

Article

Design and research of intelligent watt hour meter fault early warning system based on data mining technology

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Abstract: With the rapid development of information technology and the continuous improvement of communication technology, electric energy meters are innovating and developing towards networking, informatization and intelligence. This research constructs a model design of electric energy failure early warning system based on big data mining technology under the background of big data. It analyzes and studies the intelligent electric energy meter failure early warning system. Through the analysis and comparison of the factors affected, comprehensive performance and application prospects of the intelligent electric energy meter failure early warning system under different data mining technologies, the research results show that the application of big data mining technology makes the heavy work of data collection and data analysis integrate big data mining technology, it can be popularized more widely and applied to more scenarios, thus reducing the manual workload, it makes the work efficiency more significantly improved, and can promote the reform of China's smart grid more quickly.

Keywords: big data; data mining technology; intelligent electricity meter; fault early warning system; data and network management

1. Introduction

With the progress of artificial intelligence technology and the popularization of big data technology, the development of smart grid in China is closer to the needs of people's life and social development with the use of Scanning Electron Microscope (SEM). In China, hundreds of millions of smart electricity meters have been installed. The later maintenance and management inspection of smart electricity meters are key development problems for power enterprises. Ma Yongchao, the operation of SEM in the power grid is becoming more and more important. The research direction is to improve the reliability of SEM for the variety of faults that will occur in use [1]. Tension, in order to reduce the data error of smart electricity meters, compares the data mining algorithm of the Gauss mixture model smart electricity meters with the traditional clustering algorithm model; Five algorithm models are calculated according to the data characteristics, and 96 fault information diagnosis models of electric energy meters are summarized based on the actual operation of electric energy meters. It is found that the error data of intelligent electric energy meters under the data mining algorithm is smaller and the performance is better [2]. Chen Guang and others proposed a quality analysis framework for SEM based on big data technology, which makes full use of production data in the modern supply chain and provides a reliable analysis of the direction and ideas of big data technology in the application of SEM [3]. Smart energy meters such as Jiang Jianfeng are advanced metering devices in

smart grid, and their fault types are complex and changeable; It has a significant impact on the safety and metering of residential electricity; The importance of fault early warning system is verified by deeply mining data through big data mining technology and establishing cloud model for fault classification and diagnosis of intelligent electric energy meter [4]. Zhang Ya's smart watt hour meter is widely popularized due to the convenience and functionality of information collection; The maintenance and service of electric power enterprises is an important challenge; Based on data mining technology, The C5.0 algorithm is used to build the fault early warning model. The model is trained by a large number of training sets, and the early warning accuracy of the model is calculated by using the test set. A fault early warning system was built through VS2016 platform, which enables the system to accurately warn the status of intelligent electricity meters during operation, reducing the waste of enterprise human resources [5]. Shang Xiwen analyzed the necessity and feasibility of smart electricity meter operation state evaluation technology through multi-source data fusion technology, providing reference for smart electricity meter data analysis technology and state evaluation technology [6]. Zhu Dongsheng aims to enable electric power enterprises to better implement marketing services and business data mining; Improve the accuracy and safety of the fault early warning system of intelligent electricity meters through data mining technology; By collecting the detection and fault data of electric energy meters in the information system, a fault database of electric energy meters is established, which also provides a basis for the performance improvement and optimization of manufacturers and suppliers [7]. Cen Hua traditional detection methods cannot detect and warn SEM well, in order to improve detection efficiency and fault warning accuracy; The monitoring system of intelligent watt hour meter based on PLC is designed; In the data mining method, input and process the operation fault data of intelligent electricity meters in the intelligent warehousing and logistics system, and obtain the fault information and rules to achieve intelligent fault early warning [8]. This paper analyzes and studies the fault data input of intelligent electric energy meter through big data mining, and finds out the correlation between data, the occurrence rule and characteristics of faults, Enhance the functionality and optimization characteristics of the fault early warning system and improve the accuracy of the fault early warning by improving the data analysis ability and intelligent level of the intelligent electricity meter; Mitigate human cost for the development of electric power enterprises.

Concept of big data mining technology

In recent years, with the development of the Internet and the characteristics of the information age; With the rapid development of new information generation methods and cloud computing, mobile and Internet of Things technologies, these technologies are also generating data all the time while developing. The data interaction generated by hundreds of millions of users' Internet services is increasing in the age of big data. The definition of big data in the Internet is a new generation of architecture and technology designed to more economically obtain value from data with high frequency, large capacity and different structural types. The data mining technology in big data is a process of finding potentially valuable and useful information and knowledge in

massive incomplete, noisy and fuzzy large databases, which is a kind of decision support. It is based on artificial intelligence technology, machine learning, statistics, etc.; In the process of data mining, inductive reasoning is made to help enterprises and users adjust market policies, reduce risks and optimize decisions. The data mining methods of big data include regression analysis, clustering analysis, association rules and neural network methods, etc. The data is mined through different methods. Yang Sen and others proposed to conduct big data analysis on single-phase customers' electrical parameters, customer files, and meter replacement information in the way of big data mining data analysis to address the problem of large workload, low efficiency, and low accuracy of single-phase electric energy meter wrong connection verification, accurately locate wrong connection customers, reduce customer complaints and improve work efficiency [9]. Wang Chao studied the future development direction of SEM through data mining technology, and explored a new direction in line with modern power grid construction and enterprise development; Under the data mining technology, the efficiency and reliability of problem finding and solving can be improved [10].

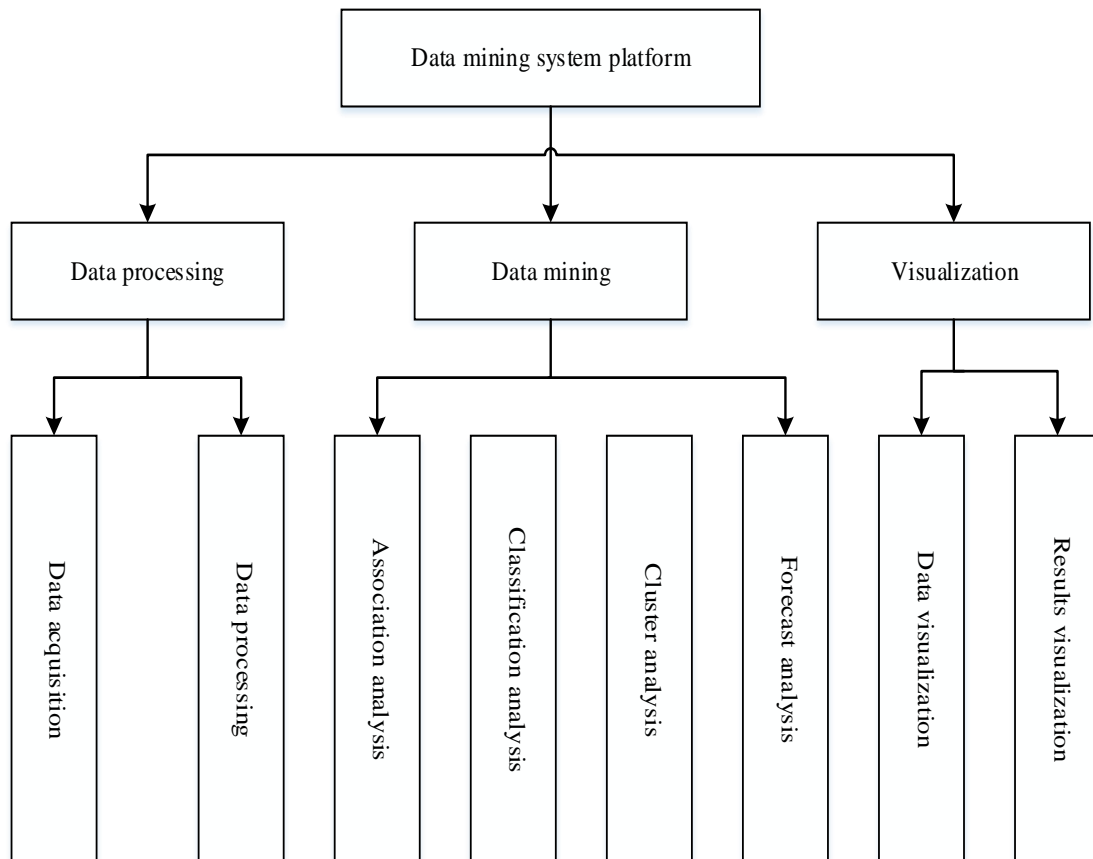


Figure 1. Flow diagram of data mining system platform.

As shown in **Figure 1**, the big data mining system platform is constructed through data processing, data mining and visualization; data collection and pre-processing, and data visualization results are obtained through data mining technology analysis methods. Data processing is a further operation after preprocessing, which may involve more complex data cleaning, feature selection, feature extraction and

dimensionality reduction. The purpose of this step is to prepare high-quality data input for data mining algorithms. Data mining is the core step that involves the application of various algorithms to discover patterns, trends, and associations in the data. The output of these algorithms will be used to generate the results for data visualization. Data visualization is the process of presenting the results of data mining in the form of graphs, charts, dashboards, etc., so that users can intuitively understand the patterns and trends in the data. Visualization helps to find anomalies, trends and correlations in data and supports decision making. In this study, the following algorithm formulas will be used to analyze and manage the data information of cluster analysis, such as Equation (1):

$$\min \sum_{i=1}^n \min_{j=1,2,\dots,k} \|x_i - u_j\|^2 \quad (1)$$

Among: x_i ($i = 1, 2, 3, \dots, n$) is the data point, u_j ($j = 1, 2, 3, \dots, K$) is the initialized data center.

2. Design idea of intelligent watt hour meter fault warning system

Some principles and research ideas that should be followed when designing the smart meter fault early warning system; the first point is to establish the smart meter database, which includes the historical fault database and real-time acquisition database, and the data is stored in the SQL2000 database platform for preliminary processing. SQL2000 database is a powerful relational database management system, which not only provides data storage and query function, but also SQL2000 database is a powerful relational database management system, which not only provides data storage and query functions, but also has built-in powerful data processing and analysis tools with strong scalability, high reliability and rich data types and programming interfaces, which can satisfy the needs of this paper's design for data storage.

There are various reasons affecting SEM faults, among which the prominent factors are the operating time and reliability of SEM according to the conditions; by discretizing the historical and real-time data, selecting the factors affecting the occurrence of faults, and dividing the attributes such as the operating time of smart energy meters, the historical fault database is discretized into a training set and a test set. After that, the smart meter fault warning model is constructed, the fault warning rules are constructed by the C5.0 decision tree algorithm, and the warning accuracy is evaluated by the training set and test set to construct the smart meter fault warning system. The C5.0 decision tree algorithm is an algorithm widely used in the field of data mining and machine learning, which is not only used for the classification problem, but also suitable for the regression problem, and has the following advantages features of fast construction speed, small model size and automatic pruning, which can meet the needs of the system design for data processing in this paper. Deng Guiping used information technology to improve the SEM life cycle quality warning and monitoring capabilities, which provides a research basis for the development direction of software design and service architecture [11].

3. Application of intelligent electricity meter fault early warning system based on data mining technology

Guo Bin analyzed the fault occurrence factors and rules of SEM, and improved the working reliability of SEM by judging the fault location; Establish a fault tree, analyze the fault characteristics, and analyze the cause of the fault with the association rule algorithm of data mining [12]. With the expansion of the application and development field of big data technology, its value in data mining and analysis has been recognized, and its effectiveness in the intelligent electricity meter fault early warning system has also been affirmed. The smart electricity meter intrusion detection method using big data technology has also been recognized. The accuracy of fault classification is improved by identifying the power meter with abnormal CPU load rate and communication flow in the statistics of metering data; Use big data mining to predict load and fault. Based on the fault early warning model, with the real-time fault database as the data source, and with the help of VS2016 platform, an intelligent electricity meter fault early warning system integrating data preprocessing, early warning model construction, intelligent electricity meter fault early warning and other functions is developed.

4. Simulation verification

4.1. Analysis of factors affecting intelligent watt hour meter fault early warning system under different data mining technologies

At the present stage, under the construction of full coverage of China's power grid, smart meter is an extremely important core equipment. Its application is conducive to the comprehensive collection of electric power information. It has the advantages of rich functionality, flexible expansion and diverse interfaces. It plays an important role in the stable and safe operation of power grid coverage. Aiming at the problem of smart meters affecting the power grid's access to power information, this study proposes to study and analyze the influencing factors of the smart meter fault early warning system based on big data mining technology in the context of big data. The influencing factors of smart meter fault early warning system under traditional data mining technology and big data mining technology are mainly meter operation time, installation conditions and self-reliability of the meter, in which the operation time of the meter is an important indicator to assess its fault risk. With the passage of time, the electronic components and mechanical structures inside the meter will gradually age, leading to a decline in performance and an increase in the failure rate; the installation conditions mainly include the temperature, humidity, electromagnetic interference, etc. of the environment in which the meter is located, and all these factors may have an impact on the stable operation of the meter. Self-reliability of the meter refers to the ability of the meter to resist failure and maintain stable performance given in the design and manufacturing process. This is usually related to the quality standard of the meter, the production process and the components selected.

According to the comparison results of the influence factors of smart meter fault warning system by traditional data mining technology and big data mining technology, the analysis and comparison data of the influence factors of smart meter fault warning

system under two different data mining technologies are obtained, as shown in **Table 1**:

Table 1. Analysis data sheet of factors affecting intelligent electric energy meter fault early warning system under different data mining technologies.

Group	Running time of smart electricity meter	Installation conditions	Self-reliability of electric energy meter
Traditional Data Mining Technology	58.69%	56.47%	57.68%
Big Data Mining Technology	90.37%	91.95%	91.08%

Table 1 shows that the application of big data mining technology has a higher impact on the intelligent meter fault early warning system than traditional data mining technology does on the intelligent meter fault early warning system, The application of big data mining technology has more advantages among the factors affecting the fault early warning system of smart electricity meters, such as the operation time of smart electricity meters, installation conditions and the reliability of electricity meters themselves.

Data visualization is conducted according to the analysis of factors affecting the intelligent electricity meter fault early warning system under different data mining technologies in **Table 1**, and **Figure 2** is obtained:

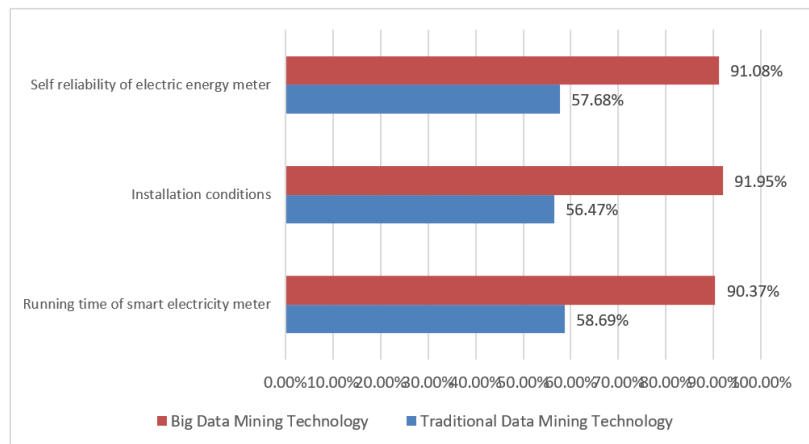


Figure 2. Data visualization diagram of factor analysis affecting intelligent electricity meter fault early warning system under different data mining technologies.

Figure 2 shows the comparison of the influence of traditional data mining technology and big data mining technology on the factors of the intelligent electricity meter fault early warning system, which can directly reflect that the application of big data mining technology has a deeper influence on the intelligent electricity meter fault early warning system, it also indirectly shows that big data mining technology can attach importance to the core factors of smart electricity meters. It can build an effective fault early warning model that can achieve accuracy through analysis and research from the smart electricity meters themselves, so as to reduce the occurrence of faults.

4.2. Comprehensive performance analysis of intelligent watt hour meter fault early warning system under different data mining technologies

With the continuous improvement of the national economic level, China’s power grid system also needs to be matched with it, constantly improved and optimized, which specifically reflects that it has made great progress in intelligent power meters, making the application of intelligent power meters more popular and extensive. The comprehensive performance analysis and comparison results of intelligent watt hour meter fault early warning system under two different data mining technologies show that the application of big data mining technology in intelligent watt hour meter fault early warning system is superior to the application of traditional data mining technology in intelligent watt hour meter fault early warning system in all aspects. By comparing and analyzing the comprehensive performance analysis and comparison data of intelligent watt hour meter fault early warning system under two different data mining technologies, **Table 2** is obtained:

Table 2. Comprehensive performance analysis data of intelligent electricity meter fault early warning system under different data mining technologies.

Group	Data acquisition	Electric energy monitoring	Model Selection	Algorithm optimization
Traditional Data Mining Technology	62.81%	64.25%	60.38%	61.90%
Big Data Mining Technology	94.39%	93.52%	90.98%	91.26%

In **Table 2**, by comparing the data of the application of traditional data mining technology and big data mining technology to the spatial guidance system of public libraries, the application data of big data mining technology is higher than that of traditional data mining technology in the process of applying the intelligent electricity meter fault early warning system, whether from data collection, power detection, model selection or algorithm optimization.

In order to more intuitively evaluate the energy efficiency of the comprehensive performance analysis of intelligent watt hour meter fault early warning system under two different data mining technologies, the comprehensive performance analysis data of intelligent watt hour meter fault early warning system under different data mining technologies are visualized, and **Figure 3** is obtained:

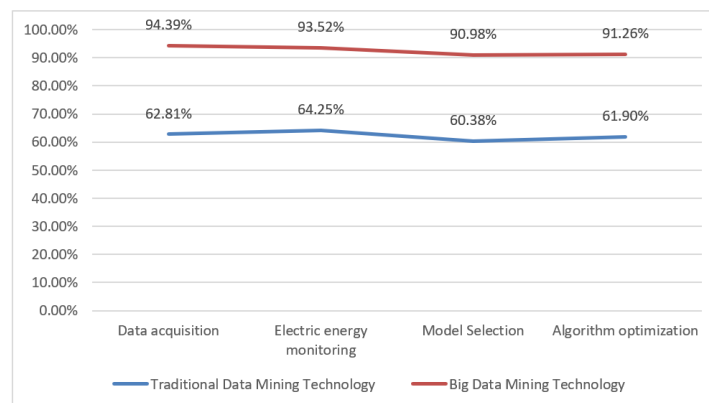


Figure 3. Visualization chart of comprehensive performance analysis data of intelligent watt hour meter fault early warning system under different data mining technologies.

Figure 3 intuitively compares the comprehensive performance analysis data of intelligent watt hour meter fault early warning system under two different data mining technologies, indicating that big data mining technology has higher data acquisition degree, better power detection effect, more diversified model selection, and more superior algorithm optimization for intelligent watt hour meter fault early warning system. This shows that the application of big data mining technology can improve the accuracy of electric energy classification. Through the application of big data mining technology, we can fully mine the massive power consumption data obtained by intelligent electric energy meters, and use big data technology to predict loads and faults, thus realizing the innovation of intelligent electric energy meter fault early warning system design.

4.3. Application prospect of intelligent watt hour meter fault early warning system under different data mining technologies

At present, people's living standards are constantly improving, and science and technology are also developing continuously and at a high speed. The requirements for multiple functions such as the fault early warning system of smart electricity meters have never stopped. It is expected that in terms of basic functions, highly intelligent electricity meters will appear, thus providing a new intelligent living space. Based on this, this research analyzes and studies the application and development prospect of intelligent watt hour meter fault early warning system from the following three perspectives: information management, analysis and diagnosis, and decision support. Through the analysis and comparison of the application prospect of intelligent watt hour meter fault early warning system under two groups of different data mining technologies, the results show that, the intelligent electricity meter fault early warning system based on big data mining technology has a higher application degree in all aspects than that based on traditional data mining technology. According to the analysis and comparison of the intelligent electricity meter fault early warning system under two groups of different data mining technologies, **Table 3** is obtained:

Table 3. Application prospect analysis data table of intelligent electricity meter fault early warning system under different data mining technologies.

Group	Information management	Analysis and diagnosis	Decision support
Traditional Data Mining Technology	59.23%	62.62%	60.91%
Big Data Mining Technology	92.53%	94.01%	91.75%

In **Table 3**, the data analysis of the intelligent electricity meter fault early warning system based on traditional data mining technology is below 65%, while the analysis and evaluation of the intelligent electricity meter fault early warning system based on big data mining technology are above 90%. By analyzing and comparing the application data of intelligent electricity meter fault early warning system under different mining technologies, we can draw a conclusion that the intelligent electricity meter fault early warning system using big data mining technology has a wider application and a better development prospect.

In order to more clearly reflect the comparison results of the application prospect analysis data of intelligent watt hour meter fault early warning system under two different data mining technologies, the visual analysis based on the data obtained in **Table 3** is shown in **Figure 4**:

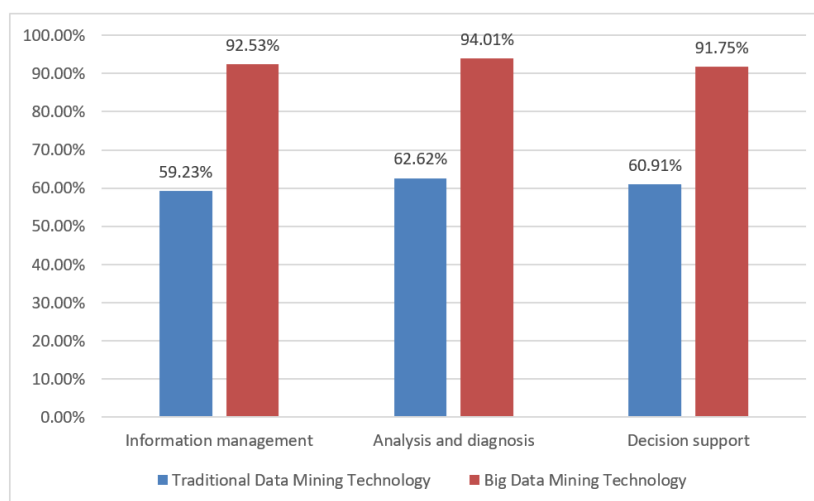


Figure 4. Application prospect of intelligent electricity meter fault early warning system under different data mining technologies.

As can be seen from **Figure 4**, with the application of big data mining technology, all items in the intelligent watt hour meter fault early warning system have been significantly improved and optimized, enabling it to mine the effective information hidden in the huge, complex and unclear database, so that the system can be better applied to information management, analysis and diagnosis, decision support and other aspects of electric energy.

In summary, by analyzing the smart meter fault early warning system based on traditional data mining techniques and the smart meter fault early warning system given in this paper, it can be seen that the smart meter fault early warning system given in this paper has a wider range of applications and a better development prospect, which can optimize the items in the fault early warning system, be better used for power information management, and can be used for different types of smart meters and power system environment.

5. Summary

This research studies and analyzes the fault early warning system of smart electricity meters and traditional fault early warning system by integrating big data mining technology, and concludes that the fault early warning system of smart electricity meters under big data mining technology is more convenient in data pre-processing and data analysis and collection, and it is convenient for power enterprise workers to reduce the waste of human resources by troubleshooting and positioning the fault rules, Reduce the risk of troubleshooting. It is more intelligent in the effectiveness and security of early warning, which guides the development of future power enterprises and promotes the construction and development of smart grid.

Author contributions: Conceptualization, TW and ZS; methodology, TW; software, ZS; validation, TP, LZ and BG; formal analysis, BG; investigation, TP; resources, TW; data curation, TP; writing—original draft preparation, HW; writing—review and editing, ZS. All authors have read and agreed to the published version of the manuscript.

Ethical approval: Not applicable.

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Conflict of interest: The authors declare no conflict of interest.

References

1. Cen Hua. Design of PLC based intelligent meter operation fault monitoring system. *Manufacturing Automation*, 2018, 40 (11): 138-141
2. Chen Guang, Chen Shaobing, Li Zekun, Cui Xiaoyu. Research on Big Data Analysis Technology for Smart Meter Quality in Modern Supply Chain. *Automation and Instrumentation*, 2021,16 (05): 180-183+188
3. Deng Guiping, Guo Yu, Gan Yiyi. Software Design of Quality Monitoring and Early Warning System for the Whole Life Cycle ofSEM. *Instrument Technology*, 2019,28 (09): 46-48
4. Guo Bin, Liu Peiqi, Feng Xingxing, Chen Jianhua, He Shengchuan, Xu Lijuan. Research on failure analysis of electric energy meters based on fault mining. *China New Technology and New Products*, 2019,14 (23): 51-54.
5. Jiang Jianfeng, Zhang Yin, Tian Shuxin, Yang Xijun. Fault data analysis ofSEM based on cloud theory. *Journal of Electric Power Science and Technology*, 2020,35 (02): 163-169
6. Ma Yongchao, Zhao Wei, Huang Songling. Overview of Research on Improving the Reliability of Intelligent Electric Energy Meters. *Electrical Measurement and Instrumentation*, 2022,59 (04): 1-7
7. Shang Xiwen, Ji Ying, Zhang Jianhuan. Overview of the research on the operation state evaluation technology ofSEM. *Electrical Measurement and Instrumentation*, 2020,57 (03): 134-141
8. Shu Juelin, Zhang Li, Hu Jian. Data mining and analysis method of intelligent ammeter error based on Gaussian mixture model. *Electronic Measurement Technology*, 2021,44 (15): 56-61
9. Wang Chao. Thoughts on the Application of Data Mining in the Fault Analysis of Intelligent Electric Energy Meters. *Metallurgy and Materials*, 2021,41 (04): 37-38
10. Yang Sen, Ma Wen, Li Long, Duan Xu, Ma Huan, Zhao Pengcheng. Research on the wiring error analysis method of single-phase electric energy meters based on big data. *Power Information and Communication Technology*, 2021,19 (11): 100-107
11. Zhang Ya, Fan Yanfang, Liu Qunjie. Design and development of fault early warning system forSEM. *Electric Measurement and Instrumentation*, 2021,58 (01): 183-188
12. Zhu Dongsheng, Li Tianyang, Xu Shiming. Research on fault analysis of electric energy meters based on data mining technology. *Automation and Instrumentation*, 2018,33 (05): 14-18