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The Design of Intelligent Transportation Video Processing System in Big Data Environment

Qian Hao[1], Lele Qin[2]

[1] Department of International Trade of Hebei College of Industrial Technology, Shijiazhuang, CO 050000 China
[2] School of Economics and Management of Hebei University of Science and Technology, Shijiazhuang, CO 050000 China

Corresponding author: Lele Qin (e-mail: Mr_qin@163.com).

ABSTRACT The intelligent transportation system in big data environment is the development trend of future transportation system, which effectively integrates advanced information technology, data communication transmission technology, electronic sensor technology, control technology and computer technology and is applied to overall ground transportation management. Hence, it establishes a real-time, accurate, efficient and comprehensive transportation management system that functions in a wide range and all-round aspects. In order to meet the demands of the intelligent transportation big data processing, this paper puts forward a high performance computing architecture of large-scale transportation video data management based on cloud computing, designs a parallel computing model containing the distributed file system and distributed computing system to solve the problems such as flexible server increase or decrease, load balancing and flexible dynamic storage increase or decrease, computing power and great improvement of storage efficiency. On the basis of this technical architecture, the system adopts BP neural network-related algorithms to extract the static transportation signs in road videos, and uses interframe difference algorithm and Gaussian mixture model (GMM) fusion algorithm to extract the moving targets in road transportation videos. In this way, they are taken as important integral parts and data sources of key frames of intelligent video image recognition to improve the recognition ability of key frames and eventually utilize semantic recognition model based on CNN (Convolutional Neural Network) to complete the intelligent recognition of whole transportation videos. Through network pressure test, computing ability test, recognition ability test and other tests, it has been proved that the intelligent transportation video processing system based on big data environment is successful and the design scheme of this system has strong practical application value.

KEYWORDS Big Data, Intelligent Transportation, Intelligent Video, Machine Learning, Neural Network

According to the reports of World Health Organization (WHO) and World Bank (WB), the road traffic fatalities will be the third most important factor affecting human health and longevity after heart disease and depression by 2020. Around the world, more than 3,000 people die in road traffic accidents every day, but it is undeniable that road traffic accidents can be predicted and prevented. Among which, the comprehensiveness and real-time of traffic data acquisition and the intelligent understanding and reading in video data are the key factors affecting the prediction and prevention. Therefore, in order to realize intelligent traffic and in view of the continual increase of urban motor vehicle population, increasing complexity of urban road traffic conditions, traffic flow characteristics presenting big change over time and regional close correlation, it needs to provide real-time traffic data and provide the users with valid information according to the vast amounts of data through intelligent algorithm. This brings a challenge to the big data platform of transport.

From the 1970s to the 1980s, intelligent transportation was proposed as a concept, but was restricted by current computing power and communication means. Hence, it resulted in slow development speed, and ITS research was just in preparation stage. Therefore, the research in this stage mainly focused on the vehicle navigation system and route planning and guidance that lied in the bottom core of ITS system [1]. Up to the end of last century, the development speed of intelligent transportation was enhanced in a large range along with the great development of data transmission speed, computing power and positioning technology. The research perspective in some developed countries such as USA, Japan and Europe was turned to the verification of intelligent transportation concept by launching some large programs. On this basis, the supporting fundamental technology was developed in an all-round way. In Europe, the governments, companies and universities of 19 countries jointly initiated PROMETHEUS program, which produced a number of advanced ITS technologies. The most representative achievement was VaMoRs experimental vehicle tested in Munich, which could realize road tracking through two forward-looking cameras [2]. In USA, Mobility2000 research team laid a foundation for the establishment of Intelligent Vehicle Highway Systems (IVHS) [3]. Later, this system was renamed to be ITS America (Intelligent Transportation Society of America) by Department of Transportation and was implemented at more than 80 places in the United States [4]. At the same time, multiple programs were initiated in Japan, with the representative ones being RACS system set up by the Ministry of Construction and AMTICS system by the National Police Agency [5]. As of today, the high-definition video, intelligent analysis, machine learning, big data and other technologies achieve a mature application. The vehicle-road collaboration, automatic driving and intelligent mobility based on artificial intelligence become the next development and research direction of intelligent transportation systems. For example, the intelligent transportation manual released by NJDOT [6] developed different policies of intelligent transportation system for New Jersey and Pennsylvania. Lumsden, Stefansson [7] and Stefansson and Sternberg [8] proposed the concepts of Smart Freight and Smart Logistics Setup respectively. Stefansson, Gunnar and Kenth Lumsden [9] put forward the concept of Smart Transportation Management (STM), believing that the basis of this system included 3 parts (i.e. Smart freight, smart transportation vehicles and smart infrastructure) and integrated advanced functions of commodity recognition, vehicle information system and infrastructure system into a conceptual framework. Sherly J and Somasundareswari D [10] developed a smart transportation system based on Internet of things technology, which managed cities and citizens by the use of advanced and powerful communication technology to achieve the goal of building a smart city. Prabhu B, Antony A J and Balakumar N [11] integrated the existing highway peripheral technology into the intelligent transportation system through the application of detection and embedding technology so as to make the car have the functions of automatic throttling, braking and steering control and thus achieve the purpose of reducing the road burden. Vivek J D R, Prashant R G, Prabhu B G [12] enriched and developed intelligent transportation system by designing and implementing software and hardware systems based on mobile device tracking and positioning technology, which could realize tracking and positioning, data sharing, SMS remote control, remote monitoring and other functions. Zhang Zhiyu [13] introduced the framework and design process of intelligent transportation system, and then conducted a detailed study on the application of several key technologies of intelligent transportation system, such as the shortest path calculation method and big data analysis. Yuan Yukun and Zhang Yu [14] focused on the application of wireless sensor network, data mining, intelligent transportation cloud and other key technologies in intelligent transportation, and made a brief introduction to the typical application of intelligent transportation by taking intelligent public transport and intelligent car as examples. Huang Yu and Wang Yanying [15] studied the top-level design architecture of intelligent transportation based on "Internet +", and analyzed the overall architecture construction content of 1+4+NX. Zhang Yanming [16] and Yang Juan [17] respectively made a detailed analysis on the design and application of intelligent transportation based on broadband mobile Internet and Internet of things. The construction scale of intelligent transportation system is expanding unceasingly. As a result, the system data, transportation monitoring data, transportation service data and other different types of huge amounts of data constituted big data [18]. Among them, the continuous improvement of video processing ability and intelligent video recognition ability is the key to realize intelligent video technology, and these data have the characteristics such as large capacity and huge data quantity. The traditional transportation data processing methods, processing architecture and intelligent video recognition algorithm have gradually failed to satisfy the requirements of intelligent transportation big data processing. But it needs related big data technology to conduct in-depth excavation and development to the intelligent transportation data, and needs to adopt more advanced recognition methods to realize data sharing and integration to achieve the purpose of intelligent services [19-21].

I. Technical model of intelligent transportation video processing system in big data environment

In order to meet the demands of intelligent transportation big data processing, maintain the flexibility of cloud server increase or decrease, reduce network pressure and guarantee load balancing, this paper designs parallel computing model and puts forward the technical architecture of distributed file system and computing system. To guarantee the effect of behavior recognition, this system classifies the recognition of video images into static traffic sign recognition and moving target recognition by combining with the characteristics of transportation videos and on the basis of this technical architecture. After recognition, they are processed by the recognition algorithm based on key frames recognition technology and semantic processing, and then the intelligent transportation behavior recognition is completed finally.

II. Processing architecture based on big data

The continuous expansion of intelligent transportation video processing construction brings different types and different structures of huge heterogeneous data including system data, video data, testing data and other data, thus the big data is formed. Obviously, traditional traffic data have already failed to meet the requirement of intelligent big data

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processing. Therefore, it is necessary to utilize big data-related technology to explore and develop the videos, realize data sharing, processing and integration and achieve the purpose of intelligent service. High-resolution transportation video data is one of very important information sources in intelligent transportation big data. Therefore, how to obtain important decision-making support information from these video data is a hot research topic in recent years. The storage and processing means of existing video data are of decentralized storage, management and processing. Obviously, it can't meet the demands. Therefore, how to realize data sharing efficiently, process the increasing mass high resolution video data effectively and establish big data sharing platform to provide flexible and efficient computing and storage mode is a problem to be solved. This paper puts forward relevant solutions by referring to the massive data sharing management modes proposed by Wang Chuanlian [22], Atmbrust M [23] and Chen Chongcheng [24] and combining with virtual technology and distributed storage technology in cloud computing.

A. Design of parallel computing model

In traditional sense, cloud computing may be classified into private cloud, public cloud and hybrid cloud according to service modes, e.g. IBM's Research Computer Cloud. This paper puts forward a parallel computing model, which is divided into two parts: distributed file system (DFS) and distributed computing system (DCS). This computing mode has the following characteristics: 1) flexible logging in or logging out of client end; 2) as the application programs of each node are consistent, it may configure different command set files according to nodes' function division and tasks; 3) simple deployment, and elastic control of computing scale and storage scale; 4) this model conceals the details of parallel computing, data distribution and load balancing, so that users can realize elastic computing and elastic processing. 5) this model has strong storage and computing power, and is fully adapted to intelligent video data processing and data storage; 6) intelligent video algorithm such as convolutional neural network can be realized easily. See parallel computing model in Figure 1.

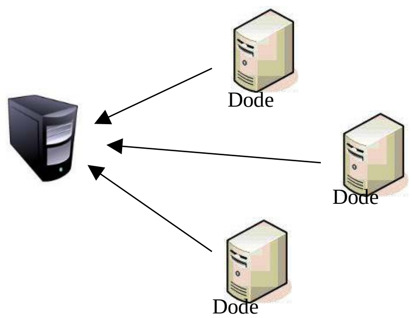

FIGURE 1. **Parallel Computing Model Based on Cloud Computing**

B. Design of distributed file processing model

The file distribution system is a component of web server, which makes it easier for users to query and manage data on the network. Distributed file system assembles the files distributed in different computers into a single namespace, and enables the following works more convenient: setting up a single, hierarchical and multiple-layer file server and sharing server. The traditional processing approach is "root node-node" model. Although it greatly simplifies the system architecture, the core "root node", assumes the task of managing all child nodes, with huge pressure. Once there is failure, the system will be collapsed and result in huge losses. See Figure 2.

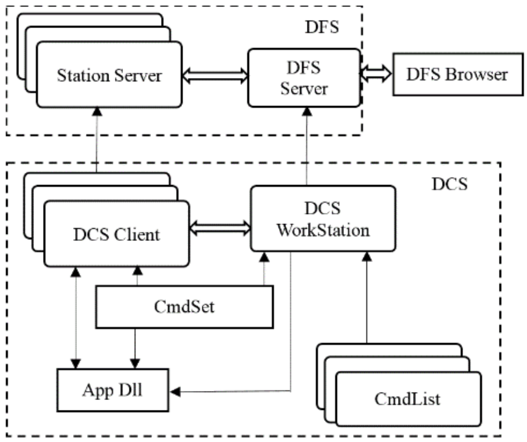

FIGURE 2. **Distributed File System Structure**

In order to solve the problem of traditional distributed file system, this paper puts forward a new mode. This mode is composed of data storage nodes and management servers, of which the data storage node is responsible for data storage and data management services, and management server is responsible for managing the service process, maintaining the service process of current registered data and analyzing data source address. The management server can be any computer in cloud. This kind of management mode is a dynamic distributed file system. The distributed computer system is suitable for a variety of data processing modes including distributed computing workstations and computing client end, which respectively implement the task allocation process and task execution process. Multiple task execution processes can be run. These task allocation and implementation processes can be deployed on any computer in cloud. Data service process is deployed in the data storage machine, which is responsible for the distribution and reception of this machine's data. This model belongs to two-layer-structure Master Worker, and Master is responsible for the task decomposition, task allocation and detection of client-end related work. Once the Worker is started, it registers the task allocation firstly, and then this process allocation task executes corresponding functions, requests or uploads data to data service process according to the demands, and reports to task allocation process according to its current status. See Figure 3.

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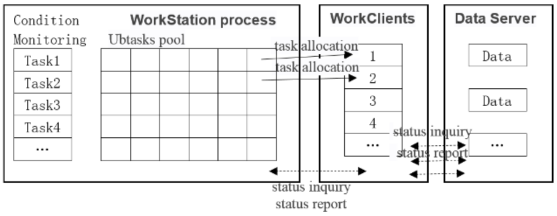

FIGURE 3. **Architecture of Distributed Computing System**

C. Design of video processing architecture

Video processing architecture consists of three parts: data service process processing (DataServer), task allocation process processing (WorkStation) and task execution process (WorkClient). Of which, multiple task execution processes can be run simultaneously according to the actual situations. The executable programs of these three processing process are the same, and the only difference is their respective command execution files (CmdFile) have different constitutions. The allocation process of data processing task assigns the tasks in dynamic scheduling way. First of all, the tasks are assigned to them based on the current registered task execution process. Once the tasks are completed, it will apply to task allocation process for a new task. At the same time, the distributable task execution process can change any time. Also, the task execution process can be joined in or withdrawn any time. Due to the sole communication between execution process and data server, it can greatly reduce communication overhead and also can reduce the additional costs from management distribution. The data service process is deployed in the video data storage server or storage server array, communicating with the task execution process. It may distribute the corresponding data according to the requirements of task execution process, and receives and stores the data processed by task execution process simultaneously. The duty of task assignment process is to analyze video data processing task and assign tasks. Also, it can be used as the task execution process after task analysis. The task execution process is mainly a video processing subtask assigned by the task assignment process. See Figure 4.

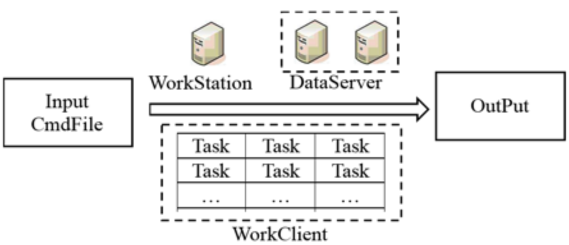

FIGURE 4. **Video Processing Architecture**

In the data storage, video data can be stored in the storage server array or in way of decentralized storage. The purpose of this is to keep the flexibility of storage. Each machine only needs to maintain its own relevant data, while the management end can be any computer in cloud.

In the process of relevant computing, it firstly runs management service process, and then starts the data service process of the machine where the data participate in the computing. Data service process registers in management service process and submits the related parameters of data source under its management in this machine. Data client end submits the necessary network data to the management service process, and then the management service process analyzes the related parameters to data client end. The data client end requests data processing services to the machine according to these parameters.

III. Design of real-time detection and recognition of static traffic signs

Road traffic signs are used to stop, warn, instruct and restrict road users to use the road in an orderly manner so as to ensure the safety. The premise of realizing intelligent transportation is to automatically identify road traffic signs in the big data environment. But because of the complexity of road traffic and in order to get effective and practical road sign recognition results, scientific and technological personnel have made a lot of research. For example, for the problem that traffic signs are difficult for positioning and recognition in complex background and environment, Yang, et al. [25] puts forward a kind of road traffic signs positioning algorithm based on certain colors of traffic signs, multiscale Retinex image enhancement and affine transformation as well as the sign recognition algorithm based on support vector machine. Yuan et al. [26] proposes a kind of Adaboost algorithm and Support Vector Machine (SVM) algorithm. Zhang et al. [27] adopts inter-frame acceleration method, continuously adaptive mean-shift (CamShift) algorithm and optical flow method to shorten the positioning time, and then conducts Back Propagation (BP) neural network recognition on the positioning results, so as to improve the detection efficiency and realize real-time video processing. In the cloud processing architecture, the research group adopts some algorithms such as color segmentation and edge detection segmentation to realize the recognition of static traffic signs.

A. Color segmentation

In real life, color image is classified into optical three-primary colors generally, namely, red, green and blue. Meanwhile, it formed three channels. As the traffic signs have clear color and style generally, the features of a certain color may be highlighted. That is, it may convert them into HSV model. The color parameters in this model are: hue (H), saturation (S) and value (V). The experiment of color segmentation is conducted with these two methods separately. Its principles are as follows:

a. RGB method: judge RGB images pixel by pixel. If this area is white, the following conditions should be met: $|G-B|/R<0.1, R\geqslant160, G-B<30, G<120, B<120$.

b. HSV method: if $V\geq0.5$ and $S\geq0.1$ and $H\leq7$ or $H\geq170$, the area is white.

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As shown in Figure 5, the experimental results show that RGB color segmentation is not ideal for target image segmentation under the conditions of insufficient light, high color similarity and unobvious change of boundary gray scale, while the segmentation of HSV space color has a better effect obviously.

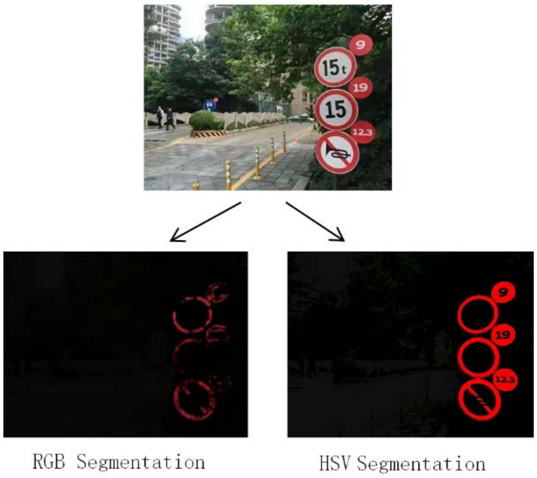

FIGURE 5. **Experimental Results of RGB Segmentation and HSV Segmentation**

The edge is the place where the change rate of gray scale is the largest in the image, which usually contains relatively obvious information. The edge of image not only retains the important information in the original image, but also greatly reduces the data amount, which meets all requirements of traffic video processing system in big data environment.

B. Recognition of static traffic signs

Through HSV space segmentation, the system can well detect traffic signs, and the next work is to identify them. In recent years, artificial intelligence and artificial neural network have showed strong learning ability. The computing ability is well applied to image recognition, behavior recognition and other fields. In this system, BP neural network is used to identify signs. BP (back propagation) neural network is a multi-layer feedforward neural network trained according to the error reverse propagation algorithm. It is the most widely used neural network and the core part of forward neural network too, which embodies the essence of artificial neural network. BP neural network is mainly applied to function approximation, pattern recognition, classification, data compression and other aspects.

1) ALGORITHM OF BP NEURAL NETWORK

Like most neural networks, BP neural network contains training process and learning process.

a. Training process: firstly, the input end receives the external data, and then transmits them to the neurons in the middle layer. The middle layer transforms the information by changing different hidden layers' structures, finally generates information and transmits to the output layer, and thus completes the forward play process of learning. If differences exist between actual output and the expected, it will enter the error back propagation process, and the error starts back propagation, namely, the error is reversely transmitted to the input layer through hidden layer. The error is distributed to each layer in the process of back propagation, so as to achieve the basis of adjusting the weights of each unit in each layer through forward and back propagation and eventually achieve the goal of training.

b. Learning process: this learning process firstly needs to initialize the network, then set error function and learning degree, input the training samples, calculate the input part and output part of the hidden layer, adjust the relevant parameters and relative weight, and finally calculate the global error and judge whether it meets the relevant conditions and then conduct storage. Ultimately, learning goals will be achieved.

2) CALCULATION OF INPUT VECTOR

Traffic signs in any country have standard style, size and color, so the input vector is used to represent the feature vector of the image. Different signs have different feature vectors, and then different feature vectors are used to distinguish different traffic signs, so as to achieve the purpose of image classification and image recognition. The sample image of system is 30×30 pixels, 63 input nodes are set, and the feature vector is calculated based on the gray value of RGB three channels, so as to achieve the purpose of recognition.

The average value of computer's RGB 3 channels is normalized to the range of 0-1, and the formula is as follows:

$$\begin{cases} R = \frac{1}{256}\left(\frac{1}{900}\sum_{i=1}^{30}\sum_{j=1}^{30} R_{i+j}\right) \\ G = \frac{1}{256}\left(\frac{1}{900}\sum_{i=1}^{30}\sum_{j=1}^{30} G_{i+j}\right) \\ B = \frac{1}{256}\left(\frac{1}{900}\sum_{i=1}^{30}\sum_{j=1}^{30} B_{i+j}\right) \end{cases} \quad (1)$$

Calculate the projected values of vi and hi in 30 vertical directions:

$$\begin{cases} v_i = \frac{1}{30}\sum_{i=1}^{30}\left(Y_{i,j} > T\right), \quad j = 1,2,3,\ldots,30 \\ h_i = \frac{1}{30}\sum_{j=1}^{30}\left(Y_{i,j} > T\right), \quad i = 1,2,3,\ldots,30 \end{cases} \quad (2)$$

Of which, Y is the gray matrix and T is the threshold. The expressions of Yi,j and T are:

$$\begin{cases} Y_{i,j} = 0.49R_{i,j} + 0.29G_{i,j} + 0.22B_{i,j} \\ T = \frac{1}{900}\sum_{i=1}^{30}\sum_{j=1}^{30} Y_{i,j} \end{cases} \quad (3)$$

63 nodes are trained as input vectors one time.

3) DETERMINATION OF OUTPUT

Desired output is used to determine network training error and decision output value. The system takes 10 traffic signs as training samples. As the desired output value is within the range of 0~1, and in order to better distinguish different categories of signs, the system output is set a six dimensional vector. The vector construction method is as follows: the value of the nth dimension of nth training sample's desired output vector is 1, and the value of other dimensions is 0. Namely, the desired output of vector training signs is arrayed according to line, thus forming a 6×6 unit matrix [28].

BP neural network features strong abilities of nonlinear mapping, self-learning and self-adaptation, and meanwhile has the abilities of generalization and fault tolerance. So, it has a good effect when applied to this system.

IV. Design of moving target detection and recognition

After the successful recognition of traffic signs, the next problem to be solved is the cars and other moving objects appeared in the video image, that is, the vehicle extraction and recognition based on video image in the road vehicle detection system. The process and algorithm proposed by the research group are shown in Figure 6. The basic idea is: firstly obtaining video and conducting preprocessing such as image filtering, optimization, then calculating the dynamic threshold of frame video and judging whether background illumination change is greater than the threshold value. If it is greater than the threshold value, interframe difference method may be started. Otherwise, it starts the GBM method. After ecological processing, moving targets can be obtained finally [29] - [30].

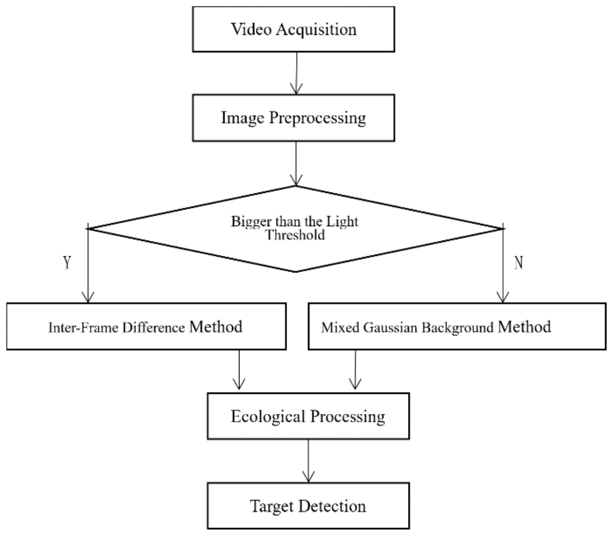

FIGURE 6. **Moving Target Acquisition Algorithm and Process**

A. Calculation of background dynamic threshold value

First, dynamic background difference permission is carried out according to the extraction of the current frame and the background frame image in the video sequence, and the expression is as follows:

$$R_{(i,j)} = |F_{(i,j)} - B_{(i,j)}| \quad (4)$$

$F_{(i,j)}$− Foreground image

$B_{(i,j)}$−Foreground image

$$R_{(i,j)} = \begin{cases} 1, & |F_{(i,j)} - B_{(i,j)}| > T + \Delta T \\ 0, & |F_{(i,j)} - B_{(i,j)}| \le T + \Delta T \end{cases} \quad (5)$$

T− Set grayscale threshold

ΔT− Dynamic threshold

$R_{(i,j)} = 1$ means the target is detected, $R_{(i,j)} = 0$ means the target is not detected. In view of the influence of light, a dynamic threshold ΔT is proposed. If the light does not change significantly, ΔT is very small, and the final threshold does not change significantly. The maximum dynamic threshold is set ΔT_{max}. If $\Delta T > \Delta T_{max}$ the frame difference method is adopted, the Gaussian Mixture Model (GMM) is adopted.

B. Inter-frame difference method

The characteristics of inter-frame difference method are that it is insensitive to the change of light. The first few frames of images before sampling are used as the background frame and the current frame to calculate the difference, while the inter-frame difference uses three consecutive frames of images to calculate, which can greatly reduce the voids, as follows:

a. Three consecutive frames of images G_{k-1}, G_k and G_{k+1}, are taken from the video sequence, and difference operations are performed on the two adjacent frames of images respectively to obtain R_k, R_{k+1}:

$$R_{k(i,j)} = |G_{k(i,j)} - G_{k-1(i,j)}| \quad (6)$$

$$R_{k+1(i,j)} = |G_{k+1(i,j)} - G_{k(i,j)}| \quad (7)$$

b. $R_{k(i,j)}$ and $R_{k+1(i,j)}$ is conducted with binarization processing according to the dynamic threshold $T + \Delta T$, as follows:

$$R_{k(i,j)} = \begin{cases} 1, & R_{k(i,j)} \cap R_{k+1(i,j)} = 1 \\ 0, & \text{others} \end{cases} \quad (8)$$

It can be seen that the determination of targets needs two consecutive binarization processing, and the targets that are both 1 can be finally determined as the target.

C. Gaussian mixture model (GMM)

Gaussian mixture model is used for the video background sequence when the light change is not sensitive. The gray scale of background pixels will change slowly under the conditions of noise transmission and interference. Each pixel in the image is independent of each other, and the change of whole pixel gray scale follows a Gaussian distribution with mean value of μ and standard deviation of δ. The occurrence probability of pixel points is as follows:

$$P(x = a_i) = \frac{1}{\sqrt{2\pi}\delta} e^{-\frac{(a_i-\mu)^2}{2\delta^2}} \quad (9)$$

a_i- The image pixel gray value of the ith frame. For the threshold T, when $P(x = a_i) \le T$, the gray scale of pixel is background gray scale; otherwise, it is the foreground gray scale.

The background established by Gaussian method needs to be updated in real time to obtain a more accurate background. The updated algorithm is as follows:

$$\begin{cases} \mu_{i+1} = (1 + \alpha)\mu_i + b_i \\ \delta_{i+1} = \max(\delta_{min}^2, (1 - \alpha)\delta_i^2 + \alpha(b_i - \mu_i)^2) \end{cases} \quad (10)$$

Of which, δ_i、δ_{i+1}、μ_i and μ_{i+1} are the mean and standard deviation of gray value b_i of a pixel of the ith frame in the ith frame and the i+1th frame separately, and δ_{min}^2 is the threshold of noise.

Each pixel of background image is modeled by the superposition of multiple Gaussian distributions. Each Gaussian distribution can represent a background scene, and the mixed use of multiple Gaussian models can simulate the multi-mode situations in the complex scene.

The method of Gaussian mixture model can be used to effectively deal with the gradually changing illumination and the characteristics of background with micro-repetitive motion. And the image pixels can be effectively divided into background area and rough target area. Finally, the accurate moving target area can be obtained by morphological processing, which is proved to be effective by experiments.

D. Morphological operation

Through the previous operation, the target to be tracked may be extracted. In addition, in order to display the tracked targets more intuitively, it needs to conduct corresponding morphological operation to the targets so as to accurately describe the targets in the video sequence. Morphological operations should be conducted in order, e.g. open operation with first corrosion and then expansion, the close operation with first expansion and then corrosion, and the convex hull operation of the first-level computer region of connected domain, so as to finally achieve the detection of moving targets. See Figure 7.

FIGURE 7. **Effect Drawing of Moving Target Extraction**

V Intelligent learning and behavior recognition design

According to the foresaid methods, the system obtains static traffic signs, road lines and other data, and also extracts the moving objects such as cars in the video screen. How to extract valuable information from these massive data efficiently becomes an urgent problem to be solved by intelligent frequency technology. That is to make the camera become a person's eye, the video transmission network becomes a person's neural network, and the intelligent recognition technology and algorithm become a person's brain to understand and judge the content of the monitored area, so as to realize the automatic recognition and alarm of abnormal driving behaviors such as speeding, reverse driving and illegal crossing. Behavior recognition of massive video data is an important integral part of intelligent transportation analysis. With the great success of deep neural network in the field of image recognition, the research group uses neural network to detect and identify video behavior, and uses semantic analysis to achieve significant results for the algorithm.

Video belongs to unstructured data. On the basis of efficient recognition of static targets such as traffic signs and dynamic targets such as cars, exploring its internal correlation is of great significance for improving the accuracy rate of video semantics. In order to eliminate some implicit correlation structure between the semantics, it needs to conduct correlation analysis to the extracted semantics and decompose the huge video semantic database into dimensionality reduction. Specific information can include basic data information of vehicles, action information and so on. System adopts a 3-layer semantic recognition based on key frames. It firstly classifies the segments of video recognition and extracts the key frames of video data to make a semantic understanding to the basic information of vehicles and road and the vehicle behaviors, and then introduces the preliminarily understood information into semantic integration link. Through semantic integration, the loss function method is adopted to learn the potential semantic relationship between different channels, enhance semantic fusion capacity, improve the robustness of semantic fusion of moving target and finally adjust the related parameters by using overall fine adjustment algorithm to make a final recognition of related behaviors in videos. The implementation diagram of learning machine training is shown in Figure 8 [31]-[34].

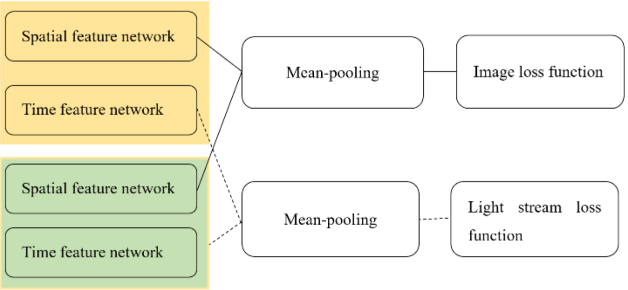

FIGURE 8. **Implementation Diagram of Learning Machine Training of Convergence network**

The semantic understanding of image can be divided into three layers: 1) image processing layer - visual features of lower layer. This layer can accurately identify the image by extracting data from static images and dynamic images. 2) image analysis layer - understanding intermediate semantic features; 3) image recognition layer - realizing the task of high-level semantic sampling. In the three-layer structure, the data support and drive are realized from the lower level to the high level, and the knowledge drive and decision drive are realized from the high level to the low level. Of which, the role of the intermediate level is to connect the preceding and the following, that is, to reduce the semantic gap between the high level and low level. The semantics of image scene belong to the domain of image semantic understanding. The mapping relationship between low-level visual features and high-level scene semantics should be established.

As mentioned above, video image recognition model based on scenic deep learning includes three levels: 1) extraction of intermediate-level semantic features; 2) multi-channel semantic feature fusion; 3) overall fine adjustment and semantic recognition. First, the system identifies the static characteristic signs of video images (such as speed limit signs and stop signs) and moving targets (such as vehicles). According to the combination of the above two, it preliminarily identifies the key frame diagrams in convolutional network scenarios, and enters into the abstraction layer, extracting the low-level features of three channels including symbol semantics S(0)s, vehicle semantics S(0)P, behavior semantics S(0)B and the context semantics S(0)C of key frame videos. Then, the semantic low-level-feature vector dimension of each channel is learned in parallel through convolutional neural network to achieve the semantic feature extraction training of multiple channels. Each channel's semantic feature extraction process includes convolutional process, sub-sampling process and full connection process. In semantic recognition process, the fusion of multi-channel semantic features can be realized(I(n+1)=[S(n+1)s,S(n+1)P,S(n+1)B,S(n+1)C])through the input of the intermediate semantic features as multi-channel semantic fusion layer (I(n)=[S(n)s,S(n)P,S(n)B,S(n)C]) and the multiple channels of convolutional neural network learning. Here, loss function is introduced, and its purpose is to learn to adjust the parameters so as to adjust each layer's semantic feature correlation. Finally, the fusion results of multi-channel semantic features are taken as the input of recognition layer. Meanwhile, the large-interval loss function is used to accurately adjust the learning parameters of overall network, and finally the task of semantic recognition is realized. See Figure 9.

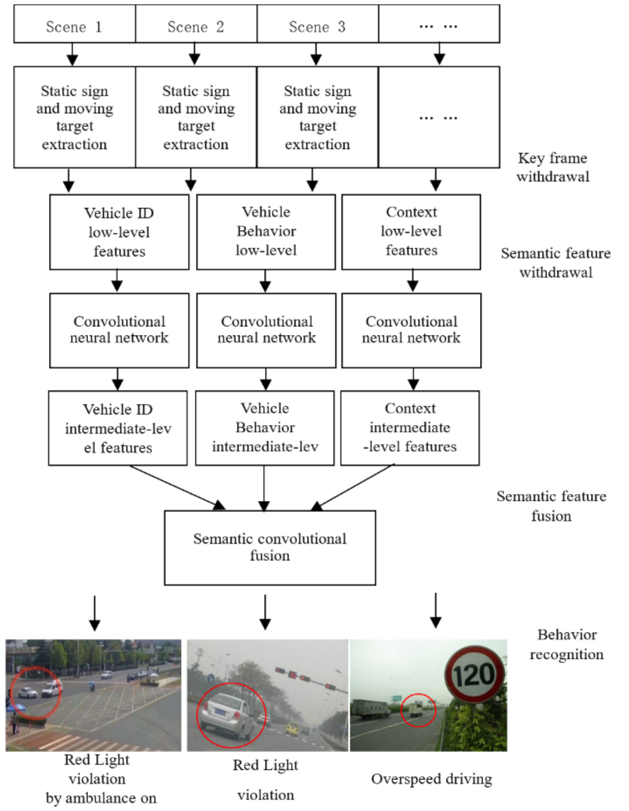

FIGURE 9. Technical Architecture of Video Semantic Recognition Model Based on Deep Learning

VI. Experimental test

In order to verify the processing speed, storage capacity, static sign identification recognition capacity, dynamic moving target recognition capacity and behavior recognition capacity of the system, the research group carries out the following tests: temporary traffic signs are installed at the sites with fewer vehicles for the test of faster driving speed; the tests of illegal vehicle's stop, road crossing and other behaviors are conducted at the experimental sites; and some tests are conducted at the sites with large vehicle flow. The test results are as follows:

A. Load capability test of systematic technical architecture

First of all, the research group conducts a capacity test to the load capacity of systematic technical architecture. The load of data server's storage capacity is as shown in Table I. In the test, the data servers are joined in the cloud in turn to constitute a big data cluster. The change of big data cluster's storage capacity is as shown in Figure 10. It can be seen that constantly joined data in big data storage capacity keeps increasing and more than 100 T video and image data can be stored. It shows that big data storage capacity can meet the requirements of intelligent transportation system.

TABLE I
TABLE OF SERVER DATA STORAGE

Server No.	01	02	03	04	05	06	07
Storage Capacity(TB)	5.7	8.6	11.5	15.7	19.8	21.2	23.4

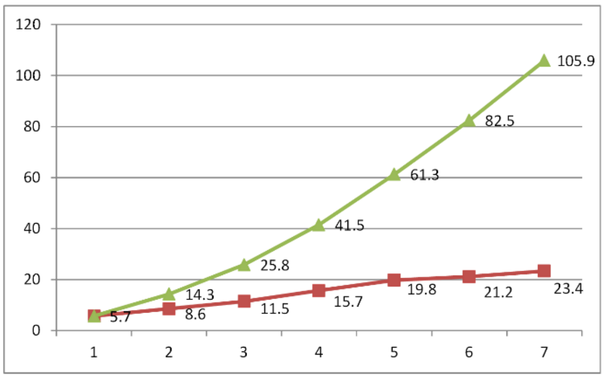

FIGURE 10. Storage Capacity Test Diagram of Big Data Server

Secondly, the statistics are conducted to the communication capability between each big data server and relevant metadata server. As shown in Table II, the relevant delay time is within 1 second, which basically meets the relevant requirements of data transmission.

TABLE II
COMMUNICATION DELAY BETWEEN EACH DATA SERVER AND METADATA SERVER

Server No.	01	02	03	04	05	06	07
Communication Delay (s)	0.2	0.3	0.6	0.6	0.7	0.6	0.8

Finally, the computing load capacity of big data server cluster is tested as follows:

a. The test results of response time of newly added static traffic signs recognition are shown in Table III, and the effect of recognition response time is good.

TABLE III
RESPONSE TIME OF STATIC TRAFFIC SIGN RECOGNITION

Traffic Sign	Response Time(s)
Speed limit sign (Round)	1
Prohibition sign(Round)	1
Expressway speed limit sign (rectangle)	2
Tunnel sign (triangle)	1
Construction sign in the front(rectangle)	2

b. The test results of traffic abnormal recognition and response time of traffic flow statistics are shown in Table IV. The result of recognition response time is relatively satisfied.

TABLE IV
STATISTICS OF TRAFFIC ANOMALY AND TRAFFIC FLOW

Recognition Type	Response Time(s)	Remarks
Vehicle Overspeed	10	
Red light violation	5	
Illegal violation	5	
Jamming warning	Approximately 60	
Future jamming early-warning		30 minutes later after successful prediction
Prediction of future road traffic		30 minutes later after successful prediction
Traffic flow statistics(30minutes)		Successful statistics

B. Test of system recognition capability

Under the conditions that the system response time, storage capacity and load capacity can meet the requirements, the recognition ability and level are tested.

a. Recognition ability test of static traffic sign

In actual application scenarios, it is expected to carry out detection and recognition to the traffic signs in real time in different environments, and conduct related test to the system. As shown in Table V, under the conditions of sunny daytime and good light, detection rate and recognition rate exceed 99%. However, in case that light intensity is not good in the night and rainy weather, the recognition rate will be decreased, but exceeding 93%. Because the video images are continuous, most test and recognition results completely meet the realistic requirements. Therefore, the test result is satisfied.

TABLE V
STATISTICAL TABLE OF STATIC TRAFFIC SIGN DETECTION AND RECOGNITION

Sign Type	Environmental Conditions	Total Frame Qty.	Accurately Detected Frame Qty.	Accurately Identified Frame Qty.	Detection Rate(%)	Recognition Rate(%)
Round	Daytime	1235	1227	1220	99.35	98.79
Round	Cloudy & Rainy Day	1365	1312	1301	96.12	95.31
Round	Night	1327	1292	1261	97.36	95.03
Square	Daytime	1356	1345	1338	99.19	98.67
Square	Cloudy & Rainy Day	1566	1479	1462	94.44	93.36
Square	Night	1376	1321	1291	96.00	93.82

b. Test of dynamic vehicle recognition ability

Similar to static testing method, dynamic vehicle recognition capability is tested, so does the recognition of vehicle plate. As shown in Table VI, similar to the static test results, detection rate and the recognition rate exceed more than 95% under the conditions of sunny daytime and better light. But under the conditions of night or cloudy or rainy weather or fast vehicle speed, the recognition rate is decreased, but exceeding more than 90%. As the vehicle plate recognition rate exceeds more than 88% basically and the video images are continuous, most test and recognition results completely meet the realistic requirements. Therefore, the test results are satisfied.

c. Test of vehicle behavior recognition ability

System interface is as shown in Figure 11. The function of interface is mainly of illegal vehicle recognition and retrieval, manual intervention of doubtful sample, intelligent study of machine, traffic statistics and so on. Due to the static test results and dynamic vehicle detection results are good, it adopts advanced scenic intelligent recognition based on convolutional neural network intelligent learning. So, the judgment of traffic abnormal behavior is accurate. The traffic

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congestion, simulated traffic accidents, overspeed and others are tested. The interface of Figure 12 provides alarm function. The experimental results shows that the alarm rate for overspeed, traffic congestion and signal light violation is close to 100%. For traffic accidents and other highly individualized conditions, the alarm rate is close to 90%. For frame test in the video, as shown in Table VII, the same as above, the system adopts threshold value intervention because the video images are continuous. When the continuous similar rate reaches a certain value, the system will make a judgment of abnormality, so accuracy is close to 100%. If there are doubts, it needs human intervention and utilizes learning machine technology for training and learning. Along with the increase of using time, machine learning sample and complex case processing, the system will become more "smart".

TABLE VI
STATISTICAL TABLE OF DYNAMIC VEHICLE DETECTION AND RECOGNITION

Vehicle Speed (km/h)	Environmental Conditions	Total Frame Qty.	Accurately Detected Frame Qty.	Accurately Identified Frame Qty.	Vehicle Plate Identified Frame Qty.	Detection Rate(%)	Recognition Rate(%)	Vehicle Plate Recognition Rate (%)
≈50	Daytime	978	956	947	938	97.75	96.83	95.91
≈50	Cloudy & Rainy Day	966	925	896	883	95.76	92.75	91.41
≈50	Night	985	946	931	902	96.04	94.52	91.57
≈80	Daytime	925	896	883	871	96.86	95.46	94.16
≈80	Cloudy & Rainy Day	933	865	851	836	92.71	91.21	89.60
≈80	Night	963	891	879	856	92.52	91.28	88.89
≈100	Daytime	921	879	855	845	95.44	92.83	91.75
≈100	Cloudy & Rainy Day	902	856	805	798	94.90	89.25	88.47
≈100	Night	970	902	865	858	92.99	89.18	88.45

TABLE VII
STATISTICAL TABLE OF DETECTION AND RECOGNITION OF ABNORMAL VEHICLE BEHAVIORS

Illegal Type	Environmental Conditions	Total Frame Qty.	Accurately Detected Frame Qty.	Accurately Identified Frame Qty.	Detection Rate(%)	Recognition Rate(%)
Red Light Violation	Daytime	898	865	860	96.33	95.77
Red Light Violation	Cloudy & Rainy Day	903	878	871	97.23	96.46
Red Light Violation	Night	892	865	858	96.97	96.19
Illegal Overtaking	Daytime	905	869	859	96.02	94.92
Illegal Overtaking	Cloudy & Rainy Day	908	852	841	93.83	92.62
Illegal Overtaking	Night	892	843	836	94.51	93.72
Overspeed	Daytime	503	481	471	95.63	93.64
Overspeed	Cloudy & Rainy Day	496	465	452	93.75	91.13
Overspeed	Night	508	476	462	93.70	90.94

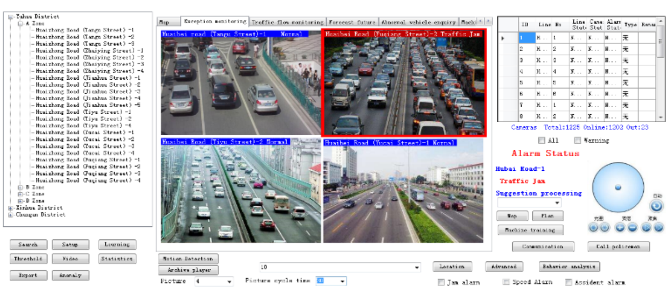

FIGURE 11. **Intelligent Transportation Video Monitoring and Processing Platform Interface**

VII. Conclusions

Intelligent transportation big data platform is one of the most important integral parts of intelligent transportation, featuring high scalability, real-time, high performance, low latency, support for heterogeneous environment and strong openness. On the basis of designing data management based on cloud computing and distributed file system and distributed computing system applied to high performance computing framework, this paper designs the detection algorithm of static traffic signs and abnormal moving vehicle targets and integrates the detected traffic signs and abnormal vehicle targets into intelligent video recognition module based on semantic environment, thereby greatly improving the recognition ability and accuracy of traffic behaviors. After pressure test, communication load ability test, traffic signs and moving vehicle detection success rate test and traffic abnormal behavior recognition test, it is proved that the intelligent transportation video processing system in big data environment is successful, and the design scheme of this system has strong practical application value.

There are many kinds of smart video algorithms, most of which are based on learning machine. The training level of learning machine and the advanced degree of algorithm are the key to identify the good and bad effects. At present, there are general algorithms based on convolutional neural network, etc. But they all have problems such as translation invariance and bad effect of experience learning. In order to change the defects of traditional learning machine, new structures such as capsule network appear, and it will certainly bring a revolution to the field of deep learning.

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References

[1]Mc Clellan, Stan, Jesus A., Jimenez, George Koutitas., Smart Cities: Applications, Technologies, Standards, and Driving Factors[M]. Springer, 2017.
[2]Graefe V, Kuhnert K D., Vision-based autonomous road vehicles[M]//Vision-based vehicle guidance. Springer, New York, NY, 1992: 1-29.
[3]Betsold R J., Intelligent vehicle/highway systems for the united states-an emerging national program[C]//Proceedings of JSK International Symposium-Technological Innovations for Tomorrow's Automobile Transportation and Driving Information Systems. 1989: 53-59.
[4]America I., Strategic Plan for Intelligent Vehicle-highway Systems in the United States: Executive Summary[M]. Intelligent Vehicle Highway Society of America, 1992.
[5]Nakashita H, Okamoto H, Kawabata T, et al., Advanced mobile information and communication system[C]//67th Annual Meeting of the Transportation Research Board. 1988.
[6]NJDOT., "Smart transportation guidebook". New Jersey Department of Transportation and Pennsylvania Department of Transportation, 2008
[7]Lumsden, Keith, "Gunnar Stefansson., Smart freight to enhance control of supply chains". International Journal of Logistics Systems and Management. 2007,3(3): 315-329.
[8]Stefansson, Gunnar, Henrik Sternberg, Kenth Lumsden., "Smart logistics systems–SLS". 11th World Conference on Transport ResearchWorld Conference on Transport Research Society. 2007.
[9]Stefansson, Gunnar, Kenth Lumsden., "Performance issues of smart transportation management systems[J]". International Journal of Productivity and Performance Management 2008,58(1): 55-70.
[10]Sherly J, Somasundareswari D., "Internet of things based smart transportation systems[J]". International Research Journal of Engineering and Technology, 2015, 2(7): 1207-1210.
[11]Prabhu B, Antony A J, Balakumar N., A research on smart transportation using sensors and embedded systems[J]. 2017.
[12]Vivek J D R, Prashant R G, Prabhu B G., "Smart Transportation System[J]". Imperial Journal of Interdisciplinary Research, 2017, 3(4).
[13]Zhang Z.Y. "Research on Design and Realization of Intelligent Transportation System [J]". Computer Disk Software and Application, 2014 (12): 38-38.
[14]Yuan Y.K., Zhang Y., Wei T.Y., et al. "An Overview of Key Technologies and Application of Intelligent Transportation [J]". Electronic Technology Application, 2015, (8): 9-12.
[15]Huang Y., Wang Y.Y., "Top-Level Design Architecture of Intelligent Transportation Based on "Internet +" [J]". Water Transportation Engineering, 2016 (10):199-202.
[16]Zhang Y.M. , "Research on Intelligent Transportation Application Based on Broadband Mobile Internet [D]". Hubei University of Technology, 2017.
[17]Yang J. Design of Intelligent Traffic System for Sichuan Expressway Based on Internet of Things [D] ". Southwest Jiaotong University, 2017.
[18]Karri R,Rajendran J,Rosenfled K.Trojan taxonomy[M]//Introduction to hardware security and trust.Tehranipoor M,Wang C.New York:Springer,2012:325-338.
[19]Wolff F,Papachristou C,Bhunia S,et al., Towards trojan-free trusted ICs:Problem analysis and detection scheme[C]//Proceedings Design,Automation and Test in Europe(DATE'2008),2008:1362-1365.
[20]Chakraborty R,Narasimhan S,Bhunia S.Hardware Trojan,Threats and emerging solutions[C]//Proceedings of the IEEE International Workshop on High Level Design Validation and Test Workshop,2009:166-171.
[21]Chakraborty R,Wolff F,Paul S.MERO,A statistical approach for hardware Trojan detection[C]//Workshop on Cryptographic Hardware and Embedded Systems CHES'2009),2009:396-410.
[22]Wang C.L., Zhang Z.S., "Design of large-scale traffic video processing frameworks based on private cloud[J]". Computer Engineering and Applications, 2017, 53(21):254-257.
[23]Armbrust M,Fox A,Griffith R,et al., "A view of cloud computing[J]".Communications of the ACM,2010,53(4):50-58 .
[24]Chen C.C., Lin J.F., Wu X.Z., et al., "Massive Geo-spatial Data Cloud Storage and Services Based on NoSQL Database Technique[J]",Journal of Geo-Information Science,2013,2013,15(2):166-174.
[25]Yang Y.,Luo H.,Xu H.,et al., "Towards Real-time Transportation Sign Detection and Classification[J]".IEEE Transactions on Intelligent Transportation Systems,2016,17(7):2022-2031.
[26]Yuan Y.,Xiong Z.,Wang Q., "An Incremental Framework for Video-based Transportation Sign Detection,Tracking,and Recognition[J]". IEEE Transactions on Intelligent Transportation Systems,2017,18(7):1918-1929.
[27]Zhang X.G.,Liu X.L.,Li J.,Wang H.D., "Real-time detection and identification of speed limit transportation signs under the BP neural network[J] ",Journal of Xidian University,2018,45(5):136-142.
[28]Shen L.H.,Sun L.H., "Transportation Sign Recognition Algorithm Based on SURF Feature[J]".China Computer and Communication,2016(1):68-69.
[29]Huang J.H.,Liang X.M.,Gui B.H., "Research on moving target detection algorithm for transportation video[J]",Modern Electronics Technique,2019,42(5):53-56.
[30]Sun T.,Qi Y.C.,Geng G.H., "Moving object detection algorithm based on frame difference and background subtraction[J]". Journal of Jilin University(engineering and technology edition),2016,46(4):1325-1329.
[31]Qin, L. L. and Kang, L. H., 2016. "Technical framework design of safety production information management platform for chemical industrial parks based on cloud computing and the internet of things[J]". International Journal of Grid and Distributed Computing,9(6): 299-314.
[32]Qin, L. L.; Yu, N. W. and Zhao, D. H., "Applying the convolutional neural network deep learning technology to behavioural recognition in intelligent video[J]". Tehnicki Vjesnik, 2018,25(2), 528-535.
[33]Qin, L. L. and Kang, L. H., "Application of video scene semantic recognition technology in smart video[J]". Tehnicki Vjesnik, 2018,25(5),1429-1436.
[34]Hao, Q.,Wang Zh.F.,Qin L.L., "Design of Beidou Satellite System in Ocean Logistics Real-Time Tracking System[J]". Journal of Coastal Research,94(SP1):204-207.

Qian Hao, male, associate professor, born in December 1978, graduated from Hebei Normal University with Master's Degree in June 2002.
He is expert of Expert Database for Organization Reform of Vocational Colleges in Hebei Province, candidate of Tier 3 of "333" Talents of Hebei Province, vice-chairman of National Cross-border E-commerce Director (President) Association, member of National Foreign Trade and Economic

Action Command Committee, member of Cross-border E-commerce Professional Teaching Instruction Committee of National Foreign Trade and Economic Vocational Education & Teaching Instruction Committee, deputy secretary general of Hebei E-commerce Vocational Education Group, standing director of Hebei Modern Logistics Vocational Education Group, deputy director of Logistics Skills Competition Committee of Hebei Modern Logistics Vocational Education Group, executive director of Hebei International Trade Vocational Education Group, and director of E-commerce Skills Competition Professional Instruction Committee of Hebei E-Commerce Vocational Education Group.

Prof. Hao has ever presided over and participated in more than 20 programs in level of state, province or ministry, published nearly 20 papers, won 2 second prizes and 2 third prizes of provincial-level teaching achievement awards, won 1 first prize in the Teachers' Teaching Ability Contest of Hebei Province and 1 first prize in Hebei Region of the 22nd National Education and Teaching Informatization Competition.

Lele Qin, male, Associate Researcher,was born in Zhangjiakou, Hebei, China on March 19, 1978. He earned a Master Degree of Engineering from Nanjing University of Science and Technology, China in 2006.His major field of study is the analysis and design of management information system.

He has been in the research of management information system, and is now dean of Teaching Operation Management, Office of Teaching Affairs in Hebei Univesity of Science and Technology. He has been teaching more than 10 courses at various levels including Management Information System, MIS Curriculum Design, and Database Principle. He has published more than 20 articles, 19 of which were indexed by SCI or EI. His research interests are the analysis and development of MIS.