PERGAMON

Available online at www.sciencedirect.com

SCIENCE DIRECT®

Engineering Applications of Artificial Intelligence 16 (2003) 39–43

Engineering Applications of ARTIFICIAL INTELLIGENCE

www.elsevier.com/locate/engappai

Fault diagnosis based on Rough Set Theory

Francis E.H. Tay[a,*], Lixiang Shen[b]

[a] Department of Mechanical Engineering, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260, Singapore
[b] Design Technology Institute Ltd, Faculty of Engineering, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260, Singapore

Received in revised form 10 February 2003; accepted 12 February 2003

Abstract

In contingency management of a complex system, identification of error condition or faults diagnosis is a very important stage. It determines the methods and techniques to be applied in the following stages of contingency management. In this paper, Rough Set Theory as a new fault-diagnosing tool is used to identify the valve fault for a multi-cylinder diesel engine. This method overcomes the shortcoming of conventional methods where each method of fault diagnosis on diesel engine can only provide one corresponding fault category. By the analysis of the final reducts generated using Rough Set Theory, it is shown that this new method is effective for valve fault diagnosis and it is a new powerful tool that can be applied in contingency management.
© 2003 Elsevier Science Ltd. All rights reserved.

Keywords: Contingency management; Fault diagnosis; Rough Set Theory

1. Introduction

The frequent occurrence of faults in manufacturing system and machinery drives up the cost of production, adversely affects part quality, reduces the production rate, and limits the flexibility of the system. A reduction in the frequency of fault occurrence can be achieved through investment in better quality machines, operators, controllers, and so on. Reducing cycle time can also help to reduce some types of failure rates (mainly those affected by machine wear). As the flexibility of a manufacturing system increases, so does the number of possible failures. Consequently, it is increasingly important to understand how faults occur in a given manufacturing system so as to determine, in a timely fashion, their location; and to manage their consequences with flexibility so as to maximize the quality of parts produced, stabilize the production rate, and minimize the ensuing costs (Tay, 1999).

With regard to contingency management, a majority of error recovery schemes concern the provision for automatic error recovery of robot-based system and man–machine systems. The formulation of the strategy to be adopted by the contingency management system necessitates the identification of the different types of error states that are either precursors to failure or are indicators of a failure. Such approaches tend to result in a large number of sensors to be installed.

The contingency management is usually embodied in a knowledge base consisting of rules that dictate the necessary recovery procedures to adopt when an error state has been detected and identified by the system (Gini and Gini, 1983; Lee et al., 1983). For example, Gini and Gini (1983) presented a knowledge base of expected sensor states and error recovery procedures expressed in the same syntax as the programming language of the robot. Lee et al. (1983) employed a forward recovery approach amounting to a kind of corrective feedback to transform the error rate into one of the error-free states further downstream.

Usually, a contingency management system consists of four stages (Wong et al., 1992). They are:

Stage 1. Conception of an overall strategy.

Stage 2. Identification of error conditions or faults.

Stage 3. Implementation of the contingency management system.

Stage 4. Verification of the contingency management system.

In these four stages, identification of error conditions or faults (stage 2) is an important stage because it will determine the methods and techniques to be implemented in the following stages.

*Corresponding author. Tel.: +65-68746818; fax: +65-67791459.
E-mail address: mpetayeh@nus.edu.sg (F.E.H. Tay).

0952-1976/03/$ - see front matter © 2003 Elsevier Science Ltd. All rights reserved.
doi:10.1016/S0952-1976(03)00022-8

Fault diagnosis on machinery is one of the applications in stage 2. This problem has been well researched in Qu and Meng (1995). Many effective methods were used to diagnose accurately and quickly a certain category of faults (Qu and He, 1981). For instance, large-scale centrifugal compressor can be diagnosed by holospectrum technique (Qu and Shen, 1993). However, up to now, traditional methods are difficult to diagnose more than one category of faults. This is especially so in diagnosing the dynamic characteristics of reciprocating machinery, such as reciprocating compressor and diesel engine. This is due to the complex structure of the reciprocating machinery. Although many traditional methods can be used to determine specific fault category, such as broken valve and cracked crankshaft (Taylor, 1980; Huang, 1995), the results obtained from such fault-specific method are not easy to interpret. There is a need to have a method that can diagnose more than one category of faults in a generic manner. In this paper, a method based on Rough Set Theory is proposed and implemented.

Pawlak first proposed Rough Set Theory in 1982 (Pawlak, 1982). This theory has been developed and used in many domains, such as medical diagnosis (Tsumoto and Tanaka, 1996), stock market forecast (Ziarko et al., 1993), fault diagnosis in engineering domain (Nowicki et al., 1992), decision making for bank manager (Slowinski and Zopounidis, 1995) and some other uses in Slowinski (1992).

In this paper, the Rough Set Theory (Pawlak et al., 1995) is applied to diagnose the fault types simulated in a 4135 diesel engine. The remainder of this paper is organized as follows. In Section 2, the characteristics of vibration signal of diesel engine will be analyzed. The features, used to compose the decision table, are introduced. All these features are extracted from vibration signal. Discretization of the continuous decision table for Rough Set Theory processing is discussed in Section 3. The diagnosis results using Rough Set Theory are discussed in Section 4 and at the end of this paper, conclusions based on the aforementioned analysis are given.

2. Data preparation

2.1. *The characteristics of vibration signals for a 4153 diesel engine*

Due to the complex structure and multi-excite sources that exist in diesel engine, the vibration signals collated from the engine surface have the following characteristics (Tan, 1995):

- Presence of a number of self-exciting vibration and forced vibration in the diesel engine that is running. Therefore the width of spectrum in frequency domain is very large.
- The vibration signals in the time domain are more complex compared to a large-scale rotational machinery, which is a pure sine curve.
- In a diesel engine, such as 4135 engine, the stroke cycles are fixed. Therefore the time series appear periodical. However in every period, there exist many other periodical vibrations within the stroke cycle.

Figs. 1 and 2 illustrate some vibration signals collected from a 4135 engine surface. The upper portion represents the time series and the bottom portion represents the corresponding fast fourier transformation (FFT) spectrum.

Four states are studied in our research. They are:

- Normal state
- Intake valve clearance is too small

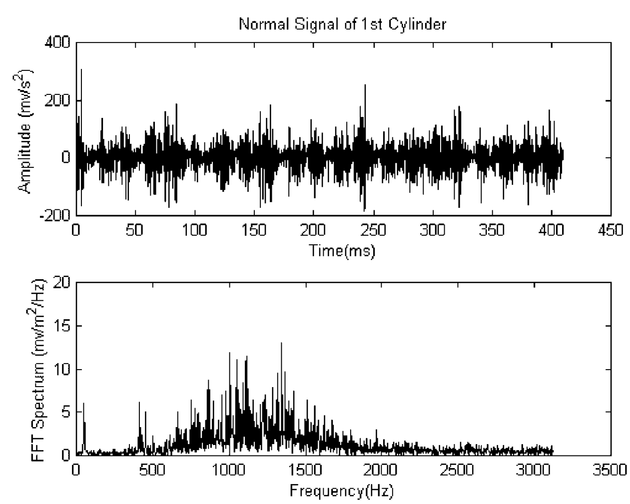

Fig. 1. Normal state (sample point 1).

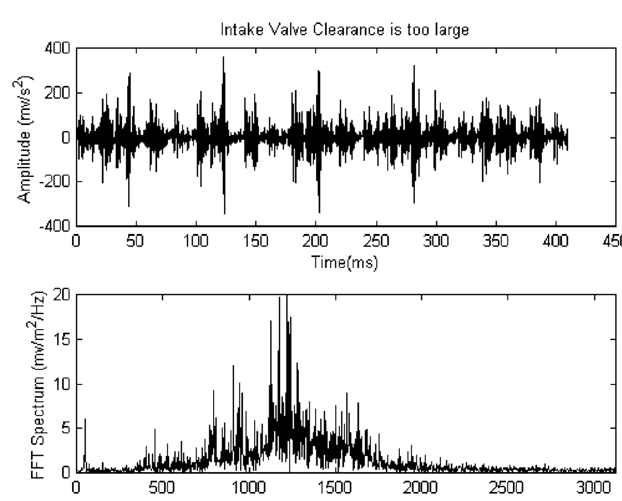

Fig. 2. Intake valve clearance is too large (sample point 1).

دریافت فوری ← متن کامل مقاله

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات