

PAPER • OPEN ACCESS

Intelligent Diagnosis of Equipment Health Based on IOT and Operation Large Data Analysis

To cite this article: Yingming Tian *et al* 2021 *J. Phys.: Conf. Ser.* **1992** 042070

View the [article online](#) for updates and enhancements.

You may also like

- [Research on key technologies of data processing in internet of things](#)
Yangqing Zhu and Peiying Liang
- [A Tomato Quality Identification Method Based on Raman Spectroscopy and Convolutional Neural Network](#)
Wu Yin, Chenying He and Qibao Wu
- [Technology assisted farming: Implications of IoT and AI](#)
N Aggarwal and D Singh

PRIME
PACIFIC RIM MEETING
ON ELECTROCHEMICAL
AND SOLID STATE SCIENCE

HONOLULU, HI
Oct 6-11, 2024

Abstract submission deadline:
April 12, 2024

Learn more and submit!

Joint Meeting of

The Electrochemical Society
•
The Electrochemical Society of Japan
•
Korea Electrochemical Society

Intelligent Diagnosis of Equipment Health Based on IOT and Operation Large Data Analysis

Yingming Tian¹, Fan Gao^{2,*} and Peng Wu²

¹College of Automation, Chongqing University, Chongqing Chuanyi Automation Co., Ltd, Chongqing, China

²ChongQing ChuanYi Automation Co., Ltd, Chongqing, China

*Corresponding author e-mail: gaofan@cqcy.com

Abstract. Predictive maintenance integrates equipment condition monitoring, fault diagnosis, fault prediction, maintenance decision support and maintenance activities. Intelligent manufacturing upgrades need to match the synchronous improvement of predictive maintenance capabilities, and predictive maintenance is the basic guarantee for enterprises to achieve intelligent manufacturing. Take the equipment condition monitoring and diagnosis system applicable in process industry as an example, this paper proposes IOT and operation big data analysis to equipment fault monitoring, diagnosis and preventive maintenance. Under the three-layer system framework of perception layer, network layer and application layer, machine learning algorithm is applied to carry out data mining on the equipment operation big data, establish expert knowledge base, obtain diagnosis rules, and realize the intelligent and efficient management mode integrating online monitoring, remote monitoring, remote diagnosis, fault matching and identification. Based on IOT and operation large data analysis, equipment health intelligent diagnosis provides the basic guarantee for equipment intelligent operation and maintenance, which helping enterprise establish new equipment management, maintenance, inspection and repair system under the concept of predictive maintenance and proactive maintenance.

Keywords: Predictive Maintenance, Intelligent Fault Diagnosis, IOT, Operation Large Data Analysis

1. Introduction

In recent years, the heat of intelligent manufacturing is increasing year by year. National Institute of Standards and Technology defines intelligent manufacturing as the application of information and communication technology to various manufacturing business links to achieve business goals. Wu Cheng from Tsinghua University defines intelligent manufacturing as the theories, methods and technologies involved in the application of new generation information technology represented by big data, cloud computing, mobile technology, etc.) [1,2].

With the development of modern industry, the working intensity of mechanical equipment continues to increase, and the production efficiency and automation level are getting higher and higher



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

(high speed, heavy load, continuous and intelligent), which greatly improves production efficiency. For enterprises, as more and more machinery and equipment are widely used, their operation status monitoring, safety and stability are also becoming more and more important. The equipment connections between the various links of production and manufacturing are getting closer and closer. A small failure will cause a chain reaction to cause catastrophic destruction of the entire equipment and even the equipment-related environment. Therefore, make the earliest and reliable detection of potential equipment failures, issue early warnings in time, remind factory operation and maintenance personnel to take appropriate measures in time, avoid unplanned shutdowns, reduce maintenance costs and ensure reliable operation, it is also the basic guarantee for intelligent manufacturing.

2. Equipment Predictive Maintenance

2.1 *Predictive Maintenance and Preventive Maintenance*

Enterprise management and equipment management experts generally reach a consensus: the basic guarantee of intelligent manufacturing is to make the earliest and reliable detection and judgment of potential equipment faults, issue early warning in a timely manner, avoid unplanned shutdown, and ensure reliable operation [3,4] Predictive Maintenance is based on continuous online monitoring of equipment operation, to determine the health status, and reasonable forecast development trend of running state, and then determine the equipment repair time, content, way and the necessary technical and material support. There is an essential difference between predictive maintenance and preventive maintenance. The latter is also called preventive maintenance, which is time-based maintenance. It performs shutdown inspections at specified time intervals to prevent fault. Compared with preventive maintenance, implementing a predictive maintenance system has the following advantages: (1) Avoid "excess maintenance", prevent unnecessary maintenance and reduce maintenance costs; (2) Effectively reduce equipment downtime; (3) Find hidden troubles as early as possible, avoid major accidents; (4) Reasonably predict the remaining life of equipment, so that the equipment can reasonably be over-service under the condition of operation.

2.2 *Predictive Maintenance Technology System*

Predictive maintenance technology system covers the state condition monitoring, fault diagnosis, prediction, maintenance decision and so on four aspects: Among them, the condition monitoring technology uses temperature, pressure, vibration, and ultrasonic sensors to monitor the equipment operation status, and uses the synergy and complementarity between multi-sensor data for effective monitoring, diagnosis and prediction, and efficiently process the data to achieve more accurate condition monitoring. State prediction technology is based on the history and current equipment failure eigenvalue analysis, to predict the future of the fault characteristic value, so as to predict the running status of equipment, predict possible fault equipment, and on the basis of these characteristic values, physical model, knowledge system and statistical model of mixed fault, to judge the equipment running status, predict equipment parts remaining service life, provide basis for early prevention and equipment repair [6].

2.3 *The Market for Predictive Maintenance*

Interact Analysis has just published a report titled The Market for Predictive Maintenance in Motor Driven Systems, as shown in Fig.1, it is pointed that revenues associated with predictive maintenance are growing exponentially.

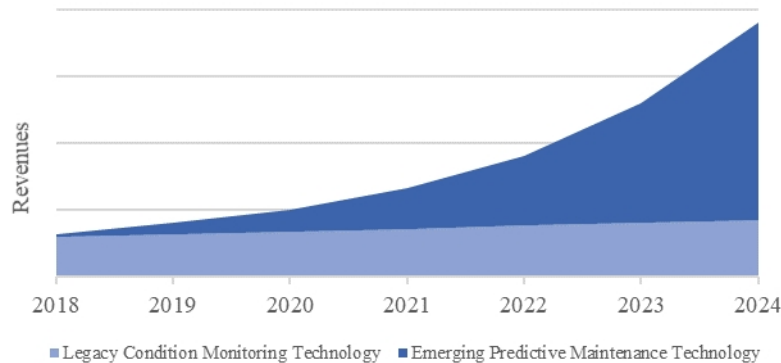


Fig.1 Growth of revenues-condition monitoring vs. predictive maintenance

The above graph shows the predictive maintenance projected to hit a valuation of nearly \$1 billion by 2024, growth in the market for predictive maintenance hardware and software in motor driven systems is fueled by the emergence of smart sensing, its dedicated software, and the new business models which have emerged to support this technology. Predictive maintenance is a low hanging fruit in the IOT space – perhaps the lowest, it is time to become familiar with this market as it is rapidly developing.

3. Application of IOT in Equipment Health Monitoring and Diagnosis

The emergence of the IOT provides new models and ideas for equipment health monitoring and diagnosis. The application of the IOT technology, through various sensors and other information collection devices, according to agreed agreement rules, all kinds of items are "put" in the network, breaking the boundaries between each other, allowing them to use the network exchanges information, so as to realize intelligent monitoring and management, and achieve "Internet of Things" [5].

Under the three-layer system framework of perception layer, network layer and application layer, as shown in Fig.2, an intelligent and efficient monitoring and diagnosis mode integrating fault prediction, remote monitoring, remote diagnosis, online diagnosis and artificial intelligence is realized.

(1) Perception layer uses the sensor nodes on the installation and equipment to collect information, and uses short-distance communication technology to transmit data to the field gateway or upper computer, so as to realize the collection and transmission of the perception layer data.

(2) After the perception layer acquires the equipment health monitoring signals and operation parameter data, then transmits them to the servers of each branch factory through the network layer, and then uploads them centrally to the equipment monitoring and diagnosis management platform of the company's headquarters, so as to realize the centralized storage of the equipment health information;

(3) The application layer mainly realizes the monitoring signal analysis and fault feature extraction, fault diagnosis and prediction. Firstly, variety of mature data preprocessing algorithms are used to reorganize, mine and reason the data, and then the data is personalized and targeted for processing, through man-machine exchange interface, valuable core information and conclusions are presented to users, and conclusions on user needs are obtained. Finally, functional requirements of device health monitoring and diagnosis based on the concept of Internet of Things are completed, and intelligent management, application and services are realized.



Fig.2 Schematic diagram of three-layer architecture of IOT system

Specifically, the main functions of IOT technology in equipment health monitoring and diagnosis are as follows: (1) The IOT technology is adopted to push real-time alarm information through mobile terminals in a timely manner to improve the efficiency of security management [7]; (2) Make statistical analysis on all kinds of online monitoring data, compare them with design parameters and historical data, use comprehensive analysis method to make trend analysis on historical data, generate trend analysis curve of equipment operation state, form trend analysis report, guide operation and maintenance management; (3) IOT is used to realize the Internet of Things electronic tag coding, performance parameter recording and management of the main equipment in the automated factory, to automatically complete the collection and diagnosis of equipment status data, and to obtain auxiliary management information including mechanical equipment identification, so as to realize the information-based management of the automated factory; (4) Transmit data, images and alarm events to centralized control center, cloud service platform and mobile terminal through private network or Internet to realize remote management and mobile office.

4. Intelligent Diagnosis of Equipment Health Based on Operation Large Data

The equipment operation status monitoring is characterized by many monitoring points, high sampling frequency and long data collection time, etc., which makes the amount of operation data to be processed present explosive growth. The generation of massive operation data means that the era of big data has entered, big data analysis and machine learning technology was applied to predictive diagnostics [6]. Flow chart of equipment health monitoring and fault diagnosis based on knowledge base is shown as Fig.3, machine learning algorithms such as clustering and decision tree are used to mine big data, establish expert knowledge base, and obtain diagnosis rules related to faults, so as to improve the reliability of equipment fault monitoring and diagnosis.

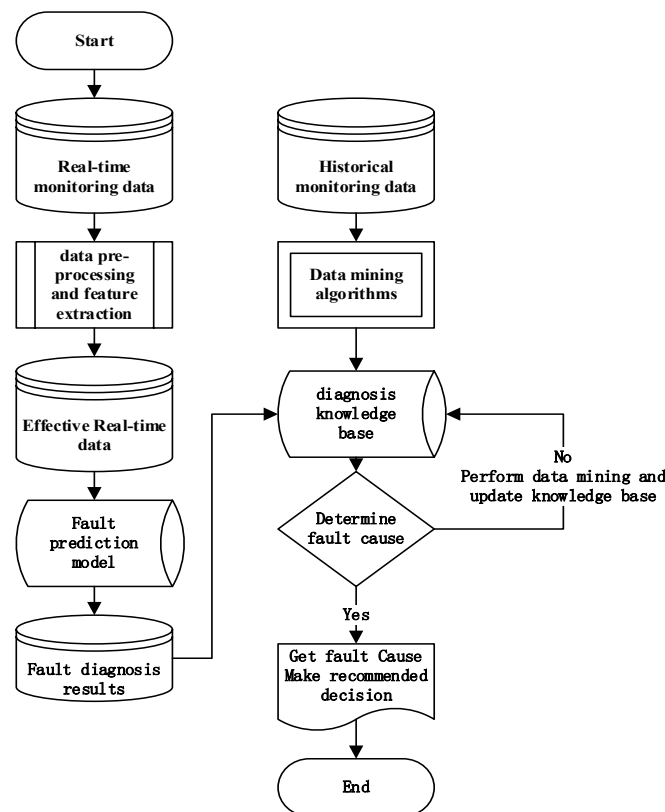


Fig.3 Flow chart of equipment health monitoring and fault diagnosis based on knowledge base

Operation big data analysis is used to maintain the equipment when the failure is about to happen. The maintenance is based on the results of state detection and fault diagnosis analysis. It is an active and active maintenance method, especially for key equipment. As shown in Fig.4, combining big data-driven judgment with expert knowledge base judgment, failure mode and key factor analysis, fault diagnosis record is comprehensively formed, which is the foundation of maintain solution [7].

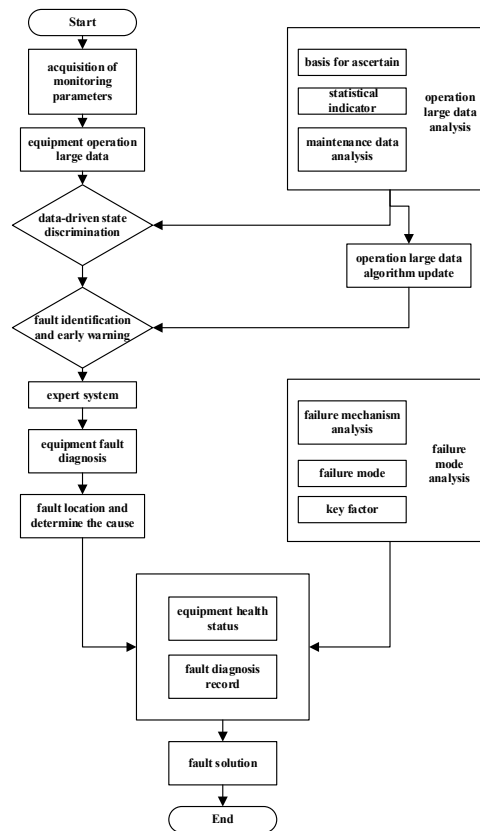


Fig.4 Flow chart of equipment operation big data analysis

5. Practical Application Cases in Process Industry

5.1 Online Monitoring and Diagnosis System Architecture

From the perspective of the overall network architecture, the monitoring and diagnosis system uses sensors installed on the key equipment of each branch to obtain the health status monitoring signals and operational data of the equipment, and uploads them to the software servers of each branch through the internal network of the enterprise, and then uploads them to the centralized cluster software server for data transfer. The cluster software and equipment health monitoring and diagnosis IOT platform jointly realize data analysis, fault feature extraction, fault diagnosis and prediction functions to realize intelligent management, application and service. The equipment health monitoring and diagnosis platform has powerful functions such as data visualization, fault diagnosis, fault alarm and fault statistics. Through real-time viewing, statistics, and traceability, information such as reliability of critical equipment, fault data, and replacement of spare parts are obtained, which provides a basis for the formulation of maintenance plans [8].

5.2 Local Monitoring and Expert Remote Analysis Joint Diagnosis Mode

The monitoring and diagnosis system combines equipment fault diagnosis technology with computer network technology to establish an open remote monitoring and diagnosis system. A new type of diagnostic technology based on the IOT, combining modern communication technology and network technology. As shown in Fig.5, through PC, mobile phone can facilitate the remote monitoring and fault diagnosis of the equipment by the data monitoring center [9]. The equipment remote diagnosis mainly includes the following three aspects: (1) through the self-diagnosis function to realize the effective identification of data collection, improve the monitoring system hardware facilities state control; (2) through remote access web-based client to realize monitor, predict and evaluate the

performance status; (3) In case of equipment failure or fault symptoms, the remote diagnosis center will timely diagnose the equipment through the network relying on a variety of professional analysis tools [10,11].

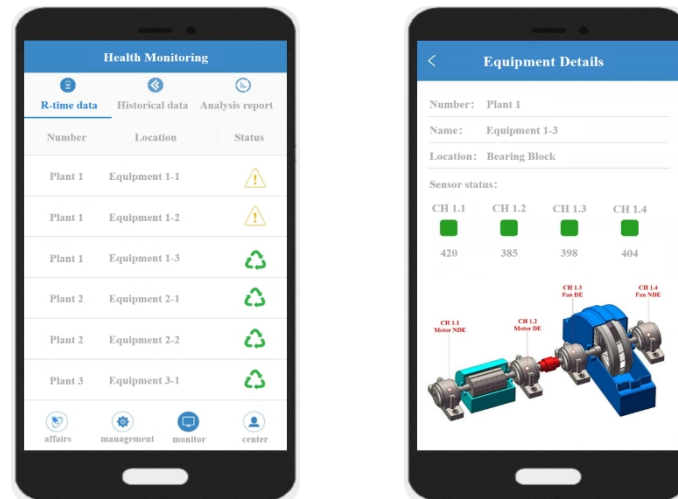


Fig.5 Equipment health housekeeper mobile APP monitoring function

5.3 Intelligent Diagnosis based on Operation Large Data Analysis

Predictive maintenance at the present stage in the fault diagnosis is mainly achieved by manual analysis, diagnostic analysis on the trend, waveform, spectrum, envelope analysis tools, combined with the transmission structure, the information such as mechanical components parameters, precision positioning and fault components equipment failure, residual life forecast, to develop reasonable plan of spare parts and maintenance scheme provides quantitative basis.

As predictive maintenance technology matures, unceasing development of big data and cloud platform technology, the library of the fault cases attributes of constantly enrich, support vector machine, artificial neural network and fuzzy diagnosis technology widespread application and the future of predictive maintenance is based on large data, cloud computing and intelligent diagnosis on artificial intelligence technology, through series of information technology, IOT, big data, system integration technology, intelligent diagnosis technology make remote diagnosis for the gathering of all kinds of data analysis, diagnosis efficiency and accuracy have been improved.

6. Conclusion

This paper aims at the practical equipment management problems existing in industries and enterprises, changed the existing equipment maintenance ideas and methods from planned maintenance to predictive maintenance and proactive maintenance, applied IOT and big data technology to equipment health status monitoring and diagnosis. Under the three-layer framework of IOT, machine learning algorithm is applied to carry out data mining on operation big data, establish expert knowledge base, obtain diagnosis rules, and realize intelligent and efficient management mode integrating online monitoring, remote diagnosis, fault matching and identification.

Application of IOT and the operation big data analysis technology could help to find the device key mechanical parts of the fault cause, to guide enterprises rapid maintenance and reasonable arrangement of production, help enterprise, industry find a shortcut to equipment operation maintenance, meet the diverse needs of the enterprises, eliminate the bottleneck of enterprises to improve productivity, and to improve the competitiveness of enterprises and economic benefits.

References

- [1] Zhou Ji: Intelligent Manufacturing---Main Direction of "Made in China 2025". China Mechanical Engineering 17, 2273-2284 (2015).(in Chinese).

- [2] Huang Zhongshan, Tian Ling: Research on Prognostics and Health Management System. Journal of Graphics 39, 855-861 (2018).(in Chinese).
- [3] Liu Jingjun, Feng Yiding: Practice and Prospect of Intelligent Manufacturing in Steel Industry. Hebei Metallurgy 4, 74-80 (2018).(in Chinese).
- [4] Chen Lei: The Design of Intelligent in Equipment Monitoring Platform. Metallurgical Equipment 246, 32-34 (2018).(in Chinese).
- [5] Zhu Hongbo, Yang Longxiang, Yu Quan. Investigation of technical thought and application strategy for the internet of things. Journal on Communications 31, 2-9 (2010).(in Chinese).
- [6] Chang Hongzhu, Yan Mei, Xu Xiaocheng, Wang Kai: Application of Internet of Things Technology in Predictive Maintenance of Equipment. Logistics Engineering and Management 40, 79-80 (2018).(in Chinese).
- [7] Liu Qiang, Chai Tianyou, Zhao Lijie, Progress of data-driven and knowledge-driven process monitoring and fault diagnosis for industry process. Control and Decision 25, 801-807 (2010).(in Chinese).
- [8] Liu Daxin, Qiu Lemiao, Wang Zhiping, Fault Diagnosis Technology for Complex Equipment Based on the Learning of Big Operation Data and Its Typical Application. ZTE Technology Journal 23, 56-59 (2017).(in Chinese).
- [9] Huang Feifei, Study on the Predictive Maintenance of Oil Gas Equipments Based on Data Mining. Information & Communications 10, 16-18 (2016).(in Chinese).
- [10] Xie Tian. Design and Implementation of Equipment Health Monitoring System Based on Internet of Things and Big Data Analysis. BEIJING JIAOTONG UNIVERSITY, (2018).(in Chinese).
- [11] Li Hongyuan, Gao Fan. Research on Application of Stress Wave Technology in Mechanical Fault Diagnosis of Rolling Mill Unit. Process Automation Instrumentation, 40, 60-63 (2019).(in Chinese).