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# 学位論文要旨

専攻名　共生環境学

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題　目　Study on Smart Condition Diagnosis Based on Feature Extraction and Pattern Recognition for Plant Machinery（特徴抽出とパターン認識によるプラント設備のスマート状態診断法に関する研究）

Recent decades, rapid technological progresses carried out in industrial and agricultural area. Machinery and manufacturing process became automatic, integrated, precise, and effective. Unplanned stops or defects of equipment or components will lead to unfavorable impact in the availability of systems, the safety of operators, the efficiency of the production, and the environment. The need of condition monitoring and fault detection of rotation machinery is critical and extensive. If problems of plant machinery can be diagnosed at an early stage, equipment and components can be better protected from the danger of breaking.

The procedures of fault diagnosis can be roughly divided into the feature extraction step and the pattern recognition step. Effective feature extraction analysis can acquire useful information from large amounts of raw data and facilitate fault diagnosis. Pattern recognition is the key point for the realization of modern fault diagnosis which is more automatic and adaptive. This thesis focuses on the smart condition diagnosis based on feature extraction and pattern recognition for plant machinery as follows:

(1) Feature extraction includes canceling noise and calculating symptom parameter. Operating conditions of different machinery are vary widely, wherefore the fault detection for plant machinery is complicated. When energy generated during operation is weak, the component defect signals and the related fault symptoms can easily be buried under machine operation noise and go undetected. Effective methods for feature extraction must be used for processing the raw data.

a) In this thesis, an adaptive filter method called statistic filter (SF), and a novel application of wavelet package transform (WPT) for feature extraction in fault diagnosis are introduced. Initial SF method is a signal extraction method composed by genetic algorithm (GA) and statistical tests in the frequency domain for the fault diagnosis. Because of the processing time cost, a speed algorithm of SF is proposed by introducing selecting discrimination index (SDI) in

this thesis.

b) After noise-cancelling, symptom parameters (SPs) will be calculated to reveal the feature of signals. Dimensional symptom parameters (DSPs) and non-dimensional symptom parameters (NSPs) are represented in this thesis. DSPs can express the magnitude of signals, NSPs can reflect the shape of signals. However, other special symptom parameters (SSPs) must be introduced to detect the specific type of failure with an appropriate accuracy. This thesis proposed SSPs for roller bearing and structure fault of rotating machinery. Moreover, the methods to obtain integrated symptom parameters (ISPs) with well performance are proposed and explained.

(2) Recent progress in computational intelligence, sensor technology and computing performance permit the use of pattern recognition technique to achieve objective. This thesis presents pattern recognition methods for fault type identification in plant machinery fault diagnosis. Since lots of classification methods are based on distance, this thesis introduced the briefly theory of Euclidean Distance and Mahalanobis Distance. In addition, the developing and application of new research methods, including decision tree, principal component analysis, ant colony optimization, and canonical discriminant analysis for pattern recognition in fault diagnosis are also be discussed.

(3) In order to verify the effectiveness of the proposed smart condition diagnosis methods, verification experiments are conducted on different objects, which are widely used in industrial production. The experimental results of fault diagnosis for a centrifugal pump system, gears in turbine machine, centrifugal blower, and roller bearings in low speed rotating machinery are represented and discussed in the thesis after explanation of the theory.