Intelligent Fault Diagnosis of Photoelectric Pod Bearing Based on Multi-information Fusion

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Abstract. Intelligent fault diagnosis technology has become the focus of research in various fields. Its realization depends on the acquisition of equipment state by sensors. Because the fault information provided by a single sensor has limitations and cannot fully reflect the fault state of the tested object, we need to use multiple sensors to collect and fuse the fault information of rolling bearings to ensure the accuracy and accuracy of intelligent fault diagnosis. Based on this, this paper analyzes the application of fuzzy rules of multi-sensor information fusion technology in the fault diagnosis of bearings in the optoelectronic pod, so as to provide a reference for the realization of intelligent fault diagnosis of each structure in the optoelectronic pod.

1. The Introduction

At present, photoelectric pods as repeated mounting equipment are faced with severe conditions such as overload shock, vibration shock and sudden temperature change in the process of use, which aggravates the rapid decline of the life of the internal components of pods and increases the probability of failure in the process of use.

Rolling bearing is one of the most important parts in mechanical equipment[1], its running state directly affects the performance of the equipment, and it is of great significance to fault diagnosis of rolling bearing. The main damage types of rolling bearings are as follows: wear, fatigue peeling, rust and corrosion, burn, plastic deformation, fracture, bonding and cage damage, etc. In addition, rolling bearings will also suffer from creep, scar, electric corrosion and other damages.
In order to improve the stability of the optoelectronic pod, strengthen the ability of fault diagnosis, and ensure the stable and reliable operation of wireless laser communication, it is necessary to monitor the operation state of the entire optoelectronic pod. Through the real-time monitoring of the weak signal of the mechanical transmission structure and the fusion algorithm of all kinds of information collected, the intelligent fault prediction is realized.

2. Principle of multi-sensor information fusion

It is the ultimate goal of the application of multi-sensor information fusion technology[2] to improve the effectiveness of the information system through the joint operation or joint operation of multiple sensors. Multi-sensor signal fusion[3] is to combine the redundant or complementary information of multiple sensors in space and time according to the set criteria, so as to obtain the consistent description of the tested object and ensure the accuracy of monitoring results.

Information fusion can be classified in terms of technology, algorithm and structure. The lower the level of fusion[4], the higher the requirement for the detailed degree of data; on the contrary, the higher the level of fusion, the more relaxed the requirement for the detailed degree of data, and the higher the degree of abstraction. Each level fusion is shown as follows:

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**Figure 1.** Data Level Fusion

**Figure 2.** Feature Level Fusion
3. Application of fault intelligent diagnosis in optoelectronic pod

3.1. Selection of sensors
In the process of bearing fault diagnosis of photoelectric pod, the role of sensor is to collect equipment information, as the basis of fault analysis and diagnosis. Therefore, in the specific application, in order to achieve accurate and effective fault identification effect, reasonable selection of sensors is the most critical content in the research process. We can understand the three stages of bearing fault development from the figure below:

a: The noise increases slightly and the temperature is normal; Vibration peak energy has a large increase; Bearing outer ring has defects; The total amount of vibration increased slightly.
b: Audible noise and slightly higher temperature; The total vibration acceleration and the total vibration velocity are greatly increased, and the noise ground level of the vibration spectrum is obviously increased.
c: The intensity of noise changes and the temperature increases significantly; The total amount of vibration velocity and vibration displacement increase obviously, while the total amount of vibration acceleration decreases.

Combined with the above characteristics of each stage of bearing faults, we can use the method of combining sound sensor and vibration acceleration sensor according to the corresponding stage characteristics. Table 1 is shown as follow
Table 1. Selection of sensor

| Type of sensor        | General model                  | role                  |
|-----------------------|--------------------------------|-----------------------|
| Sound sensor          | LM386, BYZ08 - F               | Collect sound information |
| Vibration acceleration sensor | CYT9200, YK-YB40, CT11005LC | Collect vibration information |

3.2. Fuzzy fusion algorithm

The fuzzy neural network[5] can transform the information obtained by different sensors and obtain the consistent interpretation of the current environment, and obtain the local decision value of each sensor. Then through the fusion center for fusion to obtain the global decision. For intelligent diagnosis of bearing faults in photoelectric pod, intelligent diagnosis can be made for three typical faults of bearing: inner and outer ring crack, inner and outer ring pitting corrosion and rolling body fault.

The fusion algorithm of fuzzy neural network[6] is a reasoning process for the uncertainty of the information collected by multiple sensors. Based on fuzzy rules, the fuzzy set is inferred to obtain the result of information fusion. The model is composed of two parts: the antebellum network and the antebellum network. Matching fuzzy rules is the main function of the antecedent network, which is used to generate fuzzy rules. Figure 5 is the structure flow chart of the fusion algorithm:

![Flow chart of multi-sensor fusion algorithm](image)

Figure 5. Flow chart of multi-sensor fusion algorithm

The fuzzy neural network test steps are as follows[7]:
1. Using the fuzzification model, the eigenvalues were obtained and the corresponding membership degree of the test samples was calculated.
2. The membership degree is taken as the input and output of the network to carry out neural network learning and training.
3. The experimental simulation is carried out on the test sample data to obtain the real output of the network.
4. The experimental simulation tool MATLAB is used to realize the data simulation, and BP network is established.
5. Set the training step size and the number of training layers of BP network to start the training network;
6. The trained fuzzy neural network is used to fuse the multi-source information; Through the application of the above algorithm, the intelligent fault diagnosis of bearings can be more accurate and faster. Although the accuracy rate cannot be 100%, the accuracy rate can be gradually enhanced through continuous optimization of the fuzzy model[8-9], so as to obtain a more satisfactory effect.

4. Conclusion
To sum up, the application of multi-sensor information fusion technology can significantly improve the fault diagnosis ability of optoelectric pod. It monitors the operation state of the whole optoelectronic pod, improves the stability of the optoelectronic pod, realizes the prediction of the fault, and achieves the stability of the laser communication system. The optoelectronic pod technology belongs to the domestic frontier technology, and the fault diagnosis of optoelectronic pod is in a new stage, and there are few literature reports at home and abroad.

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