the characteristics of outdoor sports with the characteristics of the current outdoor sports, and make use of the existing information technology resources and sports resources to meet the physical and mental health needs of members of the outdoor sports club, and construct a scientific and orderly network platform of outdoor sports club. So that the outdoor sports club can better serve the club members.

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# The Construction of Off-School Practice Teaching Base for Investment Major Based on Big Data

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**Abstract.** Aiming at the problems in securities investment practice teaching, such as the large gap between school practice teaching and industry demand, the core business connection in off-campus practice teaching is difficult; exploring the construction of off-campus practice bases, and reducing the gap between on-campus practice teaching and industry demand. Based on the construction of traditional off-campus practice teaching bases, this paper proposes an off-campus practice teaching base combining big data technology. The off-campus practice teaching base based on big data technology is an important part of campus construction. It not only meets the needs of “Internet +” vocational education development, but also meets the requirements for training enterprise talents. Based on the system structure of the practice base under big data, combined with the characteristics of 5 V of big data, it comprehensively analyzed the management strategies of the personnel, equipment and teaching process of the base. Through the use cases of the practice base outside the school, in the context of the era of big data, it effectively implemented the “education for the fittest is the best education” modern education concept. In this paper, a questionnaire survey is conducted on the satisfaction of students in a practical teaching base outside the school, and the teaching effect is evaluated. Experimental simulation results show that students have a good response to the experimental base. After training, the temperament and business quality of students have been improved, and teamwork awareness has been enhanced. It can be seen that the construction of a practical teaching base based on the background of big data will greatly integrate the base resources and provide timely feedback and countermeasures to the problems that arise at the base. The questionnaire survey shows that the proportion of students who are satisfied with the management of the practice base is 64%, the basic satisfaction rate is 28%, and the dissatisfied rate is 8%, which indicates that the students are mostly agreeable with the management of the practice base and are basically satisfied. The dissatisfaction accounted for 36% of the total, indicating that there is a certain deviation in the management of the practice base. Based on the big data background, the construction of an off-campus practice base for investment majors has certain research value. Big data technology can be used to improve traditional practice base some flaws.

**Keywords:** Investment science · Teaching base · Big data · Off-campus practice

## 1 Introduction

With the rapid development of IT technology, people's work, study and lifestyle are undergoing tremendous changes, efficiency has been greatly improved, and information resources are shared to the greatest extent. At present, the biggest difficulty encountered by investment majors when they go out for internships is the lack of practical ability and practical project experience. According to a survey of counterparts in professional companies related to network and cloud computing and big data, the main reason for students' lack of practical experience is that investment is a very practical, practical and comprehensive specialty, and the application of investment science in enterprises is also Comprehensive and complex.

Every graduation time, tens of thousands of students flock to the market. A large number of graduates cannot meet the job requirements of employers. They need retraining before they can take up jobs, but it is always difficult for companies to recruit suitable employees [1, 2]. In view of the difficulty of finding employment for college students and the difficulty of recruiting ideal new employees, it is proposed that school-enterprise cooperation should be strengthened and the employment capacity of students should be improved through the research on the construction of big data extracurricular training and practice bases [3, 4].

The emergence of a distributed stream big data analysis platform solves the constantly generated data stream. In streaming big data analysis, the data processing workflow is abstracted into a directed graph called topology. Data is read from memory and processed tuple-by-tuple, and the results of these processes are dynamically updated. The performance of a topology is evaluated by its throughput. Aiming at the heterogeneous flow big data analysis cluster shared by multiple topologies, Jiang proposed an efficient resource allocation scheme to achieve the maximum and minimum fairness of the throughput utilization of each topology. The simulation results show that the resource allocation scheme proposed by Jiang significantly improves the maximum and minimum fairness in the practicability of the topology throughput, and the calculation complexity is low [5, 6]. Through a four-year qualitative study of four large Scandinavian companies, Caesarius was able to develop typologies in how emerging companies deal with exploration and resistance to big data technologies [7, 8]. The maturity of the information society is characterized by mass production of data that provides insight into human behavior. Analytics (as in big data analytics) is a practice of understanding data trajectories through interactions with network devices, platforms, and organizations. Mittelstadt explores the ethical significance of special groups in analytics and believes that the privacy interests of algorithmic groups with inviolable personality must be recognized along with individual privacy rights. Individuals grouped algorithmically have collective interest in creating information about the group and the actions taken on behalf of the group. In assessing the ethical acceptability of the analytics platform, group privacy was proposed as a third benefit, balancing personal privacy and social, business, and cognitive interests [9, 10]. Due to the high complexity of today's data centers, a lot of research attempts to understand data center workloads and resource utilization. However, there is little work to explore unsuccessful jobs and task executions. Rosa researched and predicted three types of

unsuccessful execution in Google data centers, namely failure, termination, and eviction. And experimental evaluation results show that the proposed model can accurately divide 94.4% of work and 76.8% of events into four categories [11, 12].

The off-campus practice teaching base serves as an important platform for implementing practical teaching, that is, through the four-year consistent system of school-enterprise, the investment undergraduate talents are cultivated at different levels and stages, and finally the positioning of applied talents for the investment specialty is completed. This article starts from the perspective of the construction of out-of-school practice teaching bases. Both universities and enterprises jointly draft a talent training plan, jointly develop practical teaching materials, co-management and evaluation, and proposes to invest in the construction of out-of-school teaching bases based on the background of big data. The platform of educating people to cultivate students' ability of high-level employment, organically unify colleges and universities to "educate talents", students "successful talents" and enterprises "select talents" to achieve a win-win situation.

## 2 Proposed Method

### 2.1 Big Data

From the context of the development of big data, big data has four dimensions of meaning: first, the scientific dimension mainly refers to big data technology, that is, the use of business intelligence, cloud computing, visual database and other technologies to collect and analyze data. Second, the economic dimension mainly refers to the big data industry, which mainly refers to the companies that provide data production, collection, storage, processing, analysis and services, including the construction of big data infrastructure, research and development of big data related products, and big data information technology service. Third, the political dimension mainly refers to big data strategy. That is, government departments' policy plans for promoting the development and application of big data. Fourth, the social dimension mainly refers to big data thinking. That is, the widespread application of big data in the social field.

### 2.2 System Architecture of the Training Base

The smart campus under construction has a comprehensive network infrastructure and data support platform. Through the organic integration of wireless sensor networks and the Internet of Things, a wired and wireless full-coverage training base network environment has been established; through identity data, application data, and The information-aware basic database realizes the integration of data storage, middleware, supporting software and various application systems. According to the characteristics of the investment professional practice teaching base, on the basis of the support platform, five major business base systems including technology, security, income generation, energy saving, and harmony are planned. When planning the system, the scalability of the system must be considered, and each system must maintain a certain degree of redundancy. The application of big data technology in the management of

practice teaching base promotes the reform of practice teaching behavior, provides convenient services for teachers and students, improves the efficiency of practice teaching and management, and speeds up the innovation and development of school practice base construction. The technology base has functions such as intelligent workshop, training room management, attendance management, and base management application; the safety base has functions such as intelligent vehicle management, base safety monitoring, security alarm, and patrol management; the revenue-generating base has intelligent equipment, intelligent storage, and intelligent simulation And other functions to provide intelligent services for the in-depth integration of education and infrastructure; energy-saving bases have functions such as base metering, water and gas management network monitoring, intelligent lighting, and centralized control of air conditioning; and harmonious bases have base information release, digital conferences, intelligent displays, and intelligent data rooms And other service functions. Through data integration, business integration, virtual simulation, remote monitoring, visual display and other functions, it provides easy-to-operate intelligent training base integrated business management and control platform linkage services for various users or roles to make the base intelligent, teaching, learning, Systematization and integration of management, scientific research and simulation practice.

### 2.3 Application of Off-School Practice Bases Under Big Data

Although the subsystems of the practice base have their own independent functions, the information and data sharing, business integration, and collaborative management and control are better achieved through the support platform, providing intelligent services for various end users, and fostering intelligent enterprises in an intelligent teaching environment. Skilled people. It creates intelligent practical teaching and professional experience environment for students, and effectively implements the modern education concept that “suitable education is the best education”. For the practical implementation of practical teaching and management, many factors including human flow (teachers, students, administrators), logistics (equipment, materials), capital flow, and information flow (teaching resources, management information), etc. Real-time collection of relevant process information in perception and Internet of Things technology, and big data analysis, statistics and information release, so as to achieve intelligent management of practical teaching.

#### (1) Practice base personnel management strategy based on big data

Because the personnel involved in the practice base have complex structures and frequent personnel rotations: enterprises and institutions that cooperate with the base to carry out project cooperation, as well as personnel who perform skills training at the base. The traditional method of personnel management is real-time registration through paper or computer. These generated data can only be used for project acceptance and recent work summary. It is difficult to achieve data analysis, statistics and information feedback in real time. Therefore, the practice base management system collects various types of personnel information in real time and analyzes them through big data tools to form relatively complete, reliable and valuable data resources.

When students or trainees enter the base laboratory or workshop, use the RFID technology-based ID card for card swiping or face recognition system for attendance management. When the system is set up, the corresponding permissions are set according to the student grade, and the teacher swiping card is effective before the student. Send the credit card data to a remote server for statistics and review by relevant personnel, which not only reduces the work of teachers, but also improves the fairness of attendance management. For the reception and inspection staff of the relevant practice room of the base, after the visitor unit goes to the relevant functional department of the school to complete the formalities, the functional department authorizes the school receptionist in the base access control system. The receptionist leads the inspection team to swipe the card to visit, no need for practice room management. The staff waited for the door to be opened and explained by the base electronic guide PAD system.

## (2) Practice base equipment management strategy based on big data

For all the practice rooms of the base, professional teachers can declare on the practice management platform according to the teaching needs of students of all grades. After the review and review by the professional department, the school's practical training office will conduct the intelligent overall arrangement after the approval; The equipment and tool usage status of the place is quota online by the system, and real-time statistics and information release are provided. It is applied to experimental training equipment, smart sockets, materials and measuring tools through the Internet of Things RFID technology, which effectively implements practical equipment. Real-time tracking and visual management. As a result, corresponding data resources are automatically generated in the system, which are used to feedback the completion rate of practice projects for students of all grades, to consider the utilization rate of various practice rooms, the frequency of use of related equipment, measuring tools and depreciation, thus becoming equipment and facilities And update the important basis.

All water, electricity, and gas shunt switches in each building of the base are installed with digital measuring instruments with remote transmission capabilities. The real-time remote data collection and energy consumption monitoring of the measurement area through the network enable the statistical analysis of water and electricity consumption at the base Intelligent and instant stage. Designing the project as semi-open, plus related content identification and display, this can not only replace the water and electricity automation control technology practice center that has issued a building intelligence and mechatronics major, but also make the practice project closer to reality, allowing students to Enter advanced corporate actual positions in advance.

## 3 Experiments

As there is currently no practical teaching base of investment science that combines big data technology, a practical teaching base of investment science is used as an example to analyze and evaluate its teaching effect. In order to respond to the urgent needs of

employment units who are familiar with a large number of business processes, proficiently fill in forms and operate software, and have ineffective off-campus practice teaching, securities investment applicants have poor performance. Invested in a professional practical education base, and after research and exploration, since December 2018, we have jointly researched and developed a college student professional development and shaping project. According to the practical teaching arrangements of the investment training plan, the main content of off-campus practical education is the professional development and shaping of college students. The project includes business etiquette, accredited internships, market research and graduation internships, and employment contract signing. Throughout the four years of practice teaching outside the school. Each stage is seamlessly connected with the practical teaching links of the investment major. Aiming at the differences in school years, with employment and employment competitiveness as the guide, the core of cultivating and shaping college students' professional literacy, and promoting the planning and execution of individual careers, improve the employment rate and employment level of college students. In the end, zero-distance docking between college students and work is achieved. And through the survey of 50 students who participated in the investment of science and practice teaching base practice satisfaction survey.

## 4 Discussion

### 4.1 Evaluation of Teaching Effect

The practice teaching link of the investment education practice education base is shown in Table 1.

**Table 1.** Practical teaching in an investment education practice base link

Time	First grade	Second grade	Third grade	Fourth grade
Link	Business etiquette career planning	Understanding the internship	Market survey	Graduation internship sign employment
Form	Course training	On-the-job training	Social survey	On-the-job training workplace simulation

Since 2016, this investment professional practice education base has provided 156 internship opportunities for financial students in 2014, 2015 and 2016, all of which are voluntary application and two-way options. During internship week, winter and summer vacation, students make full use of their spare time. After a period of internship, students not only felt the excitement of the first visit, but also felt the hard work. They have a better understanding and reflection on what they have learned in class at work. After returning to the classroom, they showed a high degree of enthusiasm for learning, and were able to further clarify the planning of their professional students and re-plan the relationship between classroom learning, research,

postgraduate research and employment. After the internship, the passing rate of students' examinations has increased significantly, and the passing rates of qualifications in banking and securities industries have exceeded 60%. In addition, the practical education base also provided 32 graduation internship opportunities and 5 employment opportunities for investment majors in 2014 and 2015. When students cannot find a suitable graduation internship unit and job, the opportunity provided by this internship base provides students with more choices. Of course, securities companies choose the best students for internships and employment, which in turn stimulates students' enthusiasm for learning. As long as they are willing to study hard, they can find better jobs for themselves.

Since the start of the career development and shaping project for college students in 2018, investment students have completed the first phase of business etiquette training, and students have generally responded well. After training, temperament and professionalism were improved, and teamwork awareness was strengthened. It can be seen that the construction of a practical teaching base based on the background of big data will greatly integrate the resources of the base, and provide timely feedback and countermeasures to problems that arise at the base.

#### 4.2 Questionnaire Survey

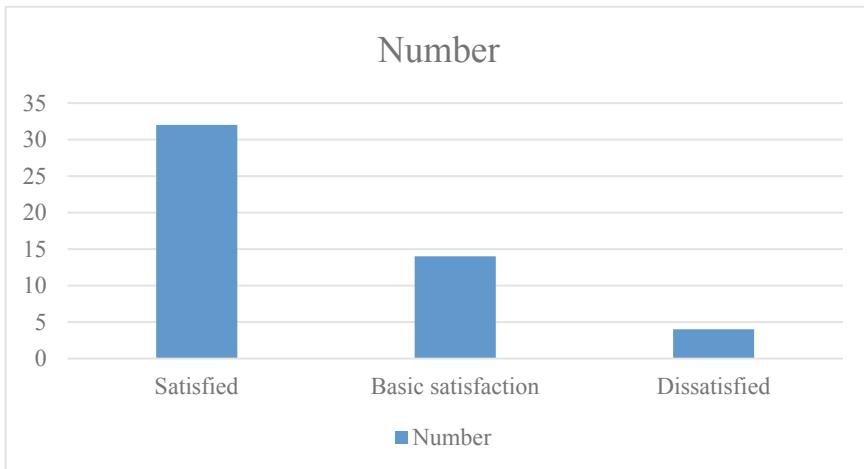
In this experiment, 50 students were selected from the students who participated in the practice teaching of the word practice teaching base to conduct a satisfaction survey. The results of the questionnaire survey are shown in Fig. 1.



**Fig. 1.** Students' evaluation of the site facilities of the base

As shown in Fig. 1, the percentage of students who are satisfied with the facilities of the practice teaching base is 80%, and the percentage of those who are basically satisfied is 20%. The dissatisfied is 0, indicating that the practice teaching base has

been recognized by the students at the venue facilities. The facilities and conditions provided by the base can meet the needs of students and allow students to learn and exercise. Students' evaluation of the management of the base is shown in Fig. 2.



**Fig. 2.** Students' evaluation of the management of the base

As shown in Fig. 2, the percentage of students who are satisfied with the management of the practice base is 64%, the proportion of basic satisfaction is 28%, the proportion of dissatisfaction is 8%, and the total proportion of satisfaction and basic satisfaction is 92%. The management of the base is mostly agreeable, and it can be basically satisfied with 36% of the total dissatisfaction, indicating that there is a certain deviation in the management of the practice base. This experiment learned through interviews with the base management staff and representatives of active students. Jian, did not have previous management experience in practical teaching activities for colleges and universities, did not do too much management constraints on students. It can be seen that the construction of an off-campus practice base for investment science under the background of big data has a certain research value, and some defects of the traditional practice base are improved through big data technology.

## 5 Conclusions

The off-campus training base based on big data technology is a training base that integrates the Internet of Things, intelligence, perception, and information using information technology such as the Internet of Things, cloud computing, and ubiquitous perception. At present, it basically covers the functional areas of teaching and management. It not only fully reflects the real-time and efficient characteristics of teaching management in training bases, but also fully reflects the transformation of modern vocational education management concepts based on educating people and

developing students. Objective requirements for development. Although there are hidden dangers such as data integrity, authenticity, science, and security in the application process, with the operation and continuous updating of the system, the investment professional training base will be increasingly perfected to better adapt to the construction of modern vocational education, Effectively serving the needs of corporate talent training, more in line with the inevitable trend of “Internet +” vocational education development.

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# Planning and Design of Transshipment Center Platform Based on Internet of Things

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**Abstract.** With the development of the logistics industry, competition between logistics companies is becoming increasingly fierce. In addition to establishing a mature and perfect logistics system, the pursuit of customer satisfaction is also one of the goals reached by modern logistics companies. The purpose of this article is to plan and design the IoT-based transfer center platform. Aiming at the disadvantages of the existing logistics transfer mode, this article analyzes the advantages of applying the Internet of Things-related technologies to the logistics industry, and based on the theoretical basis of Internet of Things technology, RFID technology and two-dimensional code technology, combined with server development language (JAVA) and Front-end development language (HTML + CSS), two development languages, designed and implemented the IoT-based transfer center platform. The performance test of this platform is conducted in this paper. The test results show that the platform can provide convenient management services for warehouse management personnel, and improve the informationization level and core competitiveness of logistics transshipment. This paper analyzes the time consuming of 10, 50, 100, 500, 1000, 2000, 4000 pieces of data at the same time, and obtains that when the amount of data reaches 4000 pieces, the running time is 10.586 s. It can be seen that the performance of the system in this paper is high, which can meet the needs of logistics transfer.

**Keywords:** Internet of Things · Transfer center · Smart logistics · RFID technology · Two-dimensional code technology

## 1 Introduction

At present, the operation mode of most logistics companies in China is the customer ordering model. The logistics company that accepts the order issues orders based on a fixed address, but this model has disadvantages. The highly evaluated customer satisfaction has not only become a new standard for measuring the maturity of logistics companies, but also broadened the customer base of logistics companies. For a long time, the logistics concept given to people in the logistics industry has been sent from the recipients according to a fixed delivery address demand. People have a more reasonable and humanized logistics experience, that is, the need for real-time logistics of logistics. The so-called real-time transshipment means that when the logistics is in a dynamic transportation state, the receiving address will be changed in real time and will

be accurately delivered to the new address. Therefore, logistics enterprises need to truly implement real-time monitoring of dynamic logistics to ensure the synchronization of goods and information flows in logistics and the accuracy of logistics information. Then make real-time and timely changes, and perform real-time synchronous feedback on logistics and transportation.

The Internet of Things can achieve real-time transmission in the following areas: (1) Multi-source collection, tracking and real-time modification of logistics information based on technologies such as RFID. In order to achieve real-time transshipment, you first need to correctly collect and enter product information. Secondly, you can grasp the logistics information of the products at any time. The most important thing is that the logistics information of goods can be changed at any time, real-time update of the logistics information, and real-time transmission. RFID technology, which is based on the Internet of Things technology, is supported as needed. RFID technology is used to achieve multi-source information collection of the project, which greatly improves the efficiency of collecting information. At the same time, the automatic reading function of RFID technology can not only improve the accuracy of the data, It can also realize the labor cost of logistics enterprises, and its tracking function can realize the full information exchange of goods from source to end. The most important thing is that the electronic label that holds the logistics information can be replaced at any time, which is beneficial to the change of logistics information and the real-time transmission very important [1, 2]. (2) Real-time monitoring of dynamic targets. The GPS/GIS technology of the Internet of Things technology realizes the GPS positioning of logistics distribution vehicles and dynamic targets, and then performs data communication. Then using electronic maps and database technology, you can determine the location and dynamic target status of logistics distribution vehicles, thereby effectively affecting the whole real-time monitoring [3, 4].

The main research content of this article is to plan and design the transfer center platform in the context of the Internet of Things. The main research is as follows: (1) The actual situation of the transfer center is analyzed, and the Internet of Things technology, RFID technology and two-dimensional code technology are discussed. (2) The use of IoT-related technologies to achieve a stable and reliable transfer center management system suitable for IoT-related pipelines, to help the Internet transformation of warehouse and logistics companies, and improve their competitiveness [5, 6].

## 2 Method

### 2.1 Internet of Things

#### (1) Internet of Things technology

The Internet of Things technology is based on the existing network technology. Therefore, radio frequency identification (RFID) technology, global positioning system, wireless communication technology, infrared sensing, laser scanners, cameras and established protocols are based on other new objects. The new technology adopted by united sensing, etc., connects related items, machinery,

people, and the Internet with each other, and carries out information communication and data exchange to form a large-scale network. Individuals can realize the intelligent positioning and identification of projects, machinery, and people, monitoring, tracking management [7, 8]. At present, the Internet of Things technology has many application types in domestic logistics, such as warehouse management systems, vehicle positioning and tracking systems, and order management systems. One of the earliest successful cases of railway logistics transportation is the automatic identification system of railway numbers.

## (2) RFID technology

RFID technology has become a widely used technology for tag identification and short-range communication, and is now used in many fields. RFID intelligent storage system is the introduction of RFID technology in the existing warehouse management, to achieve the arrival of warehouse inspection, warehouse custody, warehouse custody, movement, migration, inventory and other operations to confirm the automatic collection of data to ensure that warehouse management data on all links the speed and accuracy of the input enable the enterprise to grasp the actual data of the inventory in a timely and accurate manner, and reasonably maintain and control the inventory of the enterprise [9, 10]. Through scientific coding, it is also convenient to manage the batch and storage period of the project. Utilizing the system's location management function, you can grasp the current location of all inventory items in time, which helps improve production efficiency and reduce operating costs. Compared with traditional RFID applications, RFID smart storage systems do not require continuous investment and do not require a large number of tag purchases, so they can significantly reduce costs.

## 2.2 QR Code Technology

The two-dimensional coding technology is a two-dimensional code mode. It can comprehensively interpret the coding method that may express multi-dimensional use of binary data. The components are scanned by the two-dimensional code and the information content is read according to the two-dimensional code. The positioning points and positioning areas of different data storage areas are likely to make mistakes. The two-dimensional code is incomplete or incomplete, and the complete two-dimensional code information can be identified [11, 12].

- (1) Data analysis: Determine the type of QR code encoding, and perform text conversion according to the corresponding character set.
- (2) Data encoding: The text is converted into a sequence of 8-bit units to form a sequence, and the conversion of QR code data to content is achieved through the sequence. Letters, Chinese, Japanese, are only grouped in different ways and patterns, and the basic method is the same. Two-dimensional codes have more powerful information recording functions than one-dimensional bar codes, but they have limited capacity.
- (3) Error correction coding: According to the above requirements, the above code word sequence is divided into blocks, an error correction code word is generated according to the error correction level and the block code word, and an error

correction code word is added after the data code word sequence to become a new sequence.

- (4) Complete splicing of data information: The above-mentioned generated sequence is divided in a specific rule block, and each blocked data is calculated. Finally, the data error correction sequence is calculated to form a complete two-dimensional code data information.
- (5) Establish the matrix: Before establishing the matrix, we must first understand the basic structure of ordinary two-dimensional code. Position detection pattern, position detection pattern tap, positioning pattern: The position of each QR code used to find the two-dimensional code is fixed, but the size and specifications are different.  
After understanding the basic structure of the two-dimensional code, the detection mode, color separator, positioning mode, correction mode, and code word module are put into the matrix, and the generated complete sequence is added to the corresponding dedomain according to the corresponding rules.
- (6) Mask: Use the mask graphics in the coding area. The light and dark colors of the QR code graphics can be configured in the best way.
- (7) Format and version information: The generated format and version information will be placed in the corresponding area.

### 3 Experiment

#### 3.1 Experimental Environment

The environment and tools used in this system are as follows:

Computer operating system: Linux;  
Database: MySql5.5;  
Database modeling: Powerdesigner 15.3;  
Business model modeling: Rationalrose2007;  
Prototyping tool: AxureRP7.0;  
Code development environment: Eclipse 3.2;  
Server: JBoss.

#### 3.2 System Architecture

The entire system is divided into: infrastructure layer (Basic equipment, systems, middleware, etc. required by the system), resource layer (Various data and information libraries encapsulated by specific functions), and application support layer (All application systems provide various data) is divided (Access service center service system), application system layer (Various application systems that implement specific functions). Usually, the separation of the system only provides services in the form of interfaces used by other modules. Because a large amount of information in the module should not be disclosed to the outside, the definition of the access domain of the module needs to be divided during the design to prevent the information of the module

from being damaged due to the definition of the access domain. The object-oriented thinking mode pursues a single kinetic energy for each module, and the more independent the module, the better. In other words, when dividing a module, only the elements that complete the function are divided into modules. Therefore, the various elements within the module must be closely related. Otherwise, the module is not split. Therefore, the modules must be closely related. In other words, the degree of cohesion between modules needs to be high.

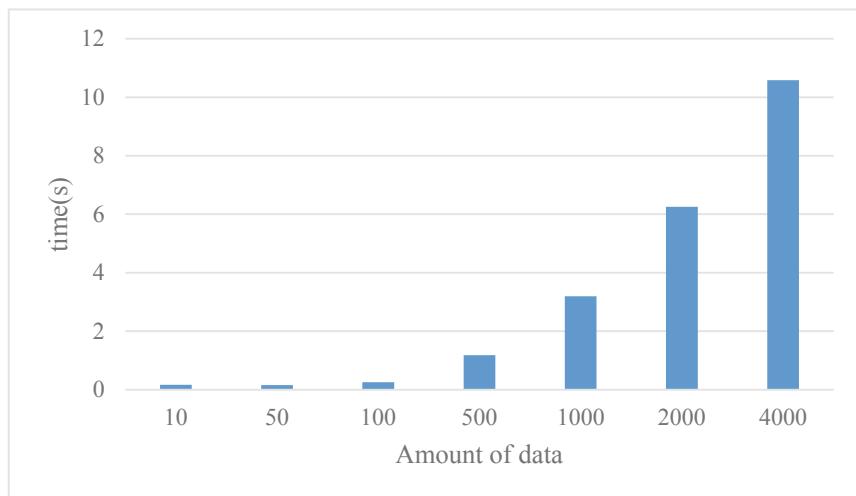
## 4 Discussion

### 4.1 Experimental Results and Analysis

This paper analyzes the running time of 10, 50, 100, 500, 1000, 2000, and 4000 data volumes by randomly generating virtual users. The performance test shows that when the amount of data reaches 4,000, the system's access time is still very stable, and the results can be returned to the user within the prescribed time. System performance tests are shown in Table 1 and Fig. 1:

**Table 1.** Performance test results

Amount of data	10	50	100	500	1000	2000	4000
Time (s)	0.167	0.158	0.254	1.181	3.196	6.254	10.586



**Fig. 1.** Performance test results

## 4.2 Suggestions for Promoting the Construction of Transshipment Center Platform

- (1) The government actively studies and implements the relevant policies and regulations of the platform

The construction of the transshipment information platform is inseparable from the cooperation between the government and the enterprise. In view of the difficulty in sharing information in the logistics field, government departments should take the lead in actively taking actions. On the one hand, reform the government management mechanism and do a good job of coordination between various departments, corresponding management norms; on the other hand, make unified planning and active guidance for enterprise information construction, regulate the container transportation market by issuing corresponding policies, and promote enterprises to avoid homogeneous and isolated competition and move towards heterogeneous information fusion.

- (2) Establish a unified technical standard system to regulate the application of the Internet of Things

Regarding the construction of information platforms, standardization should come first. The Internet of Things is not a simple and specific network or technology, but a set of technical systems from the perception layer to the application layer and from the local to the whole. Without perfect standards and specifications as support, it is difficult to achieve its purpose of “smart services”. On the other hand, it is also necessary to strengthen the formulation and improvement of operating standards for logistics related activities such as boxing, transportation, handling, stacking, and handling of import and export business.

- (3) Focus on the integration of optimization technology and information technology

When promoting the establishment of a logistics transfer information platform based on the Internet of Things, attention must also be paid to the integration of optimization technology and information technology. The so-called optimization technology is the set of feasible solutions that meet the constraints, find the best solution globally, the theory and method applicable to the process of the local best solution, establish operations theory and computer including data, etc. The modular areas of design, respectively, restrict processing, algorithm design, and program design.

From the definition of optimization technology, we can know that optimization technology has a natural connection with computer technology. Facts have proven that logistics activities themselves have a natural need for optimized technology. Numerous optimization technology achievements have been born in the field of container logistics optimization. For a long time, we all have to face many problems that the theoretical research results cannot be fully applied in practical work. Nowadays, with the rapid development of information technology, we see the hope of solving this problem, that is, an information world about container logistics built on the Internet of Things technology. Its appearance makes the theory and reality no longer far apart, and it became accessible. An information platform can be regarded as a window of the information world. It requires not only the hardware support of information technology, but also the ideas and theories of optimization technology.

## 5 Conclusion

By real-time logistics transshipment, customer satisfaction and service levels in the logistics industry can be greatly improved. At the same time, the sharing between enterprises, such as the cooperation between enterprises such as logistics warehouse sharing and vehicle resource sharing, is the use of logistics resources, which maximizes the realization of the goals of the logistics industry, and also helps companies benefit from each other win-win results. At the same time, the real-time transshipment of logistics has promoted the development of China's logistics industry to a certain extent, further promoted the development of modern logistics, and promoted the development of China's entire economy.

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# Integrated Information System of Township Power Supply Office and Team Based on Cloud Computing

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**Abstract.** Township is the weak point and weak point in the coordinated development of China's economy. It is also a link that must be strengthened in the coordinated development of China's economy. The development of power grid provides a strong guarantee for the development of township economy and related industries. With the smooth progress of "SG – ERP project" of state grid corporation of China, the informatization construction of township power supply units has made remarkable achievements, and the informatization and datamation of daily management have been basically realized. However, there still exists the construction pattern of insufficient intelligence and failure to combine cloud computing technology to support the network of power supply system, which also greatly depresses the ideal implementation effect of information system. In order to fundamentally solve these constraints, it is necessary to carry out a series of power supply team integrated information system construction. In the current power supply system, the team is the direct executor of the daily work of the state grid corporation, as well as the grass-roots organization of the entire power industry. The efficiency of the township power supply station and the team directly affects the reputation of the state grid corporation. This paper will first make a detailed description of the information status of the township power supply station, and then put forward the overall framework of the township power supply station information integration construction system in this study, then the system is deployed and tested, and finally the application value and efficiency of the system are analyzed.

**Keywords:** Cloud computing · Township power stations · Team integration · Power supply system

## 1 Introduction

Cloud computing technology in the practical application has reached a mature stage, the power supply for rural power substation and team integration information system construction also brought opportunity, but at present domestic each township power substation of team integration information system construction has not yet formed a unified standard and consensus, lack of efficient and unified management way [1, 2].

In terms of power supply and team management, the majority of township power supply stations are still in the stage of paper records or Excel management. Such a weak informatization management mode has seriously restricted the work efficiency and execution safety of township power supply stations, and it is even difficult to sustain the requirements of modern informatization enterprises [3, 4]. Therefore, township power supply stations urgently need to build a management system with specific characteristics of cloud computing to provide more efficient and safe power supply services, and strengthen the management of teams to improve the efficiency of implementation [5]. Power substation and its team of small towns is the integration of information system construction also has very important value and significance, on the one hand, the team construction of integrated information system can strengthen the application of cloud computing technology, improve the service ability of village and township power substation and service level, the villages and towns of power substation information exchange and fusion, which has important application value; On the other hand, the construction of integrated team and group information system improves the overall collaborative innovation capability of state grid corporation through the application of cutting-edge information technologies such as cloud computing, human-computer interaction and information security [6, 7].

Foreign countries have been building integrated information systems for township power supply stations and teams for many years, and have achieved remarkable results [8]. By carrying out the information-based management service based on cloud computing, they not only realized the information-based management of team construction, but also improved the management efficiency of township power supply stations, and the power supply efficiency of township power supply stations was also greatly improved [9, 10]. It can be seen that it is an effective way to improve the power supply and management efficiency of the integrated information construction of township power supply offices and teams by improving and upgrading the integrated information system of township power supply offices and teams based on modern cloud computing technology [11]. It not only meets the development needs of township power supply stations themselves, but also conforms to the planning and layout of the entire national power grid, and even plays a strong role in promoting the rapid development of national economy [12]. But obviously, at present stage our country villages and towns power substation and team integration information system construction still lags far behind the developed countries, our way of management in most villages and towns is still in paper records this way of management, not only the efficiency is very low, and realistic causes the management of the team is not in place or message does not reach the designated position phenomenon [13, 14].

In order to fundamentally reverse the lack of integrated information system in township power supply offices and teams, this study made use of the advantages of cloud computing technology to carry out field investigations in township power supply offices and conducted systematic demand analysis and functional analysis on the daily work characteristics of township power supply offices [15]. In terms of the selection of system architecture, this study selects B/S type system architecture according to local conditions, thus forming the deployment scheme of the integrated information system. In the process of deployment, the system is designed in accordance with the actual problems and requirements, and the logic interface is reserved for the future business

expansion in advance, so as to truly realize the integrated information system of township power supply office and team, which reflects the cloud computing technology and the highest execution efficiency.

## 2 Method

### 2.1 System Demand Analysis

Power substation integrated information management system of villages and towns must highlight the characteristics of the power sector, so in the design of the system must be connected to the national grid system in terms of design, function module to keep good reproductivity and inheritance, unity is power management system, can better meet the needs of staff operating experience.

In terms of compatibility, the system must consider that the township as a grass-roots government unit, its office equipment and staff business capacity may also be difficult to match the big city, therefore, the system of hardware requirements must be as low as possible. The operating system can choose Window 7, and the browser can keep the default browser for the best utilization.

In terms of data processing, because the system adopts the layout mode of local area network, the maximum throughput of the data must be limited to some extent, and the adjustment should be made according to the actual situation of the internal network, so as to ensure normal operation of other functions in the whole domain.

### 2.2 Technical Route

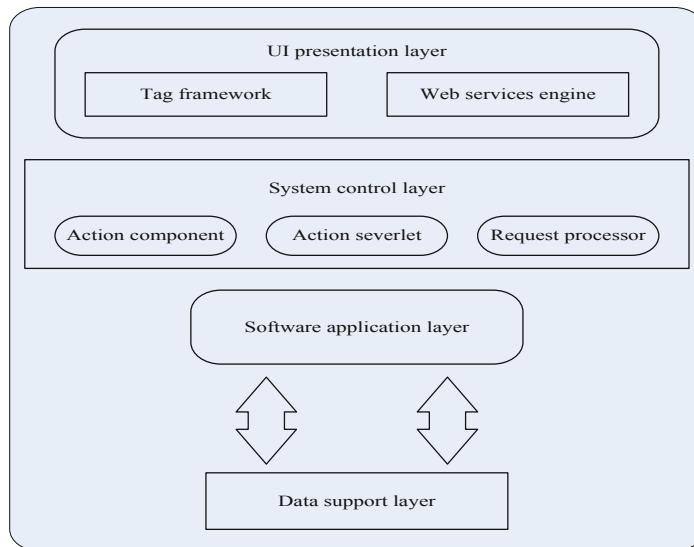
Based on cloud computing power substation and team integration information system planning of villages and towns, this study first fully collected the standards of the state grid data interface information, understand the related integration technology development, USES the high market share of J2EE technology architecture has carried on the technical specifications, to the requirements of state grid corporation of SU - GAP as the development and operation platform.

In order to ensure the compatibility with other management software, the system in the design of strict requirements for all interfaces to choose a strong compatibility of the standard interface port connection, in the underlying design of the business, the system also make full use of open technology to achieve.

To improve the operation efficiency of the whole grid system and reduce the cost to a great extent, the desktop client of this system USES is the MVP of independent research and development of state grid corporation management client, architecture platform is the integration of integrated interface and general technique to complete the registration and the application of encapsulation, and provide free access to business applications and management functions.

## 2.3 System Architecture

The architecture of the integrated information system of township power supply office and team based on cloud computing studied in this paper is divided into four logical levels, namely system control layer, software application layer, data support layer and UI presentation layer. The specific system architecture hierarchy is shown in Fig. 1 below.



**Fig. 1.** System architecture diagram

The system control layer mainly deals with the data interaction between the UI presentation layer and the software application layer. Software application layer is the core expression of system functions and the most commonly used logical request operation processing object in the whole system. Database data support layer set purpose is to provide a window to the outside world to visit, and articulated various DataProvider to access the data source of data, the level of opening of DataProvider completely open, it can easily achieve the goal of the data package as a way for objectification of code to perform the operation, and the security level is very high, need not worry about the system being attacked; UI presentation layer is also the graphical operation interface of the management system, which is the hierarchy that users have the most contact with. The interface adopts the technical mode of HTML dynamic and static web page integration to encapsulate and realize, which has the advantages of beautiful interface, excellent compatibility and so on.

### 3 Experiment

#### 3.1 System Construction

This system adopts the system architecture of B/S, which realizes the separation of use and service. Users can access this system through the network without affecting the system to execute other commands. Furthermore, users themselves can access data from other services and interfaces over the network.

The integrated information system is a complex system, including database server, browser server, management server and file manager. According to the planned deployment, the connection between them adopts the high-speed connection mode of LAN and is unified within the firewall of security scope. When the system provides services for the visitors, it also provides the double-execution interface for other applications, so that the system can easily connect with other information software and achieve the purpose of system function expansion.

#### 3.2 System Deployment

Township power substation based on cloud computing and team integration information system using the three servers, the cluster service deployment, with load balancing device after dealing with the analysis of the matching of the user requests to load pressure is relatively less in the server, the server response, the backend database, Oracle RAC cluster mode response of the server storage or written order, guarantee the reliability of data storage.

In order to avoid monorail failure, the logical architecture of the system is deployed in two parallel systems, and each set of services is deployed on a physical Server.

### 4 Discuss

#### 4.1 System Test

System performance refers to the use of special test tools, and according to the test program of the system to measure the relevant indicators, and even according to the different application needs to prepare the corresponding test tools, complete the evaluation of the system possible problems.

In the test of this system, the performance test and the safety test of the system are mainly carried out for the application scenarios of the integrated information system of township power supply office and shift group. Among them, the performance test is to detect whether the efficiency, stability, business ability and other indicators of the system operation have reached the design goal; Security testing is to detect whether there are vulnerabilities or risks in the system, so as to ensure the security during use.

##### (1) Performance test

This performance test USES simulated multi-user operations to test the response speed and processing capacity of the system to determine the system capability. Among them, we made the following evaluation principles for system response time:

- If the response time is less than 2 ms, the response speed is considered extremely fast and the level is excellent;
- When the response time is between 2–5 ms, it is considered that the response speed is fast and the level is good;
- When the response time is between 5–10 ms, the response speed is considered average and the level is average;
- When the response time is more than 10 ms, the response speed is considered to be slow and the level is poor;

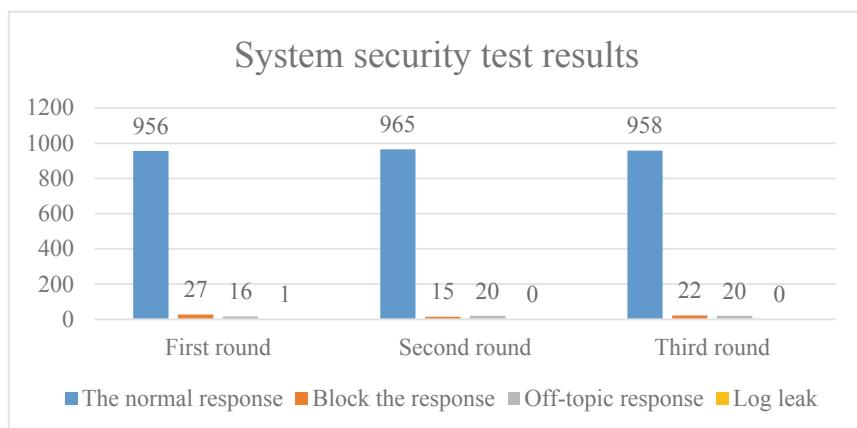
This performance test selected Loadrunner from Emma company of the Netherlands as a statistical analysis tool, and initialized to 100 users to perform operations online at the same time, and gradually increased the number of concurrent users simulated by the system to 500. The test lasted for 10 h, and the system test results obtained after two rounds of tests are shown in Table 1 below.

**Table 1.** System performance test results

Test project	Minimum time	Maximum time	Mean time
The reading test	2.15	2.95	2.55
Organization management test	3.16	3.58	3.37
Report statistical test	3.15	3.52	3.335
File manipulation test	1.14	1.56	1.35
System catalog test	1.27	1.65	1.46

## (2) Safety test

The test of system security is mainly based on whether the blocking response, off-topic response and log leakage occur in the user operation log. All contents including normal responses were screened out from the extracted logs as test analysis samples. A total of three rounds of tests were conducted, and 1000 operation logs were extracted for each round of tests. The test results for system security are shown in Fig. 2 below.



**Fig. 2.** System security test results

Combining the test standards for industrial computers with the results of this test, it can be considered that the system fully meets the requirements for industrial-grade system safety.

#### 4.2 Effectiveness Analysis

Up to now, the cloud-based integrated information system for township power supply offices and teams has reached 30 days of terminal practice in township power supply offices, marketing and maintenance teams, with an average daily usage of 1,800 people. The incidence of security and performance failures is less than 0.3%, and the practical application is good.

The application of the integrated information system based on cloud computing for township power supply offices and teams has effectively improved the information management mode of township power supply offices, which used to stay in paper-based mode, greatly improved the work efficiency and power supply security, and effectively enhanced the support of information system for grassroots business. The application of the system effectively improves the accuracy and convenience of data entry, effectively eliminates redundant process nodes, and provides a strong system platform support for team reduction. Through the use of this system, the situation that the management capacity of the township power supply station has been difficult to adapt to the requirements of modern technology for a long time due to insufficient investment, poor foundation and historical problems will be completely changed.

### 5 Conclusion

This study firstly introduces the villages and towns, the development situation of power substation and team integration information system is pointed out that the current era background, the rural power substation and team construction of the integration of information, and then take the concept of scientific and reasonable architecture of information system construction, and finally analyzes the results of the system construction. From the current practical results, the system has greatly changed the township power supply in the past paper information management situation, brought a new system platform to the management of township power supply, effectively promoted the township power supply and team integration and information level.

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# Online Sales System of Sports Club Fitness Equipment Based on 5G Network

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**Abstract.** This article explains the construction and implementation of a fitness equipment online sales system based on 5G network technology. The arrival of the 5G era will update the traditional sales model, and e-commerce is bound to have more outstanding development space. Using a 5G network to build a sales platform, buyers and sellers can break the boundaries of time and space, and experience and understand products at any time and place. At the same time, they can reduce the information gap between buyers and sellers, establish a transparent and open commodity market, and make transactions more fair. The online sales system based on the SSH framework has two prominent advantages, information security and management convenience. On the one hand, users can rest assured that they can use their own information to customize them to choose the products that are most suitable for them. On the other hand, businesses can get rid of the scorching pre-sale and after-sale order management, real-time grasp of the product sales in the warehouse, focus on sales trends, and timely Make a sales strategy response. The online sales system designed by this institute consists of two modules, the front-end and the back-end, which are targeted at the client and the manager respectively. The two modules are overlapped and independent, to meet the different needs of users in different situations. Reach a high-quality experience in the 5G era.

**Keywords:** 5G network · Network slicing · SSH framework · Online sales

## 1 Introduction

The pace of the Internet era is fast, the blink of an eye will soon be the world of 5G network. It can be imagined that for the sports and fitness industry, the arrival of 5G era will bring a brand new world: ultra-hd live pictures, the scene without delay, and the user experience with a strong sense of reality [1]. The biggest feature of 5G network deployment and application is the scene design, which undoubtedly creates more superior experience space for the majority of fitness users [2]. 5G will fully reflect the high rate, large bandwidth and low delay performance of the network, and meet the diverse demands in different scenarios [3]. Intel reports that in the next 10 years, 5G will bring \$1.3 trillion of new revenue growth opportunities to the global media and entertainment industry, and by 2025, 57% of the global wireless media revenue will be generated by 5G networks and 5G devices [4]. The biggest advantage of 5G network is that it can simplify the configuration of equipment and technical personnel, which will

greatly improve team efficiency and save costs. A team can even manage multiple projects in a day [5]. In terms of the performance of 5G network, it meets the connection requirements of people in today's world for ultra-high traffic density [6]. As is known to all, the current network communication technology operation is faced with network congestion and communication congestion, while 5G network can still maintain and provide safe and high-speed services in a variety of network application scenarios, bringing users unlimited free experience [7, 8]. Thanks to Internet +, the development of e-commerce is in the ascendant. The expanding sales network and the constantly updated sales model are exerting a great impact on the traditional business operation. Online shopping and online sales have become the only choice for customers and merchants. Through the information provided online, we trade goods with users by text, image, audio and other means [9]. The online sales system enables customers to search and purchase what they want without leaving their homes, and merchants can also realize a larger space and a longer time to operate, which is a leap experience upgrade for both buyers and sellers [10]. The development and design of the online sales system for sports fitness equipment includes two modules: the front end and the back end, in short, the user system and the business system. The functions of the user system are mainly to provide users with registration, storage of personal information, browsing of products, recommendation and preservation of desired products, purchase of products and after-sales services [11]. The maximum user-friendliness of the sales system will be embodied in the absolute protection of personal information. The Structs framework foundation of the architecture ACTS as the information protection layer to prevent network vulnerabilities from automatic disclosure [12]. At the same time, after the user completes a purchase of the service, the page will automatically pop up the option of whether to cancel the personal information completely. Once the user selects and confirms, the relevant information of the user will be completely removed, leaving no trace in the system [13]. Merchants perform management and maintenance functions in the background page, from commodity information updating and filling, price changes, customer feedback, sales statistical prediction, etc., the system's greatest friendliness to merchants is reflected in sales statistical prediction [14]. With the convenience of 5G network, merchants do not need to check the sales status regularly. The system can record and generate sales data in real time. Merchants only need to select the type of information they want to know to obtain dynamic data reports, which is straightforward [15].

## 2 Method

### 2.1 Network Slicing Technique

The network architecture of network slicing technology mainly has two modes: independent slicing and Shared slicing, which divides a single combination of physical network into multiple virtual networks without changing the logic. This single combination of logical network should be able to meet different network application scenarios. Whether it's playing games, watching movies or TV shows, or working out, the network needs to be able to automatically handle changes and conflicts between

different network needs. In order to meet the service requirements of different application scenarios and improve resource utilization, network slicing technology has been developed into the core network of 5G network technology. NFV and SDN are the key technologies for the realization of 5G slicing network technology in the future. In order to realize the function of responding to the changes of different application scenarios, mobile broadband is required to play the role of bridge connection and make use of mobile broadband to transmit a large amount of data and information unimpeded. In addition to responding to the changes of different application scenarios and service requirements, network slice technology can also bring users the best network experience in a safe and high-speed environment and avoid the worry of personal information leakage.

## 2.2 SSH Framework Construction

SSH is an integration of multiple frameworks, mainly Structs and Spring and Hibernate. SSH open source integration framework is a popular Web application development framework in the software development industry. Structs is an MVC framework based on Sun J2EE platform, which is mainly implemented by Servlet and JSP technology. The process of MVC is that the user submits the request to the controller, the controller passes the user input request and data to the business model, then the business model makes judgment and database access, and the selected data is fed back to the user through the view. The Spring framework, which is used in Java to resolve calls between objects, reduces the coupling of calls between objects, making programming easier and making applications more scalable. The Spring framework is about making IOC standard so that programmers can develop according to it. The Spring framework replaces EJB with the most basic Java beans, making enterprise application development simpler, providing more application functionality, providing a more complete development environment, and providing enterprise-class services to POJO objects. In SSH established under the framework of sports fitness equipment, online sales system will add to cart after consumer times within the sales cycle, confirm the delivery of order, or return such as consumer behavior over and over again, in view of this, with the help of calculus thought consumers the order are sold to the whole sales cycle is equal to the product of the total demand minus the amount of product be returned to use, use the formula is expressed as:

$$Q = T(n + \alpha)D - (m - 1)(1 - \beta)nD \quad (1)$$

The total inventory cost of online sellers will be composed of ordering cost, processing cost, transportation cost, cargo damage cost and inventory cost. The formula is as follows:

$$TC = A + C_r(m - 1)(1 - \beta)nDl + snDl(1 - \beta) + vmnDl + \beta C_s mnDl + H \quad (2)$$

With the support of these two technologies, the online sales system of sports and fitness equipment designed by us will be able to give consideration to the two main functions of information security and convenient sales, and realize the integration of

system interface openness, expansibility and security, so as to ensure the stable operation of the system and provide users with a good use experience.

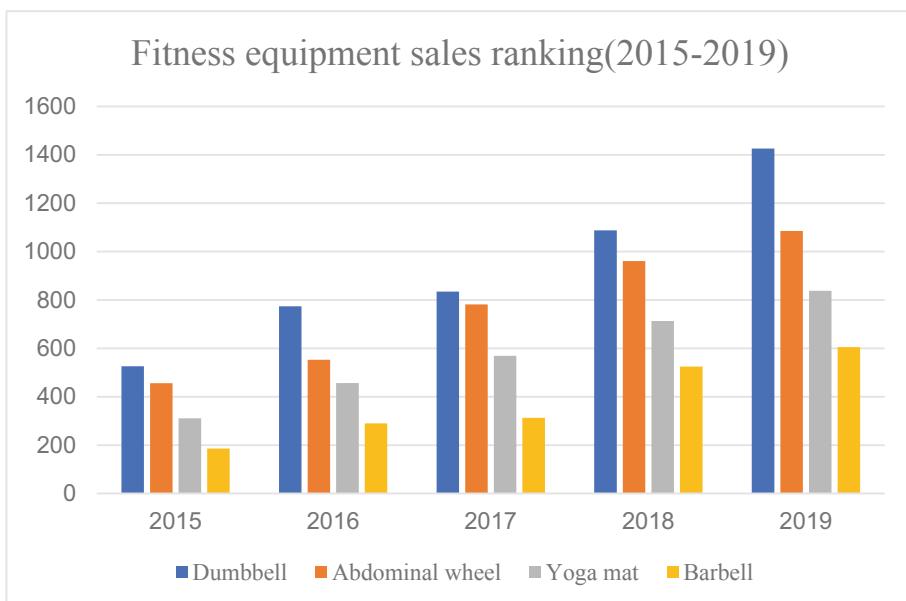
### 3 Design of Online Sales System for Sports Fitness Equipment

The system design needs to explain the construction process of a system. According to the demand analysis confirmed with the demand side, the structure of the system is designed. The whole online sales system consists of two parts: framework design and database design. The front end and the back end are two modules of the whole system. The front end is designed for customers, while the back end is the operation response platform arranged for merchants. The customer management module is built on the basis of the personal information registered by the customer after logging into the corresponding software. Here, the basic information of the customer's health is kept for the customer, and then more considerate and targeted product recommendation is given when the customer chooses the products and exercises. The commodity display module can customize the sports products for users according to the feedback of background data to meet users' understanding of the commodities before purchase. The trinity of price inquiry, shopping cart and order management can give different sellers' prices of the same product at any time, providing customers with the strategic service of comparing prices among different stores. The price performance of similar products added to the shopping cart can be compared to help users make the best purchase choices. Contact customer service module designed unriddling for the customer, in the use of taobao, jingdong shopping application of various types, such as when we can have such an experience, want to buy the goods but don't know what kind of is suitable for their own, despite the automatic recommended goods, we will still have doubts, this really works, more hope someone can advise beside her. The background customer management module is consistent with the front end. The data here can serve as a reference for improving product performance and provide data support for enterprises to constantly adjust their own sales strategies. Through clear grid management, the commodity classification module updates the stock of products in the warehouse in real time, and gives the reminder of replenishment and shortage. The order management module in the background is a response to the front end, timely responding to customers' orders and arranging shipment. The after-sales service module is a perfect guarantee for the whole sales process. It can answer users' dissatisfaction and questions at any time, grasp the actual defects of the product, and collect users' feelings. The sales statistics module plays the role of a summary and prediction, automatically generates the sales chart in real time, gives concise and clear sales report, completes the summary of the previous phase of work, and starts the plan of the next phase of work.

## 4 Discuss

### 4.1 Realization of Online Sales System

To build the basic architecture, first add the Spring core container and Hibernate framework, then build the SSH multi-framework, then add the Structs framework and Spring, as well as the corresponding configuration files. Using Structs2 validation framework to echo error information to ensure that user information is not exposed, this is equivalent to the validation protection layer of the whole structure. The final page displayed in front of the user provides a quick search box. The user can search for the desired product by voice, text and photo. After searching the product, you can consult the specific information of the product, including the mode of production, manufacturer, specification, usage, applicable population and price. When searching for a certain product, the system will automatically generate the trend report of price performance of related products. Users can directly click on the picture to place orders immediately. At the same time, users can choose to cancel their accounts after receiving the goods, which will greatly reduce the risk of personal information leakage. The administrator of the background page can check the quantity information of goods at any time, and timely modify the price of goods according to the demand, such as price reduction and promotion, etc. The sales ranking of fitness equipment made by this system is shown below, as shown in Fig. 1.



**Fig. 1.** Ranking of fitness equipment sales

## 4.2 Module Test

The system test is mainly for the order management module, the first is the function test, the second is the black box detail test.

### 4.2.1 Functional Test

The product category module is designed as an auto-adjusting data relationship, where administrators can add other categories under a large category, which can be further subdivided. The obtained commodity data information is stored in the linked list. After traversing the linked list 1 and recording the current data node, the current node is displayed, and the node is assigned to return the data depending on the operation type. The order module has the functions of adding shopping cart, placing order and canceling order. The management interface includes commodity information update, operation Suggestions, sales volume and inventory, etc. The testing process was smooth, and the test results are shown in Table 1.

**Table 1.** Commodity information display table

Fitness equipment	Price	Stock	Effect	Use time
Foam shaft	23	2000	Mild	20 min
Abdominal muscle plate	650	800	Intense	15 min
Elliptical trainer	3500	500	Mild	60 min
Spinning bike	3000	600	Intense	45 min
Abdominal wheel	11	1000	Intense	15 min

### 4.2.2 Black Box Detail Test

Equivalence partitioning is closely related to functional testing by dividing the input region into subsets and selecting representative data from each independent subset as test objects. Construct an equivalence class table, give each equivalence class a unique number, and cover as many equivalence classes as possible with test data until it contains all the equivalence classes of the entire system. Then, the boundary value analysis method is adopted to carry out the test. The input or output boundary value and the values around the boundary value are tested, including both legal data and illegal data. As an effective supplementary detection method, this method can strictly determine the value boundary range. Through the test, it is found that the front-end order management module of the system can be successfully implemented, which can give a quick response to the input data, effectively resist the illegal data, and send the danger report to the background. The basic functions of other modules are in normal operation, but the disadvantages are that the initialization speed is slow and users need to wait for a long time, which will greatly affect users' desire to buy, and this part needs to be optimized.

## 5 Conclusion

This paper made a detailed analysis of the advantages of 5G network, pointing out that it has the characteristics of fast communication network, large traffic, real-time interaction and so on, which will bring earth-shaking changes to the sales work. While bringing convenience to consumers, it is also a great opportunity for commodity sellers to update their working methods. In view of the sports fitness industry unique personal experience, combined with powerful advantages to 5G network technology, this paper designed the framework based on SSH construct online sales system, this system will live, virtual interaction, customer experience and order goods, sellers and real time management of sales and forecast bundled together again, highlight the security of user information, dynamic sales order management can bring more wonderful experience with the seller and the buyer.

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# Intelligent Environmental Art Design Course Based on Network Information Model

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**Abstract.** Since the 1990s, the development of art design education in China has entered a whole new period. With the development of the reform and opening up economy, the strong demand for art and design talents is reflected in network planning. New areas such as analog design and innovative animation development. This emerging demand has made the development of information art education an eruption period without the need to advocate for natural formation. This article is precisely in this era background, as a cutting-edge research on the development context and characteristics of information art design and the new development of art design education in the information age. Through the reading and research of related theories and literature, this article summarizes the connotation and context of the historical development of design basic education, and discusses the problems and characteristics of design education in the context of information design and information society. This article adopts the network information model, based on the new requirements of the basic teaching of art design of network information, and has made relevant adjustments to the previous courses. Not only should we take care of the content of the original curriculum arrangement, but also fully reflect the combination of basic courses and information technology. In the teaching of this article, the design philosophy and computer information technology are combined to design basic education content that can meet the requirements of the information age. It provides suggestions for the study of epoch-making intelligent art design courses.

**Keywords:** Network information model · Information art design · Design education · Virtualization technology · Humanized education

## 1 Introduction

With the development of the economy, the information age has arrived irreversibly. The necessary technology in this era: information computer technology has also become an important part of contemporary industry. The rise of this emerging technology has quickly captured the top of all fields and industries with lightning speed. This will certainly bring a huge revolution to our design philosophy and design methods. In the social background of the information age, designing basic education is increasingly showing its lagging side. The trend of contemporary information art

design drives art educators to take corresponding measures. These measures should be consistent with the current status of our country. Adaptation, covering the relevant necessary components of information art education, successfully changing the current type of art education to a new type of art education, in order to have a positive effect on education in the field of design.

Regarding the connotation and extension of new information design, the academic community still does not have relevant authority interpretations and overall coverage. Scholars of various factions have been arguing about it, and the names and disciplines related to it are far removed. Different definitions. For example, in Lo, P, Cho called “digital design”, “interface design” and “information design”, Bei GE mentioned “communication design”, “multimedia design”, “network design”, “media and virtual” “Realistic design” and so on [1, 2]. As early as the 1980s, Western design academia has begun to discuss the transition of design to post-industrial society, such as “Design, Technology and the Future of Post-Industrial Society” held by Hagen Chrapary, the Interdisciplinary Research Center of Northwestern University’s Department of Arts. The academic seminar and a series of other international academic conferences discussed the issues of computer design in the contemporary information environment and the transformation of manufacturing in the electronic environment [3]. Monie Ian’s seminar said that the debate about design and its trend in the late 20th century has become fierce, and information design has become a trend [4].

In this article, students are encouraged to make use of modern information network resources and can also display their own art design works. To improve the comprehensive quality of students, to achieve the transformation to the cultivation of innovative thinking ability. The concept of information art design is integrated into the teaching practice of design, which provides advice for the basic teaching of art design in the information age.

## 2 Proposed Method

### 2.1 Network Information Society

Under the interaction of the Internet, the real and virtual environments are interconnected [5]. The support of multimedia technology has resulted in a change in the scope of art design and the design itself. From the design method to the design object, profound changes have taken place. Information design has shown great attention to the current information life, and is not limited to the external hardware design of the design object, and shifts to the design of its internal spirit, such as intelligent and interactive information art design [6]. This design concept guide is the basic conversion from physical design to nothingness design, concrete design to abstract design, product design to specific after-sales design, and the change from physical product design to virtual product design. In this case, the traditional design concepts, design methods, and design education systems are subject to unpredictable impacts and challenges, and every link of the design and the entire design process need to be adjusted in all directions [7]. Information is changing our lives unknowingly. Such as online shopping, virtual reality, etc., the focus of design is no longer a tangible material product,

but gradually separated from the material layer to focus on pure spiritual things, design from static, rational, one-way, materiality From creative creation to dynamic, perceptual, composite, non-material creation [8].

## 2.2 Performance and Characteristics of Information Art Design

### (1) Virtualization of design form

Today's virtual reality technology makes it possible for people to enter the selfless state and integrate into the environment created by art [9]. Virtual reality technology is a composite technology that blends multimedia, human-computer interaction, graphic vision, artificial intelligence and other technologies to enable designers' imagination and virtual life to be realized. In view of the huge expressiveness of realistic 3D technology and the maturity of related operating technologies, simulated reality technology has gradually entered all aspects of the design industry: architectural design, planning and design, display design, and online interactive game design, which can be displayed on the Internet and cannot be displayed Product image. In other words, the virtual design of man-machine has become a reality. Through virtual design, for some large projects and topics, virtual reality simulation is performed, which saves a lot of human and material resources and the corresponding time consumption, thereby reducing development time and improving business. Competitiveness, reducing commercial external consumption expenditures and increasing strength to prepare for competition.

### (2) Design sustainability

Information art design is a major innovation that cares about the survival of the design community, because it is a compromise method that can reduce per capita consumption and occupation and meet the basic material needs of all people [10]. Information art design is based on the strength and achievements of advanced scientific and technological developments such as information, biology, and economy. In order to reduce the demand for material to an untouched internal spiritual demand, related solutions must rely on the formation of innovative ideas and innovation systems. The form of transformation from concrete to abstract, which is the principle of respecting the ecological environment and not regressing economic growth repeatedly mentioned in sustainable development, can become a healthy and harmonious development of environmental ecology and human society. This requirement reflects the informationization of the specific environment in the design of information, that is, the creation of infinity on the limit, and the reduction of environmental pollution and space usage.

### (3) Humanity

Taking sports fitness equipment as an example, modern fitness equipment can't provide users with more relevant information on the machine. Users only use the cold mechanical appearance and the internal fixed design that will never cause heart-breaking. When the user is running training alone, the monotony and boredom of the machine enhances the slowness of time. This indifferent state of man and machine is commonplace in modern development, which is due to the lack of this active form of

human-machine interaction [11]. This embarrassing situation will be significantly improved only by creating relevant network systems and linking their products, and adding new languages and input and output devices. This design undoubtedly shows a new design trend-humanized design.

## 2.3 Problems in China's Design Basic Education in the Information Age

### (1) Course arrangement is unreasonable

The specific manifestation is the serious disconnection between computer design and basic courses, which is a problem that is common in many art schools. Painting lessons are conducted by teachers in the art direction, while information technology is taught by computer teachers. Due to the limitations of teachers in their own specialty, it is difficult to focus on the connection with the content of other courses. The results of learning are conceivable.

### (2) Lack of practice

Students blindly add gorgeous pictures to their homework to maximize the function of the computer itself, but ignore the requirements of the design itself. Although the work they designed may be quite good in visual effects, they have no design soul.

## 3 Experiments

### 3.1 Experimental Background

In terms of teaching content, we should improve the comprehensive quality of students and realize the transformation to the training mode of innovative thinking ability. To integrate the concept of information art design into the teaching practice of design, so that students gradually master the basic information tools in the learning of basic courses. Only by combining design concept with computer information technology in teaching can design basic education content meet the requirements of the information age, and connect the content of information art design course with other subjects for a wider integration. After all, in this computer information age, while learning the basis of art design, we should also master the learning of computer operating software.

### 3.2 Experiment Collection

Students are required to use photoshop\3dsmax, VR and other software to complete creative works, add information-based design system equipment in traditional design basis, enrich course content, break the current situation of course isolation, enable students to complete the mastery of software tools, understand the specific application and design process of digital information-based design tools in design, and make the original course teaching more Three dimensional and convenient. Another thing to be mentioned is that the importance of basic courses can not be ignored. In this case, students need to show a comprehensive understanding and cognition without saying much. Computer and information technology can only be a tool to show students'

design ideas. In this case, the design ideas that need creativity and vitality can only be shown when the design laws and essence are fully grasped. At the same time, we need to further improve the aesthetic ability and strengthen the cultivation of innovation awareness. Only in this way can we use information technology to create better design works.

Practice Course Title: virtual display design class hour: 30 class hours

Objectives and requirements of the course: virtual display design is a new course of art design. The objectives are: first, to cultivate students' ability to understand the relationship between image and thinking, to generalize natural objects and forms in three-dimensional space, and to express abstract geometric language. Secondly, in the process of learning, we should use all kinds of performance skills to create all kinds of forms needed and master several key factors of image form.

## 4 Discussion

### 4.1 Analysis of Students' Courses

On the basis of the original syllabus, according to the new needs of information-based design of basic teaching, the previous courses have been adjusted. We should not only take care of the content of the original curriculum, but also fully reflect the combination of basic courses and information technology.

The teaching arrangement of virtual display design is shown in Table 1.

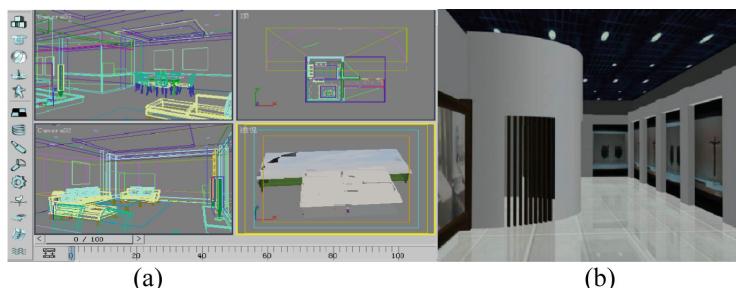
**Table 1.** Teaching arrangement

<Virtual display design> Teaching arrangement				Bibliography
Week	Lecture	Practice	Teaching content	
12			One. Objectives and requirements Second, virtual display of basic theoretical knowledge 1. Modeling elements—points, lines, areas 2. space color	“Exhibition space” Dotted Lines and Surfaces By Kandinsky
13			Topic 1 Space Display and Performance Requirements: Master the visual language and use 3DMAX, Photoshop makes 3D renderings	
14			Topic two: space exercises. Requirements: three-dimensional space morphology. Planned in a 10 m * 20 m Design a corporate display rendering in the space, Requirements: 1. Floor plan, streamline diagram 2. Perspective rendering 3. Make a reasonable function allocation layout 4. VI design in line with the brand	
15	3		Project tutoring and commentary, student discussion and mutual evaluation	

As shown in Table 1 above, during the teaching process, discuss with students. In the creative stage, we should give priority to hand-painted sketches, and also have a certain number of requirements for hand-painted works according to the actual teaching situation. We should design text planning, and require students to improve the design efficiency through network information and computer production means. In order to meet the needs of design education in the information age, students should have more practical opportunities and form effective methods of visual understanding of objective things and solving practical problems according to their own action experience.

## 4.2 Analysis of Experimental Drawing Results

In the traditional design foundation, information design system equipment is added to enrich the content of the course and break the current situation of course isolation. Another thing to be mentioned is that the importance of the basic course can not be ignored. In this case, students need to show a comprehensive understanding and cognition without much learning. Computer and information technology can only be a tool to show students' design ideas. In this case, the design ideas that need creativity and vitality can only be shown when the design laws and essence are fully grasped. At the same time, we need to further improve the aesthetic ability and strengthen the cultivation of innovation awareness. Only in this way can we use information technology to create better design works. The experimental results are shown in Fig. 1.



**Fig. 1.** Virtual picture of works (a) (b)

As shown in Fig. 1 above, in this learning centered teaching mode, interaction is the most appropriate relationship for both sides to learn and discuss. This is not a simple process of indoctrination and cramming from teachers to students, but a process of mutual communication between friends. Both sides can flexibly control the progress of teaching content, give full play to the enthusiasm and initiative of students, and cultivate the judgment ability of independent thinking. In the process of teaching, discuss with students. In the creative stage, we should give priority to hand-painted

sketches, and also have a certain number of requirements for hand-painted works according to the actual teaching situation. We should design text planning, and require students to improve the design efficiency through network information and computer production means.

### 4.3 Satisfaction Analysis of New Teaching Concept

Teachers should always keep in mind the guiding teaching method, and do not tell students the results of exploration easily. Students' innovation ability and thinking ability will be cultivated to the maximum extent in the inquiry teaching mode, and students' own quality will be significantly improved. The analysis table of new teaching concept is shown in Table 2 below.

**Table 2.** Satisfaction analysis of new teaching concept

	Experiment time	Good	General	Difference
Satisfaction	Before the experiment	42%	43%	15%
	After the experiment	58%	36%	6%
Student discrimination	Before the experiment	33%	35%	32%
	After the experiment	56%	28%	16%

## 5 Conclusions

On the basis of the original syllabus, according to the new needs of information-based design of basic teaching, this paper makes relevant adjustments to the previous courses. We should not only take care of the content of the original curriculum, but also fully reflect the combination of basic courses and information technology. This paper enables students to master the software tools, understand the specific application and design process of digital information design tools in the design, and make the original course teaching more solid and convenient.

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# Network Nature of College Students' Psychological Activities Based on Cloud Computing

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**Abstract.** With the rapid development of network and information technology, the traditional psychological education for college students has been more and more unable to meet the growing psychological education needs of college students. However, how to grasp the development trend of modern education informatization and preempt the network has become a hot topic in academic research. At the same time, we must face up to a series of network cluster events caused by the lack of psychological education in the past period of time, which not only caused different degrees of social influence, but also brought great challenges to the construction of the traditional psychological education system. The purpose of this paper is to build a six-level network model including individual factors of students and real-time education monitoring on the basis of the existing psychological activity network of college students. In terms of research methods, this paper combines the general steps of the hazard intervention early warning and psychological crisis prevention system of college students' psychological activities, and discusses how to build an information-based psychological education platform based on cloud computing. This paper's results show that college students must be accurate and objective research network psychological tendency, performance and characteristics, such as a comprehensive analysis of the causes of these psychological and influence, by taking reasonable and effective way to guide college students to a positive direction, can really help the students establish the correct outlook on life, world outlook and values.

**Keywords:** Cloud computing · Psychological activities · Nature of network · Psychological crisis prevention

## 1 Introduction

As an internet-based supercomputing model, cloud computing has brought our society into a new information age. It not only greatly reduces the office costs of enterprises and units, but also effectively concentrates various resources together to form a sharing mechanism, which has improved the educational level of colleges and universities. The rapid development of cloud computing technology not only provides a new way for college students' mental health education, but also puts forward more specific

requirements for the implementation of psychological education tasks. According to a ministry of education document published in 2017, colleges and universities must make full use of modern Internet technology, tap information resources available online, speed up the construction of a cloud-based psychological activity education model, and use cloud computing technology to conduct psychological activity assessment of college students.

College mental activity evaluation of existing relies on “three networks” model of college students’ mental health, which is mainly rely on domestic colleges and universities to carry out college students psychological quality assessment methods, the education guidance and consulting a multi-level evaluation system is conducive to mental health of college psychological health education and crisis prevention, but also quite insufficient and defect [1, 2]. Because it must rely on professionals with specialized index data to complete the assessment, even after the found mental abnormal status report must be step by step to solve the crisis, rather than in the first place will resolve and prevent the crisis, this is obviously not even dissolve the crisis or crisis of effective prevention and control of diffusion, virtually delayed [3, 4] the best intervention time limit. The psychological change of college students is a dynamic process of change, and some individuals still have hidden psychological problems. If they cannot be released in a specific environment, or cannot effectively interact with each other to achieve uploading and transmitting, they cannot achieve effective supervision and early warning [5]. Foreign universities have laid the groundwork for monitoring college students’ psychological activities for many years, and many universities have formed regular health screening cycles, conducted timely interviews and counseling for those with psychological crises, and promoted the importance of college students’ mental health through some psychological counseling [6]. This intervention model in foreign countries is an effective attempt to intervene the mechanism of students’ psychological crisis, and has achieved good results so far [7].

The research in this paper points out that on the basis of the “three-level network” model, colleges and universities should try to establish different intervention methods to carry out three-level intervention mechanisms at the early, middle and late stages in the network nature of students’ psychological activities [8]. The data obtained by the traditional psychological activity evaluation mechanism is usually lagging behind, and the psychological change process of college students cannot be acquired in time, which will greatly reduce the identification and early warning time of students’ psychological crisis [9]. The arrival of the network era is not only accompanied by the input of new technologies such as cloud computing, but also the brand-new combination and upgrading of new technologies with fields such as education and medical care, forming a synergy. In this way, a human-oriented, interactive and conversational model of network psychological education can be realized [10].

## 2 Method

### 2.1 Definition of Network Groups

There is no unified consensus on the specific definition of the concept of network group. Moreover, the title of the basic connotation of this concept is not the same. However, one thing is clear, that is, there are broad and narrow distinctions between the concept division of network groups [11]. Under normal circumstances, the broad sense of the network group is to describe any Internet users have posted their own thoughts and speech behavior on the network; In the narrow sense, network group refers to a group that takes the use of the Internet as the main medium, the expression of personal thoughts as the main form and the transmission of personal values as the form of expression, and tries to attract a certain amount of attention on the network or change the views of other netizens on something [12]. No matter in the broad sense or in the narrow sense, the composition of network groups is complex and diverse, so inclusiveness and destructiveness are the main contradictions and characteristics of network groups [13].

The network group referred to in this paper refers to the network group in a narrow sense. In the artistic conception of this study, it has two specific connotations. They are groups born on the basis of network and realistic groups. Network groups refer to those groups made by the use of network, and can also refer to those news groups and social groups. Realistic group refers to the extension of work force, class construction or agency unit communication on the Internet. And for college students, it is mainly manifested as campus post bar, classmate record, WeChat group, QQ group and chat room.

### 2.2 Network Clustering Behavior

To put it simply, the network group behavior is a kind of social phenomenon, which is manifested as a series of debates based on the Internet, in which netizens have different degrees of disagreement on a certain phenomenon or specific issue in the society. From the expression form of group behavior, it has both rational and irrational aspects. The rational side mainly shows that netizens can look at a certain issue rationally, and can consciously view a certain issue and express their opinions with logical thinking. Irrational group behavior is manifested as emotional, over-excited and even personal attacks and insults in the process of participating in the discussion.

As a social phenomenon of network society, the essence of network clustering behavior is the product of free exchange and communication between people. It is just to obtain and express information through the network, the most efficient new channel. We should not simply define the network group as network violence, but should have a dialectical understanding of it. Among college students, the network gathering is positive in most cases and represents the legitimate interests of netizens. Specifically, it is a behavior mode that college students hope things will develop in the direction they expect by releasing, re-posting and disseminating information in relevant forums and communication groups.

### 3 Experiment

#### 3.1 Data Sources for Model Construction

The data source of the network model proposed in this paper is from several well-known universities in China, and the survey data of these universities is taken as the main object and data source. During the process of model construction, 1,100 basic questionnaires for model construction were issued, and 1031 were recovered, with a high recovery rate of 93.72% and a high efficiency. The survey data were true. Among the 1039 questionnaires collected, there were 516 questionnaires from male students and 515 questionnaires from female students.

#### 3.2 Process of Network Model Construction

In the process of building the model, the main purpose is to improve mental health, and the breakthrough is to carry out special education assistance, and strive to improve the quality of students' psychological activities in the practical effect. The construction process of the whole model is mainly divided into three steps: firstly, the management mechanism is operated by relying on the evaluation index of network psychological education; Secondly, we should take expanding the work path and innovating the work method as the main ways to enhance the work effect. Finally, it is necessary to build an intensive learning support system and set up a diversified psychological activity consultation platform for college students.

## 4 Discuss

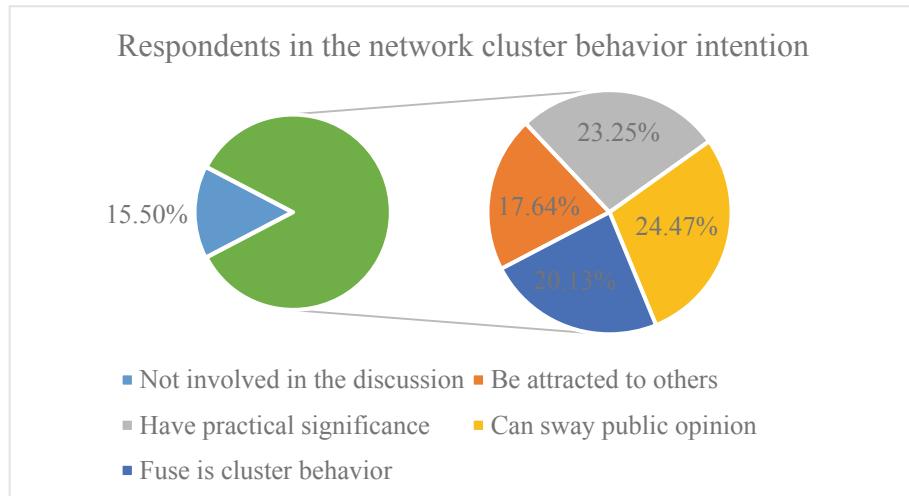
#### 4.1 Analysis of Survey Results

This paper is divided into four parts and consists of 38 questions. The first part is the basic situation of the interviewees, the second part is the basic attitude of the interviewees to the questionnaire questions, the third part is the individual judgment results of the interviewees to the hot issues, and the fourth part is the behavioral intention survey of the interviewees in the network group behavior. The fourth part is the key data supporting the survey. The survey results in this experiment are shown in Fig. 1 below.

By diagram can be seen clearly, there are 84.5% of classmates often comments or a hotspot in network communication events, in these students, 17.64% of students are attracted by public figure's words and deeds to the discussion, 23.25% of the students think network cluster behavior has great realistic significance, 24.47% of the students think network cluster behavior has a strong public opinion direction, while another 20.13% chose the incident is the clustering behavior of the fuse.

The mental health model of colleges and universities proposed in this paper is a network education model based on cloud computing, which has changed the limitations of traditional psychological education such as high cost, low benefit scope and low timeliness, and has the advantages of rich educational content and form and significant

educational effect. The comparison between the effect of cloud-based psychological education on college students and the effect of traditional teaching is shown in Table 1 below.



**Fig. 1.** Intention of interviewees in network clustering behavior

**Table 1.** Effect of psychological activity education based on cloud computing

	Unit	Traditional mode of education	Cloud computing dominates education
Cost	RMB (ten thousand yuan)	4158	3184
Beneficial radiation	Number of benefited students (10,000)	485	1021
Timeliness	/	Slower	Faster
Education content	/	Obsolescence	Rich and novel
Effect of education	Satisfaction level (%)	53.26%	83.59%

It is not difficult to find that the network mental health education based on cloud computing enables students to achieve the educational effect of paying equal attention to knowledge and practice in the process of diversified interaction and communication, constantly optimizing educational resources, innovating service forms of activities, enriching educational carriers, and effectively improving the pertinence and effectiveness of mental health education.

## 4.2 Characteristics and Innovation

### (1) Work philosophy has been updated

The psychological intervention work supported by cloud computing in colleges and universities adheres to the positive psychology orientation and sets up the humanistic concept of all-round development, fully respects the main role of students' self-education. College students can receive good mental health education through various forms of education such as "self-help, others and mutual assistance" and the learning mode of "problem situation, democratic negotiation, conversation guidance and meaning construction", so as to achieve the educational purpose of self-improvement and development.

### (2) The working mechanism was further straightened out

Through extensive cooperation among leading group members of mental health work of the college, full-time and part-time teachers of mental health education and service center, and individual space of psychological counselors of various departments (schools), the psychological activity counseling work of college students is ensured to run in an orderly and benign way.

### (3) The working platform has been innovated

Mental health education online "double path" service idea greatly facilitate the education of mental health workers flexible through the network to carry out the mental health service work, for college students to establish a comprehensive, powerful psychological support system, psychological support to the development of college students effectively, to ensure the harmonious campus construction.

## 5 Conclusion

By referring to relevant literatures and summarizing the beneficial results of previous studies, this paper concludes that the current situation of college students' psychological status education and supervision is still insufficient. On this basis, this paper puts forward that the essential and fundamental way to improve the mental health education of college students is to construct the mental activity education model of "four-level network". In the current situation that information technology products have been fully applied to colleges and universities, all colleges and universities have realized the layout of campus network, training center and computing center, all of which provide the necessary basic data sources and mechanism conditions to further ensure the supervision of college students' psychological activities.

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The conclusion of the 2019 education and teaching research project of Jilin Normal University of engineering and technology, research on the construction of College Students' mental health education curriculum from the perspective of positive psychology.

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# Design and Development of Intelligent Teaching System Supported by Internet of Things, VR and Cloud Computing

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**Abstract.** With the continuous development of network information technology and education, China's education model has begun to transform and upgrade, people pay more and more attention to the establishment of interactive teaching model. The establishment of the interactive teaching model is based on the intelligent teaching system. The development and application of the intelligent teaching system reflects the progress of the education model, which can effectively strengthen the mutual communication between teachers and students and improve students' learning initiative. Based on this, the design and development of a set of intelligent teaching system supported by Internet of things, VR and cloud computing has become the inevitable requirement of the transformation of education model and the inevitable trend of education development. The purpose of this paper is to accelerate the development process of the intelligent teaching system and promote the transformation and upgrading of China's education model through the research on the design and development of the intelligent teaching system. In this paper, related concepts such as Internet of things, VR and cloud computing are firstly summarized, combined with relevant research data, and specific ideas for the development and design of intelligent teaching system are proposed. Finally, the operation of this teaching system is tested and tested by means of comprehensive data processing algorithm. The experiments in this paper show that the intelligent teaching system is reliable and scientific, and can promote the transformation of teaching mode.

**Keywords:** Internet of Things · VR technology · Cloud computing · Intelligent teaching system

## 1 Introduction

Under the background of information technology, “Internet + education” has become the development trend of the current society. The integration of Internet and education breaks the time-space limitation of traditional education and is conducive to the reform of teaching methods. At present, most schools in China still adopt the traditional teaching mode. Due to the large number of students and limited classroom learning time, students' learning results cannot be timely fed back to teachers, resulting in low overall teaching efficiency. Traditional teaching methods have been unable to meet the needs of the rapid development of society. To change this phenomenon, we must

realize the integration of education and Internet, change the teaching model, and strive to realize the media and intelligence of learning resources. Based on this, the design and development of intelligent teaching system supported by Internet of things, VR and cloud computing has gradually become the focus of people's attention.

The intelligent teaching system is based on the Internet. Teachers can make use of information technology to let students experience the fun of learning and realize active learning. Teachers' teaching and students' learning become more efficient. However, there is still a lack of detailed research and discussion on the specific design and development scheme of intelligent teaching system, so it is particularly important to conduct in-depth research on the design and development of intelligent teaching system supported by Internet of things, VR and cloud computing [1, 2]. In recent years, with the deepening of information education, the research on intelligent teaching by domestic and foreign scholars is also deepening. Foreign studies in this field mainly focus on the study of students' learning behavior under the intelligent teaching system and the application of the system in other fields. The research of domestic scholars mainly focuses on the research on the construction of teaching philosophy and teaching mode under the intelligent teaching system [3, 4]. Through data analysis and collation, it can be seen that few studies focus on the specific design and development of intelligent teaching systems, especially the design and development of intelligent teaching systems supported by the Internet of things, VR and cloud computing [5].

To sum up, there are still many theoretical gaps in the current research on intelligent teaching system, which need further research. In order to speed up with iot, VR, cloud computing for support of intelligent teaching system design and development process, promote the transformation of education mode in our country, this article first to the Internet of things, VR, and cloud computing and other related concepts are reviewed, combined with relevant research materials and put forward the concrete ideas of development and design of intelligent teaching system, finally with the help of integrated data processing algorithm that it can detect the operation of the teaching system experiment [6, 7]. On the one hand, the design and development of this paper involves teaching, learning and management, which is of great significance to the transformation of teaching mode and the improvement of teaching efficiency. On the other hand, the research in this paper has laid a certain theoretical foundation for future relevant researches [8].

## 2 Method

### 2.1 Relevant Concepts

The Internet of things (iot) is an information technology-oriented, internet-based connection model. Internet of things is the expansion of the Internet, belonging to the special form of the Internet. The Internet of things realizes the connection between different objects through network technology, and this connection shows great advantages, mainly including intelligence, advancement and interconnection. With the continuous expansion of the Internet of things network scope and the continuous maturity of technology, the Internet of things is widely used in various industries, such

as environmental protection, traffic construction, engineering monitoring, etc. [9, 10]. The full name of VR technology is virtual reality with the help of information technology, which can be used to build the corresponding network virtual world on the basis of parameter input, which is essentially a computer simulation system. On a certain computer platform, VR technology combines with 3d dynamic technology to construct virtual practice, and produces relatively real effects in visual, auditory and other aspects, bringing relatively formal sensory experience to users [11]. This technology is the result of the fusion of various advanced technologies based on the Internet. Currently, VR technology is widely used in the military, tourism and construction industries. Cloud computing is the splitting and processing of data information with the help of computer network, which is often applied in the analysis and processing of massive data, effectively solving the difficult computing problem that is easy to occur in the traditional computing method in the processing of massive data. Cloud computing is a common form of distributed computing. At present, cloud computing is widely used in education survey, information analysis and other fields [12, 13].

## 2.2 Comprehensive Data Processing Algorithm

Comprehensive data processing algorithm is one of the common algorithms used in data analysis and processing under information technology. This algorithm can realize comprehensive calculation and processing of massive data and multi-dimensional dynamic analysis of data, thus greatly reducing the difficulty of data calculation and maximizing the speed of operation. The most important thing in this algorithm is the fusion calculation of data factors, which is closely related to the accuracy of the final results. The larger the value of the fusion factor lambda, the more network data nodes for fusion, the more data can be received by the network, and the higher the accuracy of the final data processing results. On the contrary, if the network receives less data, the accuracy of data processing results is not ideal. Data loss may occur during data analysis and processing. The specific calculation formula of data loss rate is as follows:

$$k = \frac{1 - n2}{n1} \quad (1)$$

Where, k represents the probability of data loss, and n1 represents the number of data output by the thinking network node. N2 represents the amount of data actually received by the network node. In data transmission, the data loss rate is inversely proportional to the accuracy of the calculation results. In order to ensure the accuracy of data analysis and processing results, it is necessary to calculate the accuracy of the expected results. The specific calculation formula is as follows:

$$q = \frac{\lambda}{\frac{n}{m} - 1} (1 - k) \quad (2)$$

Where, q represents the expected value of accurate results in big data analysis, lambda represents the data fusion factor, k represents the probability of data loss, and n and m

respectively represent the amount of data actually processed and the amount of data received by the network under the ideal state.

### 3 Construction and Testing Experiment of Intelligent Teaching System

The first step is data collection and arrangement. Through consulting relevant information of the wisdom teaching system, the design and research of the current wisdom teaching system are obtained, and the data are recorded and sorted in detail. Through the mastery of the research situation, it can analyze the problems that should be paid attention to in the design process of the intelligent teaching system, thus providing effective data support for the design and development of the intelligent teaching system.

The second step is the level analysis of the wisdom teaching system. On the basis of the existing research data and the combination of the current education model, it is concluded that the intelligent teaching system needs to cover the level, and the weight of each level is calculated to establish the most important level, on this basis to carry out the design and development of the intelligent teaching system.

The third step is the reliability test of intelligent teaching system. Intelligent teaching system reliability testing mainly involves the teaching effect and maneuverability, the actual running effect, through the comprehensive performance of the system, to test the reliability, can effectively avoid the intelligent teaching system problems in the process of practical application, and in a timely manner to improve and upgrade of the system, at the same time with the help of a questionnaire to evaluate the intelligent teaching system is investigated.

## 4 Discuss

### 4.1 Specific Program of Design and Development of Intelligent Teaching System

#### (1) Design and development at the teaching level

The teaching system mainly includes feedback system, physical prompt machine and interactive system. Based on the Internet of things, the feedback system can realize two-way feedback, including not only the feedback of students' self-learning, but also the processing of teachers' and students' feedback information. With the help of feedback system, different links of teaching can be effectively connected to realize the systematic teaching of teachers. The physical prompt machine is also built on the basis of the Internet of things. It is an auxiliary tool for teachers' teaching, and users have limited access to the intelligent teaching system. It is the main function of object prompt machine in intelligent teaching system to combine all teaching tools organically and make teaching tools become intelligent. The above two systems with the interactive electronic whiteboard formed the core of intelligent teaching in teaching practice, interactive system to

dynamically in the teaching of a large number of information processing, ensure that students can receive timely feedback about their learning effect, there is a problem of students can also get the answer quickly, so as to realize the communication between teachers and students.

(2) Design and development at the learning level

The design of the learning level of the intelligent teaching system mainly includes three aspects: learning mode innovation, teaching upgrade and open laboratory. In the design of the intelligent teaching system supported by the Internet of things, VR and cloud computing, the innovation of students' learning methods is first taken into account. For this reason, the extension and expansion of teaching content can be realized by virtue of the Internet of things technology, and the real learning situation can be created by virtue of VR technology to expand the main learning environment. Secondly, digital experimental teaching system is constructed by virtue of Internet of things, VR and cloud computing. This digital experiment teaching system can improve the connection probability of equipment and help to establish the subject of experiment. Finally, the establishment of the open laboratory, which is mainly supported by the Internet of things, helps students to take the initiative to learn, and can be adjusted according to the actual learning situation of students.

(3) Design and development at the management level

The design and development of management mainly consists of attendance management module and teaching management module. The attendance management module is mainly supported by cloud computing technology. The attendance management module has changed the traditional teacher-led attendance mode, and can realize the independent management of student attendance and automatically summarize it at the end of the semester. This module not only reduces the workload of teachers, but also improves the accuracy of attendance statistics. The teaching management module is built on the basis of Internet of things and cloud computing and combined with RFID technology to monitor the whole teaching process in real time, including the school's teaching department, performance assessment and teaching evaluation.

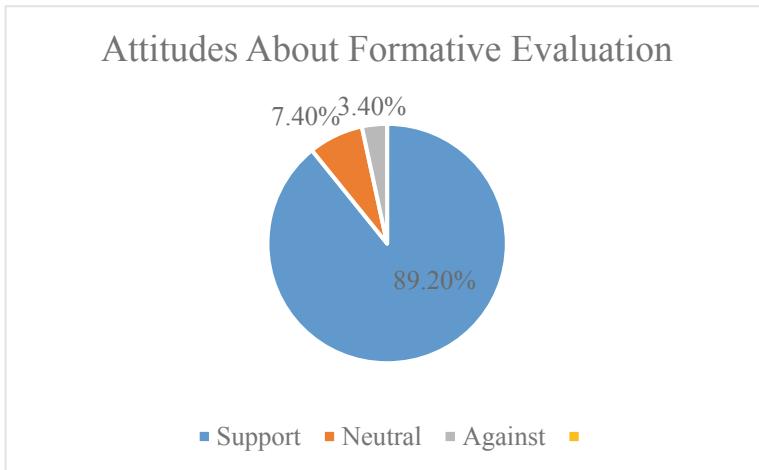
## 4.2 Detection and Analysis of Intelligent Teaching System

In order to ensure the normal operation of the intelligent teaching system in teaching practice, it is necessary to carry out simulation experiments on the intelligent teaching system and test the performance and practical application effect of the system. Through the above testing experiments, we can draw the conclusion that the intelligent teaching system designed in this paper, supported by the Internet of things, VR and cloud computing, operates well at all levels, plays a role in promoting the transformation of teaching mode, and is a scientific and reliable system. The specific experimental data are shown in Table 1 and Fig. 1. The data in the chart are the results of the author's experimental arrangement.

**Table 1.** Running test of intelligent system

System performance	Reaction time	Stability	Accuracy
Actual effect	3 s	91.27%	93.21%
Rational effect	2.5 s	95.28%	96.54%
/			
Teaching effect	Teaching methods	Teaching content	Teaching effect
/	Various	Various	Good

\*Data came from the in-depth analysis of financial data in the experiment

**Fig. 1.** Evaluation survey on intelligent teaching system

From the data in Table 1, we can find that the stability, accuracy and reaction time of the intelligent teaching system proposed in this paper are all good, especially in the stability of operation and the accuracy of the final results are more than 90%. Not only that, the system makes the teaching methods and contents become diverse, has achieved a better teaching effect; As can be seen from Fig. 1, nearly 90% of people support the development of teaching system. At the same time, we can see from the data in Table 1 that although the system has achieved a good effect, it has not reached the ideal effect under the current technology level. In general, the intelligent teaching system in this paper is reliable and scientific, but there is still room for further improvement.

## 5 Conclusion

The design and development of intelligent teaching system supported by Internet of things, VR and cloud computing plays an immeasurable role in the transformation of education model. It is the inevitable requirement of the development of knowledge economy and society, and also the inevitable trend of education to achieve its own

breakthrough. It has a good application prospect. But we must realize the design and development of the intelligent teaching system according to The Times changes need to continue to adjust, and relevant technical standards of the intelligent teaching system and teaching resource sharing and operation maintenance of equipment are not covered area, is the next step we need to focus on research content, so the design of the intelligent teaching system is a long-term process.

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# Analysis Method of College Student Physical Education Quality Based on Big Data Analysis

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**Abstract.** The importance of physical education as an important part of higher education is self-evident and has great value for improving the physical fitness of college students. According to the requirements of the new curriculum standards, “health first” as the guiding ideology of physical education requires constant attention to individuals to ensure that every student benefits. However, college students have frequent accidents due to their physical fitness, and the quality of college students’ physical education is the direct reason that affects their physical fitness. However, the traditional method of analyzing the quality of college students’ physical education lacks certain certainty. Based on this, this paper uses data mining methods, content, attitudes and methods of physical education, and combines big data analysis to establish a method that can deeply analyze the quality of physical education of college students. In order to analyze the quality of physical education of college students, most existing methods Based on the empirically determined weights and the lack of scientific and theoretical foundations, a comprehensive and comprehensive evaluation method based on the evaluation model of physical education teaching quality is proposed. Experimental results show that the algorithm can accurately reflect the quality of physical education, and at the same time achieve the goal of accurate determination of the quality of physical education. Compared with the traditional analytical method of teaching quality, the algorithm can effectively guarantee the quality of physical education of college students.

**Keywords:** Big data analysis · Quality of physical education · Data mining · Physical fitness

## 1 Introduction

College students are important builders of China’s socialist cause, and they need to have a strong physique and a healthy mental state. However, many higher vocational colleges do not recognize and make good use of the important value of physical education in actual work, and college students also lack awareness of the importance of improving physical fitness [1]. At present, college students in vocational colleges have a relatively low level of physical health, and various problems such as overweight, nearsightedness, and poor physical fitness are common. The consequences of absenteeism, decreased learning, and work efficiency have improved vocational colleges. Obstacles to teaching quality have arisen [2]. Therefore, the reform of physical education in higher vocational colleges is imminent. Schools can re-examine the physical

health of college students based on perspectives such as the body performance of college students, carry out scientific and effective innovation in physical education, and guide college students to cultivate scientific exercise habits [3]. At the same time, attention should be paid to training college students to develop healthy psychological qualities, combining college students' physical and mental health, and comprehensively improving their physical health [4].

With the continuous progress of computer technology, more and more people are paying attention to big data. Under the background of big data, people have more convenient and fast channels to obtain large amounts of data [5–7]. However, because the amount of data is too large, but it is doped with a lot of useless information, people urgently need to find a method of mining and analysis, so that they can get a lot of personalities they need within this time. Different data, at the same time, can analyze and filter the data according to their own requirements, and finally obtain information with certain reference and use value [8, 9]. The artificial intelligence technology and AI technology applied by the neural network algorithm are the latest technology in China and the future development direction of big data technology. It can analyze incomplete and fuzzy information, classify and analyze the data, and help Enterprises analyze the actual needs of users and play an important role in the actual decision-making of enterprises. Under this scenario, you can use big data analysis and mining technology to further convert a large amount of data into the data you need and store it. You can extract the information you need from the huge amount of data and build it. An intelligent analysis system is developed to better optimize the algorithm and construct the data model, so that the data mining technology is applied to the system [10].

This article uses big data analysis to mine and analyze the content, teaching methods, teaching attitude, and teaching effect of college physical education, and analyzes the quality of physical education of college students through various aspects such as changes in physical examination results of college students.

## 2 Method

### 2.1 Mining Data

The main components of a big data analysis and mining system include the four main components of the knowledge base database schema evaluation and the server. Through these four components, the most effective information can be selected from the massive and disorderly data and information. A more effective reference plan was formulated in the direction of decision-making. Among the contents of big data analysis and mining technology, the database is mainly used as a relying object to collect the required data, and at the same time to store the data and further analysis. And integration to better help decision makers in decision-making and analysis, while the server mainly provides corresponding assistance in the analysis and synthesis of related data, and can also extract information according to instructions issued by users, collect data and perform fetuses. In the process, the knowledge base is mainly used, so the analysis and induction and integration of the multiple data and information needed to perform pattern evaluation need to be measured based on what the searcher has

previously searched for, and determine their approximate interests. Complete the search and integration of the entire data Processing, thereby determining the specific evaluation parameters.

## 2.2 Measuring Methods of Teaching Effect

Analyze the body test card data, and further mine the data through data statistics, artificial intelligence, and visualization. At the same time, there are different classifications of data mining technology in many fields. The algorithms involved, of which the focus should be on input, Output, and processing. The methods for mining data can be divided into four major methods: statistical methods, neural network methods, database methods, and machine learning methods. The acquired databases and data sources contain various methods. Type, so in the process of data mining for college students' daily behavior and lifestyle, they also have different understanding of the target, and can analyze the various analysis methods in data mining in detail because database analysis methods are used in data analysis. As well as the central step in the resolution process, the neural network method further digs information by constructing a neural network. The college students use the physical test card to fully excavate and analyze their usual physical fitness tests and other information. At the same time, they will work with the administrators in the school to seek relevant data. The data is analyzed, consolidated and merged, so as to provide an effective basis for related teachers to address this problem, and also to play a good role in the students' exercise process, and to do a good job of efficient teaching quality. Six indicators, such as teaching attitude and teaching effect, are used as the teaching quality analysis system.

## 2.3 Weighting Algorithm

The traditional assessment of teaching quality is the use of grades, rather than specific quantitative values, which makes computer processing difficult. In this paper, a grade processing method based on fuzzy sets is used for the students' grades. A data mining algorithm is used to cluster the statistical quantities. (1) read the original data, the data is m rows and n columns, and multiply each column of data by the corresponding weight coefficient obtained by the AHP method to get new results; (2) calculate the characteristics of the teaching content, method, attitude, and effect Value and eigenvector, then calculate the eigenvector  $V_{max}$  corresponding to the maximum eigenvalue  $D_{max}$ ; (3) calculate the weight w as follows:

$$\omega = V_{max} j \left/ \sum_{j=1}^n \max j \right. \quad (1)$$

Among them,  $j = 1, 2, 3, \dots, n$  represents the number of evaluation indicators; in order to improve the accuracy of the weights of physical education teaching evaluation indicators, the comprehensive integration method uses AHP and ISD weighting methods to calculate the comprehensive weight, and its comprehensive weight The expression is as follows:

$$\begin{aligned}\omega &= k_1 \omega_1 + k_2 \omega_2 \\ k_1 + k_2 &= 1, k_1 > 0, k_2 > 0\end{aligned}\quad (2)$$

Among them,  $\omega_1$ ,  $\omega_2$  respectively represent the weight of AHP and ISD, which will directly affect the quality of physical education.

### 3 Experiment

Collect current data on the quality of physical education. The data mainly includes teaching content, and so on. In particular, the application data of the new generation of information technology in the training of innovative construction talents. The collection of training data must be comprehensive, and the training characteristics of innovative construction talents under the new generation of information technology must be extracted from it, and the characteristics and original data must be accurately recorded to verify the validity and reliability of the method. Of universities, each household with professional and undergraduate students as survey objects, and teamed up with school administrators of school staff to seek data correlation. The evaluation process of the quality of physical education is as follows: PE judges the quality of the matrix structure. 1: Calculate weight by AHP and ISD weight. 2: Calculate AHP-ISD comprehensive weight. 3: The evaluation data is divided into a training set and a test set. 4: SVM training data to build a predictive model. 5: Test data set.

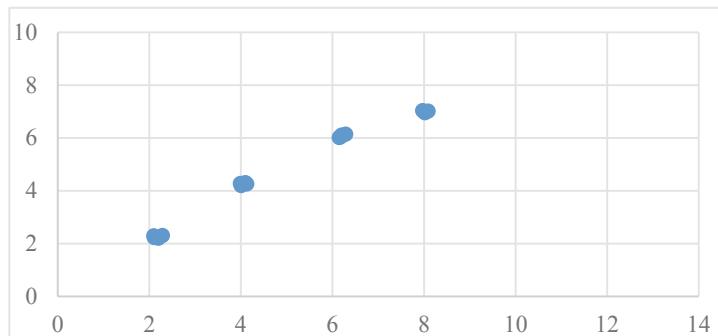
### 4 Discuss

According to the data design chart, the physical education teaching quality evaluation index system consists of 6 first-level indicators and 20 second-level indicators. Using the semantic scale, it is divided into 4 measurement levels: good, good, average, and poor. The quality evaluation standards are shown in Table 1:

**Table 1.** Teaching quality classification criteria

Evaluation value	Comment	Rating
$\omega > 6.5$	Excellent	A1
$4.5 < \omega \leq 6.5$	Good	A2
$2.5 < \omega \leq 4.5$	General	A3
$\omega \leq 2.5$	Difference	A4

According to the above calculations and the combined table of physical education teaching quality grade evaluation standards, it can be known that according to the size of the grades of each index, they can be sorted. The actual results and AHP-ISD results are shown in Fig. 1:

**Fig. 1.** The value of  $\omega$ 

From the perspective of goal protection, the quality of physical education teaching should not be limited to the superficial level of “sports skills up to standard”, but should be separated from the low-level goal of “giving people to fish” to the higher level of “giving people to fish”. From the perspective of physical education, through physical education knowledge, technology and learning methods, students can learn how to communicate, self-regulate, and cooperate with each other, and can use physical education knowledge to improve themselves, so as to achieve the purpose of “educating people.” From the perspective of investment guarantee, the input of human resources, material resources, financial resources and intellectual resources should be met. Human resources investment includes the construction of teaching staff, the rational configuration of the teaching staff structure, and the refinement of the student body to ensure that the number of teachers is sufficient and the quality is high. In terms of material resources, it is mainly reflected in the construction of venues and venues, ensuring the reorganization of venue maintenance costs. The construction of financial resources is that the input of sports funds should return to rationality to ensure that the investment of funds continues to increase; the input of intellectual resources mainly refers to students’ study inputs, leadership energy inputs, and teachers’ teaching inputs. From the perspective of process guarantee, it is necessary to guarantee the quality management system, curriculum construction, teaching methods, teacher-student relationship, and quality monitoring. The teaching quality system should be constructed strictly in accordance with a standardized and sound organizational system, taking into account the special characteristics of physical education, and conducting attendance management and inspection systems. Curriculum construction is the construction of teaching plan, curriculum structure and curriculum content. In the course construction, the main goal should be to strengthen students’ ideological and political education, mental health and will and character, and appropriately expand the teaching content to ensure the fitness of the classroom. The effect guarantee level is mainly based on two aspects: teacher teaching evaluation and student learning evaluation. Teachers’ teaching evaluation starts with the teachers’ professional ability and classroom teaching achievements. Students’ learning evaluation is based on the students’ mastery of sports knowledge, sports function and fitness methods, and the final assessment is the assessment of students’ psychological quality, social adaptability and will quality aims.

## 5 Conclusion

It can be seen from the above that in the current information age, if you want to advance the quality of physical education for college students, you need to apply big data analysis and mining technology. Through the analysis method of physical education quality of college students provided in this article, you can Accurately reflecting the quality of physical education teaching, and at the same time realizing the accurate determination of the weights of physical education teaching quality evaluation indicators, can enable relevant personnel to dig out the information that they need to have a certain value from the vast amount of fuzzy and uncertain information, so as to better the school's next decision is to provide sufficient and effective data. Ensure that the use of information technology and big data analysis and mining technology, so that schools can grasp the quality of physical education.

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# Development Analysis of Government E-Government System Under the Background of Cloud Computing

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**Abstract.** With the rapid development of Internet and computer technology, cloud computing, as a computing method under big data, is becoming a research hotspot at home and abroad. Cloud computing is carried out on the basis of the Internet platform, using the virtualization technology that has been relatively mature at present. It can manage and dispatch a large number of resources uniformly through the network, so as to provide better services for users. Especially in the rapid development of mobile communication technology, cloud computing has been widely used in the field of government administration. For government administrative work, some of the original systems mainly use SMS, MMS or some simple client to work, slightly more complex work is difficult to complete. In this case, the original simple system cannot have big data interaction under the background of modern office, nor can it bring good interaction perception, so the existing government office system needs to be upgraded. The e-government system based on cloud computing is a good attempt.

**Keywords:** Cloud computing · Government administration · E-government system

## 1 Introduction

With the rapid development and improvement of technologies such as the Internet, cloud computing, and big data, government agencies have authorized the development and self-development of many application systems, such as official document management systems, government collaborative office systems, financial management systems, and human resource management systems. The government portal management system has improved the level of government informationization and sharing [1]. However, because these information systems are deployed independently, many human, material, and financial resources are stored in each system, so large-scale data sharing between systems cannot be realized. It is urgent to introduce advanced cloud computing technologies to build an intelligent data service. The platform, in this way, can improve the performance of data services, ensure that each system shares government resources, and the government e-government system based on cloud computing technology is very necessary [2].

## 2 Overview of Cloud Computing Technology

### 2.1 The Concept of Cloud Computing

The core of cloud computing is to connect a large number of computing resources through the network, unify management and scheduling, and form a computer resource pool to provide on-demand services to users. According to the national institute of standards and technology, cloud computing is a computing model that allows data pools to be shared over the network. Specifically, cloud computing is a service model, rather than a pure technology, mainly reflected in the following aspects.

1. The Internet is the carrier. Cloud computing is a widely accepted Internet computing model. All internet-connected devices can make use of the Internet to achieve transparent and ubiquitous access.
2. The core element is service. The various software and hardware are resources and encapsulated as services, and the user only needs to see the service itself, not the implementation of the infrastructure.
3. Resources are configurable. Cloud computing has the special significance of integrating resources and expanding on demand. It utilizes virtualization technology to integrate and abstract physical resources from different data centers into dynamic and scalable virtual resources in a logical set so that they can be effectively distributed and expanded on demand.
4. The users can use resources as needed. Users can make the most use of the network to obtain the computing power they need without directly purchasing complex software and hardware [3].

The above analysis shows that cloud computing is gradually developed on the basis of parallel computing, distributed computing, cluster computing, grid computing, and utility computing. From the perspective of technology, cloud computing represents the advanced concept of information technology development and shows great vitality. Cloud computing is an inevitable outcome of the development of modern computing technology. With the further research and development of cloud computing modern technology, it will have a profound impact on people's production and lifestyle in the future [4].

### 2.2 The Key Technologies of Cloud Computing

Cloud computing involves many technologies, whether it is communication, storage, computing or resource management, scheduling, billing, etc., which are worthy of in-depth study. From the perspective of cloud computing with data as the core on-demand service, virtualization technology, distributed storage technology, cloud programming technology, SOA technology, etc. are key technologies in cloud computing technology.

1. Compute resource virtualization. The computer infrastructure in the network has two forms. One is that the large computing center mainly USES cluster technology to virtualize it into a large, symmetric multi-processing system (Virtual SMP), and provides customized computing power for users by running multiple Virtual

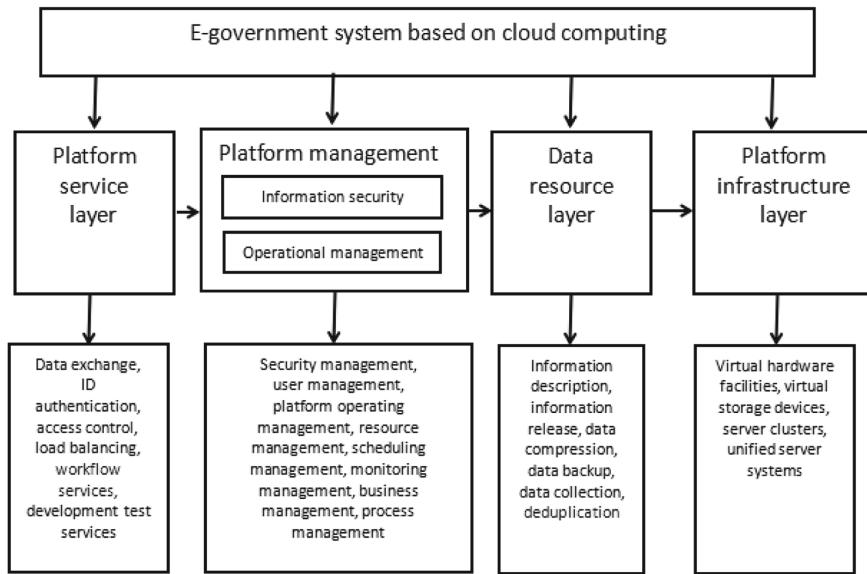
machines (VMS). Second, the independent computing facilities scattered in the same physical location in the network are abstracted into a single computing resource and used in the cloud computing system in the form of overall computing capacity.

2. Storage resource virtualization. Storage virtualization technology to different specifications of the structure of the storage facilities, including direct storage (DAS), network storage (NAS) and storage such as local area network (SAN) as a unity of abstract topology, establishing virtual network storage space, realize the integration and consistency of the storage facility use standardization, through virtualization digital storage service to provide storage service.
3. Cloud environment programming. For the cloud computing platform deployment discreteness, ability to encapsulate the underlying physical equipment standardization as well as resource management concentration etc., based on the cloud way of research and development has great difference with traditional programming methods, the programming model should be relatively simple, so as to ensure the parallel execution of complex background and task scheduling to users and programmers transparent. At present, the cloud environment programming model of service mapping - service scheduling - service execution is mostly adopted.
4. Technology related to SOA. To achieve the scalability of the cloud computing model, reliability, security, agility and maintainability, the PaaS and SaaS is based on the same layer of the global service bus (ESB) will use different hardware platforms, operating systems, and the function of the programming language unit, adopts independent interface conventions, guarantee in standard way to communicate between different functional units, the underlying technology realize decoupling and business applications [5].

### **3 Theoretical Model of E-Government System Based on Cloud Computing**

As is shown in Fig. 1, The model is mainly composed of four parts. It is a service system with complete system functions and resources that can be co-built and Shared.

In the context of cloud computing, the total amount of information has increased rapidly, which has brought development opportunities to the network. Therefore, the e-government system center must have strong data receiving, storage, processing and output capabilities. The infrastructure layer is the key layer of the system, with the help of virtual. The technology integrates all kinds of equipment into one, forming a system structure and providing services [6]. As a key part of cloud computing, the data resource layer includes outstanding data service delivery capabilities that integrate various types of storage devices in the network for data storage, business access, and other related tasks. The platform management mainly includes information security management and operation and maintenance management. The platform service layer is located on the first layer above the infrastructure layer. It mainly needs various functions according to the platform system, and provides corresponding support services and extended functions [7].



**Fig. 1.** Theoretical model of e-government system based on cloud computing

## 4 Related Applications of Cloud Computing in E-Government

### 4.1 Improve the Security of Confidential Information

In the current stage, the most important issue facing e-government in the process of information sharing is to continuously improve the security factor of information. How to better ensure the security of information has gradually become the current The government and relevant departments need to focus on the research tasks, and the rational use of cloud computing can better mobilize and synthesize the relevant e-government service systems in the cloud resources. It is not difficult to find that a reasonable application of cloud computing technology in e-government can better utilize the construction of unified clusters to ensure its ability to detect infrastructure and share information, while at the same time combining the computing power of related cloud computing technologies. Better conduct comprehensive security checks on e-government platform information [8]. Finally, the rational use of cloud computing technology into information protection will help the government to better improve the existing laws and regulations.

### 4.2 Build a Data Service Platform Associated with It

The core role of cloud computing technology as the core data service platform is to provide more diversified services for e-government data analysis. With the continuous development of technology, the construction of large databases for e-government has become more complete and perfect, and the data items contained in the database have

been further improved, which undoubtedly increases the overall difficulty of analyzing database content. At this critical moment. It is reasonable to apply the big data service platform to conduct more in-depth exploration and analysis of relevant information to ensure that the data content can be reasonably applied to the conquest department [9].

#### 4.3 Efficient Sharing of E-Government Information

Combined with the development of the existing e-government platform, the main distribution mode of China's existing e-government platform is the distribution of storage as the basic framework, but in view of the fact that there is no team e-government platform for more efficient control, so the actual there are some flaws in the platform database. Reasonable use of cloud computing technology can better optimize and upgrade this phenomenon. With the scientific control of distributed spring resources, cloud resources are slowly formed, and it is used as a basis to build an efficient search homepage, which is better. Improve the effectiveness of information sharing and discovery. The use of this technology can also better optimize the traditional distribution structure, improve the quality of management, avoid the cost of maintenance in the later cost maintenance, and save more funds for the government's work [10].

#### 4.4 Effective Overall and Aggregation of Internal Resources

Using cloud storage as the e-government data storage center can realize centralized storage of business data of each department, share part of data resources according to department level and information important level, and realize unified management of data resources, which can guarantee the security of data information to the greatest extent.

### 5 Conclusion

With the rapid development of cloud computing and big data technology, the government's e-government system construction technology also advances by leaps and bounds, which will further promote the development of government management, promote the co-construction, sharing and sharing of data, provide convenience for the government and enterprises, and at the same time, government functions have been maximized. Cloud computing technology can quickly adapt to and meet the growing requirements of e-government platform construction, and has a driving role. E-government platform construction and its service mode has prompted the government informatization focus can easily change, from the aspect of asset management has turned to service management level, but also to maximize the existing resources into the core operation and task in the process, cloud infrastructure, cloud computing and big data technology can make full use of the electronic government affairs system to get further development, achieve the purpose of save time, reduce the cost and improve efficiency, make the government responded quickly to the needs of the public, to build a satisfy the masses of the people's government.

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# Analysis of Physical Education Quality Evaluation Model in Colleges and Universities Based on Big Data Analysis

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**Abstract.** At present, the quality of physical education in most colleges and universities is relatively low, and most college students do not have adequate physical education and professional ability. In the process of physical education, reasonable evaluation indicators are used to scientifically and effectively evaluate the quality of physical education in universities. It is related to the improvement of physical education teaching and the overall development of students' body and mind. It is the key link to promote the improvement of physical education teaching level. This article aims to analyze the college PE teaching quality evaluation model based on the analysis of sports literacy and vocational ability, and to analyze these college data that require massive amounts. These data are stored in the database, and mining a large amount of unknown useful information and using big data to analyze can make the results more accurate. The original purpose is to use big data technology to evaluate the physical education and teaching ability of physical education in colleges and universities and to analyze various issues affecting the quality of physical education in colleges and universities. Taking Beijing Sport University as the research object, use the evaluation of teaching quality to obtain evaluation data, based on the perspective of big data analysis, study the impact of curriculum reform projects on quality, evaluate the status of college teaching levels, analyze the factors restricting the improvement of teaching quality, and improve school physical education. Teaching Quality.

**Keywords:** Big data analysis · Sports literacy · Professional ability · Quality of physical education

## 1 Introduction

Currently in the era of big data, it is through the compatibility and storage of large amounts of data, to accurately find the required information, and to achieve purposeful retrieval through artificial intelligence technology [1]. Big data is divided according to the type of data, and the capacity is above 10T. The real-time update speed of big data information is very fast, which is convenient for users to check the information in a timely manner. Through the update of data information, the system can maintain. The system is in a relatively active state, thereby ensuring the stability of the system operation and also ensuring accurate classification of implementation information [2].

The use of educational big data mining and data analysis technology to build relevant models in the field of education, explore the correlation between educational variables, and provide effective support for education and teaching reform will be the inevitable trend of modern information technology future teaching [3, 4].

At present, there are many teaching evaluation methods in universities, but most of the evaluation results are only numerical results after quantitative calculation under limited conditions [5]. For example, student evaluation activities are usually organized by schools using an education management system at the beginning or end of the semester [6]. The school set several teaching evaluation indicators according to the system's teaching requirements, and assigned them according to the importance of the teaching evaluation indicators. Through the students' evaluation of teachers in the teaching management system, the system finally uses the students to grade the teachers and weight the summary to get the final evaluation results of the students' teaching. Teaching evaluation results can only partially reflect the teaching situation of teachers. Teaching managers and teachers can only obtain "excellent, good, and qualified" results, and the results are often holistic and macro. Without a quantitative, micro, easy-to-learn, and operational evaluation model, teaching management and teaching work will be difficult to carry out [7]. It is impossible to find comprehensive and systematic results directly from these data. Therefore, it is difficult to provide more effective support for the decision-making of teaching managers. Using data mining technology to deeply explore teaching evaluation data can effectively solve these problems [8]. Data mining technology can extract hidden knowledge that cannot be directly observed by human eyes from a large amount of data [9]. Therefore, research the corresponding data mining methods, further explore the teaching evaluation data [10], make full use of a large amount of teaching evaluation data in the teaching management system, analyze the teaching evaluation index system, and take the students' sports literacy and professional ability as the core index [11]. Based on the perspective of big data analysis, study the impact of curriculum reform projects on the quality of classroom teaching, evaluate the teaching level of universities, analyze the factors restricting the improvement of teaching quality, explore effective methods to improve teaching quality, provide reference for teaching, and improve teaching quality Has an important role [12].

Based on the historical evaluation data of teaching, this article first analyzes the background of the topic and the practical significance of the topic selection, and briefly introduces the current situation of big data and related applications. It also introduced the related concepts of big data in detail. Secondly, it analyzes and discusses sports literacy and professional ability in detail. Focus on the analysis of sports literacy. And use the data to establish a model for the teaching evaluation of students, with the support of certain reliable data, through data analysis and draw conclusions.

## 2 Method

### 2.1 Evaluation of Teaching Quality

As the lifeline of sustainable development of colleges and universities, the improvement of teaching quality needs to improve the evaluation and supervision system, improve the evaluation standard system, and ensure that the normal work order is stable and efficient. Teaching quality evaluation activities are of great significance in education management, and can play the guiding and regulating role of “promote teaching with evaluation, promote learning with evaluation, promote management with evaluation, and promote construction with evaluation”, and are targeted for the effective completion of teaching tasks. The diagnosis, feedback, supervision and planning significance of teaching quality evaluation activities reflect the teaching level, teaching attitude, teaching organization, teaching effect and other conditions. It is the fundamental goal, key measures and effective means of teaching quality management. The joint participation of personnel from multiple stakeholders, the interaction of various levels of the index system, and an organic and unified quality control system project. Teaching quality evaluation activities should ensure scientificity, objectivity, and fairness, and scientifically optimize the efficiency of the entire process organization. The teaching management branches of universities at all levels should determine the assessment procedures at multiple levels and systematically, and comprehensively improve the mechanism of information collection, discussion and feedback. The above tasks need to rely on a multi-level index system to measure, collect and quantify the information of each index. From this, the quantitative work can play an incentive-oriented role in improving the teaching level of teachers. Objective to ensure the standardization of the implementation process based on the monitoring and promotion of teaching quality and the professional development of teachers.

### 2.2 Sports Literacy

Sports literacy is a concept of the philosophical field based on an in-depth study of philosophical theory, and the concept is extended. It is believed that literacy includes spiritual, knowledge, personality, and comprehension capabilities. Scholars at home and abroad have come up with different concepts in different fields, with many research results, but have not yet formed a unified concept. Yu Zhi believes that sports literacy is the cultivation and connotation of innate inheritance and acquired cultivation and education. From the perspective of sports skills, Zhang Hongtan expounded that sports literacy takes sports skills as its core stability and practical ability, and highlights the role of sports skills in sports literacy. Wu Wenfeng believes that sports literacy is a state of stable ability formed by continuous learning and practice in life, which includes sports ability and sports knowledge and skills. There is no clear time limit for the proposal of the concept of sports literacy in foreign countries. As early as 1969, American scholar Morrison conducted a comprehensive study of sports literacy. He believed that sports literacy refers to a person's superb ability to do things and superbly handle everything. Innovation and control. Sports literacy means that people can use their sports skills freely in social environments and social activities, and can build

confidence in sports, handle and maintain the relationship between people in sports, and better coordinate their bodies and mental state. Based on philosophical theories and studies such as monism, phenomenology, and existentialism, it is proposed that sports literacy is a long-term and stable state of competence such as the knowledge, abilities, experience, and self-confidence accumulated by individuals in the life course. There is a clear difference between domestic and foreign countries. Foreign countries regard sports literacy as a philosophical concept, while domestic is only formed as a culture. Secondly, in terms of the expression and composition of concepts, foreign sports literacy focuses on the three aspects of students' physical, emotional and cognition for both physical and mental aspects. Based on the research results at home and abroad, the author believes that sports literacy is formed on the basis of inheritance through acquired education, including sports knowledge, sports skills, sports behavior, physical fitness, and sports morality.

### 2.3 Professional Competence

Vocational and technical education must take the improvement of national quality as its fundamental purpose, focus on cultivating students' innovative spirit and practical ability, so that students have comprehensive quality and comprehensive professional ability. Therefore, the various reforms of vocational education should serve to improve the professional ability and comprehensive quality of students, and the focus of vocational education reform is mainly on the reform of training mode. This study can better grasp the connotation and formation process of vocational competence by studying the concept, characteristics and formation rules of vocational competence, so that vocational and technical education and teaching are scientific and targeted, and it is a better vocational education model reform services. We define professional ability as: the ability of individuals to transfer and integrate the knowledge, skills and attitudes they have learned in specific professional activities or situations to complete certain professional tasks.

## 3 Experiment

As shown in the figure, the feedback of core sports literacy in physical education requires systematic evaluation indicators and mechanisms. The evaluation of students' core sports literacy in physical education is divided into macro evaluation and micro evaluation. Macro evaluation is based on the overall goals of physical education teaching and conforms to the new curriculum physical education and health evaluation standards. It takes society, school, and family as the main body of evaluation to realize the function of school physical education. The coordinated development of micro-evaluation can refine the internal evaluation system of physical education. For example, expert evaluation is a professional perspective on students' exercise ability, sports ethics, and healthy behavior, and self-evaluation reflects a self-discipline behavior. Parent evaluation is mainly concerned with students' internal health development and academic progress. Teacher evaluation is based on the feedback of the effect of physical education. Social evaluation is a test of the level of physical education in schools.

### 3.1 Specific Steps

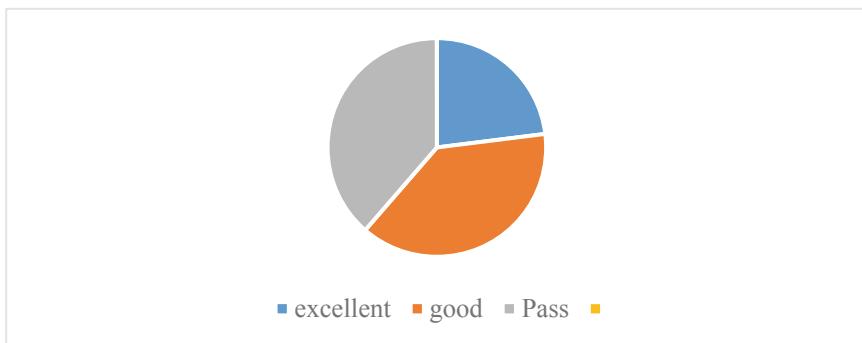
The database consisting of students' academic performance and psychological quality is pre-processed, and then operated and analyzed. Many evaluation contents and methods form an organic unified connection to realize the effective operation of the evaluation mechanism, and guide the core sports literacy of students towards a healthy and active. The comprehensive development can also effectively improve the quality of teaching and make teaching more efficient.

## 4 Discussion

From September 2018 to October 2018, a summary of the university students' public physical education curriculum is shown in Table 1, and the comprehensive performance of students is shown in Fig. 1. With the continuous deepening and emphasis on cultivating sports literacy and professional ability, the theory has gradually begun to show results in the classroom. The effect has been continuously consolidated, the school brand radiation has been continuously enhanced, and has achieved high theoretical and practical value. Theoretical teaching, practical teaching, and special quality training are important components of physical education content in middle and colleges. However, due to the uneven development of teaching resources, the development of theoretical teaching in schools in some areas lags behind. Some good practices are mainly the formation of school-level bands or training of individual specialty students, but the theoretical teaching has not really been popularized in the physical education classroom. Too many problems have made the effect of improving students' core sports literacy insufficient. E.g.:

**Table 1.** Summary of public sports courses for college students from September 2018 to October 2018

	Excellent	Good	Pass
Learning motivation	40	18	6
Classroom discipline	30	16	18
Participation in classroom activities	12	8	44
Class content mastery	18	36	10
Ability to observe problems	8	36	20
Language expression and communication skills	20	32	12
Courage and confidence	8	12	44
Leadership	12	28	24
Limb coordination	4	40	20
Improvisation, imagination, action	6	24	34
Self-knowledge and summary ability	4	20	40



**Fig. 1.** Comprehensive performance of students

- (1) The lack of athletic ability of college students lies in the unreasonable training mode. School administrators do not attach much importance to the content of physical education curriculum. They still maintain the traditional inherent model, follow the old rules, and build cars behind closed doors. They cannot really mobilize the enthusiasm and interest of students, and it is difficult to mention core literacy.
- (2) The construction of college students' physical education curriculum system cannot keep pace with the times. In the context of the new curriculum reform, students' development needs to keep pace with the times. While mastering the basic theoretical knowledge, they should also strengthen the cultivation of practical ability. In terms of physical education, although there is a loose teaching environment, it lacks the guidance of teachers to truly realize the transfer of physical education knowledge, and then students cannot fully grasp the content of the established curriculum.
- (3) Lagging of evaluation standards of physical education curriculum. Curriculum standards regulate teachers and students to carry out targeted teaching and learning in accordance with the requirements of curriculum plans and outlines. The standards have certain norms and have the characteristics of the times, which can play a role of supervision and management in the teaching process.
- (4) Lagging in the construction of physical education curriculum. The investigation found that the school does not have a comprehensive curriculum content system, which needs to be consistent with the actual development of students. It must not only have a relatively complete theoretical foundation, but also have flexible and individual curriculum content that highlights youthful vitality.
- (5) The concept of physical education is imperfect, combined with the "literacy education concept" of a university's physical education school is summarized as follows: First, in the course of a university physical education school's literacy education, it reflects the cultivation of students' new ideas, new concepts, new lifestyles, and Communication methods, but the traditional education concept is still maintained in the implementation process, and there is a serious disconnect between theory and practice. Second, the host accepts social reforms and changes.

Achieving the all-round development of students is the general goal of education, and literacy education is to train students to adapt to the continuous changes of society and become complete people. Education and teaching plans are disconnected from ideals. Third, educational thinking cannot keep pace with the times. The inherent nature of the thinking model still maintains the duck-style teaching, lacking the spirit of innovation and advancing with the times. Fourth, the one-sided pursuit of academic performance on students' core literacy ability is also a more important factor.

## 5 Conclusion

This article details the concepts related to big data. Secondly, it summarizes the related concepts of sports literacy and professional ability, and analyzes and discusses them in detail. Based on a data survey of an independent college, through related analysis, we have reached the following conclusions: Although the curriculum reform has improved the quality of teaching, the results achieved are far from sufficient, the school system is not perfect, and education. The lack of ideas is an important factor affecting the quality of teaching. Only by continuously improving the system, improving the enthusiasm of students, and cultivating good teaching ideas can we better improve the teaching quality and make the classroom more efficient.

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# Yigevisual Communication Design for Stage Decoration of Digital Media in the Context of Big Data

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**Abstract.** In recent years, with the rapid development of China's information technology and digital media technology, the traditional graphic design obviously cannot meet the needs of multimedia communications. The pace of people's lives is accelerating and the demand for information is also increasing. The requirement for rapid access to information in various forms, visual communication design is influenced by digital media, and also has a certain impact. For the digital media industry, we not only need to control the quality, but also control the optimization of design concepts, and use various design technologies reasonably in order to make the decoration design activities more vivid and three-dimensional, thereby improving the visual communication design of digital media stage decoration. This article analyzes and discusses the visual communication design of digital media stage decoration under the background of big data. In terms of methods, this article mainly improves the four aspects of strengthening the inclusiveness of visual communication design, incorporating a lot of artistic inspiration, using dynamic design, and strengthening the interaction with the audience on the basis of traditional stage decoration visual communication; In terms of experiments, by giving lectures by students and investigating people watching from the audience, it was concluded that the data strengthens the inclusiveness of visual communication design, incorporates a lot of artistic inspiration, and uses dynamic design to strengthen interaction with the audience Satisfaction in the four aspects was 55%, 67%, 53%, and 63%. Explain the effectiveness and feasibility of the method proposed in this paper. And put forward suggestions, in these four aspects, the effect is stronger than traditional stage decoration visual communication. Can consider the integration of one or several aspects.

**Keywords:** Information technology · Digital media technology · Visual communication design · Optimized design

## 1 Introduction

In the age of modern technology maturity, the application and comprehensive innovation of technology using the Internet resources as the medium have also achieved updated development. The Internet technology has been fully integrated into all aspects

of public life. The digital age has become an important feature of the times. In this context, digital media is also widely used. Based on the mature application background of digital media, there has also been a substantial change between the public's visual psychology and specific visual perception methods. In today's mature applications of mobile digital media, packaging design has evolved from a flat image to a three-dimensional visual symbol. In the new era, changing the traditional design concept can no longer adapt to the new information transmission channel. Therefore, the visual communication design system consistent with the development of the times is also enriched and improved on the basis of continuous innovation. The mature development and application of new media is not only technical innovation and improvement, but more importantly, comprehensive innovation adapted to the needs of mass communication. Looking at the application trend and background of digital media, its future will focus on serving users, not a single software service. Especially in the mature application background of intelligent technology, the entire digital media and intelligent colors are more intense. Moreover, in the context of the era of resource fusion, future technological integration and resource fusion applications have developed into important era features.

In graphic design, traditional paper media is an important carrier. Through the development of digital media, visual communication design has gradually penetrated into people's lives [1]. Unlike visual communication design classification, graphic design has no rich expressive power. It also happens in the form of media. Certain changes have promoted the development of visual communication design, and alternative design work is using requirements and expressions. For both the extension and the content, it is difficult to meet the needs of flexible and diverse visual information and detailed content. One of the characteristics of visual communication design is the continuation of graphic design. First, they share the same characteristics in terms of visual elements, design goals and rules. In the development of the information age, visual communication design will be realized. In interface design, graphic design and multimedia design, the main purpose of visual communication design is aesthetics and information transfer. Use the same visual elements during breath transfer.

In digital media marketing, advertisers, marketers, agents and other corporate brand agents use digital media to improve their product positioning and mass communication, which directly affects the visual design concept of stage decoration visual communication [2]. Digital media is defined by technology and intelligence, so its decorative visual design is more high-end. Many of the visual communications of stage decoration have given up colorful and popular elements and started to stand out in the decoration. The use of code, technology and other elements has attracted people's attention. Under the influence of digital media, the visual communication of stage decoration keeps pace with the times. Digital media affects people's lives and people's attention. Therefore, in order to satisfy public preferences, the visual communication design of stage decoration is also continuously updated and upgraded through the development of digital media [3].

In terms of methods, this article mainly improves the four aspects of enhancing the inclusiveness of visual communication design, incorporating a lot of artistic inspiration, using dynamic design, and strengthening the interaction with the audience based on the traditional stage decoration visual communication; In terms of experiments, the data was obtained by giving lectures by students and investigating the people watching the audience.

## 2 Method

### 2.1 Strengthen the Inclusiveness of Visual Communication Design

The visual communication of digital media stage decoration is realized through pictures, and it is also real-time [4, 5]. The visual communication design of digital media involves many fields such as visual language and graphic system. It integrates philosophy, art, culture, symbols and more. This is a very inclusive form. In this mode, in addition to actively communicating with the audience, designers can also strengthen communication with their peers, so as to change and innovate design concepts in a timely manner, and use advanced multimedia technology to integrate pictures, animations, text, movies, Music, etc. [6], to achieve the effects of pictures and text, audio-visual integration and other effects. Various forms of unified multi-angle visual communication provide a powerful synthesis for digital media visual design. It helps to improve the efficiency of information transmission [7, 8].

### 2.2 Incorporate a Lot of Artistic Inspiration

The relationship between artistic development and technological progress is very high. In the visual communication design of digital media stage decoration, many artistic inspirations are often incorporated, which makes it have strong personal characteristics. In the Internet era, audiences are faced with a large amount of information and diverse content, and they are more willing to accept information content with strong timeliness and visual impact, which is very consistent with the visual communication of digital media. In addition, as the main audience of digital media visual design, young people's aesthetic and psychological needs are more personalized, which urges designers to incorporate more artistic elements into the design language, thereby further improving the artistry of visual communication design [9, 10].

### 2.3 Using Dynamic Design

The visual communication design of traditional media is static and flat, while the visual communication design of digital media stage decoration is dynamic, three-dimensional and even multi-dimensional, which is also in line with people's dynamic behavior and behavior. With the popularity of communication technology, Mobile portable devices can enter people's vision more and more frequently, and have an impact on the visual communication design of digital media. People do not need to use a TV, a projector, and information can be obtained anytime, anywhere through only smartphones, tablets and other mobile devices, which lays the foundation for the dynamic design of digital media vision. On the other hand, with the advent of 3D technology, intelligent simulation instruments, computer painting and other new media technologies, designers can design through dynamic multiple pictures, animations, movies, etc., which not only effectively expands the amount of information. Communication also adds more creative elements to the visual communication design of digital media.

## 2.4 Strengthening Interaction with the Audience

The visual communication of digital media stage decoration is interactive, mainly human-computer interaction and designer interaction. The former is the interaction between the audience and mobile portable tools, which can effectively meet the audience's demand for freshness, and it is of great significance to improve audience loyalty and enhance the intensity of communication. The latter is a dynamic interaction between the audience and the designer. With the support of highly developed digital technologies, human-computer interaction has a lot of room for development. Through human-computer interaction, designers can better understand the needs of the audience, so that the design can meet the needs of the audience.

# 3 Experiment

## 3.1 Purpose of the Experiment

According to the questionnaire survey, some problems of decorative visual communication design of digital media in the context of big data and the inclusiveness of visual communication design proposed in this article are incorporated. A lot of artistic inspiration is incorporated, and dynamic design is used to strengthen interaction with the audience. Wait for suggestions and practice, and carry out the corresponding evaluation experiment scheme. To verify the feasibility and necessity of the method proposed in this article.

## 3.2 Subjects

The subjects of this experiment were some people in a certain city.

## 3.3 Experimental Design

Based on the evaluation questions analyzed in this article's questionnaire and some of the characteristics of digital media's stage decoration visual communication, this article began to design experimental schemes. This article addresses the four aspects of assigning tasks to college students, strengthening the inclusiveness of visual communication design, incorporating a lot of artistic inspiration, using dynamic design, and strengthening interaction with the audience. Pay corresponding rewards from different schools to recruit some students to make the ppt of the four aspects respectively, and finally make a unilateral speech to determine the personnel. Prepay part of the funds to boost students' motivation to play well on the stage.

The fixed number of students who started the lecture at the school was 150. At the end of the lecture, the audience was surveyed to see their satisfaction with the visual communication of traditional stage decoration. Compare the results of the four surveys, and then combine the visual communication of the effect that is stronger than the traditional stage decoration to optimize the effect.

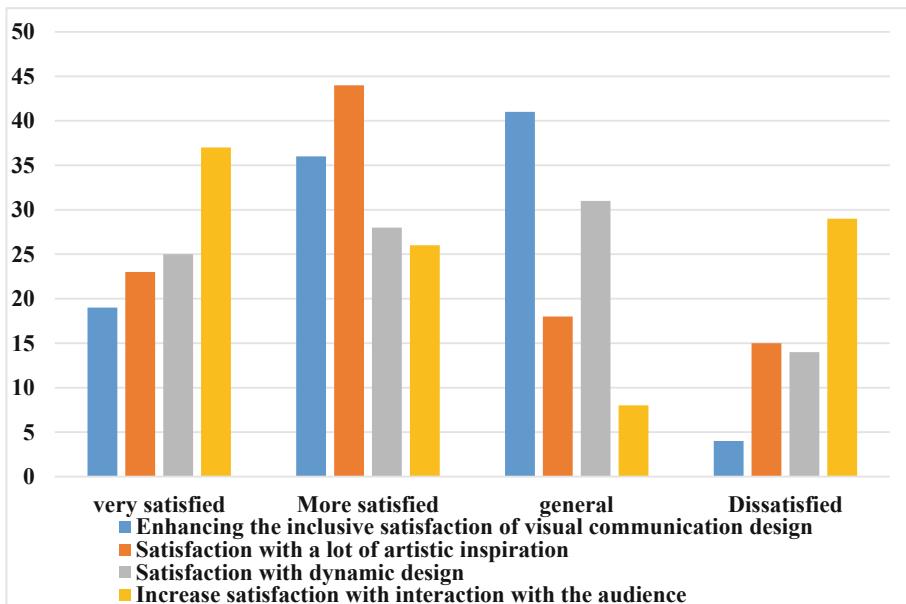
## 4 Discussion

### 4.1 Implementation of the Experiment

This article pays corresponding compensation to determine the number of college students in different schools, and then separately addresses the four aspects of strengthening the inclusiveness of visual communication design, incorporating a lot of artistic inspiration, using dynamic design, and strengthening interaction with the audience. At the end of the lecture, the number of people who watched the lecture was 150. At the end of the lecture, the audience was surveyed to determine 150 valid survey questionnaires for analysis. See its satisfaction with the visual communication of traditional stage decoration. And then combine the visual communication of the effect stronger than the traditional stage decoration to achieve the effect optimization (Fig. 1).

**Table 1.** Satisfaction of traditional stage decoration visual communication

	Very satisfied	More satisfied	Average	Dissatisfied
People	28	25	21	76
Percentage	18.7%	16.6%	14%	50.7%



**Fig. 1.** Satisfaction in four areas

As can be seen in Table 1 above, 35.3% of people expressed satisfaction with traditional stage decoration visual communication, 14% said that the effect was average, and 50.7% expressed dissatisfaction. It can be seen from the above figure that 55% of people who added to enhance the inclusiveness of visual communication design on the basis of traditional stage decoration visual communication expressed satisfaction and 4% said they were not satisfied. On the basis of traditional stage decoration visual communication, 67% of people expressed satisfaction and 15% of people expressed dissatisfaction. On the basis of traditional stage decoration visual communication, 53% of people adopt dynamic design, and 14% are dissatisfied. On the basis of traditional stage decoration visual communication, 63% of the people said that they were satisfied and 29% were dissatisfied. In these four aspects, the effect is stronger than traditional stage decoration visual communication. So consider the integration of one or several aspects.

## 4.2 Application in Web Design

The application of visual communication design in web design should fully follow the scientific principles of visual design. Compared with static pictures, dynamic pictures are usually more attractive to viewers, and have a strong visual impact and appeal. Therefore, designers should fully grasp the design characteristics during the design process. In web design, dynamic design can be used to attract the attention of the audience. At the same time, the optimization and layout of the network interface structure should be strengthened to break the traditional communication restrictions. When adjusting the page structure, a non-linear communication structure should be used so that users can read it at will without being limited by the traditional page structure. In the page layout, the structure is reasonably optimized. In addition, interaction design is also very important in web design. Interaction design mainly refers to the interaction between color and page. Important and non-critical information are shown in different colors to distract the audience. At the same time, each information node should be reasonably distributed. For example, on the bilibili website, the original design of the bullet screen should be placed at the top of the screen. Users can choose their own preferences to adjust the position, number and speed of curtains.

## 4.3 Application in Digital Advertising

In the visual communication design of digital advertisements, it is necessary to adopt dynamic display for advertisement design, that is, to use 3D technology, flash animation and AR technology to highlight the main information of the advertisement and expand the audience's stay time. When the advertisement was launched, it deepened the audience's impression and inspired the audience's desire to buy. Secondly, in the digital media era, the most important function is interactivity. Therefore, in visual communication design, we can make full use of digital technology to build interactive software, such as WeChat, Alipay and other software. In the software upgrade, we will learn about the latest features of the software in the form of question and answer. In short, the essence of visual communication design is a new way of communication. In the digital media era, both the expression and design concept of visual communication design have undergone certain changes, and the design industry has also undergone

great changes. With the rapid development of information technology, we should establish an open interpersonal information exchange platform to realize human-computer interaction, break the traditional linear structure limitation, and see better development of sensory communication design.

## 5 Conclusion

The rapid development of digital media is closely related to visual design. The visual communication design of stage decoration realizes effective communication through the carrying of digital media, continuously improves the development level of the design, better meets the overall design requirements, and expands the design ideas and design width effects. In terms of methods, this article mainly improves the four aspects of enhancing the inclusiveness of visual communication design, incorporating a lot of artistic inspiration, using dynamic design, and strengthening the interaction with the audience based on the traditional stage decoration visual communication; In terms of experiments, by giving lectures by students and investigating people watching from the audience, it was concluded that the data strengthens the inclusiveness of visual communication design, incorporates a lot of artistic inspiration, and uses dynamic design to strengthen interaction with the audience Satisfaction in the four aspects was 55%, 67%, 53%, and 63%. And put forward suggestions, in these four aspects, the effect is stronger than traditional stage decoration visual communication. Can consider the integration of one or several aspects.

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# Education of Ideological and Political Course Under the Background of Cloud Computing

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**Abstract.** Under the rapid development of Internet and computer technology, cloud computing, as a computing method under big data, is becoming a research hot spot at home and abroad. Cloud computing is based on the Internet platform, and uses the currently mature virtualization technology. It can manage and schedule plenty of resources uniformly through the network and provide users with more quality services. Especially, accompanied by the prosperity of communication technologies, Cloud Computing has been taken advantage in the Ideological and political fields in school education. For ideological and political lectures in all kinds of universities, the traditional method is mainly to use SMS, MMS or some simple clients for virtual teaching, but the slightly complex work is difficult to complete. In this case, the original simple system can not have the big data interaction in the modern teaching background, and can not bring a good teacher-student interaction. Thus, it would be much helpful if education department upgraded the original mode of ideological and political course. Obviously, it might be a excellent attempt that rely on Cloud Computing to educate students' ideology.

**Keywords:** Cloud computing · Ideological and political theory course · Teaching modes

## 1 Introduction

With the rapid development and improvement of the Internet, cloud computing, big data and other technologies, ideological and political education in different universities majoring in various fields of science has also been comprehensively developed. Among them, MOOC and flipped classroom have shown their unique advantages in the classroom, and have improved the informationization and sharing of teaching. However, due to the complexity, independence, and novelty of the teaching content, students will lose a lot of useful knowledge learning slices during their study. As a result, they will waste time on knowledge that is not so important to them, so they cannot optimize teaching resources and make learning efficient [1]. It is urgent to introduce advanced cloud computing and build an intelligent data service platform. This will improve the performance of data services and ensure that each teaching system shares educational resources. Thus, the ideological and political theory course based on cloud computing is quite necessary. In such an environment, along with the teaching features

and necessity of ideological and political course, cloud computing should be combined with its teaching, so as to fully use the teaching concepts and resources of cloud computing based on ideological and political educating. It has become an important task to found the mixed educating mode of “students-centered and teachers-led” ideological and political course [2].

## 2 An Overview of Cloud Computing Technology

### 2.1 Concept of Cloud Computing

The centre of cloud computing is to connect a great quantity of computing resources through the network, unify management and scheduling, and form a computer resource pool to provide on-demand services to users. According to the National Institute of Standards and Technology, cloud computing is a computing mode that can share data pools through the network. Precisely, it is a service mode, rather than a mere technology. It is mainly manifested in the following several areas:

- (1) The Internet is the carrier. Cloud computing is an Internet computing mode with public participation. All devices that can be connected to the Internet can use the Internet to achieve transparent and ubiquitous access [3].
- (2) Service is the core. The various software and hardware are resources and are simplified into services, and users only need to see the service itself, not the implementation of the infrastructure.
- (3) Resources are configurable. Cloud computing has the special significance of integrating resources and expanding as needed. It uses virtualization technology to integrate and abstract physical resources from different data centers into logical centralized, dynamic and elastic virtual resources, so that it can effectively allocate and expand as needed.
- (4) Users can use resources as needed. Without directly purchasing complex software and hardware, users can use the network to get the computing power they need most easily and quickly.

The above analysis shows that cloud computing is gradually developed on the basis of parallel computing, distributed computing, cluster computing, grid computing, utility computing, etc. From the only perspective of technology, cloud computing represents the advanced concept of information technology development and shows great vitality [4]. Cloud computing is the inevitable outcome of the development of modern computing technology. With the further research and development of modern cloud computing technology, it will certainly have a profound influence on the production and lifestyles of people in the future.

### 2.2 Key Technologies of Cloud Computing

Cloud computing involves many technologies, such as communication, storage, computing or resource management, scheduling, billing, etc., which are worthy of in-depth study. From the perspective of data-centered and on-demand services of cloud

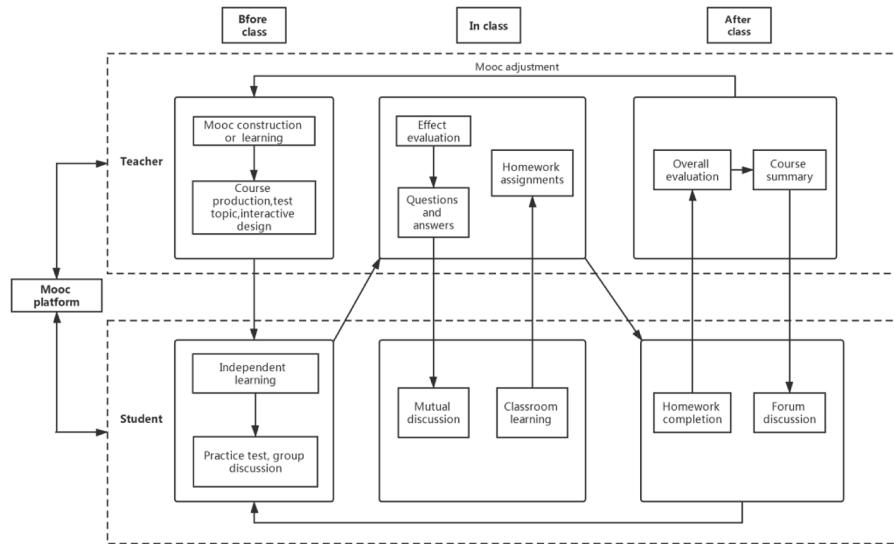
computing, virtualization technology, distributed storage technology, cloud programming technology and SOA technology are its key technologies [5].

- (1) Virtualization technology. There are two forms of computer infrastructure in the network. Firstly, the large computing center mainly uses cluster technology to virtualize it into a large, symmetrical multi-processing system (virtual SMP), and provides customized computing powers for users by running multiple virtual machines (VM). Secondly, the independent computing facilities scattered in the same physical location in the network are abstracted into a single computing resource and used in the cloud computing system in the form of overall computing power.
- (2) Distributed storage technology. Storage virtualization technology classifies the storage facilities of different specifications including direct attached storage (DAS), network attached storage (NAS) and storage area network (SAN) into a unified abstract expansion to establish virtual network storage space. Then, it implements consistent integration and standardized use of storage facilities, and provides storage resource services externally through virtualized digital storage services.
- (3) Cloud programming technology. Cloud computing platform has the features of discrete deployment of underlying physical devices, standardization of capability encapsulation and centralization of resource management. In view of this, the research and development based on cloud environment is quite different from the traditional programming [6]. Thus, its programming model should be simple, so as to guarantee that the complicated parallel execution and task scheduling in the background are transparent to users and programmers. At present, the cloud environment programming model of service mapping - service scheduling - service execution is mostly adopted.
- (4) SOA related technology. To realize the scalability, reliability, security, agility, maintainability and other features of cloud computing mode, the same global service bus (ESB) on the PaaS and SaaS layers connects functional units using different hardware platforms, operating systems, and programming languages. The independent interface protocol is adopted to ensure the communication between different functional units in a standard way and decouple the underlying technology from the business application [7].

### 3 Theoretical Model of Ideological and Political Education Based on Cloud Computing

The theoretical model of MOOC based on cloud computing is the representative of cloud computing in the ideological and political theory course at this stage. The model consists mainly of three parts. It is a service system with complete system functions, which can achieve resource co-construction and sharing, as shown in Fig. 1:

Under the background of cloud computing, the total amount of information increases rapidly, which brings the opportunities to the network, and also brings the opportunities and challenges to the virtual teaching in numerous universities located in different regions of China. Thus, the network department and the teaching department



**Fig. 1.** Theoretical model of MOOC based on cloud computing

of these schools should cooperate to present the courses taught to students with video, stories and visualizations by means of MOOC and flipped classroom. School cloud computing system to have a strong data reception, storage, processing and output capacity. The infrastructure layer is the key layer of the system, which integrates various devices with virtual technology to form a system structure and provide services. As a key part of cloud computing, the data resource layer includes outstanding data service delivery capabilities. It integrates various types of storage devices in the network for data storage, student access, and other related tasks. The platform management layer mainly includes layers of information security management and operation and maintenance management. The platform service layer is located on the upper layer of the infrastructure layer [8]. It mainly provides corresponding support services and expansion functions according to the needs of the platform system.

#### 4 The Relevant Application of Cloud Computing in the Course of Ideological and Political Theory

With the continuous development and promotion of the cloud computing mode, it profoundly changes the network environment, educational subjects, educational objects and educational process of college ideological and political course, which brings great alternations to the college network ideological and political education.

#### **4.1 Improving the Hardware and Software Construction of Network Ideological and Political Course and Reducing Costs**

The progress of college network ideological and political class requires large capital to purchase hardware equipment. However, under the progress of information technology, the updating speed of hardware equipment is faster and faster, which will undoubtedly increase the financial burden of colleges and universities and restrict the promotion of ideological and political education on the Internet. The use of cloud computing can not frequently eliminate the hardware equipment, and with using the old computer, it can be virtualized into a “host” with powerful processing functions. This will greatly reduce the cost of purchasing these hardware, reduce the cost of upgrading and maintaining the server and the required infrastructure, labor management, as well as energy consumption. In addition, cloud computing can supply a dependable and safe data storage center for colleges and universities, and store ideological and political resources on the “cloud”. Schools no longer need to concerned about data leakage, hackers, virus attacks and other security threats, also do not need to pay high administrative costs.

#### **4.2 Realizing the Co-construction and Sharing of Resources of Ideological and Political Course**

At present, there are many problems such as uneven distribution, low sharing degree, repeated investment, slow updating speed and lacking cooperation in the resources of college network ideological and political course. With cloud computing, colleges and universities can jointly build a space for sharing ideological and political course resources, share high-quality teaching resources and new teaching methods, and form a unified teaching resource pool [9]. This not only reduces the cost of developing teaching resources, but also greatly improves the efficiency. Teachers and students can simultaneously acquire cloud teaching resources and share them with others through various terminals at any time, which helps to realize education equity. Meanwhile, cloud computing can solve the problem of idle and waste of resources caused by the independent dispersion of education resources, and achieve the purpose of integrating the resources of ideological and political course. Integrating education resources through cloud computing can promote the even distribution of its resources, reduce teaching costs, achieve the popularization, sharing and exchange of quality education resources, and strengthen the quality of education and teaching.

#### **4.3 Enriching the Education Mode of Ideological and Political Course**

With the application and progress of cloud computing, it will open up new ways for the network ideological and political work in universities of a variety of levels. This technology can supply a great education resources and strong software support for the course. It will increase the space of ideological and political education and enrich the content, thus enhancing students' interest in learning. Cloud computing can be used to create virtual society and virtual scenes and other simulation teaching environments, and to change static texts, pictures, sounds, etc. into dynamic modes, which can

provide students with an immersive experience. As a result, this will greatly enhance the attraction and persuasion of ideological and political education.

#### **4.4 Helping Students to Study Independently and Cultivate Their Innovative Consciousness**

Cloud computing helps to construct three teaching environments (namely, school teaching environment, group learning environment, and students' independent learning environment) and three teaching systems (namely, automatic transmission system of teaching information, teachers' guidance and regulation system, and students' independent learning system). As long as there is a browser that can access the Internet, teachers and students can choose learning content and learning partners independently through the services provided by cloud computing without mastering complex software operation. They are free to build a individualized learning environment and make better use of convenient communication channels to communicate with other teachers or other scholars. This will not only improve learning efficiency, but also help students develop their innovative ability and lifelong learning. Besides, the cloud computing mode is more effective than the traditional one in shielding some bad information in the network, and reducing the influence of students' independent learning on their values and ways of thinking.

#### **4.5 Helping Ideological and Political Educators to Conduct Scientific Research and Exchanges**

At the moment, colleges and universities are relatively independent, and the mobility among teachers is not strong, and high-quality teachers are concentrated in a few famous schools. Through the services provided by cloud computing, we can establish a resource cloud for ideological and political education, so as to reinforced the resource sharing and exchanges among teachers in various schools, which will help improve the overall level of this course. Besides, due to the different scientific research environments in these schools, some complex scientific research projects often cannot be completed because of huge manpower, material resources and time. Using cloud computing technology will provide an accurate and powerful management system for this kind of research, and ensure the smooth development of scientific research projects under the effective data management and integration of resources [10].

### **5 Conclusion**

The development of cloud computing raises higher demands for the comprehensive quality of ideological and political course educators in dozens of universities and colleges. Building a high-quality ideological and political education team is the premise of efficient ideological and political education in the cloud computing environment. Ideological and political educators must keep pace with the times, enhance their awareness of science and technology, and constantly strengthen their own learning, and adapt to the development needs of the cloud computing era. Educators should

consciously apply cloud computing to ideological and political education, so that this education in schools can keep pace with the progress of information technology. Meanwhile, colleges and universities should also maximize the existing resources into the core operation and task process. The full use of cloud infrastructure, cloud computing technology and big data technology can further develop the teaching of ideological and political theory. In the end, it achieves the goal of saving time, learning More, high efficiency and real time, so that the cloud computing stage can reflect the needs of teachers and students, and build a knowledge community platform that both teachers and students are satisfied with.

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# The Application of Big Data in Urban Governance

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**Abstract.** After entering the 21st century, along with the rapid development of Internet information technology, big data application technology has also emerged at the historic moment, and has developed rapidly in recent years. China has also paid more and more attention to big data technology and has successively built in Guizhou and other places. The National R & D Center for Big Data has been strengthened to increase support for big data technologies. The pace of the construction of smart cities relying on big data technology has become more and more stable. This article starts with the concepts of big data and smart cities, and explains the great role of big data technology in urban governance. And important significance, and further study the multiple application modes and directions of big data technology in urban governance. Big data effectively analyzes and makes scientific decisions by collecting, mastering, analyzing, and displaying massive amounts of data. It improves the development conditions and environment of cities, improves people's living standards, and creates theoretical foundations and support. At the same time, the application of big data to urban governance is a new way to update urban management concepts, innovate social governance models, and improve government governance capabilities, and take as a key role in promoting the modernization of national governance systems.

**Keywords:** Big data · Computers · Urban · Governance

## 1 Introduction

With the rapid development of global urbanization, environmental, safety and other problems and hidden dangers brought about by the development of large cities have also frequently occurred, which has become a huge factor for urban development and a major problem for the development of modern cities. With the information technology development, relying on the big data technology-based concept of the smart cities construction has become the goal of future urban development [1]. The construction of smart cities will improve the management and service level of the entire city, greatly improve the living environment of residents, and accelerate the pace of urban construction promotes the long-term development of urban construction and has become a brand new concept of urban construction.

## 2 Characteristics of Big Data

### 2.1 Understanding of Big Data

Big data is a newest and most comprehensive form of data display. With the continuous development of information technology and rising space value, it is impossible to obtain these data through previous information technology [1]. For example, in urban and rural planning, if you want to obtain the entire city's data source in one city, which is the fundamental source of big data, data breeding is the product of a very large number of species and a wide range.

### 2.2 Features of Big Data

The basic big data characteristics are that the data is very rich, which covers a wide range of fields, runs and processes quickly, and has high data value and low density.

#### 2.2.1 Timeliness

Big data technology can collect and process massive data in time, and control system state according to data processing. The information processing and the process proceed simultaneously, this technology realizes to the process simultaneously control [2].

#### 2.2.2 Predictability

After computing a variety of data, big data technology can predict relevant information and carry out real-time dynamic monitoring [3]. Combined with the changes of data in different time periods, the change characteristics of this information can be timely reflected, and the change prediction in the future period can be carried out based on this.

#### 2.2.3 High Efficiency

This technology has greatly improved the efficiency of data mining, and can also summarize the internal relationships in data and realize the distributed processing of big data. By analyzing other information, relevant information affecting a certain information can be obtained to facilitate proper problem solving, which is a great benefit to improve the efficiency of data processing [4].

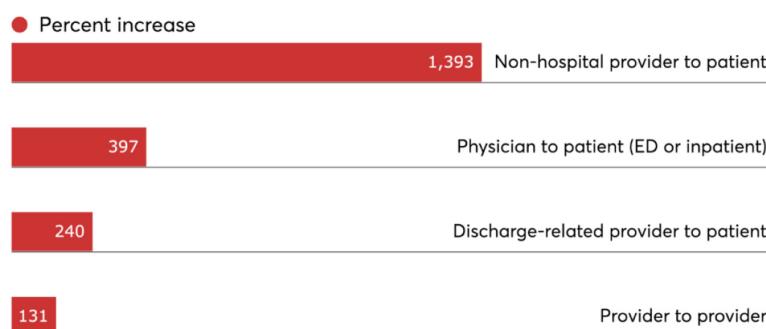
## 3 Big Data Application in Urban Governance

Big data technology can improve the quality and level of urban services, speed up urban emergency response speed, and improve the efficiency of urban management services [5]. China's past is relatively single extensive urban development model, relevant supporting quality of service, the traditional data acquisition and processing cannot satisfy the increasing speed up the pace of urban construction, unable to cope with the complex urban things processing, and through the data processing method, can be quickly in large database analysis, proposed law serves for the city construction, summarizes the treatment measures, speed up the management measures for emergency

treatment, improve the efficiency of urban services. Big data processing can optimize the structure of basic urban services, such as urban security, medical care, and transportation, supervision and power grid, realize adequate planning and management in space and time, and provide great convenience for residents' lives. And big city enterprise industry information data acquisition response, can accurate response industry development trend and characteristics of real-time change trend of the market timely and accurate feedback, so that enterprises take timely measures to have ready to deal with, improved the efficiency of corporate behavior, improve enterprise competitiveness, promote the industry market healthy development [5]. China must give greater support to the society in big data processing, speed up the big data industry development and the smart cities construction escort, mainly in the following aspects:

### 3.1 Big Data Application in the Construction of Medical Service System

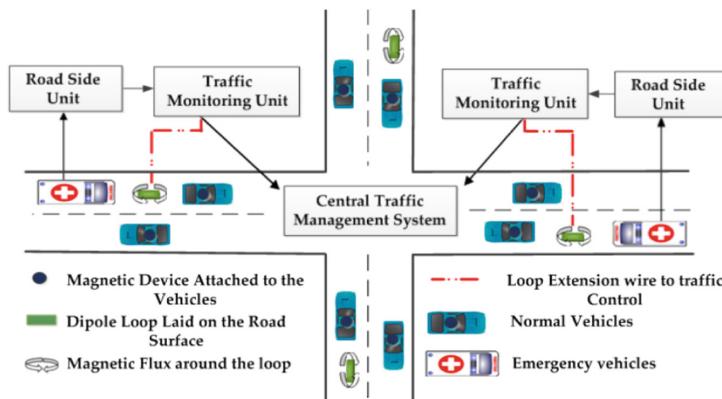
Internet of things technology covers a relatively wide range, including not only sensor recognition technology and video acquisition technology, but also multimedia communication technology [6]. Therefore, it can be fully applied to the construction process of medical service system to realize telemedicine service, as shown in Fig. 1. In this process, the patient does not need to go to the hospital to see the doctor, but can communicate effectively with the doctor through language or video call, so as to get timely and effective treatment [6]. At the same time, the big data and remote medical model under the Internet of things technology has more significant advantages, can not only in the maximum extent, shortening the time of the doctor's diagnosis and the patient's treatment time, but also can effectively reduce the patient's medical treatment cost, especially for some emergency situation, remote medical services can be further demonstrated the value of its own. In addition, the hospital staff can use some advanced equipment and technology to transmit the patient's medical record information to the telemedicine system through the network [7]. At the same time, doctors and experts can also obtain patients' pathological information through remote network technology, and make a comprehensive analysis and accurate diagnosis, so as to develop a systematic and perfect treatment plan for patients.



**Fig. 1.** Telehealth use soars 2014 to 2018

### 3.2 Big Data Technology Application in Road Transportation System

At the present stage of China, with the continuous advancement of urbanization, China's urban construction scale is also getting larger and larger, which leads to the rapid increase of urban population and vehicles. In this situation, urban road traffic has become the focus of increasing concern. From the overall situation of China's urban road traffic construction, the traditional urban road management mode has been unable to meet the development needs of today's society, and its overall management level and management efficiency is relatively low, and traffic congestion often occurs, frequently causing traffic accidents, seriously affecting people's travel safety [8]. Therefore, in the process of road traffic system management, the full application of big data and Internet of things technology can not only build a reasonable urban road traffic command system, but also further improve the management level of urban road traffic and alleviate urban road traffic congestion, as shown in Fig. 2. As in the process of urban road traffic management, through the remote management system with remote test system, not only can be carried out on the urban road traffic accurate navigation and positioning, and at the same time can also be in accordance with the relevant information of the road traffic data to effective management and control, and work for road traffic node charges to provide convenient services [9]. In addition, the remote control system can not only provide valuable data support for urban road management, but also further improve the safety of road traffic, thus reducing the frequency of traffic accidents.

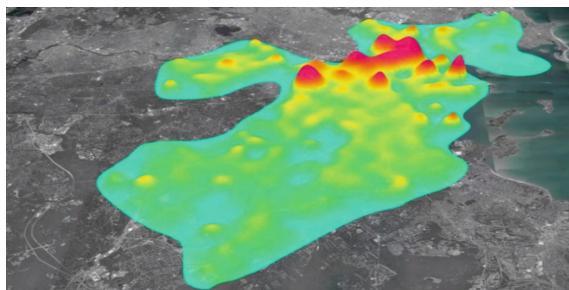


**Fig. 2.** Application of big data in transportation system

### 3.3 Big Data Technology Application in Smart Grid

In recent years, with the continuous development of China's social economy, China's electricity demand is also in constant ascension, and present a rising trend year by year, resulting in China's urban power supply appears not equilibrium, the serious influence to the stability and security of the power system operation, and a series of adverse

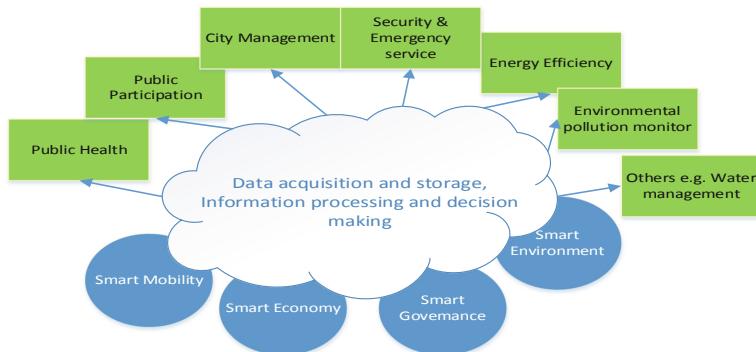
effects on the urban development, reduce the use of electrical energy efficiency [10]. In this case, by using big data and Internet technology, not only can make full usage of computer technology, sensor, and the role of communication equipment and advantages, but also can further improve the management level of power transmission, improve the overall utilization of electric power and ensure the safety and stability of power system operation, and on this basis to improve the economic benefits of power system operation and social benefits, promote the city construction of smart grid, and through the large data for urban power resource allocation to provide favorable data and theoretical support [11], as shown in Fig. 3.



**Fig. 3.** Big data technology to monitor urban electricity consumption

### 3.4 Big Data Technology Application in Smart City Management

In the process of building a smart city, there is a lot of data and information. The sources of these data are very wide. Therefore, to some extent, big data technology has a very wide range of applications, and has even penetrated into all aspects of urban development [12].



**Fig. 4.** Big data technology application in smart city system

For example, the current urban medical care, social insurance and transportation are inseparable from the support and help of data technology. Under such circumstances, the construction of a smart city should be strengthened with the combination of various information technologies, so as to form a more sound information system. In this way, the security and effectiveness of data can be improved, and information integration can be better achieved [12], as shown in Fig. 4.

## 4 Summary

With the further development of big data technology, it has not only brought challenges to traditional community governance, but also brought new opportunities for traditional community governance. With the popularity of the Internet, “smart door card” has constituted a huge database of data resources. Grassroots governments and social governance departments have made in-depth mining and analysis of data, used Shared data to timely and accurately find social problems, timely handled public events, responded to citizens’ appeals, and better served the people. But the big data applications in public affairs management at the primary level is not very deep, still need to continuously explore, not only to consider from the aspects of top-level design should also pay attention to the practicality and applicability, grassroots will big data effectively integrated into the public affairs at the grass-roots level, realize the big data and the height of the community governance fit, will be a big data is applied to the development trend of community governance.

**Acknowledgments.** Fund Project: This paper is the outcome of the study, Research on Modern Urban Governance Technology and its Operation Logic, which is supported by the Scientific Research Foundation of Tianjin Vocational Institute. The Project Number is 20182105.

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# Design and Development of the Fire Sensor System of Fitness Club Based on the Internet of Things

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**Abstract.** Since the reform and opening up, China's economy has been rapidly developed, people in the face of constantly improving living standards and increasing work pressure, their health consciousness is more and more strong, fitness exercise is more and more accepted, more and more people began to pay attention to the exercise in the work. In order to meet this market demand, the number of health clubs has mushroomed, but along with the number of health club fires has risen sharply. The development of Internet of things technology has provided a new way to prevent and reduce the occurrence of fire in fitness clubs, and helped a new way of fire induction and early warning. Emerging Internet of things technology based fire induction system of computer network and sensor network in a particular area, such as the combined effectively, so effectively improved the fitness club these traffic large place fire alarm system, monitoring means, greatly improved the timeliness and reliability of the automatic fire pre-alarm system, at the same time to the fitness club this kind of foot traffic place fire prevention management with the help of modern technology becomes simple and efficient, also make the management more diversified.

**Keywords:** Internet of things · Health clubs · Fire induction system · Real-time induction

## 1 Introduction

With the rapid development of China's economy since the reform and opening up, people also pay more and more attention to their health status, which greatly promotes the rapid development of the fitness industry. Fitness clubs of various forms emerge one after another and can be seen everywhere in the country [1, 2]. However, with the rapid increase in the number of health clubs, the number of fires also increases [3]. Using modern network technology to detect the occurrence of fire and reduce the loss caused by fire as much as possible is an inevitable trend of The Times [4]. IoT based fitness club fire induction system is dispersed in the fitness club's perception of the equipment, such as smoke detectors, flammable gas detector, thermal detector, such as induction equipment, through the wireless network, cable network, local area network, and other networking mode of network, the site operation state real-time acquisition and related alarm information, accurate and timely find all sorts of hidden faults

existing in the fire control facilities, and early warning information, warning related department to deal with in a timely and effective manner [5, 6].

International fire general pointed out that when a place there is a fire, the fire department can through the Internet of things technology of two-way interactive features, the fire happens, the start of the perception of fire place, quickly determine the location of the fire location and severity of the fire, and adopt corresponding countermeasures accordingly, assemble enough proper disposal of the fire power to the location of the fire, thus effectively avoid because of the slow fire alarm wasted fire rescue prime time [7, 8].

The purpose of this paper is to develop a wireless fire sensing system that is mainly used in places such as fitness clubs for real-time monitoring of smoke and temperature and real-time alarm. Traditional fire sensing systems are increasingly difficult to adapt to the needs of current fire safety management [9, 10]. As the lower fitness club as the representative of personnel and equipment populated areas of fire probability, as much as possible to reduce the happening of the fire of personnel and property losses, effectively improve fitness club these foot traffic place fire alarm system, monitoring means, greatly improve the timeliness and reliability of the automatic fire pre-alarm system, realize to place in a particular area of real-time dynamic monitoring, real-time view control area if there is a fire happened [11, 12]. The fire sensing system based on the emerging Internet of things technology emerges as The Times require. This system can detect real-time dynamic temperature and smoke detected by temperature sensor and smoke sensor through wireless network [13]. When danger occurs, through the wireless network real-time transmission to the host system with the temperature sensor, smoke sensor encoded data, can be realized in the fire early, real-time automatic alarm system in the automatic induction and at the same time, accurately identify the location of the fire, greatly improve the efficiency of the fire alarm, bring huge economic benefits to the society, greatly reduces the cost of manpower and material resources, extremely convenient [14, 15].

## 2 Method

### 2.1 Feasibility Analysis

At present, most of the fire induction systems used in China are wired fire alarm systems, which are restricted by the space, and the accuracy and timeliness of fire warning are very low, so they cannot meet the needs of fire prevention and alarm in the current stage. In this paper, we design the Internet of things of fire alarm system is not limited by venue space, but also USES the wireless transmission, greatly saves the cost and can be quickly and accurately to pass the information to the computer side, smoke sensors can be detected by real-time data through a data link to the nationwide network of computer terminals, relevant personnel can be anywhere at any time through the corresponding terminal system the real-time state of computer look at specific places, to see whether there is a fire the fire happened, greatly reduces the cost of manpower and material resources, is very convenient.

## 2.2 Principle of Fire Induction System

First in induction system of computer terminals for installation in a fitness club this kind of place in wireless smoke sensor in the terms and conditions set in advance good trigger alarm signal, in the actual detection process, once found to trigger the alarm signal condition data, wireless smoke sensor in the pre-set program will start, automatic alarm, and alarm signals and related information shall be transmitted by wireless data link according to the specific process; When the conditions triggering the alarm signal disappear or recede enough to trigger the alarm signal, the system will automatically remove the alarm state. Specifically, when installed in the fitness club in related area of wireless smoke sensor in the process of field testing, to detect near the fire or the intensity of light has been achieved in absolute value, to the terms and conditions that would trigger the alarm, wireless smoke alarm will be driven in the specific program automatically send alarm signal, when in the process of field detection, wireless smoke sensor to detect more than the absolute value of a predetermined temperature around the sensor, wireless smoke sensor will be in the driving of the relevant procedure automatically send alarm signal. After installation and debugging, each wireless sensor will be bound to the corresponding computer terminal one to one through specific codes, forming a real-time alarm network system that can identify and confirm the alarm area autonomously. Once the computer monitoring terminal receives the smoke and temperature alarm signals transmitted by the wireless smoke alarm through the data link network, the computer terminal can immediately identify the location of the fire. Through dynamic data receiving, accurate and timely alarm signal as the judgment basis, in the form of eye-catching sound and light, timely and effectively alert the staff to timely find the alarm signal occurrence area, as soon as possible to eliminate related faults and hidden security risks.

The hardware part of the system mainly includes microcontroller, smoke sensor and LCD screen, while the software part of the system mainly includes master control program and various corresponding subroutines. The main function of the microcontroller in the hardware part is that the information acquisition module collects data through the sensor, and the collected information is transmitted to the microprocessor, which transmits the received information through unified coding and wireless transmission with high efficiency. The principle of the circuit of the smoke sensor in the system is that the output signal of the sensor first passes through an emitter follower, then passes through ADC0832 to convert the analog signal into digital signal, and finally sends it to the single-chip microcomputer.

Liquid crystal display module of this system adopts liquid crystal 1602 as the system display interface. In the process of system work, its main function is to display the value collected by the system in real time. In order to facilitate the setting of the limit value of collected data, the system also designed a key circuit. Each key is grounded on one end and connected to the VCC via a pull-up resistor. Because the system power supply VCC is 5V. But when the key is not pressed, the input end of the single-chip microcomputer is connected to the VCC through the pull-up resistance. And because the internal resistance of the input port of the single chip microcomputer is very great, the input signal of the single chip microcomputer is close to the voltage of VCC power supply. When a key is pressed, the input terminal of the single-chip

microcomputer is quickly and short-circuited, and the input level is quickly pulled down to low level. Microcontroller through real-time scan of the keyboard level can determine whether there is a key press. The purpose of man-machine interaction is accomplished by reading the level signal of the key and executing the corresponding program.

As the main control program of the main software part of the system, it mainly plays the wizard and decision function to decide how to run the whole program. Various display states of LED dot matrix display screen are completed by calling the corresponding subroutine. When the system is powered on, the LCD and LED display the startup interface respectively, and the MCU starts to scan the keyboard. When the keyboard scan to a key press, by scanning program output corresponding operation, such as by pressing a key, output “the scarlet letter up” to the liquid crystal display screen, LED dot matrix display in the form of red up at the same time LED display, with content after returning to the initial state of the interface, the LED screen is dark state, LCD screen display menu.

### 3 Application Design

The fire induction system designed in this paper is mainly composed of the following four parts: main control part, information acquisition part, wireless transmission part, sound and light alarm part.

Information collection parts: wireless smoke sensor in the terms and conditions set in advance good trigger alarm signal, in the process of actual detection, once found to trigger the alarm signal condition data, wireless smoke sensor in the pre-set program will start, automatic alarm, and alarm signals and related information shall be transmitted by wireless data link according to the specific process; When the conditions triggering the alarm signal disappear or recede enough to trigger the alarm signal, the system will automatically remove the alarm state. After installation and debugging, each wireless sensor will be bound to the corresponding computer terminal one to one through specific codes, forming a real-time alarm network system that can identify and confirm the alarm area autonomously. Only when each wireless sensor is bound by code, can the fire alarm information transmitted by the sensor in which area can be inquired through the code in the first time in case of a fire, so as to determine the location of the fire.

Main parts: computer terminals in the induction system for installation in a fitness club this kind of place in wireless smoke sensor in the terms and conditions set in advance good trigger alarm signal, in the process of real-time monitoring, if near thermal environment has been achieved in absolute value, will trigger the fire alarm signal, when wireless smoke sensor in the process of field testing, to detect more than the absolute value of a predetermined temperature around the sensor, wireless smoke sensor will be in the driving of the relevant procedure automatically send alarm signal.

Wireless transmission part: when the smoke and temperature alarm signals of the main control part are generated, the computer monitoring terminal can quickly receive the smoke and temperature alarm signals transmitted by the wireless smoke alarm

through the data link network, and the computer terminal can determine the location of the fire in the first time.

Sound-light early warning part: through dynamic data receiving, accurate and timely alarm signal as the judgment basis, in the form of eye-catching sound-light, timely and effectively alert the staff to timely find the alarm signal occurrence area, as soon as possible to eliminate related faults and hidden security risks.

## 4 Discuss

### 4.1 Implementation of the System

First in the main control part of the PC for fitness club smoke sensor defined alarm condition, and then in the crowded area of the fitness club to install smoke sensor, wireless router and other equipment, each wireless sensor in the installation and debugging has been completed, with the corresponding computer terminals through the specific coding one-to-one binding, forming an area is able to independently identify confirmed alarm real-time alarm network system, when installed in the fitness club in related area of wireless smoke sensor in the process of field detection, Detected near the fire or the intensity of light has been achieved in absolute value, to the terms and conditions that would trigger the alarm, wireless smoke alarm will be driven in the specific program automatically send alarm signal, when in the process of field detection, wireless smoke sensor to detect more than the absolute value of a predetermined temperature around the sensor, wireless smoke sensor will be in the driving of the relevant procedure automatically send alarm signal. Once the computer monitoring terminal receives the smoke and temperature alarm signals transmitted by the wireless smoke alarm through the data link network, the computer terminal can immediately identify the location of the fire. Through dynamic data receiving, accurate and timely alarm signal as the judgment basis, in the form of eye-catching sound and light, timely and effectively alert the staff to timely find the alarm signal occurrence area, as soon as possible to eliminate related faults and hidden security risks.

### 4.2 Performance Test

According to the development status and application prospect of fire induction system, the research objective proposed in this paper is scientific and practical, and the performance index of the system is also in line with the practical significance of application. We have carried out the core power consumption test and the pyrotechnic temperature sensing sensitivity test in the system performance test. Through the measurement of these two indexes, we can judge whether the design scheme of the body club fire induction system based on the combination of things and health net can meet the application requirements.

#### 4.2.1 Power Consumption Test

Power consumption test is relatively simple, the requirements for the test environment is relatively low, normal temperature and good network signal can be. The required

instruments and equipment are the test host containing the required test software, the special test cable, the dual-channel programmable stabilized voltage power supply, and the required test modules include the wireless router, the host board, the LCD module, and the smoke sensor. The test results are shown in Table 1 below.

**Table 1.** Power consumption test results

Test directory	Design requirements	Units	Test results	Test time
Standby current	1.3	mA	0.87	40 min
Shut off the current	0.10	mA	0.008	40 min
Speak to current	330	mA	256	20 min
Current online	355	mA	310	20 min
Working current	230	mA	190	10 times

The data obtained from the test show that the implementation scheme of this study meets the design requirements at the beginning of the project.

#### 4.2.2 Pyrotechnic Temperature Sensitivity Test

Induction sensitivity refers to the absolute value of smoke, flame and temperature detected by the wireless smoke sensor when the fire alarm is triggered. In the detection process, the wireless smoke sensor should be used for detection. After the fire alarm is triggered, the wireless transmission technology should be used to transmit the data with the number of the smoke sensor and temperature sensor, so that the monitoring end can timely and accurately locate the location of the dangerous situation. Therefore, the sensitivity performance will be the guarantee to complete these tasks. Because the main purpose of the test is to verify the sensitivity characteristics of the wireless smoke sensor, we adopted the fixed-point anomalous measurement to test the sensitivity of the wireless smoke sensor in terms of smoke concentration, fire intensity, temperature and other aspects in a certain place.

For measuring way, temperature sensing precision need to build different fireworks live environment and the corresponding server, while the development of these instruments and equipment are generally what company and laboratory does not have, therefore, in terms of sensitivity of self measurement, we use only the conduction measurement methods of wireless smoke sensor sensitivity test. The test content includes capturing sensitivity and tracking sensitivity testing for 4 prototypes. The test results are shown in Fig. 1 below.

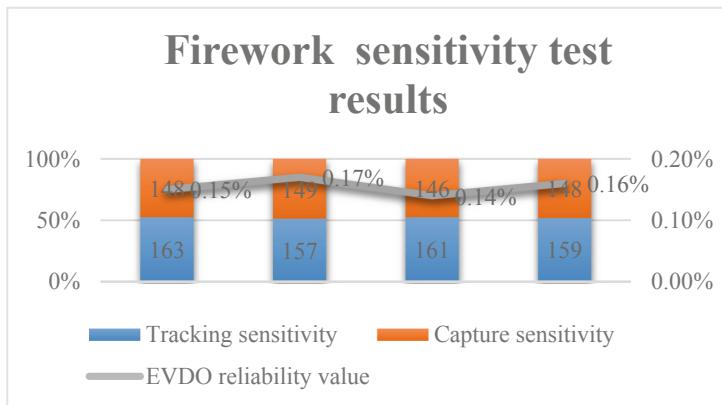


Fig. 1. Location sensitivity test results

The test results of four machines as test samples show that the scheme of this study meets the requirement of temperature sensitivity of pyrotechnics designed at the beginning of the project.

## 5 Conclusion

Traditional fire sensing system has been more and more difficult to adapt to the needs of the current fire safety management, only from the information transmission speed, there is a great delay, unable to timely and accurately transmit fire information. In this paper, the design of the fitness club fire sensing system based on Internet of things caught the technical characteristics of the age of the Internet, through the wireless network and the related computer program completed the design of this system, so as to realize the real-time induced the occurrence of fire and issued a warning, but also in terms of positioning the location of the fire case has excellent performance, thus to fitness club this kind of foot traffic place fire prevention management with the help of modern technology becomes simple and efficient, also make the management more diversified.

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# Fitness Club Customer Body Condition Detection System Based on Internet of Things

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**Abstract.** With the development of society and the improvement of people's living standards, people pay more and more attention to the state of the body, choose to go to the gym to rely on special equipment to achieve the purpose of strengthening the body more and more people. In order to meet the needs of fitness clubs for customers' comprehensive physical status assessment, this paper will design a system for fitness club customers' physical status detection based on the Internet of things technology based on the Internet of things technology. This system will meet the needs of fitness club customers for body composition detection, body fat detection, obesity evaluation and other detection, and obtain continuous, long-term and real physical status of the customer index, with strong practicality. The design of the system is composed of data acquisition terminal, Web server and data base station. The data base station and the Web server communicate and transmit by wired connection. In the application terminal, the management staff of the health club can log in the management account in the Web interactive interface to view the test data of all customers, and can realize the analysis and statistics of a large number of customer data.

**Keywords:** Internet of Things · Health clubs · Physical condition · Web server

## 1 Introduction

In today's rich material life, people pay more and more attention to physical health, and going to fitness clubs has gradually become a popular fashion. Meanwhile, equipment and systems related to health detection have gradually emerged into a huge consumption field, with a very broad market prospect [1, 2]. Coupled with the rendering of artificial intelligence and Internet of things technology, it is of great practical significance to develop a high value-added human health detection system in the fitness industry [3]. However, the reality is just another situation. At present, the detection equipment used for the basic parameters of human body can only realize recording and testing functions, but it is almost difficult to find products in the market that are humanized or highlight the current Internet era [4, 5]. From the perspective of fitness club customers, it is obvious that this cannot bring good fitness experience to this group, nor can it enable this group to know their various body indicators in a modern and trendy way, so as to self-analyze the fitness effect in the fitness club [6].

The detection and evaluation of human body status is a complex analytical process, which is recognized by sports behavior experts at home and abroad [7]. Some foreign researchers point out that in order to complete accurate assessment of physical state, on the one hand, it is necessary to identify the factors that can reflect the health state; on the other hand, it is also necessary to grasp the dimensions and indicator system that constitute health [8, 9]. Because any factor related to health has two sides, and different results will be obtained from different perspectives and positions [10]. The concept of “sub-health” was proposed by American researchers in the last century. In fact, “sub-health” describes a personal subjective feeling and is usually expressed by scale method [11]. At home, although the term “subhealth” has been well known in recent years, but due to its effect, the domestic relevant researchers testing for health knowledge level obtained the rapid development of improved, began to appear a barrage of all kinds of physical testing instruments, health assessment method are also constantly develop and perfect [12, 13]. However, at present, there is still no body condition monitoring system tailored to fitness clubs based on Internet of things technology, and even the existing detection system fails to take into account the individual differences of bodybuilders and the dynamic changes of physiological parameters, which is obviously out of line with the trend of the Internet of things era [14].

The research in this paper extends the application of Internet of things to the detection of health club customers' body status. Through various sensing devices such as positioning system, radio frequency identification and laser scanning, the communication between human body and detection device is established according to the communication transmission protocol by virtue of Internet of things technology [15]. Through the instructions issued by the client, the body detection data is collected and the database is stored and analyzed sensitively to realize intelligent body data and fitness management. It is very practical to improve the economic benefit of fitness club and people's participation in fitness.

## 2 Method

### 2.1 System Demand Analysis

The purpose of functional demand analysis is to provide a reference for the development of the test program of the system. The functional demand analysis of the system is mainly to analyze which functions are necessary when customers use the system.

According to the actual needs, this paper considers that reading body indicators, system network communication, graphical display of body data, storage and management of body status data are necessary functions of a complete body status monitoring system.

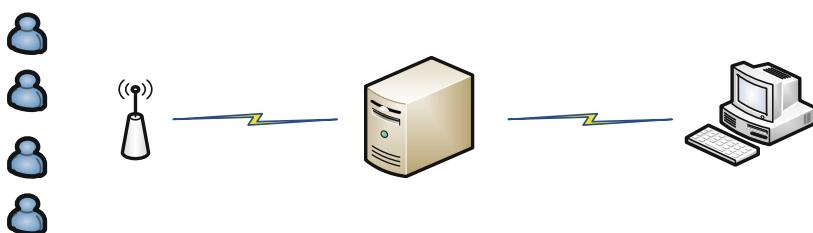
The first is the reading of body indicators. This paper believes that the most important part in the analysis of system functional requirements is the acquisition of body indicators. Only through physical fitness monitoring can we know the customer's system, can we compare with national standards, so as to recommend more appropriate and efficient fitness programs to customers; Next is the system network communication. In order to facilitate the club's customers to visually see their fitness states and

actions through the operation panel, the display device and the customer's body must have bluetooth communication facilities or WIFI transmission media, so that the physiological parameters collected by the fitness device can be sent to the center management machine for storage through bluetooth or WIFI; Again, a graphical display of body data. Body state detection in customer, make customer clearly see your body parameters information is very necessary and must be, it can let the customer intuitive understanding to oneself body state what are insufficient, both is advantageous for the targeted training measures, also make it more entertainment fitness activities, so that the detected from the body fitness training has the very strong sense of autonomy; Finally, the storage and management of body state data. The data of the customer's body status is a process of continuous change from the beginning of participating in the club's fitness training to a certain stage, which brings certain pressure and challenges to the management of the body status data. This system is a detection and management system based on Internet of things technology, which has natural advantages in information management. This system has a complete database of body state and fitness state, and provides club members and club staff with two different operating rights according to the actual needs.

## 2.2 System Architecture

There are two common system architecture modes: B/S architecture mode and C/S architecture mode. This paper chooses the more applicable C/S architecture mode according to the actual needs of multi-user multi-threading.

C/S architecture, can be simply understood as the server/client mode of operation. In this mode, body data can be obtained by simply wearing the client on the client's body, and data can be uploaded to the database of the master server through bluetooth connection with the master client, and professional analysis can be conducted to complete the detection of the whole body state. The C/S architecture diagram designed by the system is shown in Fig. 1 below.



**Fig. 1.** C/S architecture diagram

In this system, the primary server is always on, ready to respond to requests from the client. After the client of the club sends the request to the server through the physical detection client, the server can listen to the request from the user, store and analyze the data from the client, and finally save it to the database.

### 3 System Design Process

Due to the wide range of fitness club customer groups, the data types to be collected and fitness physiological parameters are also different, which requires the software design of each small tablet to detect the client.

The connection link between the small tablet and the central computer in this system is the transmission of fitness data through wi-fi wireless communication technology. Similar to the operation mechanism of bluetooth communication module, wi-fi communication technology adopts Socket programming based on TCP/IP protocol. In order to wiring convenient and neat and beautiful, the central machine and small flat, small flat and fitness equipment use wireless network as a means of communication.

In the design of the communication structure between the hardware of the system, in order to realize the seamless connection between the small flat plate and the detection device and the central machine, considering the transmission distance and rate, the system adopts bluetooth and wi-fi wireless communication technologies to realize the system networking mode. The detection device communicates with the small panel through the external serial port connected with bluetooth; The small tablet takes full advantage of the built-in capabilities of existing hardware devices to communicate with the central machine through wi-fi technology, which optimizes the networking mode of the entire system.

In the client design stage, this system USES the small size analyzer of lenovo i803Q1. This is because it does not need to store a large amount of detection data, but only to display the data in graphical form, so the selected small size analyzer can meet the needs of the system.

## 4 Discuss

### 4.1 Implementation of the System

The design interface of the whole system is designed based on the web center of “chaoyang sports network”. On this website, several core modules designed by the system can be inserted to achieve the design and realization of the operation interface for the physical state detection of club customers. In the operating interface of the central machine, there are three main functional modules, namely “one-click body detection”, “view the body indicators analysis data” and “sign up for fitness”. Through one-click body detection, the user can quickly send the command to the central machine to detect the various indicators and values of his body status. The view body indicator analysis data module is a functional module for users to view their body status indicators after clicking the body detection module. In this module, users can clearly understand their body status in a graphical form. The registration fitness module is a module connected to the membership registration of the fitness club. Users can quickly choose the fitness classes of the fitness club through this module after knowing their own body status.

## 4.2 System Test

Every software system is realized through a series of complicated processes from development to operation, and it is difficult to perfect the system design in one step. Therefore, before the software system is put into use, a large number of experiments and tests need to be carried out on the designed system, and software programming adjustments and modifications are made to the system through tests, so as to reduce and avoid errors in the system operation as far as possible.

Before the health club customer body condition detection system is put into use, it can be tested and improved to improve the quality of system operation and improve the interface interaction. In this system, mainly to the system running function module and system overall stability test, to ensure that the system can smoothly execute each command, to achieve the design purpose of system functions.

### 4.2.1 System Function Test

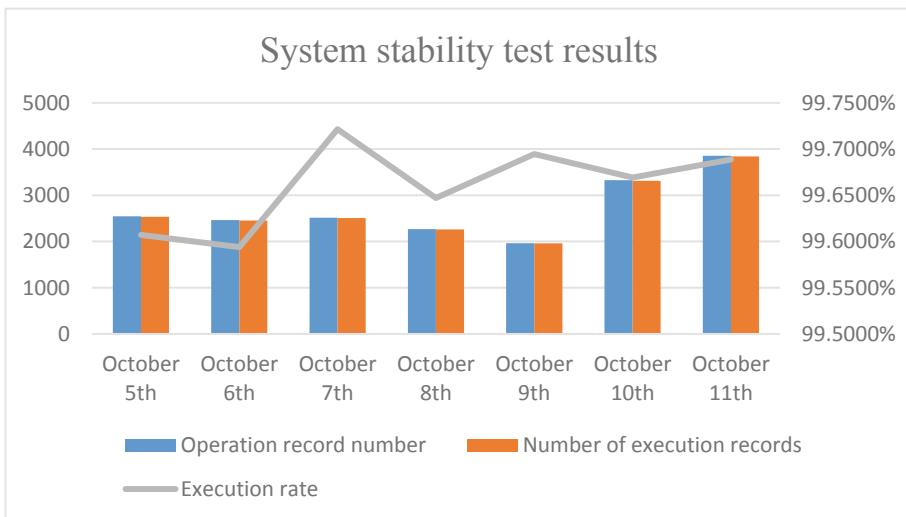
There are three core modules in the fitness club customer body status detection system. In the test, in order to ensure the accuracy of the test results, this test adopts Mifare test method for certification test. The test includes heart rate test, blood pressure monitoring, IBM weight test, physique test, data imaging test, etc. The functional test results are shown in Table 1 below.

**Table 1.** System function test results

Funid	Function module	Test case	International test standard	Actual test times	Test result
1	Heart rate detection	Can you read heart rate data	5000	5134	Pass
2	Blood pressure monitoring	Can you read the blood pressure data	5000	5043	Pass
3	IBM weight test	Analyze your body mass index	2000	2053	Pass
4	Physical testing	Read the constitution information of members	1000	1025	Pass
5	Data graphical detection	Member body information can be visually displayed	10000	10546	Pass
6	Dynamic balance	Read member body balance index	5000	5075	Pass
7	Data modification	Modify member body data information	10000	10035	Pass

#### 4.2.2 System Stability Test

Stability is a test that a system must pass when it enters the commercial phase. Just imagine, if the stability of the system has serious defects, then not only the function of the system itself can not be realized, but also the economic interests of businesses will achieve significant damage. The stability test of this system will be conducted in the form of extracting packets for 7 consecutive days from the operation log to check whether each operation is corresponding. The specific test results are shown in Fig. 2 below.



**Fig. 2.** System stability test results

Through the functional test and stability test of the system, it is found that in the functional aspect of the system, the functions of each functional module can be used normally, and the test results are in line with expectations. In terms of system stability, according to the extracted operation logs, the packet loss rate of all operations is very low, almost negligible, and there is no system crash. Therefore, the functions of each part of the system have been well realized and can meet the design requirements.

## 5 Conclusion

Internet of things technology has gradually become a hot technology, and smart sports is also a concept rising in this context. This system is the combination of Internet of things technology and smart sports, the development and design of a fitness club customer body status detection system. This system has seized the historical opportunity period when the WIFI and bluetooth transmission protocols based on the Internet of things technology will eventually replace the traditional wire transmission medium, and the system designed has achieved the target function, and the operation is smooth and stable, which is a system product that can be quickly put into the market of sports and fitness clubs.

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# Correlation Degree of Student Status Management Based on Big Data Analysis on Student Employment

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**Abstract.** China's higher education has entered the stage of popularization, the rapid growth of college graduates makes the employment problem become the focus of the whole society, and the correlation degree of the student status management provided by colleges and universities to the employment impact has become a hot issue in higher education research in recent years. Based on the current related research in colleges and universities and the society as a whole level, qualitative research is more, based on this, the purpose of this study is to put the students as employment guidance service "customers", from the perspective of big data based on ASP technology to analyze students on its employment in the school roll management, the institute established ACSI model is on the basis of the original model structure joined the exogenous variables, at the same time using the customer satisfaction theory and model study, from the practical level of employment guidance for colleges and universities service provides the specific data and theoretical support. This technology from the employment policy norms, employment situation analysis, career choice psychological guidance and career choice skills training and other aspects to guide the smooth employment of college students. The experimental results show that the student status management system based on database development accordingly, then you can to a certain extent affect the students employment problem, and the system itself and transfer the information of access, and other functions, is one of the most direct way for college students to provide perfect student status management, facilitate data management personnel to operate, can also be convenient for internal departments can get the latest data of the students' status files, conducive to the students' employment career.

**Keywords:** Big data · Student status management · ASP technology · Degree of correlation

## 1 Introduction

Many influence factors of university students' employment, including the concept of choosing a capital, human capital and family, and even the whole employment environment, for colleges and universities, cope with the problem of college students "employment" means including efforts to improve the teaching quality, ease graduate

employment pressures, etc., is one of the most direct way for college students to provide perfect student status management, convenient in the process of employment guidance education, training, information, consulting and other services, from the employment policy, employment situation analysis, choosing a career counseling and career skills training and other aspects, guide students to graduate, choosing and employment.

From the perspective of all countries in the world, they emphasize the security of student status information, legal guarantee, legality and the way of resource circulation [1]. Put forward the naming, classification, storage, recording, standardized evaluation of documents, some organizational responsibilities, archive preservation time and other related issues [2]. But in the specific study of college student status information management is still not too much to see. Domestically, the establishment of sound electronic files has been taken as an important research and development task by the relevant departments of the state [3]. Using foreign relatively mature technology to formulate relevant laws and regulations, using the current information management technology, improve the efficiency and efficiency of electronic document management. To improve the network system of school education and teaching management, the development and design of a set of powerful school roll management software system is emphasized, so as to quickly respond to the needs of teachers and students for management, timely provide real-time services, and provide teachers and students with an efficient and convenient management environment [4].

To this end, through a variety of research and comparative research, the subject proposed to use easy to understand the design of the project, using ASP (Active ServerPages abbreviation) dynamic server home page technology design college student status information management system, in order to achieve the automation of student status management [5, 6]. Using ASP as the development software platform to develop and utilize ACCESS database, using ASP technology can provide the system with perfect and reasonable instructions, control statements, objects and rich data types, to ensure the modularization of background code [7]. Without any increase in digital network platform hardware cost under the premise of this topic in the field of making full use of management and computer knowledge, design to build a student status management and information collection and processing of the system of managing student file is an important application of the digital campus network, it is to improve the educational administration teaching management in colleges and universities, improve the level of modernization of school management has practical value and significance of reality [8, 9]. This provides the basic conditions for the university to implement the student status information management. Other than that. At the same time, this system also has the function of serving the teaching evaluation of colleges and universities, the construction of digital campus of colleges and universities, and it has important application value for some developing colleges and universities to catch up with the high management level of colleges and improve the advanced management level for them [10, 11].

## 2 Method

### 2.1 ACSI Model Evaluation Method

In the attempt to use the ACSI model in colleges and universities, the models established in the research all add the exogenous variable “school image” on the basis of the original model structure, that is, it is not affected by other variables in the model, but has a certain direct or indirect impact on other variables [12]. Experts believe that the relationship between school image and other structural variables is as follows: it has a direct impact on students’ expected quality, students’ perceived quality, students’ perceived value and students’ satisfaction. Other experts believe that in addition, school image has an impact on student loyalty [13]. However, they all take student satisfaction as the target variable, take school image, students’ expected quality, students’ perceived quality and students’ perceived value as the cause variables, and take student complaints and student loyalty as the result variables. The setting of the second-level indicators is basically the same, while the third-level indicators are slightly different. On this basis, the students’ learning initiative influence student perception of the teaching quality of service, the student individual behavior pattern has a direct influence on perceived value, students invest time, effort, have a great effect on higher education teaching satisfaction, and joined the students “initiative” in the above model of exogenous variables, adopted the following three observations in the measurement of the specific variables: reflect the characteristics of the students subjective learning objective, learning effort and the degree of students’ self-management. The above related studies have verified the feasibility of the application of ACSI model in the field of higher education, and have certain reference significance for the construction of the measurement model of college employment guidance service satisfaction in this paper.

### 2.2 ASP Technical Data Collection Method

ASP technical data collection refers to various types of unstructured, semi-structured and structured mass data obtained by means of hardware data, business system data and social network data, which is the foundation of big data knowledge service model. In the specific management and technical aspects of the implementation is difficult, so in the group analysis, the final use of winform interface, safe C/S architecture, the advantages of this architecture is: the interface and operation can be very rich, security performance can be easily guaranteed, multi-layer authentication is not difficult to achieve, response speed. And the B/S rack in different browsers to display and use the program is not as good as people.

The data request between the B end and the server end is the server response mode, which often requires manual page refresh or local refresh. It focuses on intelligent recognition, transmission, perception, access and adaptation of large data sources. Combined with integrated management system and the construction of school departments have a lot of business system, can produce a large number of valuable business information resources, the formation is compatible with the national information resources standard and can satisfy the present situation of the informatization of data standards and information resources classification system, and at the same time,

establish a catalog from data acquisition, data storage, data analysis, data mining of whole life cycle of data fusion and management process.

### 3 Experiment

The experiment of this paper is to analyze the correlation degree of student status management system on students' employment based on big data through the study of college graduates in Shanghai. Through the analysis of the definition of university system and university student management, combined with the research status, this study believes that the university student management system is an important part of the modern university management system, and is a normative system for universities to regulate and control various relations and individual behaviors related to students. During the experiment, university students' management system from the large data analysis of the education management departments at all levels and the universities to establish rules of formal rules, regulations, articles of association, notice to generally in the form of system text, the formal rules, usually in the form of campus culture and so on performance modeling and informal rules of analysis of the working mechanism. In this study, the management of university student status is mainly analyzed and studied through big data. In the design of the student status management system in colleges and universities, the principle of "people-oriented" should be used to guide students' individual development, pay attention to strengthening the flexibility and flexibility of student management, respect students' individual development, give students the right to choose their own career and employment, and try to meet students' individual and diversified employment needs.

### 4 Discussion

#### 4.1 Function Analysis of Student Status Management System

To develop and design the university student status information management system, we must first describe its system functions. The requirements to describe the system come from two external bodies, one is the student, the other is the teacher. The main purpose of students is to inquire the information of school roll, while the main job of teachers is to input and modify the information of school roll. Therefore, the main function of the system can be divided into two subsystems: student query subsystem and teacher management subsystem. Students from different regions can upload their own basic files in different places and at different times through a variety of ways, and the administrator can clear the unqualified student status information. Student status information can be provided to relevant schools and class personnel for relevant inquiries. Through the network in any place, the school records management personnel can at any time in the transfer, transfer out of the students to add and delete, to achieve the dynamic management of school records. After the students admitted to the university of business analysis, business process reengineering to the original business, conforms to the university student status is analyzed with the function of pipe system

mainly divided into six categories, they are: management, performance management, student status changes graduate employment management, student status management and management and so on five big functions, can realize the various functions of data query, modify, merge, transfer operations, such as business process reengineering in this way, complete can meet the vocational middle school management of the students admitted to the university. Through the analysis of the data, the contribution of the above factors in the realization of the system function can be obtained. The functional analysis results of the student status management system are shown in Table 1 below.

**Table 1.** Function analysis results of the student status management system

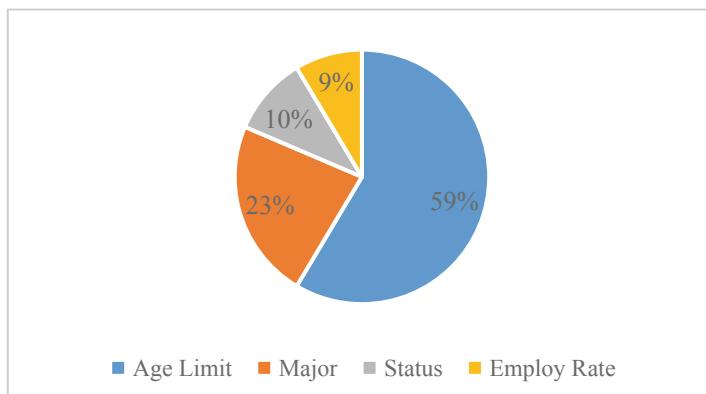
System	Grade	Negation	Graduation	Roll	Employ rate
Search	22.4	25.7	33.6	19.8	17.4
Modification	7	9	6	6.9	8.2
Merge	15	29	23	31	22
Remove	0.71	0.62	0.83	0.74	0.67

Through the above data analysis of the above, it can be seen that one's status as a different dynamic management, grade management, graduate employment management, student status management and management and so on five big function in the query, modify, merge, transfer the data such as operation, respectively by the contribution to system function implementation from 17.4 to 33.6 value, the influence of different level to make data analysis for the adjustment of the system. When the data is transferred, its influence factor fluctuates at 0.74, which is relatively stable and conducive to the business process reengineering in the process of system function realization.

## 4.2 Perception Test of Impact of Student Status Management on Employment Rate Under Big Data Analysis

Since the founding of new China, the development of university students' management system in China has distinct characteristics, fully reflect the information technology in the college campus integrated system management important role and value, through the development process of the related design and related to tell, its core is a further generalization of the system management, including admission registration, payment and so on five big subsystem detailed design and implementation of the relevant operation. We carried out the overall design of the system, including system function design, database design, system security protection design, system operation process design, system interface display and logic design and so on. Database design includes database content design, storage design, security design and so on. At this point, the research process of campus integrated system enters the stage of burnout test. We test whether the system meets the design standards by browsing the major modules of the system and the functions of the operating system, and timely fix the errors in the system. Therefore, this paper selects three groups of graduates of different degrees,

based on the following aspects of school roll management. The second is to decide students' major adjustment independently; Third, manage students' school roll independently; Fourth, we will choose employment by ourselves. Therefore, the perception effect of these factors is tested. The perception test results of the impact of school roll management on employment rate under big data analysis are shown in Fig. 1 below.



**Fig. 1.** Perception test results of the impact of school roll management on employment rate under big data analysis

Through the effect perception test under the big data analysis, the influence of four factors on the weight of employment rate was detected. From the experimental data in the figure, it can be concluded that the independent determination of students' learning years, the independent decision of students' major adjustment and the independent choice of employment have a small weight on the employment rate, both around 10%. And the self-managed student status affects the employment rate of students to a large extent, with the influence weight as high as 59%. This result also provides data support for the construction of the school status management system.

## 5 Conclusion

Employment is the foundation of people's livelihood. This paper, based on first-hand employment quality survey data, constructs the explained variables of the influence of student status management on employment based on big data analysis, and makes an empirical analysis on the main influencing factors and mechanisms of graduates' employment quality by using ASP technology. The first is the allocation of user permissions to ensure the convenience of the query. In addition, the development of two-dimensional code query, the student status information and two-dimensional code combined; Finally, it is necessary to strengthen the unification and popularization of student status information between colleges and universities, improve the construction of network platform for student status management, and realize resource sharing. In

order to further improve the efficiency and quality of university roll management, and strive to train high-quality talents to meet the social needs.

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# A Method of Resource Isolation and Security Enhancement of Container Cloud Based on Multiple Security Domains

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**Abstract.** Container cloud adopts the container virtualization technology with weak isolation. In order to ensure the security of container cloud, the problem of isolation of computing, network and storage resources of different tenants in container cloud environment should be solved first. This paper presents a multi-security domain-based container cloud security enhancement method, which provides a complete resource isolation solution for container cloud.

**Keywords:** Multiple security domain · Container cloud security · Container security enhancement

## 1 Introduction

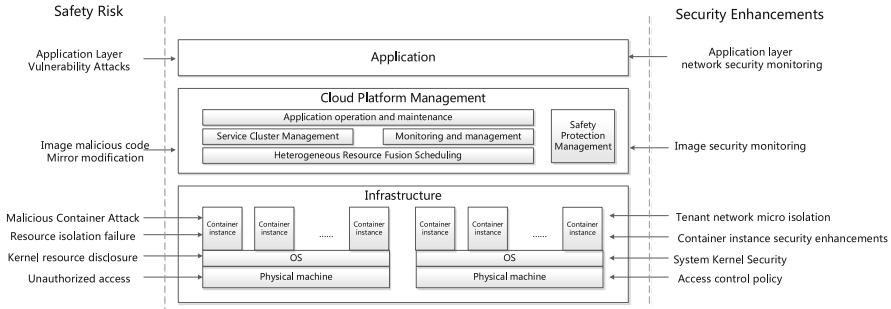
Cloud computing provides users and applications with an isolated virtual computing environment based on virtualization technology [1]. Container cloud platform uses container virtualization technology, which can isolate and control resources through Linux kernel characteristics. It does not need to go through additional abstraction layer. It is more efficient than traditional KVM virtualization technology, but the isolation of containers is weak and the security risk is high [2]. Therefore, in the container cloud environment, the security of container cloud can be enhanced through the security isolation of computing, network and storage in different tenant security domains.

In view of the characteristics of container cloud technology, this paper proposes a tenant resource isolation scheme for container cloud from three aspects: computing resources, network resources and storage resource.

## 2 Computing Resource Isolation and Security Enhancement

Container-based cloud environment faces security risks, including unauthorized access to physical hosts and operating systems, leakage of system kernel objects, failure of resource isolation and threat of malicious container attacks for container instances, threat of mirror malicious code and mirror modification for cloud platform management level, and threat of vulnerability attacks for application level, as shown in Fig. 1.

For this reason, in view of the weak isolation of containers, the security enhancement measures such as system access control strategy, system core security reinforcement, container instance security enhancement, mirror security detection and so on are adopted to enhance the security guarantee capability of the whole virtualized cloud environment.



**Fig. 1.** Principle and structure of automatic elastic expansion

## 2.1 Host and Operating System Kernel Security Enhancement

Because the security enhancement of container host is based on the domestic Linux operating system, it implements mandatory access control and security audit functions [3]. Therefore, a secure and reliable cloud platform will enhance the security of the Linux operating system kernel by enhancing the access control capability of the operating system. Specific implementation methods are mainly through Linux Security Modules, Loadable kernel module, SELinux, Seccomp, Apparmor and other security modules to achieve mandatory access privilege attribute setting engine and host/object access authorization mechanism, and integrate Linux Namespaces mechanism to achieve container instance-centric access control mechanism [4].

## 2.2 Integrated Safety Testing of Vessel Mirror

The container image contains the file system and its contents needed to start the container [5]. The bottom layer is bootfs, and the top part is rootfs. Bootfs is similar to the Linux bootstrap, and the container will be unloaded automatically when it is started. Rootfs is located on top of bootfs and is a file system visible to the internal process at container startup. When the container system starts, a read-only rootfs layer is mounted first, and then the read-write layer is mounted after the system detects its integrity. Therefore, static security hazards mostly exist in rootfs layer, and dynamic real-time security hazards mostly exist in read and write layer. In order to ensure the safety of container image and fine-grained security analysis, a combination of various means is needed, including: (1) To detect vulnerabilities in the stateless application of the container mirror read-only layer to ensure that there are no serious security vulnerabilities in the base layer of the container mirror. (2) Antivirus detection of stateless binary program

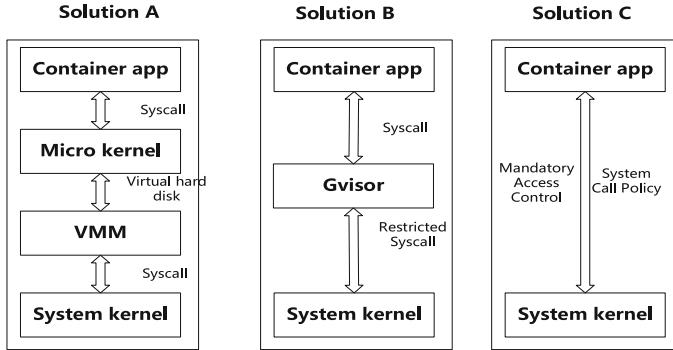
of container mirror read-only layer to ensure that it is not infected by malicious code. (3) Compliance detection of text configuration class files to ensure that there is no weak configuration. (4) Through web shell backdoor detection, the existing script files are semantically parsed to determine whether there are vulnerabilities or malicious code. (5) Through sandbox technology, the binary files written to the image file with abnormal behavior are dynamically analyzed to ensure that the executable programs in the image file are free of malicious programs, and the mandatory access control rules are automatically generated according to the behavior data.

### 2.3 Container Instance Security Enhancements

Container instance resource isolation currently has three main solutions: (1) The first is a lightweight virtual machine solution. The scheme is represented by Kata Containers, which is a lightweight virtual machine based on QEMU. At present, it mainly consists of six modules: Agent, Runtime, Proxy, Shim, Kernel and QEMU. In this scheme, each container has its own lightweight virtual machine and small kernel, which provides container isolation through hardware virtualization and is compatible with the OCI standard of container runtime. Currently, only X86, X86-64, ARM and other CPU architectures are supported. (2) The second is the sandbox when the lightweight container is running. This solution, represented by Google gvisor, is a user space kernel. API simulation restricts the application's direct access to the host kernel, while maintaining the desired access results of the application. At present, it only supports X86 architecture. (3) The third is Linux's native security capabilities. This scheme is enforced by the security mechanism already implemented in the host kernel, and can be widely used in Linux systems under various CPU architectures. The main functions are as follows: Through the SELinux and Apparmor modules provided by the Linux kernel, the access and transformation rights of each container instance in the system are defined, and the interaction between these instances is controlled by security policies, so as to achieve mandatory access control. Through the Linux Capabilities security access control mechanism, the power of process and executable file is judged. According to the power size, the system is divided into different process whitelists. The system controls the access rights of user processes according to the process whitelist.

If a sufficiently complete strategy is defined, the third alternative is an excellent way to replace the two schemes mentioned above and maintain native performance. In practice, however, it is very difficult to reliably define policies for arbitrary, previously unknown applications, making this approach challenging.

The implementation principles of the above three solutions are compared as shown in Fig. 2. The third scheme can provide mandatory access control and system call strategy for container instances, and provide basis for resource isolation of container instances. Therefore, on the basis of this scheme, we can provide policy basis for container instance isolation through fine-grained mirror analysis results.



**Fig. 2.** Three solutions for container instance resource isolation

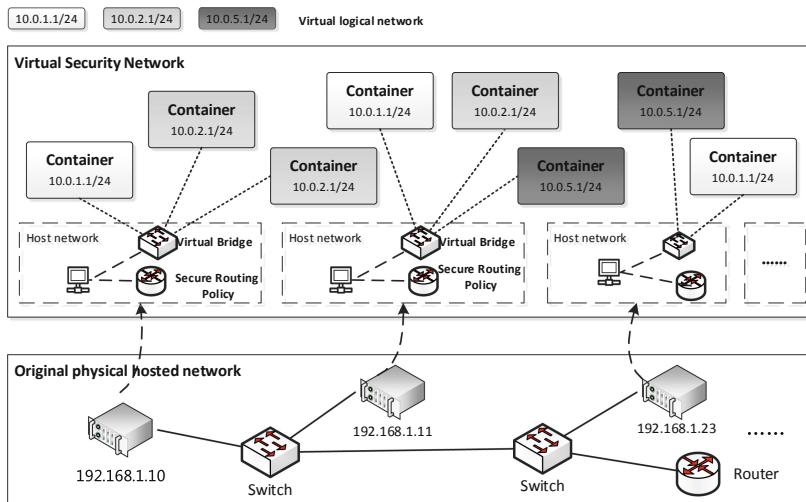
### 3 Network Resource Isolation

The isolation of tenant resources between security domains is mainly based on different security strategies [6]. The network isolation technologies such as boundary isolation and boundary access control are used to implement the necessary security isolation measures for different security domains. Computing, storage and other devices in the security domain can only serve the systems and services within the domain.

The main methods of security domain network isolation include VLAN logical isolation, IP logical isolation and physical isolation. (1) VLAN Logical Isolation. VLAN logical isolation mainly refers to dividing different virtual local area networks within the same switch to divide different security domains. The scheme has good support for existing networks and is easy to operate and implement, but it has weak security and high risk. (2) IP Logical Isolation. IP logical isolation refers to the further use of different IP subnet addresses to distinguish different security domains on the basis of virtual LAN logical isolation, so as to achieve data link layer and network layer isolation. This scheme has great changes to the existing network, and its completeness is better than VLAN logical isolation scheme, and its security risk is general. (3) Physical isolation. Physical isolation refers to the complete isolation of different security domain networks and the use of independent network lines, switches, routers and other devices, without any logical or physical connection. The cost of the scheme is high and the existing network is greatly changed, but the security is the strongest and the security risk is the smallest.

Due to the lack of security planning in the early stage of most users' network and the main construction in the later stage, it is common that the IP addresses of servers and end users are in the same network segment. In this case, the traditional security domain partition principle is adopted. All computers with the same security level and security requirements will be assigned to the same network segment. This scheme requires a comprehensive network transformation, changing the physical access address and IP address of the server, and deploying firewalls and security devices at different security domain boundaries. The construction cost of this model is high, the transformation cycle is long, and the implementation is difficult.

Therefore, without changing the physical structure and IP address of the existing network, virtual firewall technology is adopted. As shown in Fig. 3, through two-layer transparent mode or three-layer routing mode, systems and devices of different security levels can be divided into different virtual logical networks. The logical grouping of virtual networks can be equivalent to the traditional security domain, and protection measures can be formulated between different logical networks. Some measures should be taken to achieve isolation and protection.



**Fig. 3.** Virtual security domain network structure

In the virtual security domain, the firewall module can adopt two-layer transparent mode and three-layer routing mode at the same time to improve the flexibility of network security deployment. (1) Computer IP in different security domains is in the same network segment. Virtual firewall can use two-layer transparent mode to configure the Inside and Outside ports of virtual firewall with different VLAN, but the IP address actually belongs to the same network segment. Server access switch ports with high security level are configured as firewall Inside VLAN, and server access switch ports with low security level are configured as firewall Outside VLAN, which can realize logical isolation of computers with different security levels without changing IP address. Access control can be achieved through the security policy of virtual firewall. (2) Computer IP in different security areas is in different network segments. Virtual firewall can use three-layer routing mode to achieve secure access control.

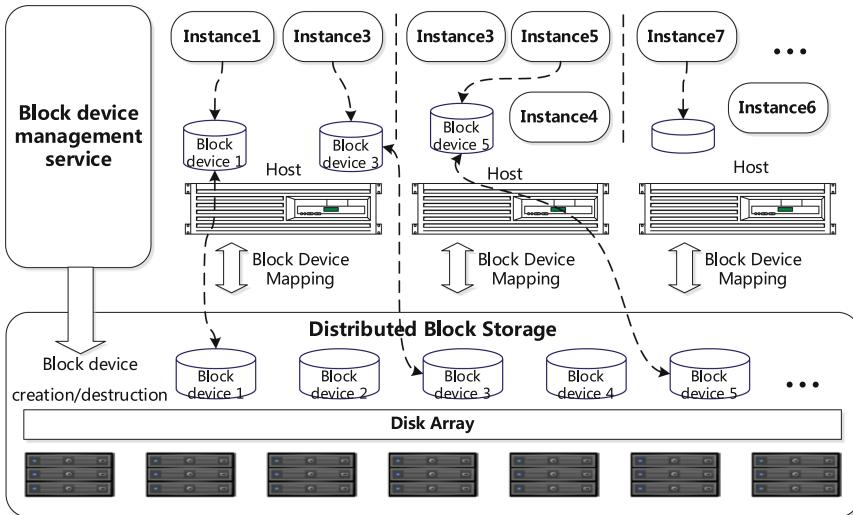
Virtual security domain uses virtual firewall of core switch instead of firewall of each security domain boundary. Different from traditional security domain, each domain boundary needs to deploy firewall. This scheme makes full use of the high-speed forwarding capability of core switch to ensure network operation efficiency, reduce costs and improve management convenience.

## 4 Storage Resource Isolation

In cloud environment, it is necessary to define the isolation mode of data storage. Hardware devices are partitioned according to the security domain [7]. It is a waste of resources to isolate the same security level system according to the hardware mode, and it can not guarantee the high reliability of data storage. Therefore, storage isolation mode based on storage virtualization can be provided for different security requirements domains.

### 4.1 Isolation Scheme Based on Block Storage

Block storage uses a controller and a set of disk drives to provide fixed size RAID blocks as volumes of logical unit number (LUN) to fully map the bare disk space to the host by centralized storage of resources in the independent disk redundancy array RAID [8].



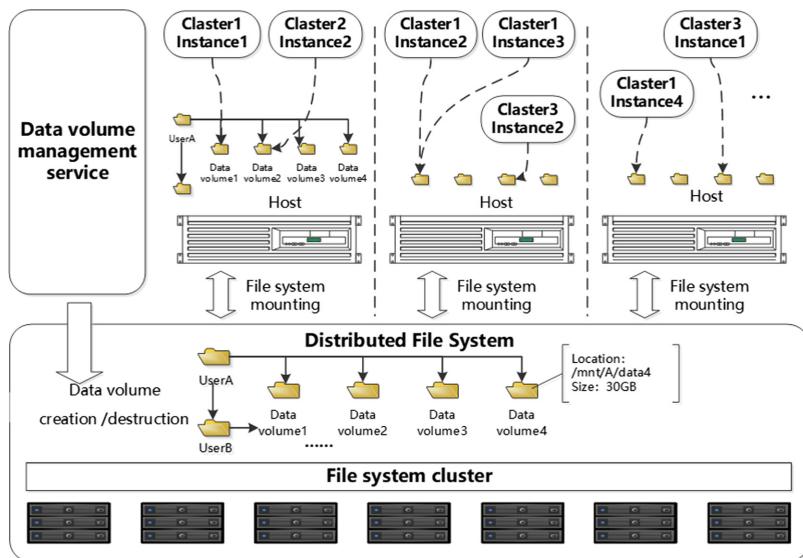
**Fig. 4.** Storage isolation scheme based on block storage technology

Block storage technology is often used to solve the storage problem of virtual machines. It is mounted in GUEST system by network disk mapping for use by virtual machines. As shown in Fig. 4, on one or more groups of disk arrays, using block device management services, the bare disk space logic is divided into N logical hard disk devices by partitioning logical disk, making RAID backup or LVM (logical volume). The logical disk is mapped to the host by mapping, and the host operating system identifies the mapped block devices accordingly. In use, there is no difference between block devices and hard disks mounted directly to the operating system, and there is no difference from the operating system level. These devices will be used as hard disk devices in GUEST system in the process of creating virtual machines in cloud

platform. Generally, GUEST takes it as the disk of operating system, and the data generated by running application on it is written to the independent device area. The isolation of data is guaranteed by the isolation of virtual machine file system.

## 4.2 Isolation Scheme Based on File Storage

The isolation scheme based on file storage refers to the storage and isolation of application data by mounting logical directories in distributed file system [9]. In this scheme, the physical storage resources managed by file system are not necessarily directly connected to local nodes, but mainly connected to nodes through computer networks.



**Fig. 5.** Storage isolation scheme based on file storage technology

File storage technology is often used to solve the storage problem of containers. It is mounted in the operation system of containers in the form of network file system for data storage [10]. As shown in Fig. 5, on one or more file system clusters, these file systems are combined to form a large file system through software level control, which supports data segmentation and multi-copy storage, improves the reliability of data storage, and solves the storage problem of large-capacity data. Then through the data volume management service, on the virtual distributed file system, the data volume (file system directory) is created according to the application partition. The distributed file system is mapped to the host file system directory by mounting, and the synchronization process of the directory specified by each host is completed. Before creating cluster containers on cloud platform, data volume is created first, then container creation and data volume mounting are completed. The isolation of container file system can ensure that the application data of single container cluster is written to the designated distributed file system directory, thus achieving the isolation of storage.

## 5 Conclusion

This paper presents a method of computing, network and storage resource isolation for multi-security container cloud. Computing resources mainly adopt the security mechanism of host Linux kernel in container virtualization technology to enforce container resource isolation, and synthetically use security enhancement means such as system access control strategy, system kernel security reinforcement, image security detection and so on. Network isolation adopts virtual firewall technology, which divides systems and devices in different security domains into different virtual logical networks, and achieves isolation protection by formulating protective strategies and measures. Storage resource isolation is based on storage virtualization, which supports block-based storage and file system-based storage isolation. By comparing the performance data before and after the safety isolation scheme of container cloud, the average performance loss is less than 10%. The test results show that the proposed container cloud security scheme not only improves the security of the cloud, but also has a smaller performance loss, which better solves the security problem of container virtualization technology.

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# Application of Big Data in Publishing Industry

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**Abstract.** The future development of publishing industry is closely related to the application of big data technology. This article analyzes how big data affects operation of various components on publishing industry supply chain. It explores the utilization mode of big data for companies on supply chain of publishing industry. Moreover, we proposes strategies and tactics on how to construct big data system and how to utilize big data in publishing industry.

**Keywords:** Big data · Data resource integration · Dynamic analysis · Inventory optimization

## 1 Introduction

Big data is an important strategic resource for the future development of publishing industry. Many literatures have discussed the application of big data technologies in various industries (e.g. Grable and Lyons [1]; Simsek et al. [2]), as well as in many kinds of tasks [3–5]. The importance of big data in publishing industry has garnered considerable attention from scholars. Biradar et al. creates new revenue modules to use machine learning and artificial intelligence for publishers [6]. Wang et al. develops a novel method named t-closeness slicing (TCS) to better protect transactional data against various attacks [7]. Karan discusses the crucial role of big data, cloud computing and social media in growing business revenue in publishing sector [8]. Some papers analyze the applying situation, challenges of big data in publishing industry and provide some ideas to utilize the advantages of big data [9, 10]. Aravind proposes a framework for building a big data platform for publishing industry. Although these papers discussed big data in publishing industry, however, more analysis about concrete application mode for various companies of supply chain in publishing industry needs to be conducted. Moreover, we proposes strategies and tactics on how to construct big data system of publishing industry and how to utilize big data technology.

## 2 The Role and Application Mode of Big Data in Publishing Industry

The application of big data helps to improve operating efficiency, achieve on-demand publishing and improve precision marketing capability. Big data can be used in precision publishing, precision marketing and precision distribution. The information

sharing in publishing industry chain can drive the overall circle of chain resources, reduce information asymmetry and realize the effective use of resources.

Application of big data can provide services for topic selection analysis. Topics selection analysis supports accurate publishing. It can provide topic selection needs and suggestions based on sales data hotspots, public opinion data and category analysis. Topics selection analysis helps managers to determine topic selection evaluations. It can conduct historical sales information evaluation and sales forecast, and use historical big data to select related topics. And it can provide pricing guidance for the products to form a topic selection report.

Application of big data provides support for operational decision. It can provide publishing and distribution companies with different information of sales, consumer demands and inventory categories. For example, it can provide managers with customer portraits analysis, which helps publishing corporations to make decision about product development and sales forecast. Marketing business analysis can support accurate marketing and distribution, which provide user group information matching marketing activities, marketing channels and variety recommendations. And it can analyze activity conversion rates, sales, inventory changes and purchases.

Publishing and distribution companies can use big data technology to analyze dynamic situations of the industry. It can analyze the sales trend, making sales hot spot analysis. It can provide channel analysis, such as, conduct multi-channel book ranking, according that the managers can make decision about channel selection, layout and adjustment. It helps publishers to understand changes in consumer demand, industry development trends, products categories and distribution channel dynamic changes. Companies can predict dynamic market competition with these messages. The publishing dynamic service provides an overview of sales situation for issuers. That can be used to analyze new products sales and products market sales.

Big data analysis helps distribution companies and retailers to manage inventory, predict purchase and sales, which reduces inventory pressure and complete inventory optimization. Inventory optimization is to analyze store subscription satisfaction rate, purchase arrival rate to get information on purchase level and the satisfaction of the publishing agency through intelligent purchase method. Publishing companies can design and implement an intelligent purchase model to manage inventory demand. The intelligent purchase system can provide data support for purchasing and restocking in advance, which reduces inventory pressure. Inventory optimization is based on big data support, which can solve business pain points of overstocking or under stocking caused by long-term overstocking of inventory. It provides a path for inventory optimization, providing inventory analysis and early warning.

Additionally, publishing distribution and retail companies can use big data to provide services such as user portraits, marketing service support, sales analysis and inventory optimization. They can conduct user analysis through user portraits. They can analyze preferences, consumption and contact behaviors of users. They generalize class tag through data exploration, preprocessing, data statistics derivation, index screening, model construction and information output. They can realize segmentation of user groups, intelligent recommendations based on user behaviors, which helps to improve user stickiness. Moreover, full-process marketing management can be implemented based on the user's life cycle analysis to achieve group marketing for

users at different stages. That improves precision marketing capabilities of publishing distribution and retail companies, and promotes prediction capabilities.

### 3 Construction of Big Data System and Application in Publishing Industry

#### 3.1 Overall Strategic Thinking of Big Data System Construction

The construction and application of big data systems in publishing industry is the core strategy for development of publishing industry. Government, industry organizations, enterprises and scientific research institutions need to work together to create a new pattern of big data in publishing industry. First, the government do a good job in the top-level design and planning, make statistics and sort out the current status of industry data. Combined with the need of big data for development of industry, government timely formulates and promulgates relevant policies and regulations to ensure construction and application of big data system. Second, promote the establishment of organizations that are suitable for application of big data systems. Third, government, companies and others should increase the advancement of technology research and development, and build a big data technology research and development system composed of financial funds and institutional construction. Fourth, strengthen the development and application of big data standards. Fifth, provide platforms for exchange, operation and sharing of technology, qualifications and carrier for research and development of big data systems. Sixth, establish a content resource identification management service system for publishing industry. Establish a meta data management agency and a meta data management service platform. In terms of data circulation, they can establish a publishing and distribution data sharing system, a national publishing and distribution data center. They should build a national knowledge resource service system and a national knowledge service platform. Seventh, actively promote data interchange within the industry, between publishing industry and other industries. Promote the application of big data through the development and operation of public welfare projects and industrialization projects. Eighth, actively explore business models of big data systems.

#### 3.2 Data Resource Integration

The big data of publishing industry includes publishing section data, publishing group data, store data, e-commerce data, third-party data and open network data, etc., covering various business data such as teaching materials, library distribution, books and e-commerce. In order to fully reflect the market, logistics and publishing situation in a timely and comprehensive manner, and to realize the requirements of industry big data services from static to dynamic, timely and accurate, data resource integration is the key to the implementation of big data services. Establish relevant industry policies and management scheme to collect industry enterprise data. The process should break exclusiveness and barriers of data resources. The cleaned business data of enterprises at

all levels should be transferred to the industry dynamic data resource platform through the resource platform interface to realize the intensification of data resources.

### **3.3 The Construction of Resource Platform**

The construction of big data resource systems should strengthen resource integration and information sharing. A working pattern composed of cooperation among industry organizations, university and research organization, which guided by government needs to be constructed. Government should encourage and support enterprises to take the lead in participating, cross-regional collaboration and cross-field cooperation to gradually advance the construction of big data. The resource platform construction adopts a hierarchical payment service application model. The data service module is provided in a hierarchical manner, and hierarchical payment is provided according to the service level, such as basic analysis, advanced analysis, customized business decision support and domain knowledge services to meet various needs.

### **3.4 Building a Special Data Service Agency for Publishing Industry**

To comprehensively implement the construction and application strategy of big data systems, the organization providing of big data management and application service needs to be established. The establishment of the organizations should adhere to some principles. First, the nature of such institutions should be neutral institutions under the management and guidance of government departments. They should not participate in market-based competition. Second, such institutions should provide data support and guarantee for the government to carry out social-oriented big data public services. Government can purchase related data application services through government procurement from this organization. In addition, this organization can provide market-oriented data products and services for publishing companies, which promotes the active use of big data. And it can provide support for publishing companies' secondary entrepreneurship and innovation development based on big data resource.

### **3.5 The Operation Logic of Big Data Application**

The construction and application of big data systems shouldn't follow the logic of traditional publishing industry's operating activities. It should formulate a full-scale process reengineering based on the top-level design of future publishing form. However, some publishing organizations haven't formed a new understanding and long-term strategic layout about the form of publishing in the future. The main purpose of their involvement is to follow suit and beautify the performance report. The construction of philosophy, operating system, business model and organizational structure should be under new thinking. Big data system is not an incidental item of the traditional business model, nor should it be the decoration of the publishing organization to whitewash the wall.

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# Exploration and Practice of Teaching Reform of Computer Public Courses Under Big Data Environment

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**Abstract.** Computers are the necessary professional knowledge of modern talents, and universities offer computer public courses to meet the needs of social talents development. At present, there are many problems existing in the computer courses teaching in colleges and universities, such as loose content, lagging mode, slow feedback, etc., and the classroom teaching is not efficient. Based on the big data environment, applying information technology to the teaching of computer public courses can re-plan the course, improve the teaching mode, collect students' teaching evaluation, and improve the teaching effect. The article will analyze the problems existing in the teaching process of computer public courses in China, and propose corresponding reform strategies, aiming at promoting the development of teaching in colleges and universities, improving the quality of talents and meeting the development needs of the times.

**Keywords:** Computer public courses · Big data environment · Information technology · Teaching mode · Problems · Strategies

## 1 Introduction

Nowadays, the shadow of big data has gradually filled every functional field in all walks of life, used in medical, transportation, and financial fields for a long time. In the field of education, this technology has not been fully utilized, and it is now used for data management of teachers and students. Information technology is the theme of the development of the times, which promotes the development of social science and technology, and enhances the sharing of data and information. The education industry based on the big data environment has also ushered in new opportunities, changing the traditional teaching mode and enriching of classroom teaching, increasing the information connectivity among students, teachers, and classrooms. The computer course is an important public course in colleges and universities directly related to the future employment of students. Throughout the current situation of the computer public courses in China, there are still problems, such as single content, low quality, lagging mode, slow information feedback, etc., above all delay the reform of curriculum

teaching [1]. Based on the reform and development of computer public course teaching under the big data environment, it is necessary to explore how to make information and efficiency of computer public courses teaching.

## 1.1 Analysis on the Problems and Causes of Computer Public Course Teaching

### (1) Loose Content and Strong Professionalism

Computer public courses have obvious comprehensiveness, involving knowledge in electronics, communication, mathematics, etc. The connectivity among all kinds of modules is not strong and the knowledge is wide-ranging with very strong professionalism. When students are learning, it is easy to come into a sense of “lost mind”. Because of the poor coherence of knowledge, there are often many problems such as confusion and low internalization, so the learning effect of students is not satisfactory [2].

### (2) Backward Mode and One-Way Teaching

The computer public course is a course closely related to information technology, which is very modern, scientific and innovative. However, there is no significant difference between the computer public courses and other professional knowledge subjects in the actual teaching process. There is more theoretical knowledge and fewer practical links. Teachers still use the teaching mode in the learning process, which seriously dampens the independent learning of college students. In the one-way teaching mode, students' information on the situation can't be timely feedback, which weakens the inter-connectivity between teachers and students. Students' motivation for learning is insufficient, interest is also weakened, and classroom development is not effective. Especially in the big data mode, more emphasis is placed on innovative teaching, information sharing learning, and self-inquiring knowledge.

### (3) Lack of Evaluation, Thinking and Learning

Classroom is a classroom shared by students and teachers. However, there is no two-way classroom information exchange between students and teachers in the past teaching mode, and there is a lack of systematic and diversified classroom teaching evaluation system. Students can't express their own learning problems in public courses in a timely manner. Teachers can't make targeted teaching adjustments based on students' academic information, and lack of teaching information and feedback on academic information. In addition, there are a large number of students in computer public courses. One teacher often needs to teach multiple classes at the same time, and meanwhile undertakes the teaching of the major. It is difficult to record the student information one by one, even if some teachers aware of the problems in the teaching.

## 1.2 Teaching Exploration and Practice of Public Computer Course

In the big data environment, information technology and education combine to provide rich teaching resources, and provide necessary information channels for students, teachers and classrooms to exchange information, which is conducive to developing a

diversified teaching mode and building qualified big data platform. It is necessary to adhere to the application-oriented and give play to the social benefits of educational resources, so that educational resources can counteract the formation of a good construction atmosphere. In the construction of educational resources, more attention is paid to the educational resources, but the targeted research on educational resource users (teachers and students) is neglected. Teachers need to make use of the social benefits of educational resources and improve the effectiveness of their use.

### 1.3 Courses System Construction

#### (1) Content Analysis

The computer public course knowledge has a wide range of knowledge, which is characterized by professionalism, content and diversity. According to the different teaching of different departments, there are subtle differences, which can be divided into three types: professional, general and cross [3]. General type mainly including computer environment, system platform and other knowledge, mainly for the discipline of literature and history; professional type mainly including program development, basic algorithm, information processing, data management and other aspects of knowledge, more suitable for communication, numerical control and other engineering students. Cross type mainly including information processing, data management, computer environment, system platform and other aspects of knowledge, which is more suitable for students majoring in economic management. However, due to the differences of teachers, colleges will adjust their professional knowledge according to the actual situation of their own [4].

#### (2) Relying on the Platform with Scientific Construction

In constructing the knowledge system, the teacher must first break the mindset and change the current situation of teaching according to the special knowledge. In the actual teaching process, the teaching should be carried out according to the “data transmission and calculation”, which is used as the course teaching idea and the individual unit knowledge points. Reconstructing and rationally organizing teaching so as to achieve interlocking and inter-connected teaching, build new knowledge links, reduce students’ sense of difference in knowledge learning, and let students follow the “data transmission and calculation” knowledge points, solving the problems of computer public course due to the wide range of professional knowledge, and the confusion of computer teachers in the teaching process [5].

### 1.4 Teaching Mode Design

#### (1) Inquiry Teaching with Multiple Innovation

Teaching reform and practice based on big data environment can not be blindly created, but should be based on scientific theory to verify teaching. In the process of designing a diversified teaching mode, it mainly relies on the four theoretical theories of behaviorism, constructivism, cognitive learning, and humanism, respecting the students’ subjective status, and giving rational use to teachers’ classroom guidance. The construction of

educational resource pool will help realize the informationization of teaching at an early date, promote the efficient use of high-quality resources, and bring into play the social benefits of educational resources. The computer public course based on the big data mode can be divided into multi-teaching and multi-learning. Diversified teaching can be divided into teaching interaction, teaching guidance, teaching exchange and teaching transmission. Each part can be divided into 3 to 4 branches, as shown in Fig. 1. Diversified learning can be divided into course study, exploratory study, writing study, situational learning, and experimental practice. Each part can be divided into three branches. Multi-learning corresponds to multi-disciplinary teaching, but in the process of public curriculum development, there is a cross between multi-teaching and multi-learning [6]. This forms feedback on the teaching information, as shown in Fig. 2.

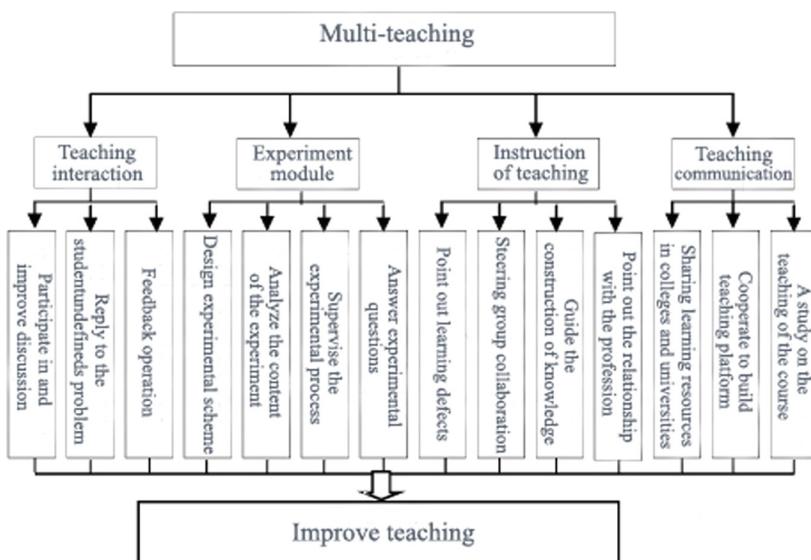
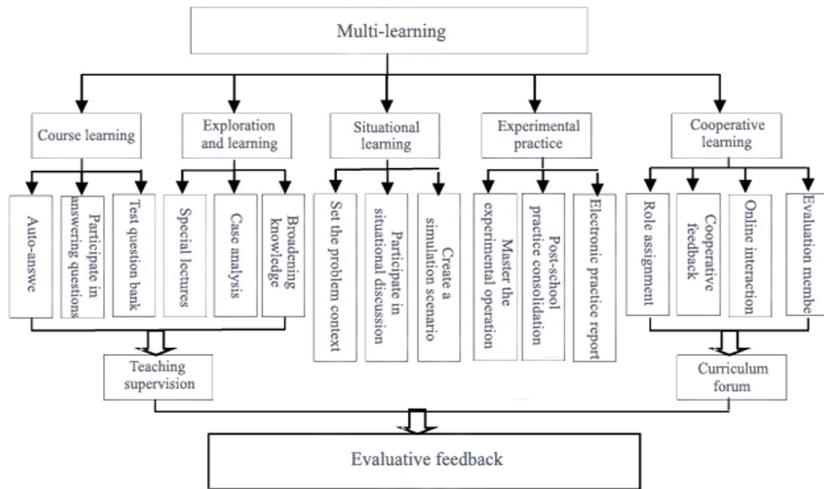


Fig. 1. Diversified teaching mode of computer public courses

## 2 Innovating Mode and Building Platform

### (1) MOOC Teaching

The MOOC is a teaching mode based on network resources. The main teaching method is online, which separates teachers from computer public courses and students [7]. Computer teachers can use the MOOC to complete online and offline teaching, and extend the value of computer public courses. The MOOC teaching mode can realize various functions such as after-school homework discussion, practical operation test, and academic information feedback in the classroom.



**Fig. 2.** Diversified learning mode computer public course

## (2) Mini-class Teaching

There is a certain difference between micro-teaching and MOOC teaching. Although they all use information technology to carry out teaching, mainly focusing on video teaching, and quickly help students grasp the key points of classroom teaching through short and precise videos in the actual process [8]. Therefore, the teacher can systematically record the video of the micro-course, let it be sorted and forwarded to the students, let the students choose themselves, and meet the three learning needs of students' independent learning, special and flexible learning. In addition, the video of the micro-courses recorded by the computer public course teachers also prevents students from deviating when they refer to the relevant learning materials [9].

## 3 Teaching Supervision, Thinking and Learning Together

Classrooms without feedback on academic information, teaching evaluation and supervision can only be stagnant, unable to make new progress, and meet the needs of computer public courses in the era of big data. Computer teachers can use information technology to connect students, allowing them to express their opinions by anonymously posting messages in the exchange forum [10]. Meanwhile, teachers can also use the software to count the number of times students who answer questions in class, and collect feedback from students on some knowledge. In this process, students must be involved to meet the learning needs of students, scientifically construct and transform the class, check the progress of students, realize the teaching progress and evaluation, and let the teachers and students learn together.

## 4 Conclusion

The jobs of college students after graduation is inseparable from computer and it is necessary to improve the teaching effect of computer public courses. Facing the problems in the teaching computer public courses, teachers should grasp the trends, apply information technology to the computer public courses, rebuild the knowledge teaching system, build an independent learning platform, and realize diversified teaching. Students are encouraged to participate in the evaluation of the curriculum and optimize the curriculum to truly realize the purpose of improving the computer public courses.

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# Influence of Chinese English Bilingual Corpus of Traditional Chinese Medicine Prescriptions on ESP Writing Under the Background of Big Data

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**Abstract.** Objective: the construction and application of Traditional Chinese Medicine (TCM) English corpus is the new trend of TCM English research and development. The establishment and development of TCM bilingual corpus is conducive to ESP teaching, the formation of unified standards and norms of TCM English, the provision of reference standards and basis for TCM English translation, and ultimately the rapid development of TCM English subject, and the internationalization of TCM Service. Methods: the corpus used in this study is from the Chinese-English version of “Jingui Yaolue” (Synopsis of the Golden Chamber) translated by Li Zhaoguo and Liu Xiru, and the self translated version of “Tang Tou Ge Jue” (Decoctions in Rhymes). The research on English corpus of Traditional Chinese medicine based on corpus linguistics is briefly summarized, and the role and significance of the construction of English corpus of TCM prescriptions for English writing of traditional Chinese medicine are analyzed and expounded. The junior students ( $n = 80$ ) of a college of TCM were randomly divided into two groups: experimental group ( $n = 40$ ) and control group ( $n = 40$ ). The experimental group used bilingual corpus of prescription terms as the driving force in the process of writing TCM English. The control group adopted the conventional writing mode, that is, the teacher explained the Chinese medicine vocabulary that may be involved in the writing process firstly, and then the students reviewed and wrote. In this study, a self-designed ESP writing ability scale of TCM was used to measure the writing ability of the experimental group and the control group. Results: in the five dimensions of word accuracy, sentence structure, text structure, writing efficacy and writing motivation, the post test of the experimental group and the control group were significantly better than the pre test ( $p < 0.05$ ); in the post test, the performance of the experimental group was significantly better than the control group ( $p < 0.01$ ). In the two dimensions of grammatical accuracy and content innovation, the post test scores of the experimental group and the control group were significantly higher than the pre test ( $p < 0.05$ ), but in the post test, there was no significant difference between the experimental group and the control group ( $p > 0.05$ ). Conclusion: the traditional teaching method of foreign language is mainly based on the rules taught by teachers, while the data-driven ESP

teaching method, from the perspective of language acquisition, focuses on students, provides students with a language environment, enables students to discover language rules from the corpus, and greatly enhances students' autonomous learning ability.

**Keywords:** Big data · Traditional Chinese medicine prescriptions · Corpus · ESP · English writing

## 1 Introduction

Formulas of Chinese Medicine (Science of Prescriptions) is one of the main foundations of TCM. The terminology of prescription science is an important part of the terminology of TCM, and it is also the embodiment of the means of treating diseases. Among them, 260 basic terms are the core terms of the terminology of prescription science. It plays an important guiding role in the study of the standardization of English translation of 260 basic terms. Due to the complexity of the nomenclature of prescriptions, the lack of a unified standard in the translation of terms, and the failure of the translation of some prescriptions to accurately express the cultural connotation, western people have some misunderstanding of TCM, which hinders the process of internationalization of TCM and the spread of TCM culture to the outside world.

### 1.1 Overview of Translation Methods of TCM Prescriptions

The name of prescription is a cultural reflection of the treatment and comprehensive use of TCM by many doctors in the past thousands of years. Jiang believed that the domestication translation of the names of TCM prescriptions refers to the direct expression of the functions and effects of the prescriptions, which can be understood by the readers as soon as they read them, not to mention the cultural conflicts and misunderstanding, “White Tiger Decoction”, “Bai Hu Decoction (for Eliminating Heat)” are mainly used as the translations. Based on the classic interpretation of TCM, “Bai Hu” (white tiger) is the western God. Because the autumn pertains to the lung. In summer, it is hot and it is cool in autumn, the qi of summer can be stopped in autumn. The order of autumn arrives at the Limit of Heat, which is to use “Bai Hu Tang” to stop the heat [1, 2], “Bai Hu Tang” is to treat the symptoms as strong heat, heavy sweat, thirsty to drink and full pulse, which belong to the heat of Yang Ming. The prescription uses gypsum, with the characteristics of pungent, sweat and great cold, to clear the pathogenic heat of the lung and stomach, relieve the heat of the muscles, promote the growth of the body fluid and quench the thirst, which is served as the monarch drug. It is assistant with Anemarrhena with bitter, cold and moist, to help gypsum clarify qi and separate solid heat, and treat Yin injured. Japonica rice and Glycyrrhiza can benefit stomach and protect body fluid, and prevent gypsum from being injured by great cold, which is named as adjuvant [3]. All of the above indicates that this prescription has the function of clearing away heat and promoting fluid production. Therefore, it is proposed that “Bai Hu Tang” should be translated into “Decimation for Eliminating heat” [4]; Some scholars think that if “Bai Hu Tang” is translated into “White Tiger

Decoction”, it will be misunderstood that this method is to treat the disease of “white tiger”, or to take some organ of “white tiger” for medicine [5], while Xia et al. proposed that the strategy of translation should be as the pattern “animal name (transliteration) + dosage form name (English counterpart) + English Annotation”, that is, it can be translated into Bai Hu Decoction (for Eliminating Heat) [6].

The names of TCM prescriptions in the Chinese English Medical Dictionary edited by Jin Kuihe are translated by domestication, for example, the translation of “Shi Xiao Powder” is “Wonderful Powder for Relieving Blood Stagnation”; “Bao He Pill” into “Pill for Promoting Digestion”; “Taishan Panshi Powder” etc. [7].

The foreignization translation of TCM prescription names is different from the domestication translation. Foreignization translation emphasizes the leading role of the source language. The target language should retain the linguistic characteristics of the source language, respect the identity and status of the source language culture or try to keep its foreign characteristics intentionally. For example, “Shi Xiao Powder” can promote blood circulation, remove blood stasis and relieve pain. After the patients take it, they can't help laughing when they get rid of all the symptoms unconsciously, so it's called “Shi Xiao Powder”. Using foreignization translation, translating “Shi Xiao Powder” into “Sudden Smile Powder” [8] or “Breaking into a Smile Powder” [5] can fully express the naming intention of the party. Another example is “Simiao Yong'an Decoction”. This prescription has only four kinds of medicine and excellent effect. It is powerful and specific in quantity, brave and rapid, which can eliminate pathogenic diseases, keep healthy and safe. Therefore, it is called “Simiao Yong'an Decoction”. English translation includes “Mysterious Four Resting Hero Decoction”, “Decoction of Four Wonderful Drugs for Quick Restoration of Health”.

Compared with the methods of domestication and foreignization, Li believed that when the simple names of TCM prescriptions were translated into English directly, there would still be tedious and lengthy disadvantages, such as the translation of “Jiao Ai Decoction” translated as “Decoction of Collac Corii and Folium Artemisiae”. In addition, the translation of prescription names should also be indirect and informative. For example, when “Biyu Powder” is translated into “Jasper Powder”, while some of the translated names are only informative and not concise, such as “Liang Ge Powder” is translated as “Powder for Clearing Away Heat in Upper Warmer” [9].

## 1.2 Overview of ESP Research Based on Corpus

At present, ESP teaching research has gone through five stages: register analysis, rhetoric or discourse analysis, target situation analysis, language skills and learning strategies analysis, and student-centered.

Data driven is a new method of foreign language learning based on corpus proposed by Tim Johns in the early 1990s. It mainly guides learners and researchers to observe, generalize and summarize language facts based on a large number of corpus data, and use them to discover grammar rules, meaning expression and pragmatic features. Wen put forward the concept and significance of the construction of TCM English corpus, and had been committed to the corpus research of “Huangdi Neijing” (The Inner Canon of Huangdi) [10]; Xue advised the plan of the construction of TCM English Corpus [11]; Ni analyzed the specific implementation methods from the principles of the

construction of TCM English corpus [12]. But these studies cannot directly point to practice. Second, in the creation stage (2009 till now), scholars put forward the details and solutions of establishing parallel TCM corpus. Guan and others started the research on the establishment and initial application of English Chinese medical parallel corpus [13], and Lan designed and constructed the Chinese English Parallel Corpus of TCM [14]. In addition, Lan and other scholars analyzed the translation of “meridians” and “pulse” based on the Chinese-English Corpus of TCM books, and believed that “vessel” refers to the three-dimensional channel in human body, which is the appropriate translation of “meridians” [15]. Jiang, using the English version of Renmin Network as the corpus source, established a small corpus for English reports of TCM, analyzed the external reports of TCM, and pointed out that the core of English reports of TCM should be the history and culture of traditional Chinese medicine [16].

## 2 Construction of Bilingual Corpus of TCM Prescription

In the past 20 years, with the application of modern information technology represented by computer and Internet in the field of education, corpus based on big data has been widely used in foreign language teaching. The study of corpus linguistics in foreign countries is extending naturally from theoretical research to teaching application [17, 18]. Corpus is widely used by teachers to assist oral, translation, writing and other teaching activities. Benson (2001) believed that unlike the traditional methods of foreign language learning and research, the data-driven method based on corpus has the characteristics of reliability, authenticity, objectivity and probability. It changes the traditional mode of teaching and learning - “cramming”, pays attention to the initiative and interest of learners, and cultivates the real sense of “autonomous learning”. Based on corpus data-driven, ESP English Writing Teaching of TCM makes full use of modern educational technology such as computer, network and relevant retrieval software to provide learners with a large number of authentic language materials. Through the independent training of “reading-imitation-innovation” for learners, it has changed the past style as teacher centered and realized the language teaching of knowledge exploration.

Hyland used genre analysis teaching method in writing teaching by using corpus, and believed that genre analysis teaching method has become one of the most important and influential teaching concepts in language education [19]. This teaching method focuses on outlining the overall structure and order of texts to illustrate the similarities and differences between different genres of texts [20]. Its core concept is the discourse community, which determines the knowledge and language characteristics of texts [21]. Restricted by the discourse community, academic papers have formed unique discourse structure and rhetorical features. Therefore, it is necessary for the academic English writing course to let students clearly understand the structure and writing methods of different types of articles through genre analysis teaching method, so as to provide students with appropriate and accurate language forms [22]. Genre analysis uses the terms “moves” and “steps” to describe the overall structure and development order of academic papers.

First of all, the scanner OCR technology was used to identify the Chinese-English version of the synopsis of the “Jingui Yaolue” (Synopsis of the Golden Chamber) translated by Li Zhaoguo and Liu Xiru as well as the self translated version of “Tang Tou Ge Jue”. Secondly, the lexical index software is used to retrieve and count the recurrence rate of the words in the corpus, and some functional words are proposed. The professional words with recurrence rate more than 5 times are classified into “word family” and “word type” with segmentation, classification, noise reduction, alignment and proofreading. After that, it was to use “Stand-off XML” to build two sub corpora - bilingual corpora of “Jingui Yaolue” and “Tang Tou Ge Jue”. Each corpus contains four columns: ancient Chinese, modern translation, English translation and annotation. Antconc 3.3.0 was used in the research to retrieve and analyze the data.

### **3 Application of Bilingual Corpus of TCM Prescriptions in Teaching**

In order to verify the role of bilingual corpus of TCM in the teaching process, the junior students ( $n = 80$ ) from a university of TCM in Jilin Province, China, were selected as the subjects. They were randomly divided into experimental group ( $n = 40$ ) and control group ( $n = 40$ ). The experimental group used bilingual corpus of prescription terms as the driving force in English writing of TCM. The subjects of relevant TCM prescriptions were advanced through retrieval software. It is essential to find out the specific semantic words and phrases from the corpus, and how to connect the relevant topic sentences through intralingual and extralingual conjunctions. The subjects further searched the corpus of relevant papers through the subject words, combined with the theoretical guidance of teachers, from the analysis of language level to the semantic function level analysis of the text. Compared with the experimental group, the control group adopts the conventional writing mode, that is, the teacher first explains the TCM vocabularies that may be involved in the writing process, and then the students reviewed and applied them in the writing. The whole experiment lasted for a semester (4 months), and the writing training was conducted once a week for two hours. The experimental group and the control group were conducted simultaneously.

In the study, a self-designed “ESP Writing Ability Scale” was used to measure the writing ability of the experimental group and the control group. ESP writing ability scale was divided into seven dimensions: words accuracy, grammar accuracy, sentence structure, text structure, content innovation, writing efficacy and writing motivation including 28 items. It was adopted as Likert-type scale with 5 points. The Cronbach’s alpha coefficient of the whole scale was 0.762, which showed that the scale had a good reliability.

Before the experiment, the experimental group and the control group were pre tested. The results showed that the experimental group ( $2.86 \pm 0.78$ ) and the control group ( $2.77 \pm 0.64$ ) both belonged to the lower middle level, and there was no significant difference in writing ability and sub dimensions between the two groups ( $p > 0.05$ ). After 16 times (32 h) of academic writing trainings, through the paired sample t-test, it could be seen that the experimental group ( $4.236 \pm 0.47$ ) and the control group ( $3.455 \pm 0.57$ ) had significantly improved on their writing ability

compared with that before the experiment ( $p < 0.01$ ). In terms of the words accuracy, grammar accuracy, sentence structure, text structure, content innovation, writing efficacy, writing motivation, the post test of the experimental group and the control group were significantly improved compared with the pre-test ( $p < 0.01$ ). Through the independent sample t-test, in the five dimensions of words accuracy, sentence structure, text structure, writing efficacy and writing motivation, the experimental group was significantly higher than the control group ( $p < 0.01$ ), but in the two dimensions of grammar accuracy and content innovation, there was no significant difference between the experimental group and the control group ( $p > 0.05$ ). Therefore, it is obvious that the bilingual corpus of TCM prescription terms based on data-driven theory can effectively improve the writing ability, especially in the five dimensions of word accuracy, sentence structure, text structure, writing efficacy and writing motivation.

## 4 Conclusion

Adaptive teaching is the optimal teaching state of corpus under the background of big data. Adaptive teaching mainly refers to teaching content, teaching methods and the whole teaching process are arranged according to the situation of learners. As an intellectual resource, corpus has the resources of knowledge popularization and ability improvement for students. The construction of bilingual corpus of TCM prescription terms can deepen researchers' understanding and learning of academic knowledge, improve their academic communication ability, and make better use of professional English for reference and writing. "Human-computer interaction" is a trend of education and teaching in the future. Bilingual corpus of TCM prescription terms can realize this new teaching mode through various modern teaching means and equipment such as Internet and big data.

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# Research on the Application Strategy of Big Data in University Financial Management

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**Abstract.** With the advent of the cloud era, the application of big data has expanded from it to other fields, but there is little research on the application of big data in university financial management. This paper analyzes the characteristics of university financial data changes in the era of big data, and puts forward the application strategies of university financial management big data from the aspects of data integration, processing, software and hardware environment, shared financial data warehouse, etc.

**Keywords:** University finance · Big data · Strategy

## 1 Introduction

Today, with the strengthening of data management and value management, the application of big data is quietly entering the financial management from other industries. Because of its unique background, university financial management needs to gather teaching, scientific research, students, logistics, etc.

Most of the data of operation and management [1] are analyzed, and the analysis results and evaluation conclusions are obtained, which can provide reference for university leaders. It can be seen that the financial management of colleges and universities is gradually moving from theoretical analysis to data analysis. The application of big data is not only of practical significance to the financial management of colleges and universities, but also the development direction of financial management in the future [2, 3].

## 2 The Application of Big Data in University Financial Management

- (1) Data integration. Data integration is to process massive data. At present, a large number of business and management data of university finance are scattered in many systems. The asset management system has a large number of financial related equipment, books, real estate and other data, the personnel management system has a large number of financial related personnel, wages, labor insurance and other data, and the student management system has a large number of financial related students, tuition, accommodation fees, credit course fees and other data.

Therefore, the future development direction of financial management is how to integrate these scattered massive data sources in a faster and more effective way, and then generate big data under financial management. Therefore, the first is that colleges and universities need to formulate action strategies, that is, from the perspective of College strategies, to formulate plans for financial information integration.

Under the leading strategic framework, a leading group is established to carry out data management and provide support and guarantee for the integration. The second is to formulate data standards to solve the problem of data inconsistency in all departments. Third, carry out data integration work on the basis of information management personnel and financial personnel training.

- (2) Data processing. The strategic significance of big data is not to master huge data information, but to professionalize these meaningful data, improve the processing ability of data, and realize the value-added of data through processing. In tens of millions of data, different financial analysis results can be obtained according to different data, users, time, space and different data processing methods. Therefore, it is necessary to establish a unified processing flow so that big data can provide the same potential for financial management.

Therefore, the first is to process big data. Big data processing is the processing of massive data, rather than the sampling processing of some data. It makes full use of the correlation characteristics of data to classify and analyze, and finds out the correlation and causal relationship between big data. Taking the financial data of colleges and universities as an example, such data as school income, teachers' salary, and class fee of each class are all related to the cost of students, so the relevant coefficient can be calculated, and the change of data can be known according to the relevant coefficient. Second, data mining for big data. Although correlation research can save a lot of data processing work, whether there is a deeper reason behind the data conclusion, we need to introduce the concept of data mining. Using the 4V characteristics of big data, i.e. volume (large data capacity), variety (multiple data types), velocity (fast data generation), veracity (high data accuracy), through the application of data mining technology, in-depth mining the past, reality, clear, fuzzy, internal and other multi-level and multi angle information, using fuzzy mathematics, neural network, human Various mathematical methods, such as industrial intelligence, mathematical statistics, data mining, etc., are used to calculate and analyze the effective information. That is, after the initial processing of big data, based on the results of the initial processing, data mining of single indicators or comprehensive indicators that can better explain the problem is performed, and then "find the data behind the data, find the reason behind the phenomenon", and further Improve the ability of financial intelligent decision analysis.

- (3) Advanced software and hardware environment. Big data processing work must rely on larger data storage space, faster data processing speed, and more efficient data processing software. To quickly and efficiently process and mine massive amounts of data generated by daily financial operations, large-capacity storage devices and high-speed processors are required. The method is that massive data can be stored

on a more standard, more open, more scalable and higher performance cloud platform architecture for cloud computing, enabling centralized storage, processing and development of big data.

- (4) Building a more intelligent information management system. Big data must conduct in-depth mining and analysis of various information accumulated in colleges and universities in business, finance, students, and personnel, and find out opinions that can help and guide financial management or school development. This is bound to break the barriers to data storage. It is necessary to update the existing information management system and promote the construction of big data processing platforms to make them more intelligent. Through intelligent construction, big data can collect various types of data related to the operating costs of colleges and universities in a timely manner, and apply these massive data to the cost control system of colleges and universities. Through scientific collection and distribution, various costs can be calculated more accurately So as to provide scientific decision-making basis for effective cost control in colleges and universities, and provide data support for the scientificity, rationality and accuracy of comprehensive budgets.
- (5) Build a compatible and shared financial data warehouse. The data warehouse is an integration and exchange center for various data, receiving data from internal and external finance, including internal financial-related data from school education, scientific research, students, personnel, assets and other departments or provincial finance department, education department, bank Various external structured and unstructured data, and in accordance with the requirements of new financial subjects, unstructured, semi-structured and multi-source structured data are integrated through ETL, and classified, cleaned and converted and processed accordingly Stored in the data warehouse as the basic data for budgeting, analysis, and decision-making. On this basis, establish master data, including project master data, budget master data, financial master data, teacher master data, student master data, bank master data, other master data, etc., and provide data sharing and information sharing between systems for the project. Accounting and execution provide uniqueness, and realize the management ability of distributed multi-source heterogeneous data.

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# **Technical Tracks 4: Machine Learning, Computer Vision, Image Processing, and Their Intelligence Applications**



# Fuzzy Comprehensive Evaluation of Sales Decline of Automobile Industry Under the Background of Artificial Intelligence

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**Abstract.** Analysis of the rapid decline in sales of the automobile industry in recent years, to determine the indicators affecting the development of the automobile industry. According to the sales drop and the relationship of industrial structure adjustment, to build a comprehensive evaluation index system for the continuous decline of automobile industry sales, using the Analytic Hierarchy Process (AHP) to empowerment of indicators. It provides a basis for fuzzy comprehensive evaluation of the risk degree of sales decline in the automobile industry and the development forecast of the combination of the automobile industry and artificial intelligence.

**Keywords:** Automobile industry · Sales decline · AHP · Comprehensive evaluation · Artificial intelligence

## 1 Introduction

Automobile industry is the pillar industry of the national economy. Taking the automobile industry as the research object of comprehensive evaluation of product sales decline, it is not only representative, but also has a strong practical application value. The integration of the whole automobile needs thousands of parts and components, and the manufacturing of parts and components inevitably needs thousands of manufacturers to cooperate with each other. The development of the automobile industry involves energy, chemical industry, material, steel, communication, electronics and other industries, so the evaluation of automobile industry needs comprehensive evaluation. From the perspective of new energy vehicles, artificial intelligence, inter enterprise competition, labor cost, subsidy decline, and international trade friction, a comprehensive analysis of the declining trend of the volume, we should not only start from a single study on automobile sales, but also dig into various factors and indicators that affect the automobile industry.

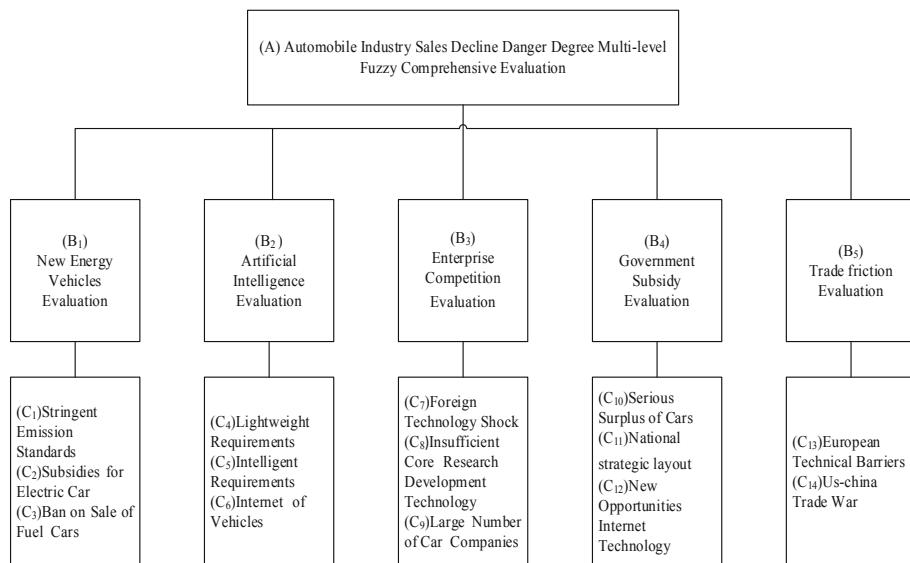
According to Jato Dynamics, which is a veteran international automobile data research organization. It points out that plateau phenomenon is emerging in major markets all over the world, and the growth rate of fuel cars is becoming smaller and smaller, and there will be a recession in the next few years. Causes led to a decline in the sales performance of fuel vehicles worldwide, including more stringent emission

standards in Europe, Sino US trade war, preferential subsidies for electric vehicles, national fuel car ban programs, big data Internet, intelligence, lightweight, etc. Therefore, many factors restrict the development of automobile industry. However, there is no comprehensive evaluation of the overall decline of the automobile industry. In order to deeply explore the risk degree caused by the decline of automobile sales, this paper will evaluate the current risk degree through multi-level fuzzy comprehensive analysis.

## 2 Multi-level Fuzzy Comprehensive Evaluation

### 2.1 Evaluation Indexes of Automobile Industry

By consulting industry experts, public information of automobile enterprises, to determine the degree of decline in the automobile industry questionnaire, and to select degree of the first and second indicators. This paper does not consider the internal structural adjustment of enterprises. The comprehensive evaluation index system includes 5 primary indicators and 14 secondary indicators, as shown in Fig. 1.



**Fig. 1.** Schematic diagram of comprehensive evaluation index system

### 2.2 Determine the Weights of Indicators

Analytic hierarchy process (AHP) has the characteristics of systematic and hierarchical, and can be combined qualitatively and quantitatively to solve multifactor decision making problems, in accordance with the overall goal and each goal sequence is divided into different hierarchies, and calculate the comparative judgment matrix, the

weights are obtained by various factors, to make fuzzy comprehensive evaluation to the decline in sales, ultimately determine the decline risk level.

### 2.3 Establish Comparative Judgment Matrix

When using the AHP method, the intrinsic comparative importance of each factor in the same level is compared with each other, and the relative importance is expressed numerically by 1–9 scale method proposed by the famous American scholar T.L. Saaty, so as to establish the judgment matrix [1, 2], such as two elements i and j, as shown in Table 1.

**Table 1.** The meaning of scale 1–9

Scale	Meaning
1	The ratio of i to j is 1, i is equivalent to j
3	The ratio of i to j is 3, i is slightly greater effect than j
5	The ratio of i to j is 5, i is significantly greater effect than j
Scale	Meaning
7	The ratio of i to j is 7, i is strongly greater effect than j
9	The ratio of i to j is 9, i is extremely greater effect than j
2, 4, 6, 8	Comparison of two elements is in the middle of the above adjacent importance judgment
Reciprocal	The ratio of $a_{ji}$ is the reciprocal of $a_{ij}$

### 2.4 Weight Parameter Selection and Verification

Determine the comparison matrix and calculate the eigenvalues and eigenvectors, then select the maximum eigenvalue and eigenvector. According to formula (1) and formula (2), the consistency index and consistency proportion index of matrix are analyzed. If the analysis hypothesis is passed, the normalized maximum eigenvector is defined as the weight vector; on the contrary, if the analysis hypothesis is not tenable, the comparison matrix is reconstructed and the above operations are followed. According to the matrix theory, it is the precondition of using AHP to calculate the factor weight that the judgment matrix satisfies the consistency test [2]. In order to achieve the consistency goal of matrix verification, the formula (1) for  $\lambda_{\max}$  and CI are calculated as follows:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (1)$$

Where  $CI$  is the consistency index,  $\lambda_{\max}$  is the maximum eigenvalue and  $n$  is the matrix order. Refer to the matrix of order 1–8 to repeatedly calculate the average random consistency index, and determine the consistency inspection index RI of judgment matrix, as shown in Table 2.

**Table 2.** The average random consistency index

Rank	RI	Rank	RI
1	0	5	1.12
2	0	6	1.26
3	0.52	7	1.36
4	0.89	8	1.41

The consistency proportion index CR of the judgment matrix is calculated by the formula (2):

$$CR = CI/RI \quad (2)$$

Where CR is the consistency proportion index; RI is the average random consistency index.

When the consistency ratio CR of the matrix is less than 0.1, it is considered that the above theory can be used directly within the allowable range of the error, and the normalized characteristic matrix can be used as the weight vector, and if the comparison matrix is not within the error range, it must be modified. [3–6]. According to the established judgment matrix, As the set of weight vectors, the eigenvectors of the matrix can be allocated as follows. The weight of each evaluation factor index is  $W = \{W_1, W_2, W_3, \dots, W_n\}$ .

## 2.5 Establish Evaluation Set

The degree of danger of sales decline in the automobile industry can be divided into: light, medium and severe, evaluation set  $V = \{V_a, V_b, V_c\} = \{\text{less dangerous; Moderate dangerous; serious dangerous}\}$ . If the risk is relatively light, it indicates that the structure of the automobile industry is updating. The medium dangerous indicates that the future automobile industry may have a greater decline, which is worth vigilance. The severity of the danger indicates that the auto industry has been badly hit and that important adjustments must be made to deal with the serious crisis that is about to occur.

## 2.6 Establishment of Fuzzy Evaluation Matrix

By analyzing the risk degree of sales decline in the automobile industry, it can make scoring table of influencing factors of the comprehensive evaluation index system, then this survey invites the graduates and teachers of the employment class of automobile major in the school of mechanical engineering to score, the fuzzy membership degree of each factor was obtained through statistical analysis, and the evaluation matrix was established [7–10].

$$R_m = \begin{bmatrix} r_{11}^m & r_{12}^m & r_{13}^m \\ r_{21}^m & r_{22}^m & r_{23}^m \\ r_{31}^m & r_{32}^m & r_{33}^m \end{bmatrix}, (m = 1, 2, 3, 4) \quad R_5 = \begin{bmatrix} r_{11}^5 & r_{12}^5 & r_{13}^5 \\ r_{21}^5 & r_{22}^5 & r_{23}^5 \end{bmatrix}, (m = 5) \quad (3)$$

Level one comprehensive evaluation: the weight of each factor of level one index is  $W_i (i = 1, 2, 3, 4, 5)$ , and the result of level one evaluation is as follows:

$$F_i^{(1)} = W_i \cdot R_i, (i = 1, 2, 3, 4, 5) \quad (4)$$

$$F^{(1)} = [F_1^{(1)} F_2^{(2)} F_3^{(3)} F_4^{(4)} F_5^{(5)}] \quad (5)$$

## 2.7 Comprehensive Evaluation Results

Secondary comprehensive evaluation: the secondary index weight vector is  $W$ , and the secondary evaluation result is:

$$F^{(2)} = W \cdot F^{(1)} \quad (6)$$

According to the principle of maximum degree in fuzzy theory, the two-level evaluation is carried out.  $F^{(2)}$  is final evaluation result, and the dangerous degree category of sales decline in the automobile industry studied in this paper is determined.

## 3 Practical Application

### 3.1 Current Situation of Automobile Industry

Many countries, including the Netherlands, California, Norway, Germany, India, France and the United Kingdom, will ban the sale of conventional fuel vehicles around 2030. China will ban the sale of fuel-powered cars by 2035, according to an unofficial announcement. Major automobile enterprises in various countries around the world have stopped producing production lines of fuel cars and devoted themselves to the research and development of electric cars. The Geely automobile plans to take 90% of the sales of new energy cars in geely's overall automobile sales in 2020. Mercedes-benz expects that in 2022, all automobile products will be electrified and traditional fuel cars will be completely discontinued. Changan will be fully electric by 2025, when it will officially stop selling fuel-powered cars. Baic stopped manufacturing and selling conventional fuel vehicles in China in 2025. Global sales of pure electric vehicles rose 92 per cent in the first half to 765,000 units. According to the sales volume of pure electric vehicles in the global market in the first half of this year is about 780000. In the first half of this year, 430,700 pure electric vehicles were sold in China, an increase of 111% year-on-year. In global battery car sales ranking in the first half of the year, the tesla Model 3 jumped to the top of the sales list due to its excellent performance in the us and the China market.

There are 2,143 automobile manufacturing enterprises in China. There is still a lack of core engine technology and special steel manufacturing technology, which has become an important obstacle to the development of the industry. With the introduction of the internet of vehicles technology, China's traditional automobile manufacturing industry is facing greater challenges. Due to the insufficiency of traditional research and development technology and the integration of new technology, major automobile enterprises are involved in important structural adjustment. In recent years, the United States and the European Union have tried every means to set up trade barriers, increase trade tariffs and technical blockades in order to curb China's development. The trade war has seriously aggravated the expansion of the automobile market.

### 3.2 The Comprehensive Evaluation System of Automobile Industry

Based on the above theory, this part follows the steps of comprehensive factors and risk analysis of automobile sales volume. It uses the scoring method of Table 1 to construct the two-level factor judgment matrix, finally it takes CR verification as the criterion to determine whether it meets the consistency verification. According to Table 2, the average random consistency index RI is 1.12. According to the judgment matrix table in Table 3, the maximum eigenvalue is 5.2233. Through the calculation of formula (1) and formula (2), it can be seen that CR is equal to 0.0498, and its value is less than 0.10, meeting the requirements of consistency proportion. The weight result of each factor is obtained, as shown in Table 3.

**Table 3.** The evaluation index system second-level judgment matrix and weight

A	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	W
B <sub>1</sub>	1	1	5	1	7	0.298
B <sub>2</sub>	1	1	3	1/3	5	0.204
B <sub>3</sub>	1/5	1/3	1	1/5	4	0.084
B <sub>4</sub>	1	3	5	1	7	0.377
B <sub>5</sub>	1/7	1/5	1/4	1/7	1	0.037

Through Internet in the form of questionnaires, the main participation of staff are college students and many years in automotive industry car workers to score expert questionnaire (a total of 10 copies of questionnaires, effective 10), then the table statistics and analysis, the fuzzy membership degree of various factors and establish the evaluation matrix.

$$\begin{aligned}
 R_1 &= \begin{bmatrix} 0.20 & 0 & 0.80 \\ 0.35 & 0.15 & 0.50 \\ 0.42 & 0 & 0.58 \end{bmatrix} \\
 R_2 &= \begin{bmatrix} 0.79 & 0.21 & 0 \\ 0.36 & 0.34 & 0.30 \\ 0.63 & 0.30 & 0.07 \end{bmatrix} \\
 R_3 &= \begin{bmatrix} 0.32 & 0.68 & 0 \\ 0.13 & 0.71 & 0.16 \\ 0.23 & 0.25 & 0.52 \end{bmatrix} \\
 R_4 &= \begin{bmatrix} 0.72 & 0.28 & 0 \\ 0.89 & 0.11 & 0 \\ 0.34 & 0.45 & 0.21 \end{bmatrix} \\
 R_5 &= \begin{bmatrix} 0.23 & 0.64 & 0.13 \\ 0.78 & 0.22 & 0 \end{bmatrix}
 \end{aligned}$$

The weight calculation of each factor in the first-level factor layer is the same as that above, which meets the consistency test, and the weight result of each factor is shown in Table 4.

**Table 4.** Weight distribution at all levels

Rule layer	Level 2 weights ( $W^{(2)}$ )	Factors layer	Level 1 weights ( $W^{(1)}$ )
B <sub>1</sub>	0.298	C <sub>1</sub>	0.101
		C <sub>2</sub>	0.674
		C <sub>3</sub>	0.225
B <sub>2</sub>	0.204	C <sub>4</sub>	0.333
		C <sub>5</sub>	0.097
		C <sub>6</sub>	0.570
B <sub>3</sub>	0.084	C <sub>7</sub>	0.637
		C <sub>8</sub>	0.105
		C <sub>9</sub>	0.258
B <sub>4</sub>	0.377	C <sub>10</sub>	0.094
		C <sub>11</sub>	0.739
		C <sub>12</sub>	0.167
B <sub>5</sub>	0.037	C <sub>13</sub>	0.667
		C <sub>14</sub>	0.333

According to Eqs. (4) and (6), the evaluation results of two levels can be calculated as follows:

$$F_1^{(1)} = W_1^{(1)} \cdot R_1 = [0.3506, 0.1011, 0.5483]$$

$$F_2^{(1)} = W_2^{(1)} \cdot R_2 = [0.6571, 0.2739, 0.0690]$$

$$F_3^{(1)} = W_3^{(1)} \cdot R_3 = [0.2768, 0.5722, 0.1510]$$

$$F_4^{(1)} = W_4^{(1)} \cdot R_4 = [0.7822, 0.1828, 0.0351]$$

$$F_5^{(1)} = W_5^{(1)} \cdot R_5 = [0.4132, 0.5001, 0.0867]$$

The comprehensive results are as follows:

$$F^{(1)} = \begin{bmatrix} 0.3506 & 0.1011 & 0.5483 \\ 0.6571 & 0.2739 & 0.0690 \\ 0.2768 & 0.5722 & 0.1510 \\ 0.7822 & 0.1828 & 0.0351 \\ 0.4132 & 0.5001 & 0.0867 \end{bmatrix}$$

$$F^{(2)} = W^{(2)} \cdot F^{(1)} = (0.572, 0.2215, 0.2066)$$

The established evaluation result is  $V = \{V_a = 0.572; V_b = 0.2215; V_c = 0.2066\} = \{\text{Less dangerous; Moderate dangerous; Serious dangerous}\}$ , because  $V_a > V_b > V_c$ , according to the principle of maximum membership degree in fuzzy theory, the automobile industry studied in this paper has a relatively less dangerous of sales decline in recent years, which belongs to the normal range.

## 4 Conclusions

In this paper, influence factors are determined based on actual engineering research methods, and a second-level comprehensive evaluation index system is established. Then, an expert survey method is adopted to evaluate and score individual influence factors, multi-level fuzzy comprehensive evaluation model was innovatively proposed. The application of multi-level analysis method can avoid the error brought by the subjective analysis. In a comprehensive view, the current automobile market is not in a dangerous situation. Most of people think that this is just an industrial transformation, which will not cause serious harm and is in a normal controllable category. The saturated automobile market needs new technologies such as the Internet of vehicles, so there will be new opportunities. In the future, there will be a turning point in the development of the automobile industry. Due to the new technology of artificial intelligence, the market of the automobile industry will be more expanded. The current short-term sales decline is the only way for every industrial change. Through the research of this paper, the development of automobile industry can be systematically and clearly evaluated.

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# Countermeasures for Training Computer High-Skilled Talents in the Era of Artificial Intelligence

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**Abstract.** With the rapid development of artificial intelligence, the competition between various computer enterprises is becoming increasingly fierce. In this fierce competition, talents will inevitably become the key factor for the survival and development of various enterprises. However, computer professionals vocational ability and enterprise's expectations, but there is a certain gap between especially in computer skills training, often exist in understanding unclear demand trends to unit of choose and employ persons, unpredictable phenomenon, therefore, under the background of the rapid development of artificial intelligence computer lack of high-skilled talents reserves has become the hot topic of the whole society. In reaction to the phenomenon, this paper puts forward the innovative entrepreneurial, engineering education concept into the high-skilled talents cultivation in computer system, based on the analysis of computer training institutions and universities about the present situation of computer training, fully elaborated in this paper, the computer high-skilled personnel training target, training, strategy of the new theory, new points, will strive for applied talents cultivation idea is applied to the computer talents training, so as to get rid of computer high-skilled personnel training speed can't keep up with development of artificial intelligence.

**Keywords:** Artificial intelligence · Highly skilled personnel · Cultivation strategy · Professional ability

## 1 Introduction

In May 2016, the state issued relevant guidance on actively promoting the development of the Internet industry, officially listed the development of the artificial intelligence industry and related talent training as a national strategy for the first time, and made detailed arrangements for the development layout of the artificial intelligence industry in relevant documents [1, 2]. The Chinese President also emphasized in relevant meetings that artificial intelligence is an important driving force for a new round of industrial transformation and scientific and technological revolution, and whether China can seize this strategic opportunity is related to whether China's economic development in the next few decades can move forward toward an innovative economy [3]. Based on this background, how to strengthen the construction of computer

professional talent team, strengthen the strength of back talent training, with greater determination, more powerful measures to create a high standard computer talent training system, for the development of artificial intelligence industry to provide adequate talent and intellectual security is urgent [4, 5].

After studying the development process of foreign artificial intelligence, this paper found that foreign countries have always placed computer talent training in universities, focusing on improving the training mechanism of computer talents [6]. In the 1880s, the computer industry association to the United States at the Massachusetts institute of technology, puts forward the opinion, think the current computer professional graduates generally has a rich theoretical knowledge, but in practice, few students can smooth the kinetic energy convert their theoretical knowledge into practice, can't talk to the practice of innovation, and there are more serious team collaboration ability and logical analysis is not thorough [7]. After entering the new century, the practice effect was gradually incorporated into the training system to balance the imbalance between practical ability and theoretical knowledge. Remarkable results have been achieved over the past ten years [8]. In China, due to the late start of computer development, the relevant research on talent cultivation strategy is also more than 10 years later than that of western developed countries [9]. About 2000, it was also China's universities that took the lead in implementing the computer talent training strategy in the mode of university majors. The original intention of the implementation was to integrate into the development trend of the world entering the era of computer, so as to enhance the strength of computer talent training in China [10]. As academic exchanges between colleges and universities to promote and government policy support, quickly to learn computer boom across the country, more and more scholars began to study computer personnel training mode, but have to admit the fact that our country still failed to form a scientific and effective computer senior talent cultivation system, serious lack of high-level talents with innovative ability, changing era of artificial intelligence is a lack of leading ability [11, 12].

Based on the analysis of the research status at home and abroad, on the basis of argue that current our country can not effectively develop computer skills because there is no solution of the social demand of choose and employ persons and there is contradiction between supply and demand between the existing computer personnel training mode, unit of choose and employ persons tend to surround themselves with highly skilled talents with open thinking and innovation ability, but the current training mode often only can be produced with rich experience in the theory of talent, to develop computer skills with time characteristics [13, 14]. Therefore, this paper proposes a new training model for computer talents with high Skills – CISM model (Cooperationabilities, Innovation and Open thinking, Skills career planning ability, Management and Communication Skills), and selects a computer department of a well-known university in China as the training sample. The results show that: This training mode can cultivate more powerful application-oriented and skilled senior talents for the society, which undoubtedly finds a new way for China to solve the bottleneck of the current computer advanced talent training mode [15].

## 2 Method

### 2.1 Analytic Hierarchy Process

Analytic hierarchy process (AHP) is an evaluation method based on multi-objective comprehensive evaluation method and network system theory, which was proposed by American defense department in 1974 when it calculated the contribution of American departments to national welfare. It is a hierarchical and systematic decision-making analysis method combining quantitative analysis and qualitative analysis. Through this method, the decision maker can decompose the complex problem into several factors or modules for hierarchical rearrangement and combination, and then determine the factor weight according to the vector of the combination matrix and the maximum characteristics, so as to provide more accurate decision for the decision of the problem.

According to the actual application needs, this paper first establishes a reasonable talent cultivation ability index system, in order to facilitate the quantitative analysis of the ability of computer high-skilled talents. In the specific practical operation, only the evaluators need to give two relative qualitative descriptions, and then through the weight of the evaluation elements, analytic hierarchy process can be well combined with the qualitative analysis of the computer, so as to greatly enhance the effectiveness and scientific nature of the evaluation process. Therefore, the evaluation system of computer talents is really applicable to China's market, which provides methodological support for training more applied computer talents.

### 2.2 Training Ability Index System Based on Analytic Hierarchy Process (AHP)

A Construction of CISM model proposed in this paper, mainly including cooperation ability, innovation and open thinking ability, career planning, management and communication skills, to master plan, according to the characteristics of the development of artificial intelligence under the age of computer analysis of the enterprise post demand and social demand, visiting investigation into the interest groups, and then designed the index system of computer high-skilled personnel training.

The index system constructed in this paper takes the capstone project as the core, determines the second-level project and then decompresses the third-level project, and then organizes and cultivates the main courses according to the technical points of the capstone project, so as to provide fundamental guidance and logical compliance for the whole project curriculum system.

In the development and design of three-level projects, this system always follows the premise of teamwork and open thinking, and guides each team to improve their career planning ability and management and communication skills. As for the design of practical teaching system in and out of class, concept learning is designed for the threshold of talents with advanced skills. After completing the study of basic knowledge, it is necessary to sublimate these foundations qualitatively so as to improve the professional quality. After the improvement of the professional quality of the practical design of the project, the skills of learners can be consolidated and improved. Furthermore, the self-confidence of learners, their ability to analyze and solve problems, as

well as their career planning, management and communication skills will be exercised in this link. The scientific nature of the system is also reflected in the practice of cooperation with the society. The training base directly introduces computer talents from the curriculum theory to social practice and directly touches the needs of the society, which lays a solid foundation for the growth of talents.

### 3 Experiment

#### 3.1 Experimental Data Sources

The experimental measure selected in this paper is to conduct the investigation by means of electronic questionnaire, which is the data source of this study. The focus of the survey is to analyze the employment needs of computer enterprises, and to ask questions about the education of computer professionals, so as to obtain first-hand data and provide new ideas for the training of computer senior talents. In this article at the beginning of the creation, the questionnaire also start simultaneously, began to issue the questionnaire in August, September began to recovery, after two months, as before the draft, a total of 200 questionnaires, 185 questionnaires taken back, after the analysis of the questionnaire, eliminate invalid questionnaire 15, remaining effective questionnaire 170, questionnaire recovery rate reached 92.5%, effectiveness is 85%, conform to the requirements of the specification of statistics, the experimental data is valid.

#### 3.2 Experimental Process

After the questionnaire was collected, the questionnaire was analyzed logically. According to the evaluation index of CISM model, the analysis of cooperation ability, innovation and open thinking ability, career planning ability, management and communication ability were successively carried out. According to these analysis results, a series of targeted teaching practices were carried out, and the practice results were tested by questionnaire.

### 4 Discuss

#### 4.1 Analysis of Survey Results

In the experiment of this paper, the computer talents cultivated under the CISM mode were named as the experimental group, and the 170 randomly selected online questionnaire subjects were named as the control group. The validity of CISM model is tested from two dimensions of individual employment situation and actual ability.

##### (1) Comparison of employment situation

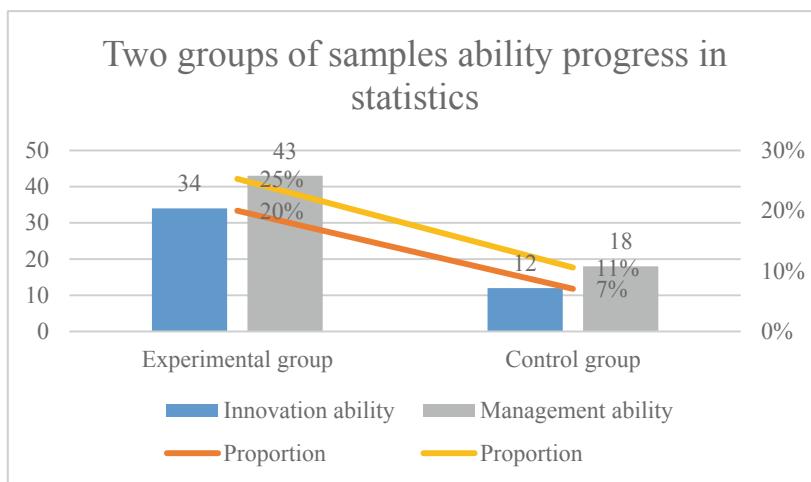
In this link, the estimated results of the employment prospects of the experimental group and the control group were statistically analyzed, and the statistical results were shown in Table 1 below.

**Table 1.** Employment prospects of the two groups of samples

Employment outlook		Experimental group		Control group	
		Number of persons	Proportionality	Number of persons	Proportionality
Pretest results	Care-laden	32	18.82%	46	27.06%
	A little worried	63	37.06%	67	39.41%
	No big problem	46	27.06%	41	24.12%
	Full of confidence	29	17.06%	16	9.41%
Posttest results	Care-laden	13	7.65%	43	25.29%
	A little worried	32	18.82%	63	37.06%
	No big problem	84	49.41%	45	26.47%
	Full of confidence	41	24.12%	19	11.18%

## (2) Comparison of personal abilities

After the training of CISM culture mode, the control group showed obvious differentiation with the control group in terms of innovation ability and management ability. The ability of computer talents in the experimental group was greatly improved compared with the control group in various aspects, as shown in Fig. 1 below.

**Fig. 1.** Changes in occupational abilities of individuals in the two groups

## 4.2 Countermeasures for Training Computer Talents with High Skills

The above experimental research shows that the CISM model proposed in this paper is conducive to the incubation and training of computer high-skilled talents. Therefore, this model can be vigorously promoted. Specifically, the countermeasures of this paper can be summarized as the following points:

### (1) Determine the correct culture orientation

In the context of artificial intelligence, the computer covers a wide range of areas, whether it is college or computer training units, must be clear about their own training objectives. If the curriculum plan for the purpose of making profit is made randomly, it will inevitably lead to the students' lack of deep understanding of the courses they have learned. Therefore, the trained students are bound to be far away from the requirements of the society, so that they do not have the qualities that the talents with high computer skills should have.

### (2) Improve the teaching model

Whether it is computer training institutions or universities, the common phenomenon is still in the use of the old era used to indoctrinating teaching model, under this teaching model, students lack the initiative to learn, let alone cultivate the soil of creativity. This teaching mode with huge limitations is often difficult to achieve a better teaching effect, nor can it be integrated with other courses, although it is difficult to give full play to the teaching effect.

### (3) Enrich practical teaching

In the process of training computer talents, it is necessary to carry out practical teaching on double platforms, that is, the mode of combining in-class teaching with enterprise practice. This is because in the era of artificial intelligence, the advancement of computer technology lies in the rapid response to the change of social needs, if students just stay in the classroom content, will not be able to smell the change in demand. Therefore, in the process of talent cultivation, we should strengthen the analysis, grasp and benchmarking of social needs.

## 5 Conclusion

In the era of artificial intelligence is coming today, the development of science and technology changes with each passing day, in order to preempt the application of artificial intelligence, we must realize that talent is the key to win in the competition. In computer high-skilled personnel training strategy, this paper put forward the mode of CISM set up the support double and personnel training mode and training system, is a set of produce artificial intelligence, thinking of the new scheme of computer skills, with countermeasures presented in this paper for computer personnel training strategy close to the time background, close to the market demand.

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# Image Resolution Enhancement Technology Based on Deep Neural Network

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**Abstract.** Improving image quality is an important subject in the field of image processing. Images have a wide range of important uses in modern society, such as security surveillance, remote conferences, medical images, etc. Different from drawing-based graphics, it is often difficult to obtain images with sufficient accuracy due to the accuracy of the acquisition equipment. Especially in the field of video surveillance, because of the large amount of data storage, the limited bandwidth of the transmission link, and the limitations of the CCD manufacturing process and cost, it is often difficult to improve the resolution of the camera. The purpose of this paper is to study image resolution enhancement techniques based on deep neural networks. In this paper, in order to solve the problem of image resolution enhancement, the related theories and methods of super-resolution are studied. A processing framework for resolution enhancement is designed for real images. The effect of the resolution enhancement method is improved through process. Normalization method. Aiming at image resolution enhancement, a resolution enhancement method based on deep neural networks is proposed. Through the enhancement of various images, the visual effect of the experimental results is effectively improved. The research results show that image resolution enhancement processing can improve the spatial resolution of images under the same hardware conditions to a certain extent, improve image degradation and resolution degradation due to insufficient hardware conditions, and make up for the lack of image resolution to a certain extent to make the image clearer.

**Keywords:** Deep neural network · Image resolution · Resolution enhancement technology · Image application

## 1 Introduction

With the advent of the era of big data and the significant improvement of computer computing capabilities, intelligent algorithms led by deep learning are increasingly subverting everything in daily life. The improvement of image resolution can be achieved by improving the accuracy and stability of the shooting system. However, the cost of doing so is high, so it is difficult to be satisfactory in terms of economic consumption, and it is difficult to implement the production technology, so the problem of improving image resolution cannot be solved well. However, as one of the deep learning models, the convolution neural network has a high accuracy rate in the field of image recognition and is more accurate than the human eye. Therefore, combined with

the excellent performance of deep neural network in image resolution enhancement technology, the research is based on deep neural network. The image resolution enhancement technology is of great significance. Image information plays an important role in our life and work. The resolution of an image is one of the important indicators of image quality, so we can also use the advantages of deep neural networks to aggregate images and neural networks related to them. Together, it is not only used for image resolution enhancement, but also widely used in other areas of image processing, so as to get the results we need.

The image resolution enhancement technology discussed in this article mainly refers to super-resolution technology. Before the 1980s, different methods such as the excessively long ellipsoidal wave function method, linear extrapolation method, and superimposed sine template method were proposed for super-resolution. The effect is not good [1]. Since the 1980s, super-resolution technology has made breakthrough developments. When Huang used multiple remote sensing images to restore a high-quality Landsat satellite image, they used multiple satellite images to enhance one image and achieved better results. Effect [2] subsequently, reconstruction-based methods flourished, forming different methods based on interpolation, iterative back projection (IBP), maximum posterior probability (MAP), convex set projection (POCS), regularization methods, etc. [3]. The above methods belong to the spatial domain method. In addition to the spatial domain method, some scholars are committed to the research of the frequency domain method [4]. The basic idea of the frequency domain method is to improve the spatial resolution of the image by eliminating spectral aliasing in the frequency domain. The theoretical basis is the translation characteristic of the Fourier transform [5]. At present, few scholars have further studied the frequency domain method. Correspondingly, the spatial domain method has been greatly developed due to its flexibility, and various methods are in full bloom [6]. For various factors of image quality degradation, different mathematical methods are used to describe the imaging and degradation processes of the image, and many mature mathematical methods can be used to solve it. The difficulties that need to be overcome are the complexity of the model and the difficulty of solving. A large number of scholars have done a lot of work in this field [7, 8]. The method based on deep neural network is a current research hot spot in the field of super-resolution research. Compared with the traditional super-resolution method, the biggest difference of this method is that the prior information that guides the enhancement of image resolution does not come from the summary of scholars, and It is derived from a large number of high-resolution images as a reference neural network [9]. Through the study of the regularity between the high-frequency information and low-frequency information of the reference image, it summarizes different forms of prior information such as high-frequency blocks and low-frequency block equivalents to guide the recovery of high-frequency information missing from low-resolution images [10].

In this paper, based on the deep neural network for the actual image resolution, an image resolution enhancement framework is designed, proper process is introduced, the illumination is normalized by Retinex theory, and the traditional Retinex method is slow and does not conform to The disadvantages of prior constraints such as Retinex theory, the Retinex method based on geometric envelope is designed. By enhancing the

image resolution in various aspects, the visual quality of the experimental results is effectively improved, and the experimental results are closer to the original high-resolution images.

## 2 Method

### 2.1 Digital Image Imaging and Degradation Models

The purpose of super-resolution is to restore the “original” high-resolution image from the observed low-resolution image. The essence is the inverse process of the observation process, so firstly, a simple and factual imaging model and degradation model need to be established. First, suppose that the high-resolution image is a matrix. The matrix is written in the form of a row-connecting vector, where the row vector formed by each row of the image is connected in sequence in order to form a one-dimensional vector. Here,  $x$  is an “ideal” image, that is, it is acquired from the original continuous scene at the sampling rate or higher. It contains all the information of the original scene and can completely recover the original signal. The “ideal” high-resolution images obtained by sampling cannot be directly observed by humans or recorded by instruments, because this is only an intermediate result in the observation process. Due to the non-uniformity of light propagation in the air, the relative movement of the lens and the scene, and the transmission defects of the lens, the “ideal” high-resolution image has undergone blurring factors such as spatial transformations such as translation and rotation. The effect is projected onto the CCD photosensitive plate. Due to the limited density of CCD granularity, its sampling process is a down sampling process, that is, the size of the image is further reduced. Finally, there are fuzzy factors added in the process of photoelectric conversion and transmission, which is a complete observation process. The complete observation process can be expressed by the following formula.

$$y_k = DB_k M_k x + n_k \quad (1)$$

Among them,  $y_k$  is the observed  $k$ -th frame image,  $x$  is the “ideal” image,  $M_k$  is the spatial transformation matrix,  $n_k$  is the fuzzy matrix,  $D$  is the down sampling matrix, and  $n_k$  is the noise of the  $k$ -th frame image.

In the super-resolution field of face images, most literature do not consider such a complex observation model, but simplify it to

$$y = Dx \quad (2)$$

That is, the blur and noise factors are ignored, and the face image registration is done in advance, that is,  $I$  is the identity matrix.

### 2.2 Retinex Lighting Model

Super-resolution technology based on deep neural networks guides the enhancement of low-resolution images through the similarity between the input images of the neural network and the images in the training library, but in actual images, even the same scene will be under different lighting conditions. Presents a completely different

grayscale distribution. So how to normalize the illuminance of an image is also a research problem in the field of super-resolution based on neural networks. Retinex theory, based on the observation principle of the human eye, better explains visual theoretical problems such as lighting and color, and is a breakthrough in solving the problem of normalization of illumination [11]. Traditional color theory believes that the human eye perceives light by determining the nature of the light reflected from the object. This theory is inconsistent with certain phenomena in people's daily life, as an article reflects significantly different light under different lighting environments, but the human eye can roughly sense that the color of the object has not changed [12]. Land put forward different views on this. He believes that humans perceive color not only through the light and retina of the eyes, but also with the involvement of the cerebral cortex [13]. He believes that through the perception of different ratios of long, medium and short wavelengths, certain colors are formed in the brain through certain calculations. Based on this, Retinex (Retina + Cortex, Retina Cortex) theory is proposed and used for image enhancement And other research areas [14]. Retinex theory believes that a natural image is formed by the reflection coefficient of the scene and the incident light, which is expressed by the formula:

$$S(x, y) = R(x, y) \times L(x, y) \quad (3)$$

Among them, R is the reflection coefficient distribution image of the scene, L is the light intensity distribution image, and S is the natural image formed. This paper proposes the Retinex algorithm based on geometric envelope, which has achieved good results in both time efficiency and experimental results. It has been applied to image resolution enhancement preprocessing and achieved good results.

### 3 Experiment

- (1) Acquisition of image data. Obtain and record the data, analyze the mechanism of the model, and through the analysis of the mechanism, find out the problems that need to be paid attention to during the construction of digital image imaging and degradation models based on deep neural networks.
- (2) Model construction and detection. A mathematical algorithm based on deep neural network digital image imaging and degradation model and Retinex lighting model is used to calculate and classify the various levels and types of the image. In the calculation process, we must ensure the accuracy of the data, and then build digital image imaging and degradation models and Retinex lighting models according to mathematical algorithms. After the model is constructed, the model is tested, and the overall effect, error, and accuracy are tested. Experiments are performed to check whether digital image imaging and degradation models and Retinex lighting models have improved image resolution.
- (3) Design and application of models. According to the above-mentioned experimental result data and the characteristics of image resolution, the image imaging and degradation model and Retinex lighting model are designed, and the relevant designs are tested for practical application. Confirm the consistency between the

design and application of the model. Record the difficulties encountered in the actual design and the shortcomings in your real application, and further modify the model according to the actual situation.

## 4 Results

### 4.1 Comparative Analysis of Method

Retinex theory has conducted in-depth research on the interaction between the human eye and the image, and its theoretical basis is to decompose an input image into two parts: the illumination component and the reflection coefficient component that reflects the essential attributes of the object. If the illuminance component of the image is separated using Retinex theory and only the reflection coefficient component is retained, a good illuminance normalization effect can be achieved. The classic methods of Retinex theory include path comparison-based methods, convolution-based methods, and variable frame-based methods. Among them, the more mature and better methods are MSR and Kimmel. MSR method belongs to convolution-based method, and Kimmel method belongs to variable frame method. This paper proposes a method based on geometric envelope, which can better meet the basic assumptions of Retinex theory, obtain good experimental results, and improve time efficiency. Based on the comparison of the experimental results of the geometric envelope method and the MSR method with the Kimmel method, the time efficiency of the three methods is compared from both theoretical and experimental aspects. The specific comparison effect data is shown in Table 1:

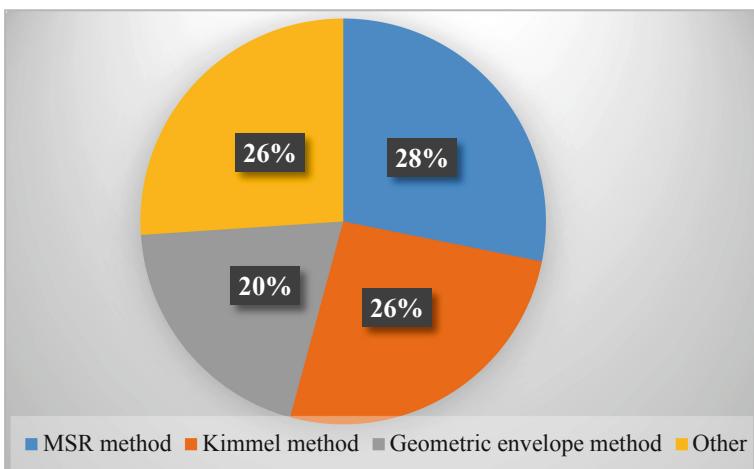
**Table 1.** Comparison of the efficiency of the three methods

	Geometric envelope method	MSR method	Kimmel method
Theory	78%	86%	89%
Experiment	76.43%	85.65%	87.23%

The Retinex method is often used in the fields of thin cloud and mist removal, color restoration, and uneven illumination correction. The geometric envelope method proposed in this paper has achieved good experimental results in these areas, and improved the traditional Retinex algorithm, which has the disadvantages of low contrast, color distortion, and slow time efficiency. This method proposed in this paper is mainly used to correct the interference of thin clouds and fog, the distortion of color and the difference in illumination. In this paper, 10 thin cloud images, color distortion images, and low-light images are selected for experiments. These image sources include selfie images and Retinex's standard test images. It can be seen from the experimental results that the contrast enhancement degree of the MSR method is sometimes insufficient, and the experimental results are not obvious. The advantages are that the image restoration results are more natural and the visual effect is better. Kimmel's method is prone to

produce over-enhancement effects. It also amplifies the noise a lot, is sensitive to noise, and is prone to halo at the junction of bright points, light sources, and light and dark. In many cases, the experimental results have poor results. The method in this article can well achieve the effects of contrast enhancement, color maintenance and restoration, and illumination complementation. It can remove the thin clouds and fog while maintaining natural colors and good visual effects. Perform recovery.

When the number of images processed in a batch is large, the improvement of time efficiency has important practical significance. The multi-resolution geometry-envelope-based method has obvious advantages in time efficiency compared with the MSR and Kimmel methods that have been proposed so far. The following first analyzes the time complexity of various Retinex methods theoretically, and then gives the proportion of each algorithm in practical application as shown in Fig. 1.



**Fig. 1.** Proportion of actual application of the three algorithms

The experimental results further verify the practicability of the three methods. Although the MSR method is a non-linear time complexity, the added complexity is only the multiplication of logarithmic terms, which is very close to the linear complexity. The Kimmel algorithm requires a large number of iterative calculations, and the calculation formula of each iteration is more complex, so the speed is slower. Therefore, the method proposed in this paper can obtain the advantages and disadvantages of each method through the design of deep neural networks.

## 5 Conclusion

Image resolution enhancement technology is an important research topic. Image super-resolution based on deep neural network is a research focus and hotspot in this field. It can be widely used in security surveillance, public security investigation, national

security and other fields. For the image resolution enhancement technology, this paper points out that the input image in practical applications often has inconsistencies in illumination and spatial orientation with the images in the training library, which reduces the effect based on deep neural networks and designs image resolution enhancement. The method framework, by introducing appropriate process and corresponding post-processing, enhances the combination of the algorithm and the effect of image resolution.

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# The Effective Marketing Channels of Agricultural Products in the Artificial Intelligence Environment

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**Abstract.** The development of artificial intelligence is changing our living conditions and consumption patterns, and then it has a profound impact on the traditional marketing methods. But at present, there are few researches on the application of artificial intelligence in agricultural product marketing. The purpose of this paper is to explore the effective channel of agricultural product marketing based on artificial intelligence. Explore the marketing channels of agricultural products, carry out field visits and personal interviews with agricultural enterprises and self-employed households, conduct questionnaire surveys on consumers, and use the survey data to analyze, to explore the prospects and obstacles of new media marketing of agricultural products. The experimental results show that 100% of consumers who choose to buy agricultural products online will choose supermarkets or convenience stores, but the proportion of consumers who choose wholesale market of agricultural products trade is 0%. Only 32.6% of consumers also choose to buy in the mobile vegetable market, while those who do not choose to buy agricultural products online basically choose supermarkets or convenience stores. The proportion of consumers who choose the wholesale market of agricultural products trade is 0%. Good new media marketing can open up the main battlefield of offline stores, supermarkets and convenience stores, which is an effective way to cultivate loyal consumers.

**Keywords:** Marketing channel · Agricultural product marketing · Artificial intelligence · Information network

## 1 Introduction

China's natural environment is complex and diverse, and the varieties of agricultural products are rich and distinctive. How to effectively build and promote market demand is a problem that has been hard to solve in the marketing of agricultural products [1, 2]. The new media marketing is based on the rapid development of e-commerce in the artificial intelligence environment. The new concept of new media marketing is integrated into the new technology support system. The updated marketing channels and methods, and the unchanged marketing purpose [3, 4]. Compared with the traditional marketing method, the new media marketing based on artificial intelligence

environment has detailed content and novel form, wide range of communication, no time and geographical restrictions, more close to the target population and multi-directional communication, and relatively low operating cost [5, 6]. The new media marketing mode of agricultural products is the future development demand and direction for agricultural enterprises, agricultural product operators, farmers, etc. to carry out product marketing, which is conducive to promoting the marketization process of agriculture, and is an effective way to realize enterprise development, entrepreneurship of the whole people, and income increase of farmers [7, 8]. Therefore, how to grasp the opportunity of the times and use the diversified channels and modes under the artificial intelligence environment to serve the marketing of agricultural products is a problem worthy of in-depth discussion with practical significance and theoretical value [9, 10].

From the perspective of change, farmers need to get the latest and accurate information to improve the quality and quantity of agricultural product marketing. Information and communication technology plays a key role in the marketing of agricultural products by accelerating information transmission. Wang took 109 agricultural experts and extension workers as the research objects, and all of them adopted the survey method. Descriptive results show that China's agricultural marketing is in good condition. ICT also plays a role in improving the marketing of agricultural products. The regression results show that the information networks of local markets are experienced promoters in the application of information and communication technology to marketing, the delivery service centers for agricultural marketing are lack in rural areas, the appropriate information and communication technology cannot be determined and ensured, and the private sector investment in agricultural marketing lacks sufficient support, The rules and regulations for developing information and communication technology in agricultural marketing are not sound and effective, which determines 55% of the marketing differences of agricultural products [11]. Zayats pointed out the significance of agricultural products marketing channel from the current structure of agricultural products channel, and further analyzes the existing problems of the current channel. Then, combined with the characteristics of agricultural products and the economic environment, the paper puts forward countermeasures to improve the marketing channels of agricultural products [12].

(1) Innovation of research perspective. According to the development trend of the times, the new media marketing based on the artificial intelligence environment is playing an increasingly important role in the marketing industry. This paper proposes to break through the traditional way of agricultural product sales with the help of artificial intelligence, and discusses the agricultural product operators to make full use of human intelligence to grasp more opportunities and new product marketing models for agricultural product marketing. (2) Innovation of research content. Based on the traditional marketing theory of agricultural products, the innovative ideas, the characteristics and advantages of artificial intelligence research summed up a more systematic theory, to provide practical reference for the marketing of agricultural products. In view of the current situation of domestic agricultural products relying on artificial intelligence new media and other marketing methods, this paper finds out a variety of feasible strategies and rules of new media for agricultural products marketing.

## 2 Proposed Method

### 2.1 Marketing Channels

Marketing channels are interpreted as distribution channels, and also as circulation channels. There are also many definitions of marketing channels, the most typical of which include organization structure, circulation process, and organization member relationship. In a word, marketing channel refers to a series of channel members' secondary transfer of products or services until the circulation, process and relationship of consumers. A kind of Traditional marketing channels are usually divided into direct distribution channels and indirect distribution channels according to whether there are intermediate links. The so-called direct marketing channel refers to the channel that the end user purchases directly from the manufacturer, also known as direct marketing; the marketing channel that at least one middleman participates in the marketing process is the introduction marketing channel, also known as distribution. Traditional marketing channels classify the number of middlemen. The two ends of the direct distribution channel are producers and consumers. Without middlemen, it is a zero level channel. Indirect distribution channels are generally divided into one, two, three or even multi-level channels according to the number of intermediate links.

### 2.2 Marketing Channels of Agricultural Products

The marketing channel of agricultural products generally refers to the circulation process of agricultural products from farmers to buyers. In this circulation process, farmers, namely producers, are the starting end, while consumers are the most terminal. The bridge between producers and consumers needs to be connected to deliver products to consumers. The development of network, online and offline development mode is the most important sales mode used by modern producers and sellers. The network sales platform can effectively and quickly transfer the information of agricultural products. With the development of market economy and agricultural economy, the current marketing channels of agricultural products have been unable to meet the current needs of life, which has become an important factor limiting the rapid development of rural economy. After decades of development, the marketing channels of agricultural products have been constantly innovating to find more suitable marketing channels for agricultural products, and a pattern of simultaneous existence of multiple marketing channels has emerged.

#### (1) Direct sales

The direct sale type refers to that the producer directly sells to the consumer through the agricultural trade market or the wholesale market of agricultural and sideline products. This kind of sales mode without any intermediate link is also very simple in the means of transportation, that is, the corresponding products are directly transported to the market and sold to the consumer. This mode of sales saves the intermediate link and can obtain more profits, but at the same time, it will consume a lot of human and material resources, and has certain non loss and supply and demand risks.

(2) Multi level sales

This kind of sales mode refers to the existence of multi-layer wholesalers between farmers and consumers, which can be delivered to consumers through many different links. In the middle, through multi-layer wholesalers to increase prices, either to reduce the purchase price, or to increase the sales price, reduce the income of farmers, do not understand the needs of consumers, resulting in market confusion.

(3) Marketing mode of processing in sales

In this mode, wholesalers directly find farmers to purchase in large quantities, and then process the products after purchase and before sale, so as to increase the price of the products and sell them to consumers and earn certain benefits. The most significant is the wholesale mode. Wholesalers purchase products in a unified way. They are packaging and primary processing products and selling them through enterprises. In this way, wholesalers tend to keep prices down, the cost of primary processing and transportation is too high, and the price of products in the hands of consumers has doubled or even more.

### 3 Experiments

#### 3.1 Analysis of Consumer Behavior

New media marketing, including agricultural products, is aimed at consumers. All marketing activities need to be planned according to the changes of consumer characteristics and behavior patterns, and strategies should be formulated according to reliable data analysis and marketing basis. Therefore, in order to carry out effective Internet marketing activities, it is necessary to study consumers' purchase motivation, purchase behavior and psychological characteristics. To solve this problem, this paper carries out a questionnaire survey in order to truly reflect the current situation of consumers' purchase of agricultural products.

#### 3.2 Questionnaire Design

From November 2019 to December 31, 2019, this paper conducted a sampling survey of online shopping of agricultural products by consumers. A total of 200 questionnaires were distributed online and offline, and 200 of them were recovered, including 200 valid questionnaires. The survey time is from November to December, during which e-commerce experienced the craziest "double 11", "double 12", "thanksgiving" and "Christmas" in the whole year. Because these two months are the craziest sales season of e-commerce in the whole year, the probability of obtaining effective samples is relatively high. This analysis adopts the random sampling questionnaire survey method, in which 100 questionnaires are distributed through the network, and the other 100 questionnaires were randomly distributed offline. The index system designed by the questionnaire can objectively reflect the current attitude and behavior of consumers towards online shopping of agricultural products. The collected information shows that

the level of cultural background is more comprehensive, the age spans all stages, and the gender ratio of the object is reasonable. Therefore, the reliability of the survey results is high.

### 3.3 Data Analysis Method

According to the questionnaire results of agricultural and sideline products Internet sales, data processing and data analysis are carried out for the samples. According to the groups who purchase agricultural products through Internet media channels, the consumption psychology, consumption habits, consumption characteristics and consumption behavior are analyzed.

## 4 Discussion

### 4.1 Analysis of Consumers' Shopping Behavior

According to the survey data, 100% of the consumers who choose to buy agricultural products online will choose supermarkets or convenience stores, but the proportion of the consumers who choose the wholesale market of agricultural trade is 0%. Only 32.6% of the consumers also choose to buy in the market of flowing vegetables, while those who do not choose to buy agricultural products online basically choose supermarkets or convenience stores, and the proportion of the consumers who choose the wholesale market of agricultural trade For example, 0%. In daily life, consumers who have relative requirements for shopping environment and purchasing experience of agricultural products are often potential consumers of agricultural products online shopping. Price is not the most important factor they care about in purchasing agricultural products. In real consumption, they will choose supermarkets and fresh fruits and vegetables convenience stores that gradually replace the mobile agricultural market. Therefore, in the marketing strategy of agricultural products, we can focus on this part of consumer groups and do a good job in product development. For some large-scale agricultural and sideline products enterprises, a comprehensive new media marketing can open up the main battlefield of offline physical stores, supermarkets and convenience stores, and it is also an effective way to cultivate loyal consumers.

Among the agricultural and sideline products purchased through the Internet platform, the most choices are nuts, snacks, fruits, local specialties and seafood meat (Table 1).

In the era of artificial intelligence, Internet media platform and various application software are in the change of data volume at every moment. Data will become assets and become an important basis for enterprises to analyze consumer behavior. However, agricultural products enterprises start late in the field of e-commerce, and their products are special. In recent years, they have been developing rapidly. They should keep up with the market trend, pay attention to enterprise products, consumer behavior and Big data collection related to the target market, all kinds of data generated through artificial intelligence are close to the consumers, more understanding of consumers' psychology and demand. The closer to the consumers, the higher the discourse power in the

**Table 1.** Proportion of agricultural products purchased (Note: This statistic is multiple choice total votes)

Varieties	Proportion
Grain	12%
Eggs	6.5%
Grain and oil	9%
Local specialty	20%
Nuts, dried fruits and other snacks	86%
Tea	12%
Seafood meat	14%
Dried food	11%
Fruits	46%

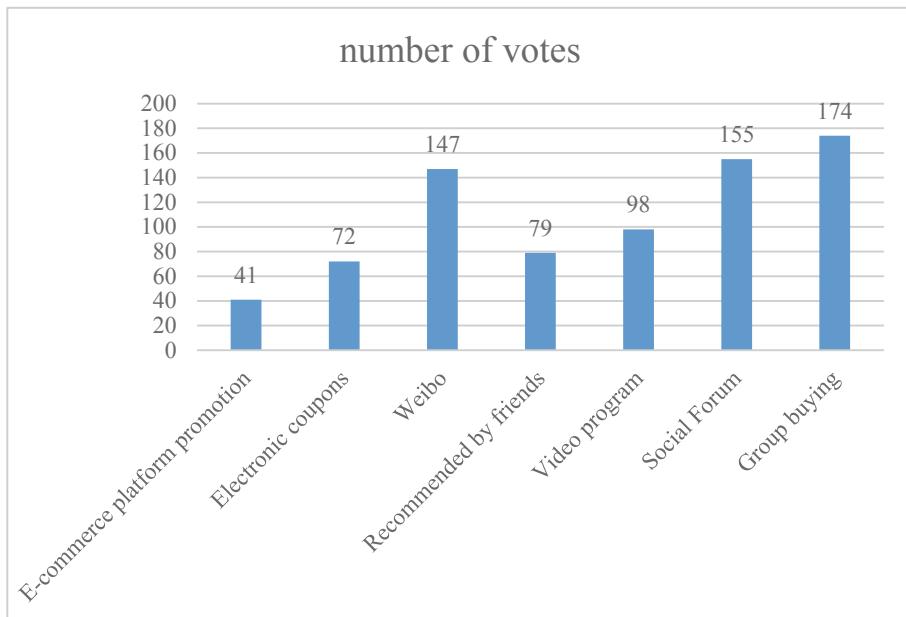
agricultural product industry chain, and the more competitive products can be launched.

#### 4.2 Analysis of the Marketing Model Affecting Consumers' Shopping

The way for consumers to understand and purchase agricultural products is no longer a single online store. The diversification of media forms and channels makes the marketing mode change accordingly. In view of the impact and role of artificial intelligence new media on consumers in the field of agricultural products marketing, relevant questions are also focused on in the questionnaire survey. Based on the objective data and actual situation, more effective strategies and marketing methods are proposed.

According to the survey, consumers are most grateful for group buying, microblogging, wechat, friend push information sharing and Social Forum celebrity recommendation. Through this way of information sharing, commodities or brands that would not have been purchased were moved. This shows that the focus of this kind of new media marketing can be to increase the deep connection between commodities and consumer demand, such as local specialty five grain miscellaneous Food is for health and beauty consumers, nuts and other natural products are for those who like snacks and are worried about health (Fig. 1).

Agricultural products enterprises should first investigate and analyze the basic background, consumption characteristics and regional habits of the target consumers, use social media such as QQ group voting, wechat voting, microblog voting and other channels for investigation, and then combine the available big data for analysis, seize the part that can resonate with the internal needs of consumers, fully tap the versatility of agricultural products, and build the internal brand of the enterprise. In terms of cultural identifiability, we should do a good job in cultural positioning, and penetrate brand culture into all aspects of product R & D design and marketing strategies. By comprehensively integrating new media around consumers' lives, we should gradually penetrate into consumers' hearts, so that consumers can be fresh and at the same time be imbued with the product demands of "I need".



**Fig. 1.** Voting on the potential purchase interest of unplanned agricultural products due to media  
(Note: This option is calculated by the total votes of multiple choices of consumers)

## 5 Conclusions

This paper focuses on the theme of new media marketing of agricultural products, analyzes the marketing of agricultural products as the starting point, combines with the current trend of market segmentation and consumption habits, and expounds the necessity, advantages and disadvantages and possible obstacles of new media marketing of agricultural products based on artificial intelligence, aiming at domestic agricultural products. The typical cases of marketing are analyzed, and the strategy suggestions of agricultural products marketing using new media are given based on the future development trend.

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# Construction and Application of Online Course Teaching in Intelligent Learning Environment

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**Abstract.** At present, the development of intelligent education is in full swing. As the cornerstone of intelligent education, intelligent learning is the inevitable trend of learning mode transformation driven by the wave of intelligent education. The purpose of this paper is to study the construction and application of online course teaching in the intelligent learning environment. Firstly, it studies the technical support of intelligent learning environment and the teaching application of intelligent learning environment. Secondly, it discusses cloud computing technology, Internet of things technology and learning analysis technology. The questionnaire is based on the actual learning experience of students. The questionnaire is divided into four dimensions: perceived usefulness (5 items), perceived ease of use (4 items), course satisfaction (6 items) and learning interaction (6 items). The purpose of the questionnaire survey is to obtain students' learning experience comprehensively and truly, and to verify the feasibility and effectiveness of the research model. The experimental results show that the scores of the two dimensions of the questionnaire design are all around 4.20, with an average of 4.23, which shows that students have a good evaluation of the online learning environment based on the research model, recognize its convenient use of platform functions, effectively obtain learning information, present clear and accurate content, and communicate with teachers and peers flexibly.

**Keywords:** Smart learning · Smart education · Online courses · Teaching platform

## 1 Introduction

With the emergence of the concept of “smart earth”, the concept of “smart” has penetrated into all fields of life. New concepts such as smart city, smart medical care and smart education have been proposed gradually [1, 2]. With the continuous development of the new generation of information technology and the construction of a new intelligent learning environment, intelligent learning has emerged [3]. Under the environment of intelligent learning, not only the concept, mode and form of education have changed greatly, but also the way of teaching and learning will have revolutionary changes [4, 5]. Therefore, the study of teaching strategies in the context of intelligent learning is a problem that must be studied and solved in the current teaching reform, and also a prerequisite to ensure the smooth implementation of intelligent learning [6, 7].

With the help of information equipment and other ways to start online learning, learners can effectively overcome the limitations of geographical culture and other aspects, and can more friendly, multi-way, convenient and efficient access to a large number of detailed knowledge [8–10].

Nathan foulquier used a framework developed for non synchronous constructivism courses to examine the availability of social constructivism online teacher preparatory courses. In particular, the method of interactive learning is studied. Students from all over the world took the course. Weekly feedback data is analyzed using phenomenology, a qualitative research method that examines data from a student's perspective and a description of the student's experience. The results of weekly feedback analysis identified three different types of interaction: group work, synchronous meeting and interpersonal interaction in learning management system. In these three types of interaction, there are differences in students' learning styles. At the end of the analysis, the problems that the curriculum designer should pay attention to are discussed [11]. In a recent survey conducted by Chenguang Yang, 100% of the respondents think that students' participation is a challenge, no matter how long they have taught online. This paper discusses various strategies that can be adopted in the design of online learning courses in order to cultivate students' high degree of participation on the basis of multiple teaching methods. In addition, the role of collaborative student engagement tools in the design and delivery of online courses, as well as the role of these tools in creating an atmosphere in which students actively participate in learning activities and contribute to lively discussions, were discussed [12].

There are two innovative points in this study: first, introducing the paradigm of teaching platform, theol, to explore its theoretical basis and feasibility of application in intelligent learning, to analyze the elements of intelligent learning supported by theol, on this basis, to build the intelligent learning mode supported by theol, to expand the theoretical research and application scope of theol. Second, although there are some researches on intelligent learning in China, most of them stay at the theoretical level. This research designs the intelligent teaching platform based on the theol, and puts it into the first-line practice, providing more reference materials for the application of intelligent learning theory and the teaching reform research in Colleges and universities, which is conducive to promoting the change of College Students' learning mode, and has certain cutting-edge and challenging.

## 2 Proposed Method

### 2.1 Technical Support for Intelligent Learning Environment

Technology promotes the reform of education. At the same time, the development of technology provides a strong support for the construction and application of intelligent learning environment, and promotes the corresponding changes of learning and teaching methods. Internet of things technology connects physical space to realize situational awareness of learning environment; artificial intelligence technology identifies learning environment, diagnoses pre-school learning situation, intelligently pushes learning resources and provides personalized learning services; cloud computing technology can

provide rich learning resources and realize digitalization of resources; rich media technology enhances learners' interaction, improves participation and improves learners' learning experience; big data and Learning analysis technology can collect and mine big data related to teaching activities in the intelligent learning environment by using learning analysis technology.

## 2.2 Teaching Application of Intelligent Learning Environment

The teaching application of intelligent learning environment is nothing more than the reflection of the relevant functions that intelligent learning environment can achieve in the teaching process. Intelligent learning environment relies on information technology to connect intelligent services, intelligent learning activities and learning places, perceive the environment, identify scenarios, connect communities and record processes, so as to promote learners' relaxed, committed and effective learning.

## 2.3 Key Technology Foundation

The construction of intelligent learning environment can rely on a variety of technologies. It is clear that the role of technology in it is far from enhancing learning and should be changed into enabling learning. Although many new information technologies need to be integrated in the construction of intelligent learning environment, here we only discuss some key technologies necessary in the construction.

### (1) Cloud computing technology

Cloud computing is to virtualize all kinds of network resources (software, hardware, services, etc.) as a kind of public infrastructure to provide users, like water, electricity, gas, etc., to provide elastic computing services, according to the actual use and needs of users, users do not need to understand its working principle, buy its services rather than products, the main service forms of cloud computing are SaaS, IAAs. The advantage of cloud computing in the construction of intelligent learning environment is that it greatly reduces the cost of software and hardware procurement, and simplifies the operation and maintenance work. It is very suitable for the reality that universities have multiple campuses and a large number of equipment.

### (2) Internet of things technology

The English name of the Internet of things is: Internet of things, so it can be seen that the Internet of things is based on the Internet, which is the expansion and extension of the Internet; at the same time, the terminal equipment connected to the network has become any "thing", where the "thing" is a generalized "thing", including both people and things. The above two points are generally accepted consensus. Although there has not been a strict unified definition since it came into being, people generally accept that the Internet of things is to connect any article with the Internet for information exchange and communication through information sensing equipment such as radio frequency identification (RFID), infrared sensor, global positioning system, laser scanner, etc. according to the agreed protocol, so as to realize intelligent identification A network of other,

location, tracking, monitoring, and management. The Internet of things can be constructed from three aspects: perception layer, network layer and application layer. The remarkable characteristic of intelligent learning environment is to make the environment intelligent. Internet of things technology is a powerful tool to realize intelligent control of physical environment and intelligent analysis of virtual information. At present, colleges and universities all have “one card” and “equipment management” systems. On this basis, “Internet of things” technology can be used to upgrade and transform, so that the intelligent learning environment can more easily support intelligent attendance, intelligent automatic management hardware equipment, equipment safety monitoring and other functions.

(3) Learning analysis technology

In the face of the dilemma that data sets with 4 V characteristics (volume massive data scale, velocity rapid data flow and dynamic data system, variety diverse data types, value huge data value) can not be processed by mainstream software, learning and analysis technology should come into being at this time. It draws lessons from the business field, and businesses analyze the potential consumption through data mining of consumer activities in the trend. Learning analysis technology analyzes the massive data generated in the learning process through five steps: data collection, analysis, student learning, feedback and intervention, which is the core technology to make our intelligent learning environment truly play its “wisdom” characteristics. We should fully and deeply capture and analyze the “track” of learners’ interaction with the existing teaching platform, and carry out targeted diagnosis for learners. Finally, realize personalized guidance.

(4) Mobile Internet technology

With the popularization and development of mobile terminals, the combination of traditional Internet and mobile communication network gives birth to mobile Internet, which is the application of Internet technology to mobile network. Its key technologies include mobile communication technology and heterogeneous information acquisition and integration in big data environment. Mobile communication technology ensures that mobile terminal equipment can pass through wireless at any time and place. The data of various types can be acquired and integrated in one platform, and finally form comprehensive information. This technology provides a guarantee for us to carry out all kinds of teaching mode innovation based on intelligent equipment in the intelligent learning environment.

### 3 Experiments

#### 3.1 Questionnaire Design

First of all, the questionnaire is based on the technology acceptance model, combined with the purpose of verifying the actual effectiveness of the course construction under the guidance of the online teaching platform resource organization optimization model oriented to knowledge service, to select the basic conditions that meet the research content, and then carry out the overall organization and design of the questionnaire. At the same time, through the evaluation of teachers and students on the questionnaire,

the contents that are unclear, repetitive and invalid are expressed. After the experiment course, the final designed questionnaire will be distributed to the experimental students to fill in.

The content of the questionnaire is based on the actual learning experience of the students, and is compiled with Likert five point scale. Each question has five options, which are “totally disagree”, “disagree”, “not necessarily”, “agree” and “fully agree”. The score is “1, 2, 3, 4, 5” in turn. The higher the score of the whole questionnaire, the more consistent the students are with the description of the item. The questionnaire is divided into four dimensions: perceived usefulness (5 items), perceived ease of use (4 items), curriculum satisfaction (6 items), and learning interaction (6 items). The purpose of the questionnaire is to obtain students’ learning experience comprehensively and truly, and to verify the feasibility and effectiveness of the research model.

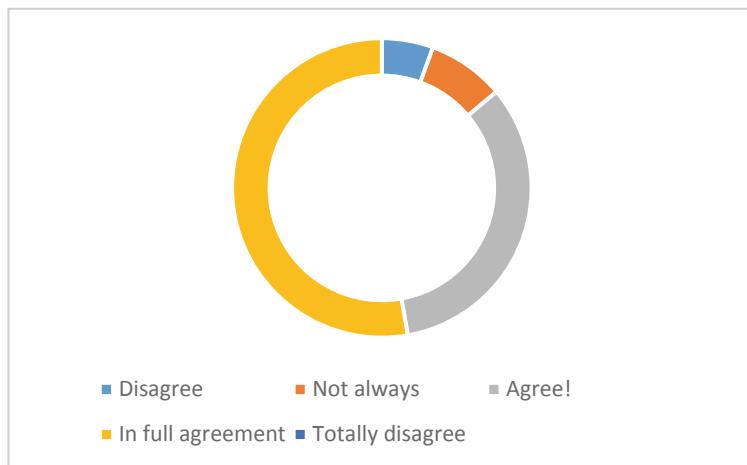
### 3.2 Survey Tools

Technology acceptance model is often used to explain users’ perception and acceptance of information system. The purpose of the research is to construct an online learning environment of online courses under the guidance of research model. Through the perception of students on the model, a questionnaire is designed from the perspective of perceived usefulness and perceived ease of use of the model, so as to verify the feasibility and effectiveness of the research model.

## 4 Discussion

### 4.1 Evaluation and Analysis of Learners’ Use of Online Teaching Platform

The first item in the questionnaire design “I’m very satisfied with using the platform for online learning” is to collect feedback from learners on the evaluation of using the teaching platform for learning. The results are shown in Fig. 1. According to the data, only 5.56% of the learners are not satisfied with the use of the platform, 8.33% of the students are generally satisfied with the use of the platform, while more than 86.11% of the learners are satisfied with the use of the platform. Therefore, learners are keen to construct learning environment under the guidance of research model for online learning. In the interview with students, students have expressed their love for learning in the platform. They reflect that in the course of learning, not only the frequency of communication with teachers and peers increases, but also the interactive content is not only the course knowledge, with a broader content extension. For example, in the learning process, in addition to the problem-solving involving software operation, it also includes the experience sharing of game design thinking. On the other hand, provide corresponding learning resources according to the learning process in real time, so that they can better follow up the learning, and for example, in the teaching, when the software is operated, the platform presents many knowledge points and common problems in the operation, while in the creation of works, it provides case study and work design guidance to make their learning more engaged.



**Fig. 1.** Students' satisfaction evaluation of online teaching platform

#### 4.2 Usability Analysis

According to the analysis of the usability of the research model, the intention is to analyze the degree of change from the initial contact with the experimental course to the easy use of the design activities for the course design, and analyze whether the application of the model promotes the learners' positive learning attitude. Here, the study considers the usability of the research model from the aspect of the use of online learning environment, that is, the perception usability survey of the questionnaire focuses on the four aspects of "convenience of platform functions, effectiveness of information acquisition, clarity of content presentation, and flexibility of communication and exchange" to collect student evaluation information. The results are shown in Table 1.

**Table 1.** Assessment results of students' perception of learning environment

	Platform function	Information acquisition	Content presentation	Interaction tool	Whole
N	59	59	59	59	59
Maximum value	5.00	5.00	5.00	5.00	5.00
Minimum value	2.00	2.00	2.00	2.00	2.00
Average value	4.16	4.33	4.56	4.03	4.23
Standard deviation	0.81	0.70	0.74	0.83	0.77

The data shows that the scores of the two dimensions of the questionnaire design are all around 4.20, with an average of 4.23, which shows that students have a good evaluation of the online learning environment based on the research model, recognize

its convenient use of platform functions, effectively obtain learning information, present clear and accurate content, and communicate with teachers and peers flexibly. Therefore, the online teaching environment based on the resource organization optimization model of the online teaching platform for knowledge service is easy to be accepted by learners and has corresponding ease of use. When considering the usability of the research model, the researchers also interviewed the students' online learning. Some students said that the reason why they are keen to use the theol online teaching integrated platform for online learning is that the use of interactive tools promotes their feelings with teachers and peers, especially when they encounter learning difficulties or enter learning errors, teachers and peers can help themselves to correct their learning errors in a timely and effective manner through the platform; at the same time, the learning provided by the platform Learning resources make them more clear about their learning objectives and more convenient to obtain the target content. It can be seen from the above information that students are supportive of online teaching under the guidance of research model and can participate effectively, with the participation rate of 100%.

## 5 Conclusions

This paper tests whether the resource organization optimization model of knowledge service-oriented online teaching platform can promote the occurrence of learners' autonomous learning behavior, and whether it can strengthen the interaction between the various elements of learning in the online teaching system. And through interviews and questionnaires to collect learners' feedback on the experimental courses, through data analysis, starting from the technology acceptance model, considering the usefulness and ease of use of the research model, we can get that learners are keen on the course learning under the guidance of the model, and promote the improvement of learners' performance through the interaction of design. From the final learners' works and feedback on the course, we can see that learners' course learning under the guidance of resource organization optimization model of online teaching platform based on knowledge service has achieved positive results.

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# Computer Aided Diagnosis of Early Breast Cancer by Multimodal Imaging

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**Abstract.** Breast cancer is one of the common tumors threatening women's health, early detection and treatment is an important way to improve the cure rate of breast cancer and save the lives of patients. In recent years, with the development of sequencing technology and pathological image technology, a large number of multimodal data of omics and pathological image have been accumulated. The introduction of the above multi-modal data in early breast cancer research can greatly improve the cure rate of breast cancer. Therefore, how to effectively integrate the above multi-modal data is an urgent problem in the field of early breast cancer diagnosis. In addition, computer-aided diagnosis is one of the important applications of medical imaging. It helps doctors to draw conclusions on reading films through automatic detection and recognition, effectively solves the problem of easy fatigue and uneven professional skills of doctors, and has great application value in medical diagnosis. So based on related literature, technology and academic research on the basis of the analysis, combining the multimodal imaging and computer aided, used in the diagnosis of early breast cancer, and to analyze the results, aims to improve the diagnosis of early breast cancer rate and quality, providing certain theoretical basis for related research.

**Keywords:** Multi-mode image technology · Early breast cancer · Computer aided diagnosis technology · Ultrasonic imaging

## 1 Introduction

Breast cancer is a common malignant tumor for women, and its development to the late stage will bring serious physical damage, and even life, so how to find breast cancer faster has become the focus of people's attention. Early stage breast cancer generally has no obvious clinical symptoms and needs to be diagnosed by medical imaging [1]. Up to now, the commonly used medical imaging techniques are breast ultrasound, X-ray photography and MRI [2]. Among them, breast ultrasound and X-ray photography have the characteristics of low sensitivity and low specificity, which cannot fully meet the clinical needs. MRI, with its prominent feature of high soft tissue discrimination, plays an obvious advantage in the detection and diagnosis of early breast cancer [3, 4]. However, MRI is also a time-consuming and expensive examination and contraindications, which force people to stay away from it. Therefore, ceus has been applied to the early diagnosis of breast cancer and gradually gained more and more attention.

Although the application of ceus in mammary gland is at the preliminary stage, its advantages are obvious. Ultrasonic light scattering technology can measure functional information within the organization, its most significant advantages is that it can more accurately quantitatively reflect the biochemical information within the organization, can provide clinicians with hypoxia and new blood vessels form indicators closely related to the malignant degree, effect on the detection of breast cancer with potential [5]. Based on this, multi-mode imaging plays an important role in the diagnosis of early breast cancer, and the combination with the computer-aided system can further promote the accuracy and timeliness of the diagnosis results, which has certain theoretical and practical significance for relevant studies [6].

Based on relevant theory, technology and academic research, on the basis of collection and analysis, respectively discusses the ultrasonic imaging and enhanced resonance imaging, ultrasonic imaging scattered light and other new technology of ultrasonic and method in the diagnosis of early breast cancer, multimodal images were obtained, the result of the computer aided diagnosis of early breast cancer, and analyses its research.

## 2 Method

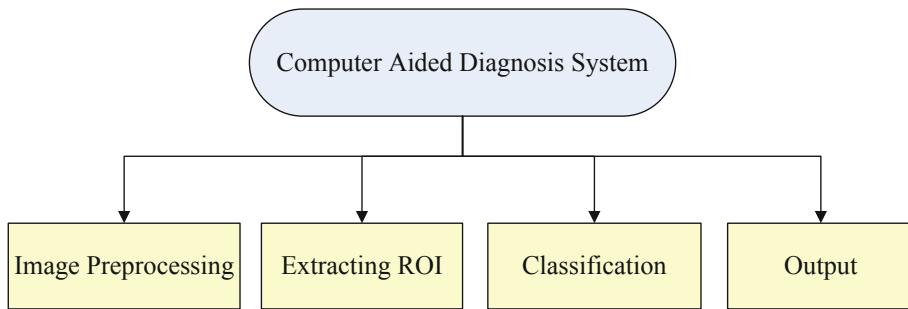
### 2.1 Multimodal Medical Imaging

Medical image processing is the first step of analysis of tumor diseases, medical image segmentation is a complex in the field of medical imaging and image analysis and crucial step, its purpose is to normal tissue and tumor lesion detection in medical images, and distinguished from distinguish tumor area and on the performance and characteristics of pathological changes in the medical image analysis, to determine clinical diagnosis and treatment and prognosis of management to provide a more solid theoretical basis, and the doctor make an accurate diagnosis, treatment and curative effect analysis [7, 8] provide auxiliary function. Although with different pathological changes and different modal tumor image segmentation has been a lot of research work, because of medical image is different from natural visual image, its characteristic performance for the imaging of complex, lesions and changeful, specific segmentation accuracy are still are under the influence of the noise, gray is not equal, so multimodal medical image tumor automatic segmentation in medical field is still a complex task.

### 2.2 Computer Aided Diagnosis Technology

Computer-aided diagnosis technology is a technical method to perform intelligent processing and analysis of medical information images through computer algorithms, detect and/or classify pathological tissues, assist clinicians to improve the diagnostic accuracy and make correct clinical decisions [9]. Traditional image classification consists of two processes: feature extraction and feature classification. After using different algorithms to extract features, the classifier is used to classify them and the final result is obtained. CAD model has various forms, but the basic structure is divided into four steps. As shown in Fig. 1: first, image processing algorithm is used to

preprocess the image; Second, extract ROI features and quantify them. Third, ROI is classified according to pre-set thresholds; Fourth, output data image or value. The emergence of CAD technology stems from the increasing demand of clinicians for high-resolution imaging images. CAD technology can significantly reduce the pressure on clinicians to read films, shorten the diagnosis time, objectify and standardize the quantitative detection of lesions, improve the accuracy of disease diagnosis, and reduce the rate of missed diagnosis and misdiagnosis [10].



**Fig. 1.** The module of computer aided diagnosis system

Effective feature extraction is a complex feature engineering. For example, for morphological and texture features, a series of image processing, image segmentation to extract morphological features, image decomposition to calculate texture features, etc. The results of computer image segmentation often require manual intervention to improve the accuracy of contour segmentation through parameter adjustment, manual correction and scheme selection. Extracting useful features is also highly dependent on each intermediate result in the image processing steps, which usually requires repeated design and trial and error before a satisfactory intermediate result can be found. Among them, manual intervention leads to the disappearance of objectivity, and the cumulative deviation of intermediate results may eventually lead to the error of diagnosis.

### 3 Experiment

#### 3.1 The Data Source

- (1) Contrast-Enhanced Ultrasonography and Enhanced Magnetic Resonance Imaging  
In this study, 65 patients with breast lumps found in a hospital from June 2018 to December 2019 were selected, all of whom were female, aged between 25 and 78 (average age  $45.96 \pm 9.79$  years), and the lesions were all single lesions. The patient did not receive any surgical treatment before, such as endocrine, chemotherapy and other treatment measures. CEUS and dce-mri were performed within one week before surgery, and the patient was confirmed by pathology after surgery.

(2) Ultrasonic Light Scattering Imaging

From May 2018 to October 2019, 126 patients with breast masses in a certain hospital were admitted to general surgery and hospitalized for surgical treatment, all of which were single lesions, and all of which were diagnosed by preoperative breast ultrasound and ultrasonic DOT examination. All patients were female, aged 24–73 years, with an average age of  $(43.88 \pm 11.82)$  years. None of them received any treatment before surgery and all of them were confirmed by postoperative pathology.

(3) New Ultrasonic Technology and Other Imaging Methods

From June 2018 to July 2019, a total of 75 patients with breast disease diagnosed by pathology after surgery in a hospital were selected, all of whom were diagnosed by mammography, ultrasound and MRI before surgery. All patients were female, aged 28–86 years (mean  $41.21 \pm 12.01$  years), with a total of 75 lesions, all unilateral single lesions, all  $\leq 2$  cm.

### 3.2 Experimental Instruments and Methods

(1) Contrast-Enhanced Ultrasonography and Enhanced Magnetic Resonance Imaging

The model used by CEUS is GE Logiq E9 ultrasonic diagnostic instrument with 9 L probe and frequency of 7.0–10 MHz. Sono Vue was injected into the elbow intravenous mass of microbubble ultrasound contrast agent, and the measurement was about 4.8 ml. After that, 5 ml saline was injected to flush the tube. Doctors need to manually draw the contour curve of the lesion and define the scope of the lesion as ROI, and the early breast cancer diagnosis system will automatically generate graphs of time and intensity. DCE-MRI is selected GE Signa EXCI-TE1.5T superconducting MR instrument, using cross-sectional fat suppression sequence T1WI and T2WI sagittal fat suppression sequence scan, the elbow midline gadolinium injection intravenous paramagnetic contrast agent for acid methylamine (Gd-DTPA0.1 tendency/kg) in 2.0 ml/s intravenous injection.

(2) Ultrasonic Light Scattering Imaging

The instrument used for ultrasonic examination is Toshiba Aplio500, with the probe operating frequency of 7–10 MHz. The patient needs to adopt supine position posture, carry on scanning to mammary gland of many Angle, many cut face. Ultrasonic wave scattering imaging instrument selection is new arbor for technology co., LTD production of OPTIMUS II type ultrasonic light scattering imaging system, the system can combined ultrasonic and optical, and equipped with modular ultrasonic transducer and optical fiber integrated composite probe, the work frequency of the probe for 5–10 MHz. In addition, the instrument selected a threshold value of 140 mol/L for the maximum hemoglobin concentration, below which it was considered to be benign, and above which it was considered malignant.

(3) New Ultrasonic Technology and Other Imaging Methods

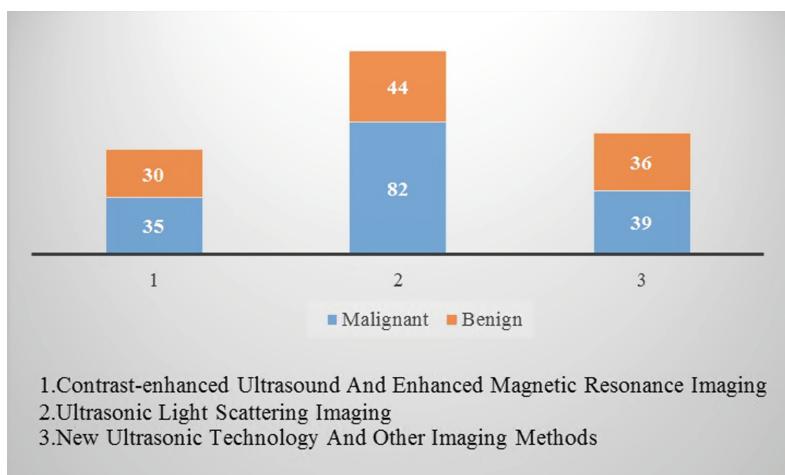
Ultrasonic light scattering imaging, elastography and ceus should be performed on the basis of conventional ultrasound. Conventional ultrasonic instruments were selected as Toshiba Aplio500 model from Japan and LogiqE9 color doppler, and

the working frequency of the probe was 7–10 hertz. Selection for new ordered for ultrasonic wave scattering imaging system technology co., LTD., production OPTIMUS - II type. Patients still need to remain supine, so that the patient's breast can be scanned in multiple sections and angles, after which the machine automatically gives the data and analyzes it to get the conclusion. By collecting the hemoglobin concentration and oxygen saturation and other optical parameters inside the mass, the breast mass was classified. The maximum hemoglobin threshold set by the instrument was also 140 mol/L.

## 4 Discuss

### 4.1 The Pathologic Result

For the application of ceus and enhanced magnetic resonance imaging, ultrasonic light scattering imaging, new and new ultrasonic technology and other influential methods in the diagnosis of early breast cancer, the pathological results after imaging diagnosis are shown in Fig. 2. The number of lesions was 65, 126, 75, 35, 82, 39 malignant lesions, 30, 44, 36 benign lesions. Malignant lesions mainly included ductal infiltrating carcinoma, lobular carcinoma in situ, intraductal carcinoma, ductal carcinoma with lobular carcinoma, mucinous carcinoma, neuroendocrine carcinoma, infiltrating ductal carcinoma with mucinous carcinoma, and local squamous cell carcinoma of non-specific infiltrating carcinoma. Benign lesions mainly include fibroadenoma, intraductal papilloma, adenopathy, hyperplasia nodules and inflammation.



**Fig. 2.** Pathological results of each imaging diagnosis

## 4.2 Comparison of Image Diagnostic Methods

The sensitivity, specificity, positive predictive value and negative predictive value of each image diagnosis are shown in Table 1. The sensitivity and negative predictive values of three diagnostic methods, DOT+UE+CEUS, MRI and USG+XRM+MRI, were all better than mammography, with statistically significant differences ( $P < 0.05$ ). The specificity of DOT+UE+CEUS was the highest, with statistically significant differences compared with mammography ( $P < 0.05$ ). Kappa consistency test was performed for all imaging diagnoses. The Kappa values of light scattering, elasticity, contrast-enhanced ultrasound, combined ultrasound, molybdenum, magnetic resonance and all combined imaging techniques were 0.678, 0.624, 0.705, 0.758, 0.439, 0.677 and 0.676, respectively. The consistency of combined ultrasound imaging (DOT+UE+CEUS) was better than that of other tests.

**Table 1.** Index table for each image diagnosis

Diagnostic Imaging	Sensitivity(%)	Specificity(%)	Positive Predictability(%)	Negative Prediction(%)
USG				
DOT	89.74	77.78	81.40	87.50
UE	87.18	75.00	79.07	84.38
CEUS	92.31	80.56	83.72	90.63
DOT+UE+CEUS	94.87*	82.56*	84.09	93.55*
XRM	74.36	69.44	72.50	71.43
MRI	94.87*	72.22	78.72	92.86*
USG+XRM+MRI	97.44*	69.44	77.55	96.15*

## 5 Conclusion

This research in view of the conventional ultrasonic BI-RADS3-4 or smaller early atypical breast lesions, further explore contrast-enhanced ultrasound, ultrasonic light scattering imaging study of such lesions diagnostic value and a variety of imaging diagnostic value of contrast research, the following conclusions: first, the qualitative and quantitative analysis of contrast-enhanced ultrasound, can better reflect the characteristics of the tumor blood perfusion, compared with dynamic enhanced magnetic resonance (NMR) has good consistency, the BI-RADS3-4 breast lesions the differential diagnosis of benign and malignant tumors have clinical application value. Secondly, ultrasonic DOT value higher than conventional ultrasound to the diagnosis of early breast cancer, the DOT of the most obvious advantage is that it can be more accurate quantitative biochemical information within the organization to reflect, as a kind of functional testing technology, can be a noninvasive, repeated evaluation of breast

lesions new blood vessels, and has important clinical value for early diagnosis of breast cancer. Finally, various imaging diagnosis technologies have their own advantages in the diagnosis of benign and malignant breast lesions. Combined diagnosis by ultrasound (Light Scattering Imaging + Elastography + CEUS) can improve the diagnosis rate of breast cancer, which can be regarded as one of the preferred methods for early clinical diagnosis of breast cancer. It is found that the computer-aided diagnosis of early breast cancer in multi-mode has achieved a better effect in clinical practice, which can more effectively identify the disease, achieve early detection and treatment as far as possible, and thereby improve the cure rate of breast cancer.

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# Machine Vision Based Macro Measurement System Detection

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**Abstract.** This paper uses machine vision to construct a system that can measure the irregular outer dimensions of small parts, and solves the problem of low efficiency and low precision of outer edge detection in the manufacturing process of small parts. Firstly, the image is subjected to the binarization of the intermediate threshold. Secondly, the Canny operator is used for edge detection. Then, through the morphological gradient processing and the contour picking algorithm, the edge contours are picked up, and the detection and measurement of the tiny irregular outer edges are realized. The measurement accuracy of the system meets the manufacturing requirements of the parts, and the measurement time is effectively shortened, and the wear of the parts directly by the contact of the parts is reduced.

**Keywords:** Machine vision · Image processing · Precision measurement

## 1 Introduction

Most of the mechanical parts of a brand are hand-polished, and the parts are very small in size, and the size is mostly within 10 mm. It is usually done using standard mold comparison measurements or manual measurements. Since most of the parts are irregular in size, manual measurement is usually not accurate enough, and direct contact of the measuring tool with the parts can cause wear on the surface of the part, which is not conducive to the manufacture of high-precision parts.

Based on the actual needs, this paper aims to solve the problem that the measurement of small parts is difficult, the precision is not high, and the direct contact measurement is easy to cause damage to the parts. Introducing machine vision into the measurement of scales on tiny irregular objects. First, use a high-magnification microscope head to align the parts to be measured, and use the video to capture the part shape information for a period of time. Then, each frame of the video stream generated by the part is subjected to image preprocessing such as gradation transformation, binarization and morphological gradient. Then use the Canny operator to perform edge detection on the image. For the edge detection image, the contour extraction algorithm of the binarized image is used to extract the edge contour of the part, and the basic parameters of the microscope head for image acquisition need to be calibrated to obtain the size information finally measured by the system. Finally, the measurement accuracy

of the system is calculated by measuring the dimensions and the actual dimensions of the parts measurement, and the feasibility of the system is evaluated (Fig. 1) [1–3].



**Fig. 1.** A brand of mechanical watch gasket parts

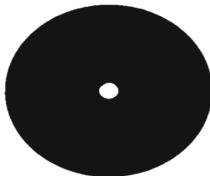
## 2 Image Preprocessing

In order to realize real-time measurement of the part to be tested, the error caused by the change of the relative position between the measuring lens and the device to be tested is reduced. The image information of the device to be tested is captured for a period of time by the camera, and the average value of the device to be tested is obtained by processing the image of the multi-frame.

The information on each frame of the image is distributed on the three color information channels of RGB. In order to speed up the image processing, the amount of unrelated color information on each frame of the image is reduced, and the grayscale processing of the image is first performed for each acquired image. The theoretical formula of gray processing [4, 5]:

$$Gray(i,j) = 0.299 * R(i,j) + 0.578 * G(i,j) + 0.144 * B(i,j) \quad (1)$$

In order to further reduce the amount of information on the picture, the object to be tested on the image is distinguished from the background, and the median binarization process is used to separate the object from the background (Fig. 2) [6].



**Fig. 2.** Image preprocessing results

$$\begin{cases} G(i,j) = 255 & (G(i,j) \geq threshold) \\ G(i,j) = 0 & (G(i,j) < threshold) \end{cases} \quad (2)$$

## 2.1 Edge Detection

Since the transmission and reception of images between systems is limited by hardware, there may be information loss or interference from random signals, which may generate noise in the image, so the image needs to be filtered. The canny edge detection operator used in this system includes a Gaussian smoothing filter to denoise the image convolution. Gaussian filtering uses a Gaussian function (a commonly used two-dimensional zero-mean discrete Gaussian function as a smoothing filter) [7, 8]:

$$G(x,y) = Ae^{\frac{-(x-u_x)^2}{2\sigma_x^2}} + \frac{-(y-u_y)^2}{2\sigma_y^2} \quad (3)$$

Generate a set of normalized Gaussian kernels:

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad (4)$$

$$G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \quad (5)$$

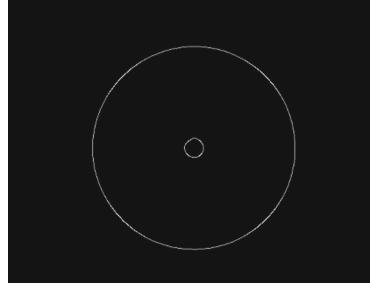
Convolve with the pixels in the x, y direction of the image and apply the formula:

$$G = \sqrt{G_x^2 + G_y^2} \quad (6)$$

$$\theta = \arctan\left(\frac{G_y}{G_x}\right) \quad (7)$$

Calculate the pixel gradient magnitude and direction in the x, y direction.

The gradient amplitude is used to determine the point where the intensity value adjacent to the gray point of the image changes significantly, and the edge feature is enhanced. Then, through the canny non-maximum value suppression algorithm, the point pixel value on the edge that is not the maximum value in the field is set to zero. Finally, the edges in the image are connected into a closed edge by a double threshold algorithm (Fig. 3).



**Fig. 3.** Canny edge detection results

## 2.2 Morphological Gradient Processing

In order to highlight the information of the edge contour, the image is subjected to morphological image processing. The most basic morphological operations are: expansion and corrosion, and the mathematical expressions are as follows:

$$A \oplus B = \{x, y | (B)_{xy} \cap A \neq \emptyset\} \quad (8)$$

$$A \ominus B = \{x, y | (B)_{xy} \subseteq A\} \quad (9)$$

Both algorithms take a convolution kernel and perform a convolution operation with the image. The former takes the maximum value of the region after the convolution operation, and the latter takes the minimum value. Morphological gradient processing is to etch and swell the image separately, and then subtract the etched image from the expanded image. Such an operation helps to highlight the outline of the image while ignoring other information inside the image. Further reduce the information on the image.

## 2.3 Contour Picking

In general research, after obtaining the edge information of the contour, the contour is fitted to the normalized figure by contour fitting, but the system is designed to be applied to the measurement of parts with irregular edge contours, and can not be used with regular graphics. Fit the edge contour. Therefore, the system adopts the contour picking algorithm, which is based on the idea of Satoshi Suzuki paper. The contour is recorded by coding, and the input binary image is detected, that is, the pixel values are only 0 and 1.  $f(i, j)$  is the pixel value of the point on the image, if any [9]:

$$f(i, j - 1) = 0, f(i, j) = 1 \quad (10)$$

$$f(i, j) \geq 0, f(i, j + 1) = 0 \quad (11)$$

It means that the boundary is detected, (10) represents the detection of the outer boundary, and (11) represents the detection of the boundary of the hole. A unique

boundary identifier is assigned to the new boundary each time a new boundary is detected, and the identifier is incremented by one. In this way, the boundaries of the various levels are marked, and the outermost contour of the part to be tested can be detected by the algorithm, and the contour number of each part of the part can be extracted to the edge of the contour required for the measurement (Fig. 4).



**Fig. 4.** Outline extraction results on the original image

### 3 Machine Vision Acquisition System

The hardware part of the system consists of a CMOS camera, a uniform backlight, a workbench and a notebook computer. The image is used to measure the size of the part, because image processing of the captured image of the part is required. There are clear requirements for the imaged image. The material to be tested is made of metal, and the detection of the edge by the reflective part will cause serious interference, and it is necessary to eliminate the reflection of the metal. After many experiments, it was found that the test object was placed on a uniform backlight, and the brightness of the light was adjusted to make the image have strong contrast, the foreground background was clear, and the generated image was better after image processing. The camera used is a color CMOS camera with an image resolution of 1280 (H) \* 1024 (V) [10].

#### 3.1 Camera Calibration

After the image is acquired, the vision system needs to be calibrated. The system uses the contrast calibration method. The lens uses a zoom microscope head. When measuring different parts, different magnification factors are selected. Using the method of comparison calibration, the size of the device to be tested can still be accurately measured without knowing the lens parameters in advance, and it is also simpler and more convenient. First select a precision micron-sized small steel ball as the calibration object, and determine the lens parameters [11]:

$$p_x = \frac{L}{l} \quad (12)$$

In the above formula,  $p_x$  is the number of pixels per unit length (number of pixels/mm);  $L$  is the number of pixels of the edge contour of the image;  $l$  is the actual length (mm) of the edge contour of the calibration object,  $p_x = 42.232$  pixels/mm.

### 3.2 Focus Position Adjustment

In a general machine vision measurement system, usually the length of the workpiece to be measured is not perpendicular to the length of the lens. The size of the measuring part of the system is too small, and a larger lens magnification factor is selected. The height of the vertical lens of different parts is different. Making the lens focus position is different, which will make the image partially blurred, which will affect the measurement accuracy. When measuring, the magnification of the fixed lens does not change, and the focus is adjusted to the place where the object to be tested and the calibration need to be measured. This reduces the influence of the inconsistency of the camera's in-focus position on the measurement accuracy.

The parts tested in the above experiment were measured by a conventional tool to have a diameter  $D = 7.53$  mm. The dimensional data of the part measured by the system multiple times is as follows. The experimental data measured by the system is compared with the measured results of the traditional measuring tools, and the measured data of the system is compared (Table 1).

**Table 1.** Test piece data measured by the system

Parameter	Number of experiments						
	1	2	3	4	5	6	7
Measurements/mm	7.523	7.536	7.527	7.525	7.520	7.536	7.523
Deviation/mm	-0.007	+0.006	-0.003	-0.005	-0.01	+0.006	-0.007
Relative error/%	-0.093	+0.080	-0.040	-0.066	-0.133	+0.080	-0.093
Measure time/s	9.866	9.012	10.547	9.723	10.893	8.954	9.479

The measurement error of the system is within  $\pm 0.15\%$ , the diameter deviation is within  $\pm 0.01$  mm, and the deviation is close to the pixel level. However, the time used is approximately 10 s, and the measurement takes a long time. It is because after many measurements, the time should not be too short. Wait for the brightness of the lens to stabilize, and the brightness of the light source will not change. At this time, the measured part accuracy is high. Through the analysis of the above table, the deviation of the accuracy of the measurement of the system and the accuracy of the measurement of the conventional tool under the same conditions has little effect on the manufacture of the part and can be ignored.

At the same time, some important part structures are not suitable for direct measurement, as shown in Fig. 5 is the gear shaft parts in the clock system. It can be seen that the traditional measuring tool cannot accurately measure the outer contour size when measuring the part. However, the size of the part is still measured with high

precision by the system. Figure 5 is the case where the system detects the contour of the gear shaft edge.

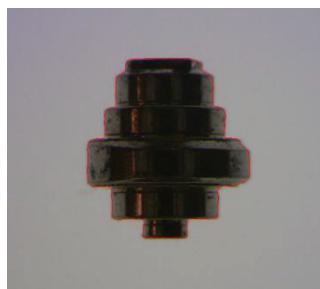


Fig. 5. Outline extraction results on the gear shaft

## 4 Conclusions

The machine vision-based macro measurement system described in this paper achieves high-precision measurement of small parts under the premise of improving part measurement accuracy and efficiency. The diameter error of the system is within 0.01 mm, which achieves the accuracy level of traditional tool measurement. However, from the point of view of the measurement method, the system greatly simplifies the measurement method of the parts. At the same time, the non-contact measurement method adopted by the system is beneficial to reduce the wear of the parts during the measurement process. The systematic error of the system will be further eliminated in subsequent work to increase the measurement accuracy level of the system. In addition, the system can be extended to simultaneously detect the microscopic damage of the part, and the overall information of the part can be extracted.

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# Genetic Algorithm of the Mutual Selection Between Teachers and Students in Online Learning

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**Abstract.** With the development of education, computer application has penetrated into all aspects of people's life. Computer makes the complicated data management work easy and efficient. In addition to the major, the current university courses are studied by students' self selected subjects. This system can meet the choice wishes of teachers and students as much as possible, accelerate the speed of selection and matching, and change the shortcomings of the previous manual course arrangement. In this paper, when we study the system of teachers and students' mutual selection, we focus on building a mathematical model of teachers and students' mutual selection, combining with the theory of genetic algorithm, to explore a suitable algorithm to solve the problem of automatic combination and collocation in the process of teachers and students' mutual selection. At the same time, we use MATLAB software to generate a system of teachers and students' two-way selection based on genetic algorithm.

**Keywords:** Genetic algorithm · Penalty function · Fitness function · Constrained optimization problem

## 1 Characteristics of Genetic Algorithm

Genetic algorithm is a general algorithm to solve the search problem, which can be used for all kinds of general problems. The common characteristics of the search algorithm are: (1) forming a group of candidate solutions first; (2) calculating the fitness of these candidate solutions according to some adaptability conditions; (3) reserving some candidate solutions according to the fitness and giving up other candidate solutions; (4) performing some operations on the reserved candidate solutions to generate new candidate solutions. In genetic algorithm, the above features are combined in a special way: parallel search based on chromosome group, selection operation, exchange operation and mutation operation with guessing property [1]. This special combination method distinguishes genetic algorithm from other search algorithms.

## 2 Coding of Mutual Selection Between Teachers and Students

### 2.1 Coding Principles

According to the pattern theorem, de Jong put forward a more objective and clear coding rule

- (1) Meaningful block coding rules: the block coding should be easy to generate short and low-order blocks related to the problem.
- (2) Minimum character set coding rule: the minimum character set is adopted in the coding to make the problem get a natural representation or description.

Rule (1) is based on pattern theorem and block hypothesis, and rule (2) provides a more practical coding principle [2].

### 2.2 Coding Method

The symbol coding method is adopt, which means that the gene value in the individual chromosome coding string is taken from a symbol set with no numerical meaning but only code meaning.

U: [student 1 teacher 4, student 2 teacher 3, student 3 teacher 6, student 149 teacher 4, student 150 teacher 55, student 151 teacher 77].

## 3 The Setting of the Fitness Function

The concept of fitness is used to measure the degree that each combination scheme in the combination group can reach or approach to the optimal combination in the optimization calculation. The combination with higher fitness has a higher probability of inheriting to the next generation, while the combination with lower fitness has a lower probability of inheriting to the next generation [3]. The function to measure the fitness of a composite scheme is called the fitness function.

### 3.1 Evaluate the Fitness of Each Combination

The general process to evaluate the fitness of each combination is:

- (1) Get the plan of each group of teachers and students choosing and combining each other.
- (2) The objective function value of each combination scheme can be calculated from the combination scheme group.
- (3) According to the types of optimization problems, the fitness of each group of schemes can be calculated according to certain conversion rules.

The fitness of each group of schemes:  $F(x_i)$  of each combination scheme is calculated by the individual's unprocessed fitness  $f(x_i)$  relative to the fitness of the whole combination population, i.e.

$$F(x_i) = \frac{f(x_i)}{\sum_{i=1}^{N_{ind}} f(x_i)} \quad (1)$$

Where,  $N_{ind}$  is the population size,  $x_i$  is the performance value of individual i.

### 3.2 The Function of Fitness Function

The following two cheating problems will appear in the selection operation of genetic algorithm

- (1) In the early stage of genetic evolution, there are often some unusual combination schemes. If the proportion selection method is used, these unusual combination schemes will control the selection process because of their outstanding competitiveness, which will affect the global optimization performance of the algorithm [4].
- (2) In the later stage of genetic evolution, when the algorithm is close to convergence, due to the small difference of fitness of each combination scheme of the combination population, the potential of continuous optimization is reduced, and a local optimal solution may be obtained. If the fitness function is not designed properly, these two problems may occur. So the design of fitness function is an important aspect of genetic algorithm design.

In order to prevent the generation of extreme combination scheme and premature convergence, we can limit the regeneration range. Our combination scheme here is to calculate the fitness according to their order in the combination group [4, 5]. A variable Max is often used to determine the offset or selection intensity. The fitness of the most suitable combination scheme and other combination schemes is obtained by the following formula:

$$\begin{aligned} \text{MIN} &= 2.0 - \text{MAX} \\ \text{INC} &= 2.0 * (\text{MAX} - 1.0) / N_{ind} \\ \text{LOW} &= \text{INC} / 2.0 \end{aligned} \quad (2)$$

Here, MIN is the lower bound, INC is the difference of fitness between adjacent combinations, LOW is the expected experimental value of the minimum fitness combination, and Max is the typical selected value in the interval [1.1, 2.0]. The fitness of collocation scheme in the population of teacher-student interaction can be calculated directly:

$$F(x_i) = 2 - \text{MAX} + 2(\text{MAX} - 1) \frac{x_i - 1}{N_{ind} - 1} \quad (3)$$

In formula (3),  $x_i$  is the position of teacher-student combination i in the ordered combination population.

## 4 General Operation

### 4.1 Selection Operation of Teachers and Students

(a) Population of Initial Teacher-Student Interaction

$U_1 = [\text{student 1 teacher 22, student 12 teacher 35, student 63 teacher 78, student 77 teacher 24, student 68 teacher 22, student 79 teacher 14, student 30 teacher 33, student 21 teacher 101, student 82 teacher 3}]$

$U_2 = [\text{student 24 teacher 36, student 2 Teacher 39, student 76 teacher 82, student 77 teacher 15, student 26 teacher 88, student 35 teacher 99, student 80 teacher 27, student 68 teacher 53, student 63 teacher 9}]$

$U_3 = [\text{student 17 teacher 74, student 63 teacher 21, student 23 teacher 25, student 37 teacher 66, student 78 teacher 99, student 8 teacher 21, student 80 teacher 68, student 35 teacher 73, student 66 teacher 57}]$

$U_4 = [\text{student 31 teacher 57, student 28 teacher 13, student 34 teacher 85, student 46 teacher 28, student 67 teacher 46, student 29 teacher 28, student 69 teacher 25, student 21 teacher 99, student 58 teacher 1}]$

$U_5 = [\text{student 14 teacher 85, student 52 teacher 36, student 73 teacher 25, student 82 teacher 63, student 79 teacher 26, student 19 teacher 99, student 32 teacher 15, student 66 teacher 35, student 82 teacher 78}]$

$U_6 = [\text{student 71 teacher 72, student 52 teacher 39, student 32 teacher 21, student 56 teacher 77, student 32 teacher 94, student 79 teacher 91, student 80 teacher 25, student 81 teacher 35, student 82 teacher 79}]$

(b) Calculate the Fitness Value of  $U_k$

Selection is used to determine the recombination scheme or cross group scheme, and how many sub generation schemes will be generated by the selected scheme, and calculate the fitness value  $\text{Eval}(U_k)$  of each scheme  $U_k$ :

$$\text{eval}(U_k) = f(x_k), k = 1, 2 \dots \quad (4)$$

Calculated according to formula (4):  $\text{eval}(U_1) = 34.5674$ ,  $\text{eval}(U_2) = 31.3852$ ,  $\text{eval}(U_3) = 29.5621$ ,  $\text{eval}(U_4) = 33.1873$ ,  $\text{eval}(U_5) = 35.8762$ ,  $\text{eval}(U_6) = 28.8743$

(c) Calculate the Sum of Group Fitness Values of Combined Schemes

$$F = \sum_{k=1}^{\text{pop-size}} \text{eval}(u_k) = 193.4525 \quad (5)$$

(d) Calculate the Selection Probability of Each Combination

$$p_k = \frac{\text{eval}(u_k)}{F} \quad (6)$$

Calculated according to formula (6):

$$P_1 = 0.178687, P_2 = 0.162237, P_3 = 0.152813, P_4 = 0.171553, P_5 = 0.185452, P_6 = 0.159258$$

(e) Calculate the Cumulative Probability of Each Combination

$$Q_k = \sum_{j=1}^k P_j, j = 1, 2 \dots \quad (7)$$

(f) Creating New Groups of Teachers and Students

In the calculation and operation of the system, a random number  $r$  between  $[0, 1]$  is generated. If  $r \leq Q_1$ ,  $U_1$  is selected; otherwise, the  $k$ -th combination scheme  $U_k (2 \leq k \leq pop - size)$  is selected to make:  $Q_{k-1} < r \leq Q_k$ .

Now suppose we choose a group of schemes in a new combination population at a time. Suppose we generate six random numbers between  $[0, 1]$  as follows:

0.332146 0.187329 0.739281 0.925621 0.932563 0.543263

The first random number  $R_1 = 0.332146$  is greater than  $Q_1$  and less than  $Q_2$ , so the combination scheme  $U_2$  is selected; the second random number  $R_2 = 0.187329$  is greater than  $Q_1$  and less than  $Q_2$ , so the combination scheme  $U_2$  is selected again. Finally, the new combination population consists of the following combination schemes:

$U_1 = [\text{student 24 teacher 36, student 2 Teacher 39, student 76 teacher 82, student 77 teacher 15, student 26 teacher 88, student 35 teacher 99, student 80 teacher 27, student 68 teacher 53, student 63 teacher 9}]$

$U_2 = [\text{student 24 teacher 36, student 2 Teacher 39, student 76 teacher 82, student 77 teacher 15, student 26 teacher 88, student 35 teacher 99, student 80 teacher 27, student 68 teacher 53, student 63 teacher 9}]$

$U_3 = [\text{student 14 teacher 85, student 52 teacher 36, student 73 teacher 25, student 82 teacher 63, student 79 teacher 26, student 19 teacher 99, student 32 teacher 15, student 66 teacher 35, student 82 teacher 78}]$

$U_4 = [\text{student 71 teacher 72, student 52 teacher 39, student 32 teacher 21, student 56 teacher 77, student 32 teacher 94, student 79 teacher 91, student 80 teacher 25, student 81 teacher 35, student 82 teacher 79}]$

$U_5 = [\text{student 71 teacher 72, student 52 teacher 39, student 32 teacher 21, student 56 teacher 77, student 32 teacher 94, student 79 teacher 91, student 80 teacher 25, student 81 teacher 35, student 82 teacher 79}]$

$U_6 = [\text{student 31 teacher 57, student 28 teacher 13, student 34 teacher 85, student 46 teacher 28, student 67 teacher 46, student 29 teacher 28, student 69 teacher 25, student 21 teacher 99, student 58 teacher 1}]$

## 4.2 Crossover Operation of Mutual Selection Between Teachers and Students

### (a) Randomly Select a Set of Crossing Objects

Crossover is the combination of information from the parent mating population to produce a new combination scheme [6]. I use single point crossover operation to randomly select a node of combination scheme, and then exchange the right end of two combination nodes to produce.

Suppose that the schemes of the two combinations are as follows (the nodes are randomly selected in the 78th group of the combination of teachers and students):

$U_1 = [\text{student 1 teacher 22, student 12 teacher 35, student 63 teacher 78, student 77 teacher 24, student 68 teacher 22, student 79 teacher 14, student 30 teacher 33, student 21 teacher 101, student 82 teacher 3}]$

$U_2 = [\text{student 24 teacher 36, student 2 Teacher 39, student 76 teacher 82, student 77 teacher 15, student 26 teacher 88, student 35 teacher 99, student 80 teacher 27, student 68 teacher 53, student 63 teacher 9}]$

### (b) Define Crossover Probability

Assuming that the probability of crossing is  $P_0 = 25\%$ , that is to say, 25% of teachers and students have crossed in the average level. The cross process is as follows:

```

start
  K ← 0;
  Continue at k ≤ 10
    rk ← [ 0, 1] Random number between [ 0, 1];
    If rk < 0.25, then
      Choose as a cross parent combination scheme;
    End
    K ← k+1;
  End
End

```

### (c) Combination Scheme After Crossover Generation

Suppose the random number is as follows

0.242155 0.342522 0.274232 0.032445 0.378654 0.654332

So, it means that the combination  $U_1$  and  $U_4$  are selected as the cross parent combination. Here, we randomly choose an integer between [1, 81] (because 82 is the number of pairs of the whole combination) as the intersection. Hypothesis: if the generated integer POS is 77, then the two parent combinations are divided from the first, and the new combination scheme is generated by exchanging the right part of the first pair, that is

$U_1 = [\text{student 24 teacher 36, student 2 Teacher 39, student 76 teacher 82, student 77 teacher 15, student 26 teacher 88, student 35 teacher 99, student 80 teacher 27, student 68 teacher 53, student 63 teacher 9}]$

$U_4 = [\text{student 71 teacher 72, student 52 teacher 39, student 32 teacher 21, student 56 teacher 77, student 32 teacher 94, student 79 teacher 91, student 80 teacher 25, student 81 teacher 35, student 82 teacher 79}]$

$U_1^* = [\text{student 24 teacher 36, student 2 Teacher 39, student 76 teacher 82, student 77 teacher 15, student 32 teacher 94, student 79 teacher 91, student 80 teacher 25, student 81 teacher 35, student 82 teacher 79}]$

$U_4^* = [\text{student 71 teacher 72, student 52 teacher 39, student 32 teacher 21, student 56 teacher 77, student 26 teacher 88, student 35 teacher 99, student 80 teacher 25, student 81 teacher 35, student 82 teacher 79}]$

### 4.3 The Operation of Variation in the Combination of Teachers and Students' Mutual Selection

#### (a) Selection mutation operator

Using the basic bit mutation operator, suppose that the third gene of combination scheme  $U_1$  is selected as mutation, that is, if the teacher-student collocation is student 76 teacher 82, the teacher-student collocation can be student 82 teacher 76, then the combination will be:

$U_1 = [\text{student 24 teacher 36, student 2 Teacher 39, student 76 teacher 82, student 77 teacher 15, student 26 teacher 88, student 35 teacher 99, student 80 teacher 27, student 68 teacher 53, student 63 teacher 9}]$

$U_1^* = [\text{student 24 teacher 36, student 2 Teacher 39, student 82 teacher 76, student 77 teacher 15, student 26 teacher 88, student 35 teacher 99, student 80 teacher 27, student 68 teacher 53, student 63 teacher 9}]$

#### (b) Define mutation probability

The mutation probability is set to  $p_m = 0.01$ , that is to say, it is expected that 1% of all genes in the population of the combination scheme will be mutated at the average level. In this case, there are  $82 * 6 = 492$  genes in total. We hope there are 4.92 genes in each generation [7, 8]. The probability of each gene mutation is equal. Therefore, we want to generate a series of random numbers  $r_k (k = 1, 2, \dots, 492)$  between [0, 1]. Assume that the genes listed in the Table 1 will mutate.

**Table 1.** Example of gene variation

Collocation position	Combined position	Number of pairs in this group	Random
3	1	3	0.009543
83	2	1	0.008732
320	4	78	0.002342
491	6	81	0.003422

#### (c) Population of teachers and students combination after generating variation

After the mutation, the final population of the next generation combination scheme is obtained:

$U_1^* = [\text{student 24 teacher 36, student 2 Teacher 39, student 82 teacher 76, student 77 teacher 15, student 26 teacher 88, student 35 teacher 99, student 80 teacher 27, student 68 teacher 53, student 63 teacher 9}]$

$U_2^* = [\text{student 36 teacher 24, student 2 Teacher 39, student 76 teacher 82, student 77 teacher 15, student 26 teacher 88, student 35 teacher 99, student 80 teacher 27, student 68 teacher 53, student 63 teacher 9}]$

$U_3^* = [\text{student 14 teacher 85, student 52 teacher 36, student 73 teacher 25, student 82 teacher 63, student 79 teacher 26, student 19 teacher 99, student 32 teacher 15, student 66 teacher 35, student 82 teacher 78}]$

$U_4^* = [\text{student 71 teacher 72, student 52 teacher 39, student 32 teacher 21, student 56 teacher 77, student 32 teacher 94, student 91 teacher 79, student 80 teacher 25, student 81 teacher 35, student 82 teacher 79}]$

$U_5^* = [\text{student 71 teacher 72, student 52 teacher 39, student 32 teacher 21, student 56 teacher 77, student 32 teacher 94, student 79 teacher 91, student 80 teacher 25, student 35 teacher 81, student 82 teacher 79}]$

$U_6^* = [\text{student 31 teacher 57, student 28 teacher 13, student 34 teacher 85, student 46 teacher 28, student 67 teacher 46, student 29 teacher 28, student 69 teacher 25, student 21 teacher 99, student 58 teacher 1}]$

The corresponding fitness value is:

$F1 = 38.3321, F2 = 34.2352, F3 = 29.3214, F4 = 35.3918, F5 = 32.1456, F6 = 28.9041$

So far, the first generation of genetic algorithm has been completed.

## 5 Conclusions

This design uses the global optimization and fast convergence characteristics of genetic algorithm, combined with the advantages of random selection method and fitness sorting method, to design an algorithm for the combination of teachers and students, so that the success rate and speed of the combination of teachers and students have been significantly improved. According to different needs, genetic algebra can be set up for 100 and 150 generations. The combination results will be different, but also depends on the crossover and mutation operators, and the combination close to the optimal may be generated in the process of inheritance [9, 10]. In order to make the combination of teachers and students to achieve a relatively more satisfactory scheme and further improve the convergence rate, further research is needed.

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# Data Mining Method of Logistics Economy Based on Neural Network Algorithm

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**Abstract.** With the development of the trade and logistics industry, the calculation and analysis of big data in this industry has become a hotspot. In the field of engineering applications, the corresponding theoretical models and algorithm research results are urgently needed. This paper combines the actual cold chain logistics research project to carry out research from three aspects of storage, calculation and analysis of logistics big data. The theoretical model and key technologies are studied for logistics big data storage performance optimization and data security issues. On the basis of data storage, an effective theoretical model, strategy and key algorithms are proposed for logistics distribution calculation and shared transportation. In order to further improve the application value of logistics data analysis algorithms, distributed parallel algorithms are implemented on the basis of the original algorithms.

**Keywords:** Data mining · Neural network algorithm · Logistics economy

## 1 Introduction

Classification algorithms are an important part of various data mining applications. There are many types of classification algorithms. The characteristics of different classification algorithms are different. We know that there is no problem that can solve all classification problems. The algorithm we need to find different classification algorithms to solve different classification problems. When applying the same classification problem, there may be many different classification algorithms, so we still need to discuss the characteristics of the data set and to discuss which of several different algorithms, where classification algorithm works.

Therefore, in-depth study of multiple classification algorithms on different data sets, and compared with a wide range of application prospects. Through our research, it can be applied in practical applications. In general, research on data mining classification algorithms based on neural networks has been concentrated in recent years. First, to study the advantages and disadvantages of various classification algorithms, we need to use the superior algorithm to apply it to some kind of actual in the case. Secondly, in order to improve a certain classification algorithm and analyze the improved results, the improvement of the law has a narrow scope and is mainly concentrated on small data sets. However, for several different real numbers, it is rare to use some classification algorithms to conduct comparative research. In order to make up for this deficiency, this paper introduces the network structure of three artificial neural network algorithms in detail for the classification problem in practical applications.

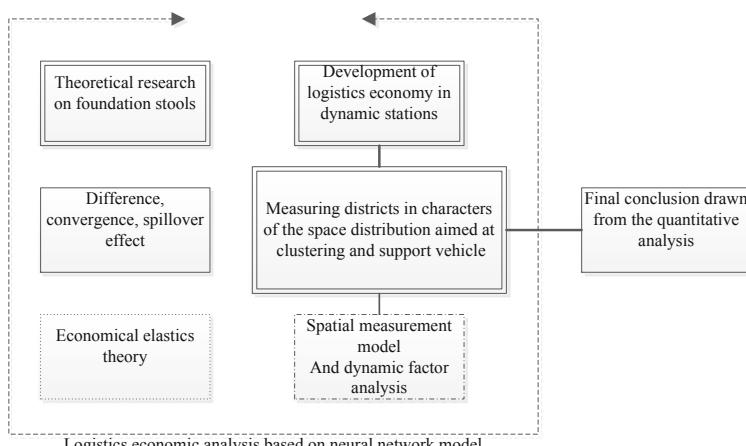
## 2 Distribution Recommendation Model and Algorithm for Massive Logistics Data

### 2.1 Determine the Framework of the Neural Network Algorithm

The logistics distribution business is a logistics activity that ships, sorts, distributes and transports designated locations from warehouses according to user requirements. This topic is based on the research of the largest fourth-party logistics platform in worldwide level [1]. The logistics information platform not only brings together a large number of third-party logistics and distribution companies, but also attracts a large number of customers and logistics distribution service providers [2].

Due to the large number of third-party logistics distribution services, a large number of customers are lacking in many distribution services, and the “information overload” problem is highlighted in the platform [3]. This chapter focuses on the logistics distribution recommendation model and distributed parallel algorithm implementation.

The distribution recommendation algorithm based on logistics big data has the following differences from the traditional recommendation algorithm [4]. The logistics operation big data environment is complex, and the real-time data generation speed is fast. In the big data recommendation scenario, the high-dimensional data is obviously sparse. When multi-source data streams are merged, unstructured and semi-structured streaming data becomes the mainstream data type. Therefore, the proportion of structures in the big data of the logistics industry is very complicated, which leads to more serious problems of noise data and redundant data. In order to solve the above problems and to do research on the recommendation algorithm for logistics distribution services [5], it is necessary to study the logistics distribution recommendation algorithm suitable for distributed parallel processing to improve logistics distribution due to the accumulation of big data in the logistics industry (Fig. 1).



**Fig. 1.** Regional and time fixed effect space lag model maximum likelihood estimation

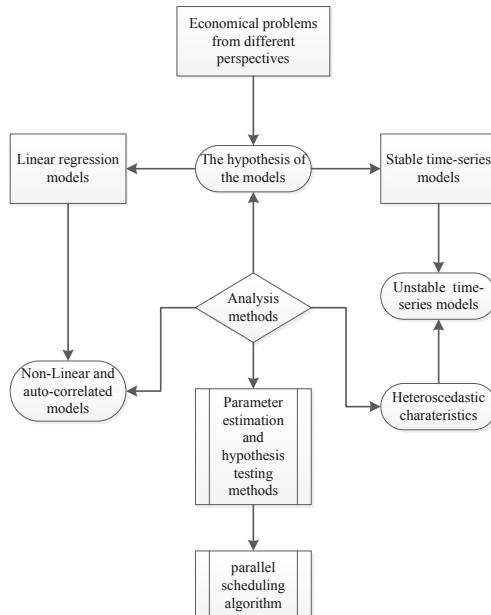
## 2.2 Convergence Analysis of Logistics Economic Development Level

It is rational to recommend the application value of the algorithm to improve the user experience in the logistics industry, and ultimately to improve the resource utilization of big data in the logistics industry, bringing economic benefits to the operation and management of the enterprise. The operation of the trade logistics information platform will inevitably generate massive transaction data, user service data and logistics production and transportation data. Since the logistics distribution recommendation service is based on large-scale data calculation, the core recommendation algorithm is used to quickly select the distribution service plan suitable for the user.

This chapter studies logistics service recommendation models and parallel distributed algorithms, and discusses big data related technologies for business logistics data analysis, including big data framework suitable for logistics data analysis, key data storage systems and big data computing frameworks such as Spark and Hadoop [6]. Through research, it is found that big data computing frameworks can provide big data analysis technology. However, because the recommendation algorithm involves a large number of iterative operations, the placement strategy of the intermediate data directly affects the performance of the parallel algorithm [7]. Therefore, the experiment shows that the Spark parallel processing algorithm is designed in order to meet the requirements of users for computing performance.

## 2.3 Full-Scale Capacity Sharing Parallel Scheduling Algorithm

Better parallel acceleration performance with a larger data set size in the research finds that various recommendation algorithms are sensitive to basic configuration parameters



**Fig. 2.** Structure chart of econometric model analysis

such as data nodes. Faced with the data scale of various application scenarios, it is necessary to continuously use experimental methods to determine configuration parameters. This is a drawback and is also a future research. The research results in this chapter can improve the efficiency of users' delivery of goods. The feedback information of customers can promote the service quality of distribution companies, in order to improve the brand effect of distribution enterprises, and accelerate the development of logistics enterprises. Structure chart of econometric model analysis is shown in Fig. 2.

### 3 Research on Logistics Shared Capacity Scheduling Algorithm Based on Trajectory Big Data

#### 3.1 Similar Trajectory Matching Algorithm Considering Timing

Based on the large data of mass cargo and transportation trajectory, this chapter studies the logistics cargo sharing transportation scheduling mode and related algorithms, aimed at solving the problem of each logistics enterprise sharing and transportation through the shared logistics information platform. The transportation model is designed with corresponding parallel processing algorithms, in order to meet the needs of real-time data processing. For the research of full-scale shared capacity scheduling mode and algorithm, a slack time constraint range is generated by scheduling time window [8].

Massive similar trajectory classification is implemented in scheduling time window, through which detailed GPU heterogeneous cluster parallel processing algorithm is designed. The simulation scheduling test shows that the algorithm has a better parallel acceleration ratio, and the acceleration ratio reaches the goal when the data size is large. In the simulation experiment of small and medium-sized cargo dataset, it is found that the loading rate of transportation vehicles can be effectively improved and the arrival time of goods can be optimized. For the incremental shared capacity scheduling mode, the real-time database of cargo parcels is established and the space-time index is optimized, during which time it effectively solves performance requirements for real-time scheduling [9].

The match generates a scheduling result and simulation experiments show that the incremental shared capacity scheduling can effectively improve the cargo loading rate during vehicle transportation. The parallel processing algorithm has better speedup and scalability.

The incremental scheduling mode is that the transportation vehicle space is not full and the pre-selected objects are searched from the partial cargo collection is combined to increase the loading space of the transportation vehicle. Algorithm 5.7 is based on the incremental shared capacity scheduling algorithm input: candidate distribution set  $CS = \{C_1, C_2, \dots, C_n\}$ , candidate transport vehicle set  $VS = \{V_1, V_2, \dots, V_k\}$ . The specific algorithm and the matching of the transportation capacity with the cargo are as follows (Tables 1 and 2).

**Table 1.** Comparisons between different sizes of the file searching quality

Scales of files	Without SSD mechanism		Within SSD mechanism	
	Mean reversion	Standard deviation	Mean reversion	Standard deviation
5000	2.382	0.173	2.457	0.158
100000	5.682	0.199	2.770	0.169
1000000	9.943	0.212	4.072	0.180

**Table 2.** Comparisons between encryption and non-encryption systems of the file storage quality

Scales of files	Encryption systems		Non-encryption systems	
	Mean reversion	Standard deviation	Mean reversion	Standard deviation
5000	3.657	1.506	2.356	0.106
100000	4.278	1.958	2.723	0.172
1000000	6.724	2.538	4.153	0.193

### 3.2 Increment-Based Shared Capacity Scheduling Algorithm

The traditional aerobics teaching keeps the teacher's teaching methods, requirements, demonstrations, and students' practice. The traditional teaching methods are relatively fixed, and the starting is slightly single. The main carrier of aerobics teaching content in network multimedia teaching is the network. Using online teaching, on the one hand, learners can share the aerobics teaching resources of different countries or log on to other educational websites to learn the information needed, enrich the teaching content, open up the horizons of learners, and on the other hand, enable learners to see the dynamic aerobics integration information, which is both graphic and audio-visual, has changed the inherent learning style of aerobics learners [10].

### 3.3 Transport Trajectory Measurement Method

Key issues such as algorithm performance analysis and parameter adjustment are deeply studied. The above research can be applied to data center construction and actual R&D applications of large and medium-sized logistics enterprises, achieving low-cost storage of logistics trajectory big data, video monitoring data, logistics distribution and shared transportation scheduling. The description of the algorithm, as well as the advantages and disadvantages of the three algorithms, focuses on the theoretical basis of the extreme learning machine [11]. The limited learning machine is applied to six real data sets to implement the classification application test, and the experimental results are consequences of the neural network which is compared and analyzed in three classification algorithms on different data sets.

Compared with the different characteristics of the results, the advantages and disadvantages of the three algorithms are mastered in the environmental conditions required for their operation. It is helpful for subsequent researchers to understand algorithms, to select algorithms and to improve algorithms.

## 4 Conclusion

The main work of the thesis is summarized as follows. In the multi-level hybrid storage system with SSD as the cache layer, the optimization scheme for improving data access performance is studied. After analyzing the data access rules of cold chain logistics, the data heat state is quantified, and the nonlinear relationship between data access characteristics and data heat is explored. The thermal data prediction model is established by wavelet neural network. Data migration is performed through the hot data prediction model, and frequently read data is migrated to the SSD in the hybrid storage. The cold data is saved to the mechanical hard disk with a certain compression and backup strategy and the data of the cold chain logistics production operation process is extended. The storage cycle provides basic data protection for enterprise decision management. The simulation results show that the thermal data prediction model has better prediction accuracy and robustness.

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# Application of Multimedia Computer Aided Techniques in Football Teaching and Training

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**Abstract.** With the continuous education reformation, computer multimedia technology, as a modern teaching and training method, is playing an increasingly important role in the teaching and training process. Multimedia teaching and training is a teaching and training method that uses multimedia courseware, including text, image, sound, animation and other means to arouse students' interest in many aspects. The use of multimedia electronic information technology for football course teaching and training can well integrate theoretical knowledge and technical practice. Its interactivity can allow teachers to guide students' directions according to teaching content, improve teaching quality and efficiency. It can solve the problem of disconnecting theoretical knowledge from practice. In the research process of this article, comparative experimental method, mathematical statistics method and logical analysis method are used to study the models and processes of multimedia-assisted football teaching using 40 students with different majors.

**Keywords:** Intelligent computer · Assisted instruction system · Football teaching

## 1 Introduction

With the quality and efficiency of football teaching rapidly improved [1], the management will become more comprehensive and complete. For football course teaching and training, it is one of the key components of physical education teaching and training. Football course teaching and training can enhance students' basic professional knowledge, exercise their sports skills and teamwork, which can help students to deepen the understanding of the theoretical knowledge of action essentials [2, 3]. It can also improve teaching quality and teaching efficiency, and lay a solid foundation for students' future growth. If the teaching of football courses is divided into two categories, they can be divided into two parts: theoretical knowledge and sports skills exercises [4]. Both are closely related to teaching and exercises, interacting and affecting each other. For the teaching and training of football courses, the focus is on the study of action skills. Therefore, the theoretical knowledge and sports skills are demonstrated using a specific teaching mode, which can allow students to watch more intuitively [5]. The use of multimedia electronic information technology for football course teaching and training can well integrate theoretical knowledge and technical practice. Its interactivity can allow teachers to guide students' directions according to

teaching content, improve teaching quality and efficiency. It can solve the problem of disconnecting theoretical knowledge from practice [6].

Nowadays, due to the continuous shortening of teaching and practice time and the limitation of external environmental conditions, the teaching and training of football courses have been greatly affected in terms of knowledge content and intuitiveness. If the teaching mode and practice method of the conventional mode are still used, it is extremely difficult to deal with the existing problems. According to the characteristics of football course teaching and training, the courseware design process mainly includes three aspects: teaching content, training content, detection and help content [7]. As for the teaching and training content, it is mainly applied in the course explanation and practice. The test content is mainly to test the student's ability to facilitate teachers to understand students' weak points. The detection content mainly includes three types of tests: comprehensive detection, single detection, and single motion detection. The detection content is mainly to facilitate students to use the courseware to ask questions to teachers and complete the interaction between teachers. In teaching and training content, it is mainly based on the theoretical knowledge of football courses, combined with a certain voice to explain. The main application of the layout is to play images, pictures, sounds [8, 9]. As far as football sports skills are concerned, the main contents include: passing sports skills, shooting sports skills, overhead ball sports skills, ball grabs, interception sports skills, shooting sports skills. Each sports skill is closely related to itself. For football tactics, the main contents include: offensive tactics, defensive tactics [10]. For the rules of the game, it mainly includes: court rules, referee duties, about rules, foul rules, free kick rules. Using multimedia courseware for football courses, teaching can stimulate students' enthusiasm for learning, encourage students to take an active part in teaching activities, understand the content of courses, and improve teaching quality and efficiency. When making multimedia teaching courseware, its content and scope need to focus on the action skills, essentials analysis, training methods, and corrective actions of human body parts. At the same time, corresponding exercises are arranged to allow students to consolidate the grasp of the content to lay a solid foundation for students' future learning and growth.

## 2 Multimedia Technology Teaching

### 2.1 Preparation Method of Multimedia Technology Courseware

The equipment used for the preparation of courseware using multimedia technology mainly includes the following: recording equipment, scanning equipment, electronic computer, corresponding software, sound card and capture license. The methods used to prepare multimedia courseware using multimedia technology include the following: video processing technology, second, image processing technology, sound processing technology, word processing technology.

## 2.2 Preparation of Multimedia Technology Courseware

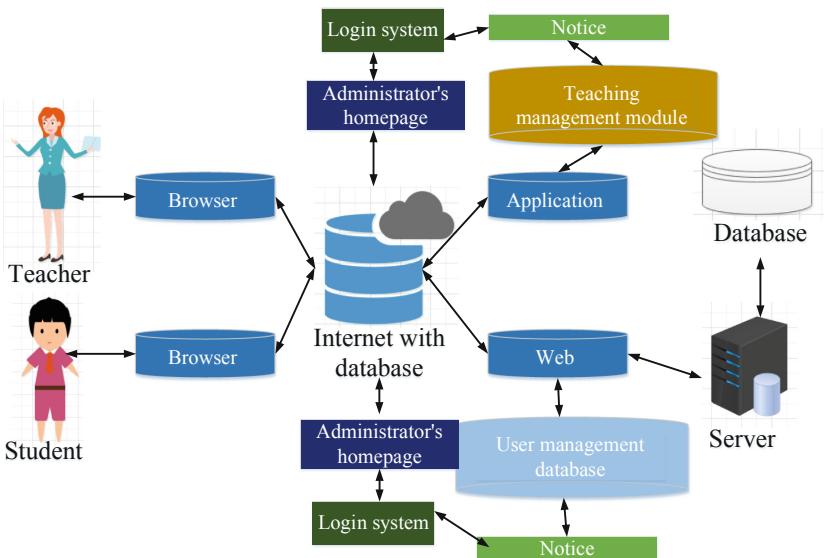
In order to prepare good multimedia courseware, the following conditions are required. First, faculty members need to have corresponding teaching experience. They have to master the basic course content, clarify the difficult points, key contents in teaching, and grasp the teaching progress. Second, faculty members need to understand certain electronic information technology, and can write simple multimedia teaching courseware and programs. Third, they have appropriate hardware for playing courseware. As shown in Fig. 1, the use of computer-assisted teaching systems in the process of physical education will stimulate teachers' initiative in teaching. Therefore, in computer-assisted teaching, physical education teachers can choose teaching through group collaboration. Therefore, in innovative teaching of physical education, teachers must take the initiative to understand the different needs of students in physical education. Comprehensive factors of students' comprehensive quality development are considered, and reasonable teaching courseware is developed from the current teaching situation to mobilize the enthusiasm and initiative of physical education teachers.

## 2.3 Problems of Multimedia Technology Courseware

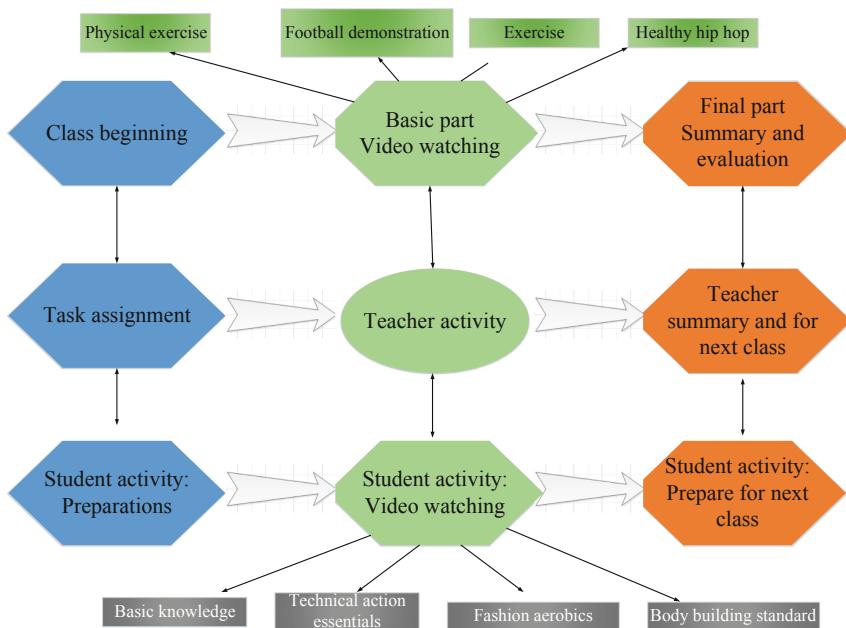
These problems cannot be solved well through conventional teaching and training methods and teaching and training aids. There are three types of tests: "Quiz" and "Single Action Quiz". The help module is mainly to help teachers and students use this courseware. The teaching and training modules are based on the basic techniques and theories of football, and are explained by relevant theories. The layout uses graphics, text, images, and sound effects, which is the central part of the entire software production.

## 2.4 Multimedia Teaching Process

As shown in Fig. 2, the multimedia-assisted football-teaching program is also divided into the preparation part, the basic part and the end part. However, the multimedia-assisted teaching method requires more preparation before the class. Teachers should not only read the syllabus carefully before class, but also look at many reform trends about football teaching, and the professional knowledge of multimedia technology. In the basic part, the teacher plays the prepared teaching video and organizes the students to watch collectively. Students watch videos and think while asking questions. After watching it, students imitate the exercises with my own understanding of the video, memory, and the accumulation of pre-class review. Teachers classify students into groups. After the students practiced, they organized the students to watch the video again, and compared the differences between their own movements and the movements of professional athletes. Compare with the poor movements, teachers ask the students to say what is wrong with their movements, and then propose ways to improve. Next, teachers give the students time to discuss what they have learned freely, as well as exchange and interaction between classmates and classmates, and learn from each other. At the end of the lesson, the teachers organize the students to conduct a summary evaluation. The students themselves told what they did well and what they did not do well in the lesson. At the same time, they asked the students to communicate their



**Fig. 1.** The schematic diagram of multimedia teaching to physical education theory teaching



**Fig. 2.** Multimedia aided teaching process

experiences with other students. Finally, the teacher arranges the new content of the next lesson and assigns homework. The teacher will provide corresponding guidance under the class according to the specific situation of the student, so that the student's problem can be solved in time.

### **3 Methods and Effects of Teaching and Training for Football Courses**

#### **3.1 The Method of Applying Multimedia Technology in the Teaching and Training of Football Courses**

Through the method of picture analysis, the students are required to understand the essentials of each movement in the dribbling process and explain the theoretical knowledge in the textbook. Then, the teacher uses the slow-motion function of multimedia to let the students just compare the contents one by one with the mastered content, and deeply memorize the relevant knowledge. Finally, the teacher divides the students into several groups to let the students discuss which situation can pass the ball and which situation needs to pass, to promote students' communication and exchange. In addition, teachers can also use multimedia games to motivate students to learn. For example, when a teacher explains the content of "Football Tactical Coordination", he can create a simulation football game for students to allow students to arrange and play games with each other, and simulate tactics to cooperate with related content, to mobilize students' enthusiasm for learning. It can promote students' interest in football learning, take the initiative to learn knowledge, improve teaching quality, and improve their own development. At the same time, students can also use multimedia courseware for self-study to broaden their horizons and insights. For example, the teacher can help students consolidate their knowledge after explaining the course and let students find some corresponding action cases in the spare time. If students have problems in watching the multimedia teaching courseware by themselves, they can consult with the teacher and leave a message for the teacher. Thus the teacher can better understand the student's ability, and help students to answer questions and help students improve their own development.

#### **3.2 Effects of Applying Multimedia Technology in the Teaching and Training of Football Courses**

The use of multimedia courseware for course teaching and training can be based on the syllabus standards, combining simulation exercises, theoretical knowledge, and effect detection in football teaching to make it more scientific, practical and interesting. Use multimedia courseware for teaching to integrate the text, graphics, sound, and video into a clearer and standard presentation of the course content. The teaching is more rigorous, the classroom environment is easier, and students' love of football is cultivated with a deeper grasp of relevant knowledge. The teaching quality and effect are better. Teaching with multimedia courseware can save teaching practice, complete the requirements of the syllabus on time, and give students more creativity and imagination. Using multimedia

courseware to carry out teaching activities during the teaching and training of sports football can obtain better results. The courseware has a certain demonstration role, and the actions are more standard and correct, helping students to create good technical habits.

### 3.3 Changes in Students' Motivation for Learning Football After Multimedia-Assisted Football Teaching and Traditional Teaching After the Experiment

As shown in Fig. 3, the questionnaire was re-issued to students after the teaching experiment. The survey statistics before the start of the teaching experiment are two pie charts with similar distribution patterns. The biggest change in the students in the experimental class after the teaching experiment is that the number of students who chose football because they love this course increased a lot, almost accounting for the total half of the number of students. The students, who would choose a football class because they want to learn a technology, also accounted for 27%. It is because the number of factors such as coping with exams, simple classes, no wind and sun, and herd choices correspondingly decreased, indicating that the number of people who love football is increasing, and multimedia-assisted football teaching has achieved certain results. The proportion of students in the control class who choose football for other reasons is not much different than before the teaching experiment. It is because the number of people who like this course and want to learn it only accounts for 49% of the total number, less than half of the total number. They should be based on the enthusiasm of the students during class, the degree of practice, and the time after class how much time is spent and the overall evaluation of the final test scores to assess the quality of a student in this course. To cultivate students' interest in football, we must start with teaching methods, teaching organizational forms, and grasp of the classroom atmosphere.

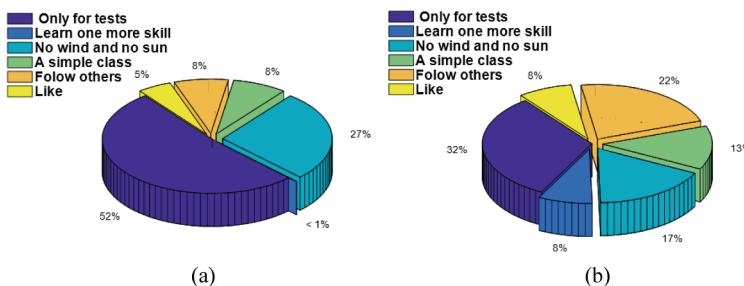


Fig. 3. Results of experiment group (a) and control group (b)

## 4 Conclusion

In school physical education, computer multimedia technology plays an important role. The majority of physical education teachers should update their concepts and clarify the relationship between multimedia teaching and traditional physical education. It

makes reasonable use of multimedia to stimulate students' thinking, and mobilize students' initiative to participate in exercises. However, multimedia-assisted teaching is only an aid tool. We must not only accept advanced multimedia teaching concepts, but also combine traditional physical education teaching methods to combine the two. As mentioned above, computer multimedia technology has not only changed the monotonous physical education teaching mode, but also provided diversified teaching methods. It has also improved the teaching ability of teachers, stimulated the initiative and enthusiasm of students, and laid a solid foundation for future physical education. The use of multimedia electronic information technology for football course teaching and training can well integrate theoretical knowledge and technical practice. The interactive nature allows teachers to guide students according to the teaching content, improve the quality and efficiency of teaching, and solve the problem of disconnected theoretical knowledge from practice. In the research process of this article, comparative experimental method, mathematical statistics method and logical analysis method are used to study the models and processes of multimedia-assisted football teaching for 40 students with different majors.

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# Investigation on Art Design Assistant Method Based on Artificial Intelligence

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**Abstract.** With the continuous development and maturity of artificial intelligence technology, a new round of technological and industrial change is rapidly emerging, profoundly affecting all aspects of human life, China is also rapidly entering the era of intelligence. In recent years, artificial intelligence has been widely applied in art design. Artificial intelligence technology has been extended to different types of art design fields. The main role of artificial intelligence in art design is assistant design. The purpose of this paper is to find out the shortcomings of artificial intelligence in the application of art design through the research on artificial-intelligence-based auxiliary methods of art design, so as to help realize the deep cross-border integration between artificial intelligence and art design. This paper first summarizes the concept and relationship between artificial intelligence and art design, and then briefly analyzes the role of auxiliary design. Then, the main problems of the current auxiliary methods are analyzed with the help of the intelligent algorithm. Finally, the improvement strategies of the auxiliary methods are proposed to solve these problems. The experiments in this paper show that the existing auxiliary design methods are general and have some problems, which hinder the deep crossover between artificial intelligence and artistic design.

**Keywords:** Artificial intelligence · Artistic design · Assistant design · Intelligent algorithm

## 1 Introduction

“Artificial intelligence” has attracted people’s attention since it was put forward, and the research on artificial intelligence by scholars at home and abroad has been gradually deepened. At present, artificial intelligence technology is gradually mature, and gradually applied to various fields, including the field of art design. The development in the field of art design makes “design artificial intelligence” gradually mature. As an important auxiliary method of art design, artificial intelligence not only extends the visual effect of design, but also promotes the transformation of art design ecology. However, there are many problems in the application of artificial intelligence in art design, which hinder the deep crossover between art design and artificial intelligence.

At present, domestic and foreign scholars have conducted a series of studies on artificial intelligence. In [1], the author sorts out the development history of artificial intelligence, and on this basis, gives an overview of the engineering practice of artificial

intelligence. In [2], the author discusses the prospect and realization of artificial intelligence, and puts forward some Suggestions for realizing artificial intelligence, which provides a good reference for the development of artificial intelligence. In [3], the author focuses on the technical research of artificial intelligence, and regarding the main problems existing in the current technology, the author believes that the biggest problem existing in the current artificial intelligence technology is the problem of artificial intelligence algorithm, as long as the algorithm technology is solved, the development of artificial intelligence will step into a new stage.

With the application scope of artificial intelligence expanding gradually, researchers begin to pay attention to the crossover fusion of artificial intelligence and a certain field. At present, many scholars have also carried out relevant research on the application of artificial intelligence in the field of art design. In [4], the author focuses on the application of ai in art design teaching. In [5], the author studies the auxiliary role of artificial intelligence in art design, and points out the important role of artificial intelligence in improving design quality and liberating human design. In [6], the author studies the application of artificial intelligence assistance methods in art design and the existing deficiencies.

In order to realize the deep integration of artificial intelligence and art design, this paper firstly summarizes the concept and mutual relationship between artificial intelligence and art design, and then briefly analyzes the role of auxiliary design. Then, the main problems existing in current auxiliary methods are analyzed with the help of intelligent algorithms, and finally, the improvement strategies of relevant auxiliary methods are proposed to address these problems [7, 8]. On the one hand, the research of this paper promotes the integration of art design and artificial intelligence, and realizes the efficient development of art design; On the other hand, it provides certain reference significance for future relevant researches [9].

## 2 Method

### 2.1 Artificial Intelligence and Artistic Design

Artificial intelligence is to use computer technology as the support, machine or platform as the media, with the help of relevant intelligent algorithms to simulate human activities. According to different views of artificial intelligence, artificial intelligence is roughly divided into two categories, namely weak artificial intelligence and strong artificial intelligence. The view of strong artificial intelligence is that artificial intelligence technology can completely reach the level of human brain; The viewpoint of weak artificial intelligence is that although artificial intelligence is similar to human brain, it cannot really reach the level of human brain due to its lack of independent self-awareness [11, 12]. In terms of the current technology level and the background of big data, weak artificial intelligence in art design is more in line with its needs. Artificial intelligence plays an important role in art design, which not only effectively improves the overall efficiency of art design, but also makes art design show a new form of expression. Most importantly, with the help of artificial intelligence, the aesthetic thinking of art will also undergo profound changes. Taking the intelligent design system of alibaba group as an example, it realized the automatic design and generation

of commodity posters according to the characteristics of different brands during singles' day, which not only greatly improved the design efficiency, but also took into account the personalized characteristics of design [13]. This case shows that the application of artificial intelligence in the field of art design has realized the full coverage of graphic design and three-dimensional design. In short, artificial intelligence plays a powerful auxiliary role in art design.

## 2.2 Intelligent Algorithm

Intelligent algorithm is a common algorithm in artificial intelligence program. In the art design of this paper, the intelligent algorithm can realize the comprehensive analysis of design requirements and auxiliary design methods. Let the number of features extracted from the analysis data of art design application of artificial intelligence be  $m$ , which together constitute an initial feature set  $F = \{f_1, f_2, \dots, f_M\}$ ,  $m$  stands for the number of original features. Here, some eigenvectors that have less impact on the analysis results are removed. If a feature is selected, then the eigenvalue is equal to 1; otherwise, the value is equal to 0. In general, the selected feature set is explained in binary form, that is,  $S = \{s_1, s_2, \dots, s_m\}$ ,  $s_i$  is equal to 1 or 0. The mathematical model formula for the application of artificial intelligence in the field of art design to analyze feature selection is as follows:

$$S = \{s_1, s_2, \dots, s_n\}, s_i \in \{0, 1\}, i = 1, 2, \dots, m \quad (1)$$

In this paper, support vector machine (SVM) is selected as a performance analysis algorithm for the application of artificial intelligence in the field of art design. The application performance analysis formula of artificial intelligence in the field of art design is as follows:

$$f(x) = \sum_{i=1}^n \alpha_i \gamma_i k(x_i, x) + b \quad (2)$$

In formula (2), threshold  $b$  will have a direct impact on the application performance analysis effect of artificial intelligence in the field of art design, so it must be optimized. It can be seen from the above two formulas that feature selection and optimization and algorithm parameter optimization targets can obtain high precision analysis results of the application performance of artificial intelligence in the field of art design.

## 3 Analysis and Experiment of Auxiliary Methods

In this paper, using literature method, case analysis method, interview method, three methods of existing art design experiment aided design method for the analysis of the experimental purpose of this article is based on artificial intelligence technology art design under the auxiliary methods of analysis, find out the defects of existing auxiliary

method in art and design, promote the further increase of aided design method. Firstly, by referring to the existing research data, the relevant research theories are classified and sorted out, and some main research conclusions are drawn. Secondly, typical cases of artificial intelligence in art design are collected and analyzed. Then, interview experts and scholars, collect experts and scholars in this aspect of the views and opinions, and do a good record; Finally, based on the existing research data, practical cases and the views of experts and scholars, this paper analyzes the aid-aided design methods used in current art design, finds out the shortcomings of the aid-aided design methods, and puts forward relevant improvement strategies.

## 4 Discuss

### 4.1 Problem Analysis of Auxiliary Design Methods

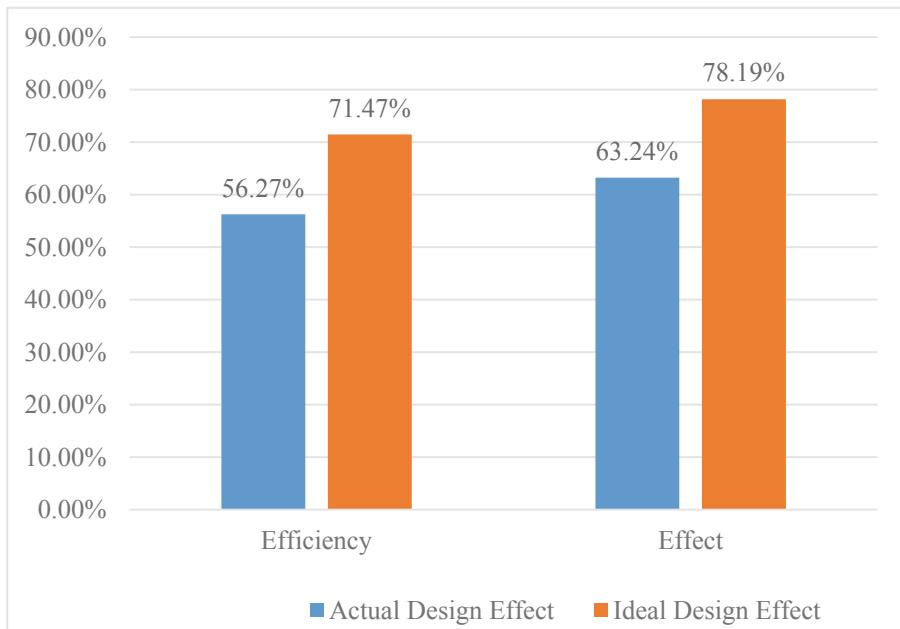
From the above analysis and experiment of auxiliary methods, we can draw the conclusion that the problems of the auxiliary methods of artificial intelligence mainly include two aspects: one is the problems of auxiliary methods themselves, the other is the problems of auxiliary methods in practical application. These two problems have a negative impact on the efficiency of artistic design and the design effect. The specific experimental results are shown in Table 1 and Fig. 1. The data in the chart are the results of the author's experimental arrangement.

**Table 1.** Classification of aided design methods

/	Proportion	Impact
Insufficient data mining	54%	53.21%
Low degree of discipline integration	46%	46.79%
Composite scores	63.54	

\*Data came from the in-depth analysis of financial data in the experiment

It can be seen from Table 1 that the existing auxiliary design methods mainly have two problems, namely, insufficient data mining and low integration of disciplines. The former is the problem of the aided design method itself, while the latter is the problem of its practical application. From the data in Fig. 1, it can be found that the problems existing in the auxiliary design method not only affect the efficiency of artistic design but also affect the actual effect of artistic design. In general, the application effect of the existing artificial intelligence auxiliary methods is poor, and the comprehensive score is only 63.54 points.



**Fig. 1.** Analysis of the influence of auxiliary methods on artistic design

#### 4.2 Improvement of Auxiliary Design Methods

Aiming at the problems of the aided design method reflected in Table 1 and Fig. 1 in Sect. 4.1 and its application, this paper proposes the following two improvement strategies:

(1) Increase the mining of data of aided design methods

The data of art design directly affect the final effect of art design. As far as the current situation is concerned, aid-design methods lack of specific data mining and analysis, and the structure of artistic design is not prominent enough. Therefore, it is necessary to construct the data base of art design, and make the professional knowledge of art design structured and precipitated to some extent by means of data. Researchers have long tried to build artificial intelligence visual experience through the collection and construction of image data. We can introduce this research into the aided design method, establish the corresponding image data set in the aided design method of art design, maximize the release of man-machine collaborative artistic design ability, and better promote the cross-border integration between the two.

(2) The combination of auxiliary design methods and art design disciplines

At present, in the daily study of art design, there is a lack of learning of auxiliary methods. The auxiliary method is relatively independent from the art design discipline, and the two are in a state of separation, so the designer is not proficient in the application of the auxiliary method. Therefore, efforts should be made to integrate the ability and knowledge of artificial intelligence into the discipline of art

design, especially into the discipline of auxiliary design methods, to help designers realize the flexible application of auxiliary methods, so as to maximize the role of creative leverage. In addition, in the training of application-oriented artistic design talents, the aid-design methods of artificial intelligence must be really implemented in the teaching of colleges and universities, so as to explore more possibilities for the aid-design assistance in artistic design.

## 5 Conclusion

In the field of art design, the application of artificial intelligence is gradually popularized and gradually deepened. At the very beginning, when I entered the field of art design, I did not push it further due to my first contact with it. With the deepening of research and the continuous maturity of technology, the advantages of the convenience of artificial intelligence make it rapidly implemented in the field of art design. As an important auxiliary method of art design, artificial intelligence not only promotes the development of art design, but also has some problems. Only by exploring and overcoming the problems in the methods of aided design can the reform and development of art design be further promoted.

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# The Computer Information Technology Application of Big Data Era in Urban Planning and Design

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**Abstract.** Social science and technology have developed rapidly in the 21st century, and the era of network information based on computers, networks, and various scientific and technological means has developed rapidly. With the increasing requirements of social development, all parts of urban construction are also closely connected with modern network information technology. Especially from the general application of modern Internet of Things, cloud computing and various types of information sensing equipment, the data requirements of urban planning are becoming more and more strict, and at the same time, these accurate and valuable data also provide future urban planning. Important material. This paper analyzes the information capacity and characteristics in the era of big data, and provides the application method of Auto CAD drawing technology, the application method of GIS geographic information technology and the application suggestions of Network technology for the information technology development direction in urban planning and design.

**Keywords:** The era of big data · Computers · Information technology · Cities · Planning and design

## 1 Introduction

In recent years, network technology information technology has developed rapidly around the world. At the same time, a large amount of social data such as intelligence, real-time, and publication in society appears in all aspects of life and work. In 2012, the United Nations made a special interpretation of the “big data era” and published a white paper entitled “Big Data for Development: Challenges and Opportunities”. Source data and the collection and use of data in multidisciplinary fields are explained in detail [1]. The “Big Data Research and Development Plan” released by the White House Office of Science and Technology Policy on March 29, 2012, marks the United States’ promotion of big data technology to the national strategic level, forming a mobilization pattern. Since the beginning of the 21st century, in a wide range of social life, electronic devices such as mobile phones and computers have been continuously completing personal information data, while video surveillance, medical information, and other information data in modern society have continued to feature massive and real-time development [1]. Therefore, the era of big data has arrived, and all aspects of modern society present the characteristics of data space-time.

## 2 Impact of the Era of Big Data on Urban Planning

### 2.1 From Static to Dynamic

The advent of the big data has provided data information and technical support for urban development to change from static to dynamic. A variety of spatiotemporal data improves the fineness of urban planning, can deal with relevant information issues in the development of urban planning in a timely manner, and provides support for the adjustment and improvement of urban planning. In the era of big data, urban planning has realized a virtuous cycle of integration of the implementation process from planning and design to feedback correction [2]. Through the flexible interaction between various subsystems in urban design and planning, the design concept can be completed faster and more accurately.

### 2.2 From Space-Based to Human Text

With the information processing diversification in the era of big data, data information for individual residents continues to emerge, thus the information diversification shows the residents' information interaction in the city [3].

Using big data to analyze the urban planning and design and make a derivation, you can study the data information of specific residents, so as to achieve the overall picture that traditional urban planning and design cannot achieve. In the urban planning and design specific implementation, it is shown that mobile phone data, floating car data, and bus credit card data can be used as the basis, and urban population data and land use conditions can be used for visual analysis and quantitative comparison to obtain important directions for future urban development. By controlling detailed data information and using the activity density of residents reflected by mobile phone data, the planning and design of the indicator system is improved [4].

## 3 Urban Planning and Construction in the Data Age

### 3.1 Collection and Management of Urban Planning Information in the Era of Big Data

With the development of the city's Internet of Things and the Internet, data collection and update of various types of sensors in cities are becoming more accurate and faster. Whether it is smart terminal data such as mobile phones, computers, wearable devices, smart homes in households, climate change data, traffic conditions and facility data in cities, and medical, education, health and safety data in cities, etc. come and record more accurately in real time [5]. With the massive and diversified collection of urban planning information, the data changes of various influencing factors in urban space and the dynamic range of urban data have become more and more refined. Judging from the changes in the observed urban dynamic data such as buildings or public facilities and electronic technology products, data in all aspects of urban planning are becoming more abundant and accurate.

### 3.2 Urban Planning Indicators and Evaluation in the Era of Big Data

At present, China's urban planning mostly uses qualitative analysis in forecasting and evaluation. For example, quantitative analysis methods of land use simulation and geographic information system are gradually applied in GIS software of panoramic urban panoramic information system. In addition, computer artificial intelligence the related agent model studied provides distributed computing and other computing methods to simulate the urban planning scheme. Through simulation, the data and plans are more intuitively displayed, and the public facilities, transportation, residential activities, commercial spaces, and climate solutions in the city are also clear at a glance [6]. According to the current stage of urban development, more data must be available for urban planning to demonstrate the impact factor indicators of urban development, and the real-time update of data should be promoted according to the capabilities of scientific and technological networks, so that the analysis of urban planning relies on detailed and multi-source data Closer to real urban development. Based on urban simulation and real-time observation data changes, specific evaluation and analysis of urban land use, public facility use, meteorological disaster data, and traffic forecasting plans are developed to promote the efficient development of urbanization [5]. By analyzing the population size in the process of urban time and space development, and discovering the interrelationships between urban public facilities, living spaces, and traffic conditions, and incorporating them into the original index categories and data for in-depth analysis, it is possible to achieve.

### 3.3 Data Visualization and Public Participation in Urban Planning

With Internet information technology development, public participation in the era of big data is increasing. The planning and construction of cities also increasingly affects the public. On the one hand, with the development of data visualization and Internet data sharing, the development of intuitive visualization icons and other network communication platforms, professionals and the public are talking, and urban planning and construction are becoming more and more "grounded". On the other hand, the public has more in-depth exchanges on the service status of urban public facilities and the ecological environment and traffic conditions of the city at this stage. The residents' intentions and impacts on urban planning and the judgement of the pros and cons of the plan have also been in-depth understanding. In the field of urban medical and health control, the application of big data has also developed in depth. From the perspective of predictive control of infectious diseases in cities, on the one hand, according to the medical data of residents' health, a detailed public onset time and space positioning is established [7]. Google has successfully predicted the epidemic by searching the spatial location of users with specific keywords. The spread of the disease in a specific area (city, state, or country). Urban residents can pay attention to the city's traffic, disasters, diseases, etc. through the network, obtain the first-time event information, and protect their lives, health and safety.

## 4 The Application of Big Data Information Technology in Urban Planning and Design

### 4.1 The Auto CAD Technology Application in Urban Planning

Auto CAD (Auto desk Computer Aided Design) is a computer-aided design software that can be used for two-dimensional drawing and three-dimensional design. It can be used for civil construction, engineering drawing, transportation network layout, urban hydropower planning layout, urban network distribution. In many aspects, urban planning and design fields have been widely used in China's urban planning and design departments [8]. With the support and promotion of CAD applications by big data, digital office and e-government have been widely promoted, which has accelerated the design progress of specific parts of urban planning at the design technical level, and has also improved the urban planning department Electronic data file, as shown in Fig. 1.



Fig. 1. Application of Auto CAD integrated big data in urban planning

### 4.2 Application of GIS Geographic Information Technology in Urban Planning

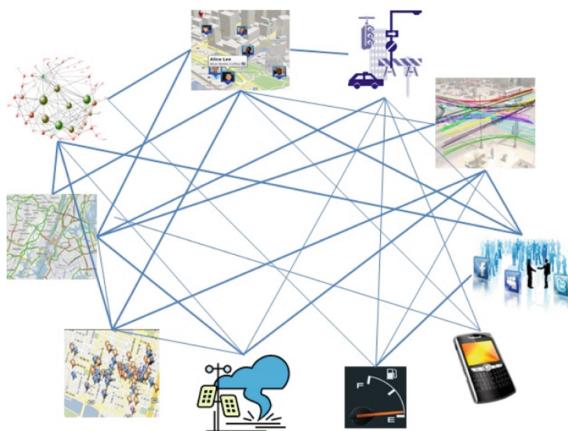
Geographic Information System (GIS) is an important technical tool for data application in general application and urban planning [9]. Through the integration of numbers and words, it makes statistical analysis and integrated processing of urban planning. In the context of big data, the amount of information obtained by data is extended. GIS has been perfected with big data in spatial analysis and model analysis, and it can already be used in the evaluation of design ability. Make a reasonable distribution of urban facilities and resources in terms of time and space. GIS uses big data to organize, enhance storage and management capabilities, and provide effective management methods and information distribution for the implementation of urban planning solutions. This speeds up the process of urban planning from design to implementation [10].

### 4.3 Application of GPS Positioning System in Urban Planning

The era of big data has promoted the development of information technology from different directions. Global positioning systems and remote sensing technologies are particularly prominent, thereby achieving the widespread usage of information technology in urban design and planning. The era of big data has promoted the application of GPS in urban planning [11]. Its accurate and high-speed timing navigation information has greatly improved the informatization level of urban planning and design. Urban planning is to obtain information from both space and time to complete management technology and service systems. Require accurate geographic information, so as to realize the multifunctional service of information. The future digital city's system service ability and excellent management ability are the reflection of its important value, and the application of GPS is an important component of digital city [11]. Through the electronic navigation map to GPS real-time positioning technology, digital traffic construction can be completed in urban planning, thereby real-time release of traffic information.

### 4.4 Application of Network Technology in Urban Planning

Network technology can share multiple resources and build interactive information platforms through data information. Its powerful remote terminal protocol and file transfer protocol and other service data create effective ways for city management sharing and updating, as well as management and communication [12]. Such big data information planning can be effectively applied to urban construction planning, strengthen the communication between management personnel, and thereby improve the design of urban planning, as shown in Fig. 2. And in the opening of the network environment, people can expect people's expectations for urban planning in a large amount of information, so as to design people-oriented design solutions [12]. In this kind of urban planning and design will be closer to people's use and life.



**Fig. 2.** Application of network technology in urban big data system planning

## 5 Summary

With the development of modern science and technology information technology, the application of big data in the process of urban planning and construction has become more and more widespread. At the same time, the era of big data has also promoted the more scientific and precise planning and construction of modern cities. In the planning process and modern cities construction, a more in-depth analysis of the spatial construction of cities has been performed using the quantitative analysis method of simulated geographic information system (GIS). In addition, the integrated analysis of data for multiple impact factors in the process of urban development provides a dynamic, intelligent, and flexible urban planning for urban development and construction. In the era of big data, the coordinated development of urban planning data is gradually moving towards a people-oriented construction concept. Building a smart modern city is also an era requirement in the era of big data.

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# Fault Detection of Club Fitness Equipment Based on Image Processing Technology

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**Abstract.** The safe operation of machinery and equipment is not only closely related to People's Daily life, but also has an important impact on the economic activities of the whole society. Therefore, the detection and elimination of mechanical faults has become one of the hot topics in current research. Mechanical equipment detection based on image processing technology is a method to detect and eliminate machine faults through the technical principle of infrared thermal imaging combined with image processing technology. The traditional fault detection method is usually by professional maintenance staff use a variety of various parameters of instrument measuring machine, for it is concluded that the parameters of the analysis to find out the cause of the fault, the test method is not only requires a lot of manpower and material resources, and the operation is very complicated, difficult to real-time access to the cause of the problem. By contrast, image processing technology can accurately and quickly extract the fault characteristics of the machine and analyze and diagnose them on the relevant diagnosis platform. In this paper, the research of image processing technique to detect the machine equipment failure is mainly combined with the machinery and equipment of fitness club, gym fitness equipment are made by special management personnel responsible for the care, but because of the great usage, thus inevitably fails, but these managers also amateurs, therefore difficult to by our own technology to deal with these failures, under this background, the research developed a visualization of the fitness club equipment inspection system is very necessary.

**Keywords:** Image processing technology · Health clubs · Fitness equipment · Fault detection

## 1 Introduction

With the development of society, lack of exercise has become a common fault of modern people. Studies have shown that exercise improves heart and lung function, improves blood circulation and reduces the chance of developing chronic diseases. The use of fitness equipment for exercise can be unaffected by the weather, and has gradually become a way of exercise for many people [1, 2]. Therefore, fitness centers or fitness clubs are also becoming more and more popular, and fitness equipment in fitness centers are managed by the managers of fitness centers, who must troubleshoot or inform the manufacturers of fitness equipment to repair the equipment when it breaks down [3]. Current fitness equipment can only display the corresponding error code in

case of failure, so as to indicate the approximate location of the fault, so that management personnel or maintenance personnel can have the maintenance direction to follow [4]. However, the actual overhaul still requires considerable time to find out the faults [5]. As fitness clubs use a large number of fitness equipment and the club covers a large area, failure detection of fitness equipment by human resources will undoubtedly increase the cost of human resources for fitness center operators, and it is impossible to detect each fitness equipment one by one, resulting in poor effect of testing fitness equipment [6, 7]. Therefore, the existing testing methods of fitness equipment are still not perfect and need to be improved [8].

No matter at home or abroad, fault detection and diagnosis have become one of the research hotspots [9]. Equipment fault diagnosis technology has developed into a multidisciplinary comprehensive technology based on fault mechanism, image recognition technology, information detection technology, signal analysis technology, pattern recognition technology, computer technology and artificial intelligence technology [10, 11]. Foreign researchers have pointed out that the use of advanced fault diagnosis technology in production can bring huge economic benefits to enterprises [12]. Britain's nationalised firms have seen their annual maintenance costs plummet from £4.5 billion to £23 after using fail-detection systems. After the implementation of the troubleshooting program in Japan, the annual equipment maintenance costs were reduced by 36% and the production accident rate was reduced by 75% [13]. Since the beginning of this year, mechanical fault diagnosis has also been taken as the focus of research in China, and three relatively mature detection methods have been formed, namely, the detection method based on signal processing, the detection method based on artificial intelligence and the method based on model detection [14]. However, with the development of The Times, these methods are no longer sustainable for increasingly sophisticated and informationized mechanical equipment, and new detection methods are urgently needed to improve and develop the theory and practice of fault detection [15].

This paper proposes a device fault detection method based on image information technology, which is because image recognition technology has made important achievements in the field of artificial intelligence, and has created huge use value and economic benefits [16]. When image recognition technology is applied to the equipment fault detection of fitness club, it can not only guide the maintenance personnel to repair the equipment more accurately, but also realize the vision that simple faults can be repaired without professional personnel. Therefore, the fitness equipment fault detection method based on image processing technology has realized the full play of the benefits of equipment profitability, which is the focus of the current fitness equipment fault detection research field.

## 2 Method

### 2.1 Image Processing Technology

To put it simply, image processing technology is a technology that USES computers to analyze images to achieve ideal results. Image processing generally refers only to digital images, not paper images. The main contents of image processing technology

include enhancement, restoration, compression and recognition. Common image processing technologies include image enhancement technology and image segmentation technology.

### 2.1.1 Image Enhancement Technology

Many images after acquisition may result in image quality degradation due to a variety of factors. The image enhancement technology is a technology that can improve the image sharpness or other parameters with low quality through machine analysis, and the purpose of image enhancement technology is to improve the image sharpness and improve the visual effect of the image. At present, the image enhancement technology does not correlate with the thermal image features of fitness equipment, so it lacks pertinence in fault diagnosis of fitness equipment.

### 2.1.2 Image Segmentation Technology

Image segmentation is the main problem in low-level vision and image processing in computer vision. In order to analyze and identify the target, the accurate selection of the target from an image is a problem to be studied in image segmentation. In the application of image segmentation, people always tend to be interested in a certain part of a picture. These parts are specific areas, that is, the foreground or target mentioned above.

When the algorithm is used to preprocess the image of mechanical equipment, after removing the distortion and noise of the image, it is found that this processing technology is only effective for the image of a certain type of machine equipment, but does not have universal applicability, indicating that the technology has certain limitations.

## 2.2 Mean-Shift Algorithm for Equipment Fault Detection

In this paper, an extended mean-shift algorithm is proposed, which is based on the iterative idea of histogram description and USES vector weighting to locate the position of the target. After this practical problem, the fault detection of machine equipment is transformed into the modal detection problem of Mean Shift.

When the probability density function is in the convergent state of the peak, a peak of the Mean Shift function is a mode and converges to the peak mode of the density function. Since there is a hot region between the non-fault point and the fault point in the thermal image of fitness equipment, and the fault point is usually where the gray value is abnormal, the Mean Shift function can detect the fault of fitness equipment. Let  $K$  be a characteristic function of a sphere with a radius of  $X$  space, and let  $S$  be a finite set of Euclidean space  $X$  of  $n$  dimensions, to obtain the following formula:

$$M_\lambda(x) = \frac{1}{k} \sum_{x_i \in S_\lambda} (x_i - x) \quad (1)$$

Where  $S_\lambda$  is the region contained in the sphere with radius.  $K$  means that at  $n$  sample points  $x_i$  ( $i = 1, 2, \dots, K$  points in  $n$ ) fall into  $S_\lambda$  region.

Generally speaking, the closer the sample point  $x_i$  is to  $x$ , the more the statistical effect of  $M_\lambda(x)$  will be affected. Therefore, considering the distance factor, the extended form of Mean Shift vector is:

$$M_\lambda(x) = \frac{\sum_{i=1}^k G_H(x_i - x)(x_i - x)}{\sum_{i=1}^k G_H(x_i - x)} \quad (2)$$

When the Mean Shift algorithm is extended to find the hot region in the peak part of the image, the modal detection is realized, and the fault diagnosis is realized.

### 3 Experiment

#### 3.1 Establishment of Mean Shift Mode

In the Mean Shift modal detection, it is necessary to select an initial pixel point and find its Mean Shift vector, which leads the initial pixel point to a position closer to the target mode. Secondly, when the target mode is detected, the Mean Shift kernel function is used to obtain the real position of the image. Finally, all the target modes in the whole image are found by means of the iterative action of Mean Shift algorithm, and the regions composed of all the real positions are segmented.

The programming of the mean-shift algorithm is implemented on MATLAB platform, and the qualitative results of fault diagnosis are obtained. The results of case analysis show that the algorithm is simple to calculate and can accurately judge whether there is fault in electrical equipment.

#### 3.2 Steps of Fault Detection

The equipment and equipment of fitness clubs in the market all belong to the plural driving units. After the failure of the equipment, the control unit produces an error code corresponding to one of the driving units. The fault detection method designed by us includes the following steps:

The first step is to transmit the test capture instruction from the control device to the control unit, in which the control device is built with a plurality of test instructions, which correspond to different driving units; Second, the error code is transmitted to the control device upon receipt of the capture instruction; In the third step, according to the error code, the detection instruction of the driver unit corresponding to the error code is transmitted to the control unit; In the fourth step, the driver unit corresponding to the error code is detected according to the detection instruction, and a detection result is transmitted back to the remote control device.

## 4 Discuss

### 4.1 Qualitative Analysis of Equipment Fault Detection

This study used the Mean Shift algorithm can intuitive presents the fault diagnosis results, but because of the uncertainty of the equipment working status, and other such as images taken by the influence of temperature, temperature difference, a lot of fitness equipment work even in normal circumstances will appear to be “diagnosis”, mainly for the region’s temperature significantly higher than other area. However, such high local temperature may also be caused by the equipment continued to work for a long time, rather than equipment failure. For this kind of thermal imaging, this study found that when the color image of the thermal image is converted to the gray image, the gray value is between 0 and 255, which cannot show the actual temperature value of each point. According to the measured temperature value, the actual fault state of the equipment can be analyzed by analyzing the temperature difference rate. The severity level detected by the equipment can be divided into three categories, as shown in Table 1 below.

**Table 1.** Results of equipment fault classification rules

State type	Temperature difference rate of $\Delta T$	Temperature difference of $\Delta C$
Normal	$\Delta T < 9\%$	$\Delta C < 10^{\circ}\text{C}$
Warning	$9\% \leq \Delta T < 90\%$	$10^{\circ}\text{C} \leq \Delta C < 25^{\circ}\text{C}$
Abnormal	$90\% \leq \Delta T$	$25^{\circ}\text{C} \leq \Delta C$

According to the rule data in the above table, when the temperature difference rate of a certain area of the equipment is greater than a certain range, it can be determined whether it has a fault.

When the range of temperature difference rate is more refined, the fault can be further divided into different corresponding levels or emergency degrees. In this paper, the emergency degrees are divided into warning and abnormal levels. Moreover, the detection results of common far-infrared imager equipment fault state and image processing technology supported by Mean Shift algorithm were compared and analyzed respectively. The comparison results are shown in Table 2 below.

As can be seen from the results in the above table, ordinary far-infrared imager can only detect the maximum temperature of fitness equipment, but cannot obtain other data; The image processing technology supported by Mean Shift algorithm can analyze the maximum temperature, average temperature and minimum temperature through the obtained thermal images, wait for the temperature difference rate data, and analyze the temperature difference rate.

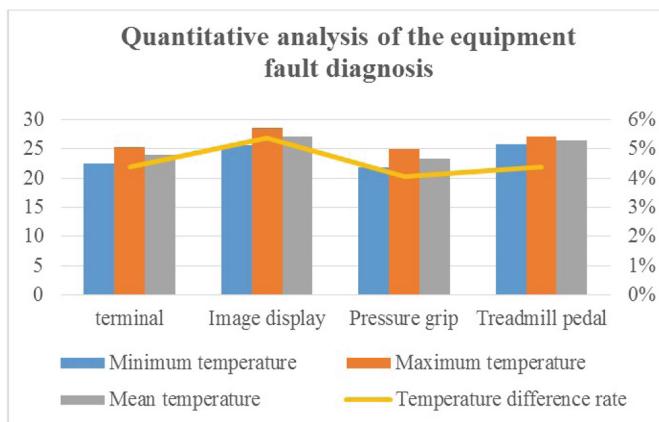
**Table 2.** Comparison results of fault detection data of the two technologies

	Minimum temperature °C	Maximum temperature °C	Mean temperature °C	Temperature difference rate $\Delta T$
Ordinary far infrared imaging	/	31.6	/	/
Nshift algorithm supports image processing techniques	26.037	31.1843	27.4875	13.37%
Error rate	/	2.75%	/	/

## 4.2 Quantitative Analysis of Equipment Fault Diagnosis

In fact, before using the Mean Shift algorithm for fault analysis, it is necessary to quantitatively pre-process the thermal image of fitness equipment. It can effectively remove the interference of inherent characteristics of equipment, signal conversion rate, environment variables and other factors, and effectively avoid the wrong operation of image correction.

In this part, the terminal posts, image display screens, pressure grips and treadmill pedals of fitness equipment were selectively simulated and analyzed, and quantitative data of simulation analysis were obtained. The analysis statistics of these data are shown in Fig. 1 below. In fact, these devices are in normal working condition, but have been caught abnormal high temperature alert. Therefore, it is not possible to determine whether a part is a normal heating state in the operating state or a fault state based on the local temperature of the equipment.

**Fig. 1.** Quantitative analysis results of equipment fault diagnosis

According to quantitative parameters calculation, therefore, can eliminate some fitness equipment in normal working state of heating situations, this is consistent with actual situation, in the acquisition of the electrical equipment hot like figure, there will

always be some relatively “hot spots”, these hot if only from the image point of view, is unable to distinguish whether the normal condition or fault, and the improved Mean Shift algorithm solved the problem very well.

## 5 Conclusion

In the field of fault detection of club fitness equipment, fault detection method based on image processing technology is becoming a hot topic. It is obvious that the traditional instrument and equipment fault detection methods are more and more difficult to meet the needs of reality detection, while the detection methods based on image processing technology emphasize the application of image enhancement and image segmentation, thus achieving the best application of Mean Shift algorithm. The detection method of club fitness equipment based on image processing makes use of the active sending of capture instruction and detection instruction to the fitness equipment, so that the faulty fitness equipment can be detected and then transmitted back to the control device, effectively improving the efficiency of the detection of fitness equipment, and effectively reducing the maintenance cost.

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# Multi-objective Optimization of Construction Project Based on Multi Ant Colony Algorithm

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**Abstract.** Modern construction projects involve many aspects, frequent safety accidents also show that the traditional project management model has been unable to adapt to large-scale complex construction projects. An advanced method is needed to deal with the growing construction projects. Based on this, this paper proposes a multi-objective optimization research of construction project based on multi ant colony algorithm. Taking the construction period, cost and quality of the construction project as the object of optimization, the pavement reconstruction project of Dongjiangyuan Avenue in Ganzhou City, Jiangxi Province is selected for demonstration. The results show that the multi-objective optimization method proposed in this paper accords with the reality. The total quality score of the optimized project is 79.6, the total cost is 4.05 million yuan, and the total construction period is 120 days.

**Keywords:** Construction project · Multi-objective optimization · Multi ant colony algorithm

## 1 Introduction

Construction projects play an important role in the process of economic and social development, supporting the economic development [1]. The development level of the construction field will also affect the pace of the overall economic progress [2]. In the process of construction projects, the realization of economic benefits is very important. The time spent in project construction, project cost, project quality and project risk are all factors that need to be considered in the construction project [3]. Only by controlling the balance of these objectives can we achieve the overall optimization of the project. This is of great practical value to the practical operation of construction projects.

In the research of multi-objective optimization, many experts and scholars have done research and achieved many results. In [4], the author puts forward the cuckoo optimization algorithm and finds the Nash equilibrium point of the non-linear non cooperative game, which becomes an alternative method to solve the multi-objective optimization problem. In [5], the author proposes a multi-objective ant lion optimizer, which uses a set of standard unconstrained and constrained test functions to solve many multi-objective engineering design problems such as disc brake design, safety isolation transformer design, etc. In [6], inspired by grasshoppers in nature, the author proposes a grasshopper optimization algorithm for solving multi-objective optimization problems. Firstly, a mathematical model is used to simulate the interaction of individuals in

swimming, and then a mechanism is proposed to use the model to approach the global optimization in a single target search space. In [7], aiming at the multi-objective optimization problem of feature selection in biomedical field, the author proposes a multi-objective particle swarm optimization algorithm based on cost feature selection. The algorithm uses probability based coding technology to improve the search ability of the algorithm. Although the above research has achieved some results in the multi-objective optimization problem, the effect is not good in the multi-objective optimization problem of the construction project. The quality model of the construction project needs to be built, and the coordination among multiple objectives needs to be considered to achieve the comprehensive optimal effect.

Ant colony algorithm has a high degree of parallelism, and can get multiple optimal solutions at a time when solving the multi-objective optimization problem of construction projects. This method is more reasonable in determining the impact of each link of the project on the whole project. Ant colony algorithm has been used in many fields. In [8], the ant colony algorithm is applied to the path planning of mobile robot in grid representation environment to find the optimal path. In [9], the ant colony algorithm is used in wireless sensor networks to make effective data routing in wireless sensor networks with limited energy. The results show that this method saves the energy of nodes and prolongs the network life. In [10], the improved ant colony algorithm is applied to the dynamic hybrid flow shop scheduling problem with uncertain processing time to reduce the frequency of rescheduling. Considering the advantages of ant colony algorithm, the improved ant colony algorithm is applied to the multi-objective optimization of construction projects.

In view of the influence of time limit, cost and quality, this paper proposes a multi-objective optimization research of construction project based on multi ant colony algorithm, in order to provide reference for related work.

## 2 Method

### 2.1 Overview of Multi-objective Optimization of Construction Projects

In the field of practical engineering projects, the problem of multi-objective is often encountered. For the construction project plan, when measuring the merits and demerits of the plan, it is necessary to consider multiple objectives comprehensively, instead of only making a judgment with a single objective. However, there is also a problem that many of these goals are not coordinated, but may be contradictory. The project is mainly considered from three aspects: project duration, cost and quality.

### 2.2 Basic Ant Colony Algorithm

After the ants start, they determine the next movement direction by the perception of pheromone concentration, and finally reach the end point, which is the step of searching solution. The process of basic ant colony algorithm is as follows:

Step 1: Initialize first. All ants start from the starting point. At this time, there is no pheromone in the path. All ants randomly choose one direction to move to the next node.

Step 2: Different ants move to different nodes and mark pheromones on the path of movement. These pheromones will be perceived by other ants, and the ants will continue to move until the end position. When the ant that has traversed the end node returns to the second iteration, it will be guided by the pheromone on the path. Step 3: Pheromones on the path volatilize according to the incidence rate, update the pheromones, and let the ants repeat step 2.

After many iterations, there are more pheromones in one path than other paths, which is the optimal path searched by ant colony algorithm.

## 2.3 Construction of Multi-objective Optimization Model of Construction Project Based on Multi Ant Colony Algorithm

The objectives considered here are project duration, cost and quality. Firstly, the models of these three objectives are constructed respectively, and finally the multi-objective comprehensive model is constructed.

### (1) Duration model

Duration is the time it takes to complete a project. The total construction period is determined by calculating the total time spent by each construction mode on the critical path. Suppose that  $n$  processes are needed to complete the project, and there are  $m$  operation modes for a process. The construction period model is as follows:

$$F_T = \sum_{t \in A} t_{kj} \quad (1)$$

In the above formula,  $t_{kj}$  represents the time spent in selecting the  $j$ -th operation mode to complete the  $k$ -th operation, and  $A$  represents the time set spent in each key operation mode of the project.

### (2) Cost model

The material cost, labor cost, machinery use cost and indirect cost (daily indirect cost multiplied by total construction period) in each process are taken into account. The cost model is as follows:

$$F_C = \sum_{k=1}^n DC_{kj} + \sum_{t \in A} t_{kj} \times IC \quad (2)$$

In the above formula,  $DC_{kj}$  refers to the material cost, labor cost and machinery use cost for the selection of the  $j$ -th operation mode for the completion of the  $k$ -th process;  $IC$  refers to the indirect cost generated by the selection of different operation modes.

### (3) Quality model

Through the experts' evaluation of each operation mode, the weight of each single process in the whole project is determined. The quality model is as follows:

$$F_Q = \sum_{k=1}^n w_k \times q_{kj} \quad (3)$$

In the above formula,  $w_k$  represents the corresponding weight of the k-th process;  $q_{kj}$  is the quality score of the j-th construction method after the k-th process is executed.

### (4) Construction of multi-objective optimization model

After comprehensive consideration, the target thresholds of construction period, quality and cost are determined. That is to say, the latest construction period allowed by Party A is  $T_{\max}$ , the maximum project cost recognized by Party A is  $C_{\max}$ , and the minimum requirement standard of Party A for project quality is  $Q_{\min}$ . Therefore, the comprehensive model of multi-objective optimization is as follows:

$$\begin{cases} F_T = \sum_{t \in A} t_{kj} \\ F_C = \sum_{k=1}^n DC_{kj} + \sum_{t \in A} t_{kj} \times IC \\ F_Q = \sum_{k=1}^n w_k \times q_{kj} \end{cases} \quad (4)$$

The constraints are:

$$\begin{cases} T_{\max} \geq F_T \\ C_{\max} \geq F_C \\ Q_{\min} \leq F_Q \end{cases} \quad (5)$$

## 3 Experiment

In order to verify the effectiveness of this method, the pavement reconstruction project of Dongjiangyuan Avenue in Ganzhou City, Jiangxi Province is selected for demonstration. The pavement reconstruction project of Dongjiangyuan Avenue is from Xiamen Chengdu Expressway to Xingguo Road, with a total length of about 13.05 km. Through the evaluation of the project duration, cost and quality of the reconstruction project, the multi-objective optimization of the construction objectives is studied. Set the population number of ant colony to 5, the number of ants of each population to 80, and the number of iterations of ant colony to 150.

## 4 Results

### Result 1: Operation conditions

A project is composed of many assignments, and there is a sequence of completion among them. There are many ways to do different tasks. There are also corresponding time and cost to complete the work. In the project, give the corresponding quality weight to the single operation, and ask the experts to give the operation quality score. The specific conditions of each operation are shown in Table 1.

**Table 1.** Operation parameters

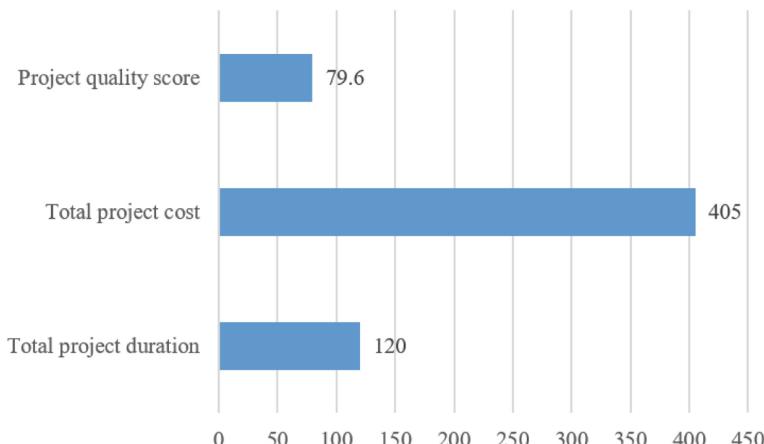
Work name	Work content	Subsequent work	Operation mode	Spend time/d	Direct cost/Ten thousand yuan	Quality weight (%)	Work quality score
A	Demolish old pavement	C, D	1	24	149	16.1%	81
			2	22	161	16.1%	74
			3	19	170	16.1%	62
B	Baffles on both sides	C, D	1	20	71	11.2%	70
			2	26	65	11.2%	73
C	Elimination of waste soil	E	1	12	30	18.4%	75
			2	10	33	18.4%	77
D	Reinforced baffle	F	1	13	24	10.4%	81
			2	15	22	10.4%	80
E	Cement injection	F	1	30	120	35.2%	83
			2	24	103	35.2%	73
F	Remove baffles and other tools		1	13	19	8.7%	81
			2	17	15	8.7%	76

From Table 1, it can be seen that the cost and quality score of different processes are different under different operation modes. In this case, the multi-objective optimization problem of construction engineering appears. It is very important to optimize the construction period, quality and cost. In Table 1, the cost of the short-term operation mode is high, and the quality of the completed operation is also high and low.

### Result 2: Multi objective optimization result

The operation parameters obtained in result 1 are summarized and then run in the multi ant colony algorithm. In the optimized construction scheme, through comparison and selection, in the better scheme, the sequence number of operation mode corresponding to operation A, B, C, D, E and F is 1, 2, 1, 2, 1, 1, respectively. The total construction period, total cost and total quality score are shown in Fig. 1.

It can be seen from Fig. 1 that after the multi-objective optimization of the construction period, cost and quality of each link of the construction project, the total quality score of the project is 79.6, the total cost is 4.05 million yuan, and the total construction period is 120 days. This is to make the duration, cost and quality reach the goal of common optimization within a certain range, without sacrificing one goal to optimize the other two goals. In addition, in the process of project construction, it is



**Fig. 1.** Total construction period, total cost and total quality score of the optimized scheme

necessary to improve the sense of cooperation between management and construction personnel to achieve the best optimization effect of the project. Project participants should remember to put the quality of construction projects in the first place. The work quality and management system of the personnel involved in the project are helpful to optimize the objectives. Cost is the problem that investors pay attention to, but we can't pursue to reduce cost and reduce project quality. Under the condition of ensuring the quality of the project, we can reduce the project duration and project cost.

## 5 Conclusion

Multi-objective optimization is a common situation in construction projects, and the optimization process is very complicated. In this paper, the multi-objective optimization of construction project based on multi ant colony algorithm is proposed, and the project duration, cost and quality are the research objects. Combined with the actual situation of the project, the scientific choice is made, which avoids the major quality accidents and economic losses caused by the wrong decision-making, and improves the integrated management level of the project.

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# Sports Game Management Method Based on Intelligent Computer Computing

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**Abstract.** With the development of social science and technology, the popularization rate of artificial intelligence is getting higher and higher. People apply artificial intelligence to all aspects of life and provide convenience for people's lives. The management of sports competitions is an important part of sports competitions. It is necessary to ensure the quality of sports competitions on the principles of fairness, impartiality, and openness, to ensure the discipline of the competition, to maintain the order of the stadium, and the safety and security of traditional sports competition performance management systems. The management results are relatively unreliable and require more human resources. Therefore, this paper proposes a method for managing sports games based on intelligent machine calculations, and uses this method to design a management system. The system uses a network platform to transmit data. By analyzing user needs and functional requirements, the network platform is designed to implement data transmission between the system and the client, and the system is tested. The research results show that this paper is designed based on the intelligent computer computing method of sports competition management. The system results management results are reliable and the system performance is strong.

**Keywords:** Intelligent machine computing · Sports competitions · Artificial intelligence · Competition management methods

## 1 Introduction

With the development of social science and technology, artificial intelligence is becoming more and more popular. Artificial intelligence has penetrated into all aspects of people's lives, and intelligent computer computing has also been widely used [1–3]. Competitive sports plays an important role in the construction of campus sports culture in our country. We need to re-examine the relationship between competitive sports and campus sports culture. From the impact of competitive sports on campus sports culture, it can be seen that competitive sports are of great significance in cultivating the correct point of sports culture, and its purpose is to improve the understanding of competitive sports and enable competitive sports to more effectively promote campus sports Benign development [4–6]. School sports games or sports competitions are the main manifestations of school sports competitions, which promotes the further popularization of physical exercise among students, improves the quality of teaching and training, and is

conducive to the construction of socialist spiritual civilization. Therefore, the correct implementation and promotion of school sports competition management is a crucial step [7, 8].

Most school games and sports competitions are based on traditional manual operations, which will cause incomplete information, timely collection of information, and prone to data loss, statistical errors, and other problems. In addition, the labor intensity is high, the speed is slow, and labor and material resources are consumed. Using computer, network, database and other information technology means can complete the above work efficiently and accurately [9, 10]. Therefore, the use of intelligent computer calculation to replace manual operations to avoid manual errors and errors has become the best choice for school sports meets and sports competition organizers. Through information management, problems such as the large number of participants in the past during the games and sports competitions, complicated project settings, tight schedules, and difficult scheduling were solved. At the same time, it can minimize the interference of human factors on performance and reduce the occurrence of cheating on the field [11, 12]. In addition, intelligent computer computing and information can also provide relevant coaching and athletes with timely and accurate information about the competition. It is not difficult to see that the application of intelligent computer computing information technology in information management has greatly improved the real-time, accuracy, security and reliability of information. Therefore, the integration of intelligent computer computing information technology has become an inevitable, and has gradually become the core of the information management of the Games. Therefore, it is necessary for us to study a method suitable for school physical education management.

The widespread application of computer technology in the field of sports has solved the problems of heavy workload and complex data management of sports events. However, the research on the competition scheduling system for swimming sports is not mature enough. On this basis, Ranjan Kumara Weerakoon designed an artificial intelligence-based swimming competition schedule system. Ranjan Kumara Weerakoon designed the system on the Windows 7 operating system based on a brief analysis of the problems in the current swimming competition schedule, using SQL Server 2012. Its communication interface uses the TCP/IP protocol, and then the system architecture is explained, and the presentation layer, business logic layer and data access layer of the system are described in detail. In addition, in order to avoid the redundancy of database information, the system database is designed by a designer, and 8 data tables are set to store all the data in the system. Ranjan Kumara Weerakoon's experimental results show that the system can reduce the input of human and material resources [13].

This paper proposes a method for sports competition management based on intelligent computer calculation, and uses this method to design a system. The designed system is tested. The test results show that the system is designed based on the calculation of sports competition management method based on intelligent computer. The management results are reliable and the system performance is strong.

## 2 Method

### 2.1 Analysis of Artificial Intelligence Concepts and Characteristics

#### 2.1.1 The Concept of Artificial Intelligence Technology

Analyzing a broad and deep understanding of the concept of artificial intelligence can give us a better understanding of its applications. Artificial intelligence refers to a new way of using computers. It uses computers to imitate the way the human brain thinks, fires people's behaviors, and achieves better technical development requirements. The scope of use of this technology. It is very extensive and is well known to us. For example, the use of artificial intelligence technology in some factories for family planning labor, the use of artificial intelligence technology in the field of psychology, etc., the use of such technology can help us better save labor Cost and improve our standard of living. The use of artificial intelligence technology is very demanding, and it is not just a simple imitation. The use of artificial intelligence technology is first based on the analysis and research of human big data. Artificial intelligence belongs to the pioneers of intelligent technology. It is based on the analysis of human behavior and thinking methods, and inputs the results of the analysis. In computer systems, imitating human life.

#### 2.1.2 Characteristics of Artificial Intelligence Technology

Artificial intelligence technology has certain characteristics. Such characteristics are also the basis for its better application in computer network technology. The first is the high requirements for comprehensive data. The single data processing is simple, but it does not have a certain objectivity, and it is very low in utilization rate. Artificial intelligence technology is exactly what makes up for this shortcoming. The formation of artificial intelligence technology is not simple data use. It is based on large-scale data analysis. Therefore, data accuracy requirements are high and accuracy requirements are more stringent. The second is to continuously improve the data. In the development of artificial intelligence technology, it is not immutable, but it is continuously revised and improved with the use of artificial intelligence technology. This is also a fundamental reason for the wider and deeper use of artificial intelligence technology. With the development of artificial intelligence technology, it is becoming more and more widespread in computer applications, but it also presents certain problems. For example, although the monitoring methods in China are very strict, a specialized network management system is gradually being established. But the accuracy of the information checked by the computer is not enough, and the authenticity of the information is difficult to distinguish. Therefore, it is difficult to ensure that every data is available in the collection of big data, so the data is often poorly targeted. When we are doing intelligent search, when there is a huge amount of data, there is often confusing data. The development of artificial intelligence technology is subject to certain restrictions. Advantages, seeing its development problems, looking for measures to develop artificial intelligence more efficiently. For example, in our process of using Taobao, when we enter an information, artificial intelligence can immediately process the information we search for. After we select a certain product, we will find that the Taobao platform pushes more for us. Many related products, this is the result of

the development of artificial intelligence in the era of big data, but such push will also cause us to waste more time in similar products. It can be said that the artificial intelligence without considering our actual situation Utilization is also an obstacle to our development, and it is also unfavorable to our needs.

## 2.2 System Requirements Analysis

### 2.2.1 User Needs

- (1) The operation interface is concise and easy to understand. The main interface of the program sets the login part. The user needs to pass the username and password to verify before entering the system function menu.
- (2) The system function menu should be able to achieve the functions of game management, query, statistics, pre-arrangement, and system management.
- (3) The system must have the functions of information recording, information identification, information error reporting, etc., and alert the operator when there is an error in receiving the information.
- (4) The system can provide timely and accurate match information for coaches and participants to browse, and can easily assist in the conduct of various matches.

### 2.2.2 Functional Requirements

- (1) System management module: It includes five modules: user management, data backup, role management, logging, and data recovery. These modules serve the entire system. The system sets four roles: information auditor, information administrator, athlete, and system administrator. Set different system permissions for them according to their characteristics.
- (2) Basic information module: Provides management and maintenance of some basic information in sports competitions, including group information, competition information, order book information, athlete information, representative team information, and game event information. The game item information also specifically includes the setting of the game item rules. Information such as the grouping of events is automatically generated by the system.
- (3) Competition process module: This module contains six sub-modules: match schedule, preliminary results entry, registration completion, preliminary group, final group, and final results entry. The entire competition process runs through all sports events, and as the competition process ends, all events will end.
- (4) Grade management module: contains grade inquiry and grade statistics. Results query can query the ranking of each team and the ranking of the athletes in each event. Results statistics can complete the score statistics and ranking of the representative team.

### 2.2.3 Security Requirements

The system follows the principle of opening to the inside and closing to the outside. And the entire log is recorded, and all operations are documented. It is easy to

understand when and by whom the system performed what operation. When there is a problem with the system or data, the log can be restored and restored in time.

- (1) System access agreement System access agreement means that in the system, one must ensure that only legitimate users can log in to the system, and the other is to ensure that logged-in users can only operate and see the content of their corresponding roles, that is, system permissions control. RBAC authority control includes user management, role management and user authorization. First: User management User management provides system administrators with management functions for all users in this system, including operations such as adding users, editing users, deleting users, and changing passwords. Non-system administrators can create their own sub-users and manage them if they have permissions. Second: The basic access control unit in the role management system is a role. A role represents the smallest unit with some operation permissions and menu permissions. Users participating in the system must rely on roles to interact with the system. But a user can have different roles. The specific role division should be divided according to the business needs of the actual project and assigned to users. Third: user authorization User authorization is to grant different role information to existing users. Only after a user has a certain role can the user be using the system and follow the permissions of the role. A user can have multiple roles and have all the permissions of the assigned role.
- (2) System operation monitoring System operation monitoring means that all system operations are recorded in the form of logs. Including operation time, operator, data involved in the operation, and specific operation behavior. And the log record is separate from the business logic of the system itself, which will not cause the business process of the system to slow down because of monitoring the system.
- (3) Data changes can be checked. When the system performs data update operations, the initial state and updated state of the data are recorded. In order to follow up later, you can clearly find the operation of each step on the data. It also provides a basis for recovering data and restoring state.
- (4) Data recovery Data recovery is to restore the system through the backed up data and programs to make it work normally when the system cannot work normally. Data recovery consists of two parts, data backup and program backup. Data backup refers to backing up persistent data, such as database data, to a file. Program backup refers to copying and backing up the system's source programs.

### 3 System Test

The system test mainly checks whether the business functions of the system can run normally and are easy to operate. The test uses a combination of random data generation and manual operation for testing, which specifically includes the following: the administrator logs in to the system to bind the event, and sets the project. Registration data is generated randomly and submitted to the system for processing. Review relevant registration data and publicize registration data. Generate groups and arrange them in groups. Log in as an athlete, perform related registration and performance information

inquiry, performance entry, and performance statistics. After testing, the data of each link comes from the processing of the previous link and must be performed in turn. No error data is displayed. And only give relevant operation buttons where the user must operate, can complete each link quickly, improve efficiency and reduce the probability of misoperation.

Perform a full field test run of a university's 2018 Spring Games, observe whether all functional modules are operating normally, whether any information is lost, whether all information is normally distributed in accordance with the expected process, and for registration and score entry during the competition. The response rate of operations such as queries is recorded.

## 4 Discuss

### 4.1 Performance Test

Simulate 50,000 users for querying results. According to the server CPU share, the experiment found that when 30 concurrent access users are started, the server CPU reaches 93% (the test will fail when the server CPU reaches 100%), and the server is basically saturated, and the test is started (if there are 30 concurrent users at a time Visits, equivalent to millions of page views, that is, the scale of a medium and large interactive system). The aggregate report of the registration process test is shown in Table 1.

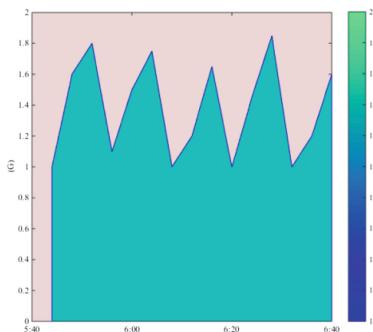
**Table 1.** Aggregation report of the registration process test

URL	#Samples	Average	Median	90% line	Max	Error %	Throughput
HTTP data insert	10000	1525	762	4155	14308	0.00%	18.5/s

### 4.2 Operation Trend Analysis

The server and client worked fine during the test. Through memory leak monitoring during the test time, it was found that the heap occupancy index is relatively stable, and no obvious memory leak exists. Its operating trend is shown in Fig. 1.

As can be seen from Fig. 1, under the conditions of simulated client-intensive access test, the server's memory usage has been maintained between 1G–2G during the test. Each garbage collection can recover the memory to a normal level of about 1G. Memory growth is also in a basically uniform range of change, without any memory leaks. Due to the role of the domain cache, a large number of zero-time objects are avoided, and the interval width is large, that is, the garbage collection frequency is low (about once every 10 min), which effectively ensures that the server provides gapless services to users.



**Fig. 1.** System operation trend

## 5 Conclusion

With the advent of the era of artificial intelligence, intelligent computer computing is constantly developing, the informatization of sports competition management is also continuously promoted, and the informatization of school sports competition management will be further and more extensively promoted. This paper proposes a method for managing sports competitions based on intelligent computer computing, and designs a management system based on this method. The system is tested for functionality and performance. First, the system's availability is tested by simulating environmental tests. Then I did the actual use and test in a college and got a good response. To a large extent, the workload of school administrators and contestants is reduced, and the accuracy and speed that were previously unmanageable by manual processing have been achieved.

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# Artificial Intelligence Knowledge Transfer and Artificial Intelligence New Product Development Quality Under Knowledge Leadership

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**Abstract.** This paper studies how artificial intelligence (AI) knowledge transfer affect AI product development under the leading style of knowledge leadership, and samples 113 AI product R&D teams from 42 Chinese entrepreneurs in Guangzhou and Shenzhen for empirical study. The test results indicate that (1) director's knowledge leadership has direct positive impact on AI knowledge transfer including both internal and external AI knowledge transfer, and AI new product development quality significantly; (2) AI knowledge transfer including both internal and external AI knowledge transfer has direct positive impact on AI new product development quality significantly, and at the same time mediates the relationship between the director's knowledge leadership and AI new product development quality.

**Keywords:** AI knowledge transfer · AI product development · Knowledge leadership

## 1 Introduction

Artificial intelligence (AI) is a technology referring to the use of computer speech recognition, translation, automatic summarization of text, automated information collection and big data computing technology, through the self-learning, value judgment, observation and logical thinking judgment of the machine human brain system, while responding to the application scenario [1, 2]. AI has brought revolutionary results in improving labor efficiency, reducing labor costs, creating new job demands, and facilitating human life. It provides new economic growth drivers for the current exhausted global economy and plays an indispensable role [3].

At present, AI products have been widely used in finance, education, medical, retail, transportation, security and other fields, resulting in AI products of face recognition identity verification, financial instrument identification, AI assisted medical image diagnosis, retail product identification, automatic driving, wearable devices. The IDC report shows that the Chinese AI market has reached to US\$1.8 billion in 2018 and will

reach US\$11.9 billion by 2023. For AI enterprises, in the face of such a fast-growing AI market, how to quickly develop innovative high-quality AI products and take the lead in seizing the market has become an urgent consideration for every AI R&D team.

However, most previous studies which researched on AI product development quality are from the aspects of technology development and technical research such as AI algorithms [4, 5], AI imaging techniques [6, 7], AI deep learning [8, 9]. Very few of them are researched from the perspective of knowledge management and team level. Zhou et al. point out that knowledge leadership is an important leadership style to improve the performance of knowledge-intensive product development [10]. It can help the R&D team absorb and manage a large amount of knowledge and quickly develop high-quality new products.

Therefore, this paper will take 113 AI product R&D teams from 42 Chinese entrepreneurs in Guangzhou and Shenzhen city as the empirical study samples, so as to discover whether and how the knowledge leadership style of R&D team's directors can help increasing the development quality of AI new product through improving AI knowledge transfer including both internal and external AI knowledge transfer, thereby to provide new suggestions for AI firms to perfect AI product research while facing the fierce market contest.

## 2 Literature Review and Theoretical Hypotheses

Skyrme pioneered the conception of knowledge leadership in 2000 from the perspective of its core functions [11]. He believes that knowledge leadership refers to the leadership that leaders provide a high level of support for knowledge workers based on their deep understanding of knowledge workers. After that, Viitala proposes knowledge leadership from the perspective of organizational environment support, refers to leadership behaviors that encourage employees to share knowledge, creating a supportive learning atmosphere, supporting learning processes, and exemplary role-playing [12]. Both believe that the implementation of knowledge leadership can significantly promote knowledge-intensive and technology-intensive R&D team members have the ability to acquire, absorb, create and apply internal and external knowledge. Which is to say that while the AI product R&D team leaders using knowledge leadership style, directors would be able to make an very good environment to guide AI team members to obtain AI knowledge and to be willing to share AI knowledge, thereby prompting the AI R&D team to transfer AI knowledge from both internal and external of the firms effectively. Meanwhile, research from Zhou et al. further demonstrates that knowledge leadership takes a significant direct effect on employee's innovating behavior and new product development quality [10]. In other words, the usage of knowledge leadership by the AI product R&D team director will take a significant effect on the AI new product development quality. Therefore, considering the above theory studies, the following hypotheses are proposed to be proved:

H1a: Knowledge leadership takes a significant direct positive effect on Internal AI knowledge transfer.

H1b: Knowledge leadership takes a significant direct positive effect on External AI knowledge transfer significantly.

H2: Knowledge leadership takes a significant direct positive effect on AI new product development quality.

Li believes that in the process of new product development, knowledge transfer is an important means to quickly acquire key knowledge and technology, and has an important impact on the speed and quality of knowledge-intensive new product development [13]. Leonard-Barton points out that the source of knowledge transfer can be divided into seven ways including consultants, customers, national laboratories, vendor, universities, other competing companies and other non-competitive companies [14]. Harem et al. argue that the source of knowledge transfer can be attributed to external knowledge transfer and internal knowledge transfer, and both ways can take comparative market advantage to the firms or team [15]. Therefore, for researching knowledge-intensive AI new products, it is necessary to transfer both internal AI knowledge and external AI knowledge so as to ensure the research speed and quality of AI products, while being in the face of fierce market competition and rapid market replacement environment. In other words, AI knowledge transfer including both external and internal AI knowledge transfer, will take a significant effect on the quality of AI new product development. Therefore, considering the above theory studies, the following hypotheses are proposed to be proved:

H3a: Internal AI knowledge transfer takes a significant direct positive effect on the development quality of AI new product.

H3b: External AI knowledge transfer takes a significant direct positive effect on the development quality of AI new product.

According to the mediating effect principle of Baron and Kenny [16] and synthesize the previous propositions of H1a to H3b, this paper believes that AI knowledge transfer including both the Internal AI knowledge transfer and the external AI knowledge transfer may mediate the relationship between knowledge leadership and AI new product development quality. Thus, considering the above theory studies, the following hypotheses are proposed to be proved:

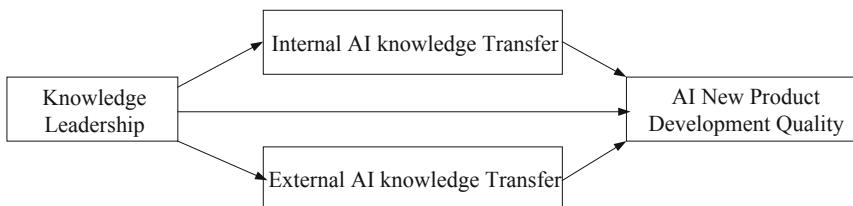
H4a: The Internal AI knowledge transfer mediates the relationship between knowledge leadership and the development quality of AI new product.

H4b: The External AI knowledge transfer mediates the relationship between knowledge leadership and the development quality of AI new product.

### 3 Study Plan

#### 3.1 Theoretical Framework

Considering with theoretical review, the theoretical framework and theoretical hypotheses are summarized in Fig. 1.

**Fig. 1.** The theoretical framework

### 3.2 Measuring Scales

All measuring scales used are 5-point Liker Scale in this study. The format and contents of the measuring scales of knowledge leadership (KL), internal AI knowledge transfer (AI-IKT), external AI knowledge transfer (AI-EKT), AI new product development quality (AI-NPDQ) are firstly developed from theoretical literatures review. The scale measurement for knowledge leadership was used from Yang and You which contained 5 items [17]. The scale measurement for Internal AI knowledge transfer was used from Ni and Lin which contained 3 items [18]. The scale measurement for Internal AI knowledge transfer was used from Harem et al. which contained 3 items [15]. And the scale measurement for AI new product development quality was used by Reeves and Bednar which contained 4 items [19].

### 3.3 Study Samples

This paper takes AI firms as study samples from Guangzhou and Shenzhen city from P.R. China. The study unit is the AI product R&D teams. All the questionnaires were issued by persons with the help of local governors lasted for three months. A total of 150 questionnaires were surveyed to 45 AI firms with 150 AI product R&D teams. 124 questionnaires got returned and 113 questionnaires were found to be valid. Using SPSS19.0 to analyze the data, the description results show that there are 11 product teams in finance, 16 product teams in education, 11 product teams in medical, 9 product teams in retail, 14 product teams in transportation, 12 product teams in security, 31 product teams in industrial robot, and 9 product teams in others. Most of these firms are in small and medium size (75.2%).

## 4 Data Test

### 4.1 Reliability and Validity Test

In order to make sure the reliability of samples, this paper used SPSS19.0 to make alpha test for the observing variables, and the tested results suggested that all the Cronbach's  $\alpha$  value of variables were bigger than standard value of 0.7 in Table 1, showing that the measurement scale of knowledge leadership, internal AI knowledge transfer, external AI knowledge transfer, and AI new product development quality has perfect reliability.

**Table 1.** Tested results for Cronbach's  $\alpha$ 

Variables	$\alpha$ value
Knowledge leadership	0.81
Internal AI knowledge transfer	0.92
External AI knowledge transfer	0.79
AI new product development quality	0.90

And the validity test of knowledge leadership, internal AI knowledge transfer, external AI knowledge transfer, and AI new product development quality is used CFA method. The results in the Table 2 show that the four-factor model has the best data fitted while considering other models, providing evidence that all the scales have good validity.

**Table 2.** CFA tested results

Model	Factors	CFI	TLI	RMSEA	$\chi^2/df$
Four-factor	KL, AI-IKT, AI-EKT, NPDQ	0.980	0.975	0.044	1.213
Three-factor-1	KL, AI-IKT+AI-EKT, NPDQ	0.914	0.897	0.089	1.890
Three-factor-2	KL+AI-IKT, AI-EKT, NPDQ	0.832	0.797	0.125	2.751
Three-factor-3	KL+NPDQ, AI-IKT, AI-EKT	0.860	0.831	0.114	2.458
One-factor	KL+AI-IKT+AI-EKT+NPDQ	0.628	0.566	0.183	4.735

## 4.2 Theoretical Model Test

Previous scholars believes that the theoretical model test by SEM should do measurement from 3 aspects containing the absolute index fit, asymptotic index fit and the summarized index fit [20]. The tested results for the theoretical model index fitness were shown in the Table 3. It indicates to us that most indexes have achieved the accepted standard, that is to say, the theoretical model of this study is acceptable and the hypothesizes tested are valid.

## 4.3 Hypothesis Test

The tested results for the theoretical hypothesis are presented in the Table 4. The tested results found that Hypothesis 1a, Hypothesis 1b, Hypothesis 2, Hypothesis 3a, Hypothesis 3b, Hypothesis 4a and Hypothesis 4b were all got supported. The standardized coefficients for the SEM model of this study presented in the Fig. 2.

The structural equation model with coefficients are in the Fig. 2.

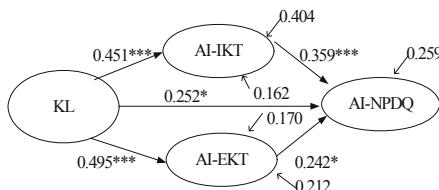
**Table 3.** Tested results with the structural equation modeling (SEM)

Whole model index fit		Perfect standard	Acceptable standard	Tested results
Absolute index fit	RMSEA	Small than 0.08	Small than 1.00	0.064
	RMR	Small than 0.05	Small than 0.08	0.063
	GFI	Bigger than 0.90	Bigger than 0.80	0.872
Summarized index fit	$\chi^2/df$	From 1.00 to 2.00	From 2.00 to 3.00	1.461
	AIC	Small than Satu. AIC (240)	Small than Indp. AIC (1040)	194.211
	PGFI	Bigger than 0.50	Bigger than 0.50	0.617
	PNFI	Bigger than 0.50	Bigger than 0.50	0.710
Asymptotic index fit	NFI	Bigger than 0.90	Bigger than 0.80	0.877
	RFI	Bigger than 0.90	Bigger than 0.80	0.848
	AGFI	Bigger than 0.90	Bigger than 0.80	0.819
	CFI	Bigger than 0.90	Bigger than 0.80	0.957

**Table 4.** The hypothesis tested results

Route	Coefficients	P-value	Hyp.	Results
KL→AI-IKT	0.451***	0.000	H1a	Yes
KL→AI-EKT	0.495***	0.000	H1b	Yes
KL→AI-NPDQ	0.252*	0.046	H2	Yes
AI-IKT→NPDQ	0.359***	0.000	H3a	Yes
AI-EKT→NPDQ	0.242*	0.034	H3b	Yes

Note: \*means P less than 0.05; \*\* means P less than 0.01;  
\*\*\* means P less than 0.001;

**Fig. 2.** The structural equation model with coefficients

In order to test the mediating effect of the hypothesis model, this paper uses Bootstrap methods recommended by Hayes to make analysis [21]. Bootstrapping results in Table 5 show that the indirect effect of internal AI knowledge transfer and external AI knowledge transfer are 0.169 and 0.106, between 95% confident interval of [0.075, 0.314] and [0.021, 0.232]. As 95% confident interval of both internal and external AI knowledge transfer are both included no zero, it indicates that the indirect

effect of AI knowledge transfer including both internal and external AI knowledge transfer is significant. Thus, H4a and H4b are supported.

**Table 5.** Bootstrap testing results for the mediating effect of AI knowledge transfer

The direct path	Indirect path	Mediating effect	95% confident interval
KL→AI-NPDQ	KL→AI-IKT→AI-NPDQ	0.169	[0.075, 0.314]
KL→AI-NPDQ	KL→AI-EKT→AI-NPDQ	0.106	[0.021, 0.232]

## 5 Conclusions

The study builds up a theoretical model through theories review to learn AI R&D team director's knowledge leadership can help increasing AI new product development quality through improving AI knowledge transfer including both internal and external AI knowledge transfer with 113 AI product R&D teams from 42 Chinese entrepreneurs in the Guangzhou and Shenzhen cities as an empirical study. Results show that director's knowledge leadership has a direct positive impact on AI knowledge transfer including the internal AI knowledge transfer and the external AI knowledge transfer, and improve AI new product development quality significantly. In addition, AI knowledge transfer including the internal AI knowledge transfer and the external AI knowledge transfer has a direct positive impact on AI new product development quality significantly, and plays partial mediating role on the relationship between the director's knowledge leadership style and AI new product development quality. These conclusions make significant contributions to the theories of knowledge leadership, AI knowledge transfer and AI new product development quality or related theory.

First, this study confirms that the AI R&D team leader using knowledge leadership is a predictive variable that significantly improves the ability and effectiveness of AI knowledge transfer including both internal and external AI knowledge transfer, and can help quickly acquired the key knowledge and key technologies required from the AI R&D team. Therefore, in order to cope with the fierce competition in the market, firms should try their best to select AI product R&D team leaders with the knowledge leadership style, to adapt the requirements of the era of knowledge economy.

Secondly, this study confirms that AI knowledge transfer including both external and internal AI knowledge transfer can significantly improve the AI new product development quality. This shows that the R&D team can develop high-quality AI products that are more suitable for market demand by absorbing, internalizing and recreating AI knowledge transferred from internal and external. Therefore, firms should build an efficacious knowledge transfer management system to make sure that knowledge can be smoothly flowed inside and outside the team. At the same time, firms should also build a harmonious knowledge sharing atmosphere to promote knowledge sharing among AI team members.

Finally, the empirical results of this paper show that AI knowledge transfer including both internal and external AI knowledge transfer plays a very significant mediating role on the relationship between AI R&D team leader's knowledge leadership and AI new product development quality. This finding reveals the "black box" between knowledge

leadership and the quality of AI new product development, indicating that knowledge leadership improving the quality of AI new product development quality is mainly by increasing AI knowledge transfer. These conclusions are of great significance for us to make in-depth understanding of the positive role of knowledge leadership in AI product R&D team management.

Limitations of the study are that the impact of AI R&D teams' features such as leaders' gender, work experience, education level is not taken into consideration while doing the empirical study. Future researches could concentrate on them.

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# Algorithm for Motion Video Based on Basketball Image

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**Abstract.** To enhance quantitative evaluation of basketball motion, basketball video and image analysis are carried out in basketball training, and a feature extraction algorithm for basketball motion video based on edge contour gray detection is proposed. The image noise of the original basketball video frame is reduced by wavelet denoising method. The gray histogram analysis and edge contour extraction are carried out. Combined with the distribution of the adjacent frames of the basketball image, the electronic image stabilization compensation is carried out. According to the results of the electronic image stabilization of the basketball video, the fast capture and feature extraction of the basketball motion action are carried out, and the accurate analysis of the motion video is realized. The proposed algorithm can achieve high frame extraction accuracy of basketball video analysis and enhance recognition of basketball motion.

**Keywords:** Basketball · Image · Basketball motion video · Electronic image stabilization

## 1 Introduction

Basketball is one of the most widely used ball sports at present. Basketball has strong skill and high requirement for action. In basketball training, analysis of basketball motions is needed. Currently, the video and image of basketball motion is normally analyzed by computer vision feature analysis method, in order to guide basketball training more effectively. When correcting basketball motions by computer 3D visual analysis, it is necessary to reconstruct and analyze the vision and image of the basketball trajectory, motion amplitude, shooting intensity and landing point, so as to construct an expert data system for comprehensive study and judgment, and guide basketball training in real time. Under the computer vision, the basketball motion correction is carried out [1]. At present, the critical node control method is mainly used to realize the limb feature analysis and the extraction of the basketball motion feature in the image. Combined with fuzzy reasoning control technology, the characteristic analysis and real-time monitoring of players' shooting movements are realized [2]. However, in the actual competition and training, basketball players have the characteristics of dynamic and sudden posture in shooting, and the features are disturbed in image collection and computer vision analysis, which results in poor performance of the basketball angle correction in the real-time and object-oriented [3].

In this work, a feature extraction algorithm for basketball video based on edge contour gray detection is proposed. The wavelet method is used for denoising the original basketball's video frame image, and the error compensation control of the video frame sequence and the basketball game training are improved. The results of simulation experiments demonstrate that the proposed method has advantages in enhancing the video analysis of basketball motions.

## 2 Image Information Acquisition and Noise Reduction of Basketball Motion Video

### 2.1 3D Visual Information Collection

Image analysis and feature extraction are carried out to correct basketball motions. Firstly, the basketball vision acquisition system is constructed to realize real-time monitoring of video frame method. Fast displacement compensation is needed to realize the stabilization of basketball video frame image. The input image is pre-processed and then filtered by wavelet denoising method [4]. First, binary segmentation method is adopted to obtain gray image of basketball video frame image  $i$ , and then motion parameters are solved according to the displacement of basketball motion. Through global estimation of the motion parameters and the acquisition of the original basketball video frame image, and the images collected can be represented by Eq. (1):

$$I(u, v) = \left( \frac{1}{2} + \frac{1}{4} \left( \cos\left(\frac{\pi u^2}{R}\right) + \cos\left(\frac{\pi v^2}{R}\right) \right) \right) \times 255 \quad (1)$$

Where,  $R$  represents a canonical constant. In the analysis of basketball video frame image,  $R = 1000$ . The 3D visual information acquisition structure model of basketball is given to collect the image information in the course of the movement. Firstly, it is defined that  $\sigma_i$  denotes the acquired 3D visual information node data of basketball motion [5].  $\sigma_x, \sigma_\theta, e_i$  are the fusion parameters of shape change of basketball motion:

$$\sigma_i = \begin{cases} \mu \sin \frac{\pi e}{2\mu}, & |e_i| < \mu \\ \mu, & |e_i| \geq \mu \\ -\mu, & |e_i| \leq -\mu \end{cases} \quad (2)$$

Where  $\mu$  is the parameter value of the contour feature point of the shape edge is denoted as  $\mu$ ,  $\mu > 0$ ; stereoscopic segmentation method is adopted to obtain the three-component transfer probability of the shape feature in the basketball process:

$$u_{eqx} = \lambda(-\hat{f}_x - \lambda_x \dot{e}_x - \alpha_x \dot{\sigma}_x + \ddot{x}_d) / (\lambda g_x + g_\theta) \quad (3)$$

$$u_{eq\theta} = (-\hat{f}_\theta - \lambda_\theta \dot{e}_\theta - \beta_\theta \dot{\sigma}_\theta + \ddot{\theta}_d) / (\lambda g_x + g_\theta) \quad (4)$$

$$u_{sw} = -K \text{sat}(S(t)/\mu) \quad (5)$$

Based on the above formula, the training set is transformed into an action vector library, thus realizing the 3D visual information acquisition of basketball [6].

## 2.2 Wavelet Denoising of Basketball Video Frame Image

Wavelet denoising method is applied to denoise the original basketball video frame image. The Harris wavelet function is used to convert the frame format of basketball video frame image, wherein the wavelet function is:

$$D(x, y, \sigma) = (G(x, y, k\sigma) - G(x, y, \sigma)) * I(x, y) = L(x, y, k\sigma) - L(x, y, \sigma) \quad (6)$$

Wherein

$$L(x, y, \sigma) = G(x, y, \sigma) \otimes I(x, y) \quad (7)$$

Where,  $I(x, y)$  represents the gray value of basketball video frame image at  $(x, y)$ ,  $L(x, y, \sigma)$  represents the kernel space, and  $G(x, y, \sigma)$  denotes the correlation information function in the image block [7].

$$G(x, y, \sigma) = \frac{1}{2\pi\sigma^2} e^{-\frac{(x^2+y^2)}{2\sigma^2}} \quad (8)$$

The corner position coordinate in basketball video frame image is judged and the image noise is obtained along the gradient direction. Based on the Euclidean distance  $E(d(x, y))$  between noise points, multi-level noise separation as well as denoising and filtering of basketball video frame image can be realized [8].

## 3 Feature Extraction and Basketball Video Image Analysis

On the basis of image acquisition and denoising pretreatment of basketball motion, a feature extraction algorithm for basketball video based on edge contour gray detection is proposed in this work. The relative motion parameter distribution matrix of basketball video frame sequence is described as follows: electronic image stabilization compensation based on the distribution of adjacent frames of basketball motion image, and the relative motion parameter distribution matrix of frame image sequence of basketball video is described as follows.

$$D = \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} \quad (9)$$

Assuming that  $\alpha$  is the eigenvalue of the basketball longitudinal displacement,  $\beta$  is the characteristic value of the motion parameter distribution of the basketball lateral

swing displacement [9], and the ratio of  $\alpha$  and  $\beta$  is  $\gamma$ ,  $\alpha/\beta=\gamma$ , the relation between the adjacent frames of the image under the basketball displacement is obtained as follows:

$$\frac{\det(D)}{\text{trace}^2(D)} = \frac{\alpha \cdot \beta}{(\alpha + \beta)^2} = \frac{\gamma}{(\gamma + 1)^2} \quad (10)$$

If

$$\frac{\gamma}{(\gamma + 1)^2} < \frac{\gamma_0}{(\gamma_0 + 1)^2} \quad (11)$$

According to the result of empirical mode decomposition, the intensity of pixel sequence is sorted, and the image stabilization compensation is carried out by combining the pixel characteristics of adjacent frames of motion image [10]. The output of image information of basketball motion under computer vision is obtained:

$$\begin{aligned} \dot{S}(t) &= \lambda \dot{s}_x + \dot{s}_\theta = \lambda(\lambda_x \dot{e}_x + \ddot{e}_x + \alpha_x e_x) + (\lambda_\theta \dot{e}_\theta + \ddot{e}_\theta + \beta_\theta e_\theta) \\ &= \delta(X, t) - mS(t) \end{aligned} \quad (12)$$

While  $t \rightarrow \infty$ , the error of block pheromone of single frame angle will tend to 0, and the pixel feature of the area surface grid of basketball is collected as:

$$P(i, j) (i \in [0, \text{int}(W/2) - 1], j \in [0, \text{int}(H/2) - 1]) \quad (13)$$

The error convergence values of basketball video frame information acquisition are expressed as follows:

$$\lim_{t \rightarrow \infty} (\lambda e_x(t) + e_\theta(t)) = 0 \quad (14)$$

The orthogonal projection sequence of the computed image is obtained:

$$S(s) = \frac{1}{s + m} \delta(s) \quad (15)$$

In the basketball sports space, with the video and image information collection, the image processing algorithm is used to analyze the motion angle correction. The distribution function of adjacent frames of basketball images is obtained as follows:

$$\left. \begin{aligned} J_1(w, e) &= \frac{\mu}{2} w^T w + \frac{1}{2} \gamma \sum_{i=1}^N e_i^2 \\ s.t. \quad y_i &= w^T \varphi(x_i) + b + e_i, \quad i = 1, \dots, N \end{aligned} \right\} \quad (16)$$

The grayscale component of the three-dimensional image of basketball is expressed as:

$$c = \left[ \sum_{1 \leq ij \leq \mu} m_{ij} \cdot x'_{i,0} \cdot x'_{j,1} + \sum_{1 \leq ij \leq \mu} b'_{ij} \cdot \Pi_{i,0} \cdot \Pi_{j,1} + \sum_{1 \leq ij \leq \beta} b_{ij} \cdot x_{i,0} \cdot x_{j,1} \right]_{x_0} \quad (17)$$

According to the electronic stabilization result of basketball video, the feature of basketball motion can be captured and extracted, and the convergence value of feature extraction is obtained:

$$\begin{aligned} \lim_{t \rightarrow \infty} S(t) &= \lim_{s \rightarrow 0} \left( \frac{s}{s+m} \cdot \delta(s) \right) \\ &= \lim_{s \rightarrow 0} \frac{1}{s+m} \cdot \lim_{s \rightarrow 0} s\delta(s) \\ &= \lim_{s \rightarrow 0} \frac{1}{s+m} \cdot \lim_{t \rightarrow \infty} \delta(t) \\ &= \text{const}/m \end{aligned} \quad (18)$$

The autocorrelation vector of 3D information of output basketball movement is:

$$\lambda(\lambda_x \dot{e}_x + \ddot{e}_x + \alpha_x e_x) + (\lambda_\theta \dot{e}_\theta + \ddot{e}_\theta + \beta_\theta e_\theta) = 0 \quad (19)$$

In the wavelet scale space, the edge contour features of the 3D visual image of basketball motion are correlated on the time axis and the frequency axis. The gray histogram analysis and the edge contour feature denoising of basketball motion video frame image is carried out. The visual feature distribution state vector of fast capture of basketball movement is obtained as follows:

$$D = \{S_{ij}(t), T_{ij}(t), U_{ij}(t)\} \quad (20)$$

Where,  $S_{ij}(t)$  represents the repeated factors of basketball position. Finally, the iterative process of frame image analysis of basketball video is obtained as follows:

$$R_1 = \frac{\mu_w}{2\pi K h m} \ln \frac{R_{eh}}{2(i+1)r_w} \quad (21)$$

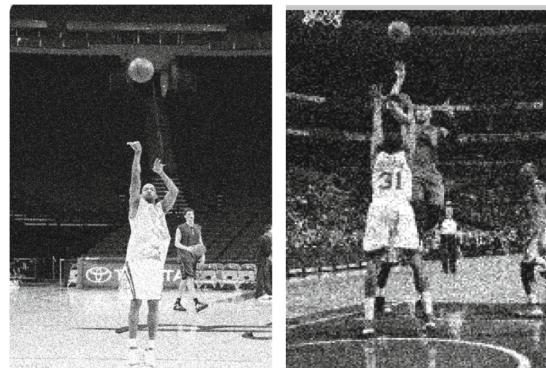
$$R_2 = \frac{\mu_w}{2\pi K h} \left[ 1.7 \ln \frac{R_{eh}}{r_f} + 12Z_f + 25Z_f^2 \right] \quad (22)$$

$$R_3 = \frac{\mu_o}{2\pi K h} \ln \frac{r_w}{r'_w} \quad (23)$$

Where, the ratio  $K$  is the differential feature coefficient, and  $h$  is the pixel intensity.

## 4 Simulation

Simulations are carried out to evaluation efficiency of the proposed method in basketball video image analysis. The frequency of image sampling is 15 kHz, the frame length is 1024 frames, and the number of video frames is 1024. The test set of basketball images includes 2000 images, and the original basketball images are collected as shown in Fig. 1.



**Fig. 1.** Original image

By using the method of video frame analysis and action feature extraction, the optimized output of basketball dynamic feature extraction is obtained, which is shown in Fig. 2.



**Fig. 2.** Optimal output of basketball image

**Table 1.** Performance test comparison

	PSNR/dB	Basketball hit ratio/%	Time cost/ms
Artificial correction	14.54	65.43	12.1
3D visual correction	51.23	76.89	43.3
Proposed method	68.32	93.21	6.5

Figure 2 shows that the proposed method can improve the image quality and enhance feature extraction. The performance comparison of different methods in recognition of motion features are shown in the Table 1. The analysis shows that the proposed method can improve the training level of basketball, increase the shooting rate and shorten the action completion time.

## 5 Conclusions

In this work, a feature extraction algorithm for basketball video based on edge contour gray detection is proposed. The image noise of the original basketball video frame is reduced by Wavelet denoising method. Combined with the distribution of the adjacent frames of the basketball image, the electronic image stabilization and compensation are carried out. According to the results of the electronic image stabilization of the basketball video, the fast capture and feature extraction of the basketball motion action are carried out, and the accurate analysis of the motion video is realized. The proposed method has higher frame extraction accuracy and improved recognition rate of basketball motion, which is expected to be super beneficial for guiding basketball training.

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# Heart Rate Variability Analysis Method Based on KNN Classification

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**Abstract.** Complex fluctuations of heart rate variability (HRV) reflect the autonomic regulation of the heart. At present, the characteristics of different HRV signals are not obvious and the classification accuracy is not high which restricts their practical use. Therefore, this paper proposes a signal pattern recognition algorithm based on KNN classification for HRV signal analysis and recognition. HRV characteristic matrix is formed by HRV characteristic values in frequency domain which is extracted by AR spectrum analysis, time domain characteristic values and nonlinear characteristic values. Then the matrix is processed by the K-nearest neighbor classification algorithm. In order to verify the accuracy of the algorithm, four types of ECG data in MIT-BIH database are used to train and detect the algorithm in this paper. The proposed algorithm's accuracy of HRV classification and recognition can be up to 93.5%, which is higher than other classification recognition algorithms of the same type. These results provide a new method for extraction and classification the eigenvalues of heart rate variability.

**Keywords:** Heart rate variability · AR spectrum analysis · K-neighbor classification algorithm

## 1 Introduction

Heart rate variability refers to the continuous tiny fluctuation of the instantaneous heart rate between sinus heart [1] because of its easy objective directly to monitor individual neurological status and physical fitness, so the mood is widely used in most dimensions of personality analysis research [2]. Currently, the main difficulties of HRV analysis and recognition is that ECG signals contain various types of information. Most signals have more than one appearance. At the same time, the classification algorithm based on machine learning has higher requirements on training samples. Therefore the analysis characteristics and classification techniques of HRV need to be further optimized. HRV characteristic analysis can be carried out from linear and nonlinear aspects. Linear analysis includes time domain and frequency domain. Time domain analysis mainly use statistical methods to describe the difference histogram shape or cardiac cycle (RR interval) histogram. The frequency domain analysis method includes classical spectral analysis method and modern spectral analysis method. Compared with the classical spectral analysis method, the modern spectral analysis method based on autoregression model has shorter requirements on the length of time series and it can truly reflect the

HRV spectrum changes. This method has advantages of smoother curve, high resolution and easy identification of spectral peak center frequency. Because HRV is a complex signal, so other useful information in the signal beyond the time domain and frequency domain also needs to be analyzed. In the classification of signals, there are many methods such as decision tree, BP neural network, and based on SVM classifier algorithm [3]. Compared with other algorithms, k-nearest neighbor classification (KNN) is a supervised learning algorithm with the characteristics of theoretical maturity, simple calculation, high accuracy and insensitivity to outliers. When there is too much crossover or overlap in the class domain of the undivided sample set, KNN has more advantages. On this basis, this paper proposes an recognition algorithm based on KNN. The characteristics of HRV in time domain are extracted by statistical method and in frequency domain are extracted by AR spectral estimation. HRV eigenvalue matrix is obtained by eigenvalues and HRV complexity. Then the acquired characteristic indexes are classified and identified by KNN. The test of public database shows that the recognition effect of this algorithm is better than other algorithms.

## 2 Basic Theory

### 2.1 Sources of Data

The experimental data of the study were sampled from the MIT/BIH arrhythmia database provided by the Massachusetts institute of technology [4]. The signal sampling frequency is 360 Hz and A/D resolution is 11 Bit. According to manually calibrated heartbeat notes on the file, four types of ECG signal data in MIT/BIH ECG database are studied in this paper such as normal electrocardiogram (class N), right bundle branch block heart beat (class R), ventricular premature beat (class V), and left bundle branch block (class L). 200 groups of 5 min long signals are extracted respectively to obtain 800 groups of data.

### 2.2 AR Spectrum Analysis

AR model is a regression model that combines several random variables in the early stage to describe the random variables in the later stage, which is a linear prediction in essence [5]. The basic idea is that stationary random signal  $x_n$  is regarded as the output of an all-pole linear system  $H(z)$  excited by white noise  $z$  with mean zero and variance  $\sigma^2$ . The AR model expressed by difference variance  $x_n$  is

$$x(n) = - \sum_{k=1}^p a_k x(n-k) + \omega(n), k = 1, 2, \dots, p \quad (1)$$

According to the formula, AR model can be solved only by calculating the coefficient  $a_k$  and variance  $\sigma^2$ . After AR model is obtained, its power spectrum  $S_X(\omega)$  can be expressed as

$$S_X(\omega) = |H(\omega)|^2 \sigma^2 = \frac{\sigma}{|1 + \sum_{k=1}^p a_k e^{-j\omega k}|^2} \quad (2)$$

### 2.3 Complexity Calculation

The concept of complexity, first proposed by Kolmgorov, is simply that the complexity of a thing can be measured in the length of the computer language used to describe it. In the late 1980s, Kasper et al. proposed the specific algorithm of random sequence complexity measure, and the complexity measure obtained by that algorithm is called Kc complexity. Because the complexity analysis method is not strict on the length of the sequence, it is widely used in the field of signal processing.

### 2.4 KNN Classification Algorithm

KNN classification algorithms is lazy learner and it is case-based learning with no explicit learning process. The data set has been classified and eigenvalues in advance, which will be processed directly after receiving new samples. The basic idea is to divide the samples to be classified into the categories where the majority of the k most similar samples in the feature space belong to. The basic process is:

The sample C to be classified contains n labeled tuples  $P_1, P_2, \dots, P_n$  and m tuples to be distinguished  $P_{n+1}, P_{n+2}, \dots, P_{n+m}$ . Any tuple  $P_j$  has a characteristic values  $(P_{j1}, P_{j2}, \dots, P_{ja})$ . Tuples with tags have data tags  $P_{jr}$ . Then set up the characteristic matrix  $C_{TR}$  with tag tuples in sample C as

$$C_{TR} = \begin{bmatrix} P_{11} & P_{12} & \cdots & P_{1a} \\ P_{21} & P_{22} & \cdots & P_{2a} \\ \vdots & \vdots & \ddots & \vdots \\ P_{n1} & P_{n2} & \cdots & P_{na} \end{bmatrix} \quad (3)$$

The label vector is

$$R = \begin{bmatrix} P_{1r} \\ P_{2r} \\ \vdots \\ P_{nr} \end{bmatrix} \quad (4)$$

The eigenmatrix CTE of pending tuples is

$$C_{TE} = \begin{bmatrix} P_{n+11} & P_{n+12} & \cdots & P_{n+1a} \\ P_{n+21} & P_{n+22} & \cdots & P_{n+2a} \\ \vdots & \vdots & \ddots & \vdots \\ P_{n+m1} & P_{n+m2} & \cdots & P_{n+ma} \end{bmatrix} \quad (5)$$

- (1) Specify K in KNN
- (2) The eigenmatrix  $C_{TR}$  of labeled tuples and tag vector R are taken as training sets. And  $C_{TE}$  is used as the test set. Starting with the first row of  $C_{TE}$  data, calculate the distance between the tuple and all tuples in  $C_{TR}$ . Euclidean distance is usually selected to calculate two tuples. For example, two tuples  $P_c = (x_1, x_2, \dots, x_m)$  and  $P_d = (y_1, y_2, \dots, y_n)$  its Euclidean distance is

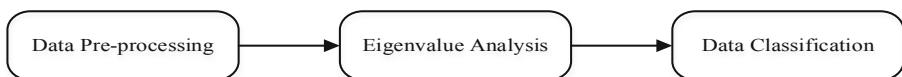
$$d = dist(P_c, P_d) = \left( \sum_{i=1}^n (xi - yi)^n \right)^{1/n} \quad (6)$$

- (3) Get the data label of K tuples with the smallest distance calculated. With the K groups of data tags as the discriminating basis, the most likely tag of the tuple is determined as the tag of the first row of data.
- (4) Continue to select the next row of data and repeat the c and d process until all the identification and classification are completed.

It can be seen from the above that the selection of k value is very important in the classification process with KNN algorithm. In general, k values range from 1 to  $\sqrt{n}$  where n is the number of sample sets and the value of k is usually less than 20. For specific values, cross validation method can be adopted: start from k = 1, use the test set to estimate the classifier's error rate. Then k increases by 1 in turn, calculate the error rate corresponding to each k value, at last select the k corresponding to the minimum error rate.

## 2.5 Method in This Paper

In this method, the characteristic values of HRV frequency domain are extracted by AR spectrum analysis. Then the HRV eigenmatrix can be composed of frequency-domain eigenvalues, the time-domain eigenvalues obtained by the statistical method and calculated complexity. Finally, the eigenmatrix is input into KNN for classification and identification. The specific process is shown in Fig. 1.



**Fig. 1.** Algorithm processing flow chart

- (1) Data pre-processing. Read the ECG signal file with manually calibrated heartbeat notation and time stamp. Then the ECG signal is denoised by the method of reference [6] to identify R wave and obtain HRV sequence.
- (2) Feature extraction. According to the correlation analysis of each characteristic index in the literature [7], the characteristic index whose correlation coefficient is less than 0.8 was selected. Time domain indicators include R-R interval standard

deviation reflecting the overall change of HRV and pNN50 reflecting parasym pathetic tone size which is defined as the number of R-R intervals differed by >50 ms from adjacent interval divided by the total number of all R-R intervals. Frequency domain indicators include: power ratio defined as low frequency/high frequency reflects sympathetic nervous system activity, the low frequency power that reflects sympathetic nerve and parasym pathetic nerve affect jointly and the heart rate that can reflect the change of the overall heartbeat with complexity. The HRV sequence needs to be processed before calculating the characteristic value of HRV frequency domain. By spline fitting and resampling [8], the stable and uniform sequence is further obtained. Then the FPE criterion is used to determine the optimal order. Finally, the power spectral density function of HRV sequence is calculated to obtain the characteristic value of HRV frequency domain. The time-domain eigenvalues and HR are calculated directly by statistical methods.

- (3) Classification and recognition. Using KNN algorithm, the eigenvalues of HRV of each group are obtained to form the eigenmatrix as the input of KNN. In order to accelerate the convergence of data calculation and unify the measurement units of each index, the data matrix should be normalized before classification. Then the appropriate K value of the matrix is selected by cross validation method and finally classification calculation is carried out.

### 3 Experimental Results and Analysis

#### 3.1 Feature Extraction

Using the above HRV characteristic index analysis method, the pre-processed 800 groups of data are analyzed respectively. For frequency-domain indexes, HRV sequences are obtained for power spectrum analysis based on AR model according to the principle and steps of AR spectrum analysis. First, cubic spline fitting processing and resampling are adopted, and resampling frequency is set as 4 Hz then uniform sampling signal is obtained. The optimal order is determined and the final prediction error criterion is adopted. Considering that the internal structure of each of the four types of data is similar, 200 groups are selected from each of the four types of data in order to reduce the calculation amount, and a total of 800 groups of data are selected for calculation and residual whitening verification. The unverified data is combined with the trend of FRE value changing with the order to make fine tuning. The mean value of optimal order of 800 groups data obtained through the experiment is 23.1, then  $p = 23$  in this paper. The AR model coefficients  $a_k$  and white noise variances  $\sigma^2$  of order 23 are obtained one by one. After that HRV power spectral density function is obtained.

For the time-domain eigenvalues of HRV and HR, The calculation is directly carried out by statistical method. Through analysis and calculation, the mean and standard deviation of SDNN, HR, LF/HF, LF, TP, pNN50, CPX from 800 groups data are extracted as shown in Table 1.

**Table 1.** The mean and standard deviation of data feature from 800 groups data in 5 min

	SDNN mean (SD)	pNN50 mean (SD)	LF/HF mean (SD)	LF mean (SD)	TP mean (SD)	HR mean (SD)	CPX mean (SD)
N1–N200	65.23 ( $\pm 4.3$ )	5.55 ( $\pm 2.9$ )	1.53 ( $\pm 0.8$ )	1.31 ( $\pm 0.5$ )	92.02 ( $\pm 23.1$ )	1.26 ( $\pm 0.1$ )	0.823 ( $\pm 0.1$ )
R1–R200	149.31 ( $\pm 10.3$ )	29.17 ( $\pm 3.4$ )	0.63 ( $\pm 0.2$ )	0.64 ( $0 \pm 0.1$ )	45.64 ( $\pm 12.7$ )	1.45 ( $\pm 0.2$ )	0.76 ( $\pm 0.11$ )
V1–V200	75.57 ( $\pm 8.7$ )	15.39 ( $\pm 6.3$ )	1.36 ( $\pm 0.7$ )	1.1 ( $\pm 0.1$ )	67.12 ( $\pm 20.5$ )	0.99 ( $\pm 0.2$ )	0.75 ( $\pm 0.2$ )
L1–L200	35.12 ( $\pm 2.3$ )	5.01 ( $\pm 1.1$ )	1.27 ( $\pm 0.5$ )	1.28 ( $\pm 0.3$ )	512.6 ( $\pm 24.1$ )	1.25 ( $\pm 0.1$ )	0.825 ( $\pm 0.09$ )

### 3.2 HRV Classification and Identification

The eigenmatrix formed by time-frequency eigenvalues of 800 groups of acquired data do the normalization operation, then combined data tags to form the matrix as the input of KNN. In order to verify the accuracy and feasibility of the method, the method of 10-fold cross validation is adopted. After randomly shuffling the data, it is divided into 10 parts one as the test set accounting for 10% of the sample set and 9 as the test set accounting for 90% of the sample set. KNN cross validation method is also used to determine the optimal K value before classification, and the K value is 4 in this paper. Finally, ten fold cross validation is carried out to obtain ten times of data classification. The accuracy of the method is estimated by the average of the accuracy of the results obtained from 10 operations. In order to ensure the accuracy of the obtained results, 10 times of 10 fold cross validation is carried out in this paper. The accuracy obtained after 10 times of verification is calculated to obtain its mean value, and the accuracy of the method in this paper reached 93.5%. According to the results, this method can recognize and classify HRV signals well.

### 3.3 Result Analysis

To verify the accuracy and effectiveness of the proposed algorithm, The data set in this paper is analyzed and calculated again with the algorithm proposed in the previous literatures. The results are shown in Table 2 [9–11]. The comparison results show that the signal feature extraction based on AR spectrum analysis and KNN classification method proposed in this paper has a high classification and recognition accuracy in ECG signals which can reach 93.5%. It can be seen that the algorithm is effective and feasible.

**Table 2.** Comparison of different ECG signals processing classification methods

Author	Signal feature extraction method	Classifier	Accuracy
WangYan	Fourier	SVM	89.4%
YuShun	Morphology	MLP	93.2%
Hamid	CWT	MLP	89.9%
Lisukor	Hermite	FNN	92.3%
The method proposed in this paper	AR/CPX	KNN	93.5%

## 4 Conclusion

Taking MIT-BIH database data as the sample, this paper proposes a signal frequency domain feature analysis extraction method based on AR spectrum analysis for obtaining the characteristic values of HRV signals and identifying and classifying HRV signals. The SDNN, HR, LF/HF, LF, TP, PNN50 and CPX seven characteristic indexes of 800 groups data of HRV are calculated to form the eigenvalue matrix and the HRV signals are identified and classified by KNN classification method. Compared with other algorithms, AR spectral analysis is used to extract and analyze HRV frequency-domain features, which has the advantages of high resolution, well performance of spectral line and better expression of HRV features. At the same time, a more accurate sample set is provided for KNN classification and identification. KNN algorithm has a high degree of implementation and no parameters estimation and no prior training are required. In particular, it has a good performance on multiple classification problems when applied to HRV recognition and classification, it can effectively solve the problem of low recognition accuracy due to various information types and sensitivity to outliers. This algorithm can obtain higher classification accuracy, which is simple and effective, and provides a new idea for extracting and classifying the characteristic values of HRV signals.

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# Three-Dimensional Human Motion Simulation and Video Analysis System for Physical Training

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**Abstract.** Introducing digital graphics and image technology into sports training to develop a three-dimensional human movement simulation and video analysis system for sports training, the system provides scientific and technological guarantee for effective sports training. In this paper, firstly, we introduce the background and significance of the development system, and then from video analysis. The key functions of the system are summarized in two aspects, including 3D motion simulation. Finally, the key problems and solutions needed to achieve these functions are explained in detail, including video motion human body extraction and tracking, 3D human motion simulation and simulation.

**Keywords:** Sports training · Video analysis · 3D human motion simulation

## 1 Introduction

The goal of competitive sports is “higher, faster, stronger”. Sports athletes constantly improve their speed and strength by constantly challenging themselves. In addition to hard training [1, 2], scientific training methods and means are important and effective in improving athletic performance. Approach. At present, competitive sports has reached a considerable level, and further improvement of sports performance is increasingly dependent on advanced science and technology. In order to ensure that our athletes achieve better results in future games, win more gold medals, and provide them with training tools and methods that introduce advanced technology to improve training efficiency has become a top priority [3, 4].

For a long time, the technology level of competitive sports training in China is relatively low, and subjective and experience-based teaching methods have been used. Coaches use the naked eye and experience to guide athletes’ technical movements. Practice to master the technical essentials, these have seriously affected the further rapid improvement of China’s competitive sports level [5]. Sports experts at home and abroad have achieved unanimous recognition after long-term practice and research: the introduction of digital technology (graphic image technology) in sports training, can Help athletes master the technical essentials of movement as soon as possible during the training process, reduce blind repetitions, greatly improve training efficiency, reduce the possibility of athletes being injured, and achieve the best training results. Based on the above reasons, we developed a three-dimensional human motion

simulation and video analysis system for sports training, which provides strong scientific and technological guarantees and favorable high-tech tools for Chinese athletes preparing for the Olympic Games, ensures the Olympic gold medal plan, and promotes the development of competitive sports in China.

## 2 Overview of System Key Function

The three-dimensional human motion simulation and video analysis system for sports training includes two functions: video analysis and three-dimensional human motion simulation. Their key functions are introduced below.

### 2.1 Video Analysis

The functional goal of video analysis is to maximize the potential of digital video in sports training and teaching applications. In training, provide convenient and fast visual feedback means, an effective platform for technical communication and exchange between athletes and coaches; after training, It provides an effective tool for in-depth analysis and comparison of technical action completion. In order to achieve this functional goal, the system needs to implement the following key functions: action video panorama synthesis, action video overlay comparison, and acquisition of human motion posture parameters.

#### (1) Panorama synthesis of action video

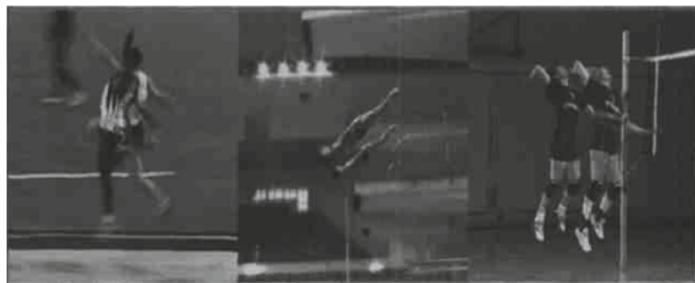
An action video is converted into a static action panoramic image (as shown in Fig. 1) to achieve the action freezing effect, so that the change process and trajectory of the action can be statically analyzed, and the overall completion and analysis of the action can be mastered and analyzed.



**Fig. 1.** The example of motion panorama

## (2) Comparison of action video overlay

Extract the athlete's human contour in one action video and superimpose it on another action video (shown in Fig. 2), seamlessly synthesized into one video, you can more clearly find the difference between the two actions, so as to grasp faster Essentials of action to improve athletic performance.



**Fig. 2.** The example of the contrast of the motion video superposing

## (3) Acquisition of human motion posture parameters

Through the video-based human motion tracking technology, the motion trajectory of each key point of the human body and the angle of the joint angle, that is, the posture parameters of the human body, are analyzed based on this, and the completion of the action is analyzed more scientifically and in depth. Figure 3 shows the athlete's chest motion during a springboard.



**Fig. 3.** Tracking results of athlete's chest motion track

In order to extract athlete regions more accurately, various processes need to be performed on the foreground, including removing shadows, removing noise, and using morphological methods to make athlete regions more complete.

Texture is an important characteristic of an image, and it represents a special arrangement of pixel values in a certain area of the image. Shadows are part of the background. Shadows have different brightness from the background, but their textures are similar. In this paper, a gradient similarity-based measure of texture similarity is used to detect shadows in the foreground. For any foreground pixel X in the current frame,  $S(X)$  can be defined to represent the texture similarity between the current frame and the background image,

$$S(X) = \frac{\sum_{u \in W_X} 2\|g(u)\| \times \|g_b(u)\| \times \cos \theta}{\sum_{u \in W_X} (\|g(u)\|^2 \times \|g_b(u)\|^2)}$$

where is Pixel center about  $5 * 5$ .

Since most of the athlete's movements occur on the court, the sports area outside the court can be regarded as noise, so the noise can be removed according to the court information. Calculate the intersection of each sports area with the court. If the intersection is empty, it indicates that the area belongs to noise, remove the area, and otherwise use this area as a candidate area for the athlete.

## 2.2 3D Human Motion Simulations

3D human motion simulation is different from the sports-assisted training function based on video analysis. It is based on digital computer simulation technology of 3D human motion, biomechanical data of human motion and real human motion data, and uses 3D realistic simulation, design and analysis technology Action, so it has a stronger guiding significance.

### (1) Action modification and design

You can edit, modify, and design new actions (as shown in Fig. 4). This tool allows coaches to design “ideal” good actions in their minds, and based on this, establish standard technical action libraries for teaching and (international) Referee training



**Fig. 4.** Visual action editing graphical interface

makes it easier and faster for athletes to master the essentials of technical movements in a visual way to improve performance.

## (2) Simulation of action scheduling

From the simulated single technical action, the coach can pick out the candidate actions that need to be orchestrated. The system will simulate the orchestration results according to the coach's wishes, and the coach can choose the best orchestration from various orchestration results (see Fig. 5). This can assist the coach in determining the preparation plan.



Fig. 5. Graphical interface for virtual orchestration



Fig. 6. Comparison of simulated motion and training video on the same screen

### (3) Comparison of simulated movements and training videos

Displaying the training video of the athlete and the standard simulated movement approved by the coach on the same screen (as shown in Fig. 6), and comparing them with the same viewpoint and synchronization can allow the coach and the athlete to analyze the difference in movement and help the athlete find out the technique disadvantages and improvements to improve training efficiency.

## 3 Analysis of Results

The experimental data used badminton game video, the image size of each frame is  $320 \times 240$ , the experimental environment is P4 CPU 2.4 GHz, 256 MB memory. In order to better analyze the efficiency of the algorithm, this paper uses the formula proposed in [5]: precision rate = tracked to the correct athlete area/tracked to all athlete areas, the results are shown in Table 1.

**Table 1.** Experimental results

Actual video	Statistical number of handkerchiefs	Precision of traditional Camshift (%)	The precision of improved Camshift (%)
Target object is not similar to background color	80	92	94
Target object is similar to background color	80	62	86

The experimental results show that the improved CamShift algorithm is more robust to tracking moving targets with similar background color. The tracking algorithm has good real-time performance, and the processing speed reaches 16 frames/s during the experiment.

## 4 Conclusions

The detection and tracking of athletes is a key step in the analysis and processing of sports videos. The adaptive Gaussian mixture model used in this paper can better deal with the slow change of lighting in a dynamic background, but when the lighting changes suddenly in the scene, such as suddenly turning on or off the lighting, a large number of “Pseudo foreground” is the background area where the light changes suddenly. In the subsequent work, we will further study the detection of light mutations in the scene and the elimination of “pseudo foreground”.

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# A Regression Model of Color Value and Substance Concentration of Colored Solution Based on Lambert Beer's Law

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**Abstract.** The paper is systematically discussed the regression model analysis based on Lambert Beer's law on the color readings of different solution materials and the concentration of substances is discussed. The data is standardized and the evaluation of the given data is completed. We derive the relevant scale factor equation according to Lambert Beer's law and establish a regression model of the color reading mean and material concentration of different solutions. In this paper, the concentration of the solution is first determined by measuring and comparing the color depth of the colored solution, and the value of R (red) G (green) B (blue) in the photograph is extracted by photographing using the different colors of the colored solution on the colorimetric test paper. By preprocessing and normalizing the data of these five different data indicators, a regression model between the RGB values of the colors and the concentration values of the colored solutions is established, and the correlation between them is determined to determine the reliability of the data. Sexuality, so that this model can be popularized and applied, and the concentration of the solution can be read efficiently and quickly by using the RGB value, chromaticity, and saturation value of the colored solution.

**Keywords:** RBG · Value Lambert Beer's law · Regression model

## 1 Introduction

Generally, the colorimetric method is a commonly used method for measuring the concentration of a chemical substance, that is, the substance to be tested is prepared into a solution and then dropped on the surface of a specific white test paper, and after it is fully reacted, a colored test paper is obtained, and then the color is obtained [5]. The test strip is compared to a standard color chart to determine the concentration level of the substance to be tested [6]. Due to the color-sensitive differences and observation errors of each person's vision, this method is greatly affected in accuracy. But with the advancement of electro-photographic technology and color resolution, we hope to establish a regression model between the color reading and the concentration of the substance, that is, as long as the color reading in the photo is input, the concentration of the substance to be tested can be obtained. Based on Lambert Beer's law, a regression model of color RGB values, HS values and five different substance concentration

values of five different chemical solutions (histamine, potassium bromate, industrial alkali, potassium aluminum sulfate, and urea in milk) was established.

## 2 Basic Concept

Digital Photo Colorimetric Method [7]: It is an analysis method for digital processing of captured images. This method is easy to operate, less time consuming, and low in cost. The principle is to select different color models according to the characteristics of the color developing solution, and the final result is obtained by the analysis software. Commonly used color models are RGB, grayscale, HSV, etc. [1, 2].

RGB value: RGB is a variety of colors in Computer Graphics by changing the three color channels of red (R), green (G), and blue (B) and superimposing them on each other. Therefore, red, green, and blue are also called three primary colors.

Lambert Beer's Law [2]: Lambert Beer's Law is the law of light absorption and applies to all color readings of solutions. The formula is  $A = \lg(\frac{I}{T}) = Wbc$ , A is for absorbance, T is the ratio of the intensity of the emitted light ( $L$ ) to the intensity of the incident light ( $L_0$ ), the molar absorption coefficient, and the thickness of the solution is the concentration of the solution.

Data standardization [3]: Data standardization is a statistically common method to eliminate the misalignment between different attributes or samples, so that the variance between different attributes or the same attribute in the same square is reduced in the same square; sometimes in order to limit the value range of the data, such as [0, 1] closed interval and so on. Some quantitative analysis methods require special standardization processes and standardization as part of their analytical approach.

Before the instrumental analysis [2] method appeared, there were many detection methods using the chemical reaction as the principle of color development. These methods include both on-site qualitative analysis and quantitative titration analysis. Although instrumental analysis has gradually replaced chemical titration, chemical colorimetry is widely used in rapid field testing because of its ease of use, low cost, and high throughput. However, such methods have color judgments that are too subjective, have large background light effects, cannot be used for quantification, and automate analysis [1]. This model proposes an image colorimetric method for the determination of colored solutions. The RGB colorimetric method is based on the difference in the reflected light of the light irradiated to different concentrations of the solution, which causes the color of the solution to change, so that the value of RGB changes.

## 3 Regression Model of Color Value and Substance Concentration of Colored Solution Based on Lambert Beer's Law

The RGB colorimetric method is based on the difference in the reflected light of the light irradiated to different concentrations of the solution, which causes the color of the solution to change, so that the value of RGB changes. According to Lambert Beer's

law [2]:  $A = \lg \frac{I_0}{I_t} = \lg \frac{1}{T} = W mc$ . The red light is:  $\lg \frac{R_0}{R_t} = W_R mc + W_{xr} mc$ . The green light is:  $\lg \frac{G_0}{G_t} = W_G mc + W_{xg} mc$ . And the blue light is  $\lg \frac{B_0}{B_t} = W_B mc + W_{xb} mc$ .

The intensity of the red, green, and blue light points  $R_0, G_0, B_0$  in the three equations respectively indicates the transmission intensity of the light of each color. And  $R_t, G_t, B_t$  is for the concentration of the light absorbing material. Weighting the above three equations to get  $C_x$  is the concentration of the light absorbing material. We can get a equation by weighting the above three to equations:

$$\alpha \lg \frac{R_0}{R_t} + \beta \lg \frac{G_0}{G_t} + \gamma \lg \frac{B_0}{B_t} = \alpha W_R mc + \alpha W_{xr} mc_x + \beta W_G mc + \beta W_{xg} mc_x + \gamma W_B mc + \gamma W_{xb} mc_x$$

Because Lambert Beer's law applies only to conditions of monochromatic illumination. The RGB colorimetric method has three different colors of illumination, so the law under this condition will produce a situation that does not conform to the original deviation [2, 6]. Therefore, it is necessary to correct the above formula. After the correction, the RGB colorimetric readings are averaged, and the relationship with the solution concentration is:  $W_0 - W_1 \lg R_t + W_2 \lg G_t + W_3 \lg B_t = mc$ .

The above formula can be expressed as:

$$C = m_1 \lg R + m_2 \lg G + m_3 \lg B. \quad (1)$$

The RGB values of five different chemical solutions (histamine, potassium bromate, industrial alkali, potassium aluminum sulfate, and urea in milk) were averaged, and the multivariate linear regression model of the color mean and the corresponding substance concentration of the colored solution was completed by MATLAB software.

(1) Substituting all the data of histamine into Formula 1, the regression equation [3, 4, 8, 9] of the color mean value of the solution of histamine and the corresponding substance concentration is

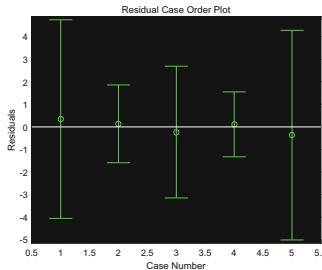
$$\begin{aligned} C_{histamine} = & -450.0043 + 1.9169 \lg B_{histamine} \\ & - 584.1057 \lg G_{histamine} + 787.3919 \lg R_{histamine} \end{aligned}$$

( $C_{histamine}$  indicates the concentration of histamine,  $B_{histamine}$  indicates the mean blue reading in the histamine color,  $G_{histamine}$  indicates the average green reading in the color,  $R_{histamine}$  indicates the average value of the red reading)

The residual analysis of the regression model was performed by MATLAB software, and we obtained:  $p = 0.0000$ , and we know that when  $p < 0.05$ , the regression model is established. The residual map is shown in Fig. 1.

It can be seen from the residual graph of Fig. 1 that the data points of all histamines are close to the residual zero, and the confidence intervals of the residuals include zeros, which indicates that the regression model can better conform to the original data.

(2) Substituting all the data of potassium bromate and urea in the formula 1, we can obtain the regression equation of the color average value of the solution of potassium bromate and urea in the milk and the corresponding substance concentration [3, 4, 9] is:



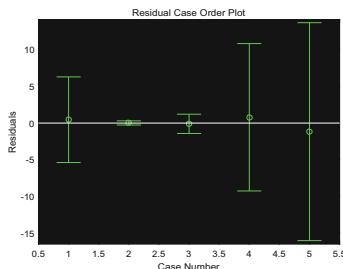
**Fig. 1.** Residual map of histamine

$$C_{pb} = 3.6999 - 0.0667\lg B_{pb} - 0.6907\lg G_{pb} - 0.9607\lg R_{pb}$$

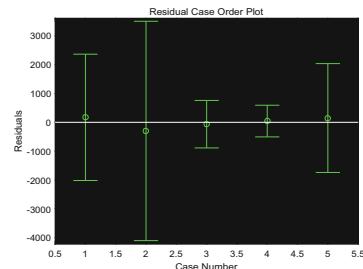
$$C_{urea} = -1.1421 - 3.1748\lg B_{urea} + 6.2048\lg G_{urea} - 2.5632\lg R_{urea}$$

$C_{pb}$   $C_{urea}$  indicates the concentration,  $B_{pb}$   $B_{urea}$  indicates the mean blue reading,  $G_{pb}$   $G_{urea}$  indicates the mean green reading,  $R_{pb}$   $R_{urea}$  indicates the mean red reading).

The regression model of potassium bromate was analyzed by MATLAB software [10] to obtain:  $p = 0.0000 < 0.05$ . It can be seen that the regression model of potassium bromate is established, and the residual map is shown in Fig. 2; the residual analysis of urea in milk is:  $p = 0.0240 < 0.05$ , the regression equation for urea in milk is eligible. The residual map is shown in Fig. 3 below.



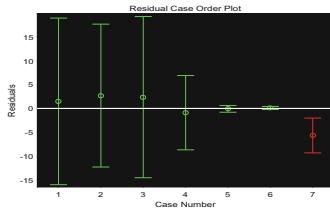
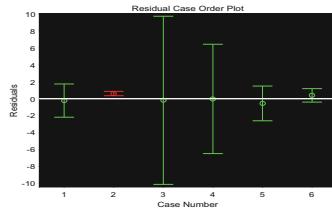
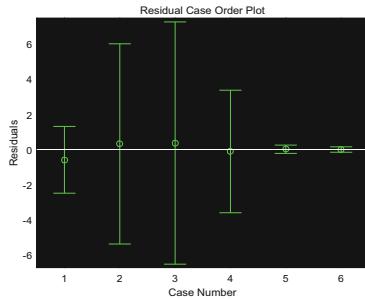
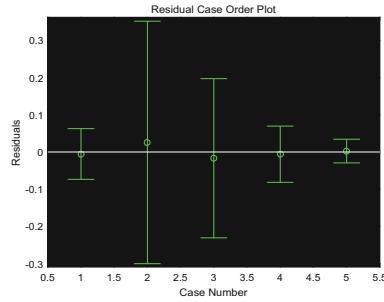
**Fig. 2.** Residual map of potassium bromate



**Fig. 3.** Residual map of urea

(3) The data of the industrial base and potassium aluminum sulfate were substituted into the MATHAB software for residual analysis, and the residuals of the two different solutions were obtained as shown in Figs. 4 and 5.

There is a set of data in Figs. 4 and 5 that do not meet the conditions, so we delete it as an abnormal point, and re-calculate the residual. Thus we obtain the new residual of industrial alkali and potassium aluminum sulfate. From Figs. 6 and 7, we get a regression model [3, 4, 9] of the following two different substances.

**Fig. 4.** Residual of industrial alkali 1**Fig. 5.** Residual of potassium aluminum sulfate 1**Fig. 6.** Residual of industrial alkali 2**Fig. 7.** Residual of potassium aluminum sulfate 2

$$C_{\text{alkali}} = 15.6112 + 9.4461 \lg B_{\text{alkali}} - 3.0848 \lg G_{\text{alkali}} - 10.2333 \lg R_{\text{alkali}}$$

$$C_{PAS} = 130.0642 - 259.2252 \lg B_{PAS} + 321.6319 \lg G_{PAS} - 134.2135 \lg R_{PAS}$$

( $C_{\text{alkali}}$   $C_{PAS}$  indicates the concentration,  $B_{\text{alkali}}$   $B_{PAS}$  indicates the mean blue reading,  $G_{\text{alkali}}$   $G_{PAS}$  indicates the mean green reading,  $R_{\text{alkali}}$   $R_{PAS}$  indicates the mean red reading).

In the residual analysis of industrial bases,  $p = 0.0405 < 0.05$ , It can be seen that the regression model is established. From the residual Fig. 6, except for the last data, the remaining data residuals are close to zero, and the confidence interval of the residual includes zero. This shows that the regression equation fits the data well, and the last data can be regarded as anomalous [11].

In the residual analysis of potassium aluminum sulfate,  $p = 0.000 < 0.05$ , It can be seen that the regression equation is established. From the residual graph, except for the second data, the residuals of the remaining data are close to zero and the confidence interval of the residual contains zero, which indicates that the regression equation can better match the original data, and the second data Can be considered an abnormal point.

In summary, the multiple linear regression equations for the color mean RGB values and the corresponding substance concentrations of five different chemical solutions (histamine, potassium bromate, industrial alkali, potassium aluminum sulfate, and urea in milk) are obtained.

## 4 Conclusions

In this paper, the multivariate regression model analysis [3, 4, 9] of the RGB color readings of different substances and their corresponding different substance concentrations based on Lambert Beer's law is mainly discussed, and the data of the different substance concentrations are evaluated by the data standardization method. We derive the relevant scale factor equation according to Lambert Beer's law and establish a regression model of the color reading mean and material concentration of different solutions. In this paper, the concentration of the solution is first determined by measuring and comparing the color depth of the colored solution, and the value of R (red) G (green) B (blue) [7] in the photograph is extracted by photographing using the different colors of the colored solution on the colorimetric test paper. By preprocessing and normalizing the data of these five different data indicators, a regression model between the RGB values of the colors and the concentration values of the colored solutions is established, and the correlation between them is determined to determine the reliability of the data. Sexuality, so that this model can be popularized and applied, and the concentration of the solution can be read efficiently and quickly by using the RGB value of the colored solution. We derive the relevant scale factor equation based on Lambert Beer's law and establish a regression model of the mean and material concentration of the color reading. This method is more complicated than the mean calculation, but from the later fitted image, the fitting effect is much better than the first method, and the method still uses the same three color readings as the first method, ignoring The influence of other factors on the results has led to the widespread application of this model, so we have reserved this method. In summary, the model we have established has the characteristics of high precision, wide range and strong adaptability. The model we have established is highly relevant to the six substances in the question, and can be promoted in a certain range, which has strong practicability. But the model has certain limitations. There is a high demand for the accuracy of color readings. Moreover, in the process of building the model, in order to facilitate the calculation, some influencing factors are not considered, and there will be certain errors in the actual application.

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# A Novel Steffensen Type Method with Memory

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**Abstract.** A novel Steffensen type iterative method with memory is proposed, which use a variable parameter with uncomplicated structure. Firstly, a modified Steffensen method without memory is presented, which has a constant parameter. Secondly, replacing the constant parameter with a variable parameter, we obtain an iterative method with memory that has convergence order 2.414. Compared with original method, new method does not increase functional evaluations. Finally, the performance of the presented method is showed by numerical experiments.

**Keywords:** Steffensen type method · Convergence order · Variable parameter

## 1 Introduction

A novel Steffensen type method with memory is proposed for solving simple root of nonlinear equations. As is well known, Steffensen method (SM) [1] converges quadratically, which can be written as

$$\begin{cases} t_n = u_n + f(u_n) \\ u_{n+1} = u_n - f(u_n) \frac{1}{f[u_n, t_n]} \end{cases} \quad (1)$$

where  $f[u_n, t_n] = [f(u_n) - f(t_n)]/(u_n - t_n)$  denotes a divided difference. Based on the Steffensen method (1), Traub [2] proposed the following second-order Steffensen type iterative method (TRM1)

$$\begin{cases} t_n = u_n + Vf(u_n), V \neq 0 \\ u_{n+1} = u_n - f(u_n) \frac{1}{f[u_n, t_n]} \end{cases} \quad (2)$$

Method TRM1 satisfies the following expression

$$\lim_{n \rightarrow \infty} \frac{u_{n+1} - \varsigma}{(u_n - \varsigma)^2} = \lim_{n \rightarrow \infty} \frac{e_{n+1}}{e_n^2} = A_2(1 + Vf'(\varsigma)) \quad (3)$$

where  $A_2 = f''(\varsigma)/(2f'(\varsigma))$ ,  $e_{n+1} = u_{n+1} - \varsigma$  and  $e_n = u_n - \varsigma$ .

Based on method TRM1, Traub [2] proposed the following method (TRM2) with memory for the first time

$$\begin{cases} V_n = -\frac{1}{f[u_n, u_{n-1}]}, \\ t_n = u_n + V_n f(u_n), \\ u_{n+1} = u_n - f(u_n) \frac{1}{f[u_n, t_n]}, \end{cases} \quad (4)$$

which reaches convergence order 2.414. We defined parameter  $V_n$  as variable parameter in this paper. Method (4) indicates that it is efficiency way to increase the order of iterative method by a suitable variable parameter. Recently, many efficiency methods have been presented by Traub's idea, see [3–11], which have higher convergence order by using variable parameters. At present, the main ways to design variable parameters is interpolation method. Therefore, it is worthy research theme to find a new way to design variable parameters. In this paper, a novel Steffensen type method with memory is proposed by using an uncomplicated variable parameter.

A modified Steffensen method without memory is obtained in Sect. 2, which is extended to a mnemonic iterative method by a variable parameter in Sect. 3. The variable parameter does not use any additional functional evaluations. Finally, numerical experiment is used to show the efficiency of new methods.

## 2 Modified Steffensen Method Without Memory

In order to construct the Steffensen type method with memory, we design the following scheme

$$\begin{cases} t_n = u_n + f(u_n), \\ z_n = u_n - \frac{f(u_n)}{f[u_n, t_n]}, \\ u_{n+1} = z_n - V(z_n - u_n)^2, \end{cases} \quad (5)$$

where  $V \in R$ .

**Theorem 1.** If  $f$  is sufficiently differentiable on interval  $I \subset R$  and  $\zeta \in I$  is a simple zero of  $f$ . Then iterative method (5) has convergence order 2, its error equation is as following

$$e_{n+1} = (A_2 + A_2 f'(\zeta) - V) e_n^2 + O(e_n^3), \quad (6)$$

where  $A_n = f^{(n)}(\zeta)/(n! f'(\zeta))$ ,  $n = 2, 3, \dots$ , and  $e_n = w_n - \zeta$ .

**Proof.** Taylor expansion of  $f(u_n)$  at zero  $\zeta$  is as follows

$$f(u_n) = f'(\zeta)[e_n + A_2 e_n^2 + A_3 e_n^3 + A_4 e_n^4 + A_5 e_n^5 + O(e_n^6)] \quad (7)$$

$$\begin{aligned} f(t_n) &= f'(\zeta)[(1 + f'(\zeta))e_n + A_2(1 + 3f'(\zeta) + f'(\zeta)^2)e_n^2 \\ &\quad + (2A_2^2 f'(\zeta)(1 + f'(\zeta)) + A_3(1 + 4f'(\zeta) + 3f'(\zeta)^2 \\ &\quad + f'(\zeta)^3))e_n^3 + O(e_n^4)] \end{aligned} \quad (8)$$

From (5), (7) and (8), we have

$$\begin{aligned} f[t_n, w_n] &= f'(\zeta)[1 + A_2(2 + f'(\zeta))e_n + (A_2^2 f'(\zeta) \\ &\quad + A_3(3 + 3f'(\zeta) + f'(\zeta)^2))e_n^2 + O(e_n^3)], \end{aligned} \quad (9)$$

$$\begin{aligned} z_n - \zeta &= A_2(1 + f'(\zeta))e_n^2 + (-A_2^2(2 + 2f'(\zeta) + f'(\zeta)^2) \\ &\quad + A_3(2 + 3f'(\zeta) + f'(\zeta)^2))e_n^3 + O(e_n^4). \end{aligned} \quad (10)$$

Using (5) and (10), we get

$$\begin{aligned} e_{n+1} &= w_{n+1} - \zeta = z_n - \zeta - V(z_n - w_n)^2 \\ &= (A_2 + A_2 f'(\zeta) - V)e_n^2 + O(e_n^3). \end{aligned} \quad (11)$$

The proof is completed.

### 3 Modified Steffensen Method with Memory

From (11), we know that method (5) has convergence order two, provided that  $V \neq A_2(1 + f'(\zeta))$ . If constant parameter satisfies  $V = A_2(1 + f'(\zeta))$ , then method (5) has convergence order three. But the zero  $\zeta$  is unknown, so it is difficult to give the exact value of  $f'(\zeta)$ . Hence, we will replace parameter  $V$  with a variable parameter  $V_n$ , provided that this variable parameter  $V_n$  satisfies the condition  $\lim_{n \rightarrow \infty} V_n = V = A_2(1 + f'(\zeta))$ . In this Section, the variable parameter  $V_n$  will be approximated by a new way.

From Eq. (3), we know that Steffensen method (SM) without memory has the asymptotic error constant  $A_2(1 + f'(\zeta))$ . Coincidentally, Steffensen method is the first two steps of method (5), so  $V_n = (z_n - \zeta)/(u_n - \zeta)^2$  can be served as variable parameter. Using iterative sequence  $z_{n-1}$  and  $x_{n-1}$  to approximate the zero  $\zeta$ , we obtain variable parameter  $\lambda_n$  as follows:

$$V_n = -\frac{z_n - z_{n-1}}{(z_{n-1} - u_{n-1})^2}. \quad (12)$$

Now, replacing parameter  $V$  with (12), we have new Steffensen-type method with memory as follows:

$$\begin{cases} t_n = u_n + f(u_n), \\ z_n = u_n - \frac{f(u_n)}{f[u_n, t_n]}, \\ u_{n+1} = z_n - V_n(z_n - u_n)^2, \end{cases} \quad (13)$$

where variable parameter  $V_n$  equals  $-(z_n - z_{n-1})/(z_{n-1} - u_{n-1})^2$ .

**Theorem 2.** If variable parameter  $V_n$  in (13) is calculated by (12), and let  $\zeta \in I$  be a simple zero of  $f(x)$ , then iterative method (13) has convergence order  $1 + \sqrt{2} \approx 2.414$ .

**Proof.** Let iterative method (IM) produce sequence  $\{u_n\}$  that converges to zero  $\zeta$  of  $f(x)$  with converge order  $O_P(\text{IM}, \zeta) \geq p$ , then we have

$$e_{n+1} \sim G_{n,p} e_n^p, \quad e_n = u_n - \zeta. \quad (14)$$

The limit of  $G_{n,p}$  in (14) is asymptotic error constant  $G_p$  when  $n$  approaches  $\infty$ . Then

$$e_{n+1} \sim G_{n,p} (G_{n-1,p} e_{n-1}^p)^p = G_{n,p} G_{n-1,p}^p e_{n-1}^{p^2}. \quad (15)$$

From (6), we obtain

$$e_{n+1} = u_{n+1} - \zeta \sim (A_2 + A_2 f'(\zeta) - V_n) e_n^2 + O(e_n^3). \quad (16)$$

Using (10) and (11), we have

$$\begin{aligned} z_n - z_{n-1} &= -A_2(1 + f'(\zeta)) e_{n-1}^2 + (A_2^2(2 + 2f'(\zeta) + f'(\zeta)^2) - A_3(2 \\ &\quad + 3f'(\zeta) + f'(\zeta)^2)) e_{n-1}^3 + O(e_{n-1}^4), \end{aligned} \quad (17)$$

$$\begin{aligned} z_{n-1} - u_{n-1} &= -e_{n-1} + A_2(1 + f'(\zeta)) e_{n-1}^2 + (-A_2^2(2 + 2f'(\zeta) + f'(\zeta)^2) \\ &\quad + A_3(2 + 3f'(\zeta) + f'(\zeta)^2)) e_{n-1}^3 + O(e_{n-1}^4), \end{aligned} \quad (18)$$

From (17) and (18), we get

$$V_n = A_2(1 + f'(\zeta)) + (2 + f'(\zeta))(A_3 + A_2^2 f'(\zeta) + A_3 f'(\zeta)) e_{n-1} + O(e_{n-1}^2), \quad (19)$$

$$A_2(1 + f'(\zeta)) - V_n \sim -(2 + f'(\zeta))(A_3 + A_2^2 f'(\zeta) + A_3 f'(\zeta)) e_{n-1} + O(e_{n-1}^2). \quad (20)$$

According to (16), (18), (19) and (20), we get

$$e_{n+1} \sim -(2 + f'(\zeta))(A_3 + A_2^2 f'(\zeta) + A_3 f'(\zeta)) G_{n-1,p}^2 e_{n-1}^{2p+1}. \quad (21)$$

Comparing exponents of  $e_{n-1}$  in (17) and (21), we obtain

$$p^2 - 2p - 1 = 0. \quad (22)$$

The solution of Eq. (22) is  $p = 1 + \sqrt{2} \approx 2.414$ . Therefore, method (13) with memory has convergence order 2.414. The proof is completed.

## 4 Numerical Examples

The modified Steffensen method (5) without memory and method (13) with memory are compared with method SM and method TRM2 by solving nonlinear equations.

In Table 1,  $|w_k - a|$  is absolute error in the first four iterations. Significant digit is 1200. The first step of iterative methods use parameter  $V = V_0 = 0.1$ .  $\sigma$  is the approximate computational convergence order, which is given by [12]:

**Table 1.** Numerical results for  $f(w)$

Methods	$ w_1 - a $	$ w_2 - a $	$ w_3 - a $	$ w_4 - a $	$\sigma$
SM	0.77e-2	0.88e-5	0.11e-10	0.20e-22	2.00
(5)	0.13e-1	0.42e-4	0.44e-9	0.49e-19	2.00
TRM2	0.13e-1	0.23e-5	0.35e-14	0.13e-35	2.43
((15), (12))	0.13e-1	0.89e-6	0.13e-15	0.17e-39	2.42

$$\sigma \approx \frac{\ln(|u_{n+1} - u_n|/|u_n - u_{n-1}|)}{\ln(|u_n - u_{n-1}|/|u_{n-1} - u_{n-2}|)}. \quad (23)$$

Following test function is used:

$$f(u) = \cos(u) - u, \quad a \approx 0.7390851332151606, \quad u_0 = 0.500.$$

From Table 1 we know that new Steffensen type method with memory (15) is certainly better than quadratically convergence methods, such as Steffensen method and method (5). New method (15) is competitive with the same order methods, such as methods TRM2, considering the accuracy of the approximations produced.

## 5 Conclusion

In this paper, we propose an uncomplicated technique to design variable parameter and get a new Steffensen type method with memory, which achieves convergence order  $1 + \sqrt{2}$  requiring two functional evaluations per iteration. New method offers an increased rate of convergence over Steffensen method with no additional cost.

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# Author Index

## A

An, Xin, 354

## B

Bai, Chen, 342

Bai, Liang, 243

Bai, Xue, 487, 501

Bo, Lei, 457

## C

Cai, Zhenliang, 464

Cao, Wenhong, 374

Cao, Yan, 501

Chen, Caihong, 125

Chen, Changzheng, 457

Chen, Hanxin, 217

Chen, Kaifeng, 317

Chen, Rui, 59

Chen, Shuang, 409

Cheng, Mao, 374

Chi, Xing-hua, 397

## D

Dong, Haoran, 632

Du, Ying, 204

Duan, Shaoyin, 25

Duan, Yixue, 25

## F

Fan, Dongliang, 217

Fan, Henghai, 417

Fang, Lu, 217

Feng, Lingyun, 382

Feng, Wang, 426

## G

Gao, Yaruixi, 390

Gou, Tingting, 741

Guan, Sheng, 725

Guo, Hongjian, 390

Guo, Sicong, 417

Guo, Yong, 180

## H

Han, Peng, 104

Hao, Yue, 680

He, Puyu, 204

He, Zheyuan, 238

Hou, Wenke, 172

Hu, Xinya, 603

Huang, Bin, 238

Huang, Hailong, 250

Huang, Jian, 212

Huang, Xiaohua, 702

Huang, Yeping, 98

Hui, Xiaobo, 417

Huo, Yan, 479

## J

Jianfeng, Shi, 426

Jiang, Haiyan, 53

Jiang, Jiao, 457

Jiang, Jingjing, 303, 725

Jiang, Li, 283, 342

Jiankun, Bai, 432

Jie, Shen, 426

Jin, Zhixiang, 792

**K**

Kangle, Zhou, 187  
 Ke, Meng, 283  
 Kuang, Dongmei, 409

**L**

Lei, Yefei, 610  
 Lei, Zhenjiang, 243  
 Li, Anliang, 417  
 Li, Haihong, 509  
 Li, Hui, 348  
 Li, Jiancheng, 390, 409  
 Li, Jiaqiang, 665  
 Li, Junfeng, 409  
 Li, Li, 671, 717  
 Li, Qian, 204  
 Li, Sile, 18  
 Li, Xiaofeng, 403  
 Li, Xiaolin, 310  
 Li, Yanyan, 748  
 Li, Yuhaao, 760  
 Li, Yuliang, 172  
 Li, Zhuo, 317  
 Lian, Shulin, 658  
 Liang, XiaoFen, 348  
 Lin, Renzao, 98  
 Ling, Zhangwei, 374  
 Liu, Bingjie, 3  
 Liu, Chunming, 694  
 Liu, Dong, 538  
 Liu, Hua, 290  
 Liu, Li, 225  
 Liu, Lijing, 814  
 Liu, Mengwei, 501  
 Liu, Qi, 417  
 Liu, Shunan, 225, 232  
 Liu, Tao, 754  
 Liu, Wangsheng, 464  
 Liu, Weigang, 148  
 Liu, Yali, 473  
 Liu, Yanli, 153  
 Liu, Yanlong, 554  
 Liu, Ying, 538, 783  
 Liu, Yubo, 243  
 Liu, Zengxiang, 161  
 Lu, CuiJing, 348  
 Lu, Hui, 501  
 Lu, Ling, 800  
 Luo, Guo, 348  
 Lv, Jirong, 531

**M**

Ma, Lei, 290  
 Ma, Lili, 317

Ma, Si-min, 180  
 Ma, Tianan, 204  
 Men, Hongli, 290  
 Miao, Wei, 11

**N**

Ning, Guo-Qiang, 180

**P**

Pan, LiMin, 348  
 Pan, Yexing, 296

**Q**

Qi, Jun, 538  
 Qiu, Ziliang, 59

**R**

Ran, Ran, 243, 538  
 Ren, Jianlan, 569

**S**

Shang, Yongwei, 658  
 Shen, Kaiqiang, 582  
 Shen, Minglai, 775  
 Shen, Zhenjun, 671, 717  
 Shi, Shuyu, 273  
 Song, Xinfang, 814  
 Song, Xue, 303, 725  
 Su, Lei, 554  
 Su, Zheqian, 658  
 Sun, Bo, 515  
 Sun, Jianhua, 617  
 Sun, Wengao, 335  
 Sun, Xinhao, 680  
 Sun, Yanzhao, 283

**T**

Tai, Nengjian, 390  
 Tan, Hang, 310  
 Tang, Bo, 283, 342  
 Tang, Jie, 374  
 Tang, Yiming, 204  
 Tang, Ying, 494  
 Tang, You, 238, 317  
 Tang, Zhongyi, 603  
 Teng, Fei, 172  
 Tian, Chong, 546  
 Tong, Pengxiang, 464

**W**

Wang, Chuncheng, 576  
 Wang, Dandan, 303, 725

Wang, Dehai, 232  
Wang, Fei, 562  
Wang, Heng, 390, 409, 417  
Wang, Jiacao, 734  
Wang, Jian, 588  
Wang, JiaShun, 303, 725  
Wang, Jiong, 652  
Wang, Li, 118  
Wang, Peng, 439, 444  
Wang, Qi, 360  
Wang, Ronghua, 204  
Wang, Rongxia, 266, 326  
Wang, Rui, 397  
Wang, Xiaofeng, 821  
Wang, Xiaoli, 232  
Wang, Xiaoming, 172  
Wang, Xin, 132  
Wang, Yanli, 522  
Wang, Yue, 479  
Wang, Zhaowei, 283  
Wang, Zhe, 113  
Wang, Zhong, 457  
Wei, Jun, 390, 409, 417  
Wei, Li, 33  
Wei, Wen, 807  
Wei, Xing, 658  
Wu, Guang-en, 180  
Wu, Yuelin, 596  
Wu, Yun-bi li ge, 397  
Wu, Zhengyuan, 652

**X**

Xi, Jianrong, 141  
Xi, Tao, 390, 409  
Xia, Ping, 40  
Xia, Yu, 243  
Xiao, Rongli, 501  
Xiao, Yang, 197  
Xie, Hui, 33  
Xie, Jingsi, 710  
Xie, Xiqiang, 450  
Xiong, Huifang, 79  
Xu, Shuo, 354

**Y**

Yan, Mengqiu, 59  
Yang, Jieyun, 768  
Yang, Liu, 225, 232  
Yang, Rui, 25  
Yang, Yasen, 342  
Yao, Yu, 342  
Ye, Zenglin, 439  
Yi, Fengpeng, 647  
Yi, Younan, 625  
Yu, Liang, 439, 444  
Yu, Ping, 687  
Yu, Xing-chao, 397  
Yuan, Xin, 639  
Yuan, ZiYan, 665

**Z**

Zeng, Ling-sha, 397  
Zhai, Ning, 487  
Zhan, Yihong, 66  
Zhang, Guangyu, 217  
Zhang, Guibin, 531  
Zhang, Guofang, 72  
Zhang, Hongzhen, 531  
Zhang, Hua, 652  
Zhang, Peng, 783  
Zhang, Shaoyu, 390, 417  
Zhang, SiWen, 348  
Zhang, Xiwen, 354  
Zhang, Zheng, 85  
Zhao, Jingchuan, 800  
Zhao, Jinghong, 538  
Zheng, Quanjun, 72  
Zheng, Shandong, 258  
Zhong, Chen, 639  
Zhou, Dapeng, 46, 92, 243, 538  
Zhou, Jianming, 783  
Zhu, Chunjin, 671, 717  
Zhu, Haixia, 596  
Zhu, Tieshuan, 367  
Zhu, Yong, 46, 92  
Zhuang, Hongwei, 800  
Zou, Wei, 792