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Application of Data Mining Technology in Fault Diagnosis of Wind Turbine

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Abstract

With the complexity of the structure of wind turbines in my country, the traditional fault diagnosis methods of wind turbines can no longer meet the requirements of safe operation of wind turbines. In order to ensure the safe operation of wind turbines and reduce the cost of operation and maintenance of wind turbines, it is necessary to deeply analyze the fault sources of wind turbines, and combine data mining technology to explore new fault diagnosis methods for wind turbines.

Keywords

Data Mining Technology; Wind Turbine; Fault Diagnosis.

1. Introduction

As a green and renewable energy source [1], wind energy has been widely used in power systems in recent years. Due to the complex structure of large-scale wind turbines and the fact that most wind farms are located in the outer suburbs and offshore areas, it is difficult to monitor the daily operation status of wind turbines, and the operation and maintenance costs are high, which greatly affects the safety and economic benefits of wind farms. In order to ensure the safe operation of wind turbines and reduce the cost of operation and maintenance of wind turbines, research on the condition monitoring and fault diagnosis of wind turbines is carried out, so as to timely grasp the operating status of wind turbines, detect potential failure symptoms as soon as possible, reduce the failure rate and reduce operation and maintenance costs, so as to ensure The safe and efficient power generation operation of wind turbines has important academic research significance and engineering application value [2]. However, due to the different ages and models of wind turbines of different manufacturers, the collected data types, number of bits and storage formats may be different, forming a large number of multi-source, heterogeneous, complex and rapidly growing wind turbine condition monitoring big data [3] . Introducing data mining into fault diagnosis, starting from the data itself to find fault rules, can effectively guide maintenance personnel to locate faults and maintain equipment, which is a new topic of fault diagnosis and early warning of wind turbines.

2. Data Mining Technology

2.1. Definition of Data Mining

Data mining, also known as data mining, data mining, is in accordance with the established business objectives from the massive data extract potential, effective and can be understood by the high-level processing pattern. It can use the query, retrieval and report function of the existing database management system and then combine multi-dimensional analysis and statistical analysis to get the statistical analysis data that can be used for reference and decision-making. it can mine the implicit knowledge in the data from the deep level and extract the

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hidden but potential information and knowledge process from the huge, noisy, fuzzy, incomplete and random practical application data..

2.2. The Process of Data Mining

The process of data mining can be roughly divided into: problem definition, data collection and data preprocessing, data mining, pattern interpretation and evaluation [4].

1) Problem definition: data miners communicate with users to understand the users' needs and expected final results; On the other hand, choose the most suitable algorithm to lay the foundation for the follow-up work and reduce the workload.

2) Data acquisition and data preprocessing: mainly including data cleaning, integration, transformation and reduction, etc., to make the processed data more standardized.

3) Data mining: define the task and purpose of mining, and perform operations such as classification, clustering and association rule discovery on the processed data information. 4) Pattern interpretation and evaluation: show the knowledge acquired by data mining in a way that users can understand, or store it in the database for use. Of course, all the patterns obtained by data mining can't be accepted by users. We can find the patterns that users are really satisfied with through evaluation and transform them into useful knowledge for users.

The main function of data mining is to find specific patterns and "dig out" useful information hidden behind a large amount of data. Its models generally include the following: one is descriptive and the other is predictive. Descriptive patterns are mainly based on common features of data. Predictive model is to summarize data, summarize data, and make predictions.

3. Wind Turbine Fault Analysis

The faults of wind turbines mainly come from gearbox, pitch system, bearing and generator of transmission system [5].

3.1. Gearbox Fault

The gearbox of wind turbine consists of three main components, i.e. gear, shaft and rolling bearing. the faults they generate usually affect each other. Due to many internal parts of gear box and low manufacturing process, various faults will occur during the operation of gear box. Common gearbox failures include: tooth profile error, tooth surface wear, gear tooth break, shaft misalignment, shaft bending, rolling bearing failure and box resonance.

3.2. Generator Failure

The generator faults of wind turbine generator set are mainly manifested through the phenomena of generator vibration, generator noise, generator temperature, and generator bearing overheating. The main factors causing excessive vibration of generator mainly include poor coupling effect with gear box, insulation damage of stator winding, poor balancing effect of rotor, broken rotor bar and loose rotating part, etc. According to statistics, the common faults of generators include: stator winding fault, bearing fault and end ring fault, shaft or coupling fault and various other faults.

3.3. Cooling System Failure

The cooling system of the wind turbine guarantees the main heat sources of the wind turbines such as the generator, the gear box, the hydraulic system, the frequency converter and the like to avoid being in an overheated state, prolongs the service life of the equipment and ensures the safety performance of the wind power system. Common faults of cooling system include low cooling water pressure, high cooling water temperature of gear box, high cooling water temperature of frequency converter, low cooling water temperature of frequency converter, cooling water temperature of generator.

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3.4. Bearing Fault

In the operation process of wind turbine, after the rolling bearing works for a period of time, the fatigue damage will inevitably occur, leading to the failure of the bearing and affecting the work. The main failure forms of the bearing are corrosion of the inner and outer rings of the bearing, and tiny cracks will be produced on the surface of the material. with the running of the bearing, the cracks will gradually become larger and eventually lead to the failure of the bearing.

4. Application of Data Mining Technology in Fan Fault Diagnosis

4.1. Artificial Neural Network Method

Artificial neural networks can simulate the structure and function of biological brain. Establishing an information system similar to human brain to handle problems. The self-learning function of artificial neural network can encode data and iteratively solve neuron, then extract complex patterns and analyze that trend. Neural networks have the ability of self-learning, self-organization, self-adaptation, association, fuzzy reasoning, nonlinear processing, robust distributed storage and association. It can process nonlinear data and noisy data well and has good prediction and classification ability for unknown data. Therefore, neural network method is often used to solve nonlinear problems. At present, common neural network models include feedback network, self-organizing network and feedforward network. However, due to the long learning time and slow convergence rate of neural networks, serious performance problems may occur in the case of large amounts of data [6].

4.2. Fuzzy Set Method

In classical set theory, the relation is either true or false, there is no concept between true and false. In a fuzzy set, partial truth is allowed to exist, and the degree of relation can be expressed by membership values of 0–1. The so-called fuzzy technology is to use the basic theory of fuzzy mathematics in the specific implementation of fuzzy control, identification, fuzzy diagnosis and reasoning process. Fuzzy natural language is often used to describe the state features in state monitoring and fault diagnosis. In fault detection, characteristic signals sometimes change continuously, and the boundaries of their states cross each other. Sometimes some fault phenomena are fuzzy, and the fuzzy set method is characterized by the concept of one of membership degrees. In fault diagnosis, although the detected characteristic signal value is not completely accurate, fuzzy inference can be effectively processed to reach the correct conclusion.

4.3. Decision Tree Method

Decision tree method, as one of classification methods in pattern recognition, mainly uses top-up recursive process to classify and express a group of cases with no order and rules in the form of decision tree. It can decompose complex multi-category classification problems and transform them into several simple classification problems, so that decision makers can make decisions in a more understandable way. The biggest advantage of decision tree algorithm is easy to use. The decision tree method is introduced in the fault diagnosis to generate a fault decision tree, and each path from the root to the leaf node corresponds to a rule, which can quickly provide a powerful decision basis for fault classification. Common decision tree algorithms include ID3 and C4.5 algorithm [7].

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5. Fan Fault Diagnosis Method based on Data Mining Technology

5.1. Fault Diagnosis of Wind Turbine based on Rough Set Attribute Reduction and Apriori Algorithm

In view of the problem that the traditional Apriori algorithm will generate a large number of redundant candidate sets when running in the face of massive data, resulting in a great waste of resources and the slow running speed caused by insufficient memory, sun hexu et al. combined with Hadoop platform in the cloud computing environment, improved Apriori algorithm based on Map R educe parallel structure to meet the requirements of parallel computing, and introduced the concept of attribute reduction in rough set theory to screen out and delete the attribute items that have nothing to do with the association rules, thus reducing the size of the transaction database. After the above improvements, an efficient association rule algorithm based on Hadoop platform is formed: MpApriori algorithm [8]. Compared with the traditional Apriori algorithm, the MpApriori algorithm reduces the number of attribute items, avoids repeated database retrieval, reduces the time and space complexity of association rule mining, and improves the mining efficiency.

5.2. Fault Diagnosis of Wind Turbine based on Cloud Model and Rough Decision Tree Algorithm

Taking advantage of the randomness and uncertainty of cloud model as well as the advantages of data mining in dealing with massive data and knowledge discovery, a fault diagnosis system of wind turbine generator set based on rough decision tree is proposed [9], which can not only manage each database of wind turbine generator set, but also monitor and diagnose the faults of generator set equipment, and realize the overall management of the system integrating database management, monitoring and diagnosis. By constructing a suitable evaluation system and selecting the correct evaluation index, then according to the fuzziness of the general fuzzy comprehensive evaluation and the randomness of the cloud model, the membership degree of each index is obtained from the forward cloud generator. This method reduces the subjectivity of the membership function in the artificial determination. Finally, the experimental calculation proves that the evaluation method based on cloud model can judge the fault state more accurately.

6. Conclusion

The fault prediction of wind turbine generator is an important link in that operation proces of the wind turbine generator set, the fault early warning accuracy rate of the wind turbine generator is improve, and the maintenance cost is greatly reduced. Introducing data mining into fault diagnosis and finding fault rules from the data itself can effectively guide the maintenance personnel to locate and maintain the faults of the equipment. this paper briefly summarizes the data mining technology, analyzes the common fault sources of the wind turbine, and introduces the application of data mining technology in the fault diagnosis of the wind turbine and two fault diagnosis methods of the wind turbine based on data mining technology.

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