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Research on Fault Diagnosis of Special Equipment Based on CAN Bus Expert System

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Abstract: This paper addresses the issues of complex faults, incomplete detection equipment, and insufficient technical capabilities of maintenance personnel in CAN bus special equipment. By integrating several mainstream fault diagnosis methods, a fault diagnosis device for special equipment is designed based on an expert system. The device mainly acquires data parameters of special equipment and diagnoses the corresponding fault causes and elimination methods through logical judgment of the expert system, effectively improving the efficiency and accuracy of fault diagnosis and elimination. In light of the latest technological developments, corresponding improvement and development directions are proposed.

Keywords: CAN bus; Special equipment; Expert system; Fault diagnosis.

1. Preface

With the rapid development of modern electronic information technology, special equipment has also increased its investment in its control technology research in order to adapt to changes in the modern situation. The controller local area network (CAN) is widely used in special equipment such as automobiles and large machinery due to its high real-time, strong reliability and good node expansion. The various components of the equipment are connected to the CAN bus through sensors and drive devices, real-time information transmission and monitoring of each component, and real-time sharing of data, thereby achieving the effect of simplifying wiring, streamlining the system, and convenient coordination. According to the use needs of special equipment, it is necessary to ensure that it is stable, reliable and timely maintenance and guaranteed. Due to the severe use environment, its failure rate remains high. The current fault detection equipment is single and expensive, and there are technical barriers to the detection equipment of each component. Therefore, it is necessary to design a CAN bus fault detection instrument with high versatility, convenient operation and update and iterative, which is extremely necessary for the maintenance and guarantee personnel of this special equipment.

2. CAN bus fault diagnosis problem

2.1. There are compound characteristics of CAN bus failure

2.1.1. Complex internal structure

Based on the structural characteristics of the multi-module collection of CAN buses, although the circuit is simplified and a large amount of costs is solved, it is easy to cause failure of one of the modules or abnormal voltages of a certain node, which will cause the data transmission of the entire bus to be paralyzed, and sometimes it will cause abnormalities in the communication protocol between nodes. At the same time, the number of equipment mounted on the CAN bus is large, and the positive and negative feedback is frequent, which greatly increases the inspection workload, which is extremely difficult for positioning and diagnosing abnormal modules [1].

2.1.2. The fault manifestation is not significant

Special equipment is designed with a simple fault diagnosis system, which can reflect relatively simple fault problems, but there are often indirect connections between the fault phenomenon reflected and the actual fault cause. Maintenance personnel need to reason and multiple inspections and diagnosis to complete the determination of the fault. This feature is precisely because of the mechanism characteristics and external factors of the CAN bus, which makes the CAN bus fault manifestation insignificant or even unrelated characteristics. This not only extends the time for fault determination, but also means that the maintenance and guarantee personnel put forward higher requirements.

2.2. Fault inspection equipment is not comprehensive enough

In response to CAN bus failure, maintenance personnel currently rely on multimeter voltage measurement, oscilloscope inspection waveforms and other methods during fault inspection. These detection equipment mainly presents several characteristics: First, general tools with low prices have large limitations in use and large errors, which require maintenance personnel to analyze and eliminate them again; second, equipment with intuitive detection effects is relatively expensive, with low distribution rate. At the same time, such equipment requires maintenance personnel to have certain training experience and have a certain principle basis. No matter which equipment is suitable for the current special equipment maintenance guarantee system. [2]

2.3. The technical capabilities of maintenance and support personnel are lacking

Special equipment using CAN bus has been vigorously promoted in recent years, and the talent training for the maintenance and guarantee of such equipment is not sound enough. Because it needs to cover the basic knowledge of software and hardware, it is also necessary to fully master the working principle and corresponding skills of the CAN bus of the equipment. However, according to the research analysis, most maintenance and support personnel have insufficient theoretical foundation, insufficient operating skills, and insufficient systematic thinking, which will lead to low accuracy, low efficiency and poor timeliness of special equipment fault judgments and dispatching of CAN buses. Combined with the current training system, it is still impossible to meet the capability standards in the short term and the subsequent sustainability is poor. In order to reduce the pressure on maintenance personnel and solve this problem from the root, it is extremely important to design an iterable and convenient operational inspection system.

3. Types of fault diagnosis methods

3.1. Fault diagnosis method based on analysis signal

This diagnostic method mainly obtains signal characteristics based on main signal processing methods such as signal spectrum analysis, and combines the selected signal characteristics and compares the standard parameters of the equipment to diagnose the current equipment's health status. The advantage of this method is that it saves the process of establishing a data analysis model and realizes that fault detection can be completed quickly. However, the disadvantage brought by this principle is that the data range is too single, and the fault location and fault identification are not accurate enough, so it is necessary to make synchronous judgments based on other data.

3.2. Fault diagnosis method based on analytical model

This method mainly analyzes the system's factual behavior, and then compares the data with the expected behavior based on the model to obtain diagnostic results. The advantage of this method is that the model constructed through data and the state information obtained by the sensor can realize accurate diagnosis of the system at the theoretical level. However, when establishing a data model, it is necessary to completely restore the system. For the complex structure of the CAN bus of special equipment, it is difficult to build an accurate data model, which leads to the inability to verify the authenticity of the diagnosis, and the utilization rate of this method is extremely low.

3.3. Knowledge-based fault diagnosis method

This method mainly relies on relevant knowledge in the field of artificial intelligence, and conducts thinking reasoning that meets human experts in solving professional problems based on the complete knowledge and rules in the current field, and finally diagnoses the faults in the current system and verifies this through the system users. However, the system is based on sufficient knowledge, and the real-time fault diagnosis is poor, and the theoretical framework of the system still needs further discussion.

3.4. Fault diagnosis method based on expert system

This method is actually a set of programs that rely on the existing knowledge base of human beings, adopt certain search strategies and solve difficult problems in a specific field through reasoning. The biggest advantage of this method is its efficiency, fastness and ease of operation. For special equipment based on CAN bus, you only need to connect to the CAN bus of the device to monitor the equipment failure situation in real time. This method has been widely used in the fields of aircraft, scientific research, aerospace and other countries in the United States, China and other countries, and the technology is relatively mature.

4. Design of CAN bus fault diagnosis device for special equipment based on expert system

4.1. Composition of fault diagnosis device based on expert system

This system uses CAN bus to grasp the status information of various components of special equipment in real time. After using the system to diagnose the acquired status information, the location where the fault occurs is accurately obtained, thereby improving the success rate and reliability of the real-time diagnosis of the fault diagnosis system.

The expert system is mainly composed of a knowledge base, reasoning machine, human-computer interaction, knowledge acquisition system, interpretation system and database, and its composition framework is shown in Figure 1.

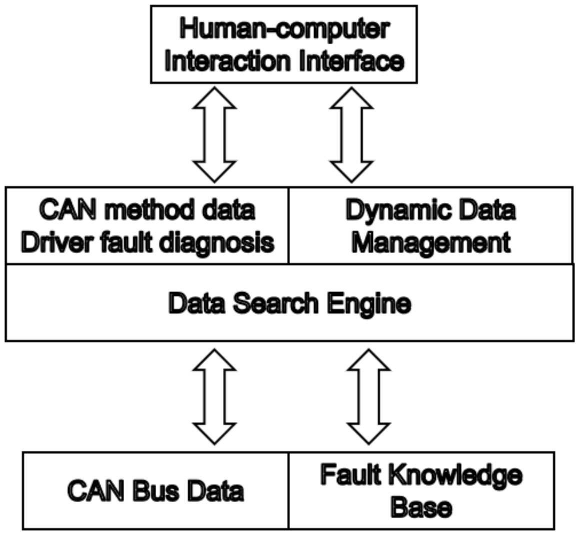

Fig. 1 Structure of a fault diagnosis system based on expert system

4.2. Classification of CAN bus fault system knowledge

Based on the characteristics of the CAN bus system, establishing diagnostic parameters standards, comprehensively and systematically classifying diagnostic parameters, and working together to form a database are the key to establishing this fault diagnosis system. According to the experience collected and organized by experts, solutions and the system's functional positioning of fault components and causes, it is mainly divided into the following categories: structure and functional knowledge of CAN bus, expert experience knowledge, working condition status knowledge, and signal characteristic knowledge. By comparing the fault phenomena displayed by the changes in these diagnostic parameters with the empirical rules summarized by experts over the years, we can find out the cause of the fault and propose corresponding countermeasures.

4.3. Fault diagnosis of special equipment based on CAN bus

This system uses the real-time CAN bus data acquisition module and the fault diagnosis system to transmit data. After the fault diagnosis system issues a detection command, it receives the current status results of various components of special equipment collected by the CAN bus in real time, and sends the data to the fault diagnosis system. At this time, the fault diagnosis system will issue a self-test command, and each component of the special equipment will conduct self-test, and then transmits the acquired data to the expert system [2].

After completing the self-test of special equipment, the expert fault diagnosis system will use the detected information as a search element and use the inference machine to infer the fault to determine the cause of the fault. In response to the complex and diverse fault phenomena, it is highly likely that the fault source cannot be located at one time. This requires first narrowing the scope of the fault cause, and then combining the equipment structure and working principle, relying on the fault tree built by the knowledge base to detect knowledge items. Relying on the detected information, it is also necessary to incorporate the external phenomenon of the fault of special equipment as a search element, and search at multiple levels, angles, and rounds until the cause of the fault is found. When the cause of the failure is found, the corresponding maintenance method is given. The specific diagnostic process is shown in Figure 2.

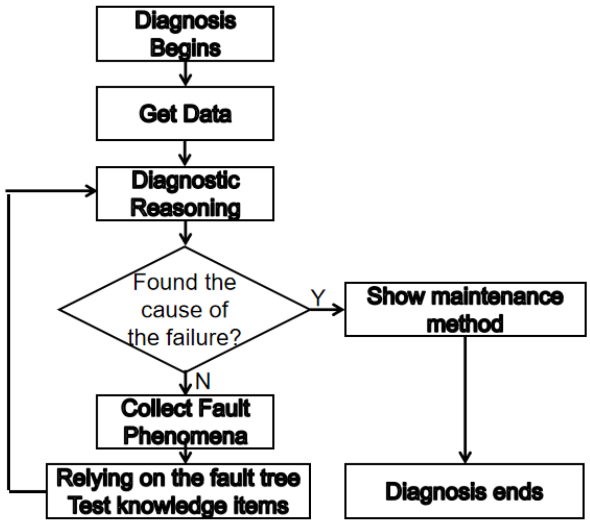

Fig. 2 Fault Diagnosis Flowchart

5. Improvement direction of fault diagnosis based on CAN bus expert system

5.1. Acquisition of optimization knowledge in combination with machine learning

In order to overcome the limitations of traditional expert systems in knowledge acquisition, optimizing the knowledge acquisition process in combination with machine learning technology is an important direction of improvement. Machine learning, especially deep learning technologies, can automatically learn failure modes and diagnostic rules from large amounts of historical data, greatly reducing reliance on domain experts. By combining machine learning with expert systems, automatic acquisition and update of knowledge can be achieved, improving the completeness and accuracy of the knowledge base.

5.2. Introducing fuzzy logic to enhance reasoning capabilities

The introduction of fuzzy logic is another important direction to enhance the reasoning ability of expert systems. Traditional Boolean logic-based reasoning methods have shortcomings in dealing with uncertainty and ambiguity, and fuzzy logic can better simulate the reasoning process of human experts and handle uncertain information in the diagnosis process. In CAN bus fault diagnosis, the relationship between many symptoms and faults is not black or white, but there is a certain degree of ambiguity. The introduction of fuzzy logic can enable expert systems to more accurately reflect this complex relationship and improve the accuracy of diagnosis.

5.3. Integrate multi-source information to improve diagnostic accuracy

Integrating multi-source information is another important direction to improve the diagnostic accuracy of expert systems. Traditional expert systems usually rely only on a single type of information (such as error frames or bus voltages), making it difficult to fully reflect the system status. By integrating information from different sources, such as electrical signals, communication data, environmental parameters, etc., the system status can be more comprehensively evaluated and the accuracy and reliability of fault diagnosis can be improved.

Future research should focus on the following aspects: First, develop more efficient and reliable automatic knowledge acquisition and update mechanisms to cope with the emergence of new failure modes. Secondly, study more intelligent and adaptive inference methods to improve the system's ability to handle complex failure scenarios. Again, explore new methods of multi-source information fusion to achieve a comprehensive assessment of system status. Finally, develop a more friendly and transparent user interface to improve the usability and credibility of the system.

6. Summary

This article is based on the special equipment CAN bus fault diagnosis system device of the expert system, which effectively solves the rapid and accurate positioning of the fault cause of special equipment maintenance personnel, and proposes corresponding troubleshooting methods, effectively guarantees the diagnostic methods of maintenance personnel and greatly improves the guarantee capabilities of special equipment maintenance personnel. Although this device has significant advantages, it still has many improvements and development directions in actual use with the development of technology.

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