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Analysis of Electrical Equipment Information Detection and Diagnosis Based on Multiple Information Integration

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ABSTRACT

This article studies a diagnostic analysis method for electrical equipment information detection based on multi-information integration. By integrating and analyzing information from multiple sources of electrical equipment, the accuracy and efficiency of equipment fault detection and diagnosis can be effectively improved. In detecting and diagnosing electrical equipment information, multiple sources of information are usually involved, including equipment operation data, sensor data, historical maintenance records, etc. This information has different forms and characteristics, so it needs to be integrated and comprehensively analyzed to fully explore the useful information within it. This article proposes a method for detecting, diagnosing and analyzing information on electrical equipment based on multi-information integration. This method first preprocesses and integrates information from different sources, then utilises machine learning and data mining techniques to analyze and mine the information. Among them, special attention is paid to the complementarity of information and fusion methods to extract valuable features and patterns from different information fully.

Keywords: Multi-information Fusion, Fault Diagnosis, Electrical Equipment

1. Introduction

As China's modernization process continues to advance, the electricity demand is also growing. Therefore, the security of the power system also has higher requirements [1]. The evaluation and diagnosis of the running state of the electrical equipment are of great significance to ensure the electrical equipment's safe operation and the power system's safety and stability [2]. Since the state has put forward the goal of establishing a strong smart grid, higher requirements for the safety and reliability of electrical equipment have been put forward [3]. No one is on duty in many parts of the national grid, so security monitoring is even more important [4].

In addition, the electrical equipment involves many aspects, and the security examination environment is terrible. Therefore, it is urgent to establish a fault detection and disaster detection system for electrical equipment based on multi-information fusion [5].

There are many signs of electrical equipment failure, the most important of which is temperature changes. Therefore, the system first monitors the temperature of the electrical equipment and evaluates its operation [6]. Once the problem is detected, the local analysis of the electrical equipment is immediately carried out through the neural network and the fault area is identified. Then, the information is analyzed. The system carries on the fusion analysis of the information and finally achieves the electrical equipment breakdown analysis goal [7]. Through this research, the electrical equipment fault point and fault reasons can be quickly and accurately found to repair the equipment according to the cause of the fault, which can reduce the economic losses and casualties caused by electrical equipment failures [8].

2. The State of the Art

Currently, the online monitoring of electrical equipment at home and abroad is to monitor or patrol a single or small range of equipment with expensive instruments and meters. It is difficult to solve large-scale, network, real-time online monitoring and early warning [9]. Domestic inspection of electrical equipment is mainly based on regular maintenance, which wastes a lot of manpower and material resources. If the fault occurs during the neutral repair period, it will cause economic losses and casualties [10]. Although the failure can be reduced to a certain extent, the maintenance mode of this broad screen is undoubtedly low efficiency and vulnerable [11]. In addition, our country is vast in territory, and it is difficult to avoid the lack of maintenance or excessive maintenance [12].

This method of periodical maintenance has great drawbacks. So now, people have adopted a form of state overhaul. Considering all kinds of status information, such as running condition, pretest condition, maintenance, family quality history, defect and online test, the diagnosis, prediction and evaluation are carried out [13]. At present, this method has important theoretical significance and practical value, which can reduce maintenance costs and greatly improve the reliability of equipment [14]. At this stage, with the development of computer technology, the use of computers in various fields has become more and more widespread. The application of computer technology in electrical maintenance reduces the occurrence of faults [15].

3. Methodology

3.1. Research Ideas and Methods of Electrical Equipment Fault and Disaster Detection System Based on Multi-Information Fusion

Information fusion is an innovative technology of information technology. Various information can be fused, analyzed, and used together, and then useful information can be analyzed. It is the technique of summarising multi-information and finally drawing a conclusion. However, in the field of electrical equipment fault detection, due to the complexity of the electrical equipment and the harsh environment, the equipment has shown many uncertainties in the failure process. There are many reasons for uncertainty: uncertainty in fact; uncertainty in the standard conditions; uncertainty in the validity of the guidelines; uncertainty of reasoning; uncertainty caused by incomplete knowledge and one-sided data. Three kinds of uncertainty are determined: randomness or possibility, fuzziness, incompleteness, and ignorance. Information fusion shows its importance in dealing with these uncertainties. This paper uses an electrical equipment fault and disaster detection system based on multi-information fusion technology to detect fault analysis and diagnosis under uncertainty. Its simple messaging model is shown in Fig.1.

3.2. Functional Requirement Design and Design Idea of Electrical Equipment Fault and Disaster Detection System Based on Multi-Information Fusion

Fig.2 shows the block diagram of the electrical equipment fault detection and disaster monitoring system based on data fusion. This is a system with low, medium and high levels of processing. Low-level information fusion is simply information fusion of a data layer. This kind of information fusion is the data fusion based on the original data. It is a kind of low-level information fusion.

The advantage of this technique is that it preserves the raw data, provides subtle information, and retains the raw data for subsequent work. However, this kind of information processing has many disadvantages. The data is generally more tedious, and there is much unnecessary information.

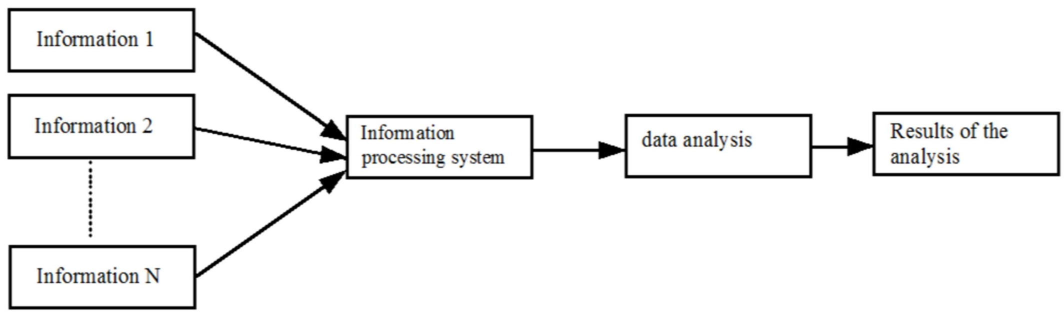

Figure 1 . System information transfer mode

Therefore, it also has the disadvantages of slow processing, poor error-correcting ability, too large communication information, and weak anti-interference ability. However, the combination of the information fusion analysis technology, which is not perfect, and the use of the following two phases shows the importance of this phase. A large amount of useful information is extracted at this stage. Because it is the most primitive data, its accuracy and integrity are very good. It lays a solid foundation for the following high-level information fusion processing.

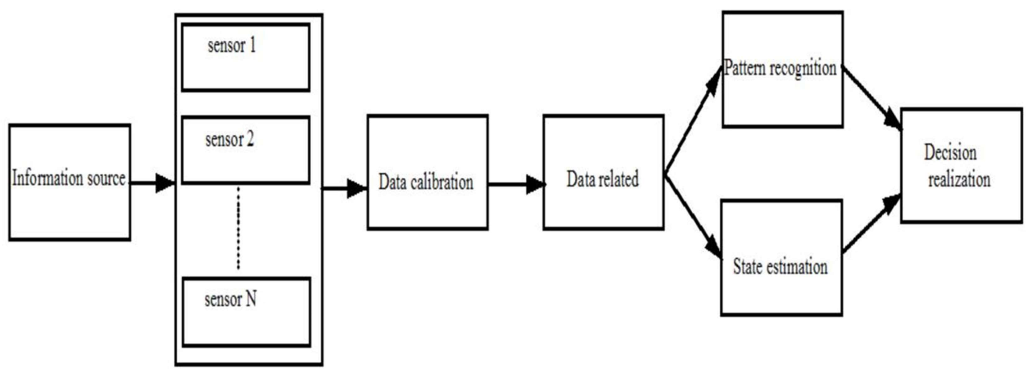

Figure 2. Block diagram of electrical equipment fault detection and disaster monitoring systems based on data fusion

The information fusion of the middle layer is called feature layer fusion. The raw information is processed and analyzed briefly, and then it enters the stage of information transmission. At this stage, feature extraction is performed for the information delivered at the last level. Then, the extracted feature information is synthetically analyzed. The information fusion of the middle layer has many advantages, which make up for the shortcomings of the original information processing. It even transforms the disadvantages of the original information into the advantages of the whole information fusion processing system. At this stage, information compression can be realized. As the information is compressed, the information becomes less and more accurate, and the information is processed very quickly. The information extracted at this stage is directly linked to decision analysis. Therefore, the extracted information is the characteristic information we need, providing the original characteristic information for the final decision.

The decision layer is the last stage of information fusion, the highest level of information fusion. The result provides the basis for decision-making information. Therefore, the information fusion of decision-making must start from the demand of the decision-making problem, and then the information extracted from the fusion can help to make decisions. The information fusion in this phase directly affects the decision-making level, and it is necessary to ensure the accuracy of this part of the information fusion. Otherwise, it will lead to decision-making errors, inaccurate fault detection, and economic losses or casualties. This part of information fusion has many advantages and high flexibility. In addition, the speed of information transmission and analysis is very fast, and the speed requirement is not high. It can summarize and analyze the information under different circumstances and analyze the causes and failures. Because this part of the information fusion is the most advanced information fusion, a lot of basic information is passed here for analysis. Even if there is an error in some of the original information, it will not affect the accuracy of the most important calculation results and have a strong ability to resist risks. Because this part of the information has been highly integrated, the amount of information entered the decision-making layer has been very small. The anti-interference ability is very strong, which makes up for the problem of poor anti-interference ability in the first stage. However, the decision-level fusion must first preprocess the original sensor information to obtain the respective decision results, so the cost of preprocessing is relatively high.

3.3. Establishment of Electrical Equipment Fault and Disaster Detection System Based on Multi-Information Fusion

The multi-information fusion of electrical equipment failure and disaster detection systems starts with use requirements and purpose. A system has been developed based on the advantages of the currently used inspection system. The detection system is divided into several major modules. A series of test data is then passed through the modules. The final analysis results are obtained by comparing the existing conclusions in the database and the expert's artificial analysis. The system's main information transfer and fault diagnosis structure is shown in Figure 3.

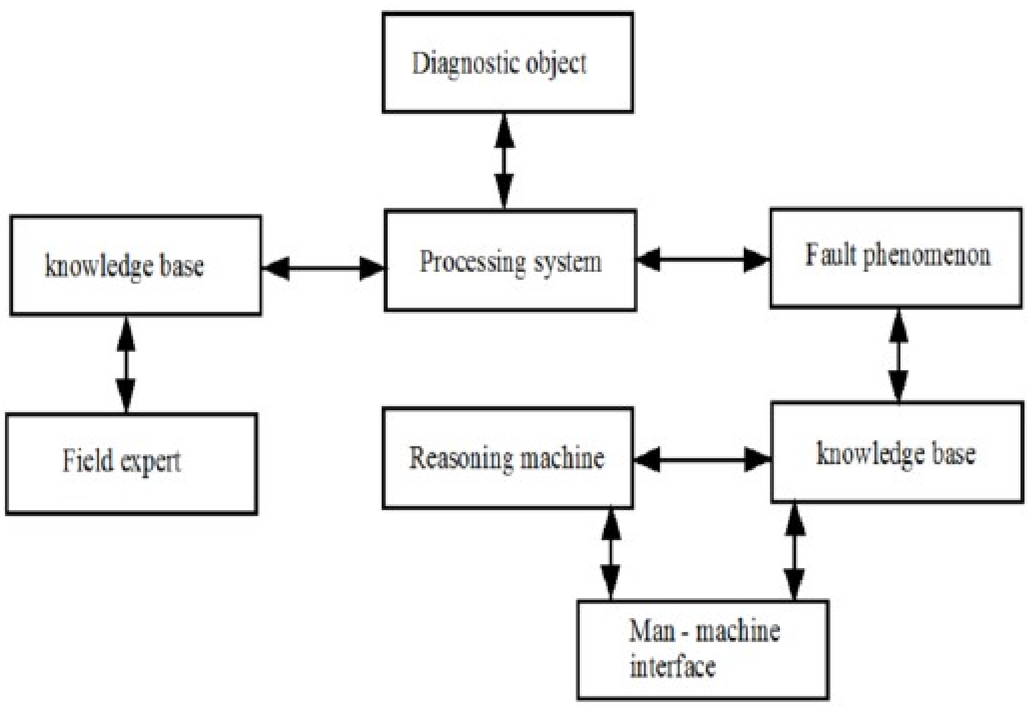

Figure 3. System of the main information transmission and fault diagnosis structure

After inputting the information collected by the diagnostic object through the analysis of the three previous stages, the information integration analysis is introduced into the central information processing module of the diagnosis structure. The fault information is analyzed and summarized here.

Different fault information is separated and compared with the fault database in the system. The system database contains all the information and processing methods that cause trouble. Common faults can be directly dealt with according to previous experience. It is known that electrical equipment failure is associated with the use of time. The relationship between the rate of electrical equipment failure and the use time is shown in Fig.4. When the system is used in the graph, the probability of failure meets the normal distribution. Therefore, it is necessary to extend the use of time defined in the system and guarantee the probability that the system can analyze the correct results by more than 99.6%. According to this relationship, the system divides the faults into the following levels: immediate processing, priority processing, normal maintenance and regular operation. This provides a solution not only for fault handling but also for the occurrence of faults. The results after processing are relatively magnified. For example, the equipment in the normal use margin is included in the normal maintenance range.

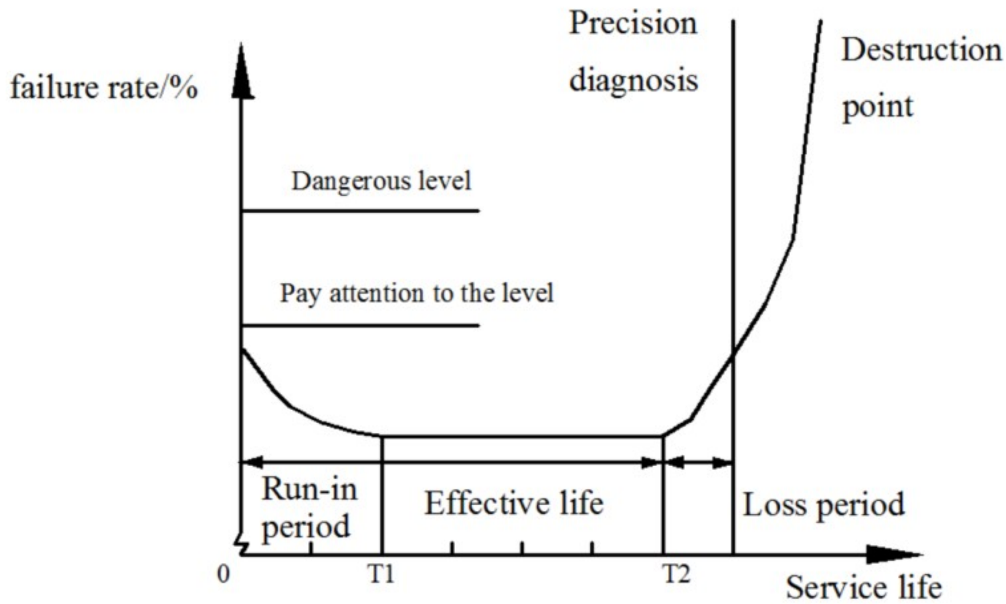

Figure 4. Electrical equipment failure rate and the relationship between the use times

However, the occurrence of failures does not follow the previous rules, which are changeable. The system is also associated with domain experts. For the problem the system can't handle, the processed information is sent to the computer of the national well-known experts, which is easy for human analysis. After the expert has received the fault situation, they may analyze the cause artificially and return to the system after the analysis processing way. Then, the system sends advice to the technical personnel for processing and maintenance according to expert opinions. Once the case has not appeared, the system will automatically add new faults stored in the database for future use. In this way, the system has formed a virtuous circle, ensuring people's lives and property safety. The system uses a lot of key technologies. Different environments and levels of information are converted into the same form and description method. In data fusion, the key problem of data correlation is to overcome the relative two meanings caused by the inaccuracy of sensor measurement and the interference and maintain data consistency. The database is divided into two parts: the real-time database and the non-real-time database. The real-time database provides the fusion results to the fusion center and stores the decision analysis results. Non-real-time databases mainly deal with historical results and historical information so that systems can be used in contrast. In addition, the system database can only collect information from expert feedback and can't input problems that have not occurred before. A national cloud database is built. The problems encountered by different system regions are transmitted to the cloud database and then shared with each region of the database, increasing the system's ability to deal with problems and speed.

4. Result Analysis and Discussion

As for the development of a system, testing is an essential stage and an important measure to implement the good use experience of software. System tests can identify system vulnerabilities in the system design and facilitate later repairs. At the same time, it also verifies that the system has achieved the desired application requirements. It can check whether or not the system information is transmitted and saved according to the scheduled route to avoid system performance problems. In addition, through system testing, it can check whether the system function is comprehensive. A system that fails to function properly is a failure. This information fusion system for electrical equipment failures and disaster detection can cause serious consequences if the system crashes or system functions fail. Therefore, the system needs to be strictly tested.

First of all, the performance of the system is tested and analyzed. When testing, one personal computer is used as a load-testing machine, and one server is used as the application server and database server. PC uses a 100 Mb/s LAN connection server. The test is conducted with Load Runner. Load Runner can simulate data transfer in various situations, which is suitable for testing this system. The ability of the system to process data and deliver results and the speed of the system are the focuses of our attention. Through our tests, it is found that when the 50 basic messages are processed simultaneously, the system response time is 5 seconds, and the response time of the system is about 10 seconds while dealing with the 100~500 basic messages. When there are more than 600 basic messages, the system response time is more than 1 minute. The test results are shown in Fig.5. Because the system is only used in a certain area, the 500 mapping points can be rapidly monitored to meet the use requirements. The system can work well if the observation points are less than 500.

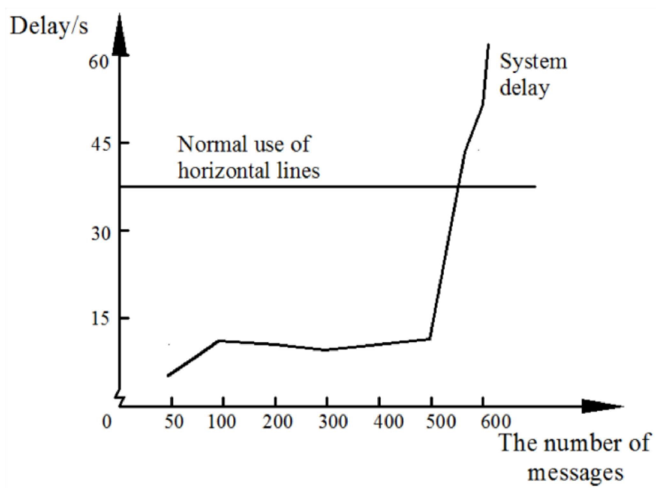

Figure 5. Test results

In addition, when the system deals with different amounts of information, the amount of CPU is also detected. It can be found that when the amount of data processed by the system is below 500, the CPU share is stable below 35%. When the system processes data at 600, the amount of CPU occupied is 71%, which has already begun to influence the system's running speed. The system has been in good shape for disk occupancy. When dealing with 600 basic messages, the system disk occupancy rate has been floating around 15%, fully meeting the application requirements. As with system delays, keeping the system handling 500 basic messages ensures that the system is safe and does not crash. The test results are shown in Table 1.

The above performance testing shows that the system can process 500 basic data simultaneously and run well. At the same time, the functionality of the system is also tested. 1000 disaster information simulations are made using computer simulations of various faults and disaster information.By using the black box testing method, the system is tested on various functions.

Through tests, it is known that the results of 1000 cases are processed by the information we set up, and it can handle the information properly, which can meet our normal use requirements. A system can only be improved continuously while using it. However, our electrical equipment fault and disaster monitoring system, which is based on multi-information fusion, can't be repaired until a problem arises. Because once the disaster occurs, it will bring huge economic losses to the country and people. Only strengthening the human system detection during the use can prevent problems caused by the system can't troubleshoot.

The number of data	100	200	300	400	500	600
CPU Take-up	33%	34%	33%	34%	35%	71%
Disk occupancy rate	14%	13%	14%	16%	16%	15%

Table 1. Disk and CPU occupancy table

5. Conclusions

The continuous use of computer technology has brought great convenience. Its application in the electrical equipment overhaul can greatly reduce the waste of human resources and waste of funds. It allows us to test and overhaul electrical equipment in the direction and direction, not in the same way as before. The electrical equipment fault and disaster detection system based on multi-information fusion built in this paper can satisfy the input of 500 basic messages and ensure the normal use of the system. Through our extensive functional testing, it is found that the system designed in this paper has a very good use function, and it is a safe and reliable detection system. The system database contains all kinds of processing methods and fault precursor information, which can ensure that the system is competent for detecting electrical equipment. Because the system's accuracy is linked to people's lives and property, the system can be regularly maintained and repaired. In the future, it is necessary to continue to check the system code for more than one person, prevent technical errors, simplify the calculation methods of the system, and speed up the system's data processing.

References

[1] Stein, B. (2010). *Mechanical and electrical equipment for buildings*. Nato Asi, *6*(7), 331–333.

[2] Zou, H., & Huang, F. (2015). A novel intelligent fault diagnosis method for electrical equipment using infrared thermography. *Infrared Physics & Technology, 73*, 29–35.

[3] Ahmed, M. M., Huda, A. S. N., & Isa, N. A. M. (2015). Recursive construction of output-context fuzzy systems for the condition monitoring of electrical hotspots based on infrared thermography. *Engineering Applications of Artificial Intelligence, 39*, 120–131.

[4] Hou, K., Li, J., Qu, T., et al. (2016). Development of a suitcase time-of-flight mass spectrometer for in situ fault diagnosis of SF† -insulated switchgear by detection of decomposition products. *Rapid Communications in Mass Spectrometry, 30*(S1), 38–43.

[5] Shang, Z. W., Liu, Z. W., Li, Y. F., et al. (2016). Time-domain fault diagnosis method of mechanical and electrical equipment based on improved dynamic time warping. *Key Engineering Materials, 693*, 1539–1544.

[6] Kruglova, T. N. (2015). Intelligent diagnosis of the electrical equipment technical condition. *Procedia Engineering, 129*, 219–224.

[7] Degeratu, S., Rotaru, P., Rizescu, S., et al. (2015). Condition monitoring of transformer oil using thermal analysis and other techniques. *Journal of Thermal Analysis & Calorimetry, 119*(3),

1679–1692.

[8] Sun, S. W., Liu, X. T., Liu, W., et al. (2015). Design of high-rise building's monitoring system for electric fire based on CAN bus. *Applied Mechanics & Materials, 734*, 104–108.

[9] Ju, T., Zeng, F., Sun, H., et al. (2015). Influence and correction of trace H, O on SF† decomposition characteristics under partial over-thermal fault. *Proceedings of the Chinese Society of Electrical Engineering, 35*(9), 2342–2350.

[10] Tsanakas, J. A., Chrysostomou, D., & Gasteratos, P. N. B. A. (2015). Fault diagnosis of photovoltaic modules through image processing and Canny edge detection on field thermographic measurements. *International Journal of Sustainable Energy, 34*(6), 351–372.

[11] Sun, Y., Wang, Y., Peng, S. B., et al. (2015). Comparison of infrared thermal imager with infrared thermometer in diagnosis of failure of electrical equipment. *Infrared, 137*(4), V01BT27A005–V01BT27A005.

[12] Yan, H. C., Zhou, J. H., & Pang, C. K. (2017). Gaussian mixture model using semisupervised learning for probabilistic fault diagnosis under new data categories. *IEEE Transactions on Instrumentation & Measurement, 66*(4), 723–733.

[13] Gao, W., Bai, C., & Liu, T. (2015). A dynamic integrated fault diagnosis method for power transformers. *The Scientific World Journal, 2015*(88), 459268.

[14] Wang, J., Hong, P., Min, T. U., et al. (2016). A fault diagnosis method of power systems based on an improved adaptive fuzzy spiking neural P systems and PSO algorithms. *Chinese Journal of Electronics, 25*(2), 320–327.

[15] Shi, W., Zhu, Y., Huang, T., et al. (2017). An integrated data preprocessing framework based on Apache Spark for fault diagnosis of power grid equipment. *Journal of Signal Processing Systems, 86*(2–3), 221–236.