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Fault Diagnosis of Airborne Electronic Equipment Based on Dynamic Bayesian Networks

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ABSTRACT

With the rapid development of the aerospace industry, the structure of airborne electronic equipment has become more complex, which to some extent increases the difficulty of fault detection and maintenance of airborne electronic equipment. Traditional manual fault diagnosis methods can no longer fully meet the diagnostic needs of airborne electronic equipment. Therefore, this chapter uses dynamic Bayesian network to diagnose the faults of airborne electronic equipment. The basic idea of using a dynamic Bayesian network-based fault diagnosis method for airborne electronic devices is to mine data based on historical fault data of airborne electronic devices, and obtain fault symptoms and training data of airborne electronic devices. For non-essential fault symptoms, rough set theory was introduced to reduce their attributes and obtain the simplest attribute set, thereby simplifying the network model.

KEYWORDS

Airborne Electronics, Data Mining, Dynamic Bayesian Networks, Fault Diagnosis, Rough Set Theory

INTRODUCTION

As an important technical system in the aviation industry, airborne electronic equipment is the core to ensuring the efficient and safe operation of aircraft and also the key factor to ensuring the normal operation of aviation flight. However, due to the complexity of the environment and working conditions, these devices are prone to failure, which poses a great threat to the safety and performance of the aircraft. Therefore, how to diagnose the fault of airborne electronic equipment quickly and accurately has become an important research direction in the aviation field. Fault diagnosis of airborne electronic equipment based on dynamic Bayesian networks has important research value and practical application significance, which is helpful to improving flight safety and equipment reliability.

The common methods of traditional on-board electronic equipment fault diagnosis mainly include fault code-based diagnosis, fault pattern recognition, and expert system diagnosis. Among them, fault code-based diagnosis is used to judge the specific cause of the fault through the fault code generated by the on-board electronic equipment. This method is simple and direct and is only applicable to

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common types of faults. Failure mode recognition means to establish a failure mode library through long-term monitoring and data collection of on-board electronic equipment, so as to carry out diagnosis based on current failure modes. This method does recognize some complex faults but requires a large amount of data and model training. Expert system diagnosis is an inference-based diagnosis based on expert knowledge and rules, which matches fault phenomena with preset rules to infer fault causes and solutions. This method is more effective when the problem is complex and requires professional knowledge, but it requires the accumulation of fault libraries and manual knowledge modeling, which makes the diagnosis more difficult for ordinary engineers and operators. The above commonly used traditional airborne electronic equipment fault diagnosis methods all have certain limitations in the face of complex faults and data acquisition difficulties, so it is necessary to find new fault diagnosis methods to make up for the deficiencies that exist in traditional methods.

As a graphical network based on probabilistic reasoning, Bayesian networks have important research value in dealing with uncertain knowledge representation and problem reasoning and have been successfully applied in many fields. Dynamic Bayesian networks are able to flexibly deal with dynamic relationships between variables and are suitable for describing complex dynamic processes in the fault diagnosis of airborne electronic equipment. It is capable of modeling the state and faults of the equipment and can be dynamically updated based on real-time data, estimating the *a posteriori* probability of the cause of the fault through probabilistic reasoning and providing probabilistic explanations corresponding to the diagnostic results. Avoiding overly deterministic diagnostic results makes the diagnostic results more reliable. This can also continuously improve the accuracy and robustness of the model based on new fault data and train it with a large amount of historical data, so as to learn the fault patterns and fault characteristics from the data and better identify and predict faults. This is especially important when facing complex fault situations and frequent changes. The use of Dynamic Bayesian Network (DBN) for the diagnosis of airborne electronic equipment faults offers the advantages of flexibility, uncertainty modeling, fault prediction capability, and real-time performance and efficiency. These advantages make dynamic Bayesian networks an effective method to improving the accuracy and efficiency of airborne electronic equipment fault diagnosis.

RELATED WORK

With the development of industry, equipment is constantly being updated, becoming more intelligent, and performing excellently in helping humans carry out various personalized and professional activities. Therefore, many scholars are researching new fault diagnosis methods for different types of equipment (Sreedevi et al., 2022). Chen et al. (2019) proposed the use of the IQA (image quality assessment) method for mechanical equipment faults diagnosis, because IQA, as an indispensable technique in computer vision, is extensively applied to image classification and image clustering. In order to verify whether the new method is suitable for mechanical equipment fault diagnosis, this study achieved fault detection through a series of operations such as data acquisition, noise removal, and image classification. Numerous experiments have demonstrated the effectiveness and robustness of this method. Jiang et al. (2023) proposed a classification model based on integrated incremental learning for equipment fault diagnosis. The model first introduced an integrated incremental learning mechanism and imbalanced data processing technology to solve the problem of imbalanced feature extraction and classification of many new data under equipment status data as well as imbalanced sample categories. Zhang (2019) proposed the use of artificial intelligence (AI) technology for mechanical equipment fault diagnosis. Because traditional mechanical diagnostic technology cannot meet practical diagnostic requirements, AI technology has advantages in solving remote control, fault diagnosis, and nonlinear problems and can predict the remaining life of the entire equipment. The utilization of AI technology in mechanical equipment fault diagnosis is beneficial for improving equipment efficiency and reliability, reducing maintenance costs, and extending service life and can also point out the direction for the growth of mechanical fault diagnosis. Shi et al. (2021) proposed

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