Application of Computer Algorithm in Fault Diagnosis System of RM Equipment

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Abstract. At present, modern mechanical equipment is gradually developing towards large-scale and intelligent, which leads to more and more complex equipment structure. Therefore, people have higher and higher requirements for intelligent fault diagnosis of mechanical equipment, which leads to the application of various algorithms to mechanical equipment. Among them, rotating machinery (hereinafter referred to as RM) mainly relies on rotating action to complete specific functions, such as gearbox, gas turbine, generator and engine, which are often the core components of mechanical equipment. Therefore, the FSGS (hereinafter referred to as FSGS) of RM equipment has become a very key link in system design and maintenance, which requires designers to constantly overcome the original intelligent diagnosis system. Through a variety of deep learning algorithms, we can improve the diagnosis efficiency of automatic monitoring and diagnosis equipment, which can also reduce the loss caused by untimely diagnosis. Firstly, this paper analyzes the types of application of computer algorithms in the fault body segment system of RM equipment. Then, this paper analyzes an algorithm, which can better improve the diagnosis efficiency of the equipment.

Keywords: Computer Algorithm, Rotating Machinery Equipment, Fault Diagnosis System

1. Introduction
RM is widely used in electric power, petrochemical, metallurgy, automobile manufacturing, aerospace and other equipment, which is often the core component of mechanical system [1]. Therefore, once the rotating mechanical equipment fails, the equipment will cause serious losses, even casualties. Therefore, the FSGS of RM equipment has become an important link in the system design [2]. At present, RM and equipment are mainly faced with a variety of faults, including imbalance, bearing misalignment, looseness, fracture and wear of gear parts, etc. Therefore, designers often use oil analysis, temperature analysis, acoustic emission detection, vibration analysis and other diagnostic methods to extract the fault characteristics of equipment [3-6]. With the development of artificial
intelligence, computer algorithms have been applied to fault diagnosis, such as k-NN, naive Bayes, SVM, artificial neural network, etc., which can classify and diagnose the fault diagnosis of RM [7].

2. Development trend of fault diagnosis of RM and equipment

2.1. Knowledge provided by domain experts to machine learning
Machine learning is a field of artificial intelligence that needs to be vigorously studied. It is a method to enable machines to acquire new knowledge and skills. Through machine learning, the equipment can reorganize the existing knowledge in the knowledge base, which can also gradually enrich and improve the system knowledge. Therefore, the knowledge provided by traditional domain experts can no longer meet the needs of society, which needs to be updated and learned automatically [8]. Therefore, machine learning will continuously improve the system, which is also the main way to improve the intelligence of FSGS. Once the diagnostic system has the ability to learn, it can learn new knowledge from the changes of the environment. Therefore, machine learning can continuously achieve self-improvement [9].

2.2. From single diagnosis method to integrated diagnosis method
At present, people have begun to study a more powerful hybrid intelligent FSGS, which can overcome the limitations of existing intelligent diagnosis methods. According to the specific application, the designer can construct the corresponding integration structure, which can complete the fault diagnosis [10]. Therefore, the traditional single diagnosis method can not meet the needs of the society, which requires the continuous integration of various algorithms. Through the combination of various diagnostic theories and neural networks, we can complete the integration of signal processing and neural networks, such as the integration of artificial neural networks and expert systems, fuzzy theory, grey theory, wavelet theory and so on [11].

2.3. Nonlinear diagnosis technology based on nonlinear dynamics theory
Traditional diagnostic techniques usually ignore the nonlinear vibration information of equipment. With the increasing function of mechanical equipment, the structure of rotating mechanical equipment is becoming more and more complex. Therefore, the nonlinear factor of system fault is more obvious, which requires us to improve the nonlinear characteristics of equipment [12].

3. Application of computer algorithm in fault diagnosis of RM

3.1. Application of neural network
Neural network is an adaptive nonlinear dynamic system established by trying to simulate biological neural system, which has the ability of learning and parallel computing. Through neural network, we can realize the functions of classification, self-organization, associative memory and nonlinear optimization. In the field of fault diagnosis, the application of neural network mainly includes two aspects. Firstly, from the perspective of pattern recognition, neural network is used as a classifier for diagnostic reasoning. Second, from the perspective of prediction, neural network is used to establish a prediction model for trend prediction. In the aspect of diagnosis and reasoning, fault recognition based on neural network has been widely studied.

The specific steps of BP algorithm are as follows. First, initialize the weight \( w \). Second, input learning samples and calculate the actual output of each neuron, as shown in Formula 1. Third, calculate the reverse error and weight increment, as shown in formula 2. Fourth, update the weight, as shown in Formula 3. Fifth, return to step 2 to know that the performance meets the requirements.

\[
y_k^{(l)} = f \left( \sum_{j=1}^{n-1} w_{jk} y_j^{(l-1)} \right)
\]
$\Delta w^{(l)}_{ji}(k) = \sigma_j^{(l)} \times y^{(l-1)}_i(k)$  

(2)

$w^{(l)}_{ji}(k+1) = w^{(l)}_{ji}(k) + \mu \times \Delta w^{(l)}_{ji}(k)$  

(3)

3.2. Application of genetic algorithm
Genetic algorithm is an optimization problem solving method proposed by simulating the law of biological evolution in nature. Genetic algorithm uses simple coding technology to represent various complex problems. Through genetic operation of coding and natural selection of survival of the fittest, genetic algorithm can search multiple regions of solution space at the same time. Genetic algorithm is not constrained by search space constraints, which does not need other auxiliary information. At present, genetic algorithm is mainly used to solve optimization problems. The fault diagnosis problem can be defined as a probabilistic causal network based on the economical covering set theory. The solution of the problem is the fault set with the maximum a priori probability. Therefore, genetic algorithm can be applied to diagnostic reasoning process.

Traveling salesman problem is a typical genetic algorithm, as shown in formula 4. The iterative flow chart of genetic algorithm is shown in Figure 1.

$$
P^k_j(t) = \begin{cases} 
\frac{\tau^a_{ij}(t) \eta^B_{ij}(t)}{\sum_{k \in \text{allowed}_k} \tau^a_{ij}(t) \eta^B_{ij}(t)}, & \text{if } j \in \text{allowed}_k \\
0, & \text{otherwise}
\end{cases}
$$

(4)

Figure 1. Iterative flow chart of genetic algorithm

3.3. Fuzzy theory
Fuzzy theory is a method to deal with fuzzy information by simulating people's logical thinking mode, which is suitable for qualitative analysis of complex large-scale systems. Due to the influence of various conditions and factors, it is difficult to use an accurate mathematical model to describe the relationship between fault and symptom. At the same time, the fault characteristics of the equipment are also fuzzy. The fault diagnosis of fuzzy theory is closer to people's thinking habits and language expression.
Fuzzy fault diagnosis mainly includes methods based on fuzzy transformation and fuzzy comprehensive evaluation. For fuzzy set $A$ on universe $U$, there are many representation methods, such as vector representation, order pair representation and function description. This paper introduces Zadeh representation. When the universe $U$ is a discrete domain, it is shown in formula 5.

$$A = \frac{\mu_A(x_1)}{x_1} + \frac{\mu_A(x_2)}{x_2} + \ldots + \frac{\mu_A(x_n)}{x_n} = \sum_{i=1}^{n} \frac{\mu_A(x_i)}{x_i}$$  \hspace{1cm} (5)

Among them, $\frac{\mu_A(x_i)}{x_i}$ is the corresponding relationship between the membership of element $x_i$ to set $A$.

When the universe $U$ is a continuous domain, as shown in formula 6.

$$A = \int \frac{\mu_A(x)}{x}$$ \hspace{1cm} (6)

4. Design of FSGS

4.1. Overall system architecture

In this paper, a RM FSGS is established, which includes a fault diagnosis expert system with simple on-line monitoring at the front end and automatic reasoning at the back end. The overall architecture of the system is shown in Figure 2.

![Figure 2. Overall system architecture](image-url)
4.2. Functional diagnosis
Compared with other fault diagnosis expert systems, the automatic fault diagnosis expert system of RM can realize the automatic reasoning of some functions. Through the automatic identification and judgment of frequency, oil analysis and temperature analysis, the system can classify faults according to frequency, oil analysis and temperature analysis according to decision tree or Fisher judgment method. For example, accurate diagnosis is divided into ten parts according to different working frequencies, namely: ultra-low frequency, 50Hz or its frequency doubling, accurate frequency division, working frequency, accurate frequency doubling, sub asynchronous vibration, frequency division lag, same frequency lag, frequency doubling lag and ultra-high frequency.

5. Conclusion
With the development of industrial production and RM and equipment have developed towards automation and intelligence. As the structure of RM becomes more and more complex, the automation level is also improved accordingly. Through a variety of deep learning algorithms, we can improve the diagnosis efficiency of automatic monitoring and diagnosis equipment, which can also reduce the loss caused by untimely diagnosis. Therefore, computer algorithms have been widely used in fault diagnosis of rotary unloading equipment.

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