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Research on Fault Prediction and Diagnosis of Mechanical and Electrical Equipment in Construction Machinery based on Big Data Technology

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Abstract: This article aims to explore how to use big data technology for fault prediction and diagnosis of mechanical and electrical equipment in construction machinery. Through steps such as data collection and storage, data feature extraction and selection, and data analysis and processing, a fault prediction and diagnosis model is constructed to achieve real-time monitoring and early warning. The accuracy and efficiency of fault prediction are improved through decision feedback and algorithm optimization.

Keywords: Big Data Technology; Mechanical and Electrical Equipment; Fault Prediction; Fault Diagnosis.

1. Introduction

With the rapid development of industrial automation, the electromechanical equipment of construction machinery plays a crucial role in modern production. The efficient and stable operation of equipment is the key to ensuring production safety and improving economic benefits. However, with the increasing complexity of equipment and the diversification of usage environments, the frequency of equipment failures has also significantly increased. In order to effectively address this challenge, research on fault prediction and diagnosis of mechanical and electrical equipment in construction machinery based on big data technology has emerged. Adopting advanced big data technology for fault prediction and diagnosis is of great significance for early detection of potential problems, reducing downtime, and lowering maintenance costs.

2. The Importance of Predicting and Diagnosing Mechanical and Electrical Equipment Faults in Construction Machinery

One is to improve production efficiency. Timely fault prediction and diagnosis can quickly locate and eliminate faults, reduce equipment downtime, and significantly improve production efficiency. This can not only reduce production delays caused by equipment failures, but also ensure the continuous operation of the production line and improve overall operation time. The second is to reduce maintenance costs. Through accurate fault prediction and diagnosis, maintenance personnel can develop scientific and reasonable maintenance plans to avoid unnecessary repairs and replacements, thereby reducing maintenance costs. Meanwhile, predictive maintenance can effectively extend the service life of equipment, reduce the frequency and cost of equipment replacement. The third is to enhance device security. The electromechanical equipment of construction machinery often involves hazardous environments such as high pressure, high temperature, and high speed. Once a malfunction occurs, it may cause serious accidents. Through fault prediction and diagnosis, potential safety hazards can be identified and addressed in a timely manner, enhancing equipment safety and ensuring the safety of production personnel and equipment. Fourthly, it can promote the development and progress of engineering technology. The fault prediction and diagnosis technology of mechanical and electrical equipment in construction machinery involves the cross fusion of multidisciplinary knowledge, such as mechanical engineering, electronic engineering, computer science, etc. With the continuous advancement of technology, the accuracy and efficiency of fault prediction and diagnosis will continue to improve, promoting the technological progress and development of the entire industry.

3. General Methods for Predicting and Diagnosing Faults in Mechanical and Electrical Equipment of Construction Machinery

The commonly used methods for predicting and diagnosing mechanical and electrical equipment faults in construction machinery include sensory detection, instrument detection, fault code diagnosis, and disassembly inspection.

3.1. Sensory Detection Method

Sensory detection method is one of the most basic fault detection methods, which judges the operating status of equipment through the operator's senses such as vision, hearing, smell, etc. For example, observing the vibration of the equipment, listening to the sound of the equipment during operation, smelling the smell around the equipment, etc., can preliminarily determine whether there is a malfunction in the equipment.

3.2. Instrument Testing Method

Instrument testing method is the use of professional testing instruments to measure and analyze various parameters of equipment, in order to determine the operating status and fault conditions of the equipment. Common testing instruments include vibration analyzers, infrared thermal imagers, fault diagnosis devices, etc. These instruments can accurately measure parameters such as vibration, temperature, and current of equipment, providing reliable data support for fault prediction and diagnosis.

3.3. Fault Code Diagnosis Method

Many modern construction machinery's electromechanical equipment are equipped with fault codes and alarm systems. When the device malfunctions, the system will automatically record the relevant fault codes and issue an alarm. By checking the fault codes and alarm information of the equipment, the type and location of the fault can be quickly identified, providing guidance for subsequent repairs.

3.4. Disassembly and Inspection Method

If the above methods cannot determine the cause of the malfunction, it may be necessary to disassemble and inspect key components. By disassembling the equipment and carefully inspecting its mechanical, electrical, and hydraulic components, possible fault points can be identified. Although this method is time-consuming and laborious, it can accurately identify the cause of the malfunction and take corresponding repair measures.

4. Research on the Application of Big Data Technology in Fault Prediction and Diagnosis of Mechanical and Electrical Equipment in Construction Machinery

The use of big data technology for predicting and diagnosing faults in mechanical and electrical equipment has its unique inherent advantages. Firstly, due to the complex structure and harsh operating environment of mechanical and electrical equipment in construction machinery, faults are prone to occur. Traditional fault prediction and diagnosis methods rely heavily on manual experience and suffer from issues such as delayed diagnosis and low accuracy. The application of big data technology can deeply mine and analyze the massive data generated during device operation, detect potential faults in advance, and improve the accuracy and timeliness of fault prediction. Secondly, the real-time and intelligent nature of big data technology also provides strong support for fault prediction and diagnosis of mechanical and electrical equipment in construction machinery. By collecting real-time operational status data of devices, big data technology can quickly identify device anomalies and provide corresponding warning information. At the same time, with the help of intelligent algorithms, big data technology can also conduct in-depth analysis of fault data, identify the root cause of faults, and provide accurate fault location and repair suggestions for maintenance personnel. Thirdly, the application of big data technology also helps to improve the maintenance efficiency and management level of mechanical and electrical equipment in construction machinery. By analyzing and comparing the historical operating data of the equipment, the operating rules and fault characteristics of the equipment can be grasped, providing scientific basis for preventive maintenance and upkeep of the equipment. At the same time, big data technology can also achieve remote monitoring and intelligent scheduling of device operating status, improving the efficiency and overall performance of device usage.

4.1. Data Collection and Storage

One is data collection. Data collection is the primary link of big data technology in the prediction and diagnosis of mechanical and electrical equipment faults in construction machinery. By installing sensors, monitoring systems, and other devices, real-time operational status data of the equipment can be collected, including various types of parameters such as temperature, pressure, vibration, and current. These data are the foundation for subsequent analysis and processing, and are crucial for improving the accuracy and timeliness of fault prediction. The second is data storage. The collected data needs to be effectively stored and managed. Due to the large amount and diverse types of data, traditional data storage methods are no longer sufficient to meet the demand. Therefore, it is necessary to adopt a distributed storage system to achieve the storage and efficient access of massive data. At the same time, it is necessary to establish storage structures such as data warehouses and data lakes to classify, organize, and archive data, providing convenience for subsequent data analysis and processing.

4.2. Data Feature Extraction and Selection

On the basis of data collection and storage, it is necessary to extract features related to mechanical and electrical equipment failures of construction machinery from massive data. The purpose of feature extraction is to transform raw data into more meaningful information that can reflect the operating status of the device. The commonly used feature extraction methods include time-domain analysis, frequency-domain analysis, time-frequency analysis, etc. These methods can reveal the vibration, noise and other feature information of equipment under different operating states. Feature selection is aimed at selecting key features that have a significant impact on fault prediction, reducing feature dimensions, and improving model performance. Through feature selection, redundant and irrelevant features can be removed while retaining useful information for fault prediction. Common feature selection methods include filtering, wrapping, and embedding, which can select appropriate feature subsets based on different application scenarios and data characteristics.

4.3. Data Analysis and Processing

Firstly, data cleaning. Before data analysis and processing, it is necessary to clean the collected data. The purpose of data cleaning is to remove noise, outliers, and missing values from the data, in order to improve the quality and reliability of the data. Common data cleaning methods include data smoothing, data interpolation, and data denoising, which can effectively improve the quality of data and provide reliable data support for subsequent analysis and processing. Next is data transformation. Data transformation is to transform data into a more suitable form for analysis and processing. Common data transformation methods include standardization, normalization, discretization, etc. These methods can eliminate dimensional and distribution differences between data, improve the accuracy and efficiency of data analysis. And the most important thing is data mining. Data mining is the core process of data analysis and processing. Through data mining techniques, hidden and valuable information and patterns can be extracted from massive amounts of data. Common data mining methods include clustering analysis, association rule mining, classification and prediction, etc. These methods can reveal the correlation between equipment faults and operating parameters, providing strong support for fault prediction and diagnosis.

4.4. Building a Fault Prediction and Diagnosis Model

One is model selection. When building a fault prediction and diagnosis model, it is necessary to select a suitable model based on the characteristics of the data and the application scenario. Common models include support vector machines, neural networks, random forests, etc. These models have different advantages, disadvantages, and applicability, and need to be selected according to the actual situation. The second is model training. Model training is a key step in building fault prediction and diagnosis models. By training the model on a dataset, the model can learn patterns and features from the data, thereby possessing the ability to predict and diagnose faults. During the training process, it is necessary to adopt appropriate optimization algorithms and parameter settings to improve the performance and generalization ability of the model. The third is model evaluation. Model evaluation is to verify the predictive and diagnostic performance of the model. By testing the dataset to evaluate the model, we can understand indicators such as accuracy, recall, F1 score, etc., in order to determine the performance of the model. At the same time, it is necessary to evaluate the stability and robustness of the model to ensure its reliability and stability in practical applications.

4.5. Real Time Monitoring and Warning

Real time monitoring is an important part of fault prediction and diagnosis. By monitoring the operational status data of the equipment in real-time, abnormal and faulty signs of the equipment can be detected in a timely manner, providing timely information support for subsequent warning and handling. Real time monitoring requires the use of efficient data collection and transmission technologies to ensure the real-time and accuracy of data. The warning mechanism is designed to send out warning signals in advance before equipment malfunctions, so that users can take timely measures to deal with them. The warning mechanism needs to set appropriate warning thresholds and rules based on the operating characteristics and failure modes of the equipment. When the operating status data of the equipment exceeds the warning threshold, the system will automatically issue a warning signal to remind users to pay attention to the operating status of the equipment.

4.6. Decision Feedback and Algorithm Optimization

Decision feedback is the process of transforming the results of fault prediction and diagnosis into actual decisions. The results obtained through fault prediction and diagnosis models can provide users with scientific and reasonable decision support, such as developing preventive maintenance plans, adjusting equipment operating parameters, etc. At the same time, users can also provide feedback and adjustments to the model based on actual situations to improve its accuracy and practicality. Algorithm optimization is aimed at improving the performance and efficiency of fault prediction and diagnosis models. By continuously optimizing the algorithm and parameter settings of the model, the prediction accuracy and diagnostic performance of the model can be further improved. Algorithm optimization requires targeted adjustments and optimizations based on actual application scenarios and data characteristics to ensure the stability and reliability of the model in practical applications.

5. Conclusion

Although significant progress has been made in the prediction and diagnosis of mechanical and electrical equipment faults in construction machinery based on big data technology, there are still some urgent issues that need to be addressed. Firstly, the issue of data security urgently needs to be addressed, and effective measures need to be taken to protect the security and privacy of data; Secondly, the interpretability of the model still needs further research to improve its transparency and credibility; Thirdly, how to better integrate big data technology with other advanced technologies to achieve more intelligent and automated fault prediction and diagnosis is also an important direction for future research. Of course, the application of big data technology in the field of fault prediction and diagnosis of mechanical and electrical equipment in construction machinery has enormous potential and value. With the continuous development of big data technology and the expansion of its application fields, the research on fault prediction and diagnosis of mechanical and electrical equipment in construction machinery based on big data technology will usher in a broader development prospect. Meanwhile, with the continuous integration and expansion of innovative application scenarios of technologies such as artificial intelligence and the Internet of Things, fault prediction and diagnosis technology based on big data technology will also play an important role in more fields.

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