The Application of Remote Monitoring and Intelligent System in Mine Engineering Machinery

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Abstract: With the development of China's economy, the use of mine engineering machinery is more and more extensive. As an important part of China's manufacturing industry, there are many problems in the use of mine engineering machinery, which cannot achieve intelligent remote monitoring. After analyzing the main characteristics of domestic and foreign mining engineering machinery, the viewpoint that the development trend will be remote monitoring and intellectualization was pointed out; on this basis, the design principles of remote monitoring and intelligent system of mine engineering machinery and corresponding remote real-time monitoring platform were introduced, and the key technologies of typical fault modeling and diagnosis of mine engineering machinery were analyzed, so as to provide some reference for the modern information management of mine engineering machinery in China.

1. Introduction

Mine engineering machinery has become one of the important industries in the development of national economy. At present, the total number of engineering machinery in service is up to 10,000, and the huge market reserves provide a guarantee for the smooth progress of many infrastructure projects [1]. But for a long time, the situation of safety operation of mine engineering machinery is very serious, mine engineering machinery products usually require high load and long time operation because of its complex system composition and bad working environment, and the maintenance system is relatively backward. As a result, the system often appears various faults, major accidents of machine destruction and human death occur from time to time, which seriously affects the progress of construction projects, benefits and the safety of people's property. In addition, due to the limitation of experience and level, it is difficult for constructors to make correct predictions and judgments, and even more unable to effectively eliminate faults [2]. At present, the service mode of mine engineering machinery industry is emergency post-maintenance, this passive service is at the cost of "accident", the maintenance cycle is long and often manifests as the inefficient situation of equipment paralysis caused by minor faults, which leads to the suspension of construction period. Therefore, how to predict and warn faults, change passive maintenance to active maintenance, greatly reduce the incidence of faults during the critical construction period, prolong the healthy service life of equipment, and improve the rapidity and accuracy of fault diagnosis and maintenance has become an urgent problem to be solved.

2. Main Characteristics and Development Trend of Mine Engineering Machinery at Home and Abroad

2.1. Main characteristics of domestic mine engineering machinery

At present, the general trend of engineering machinery development at home and abroad is to improve the degree of automation and functional integration of equipment and shorten the product development cycle. In order to improve the quality and competitiveness of products, enterprises that implement cluster remote management, monitoring and maintenance of construction machinery have begun to pay attention to the application of high and new technology, and developed from simple parameter display to safety prediction, early warning and prediction system, intelligent

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control of whole machine, fault diagnosis, and remote monitoring, maintenance and service. The application of high-tech has improved the service life, reliability, maintainability, precision, compatibility, ease of operation and development of construction machinery, and made the development of construction machinery show a rapid development trend. The main characteristics of domestic engineering machinery are as follows: the intellectualization of engineering machinery equipment in China is low, the controller mainly depends on imports, and does not have the ability of remote monitoring [3]. The ultimate goal of remote maintenance of engineering machinery is to achieve performance prediction, fault warning and intelligent maintenance. However, at present, information collection, transmission and data management are the basic means, while the most important performance prediction and fault diagnosis technologies are lack of in-depth research. As for remote monitoring, basic research on group control of engineering machinery was carried out during the Tenth Five-Year Plan period in China, focusing mainly on coordination and cooperation strategies. However, the remote data transmission has not yet been applied in practice because of the limitation of network coverage and technical level at that time.

2.2. Main characteristics of foreign mine engineering machinery

The development of mine engineering machinery and equipment in foreign countries started early, and has already formed intelligent and informational management. At present, remote maintenance technology of mine engineering machinery using satellite positioning, wireless data transmission, network and database has been widely concerned by major foreign enterprises, and overseas mine engineering machinery industry which is dominated by manufacturer has gradually expanded the industrialization of remote monitoring and fault diagnosis [4]. For example, Caterpillar Corporation of America has developed a system (mining-irrigated transportation technology system) by using technology, and partially realized condition monitoring and fault diagnosis; Japan Komatsu's remote control management system has utilized and realized the global positioning, tracking and information service of engineering machinery; the excavator part of Hitachi Construction Machine has been equipped with data acquisition and transmission system, which has preliminarily realized the function of uploading relevant operation information and location information; Liebherr, Germany, has also launched a remote radio monitoring system on its crawler crane. Overseas remote positioning and signal acquisition have been initially applied in some new products and some key systems, but the performance prediction, intelligent maintenance and industry standards of the whole system are still immature [5].

2.3. Development trend of mine engineering machinery and equipment

The software and hardware platform of low-cost and intelligent controller can be developed, and the real-time monitoring, acquisition and intelligent processing of the state information of key components of mine construction machinery can be realized. Integrated application based on network environment is the supporting technology of global remote service for next generation mine engineering machinery [6]. The faults of hydraulic system and fuel system of engineering machinery are complex and varied, and how to establish fault tree of engineering machinery by analyzing its fault characteristics is the focus of research in mine engineering machinery enterprises. In addition, establishing a remote monitoring platform for engineering machinery and helping users to carry out active maintenance will become one of the most important contents of after-sales service in engineering machinery industry.

3. Remote Monitoring and Intelligent System of Mine Engineering Machinery

3.1. Basic principles

The remote real-time monitoring and management system of engineering machinery uses the technology of neural network algorithm to realize the functions of location tracking, real-time and on-line monitoring, remote debugging, fault alarm and maintenance, expert diagnosis and so on, which effectively improves the level of remote monitoring, management and maintenance of

engineering machinery. The remote real-time monitoring and management system of engineering machinery is connected with the remote information processing center by means of mobile base station, and the remote information processing center is connected with the monitoring and management platform through wired network, thus realizing the remote control of engineering machinery and equipment [7]. At the same time, engineering machinery and equipment can also achieve real-time tracking, trajectory playback and regional management by self-positioning and provide data support for the application of monitoring and management platform, which mainly consists of vehicle controller, terminal, information processing center, database design, fault diagnosis system and remote monitoring and management platform.

3.2. Remote real-time monitoring and management platform

The remote real-time monitoring and management system of engineering machinery is based on wireless network technology, which realizes 24-hour on-line location tracking and operation status monitoring of active equipment all over the world, and requires zero delay, zero distance rapid response service and zero fault operation status monitoring of equipment under wireless network [8]. The remote monitoring system of mine engineering machinery consists of vehicle controller, terminal, information processing center, database system, fault modeling and diagnosis, and remote monitoring and management platform. Vehicle controller is installed on engineering machinery, which mainly collects the working information of equipment and executes the control of equipment unlocking machine. The terminal obtains the working information of the equipment through bus and vehicle controller, obtains the position information of the equipment through module, and then transmits the information to the remote information processing center by means of wireless network. After analyzing the received information, the remote information processing center stores the data in the database, and carries out fault modeling and diagnosis, then the diagnosis results are stored in the fault diagnosis database. The remote information processing center is connected with the monitoring and management platform through the wired network to realize the remote monitoring and management of engineering machinery and equipment. The actual position of the vehicle can be displayed in real time by using electronic map, and can be enlarged, reduced, restored and changed arbitrarily. At the same time, multi-window, multi-vehicle and multi-screen simultaneous tracking can be realized, and important vehicles and cargo can be tracked with this function. The monitoring center can monitor the running status of the vehicles in the area, dispatch the monitored vehicles reasonably, and also call the tracked targets at any time for management. Through the positioning and monitoring management system, the monitoring station can provide emergency assistance to vehicles in danger or accident; at the same time, the electronic map of the monitoring room can display help-seeking information and alarm objectives, plan the optimal assistance program, and alert the on-duty personnel with sound and light alarm for emergency treatment.

4. Modeling and Diagnosis of Typical Faults of Mine Engineering Machinery

Correct and detailed modeling of typical faults of mine engineering machinery is the premise to ensure the correct fault diagnosis of engineering machinery. According to the structural characteristics of mine engineering machinery, the construction of fault model can be divided into two categories: hydraulic system fault model and fuel system fault model. The traditional way of fault diagnosis and maintenance is to dispatch technical service personnel to the construction site after the vehicle failures, and to diagnose and repair the failures with accumulated experience, this method is backward, time-consuming and mistake-taking, and the accuracy of diagnosis is low. The remote real-time monitoring and management system of engineering machinery can diagnose the faults of vehicles in real time, and provide optimal maintenance suggestions immediately after the faults occur. When the fault occurs, the system can determine the fault source and provide corresponding maintenance strategies by analyzing the values of these parameters and judging them according to the reasonable range of parameters; when the failure does not occur, the statistical analysis of the change trend of the relevant parameters of the functional components in a period of time can be carried out to evaluate the operation status of the mechanical equipment and the

probability of the possible failure, and the early warning information can be given.

Fuzzy logic can judge faults quickly on the basis of small-scale fault sample base and inference rules. Neural network has good learning ability, which can learn from the condition monitoring data of field system, process and supplement unknown knowledge, but it can not make full use of a large number of language expression knowledge of domain experts, while fuzzy logic can make better use of linguistic knowledge, and the form of knowledge expression is easy to understand. The introduction of fuzzy control technology into neural network can greatly broaden the scope and ability of neural network to process information, which can not only process accurate information, fuzzy information or other inaccurate information, but also can realize accurate association and mapping, inaccurate association and mapping, especially fuzzy association and fuzzy mapping. Neural network has a strong advantage in learning and automatic pattern recognition, so it can be used to process fuzzy information and deal with the multi-cause fault phenomena. The learning process of neural network consists of forward and backward propagation. The input information is processed layer by layer from the input layer to the output layer in the process of forward propagation, and the state of each ganglion point only affects the state of the next ganglion point. If the desired output can not be obtained in the output layer, the error signal is transferred to reverse propagation, and the error signal is calculated according to the connection line. The gradient descent method is used to adjust the weights of neurons in each layer to reduce the error.

Generalized bell-shaped membership function is chosen as the membership function of normal state, descending Z-shaped membership function is chosen as the membership function of partial small state, and ascending Z-shaped membership function is chosen as the membership function of partial large state.

The membership function of the "partial small" fuzzy state:

$$\mu_L(x)=\begin{cases}1 & x\le a\\ 1-2\left(\dfrac{x-a}{b-a}\right)^2 & a\le x\le \dfrac{a+b}{2}\\ 2\left(\dfrac{x-b}{b-a}\right)^2 & \dfrac{a+b}{2}\le x\le b\\ 0 & x\ge b\end{cases} \tag{1}$$

The membership function of "normal" fuzzy state:

$$\mu_N(x)=\frac{1}{1+\left|\dfrac{x-c}{a}\right|^{2b}} \tag{2}$$

The membership function of the "partial large" fuzzy state:

$$\mu_H(x)=\begin{cases}0 & x\ge b\\ 2\left(\dfrac{x-b}{b-a}\right)^2 & \dfrac{a+b}{2}\\ 1-2\left(\dfrac{x-a}{b-a}\right)^2 & a\le x\le \dfrac{a+b}{2}\\ 1 & x\le a\end{cases} \tag{3}$$

5. Conclusion

With the development of our country's economy, the engineering machinery manufacturing industry and transportation industry are developing rapidly, the demand for mechanical equipment control technology and equipment is increasing day by day, and the remote monitoring technology of mechanical equipment is also developing rapidly. Based on the industrial application of vehicle

remote monitoring technology in mine engineering machinery, the establishment of distributed server system architecture was emphasized to meet the company's growing equipment access and information processing according to the management requirement of the company's various departments for remote monitoring of equipment. This research mainly describes the key technologies of vehicle controller, fault modeling and diagnosis system, so as to realize remote and real-time control of the state of mining machinery and equipment, and then to carry out prevention, overhaul and early warning.

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