Development of Mechanical Equipment Fault Diagnosis System Based on Big Data Technology

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Abstract: With the development of the times, social progress, the level of human science and technology and the continuous development of modern industry, now, the development and research of mechanical equipment fault diagnosis system in China is facing unprecedented challenges. In today's big data era, the combination of big data technology and the development and research of mechanical equipment fault diagnosis system in China has become the inevitable demand of the development of times. Therefore, in order to better make the development and research of mechanical equipment fault diagnosis system conform to the development trend of the times, this paper deeply studies the development and research status of mechanical equipment fault diagnosis system in recent years through Internet and big data technology, and analyzes the development and research potential of mechanical equipment fault diagnosis system in recent years. In the research, it is found that the development and research development of mechanical equipment fault diagnosis system in the new era tends to be more intelligent. Therefore, the development and research scheme of mechanical equipment fault diagnosis system suitable for the development requirements of the new era is formulated. It is found that the big data analysis method proposed in this paper plays a key role in the development and research of mechanical equipment fault diagnosis system, and the accuracy of mechanical equipment fault diagnosis reaches 92.5%.

Keywords: Science and Technology, Modern Industry, Machinery and Equipment, Big Data Technology

1. Introduction
"Big data" will become the next innovation frontier. All walks of life in the world are vigorously developing big data technology [1-3], expanding the application scope of big data technology. Big data needs strong technical support to effectively process complex data. Cloud computing platform, Internet, distributed database, large-scale parallel processing database, scalable storage system, distributed file system, Hadoop platform and other big data software and technologies provide technical basis for the application of big data in various industries. Traditional data management and business analysis tools and technologies are facing the pressure of big data. The new methods of data processing, analysis and application are completely different from traditional tools and technologies, including open source framework Hadoop series, hypetable, NoSQL database, spark, storm, Membase, mongodb, etc. commercial software includes IBM puredate (netezza) software, Oracle exadata, sapana, teradataaster data, EMC Greenplum, HP vertica, etc.

With the development of science and technology and the development of modern industry [4-5], mechanical equipment is developing in the direction of large-scale, continuous, high-speed, lightweight, centralized, automation, high-power and heavy-duty. On the one hand, it improves the production efficiency and reduces the production cost; on the other hand, if the equipment fails, the economic loss will be doubled. In recent decades, due to mechanical equipment failure, catastrophic events occur from time to time; resulting in economic losses, casualties and social impact is immeasurable. Therefore, on the one hand, higher requirements are put forward for mechanical equipment in terms of speed, capacity, efficiency, safety and reliability; on the other hand, it is particularly important to develop and apply advanced condition monitoring and diagnosis technology for equipment fault detection and diagnosis [6-7].

This paper mainly analyzes the research method of fault diagnosis system of mechanical equipment [8-10] Based on big data technology. With the continuous development of modern industry and computer technology, the traditional fault diagnosis system of mechanical equipment has been unable to meet the industrial needs of the current era. In order to meet the new needs of modern industry, this paper proposes to combine big data technology with mechanical equipment fault diagnosis Through the analysis of the current research status of mechanical equipment fault diagnosis system development, a set of research methods suitable for the development of mechanical equipment fault diagnosis system in the new era are developed. It is found that the big data analysis method proposed in this paper plays a key role in the development and research of mechanical equipment fault diagnosis system.

2. Research Method of Mechanical Equipment Fault Diagnosis System Development Based on Big Data Technology

2.1 Big Data Technology

Mechanical fault diagnosis based on big data processing technology is a hot spot in recent years, but most of the research still stays on the theoretical research of big data, and does not focus on the specific application of big data in fault diagnosis. On the basis of conforming to the trend of the times, our country put forward intelligent manufacturing. Many traditional manufacturing industries are trying to transform. The huge influence of big data in the world has attracted the attention of many entrepreneurs. Big data technology has strong data processing ability. In today's era of data explosion,
if you want to get fault information from massive data, you need big data technology for processing.

2.2 Fault Diagnosis Method of Mechanical Equipment

Because of the complexity of diesel engine vibration signal, it is difficult to identify the fault state according to the time domain waveform and frequency spectrum. Therefore, time domain and frequency domain evaluation indexes are extracted from signals, including frequency domain waveform complexity, time domain waveform complexity, aperiodic complexity, spectrum center frequency, time series variance and time series kurtosis:

\[ I_j = \sum_{n=1}^{N/2} X(n) \ln X(n) \]  \hspace{1cm} (1)

Time domain correlation analysis can analyze the similarity of the two signals and quickly distinguish the difference between mechanical fault signal and normal signal. The linear correlation coefficient \( \rho \) of the two random variables \( X \) and \( Y \) is as follows:

\[ \rho_{xy} = \frac{C_{xy}}{\sigma_x \sigma_y} = \frac{E[(x-\mu_x)(y-\mu_y)]}{\sqrt{E[(x-\mu_x)^2]E[(y-\mu_y)^2]}} \]  \hspace{1cm} (2)

The function of real-time spectrum analysis in this system is to transform the complex random signals collected by sensors into real-time Fourier transform:

\[ F(\omega) = \int_{-\infty}^{\infty} f(t)e^{-j\omega t} dt \]  \hspace{1cm} (3)

The parameters relative to frequency, such as amplitude, phase and amplitude density, are obtained to determine the fault type and fault type.

3. Experimental Background and Design

3.1 Experimental Background

In this paper, the fault of hoist brake system is studied. Because the brake system works under the special conditions of low speed, heavy load and vibration, the causes of brake system failure are very complex. Among them, the common faults of brake system are brake disc overheating; cavity time is too long, residual pressure is too high. When the hoist is braked, the actual contact area between brake shoe and brake disc is insufficient, resulting in insufficient braking force, resulting in excessive local contact pressure between brake shoe and brake disc, resulting in serious heating of brake disc.

3.2 Experimental Design

There are many kinds of faults in the braking system, and the factors causing the faults are also different. This paper mainly studies the main factors that cause brake system failure, including oil pressure, braking force, brake shoe clearance, brake disc deflection, etc. According to the structure of
the winch brake system, the failure forms and causes of the hoist braking system are classified. The classification results are shown in Table 1:

Table 1. The Classification of braking system failure cause

| Fault location | Fault manifestation | Failure cause analysis |
|----------------|---------------------|------------------------|
| Brake failure  | Insufficient braking torque | Butterfly spring failure, low friction coefficient, large brake shoe clearance System residual pressure too high |
|                | Excessive braking torque | The brake shoe clearance is too small, the brake oil pressure is too high, and the friction coefficient is too large |
|                | Brake open or not       | Insufficient oil pressure, brake cylinder sticking and pressure loss of hydraulic station |
|                | Brake Vibration         | There are air, pipeline fault, spring fault and spindle movement in the oil circuit |
|                | Brake cylinder stuck    | Cylinder failure, spring failure, insufficient oil pressure |
|                | Oil pressure too high   | Solenoid valve fault, system residual pressure is too high, oil pump relief valve fault |

4. Discussion

4.1 Research Status Analysis of Mechanical Equipment Fault Diagnosis System Development Based on Big Data Technology

Python is a widely used high-level common script programming language. With the continuous updating of the version and the addition of new language functions, more and more applications are used in the development of independent and large-scale projects, and it has many characteristics different from other languages. Import data into the compiler in Python_ C4.5 decision tree K_C4.5 program, the result window can display the running results of the program, that is, the corresponding characteristic attribute node and branch of decision tree, and the maximum characteristic attribute value are selected as the root node. Therefore, the gap between attributes X4 and gate2 is selected as the root node. The following division is the same. Finally, the decision tree diagnosis model is obtained. The diagnostic test results are shown in Figure 1, where I indicate that the brake shoe
clearance is too small, II indicates that the residual pressure is too large, III indicates that the brake shoe deflection exceeds the limit, and IV indicates that it is normal.

![Figure 1. Diagnostic test results](image)

As shown in Figure 1, the test results show that the accuracy rate of the small clearance of the residual brake shoe is 100%, the accuracy rate of the excessive residual pressure is 90%, the accuracy rate of the brake shoe deflection overrun is 80%, and the normal accuracy rate is 100%. The results show that the classification accuracy is 92.5%, which meets the accuracy requirements of decision tree model. Therefore, the diagnosis rule can be applied to the fault diagnosis of crane braking system.

Since it is impossible to set up a fault in the actual production, it is necessary to build a test bench in the laboratory for fault simulation test and collect the monitoring data under the fault state. This test simulates the fault by adjusting the parameters. The data of fault analysis test mainly include brake disc deflection, brake shoe clearance, hydraulic station oil pressure, contact area between brake disc and brake shoe. The data collected by the sensor enters the configuration network and is displayed on the man-machine interface. Then these data are imported into SQL Server 2008 database through K_C4.5 (improved C4.5) algorithm and original C4.5 algorithm respectively, and fault diagnosis rules are obtained and fault data are classified. Simulate each fault and collect the test data. The accuracy comparison chart of the final test results is shown in Figure 2.
As shown in Figure 2, in order to better see the improvement of the accuracy of the improved C4.5 algorithm in the big data environment, the author observes the change of accuracy by increasing the number of samples. The diagnosis rules generated by K_C4.5 algorithm and original C4.5 algorithm are used to classify the samples. When the number of samples is very small, the accuracy of the two algorithms is similar, but with the increase of the number of samples, we can see that the accuracy of K_C4.5 algorithm is significantly higher than the original C4.5 algorithm, and gradually stabilized at a higher level.

4.2 Suggestions for Research and Development of Mechanical Equipment Fault Diagnosis System Based on Big Data Technology

With the rapid development of machinery industry and the progress of science and technology, the output of intelligent and complex equipment is increasing, and the labor intensity of mechanical equipment is increasing day by day. People pay more and more attention to the economic benefits of mechanical equipment. Once the mechanical equipment is damaged, even if it is a small part, the economic loss and casualties are immeasurable. In order to identify the generation and evolution of mechanical fault timely and accurately and ensure the stable and reliable operation of machinery, it has become a hot topic in the current machinery industry to solve the mechanical fault problem in advance or quickly.

Equipment fault diagnosis technology originated in the United States in the 1960s. After decades of development, a relatively complete theoretical and technical system has been formed. However, the traditional fault diagnosis methods based on sensor technology and signal processing technology
cannot adapt to the development trend of mechanical equipment scale, complexity and automation. Intelligent diagnosis is one of the research hotspots in the field of fault diagnosis. The traditional fault diagnosis system based on artificial intelligence is applied in practice. In recent years, with the development of computational intelligence, the fault diagnosis technology based on this theory has been applied.

An intelligent fault diagnosis system for rotating machinery rotor is established. The method of combining expert system with neural network is used for fault diagnosis. The intelligent fault diagnosis system for rotating machinery rotor is composed of two subsystems: the knowledge-based fault diagnosis expert system and the neural network-based fault diagnosis system. The knowledge-based rotor fault diagnosis expert system classifies the rotor fault symptoms according to the vibration degree, vibration direction, shaft trajectory, phase characteristics and frequency of the rotor. It can speed up the search speed of rules in the process of diagnosis and reasoning, and improve the diagnosis efficiency; the rotor fault intelligent diagnosis system based on neural network uses neural network to establish the intelligent rotor fault diagnosis system. Through network training and learning, the system has learning function. The system embodies the advantages of neural network in knowledge acquisition, parallel reasoning, adaptive learning, associative reasoning and fault tolerance, and makes up for the limitations of traditional fault diagnosis expert system in knowledge acquisition and representation. The two subsystems of the rotor fault diagnosis system have their own characteristics. The diagnosis results of the two subsystems can complement and fuse each other, so as to get more accurate and reliable diagnosis results.

Fault diagnosis is a new subject which integrates various theories, methods and technologies. With the progress of science and technology, fault diagnosis is also improving. As far as the intelligent diagnosis technology is concerned, the application of new methods of artificial intelligence or computational intelligence or the integration of multiple methods in the field of fault diagnosis needs further research. The application of neural network in fault diagnosis mainly focuses on diagnosis recognition and trend prediction. Various network structures and corresponding algorithms represented by BP network have been widely and deeply studied. In the actual fault diagnosis, how to correctly select the characteristic parameters reflecting the running state of the equipment plays an important role in the success of the diagnosis. Fault feature selection based on neural network is an important research direction. The connection weights in BP network can reflect the sensitivity of characteristic parameters to fault, and based on BP network, feature parameters can be selected according to evaluation indexes. The smoothing coefficient of the generalized regression neural network represents the importance of the input parameters, and the important features can be selected according to the size of the parameters.

At present, the research focus of intelligent fault diagnosis technology has gradually shifted from the traditional artificial intelligence to the emerging field of computational intelligence. Based on sensor, dynamic test and signal processing technology, the theory of computational intelligence provides a theoretical basis for knowledge acquisition, diagnosis reasoning and diagnosis process improvement in fault diagnosis field, and has been studied and applied in engineering practice.

5. Conclusions

This paper studies the research method of mechanical equipment fault diagnosis system development
based on big data technology. In order to help the research and development of mechanical equipment fault diagnosis system development can adapt to the development requirements of the new era, this paper puts forward the method of integrating big data technology and mechanical equipment fault diagnosis system development. In order to develop a set of research methods suitable for the development of mechanical equipment fault diagnosis system in the new era. It is found that the big data analysis method proposed in this paper plays a key role in the development and research of mechanical equipment fault diagnosis system.

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