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Outline of Machinery Fault Diagnosis Method

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ABSTRACT *:* Traditional mechanical equipment fault diagnosis methods are simple, and research is relatively simple, but it can not meet the demand of modern machinery development. Thus a large number of new methods are popular about modern machinery and equipment fault diagnosis. With the development of science and technology, the methods of modern machinery and equipment fault diagnosis become more and more complex. Therefore, it is necessary primarily focus on modern machinery fault diagnosis method, in order to facilitate the researchers access to use.

Keywords–*RVM; SVM; Mechanical Fault Diagnosis; Intelligent Diagnostic Method*

I. INTRODUCTION

Activities "World Carnival" in a serious accident, the Ferris wheel Ferris car suddenly hit, five tourists from 20 meters by falling ground, all died. When the May 5, 2007 1:00 pm near, Suita, Osaka, Japan's Expo Commemoration Park Amusement Park (Expoland) roller coaster accident occurred, killing one person was killed and about 21 injured. At 12:05 on May 1, 2015 or so, Kunyang Town, Pingyang County, Zhejiang Yongsan Park playground "Scream" Project accidents, resulting in two deaths and three people were injured. To prevent such incidents from happening again, the paper focused on the research in a simple and practical method for fault diagnosis so that the accident nipped in the bud stage. In order to protect the life and property safety of tourists.

At present, domestic and foreign research results for a lot of mechanical equipment failures diagnosis, but a lot of paper research only relates to general mechanical malfunction diagnosis. Such as, heavy machinery and equipment, agricultural machinery and equipment, aviation equipment. Research site troubleshooting few, especially the study of playground machinery fault diagnosis can say very few. Based on previous research foundation, to explore a site, real-time diagnostic and predictive failure diagnosis is very important.

II. RESEARCH STATUS AND DEVELOPMENT TREND OF MACHINERY FAULT DIAGNOSIS TECHNOLOGY

2.1 Machinery fault diagnosis technology domestic and foreign research present situation

Development and research of fault diagnosis technology first began in the United States, the formation mechanism of multiple failures have a certain research; Germany and other countries have also started to study, and the results achieved in a number of areas; our research relatively late, its first, the development process is imported from abroad, self-absorption, and gradually summarize fault diagnosis theory of the three procedures. As figure1 show, fault diagnosis technology from development to date appear, it can be divided into four stage[1]:

①early stage—19 first century to the 20th century, mechanical equipment maintenance personnel through their own experience to make a judgment on equipment failure;

②the second phase—the early 20th Century to the 1960s, through the study of the performance of equipment

and materials for the life expectancy of material was evaluated, and combined with the reliability theory to equipment failure to make judgments;

③The third phase—the mid-20th Century 1960s, with the development of computer technology and sensor technology, diagnostic information about the device can be detected by the sensor is obtained, and then use the computer for sensing data obtained was analyzed, whereby the device operating state judge, is already widely used in the field of armaments, steel, nuclear equipment;

④The fourth stage— diagnostic techniques perfected. The status information of the device is to obtain a number of Eigen values device state detected by extracting a digital signal, which is determined using intelligent algorithms model made of the results. This method has the advantage of various considerations device status, and does not require a very specific state of the physical model that can promote strong, can adapt to the modern complex diagnostic device status.

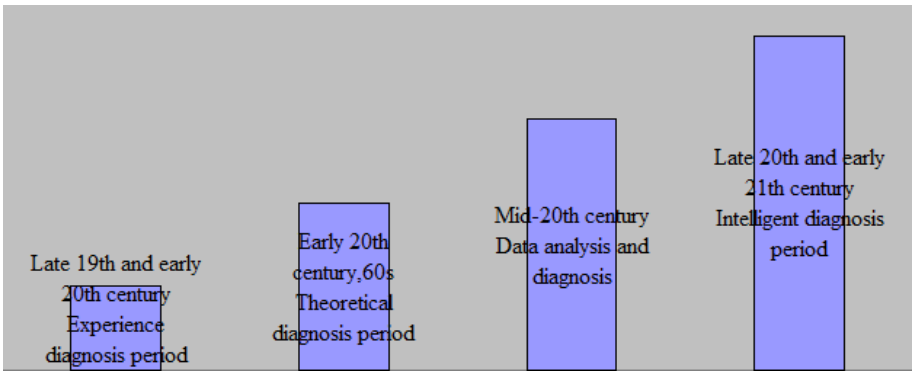

Fig.1 The overview of machine equipment diagnosis technology

Currently, the fault diagnosis of Bentley more famous American company, Westinghouse (WHEC), RID companies, BEI companies, the company is the UK's University of Manchester Wofu Sen industrial maintenance company (WIMU), machine health center; Switzerland ABB company [2].

Our research work in fault diagnosis technology focused on universities and research institutions, the results are: "a large mechanical computer turn state election monitoring and fault diagnosis system" in Xi'an Jiaotong University, the "unit vibration Harbin Institute of Technology's Computer monitoring and fault diagnosis system.”Northeastern University, diagnostic equipment engineering center after years of research, the successful development of the "rolling machine condition monitoring diagnostic system", "fan working condition monitoring and diagnosis system".

In short, over the past decade, fault diagnosis methods and technology at home and abroad focused on the following three aspects [3]:

①Policy and Mode of fault diagnosis; ②research methods and techniques and intelligent diagnosis; ③fault analysis and feature extraction feature quantity.

2.2 Machinery and equipment fault diagnosis technology trends

With the development of industry, all kinds of machinery and equipment systems become more complex, an increasing degree of integration systems, maintenance of difficulty is gradually increased. Therefore, the urgent need develop fault diagnosis way for real-time, intelligent, systematic, cost and other aspects. Although there are many theoretical approaches research in this field, but there are still a lot of us to the core theory technologies to be developed.

Machinery and equipment fault diagnosis technology is based on signal acquisition, data processing and pattern

recognition, its direction from the following aspects [3, 4, and 5]:

1) From the viewpoint of signal acquisition; the collection device signal gradually increased, so the information-gathering capabilities attendant has become increasingly difficult. At present mainly in the development of data fusion technology as a breakthrough, and has been well used in many fields; contemporary latest sensor technology;

2) From the viewpoint of data processing; intelligent fault diagnosis method should increase the scope of its application, and cross-application smart algorithm should develop, thus integrated to improve the accuracy and speed of the algorithm; using the latest signal processing method, nonlinear processing methods;

3) From the viewpoint of pattern recognition, using the latest intelligent algorithm or a combination of various intelligent algorithms such as fuzzy theory, neural networks, support vector machines;

4) Dynamic model equipment and the whole structure of the runtime and the collected information, there will be a lot of problems when applied to the circuit of these areas. For example, there are still many problems on large, complex devices expression operation of the device;

5) In the fault diagnosis device, fault diagnosis is very important, but diagnostic device design can not be ignored, especially for complex devices, diagnostic device design is reasonable or not directly affect the accuracy of the monitoring device durability and low cost. Traditional fault diagnosis system is relatively simple, it is not for people to pay attention, but with the great changes in equipment development, the traditional model is no longer suitable for the current development needs of the test device;

6) Playground Equipment intelligent fault diagnosis technology is still not well highlighted, intelligent use of space technology in fault diagnosis of mechanical equipment to run a large playground. In addition, the establishment of playground machinery fault diagnosis database is necessary. And this technique can be extended to once successful research application other mechanical equipment fault diagnosis.

III. MACHINERY AND EQUIPMENT FAULT DIAGNOSIS METHODS

After a review of recent literature, the results show, with the change of social development, a variety of mechanical equipment become more and more complex, intelligent and systematic. Thus, single fault diagnosis methods can not meet today's complex fault diagnosis work machinery and equipment systems. Mature, driving the mechanical fault diagnosis to use a variety of methods in the direction of integration of the various algorithms and theory. Currently all major mechanical malfunction diagnosis method fusion as follow:

Based on Singular Value Decomposition and SVM (support vector machine) Fault diagnosis; Luliang Liu et al [6] proposed a singular value decomposition and support vector machine fault diagnosis method based on the characteristics of this method is capable of running at the beginning of the device weak fault signal feature extraction accurate, machinery and equipment in order to achieve early failure prediction. The method is simple and effective, and easy to implement, does not require a lot of training samples can achieve accurate assessment models.

Fault diagnosis method stochastic resonance, principal component analysis and BP neural network; Ting Zhang et al. [7] developed based on stochastic resonance, fault diagnosis method of principal component analysis and BP neural network, the main features of the method of the principal component analysis of time-frequency characteristics of the signal processing, compared to the parameter estimation theory, short-time Fourier transform, adaptive filter, blind signal separation, transformation, synchronization, and chaos theory correlation detection time-frequency signal processing method is more accurate and reliable. These basic principles frequency signal processing method is to take measures to suppress or eliminate the noise, especially when the characteristic signal is weak, is likely to harm the useful signal even unable to complete the extraction of the signal. Furthermore, the method of solution using stochastic resonance characteristic fault diagnosis weak

signal problem, stochastic resonance noise signal energy can be converted into useful signal energy so weak useful signal is enhanced.

Weak signal fault diagnosis method Lorenz chaotic system; Shikai Xu et al [8] theoretical analysis and experimental results show that based on the weak signal detection method Lorenz chaotic systems to solve engineering problems in fast, sensitive features. In the case of being affected by background noise, still more accurate measured health threshold range, so that this method has better noise immunity, has good application value. However, compared to the analytical method, the method has significant limitations of any course in the main component.

Multiscale approximate entropy fault diagnosis method; Huaigang Zang et al [9] The multiscale entropy and approximate quotient combined use of different scales to extract approximate entropy as SVM input, in order to achieve different mechanical failure diagnosis. Approximate entropy (Approximate Entropy) is a method for measuring the complexity of time series, with a strong anti-interference ability, the advantages of data required for short, but can only measure the time sequence on a single scale of complexity, and multiscale entropy (multi_scale entropy, MSE) can be measured time series at different scales of complexity, therefore, the approximate entropy and multiscale entropy combined so that the method has nonlinearity, the ability to deal with non-stationary signals. However, the method for calculating complex, computationally intensive.

Failure analysis method based on vibration mechanism; Guangchang Zhao et al [10] combined with a signal characteristic of early bearing failure, failure analysis method is proposed based on a vibration mechanism. This method, although starting from the basic principles of the failure to overcome the mechanical characteristics of the device is not obvious early failure, weak signal to noise ratio is low, the fault is difficult to identify other issues, but the method was too theoretical, not easily combined with intelligent diagnosis method but also by means of the method as well as the traditional short-time Fourier wavelet theory of signal processing.

Based LCD (local feature scale decomposition) integrated fault blind source separation method; Yang Yu et al. [11] using LCD non-stationary signals, and has a good effect; the source signal LCD decomposition, get new multidimensional signal, reuse Bayesian information Criterion (BIC) and the estimated number of blind source multidimensional signal to restructure. Finally, joint approximate diagonalization, achieve signal source blind separation. The method was successfully applied to fault diagnosis gearbox. But blind separation could undermine the source signal. Theories about the method to be further optimized.

Machinery fault diagnosis method of genetic algorithms and spectral kurtosis is based; Kejun Xu et al. [12] based on quantum genetic algorithm converges faster, global optimization ability of the characteristics of the spectral kurtosis method and quantum genetic algorithm fusion is proposed a new method of fault diagnosis of rolling bearings. The method by spectral kurtosis initial band-pass filtered signal as the original quantum genetic algorithm fitness function, optimal design optimal filter, in order to design the optimal band-pass filter for filtering the original signal and envelope analysis in order to achieve bearing fault diagnosis. Although the diagnosis is good, but the method using the method of genetic algorithm, genetic algorithm process to go through complex encoding, decoding, genetic, crossover and mutation.

Mechanical Fault Diagnosis multicore non-negative matrix factorization based; Yongsheng Yang et al [13] proposed a multi-core non-negative matrix factorization method which overcomes the traditional fault diagnosis method requires the original signal feature extraction data signal loss caused by defects. Through the application of multi-core non-negative matrix factorization method to reduce the dimension, and then combined with multicore support vector machine to achieve data dimensionality reduction directly after identification. This method is also inseparable from the support to be intelligent identification.

BP neural network based method for improving mechanical fault diagnosis; Fang Min et al [14]

studied the fuzzy theory and neural networks typical of mechanical parts for fault diagnosis. Yinliang Ba et al [15] LM (gradient algorithm) optimization algorithm for automotive diesel engines use to troubleshoot combined with BP neural network, and achieved certain results. The use of artificial neural network to classify failure, requires a lot of samples for learning and training model, but the actual fault diagnosis problems unable to provide a large number of fault samples.

Based on the chaotic attractor feature amounts mechanical fault diagnosis method; Xiaohui Gu et al [16] used the chaotic attractor can portray fault vibration characteristics under different conditions of mechanical equipment, is proposed based on correlation dimension, largest Lyapunov exponent and entropy the fault diagnosis. The diagnostic method to distinguish between the different types of severity of the problem and fault, and therefore, this method has a good prospect. The method is still to combine neural networks or support vector machines and other methods.

Based on SVM (support vector machine) fault diagnosis method;Wang Bo et al. [17] describes the development and application of the results related prospects vector machine, fault diagnosis of mechanical equipment SVM support vector by studies comparing relevant opportunities, reflecting the relevance vector machine diagnostics superiority. However, the method applied in the field of mechanical fault diagnosis is still in its infancy, needs more practice and perfection.

Local mean decomposition method based on rational Hermite interpolation; Haiyang Zhao [18] for the most serious fault signal non-stationarity proposed local mean decomposition rational Hermite interpolation method. Combined with rational Hermite interpolation, contained the characteristic of conformal curve shape and adjustable parameters. And construct between the extreme points of its partial envelope curves. Proposed partial envelope preferred method based on extreme value point of symmetry, and thus improve the local mean and envelope estimate fitting approximation accuracy. This method requires a strong theoretical foundation interpolation.

IV. MECHANICAL EQUIPMENT FAULT DIAGNOSIS INTELLIGENT RECOGNITION

4.1 SVM Intelligent Recognition

SVM is made by the Vapnik in 1995[20] proposed classification algorithm based on nonlinear statistical learning theory, nonlinear transformation by converting the input space to a high-dimensional space, and then find the optimal classification surface in this new space, namely the maximum interval surface, this non-linear transformation is achieved by defining appropriate inner product kernel implementation. Since the SVM has the advantage of dealing with small sample size problem superiority and good generalization ability, to overcome the ANN (artificial neural networks) are difficult to overcome the shortcomings, it has been widespread concern of researchers in different fields, resulting in more theoretical and applied research.

Although SVM are many advantages, there are also some disadvantages [17]: ①though far less than needed to support vector training samples, but with the training set increases linearly increased, resulting in over-fitting and increase the computational time ; ②Mercer kernel function must satisfy the condition that the kernel function must be symmetric positive definite continuous function; ③not get the formula to predict the probability of not obtaining the predicted uncertainty; ④compromise needs to be estimated coefficients C (estimated time required return insensitive parameter ε), commonly used cross-validation method to determine the value of the parameter, not only increase the time computing, computational complexity also increases with training and increase the number of samples.

4.2 RVM Intelligent Recognition

In order to solve the inherent flaws of SVM, therefore, a number of new machine learning algorithms have been proposed, in which the Tipping [21,22] proposed a new machine learning algorithms based on Bayesian statistical theory: relevance vector machine (Relevance Vector Machine , RVM), some researchers call "relevance vector machine." RVM with respect to SVM has the following advantages: ①can be obtained posterior probability distribution of the predicted value; ②its decision-making function more sparse than the SVM, that is related to the ratio of support to be able to get the situation under less the same level with SVM classification accuracy; ③Mercer kernel function does not need to meet the conditions, you can construct more nuclear function based on research experience. Although the RVM have these advantages, but it also has some disadvantages [17]: ①sample training for a long time; ②need to meet Mercer kernel function, although the conditions, but in the selection of kernel functions still rely on experience; ③RVM on multiple classification Troubleshooting Problems Advantage is better SVM; ④compromise on how to determine coefficient lack of theoretical guidance. Therefore, we can use the RVM and SVM integration, while introducing Newton algorithm kernel configuration.

V. CONCLUSION

Theoretical basis of the existing artificial neural networks, pattern recognition, expert systems and other machine learning methods requires a lot of statistical sample data, thus theoretically mature machine learning methods are not suitable for all troubleshooting. For a case study of a small sample of the data, and is not suitable for application of the method. However, given the precise and sophisticated features of these machine learning methods, based on the accuracy requirements of this article, which can be fully utilized. Such as genetic algorithms, particle swarm algorithm, immune algorithm although theoretically very mature, but these only complicated arithmetic operations, the practical application of engineering inevitable short board. Throughout the history of the development of artificial intelligence and pattern recognition, there were many intelligent algorithms. However, no single intelligent algorithm is perfect, various algorithms in a certain area or a certain angle have its own unique advantages, and there are also their disadvantages. Therefore, in this research and more focus on the combination use of various theoretical approaches to achieve weaknesses, only the best of the situation.

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