Research of Intelligent Technology and Its Application in Fault Diagnosis

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Abstract. Faults of large-scale and complex mechanical equipment are characterized by complexity uncertainty syndrome. If a single intelligent technique is utilized to diagnose these faults, it would be too difficult to obtain a satisfied diagnosis result. Generally, the diagnosis accuracy of the single intelligent technique is lower and generalization ability is weaker. Thus, it is urgent and necessary to present a novel idea and method to solve these practical engineering problems.

Keywords: Mechanical device; fault diagnosis; intelligent diagnosis.

1. Introduction

Although domestic and foreign research and application of hybrid intelligent fault diagnosis has made encouraging progress, but in terms of the device itself and applied to the field of hybrid intelligent fault diagnosis technology, there are still the following problems:

① Current diagnostic methods and intelligent diagnostic system, mostly alone use some smart technology, such as based on fuzzy reasoning, neural networks, or two single smart technology in the sense of simply "stacking", failed to consider a variety of intelligent methods between organic ties and mutual integration, so there is no full play to their respective advantages in the diagnosis.

② Various intelligent diagnostic methods of the present study, usually a signal processing and feature extraction methods: for example: wavelet analysis, empirical mode decomposition, higher-order spectrum, time-frequency analysis or time domain, frequency domain statistical analysis to extract features. Single feature extraction method, there is no full use of multi-feature domain fault information, resulting in incomplete diagnostic information; simultaneously without taking into account the different characteristics of the fault diagnostic sensitivity is suppressed to improve diagnostic accuracy, weakening the intelligent classifier robustness and reliability[1].

③ Most of the current hybrid intelligent fault diagnosis method just stay in the experimental simulation stage, and early diagnosis instance, weak and very few concurrent multiple faults. According to the actual needs of the project, research hybrid intelligent diagnosis early, weak and multiple fault diagnosis, and the development of practical engineering fault diagnosis system is urgently needed to solve the problem.

④ Hybrid intelligent diagnostic technology research has just started, or traditional use feature extraction methods and intelligent diagnostic technology. In order to obtain a satisfactory diagnosis requires the use of advanced signal processing technology and smart technology. So propose a new method of signal processing and improve existing smart technology, and applied hybrid intelligent diagnosis system is another issue hybrid intelligent diagnostic technology to solve.

⑤ Existing hybrid intelligent diagnostic systems are mostly used for off-line diagnostics, leading to advanced theory, information technology and data can not be shared, resulting in a waste of knowledge resources. Therefore, the development of hybrid intelligent fault diagnosis system based on a network, so that the hybrid intelligent diagnostic technology, "Internet", saving diagnostic

resources, reduce the cost of diagnosis is the actual needs of the project, but also the urgent need to address the problem.

1.1 Fuzzy set theory

In the engineering field, fuzziness everywhere. Operating status of the device to determine, from the "safe" state to the "unsafe" there is a transition zone between the state, the two states that border is blurred. Description of the mechanical state of the system, such as noise, vibration serious, large axial deformation, are fuzziness concept. With the rapid development of modern science and technology, the increasing complexity of various devices, fuzzy set theory provides a powerful mathematical tool for large and complex fault diagnosis equipment. According to Zadeh fuzzy mathematics founder's "exclusion principle", when the complexity of the system increases, the ability to accurately and effectively describe the behavior of the system is reduced, when it reaches a certain threshold, the accuracy and validity (or related resistance) becomes mutually exclusive. Therefore, the higher the complexity of the equipment, the ambiguity of its system is also stronger [2]. Using the basic principles of fuzzy mathematics, fuzzy information processing equipment condition monitoring and fault diagnosis encountered in the analysis, fault diagnosis of complex equipment will open up new and effective ways.

University of California at Berkeley Zadeh LA in 1965 on "information control" journal published a seminal paper on fuzzy set theory(Fuzzy Set Theroy, FST)'s. First proposed the concept of expressing important things fuzziness-membership functions. Establish the concept of breaking the limitations of 19th century German mathematician Contor G. founded the classical set theory. Membership functions can be expressed by means of a fuzzy concept from "not belong" to the excessive "fully belong", it can all be quantified fuzzy concept. Proposed basis of membership functions of fuzzy theory. The common elements of the collection of membership collection can only take two values, 0 and 1, this can be extended to take any value interval [0, 1], which can be used to quantitatively describe the elements of membership in line with the concept of domain theory degree. Practice has proved that the fuzzy set theory in image recognition, atmospheric forecasting, earthquake geology, transportation, medical diagnostics, information control, artificial intelligence, and many other areas have also been noticed. From the development trend of the discipline of view, it has an extremely strong vitality and penetration [3].

1.2 Genetic Algorithms

Genetic Algorithm (Genetic Algorithm, GA) originated in a computer simulation study of biological systems conducted. Holland Michigan University professor and his students inspired by biological simulation technology to create an adaptive probability based on genetic and evolutionary biological mechanisms for complex system optimization optimization techniques - genetic algorithms. From the entire development process of genetic algorithms, the 1970s is the rise phase, the 1980s was the development stage, the 1990s was the climax stage. Genetic algorithms as a practical, efficient and robust optimization techniques, extremely rapid development, has caused scholars are highly valued.

Genetic algorithms are a class of stochastic search algorithm, which can effectively use some of the information processing has to search for those who are looking to improve the quality of solution strings. Similar to the natural evolution, genetic algorithm by acting on the gene on a chromosome, chromosome looking good to solve problems. Similar nature, genetic algorithms to solve the problem itself ignorant treatment, it needs only generated for each chromosome algorithms were evaluated, and based on the fitness value to change the chromosome, the chromosome makes the difference between good adaptability than the adaptability chromosomes have more breeding opportunities.

Genetic algorithms simulate the occurrence of natural selection and genetics and other reproduction, crossover and mutation phenomenon, starting from an initial population through

selection, crossover and mutation, resulting in a group of individuals better adapted to the environment, so that group evolved into the search space more good area, from generation to generation reproduction evolved, and finally converge to the optimal solution best adapted to individual environmental group, obtained the problem. It's the basic process shown in Figure 1-1. First, the feasible domain encoded. Then, in a group of randomly selected feasible region coding (chromosomes, individual) as a starting point for the evolution of the first generation of groups and individuals is calculated for each coding values applicable, and fitness embodies the objective function optimization information. Then, as with nature, randomly selected from the population as a number of individual sample collection before the breeding process, selection mechanism should ensure a high degree of individual adaptation to retain more of the sample, while the fitness of individuals will be kept low with less sample or eliminated. During the breeding process, the use of two kinds of crossover and mutation operators, to a certain crossover and mutation rate on the exchange after the selection of the sample to give a new individual. Finally, replace the population by the next generation of new and old individuals. Algorithm repeats the above evaluation, selection crossover and mutation process until the end condition is satisfied [4]. Typically, the last generation of the evolutionary process to adapt to the highest population of individuals is the final result of the use of genetic algorithm to solve optimization problems.

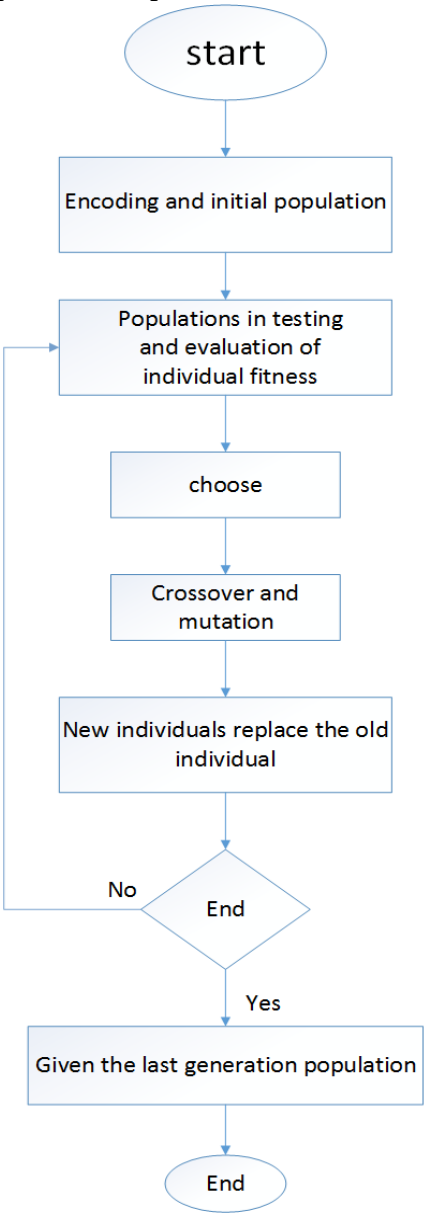

Fig. 1-1 genetic algorithm flowchart

2 Modern signal processing technique

Three steps in fault diagnosis, fault diagnosis is the key feature extraction, the traditional signal analysis techniques can not effectively extract feature information early, weak and composite failure. For large and complex diagnostic equipment, you need to use modern signal processing methods to extract fault feature. In this paper, the use of two novel non-stationary signal analysis techniques - wavelet analysis and empirical mode decomposition, the following will introduce these two modern signal analysis techniques.

2.1 wavelet transform and wavelet packet analysis

Wavelet analysis is the Fourier transform, Gabor analysis, a direct result of the development of short-time Fourier transform, which is a Fourier transform when established on the basis of frequency analysis method, has the characteristics of multi-resolution analysis is very suitable for analysis of non-stationary signals. When it is, the frequency domain signal also has the ability to characterize local features, and has a good effect in fault detection and diagnosis of dynamic systems. But it is a time for the low-frequency portion of the signal is decomposed gradually to the low-frequency range focus, high-frequency part of the reservation does not move, so the frequency resolution of the high-frequency portion of the poor [5]. Wavelet packet transform is the development and extension of the wavelet transform, which is the time-frequency localization properties inherited wavelet transform, wavelet transform is no longer continue to break down the high frequency band is further decomposed, full-band multi-level signal band division, the signal mapping to these bands, the signal in weak signal characteristics emerge, providing a more precise description of the means of the signal.

2.2 wavelet function Features

(1) Wavelet function in the time domain has a compact support (function domain finite non-zero) or similar compact support. In principle, any satisfy conditions allow (R) of the space can be used as mother wavelet function (including real or complex functions, compactly supported non-compact support function, regular or non-regular functions, etc.). However, under normal circumstances, is often chosen compactly supported or similar compact support (with a time-domain locality) have regular sex (with frequency domain locality) real or complex functions as a mother wavelet function to make the mother wavelet in the frequency domain has a better local properties.

(2) Since the mother wavelet function satisfies the conditions allow, that the DC component is zero, that is, the wavelet will have alternating positive and negative volatility.

When given below short Foureir transform and wavelet transform frequency window features:

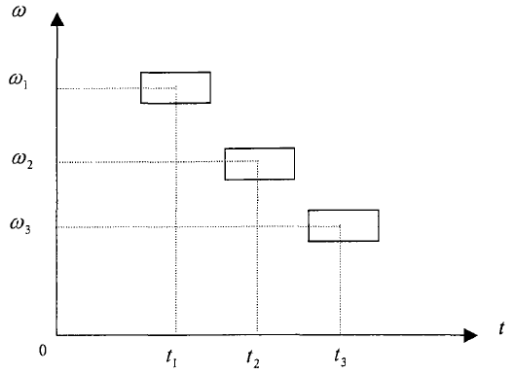

Figure 2-1 Frequency characteristics window when converting short Foureir

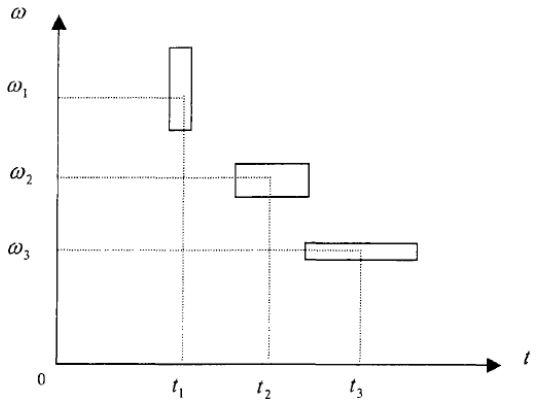

Figure 2-2 the frequency window characteristics of wavelet transform

2.3 Wavelet Packet Algorithm

The basic principle known by the wavelet transform, wavelet transform on the phase plane, with the reduced scale j, the time-domain window width corresponding wavelet function decreases its frequency-domain window width increases. That is, the frequency-domain window function with the corresponding wavelet scale decreases. In general, small scale signal contains many high frequency components, corresponding to wide-band; while large-scale signal, usually contain only low frequency components corresponding to the narrow band. This small-scale wavelet transform large frequency windows, large-scale frequency when a small window of time-frequency distribution of the same nature in the signal frequency characteristics consistent [6]. Thus, with small to large-scale changes, wavelet analysis arbitrary scale suitable for signal conversion. In fact, the wavelet transform in which time-frequency distribution is very useful in many cases, but this time in some situations the fixed frequency distribution of the wavelet transform of the window is not an optimal choice. In fact, in many of the problems in some people just interested in a specific time segment or the frequency band of the signal, as long as the extraction of the specific time, and frequency information has been. Therefore, in the hope that the natural period of interest on the time resolution of the maximum possible increase in the frequency band of interest most likely to increase the frequency resolution. The wavelet transform provides frequency phase plane will not meet this requirement.

3 Hybrid Intelligent Technology in Remote Diagnosis System

Fault diagnosis is a very practical subject, the ultimate goal of their research is effective diagnostic techniques and methods used in equipment condition monitoring and fault diagnosis, the science and technology into productivity, the carrier of these techniques and methods are monitoring and diagnosis system, its research and development is increasingly important. Therefore, pay attention to the theoretical innovation, more attention should be paid has developed some practical fault diagnosis system. According to expert analysis, the theoretical level of diagnostic technology has reached or close to international standards, but in the popularization and application, with the international advanced level is far greater for the production and application service gap. The reason is mainly theoretical and applied research site was not well combined. In recent years, the Chinese government has given high priority, "Ninth Five" climbing program, "fifteen" technological breakthroughs, 863 high-tech Research and Development Program, the National Natural Science Fund projects will also be developed fault monitoring and diagnosis system as a key content .

3.1 Logical structure device monitoring layer

Equipment monitoring layer using the measured point detection feature of the front end of the data provided in real-time monitoring and control equipment to complete the process of running and

together with complete equipment and the corresponding controller scheduling and optimization, its logical structure shown in Figure 3-1:

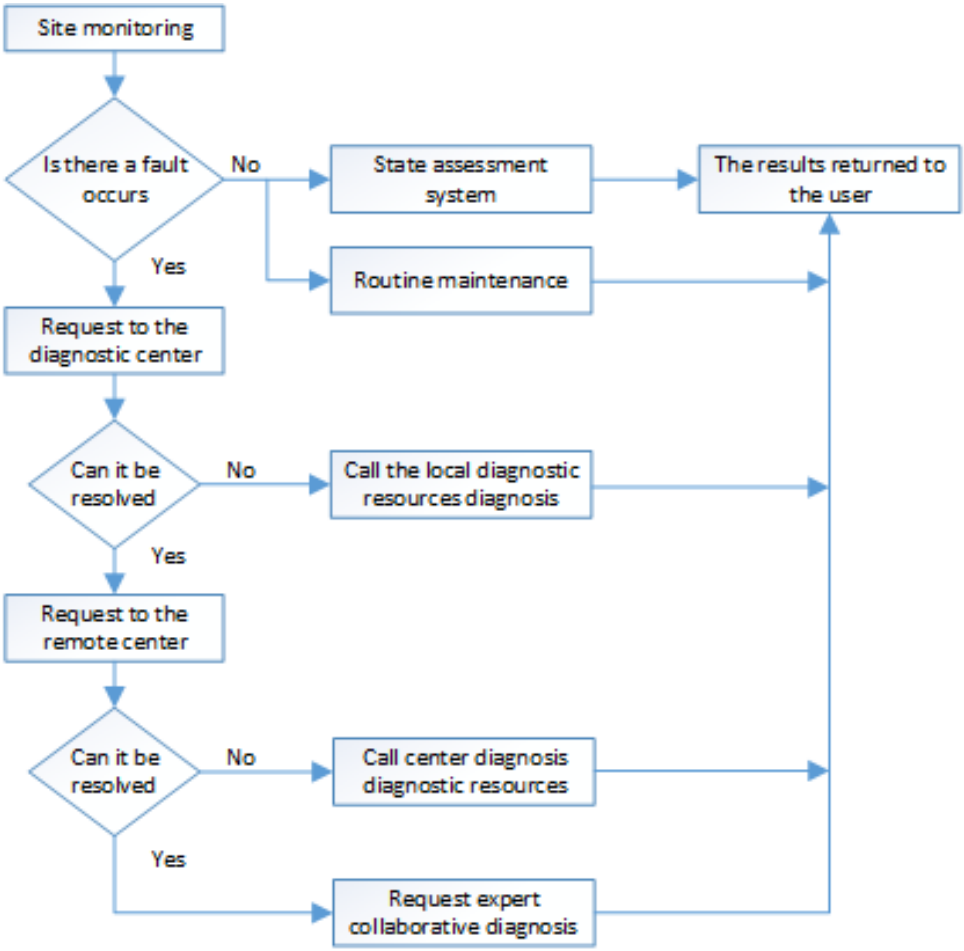

Figure 3-1 Remote Intelligent Fault Diagnosis System work flow chart

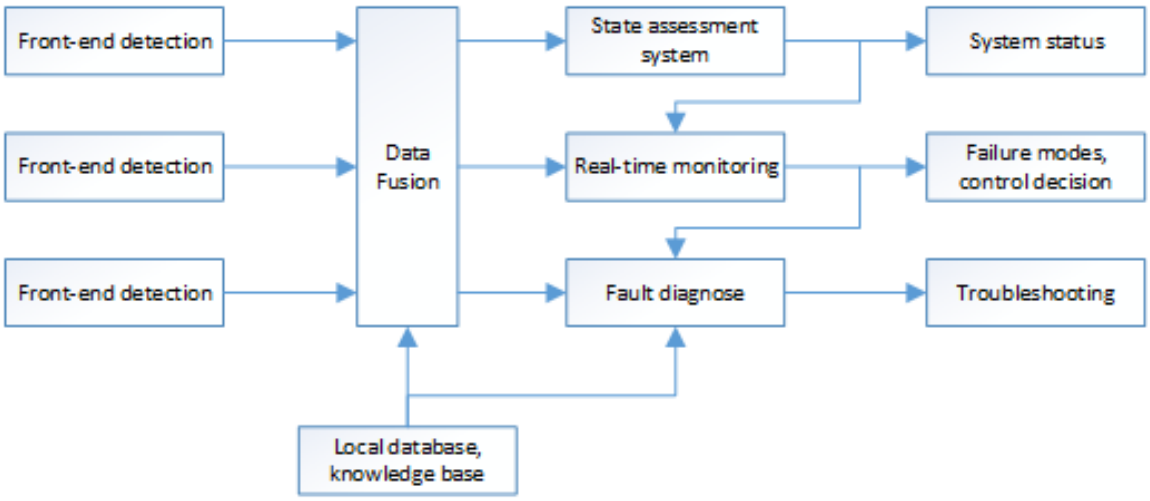

Figure 3-2 logical structure equipment monitoring layer

In Figure 3-2, the status of the underlying device and process information detected by the front-end acquisition and processing, the formation of characteristic data into the monitoring system data fusion module, forming a centralized signal. Since the signal is present focus is inconsistent, redundant and conflicting issues such as the use of a standardized data fusion process of state-specific data into the system status assessment, real-time status monitoring and fault diagnosis of the three parallel processing module. State assessment system as a reference to the ideal state to complete the

identification system is abnormal status and future trends [7]. When an exception occurs, the real-time detection module based on the failure modes during operation characteristics affect the classification and come running fault on the manufacturing process, the formation of the corresponding control strategies available to the controller, and eliminate the influence of scheduling. The status monitoring and scheduling closely linked, is the core of the monitoring system.

4 Conclusion

In recent years, due to the development of computer technology, signal processing, artificial intelligence, pattern recognition technology, and promote the continuous development of fault diagnosis technology. Especially intelligent fault diagnosis method has been widely studied. Intelligent Fault Diagnosis currently focused on the following aspects:

(1) The introduction of some new theoretical troubleshooting process, such as information fusion fault diagnosis, fault diagnosis based on evolutionary algorithms, Agent-based fault diagnosis, model-based reasoning graph theory, fault diagnosis method based on nuclear, etc., along with continuous development of new theories, work in this area is still an important part of fault diagnosis.

(2) Diagnostic systems integration, several diagnostic methods will be integrated into the integrated fault diagnosis together to achieve integration of various diagnostic methods. Such as the wavelet transform, fuzzy mathematics, neural network integrated fault diagnosis method together. Because each method has its advantages and disadvantages, this integrated fault diagnosis method must have its own unique advantages. This is also one of the elements to be studied in depth.

(3) Diagnostic system integration, the past simply by monitoring and diagnosis, the next set of monitoring, testing, diagnosis, management, forecasting and training in an integrated systematic direction.

(4) With the development of artificial intelligence, people are increasingly aware of the superiority of common sense and natural intelligence of the human operator, the fault diagnosis system appropriate to consider the role of people will reduce the failure rate of false positives and false negatives. Fault diagnosis is a very practical technology, only in practical applications in order to reflect its value. At present, although a lot of progress in the study of theory, but real engineering practice examples of successful application is also less, therefore, how advanced fault diagnosis theory and methods applied to the actual go remains to be further studied.

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