Mechanical Systems and Signal Processing 25 (2011) 2102–2124

Contents lists available at ScienceDirect

Mechanical Systems and Signal Processing

journal homepage: www.elsevier.com/locate/jnlabr/ymssp

Detection and diagnosis of bearing and cutting tool faults using hidden Markov models

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ARTICLE INFO

Article history:
Received 6 February 2010
Received in revised form
6 January 2011
Accepted 18 January 2011
Available online 2 February 2011

Keywords:
Fault detection
Fault diagnosis
Bearings and cutting tools
Hidden Markov model
Viterbi algorithm
Baum–Welch method

ABSTRACT

Over the last few decades, the research for new fault detection and diagnosis techniques in machining processes and rotating machinery has attracted increasing interest worldwide. This development was mainly stimulated by the rapid advance in industrial technologies and the increase in complexity of machining and machinery systems. In this study, the discrete hidden Markov model (HMM) is applied to detect and diagnose mechanical faults. The technique is tested and validated successfully using two scenarios: tool wear/fracture and bearing faults. In the first case the model correctly detected the state of the tool (i.e., sharp, worn, or broken) whereas in the second application, the model classified the severity of the fault seeded in two different engine bearings. The success rate obtained in our tests for fault severity classification was above 95%. In addition to the fault severity, a location index was developed to determine the fault location. This index has been applied to determine the location (inner race, ball, or outer race) of a bearing fault with an average success rate of 96%. The training time required to develop the HMMs was less than 5 s in both the monitoring cases.

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1. Introduction

Condition monitoring is important for increasing machinery availability, improving manufacturing process productivity and reliability, and reducing maintenance costs. An efficient condition monitoring scheme is capable of providing warnings and predicting faults at early stages. There are many condition monitoring systems installed in different types of engineering plants [1,2]. Monitoring systems obtain raw data from the concerned machines and provide vital diagnostic information to equipment operator. As processes and machinery become more and more complex, fault detection and diagnosis emerge as the main task of a monitoring system. This is due to the growing demand for more reliable operations, which can be achieved not only by improving the reliabilities of the individual functional units but also by effective fault detection and diagnosis [3,4]. A desirable monitoring system should be able to detect the condition of the machine (normal or abnormal), identify fault severity, and make maintenance recommendations.

With complex machinery and processes, the need to automate the fault detection and diagnosis becomes increasingly more valuable, as maintenance decisions need to be taken quickly. The automation of fault diagnosis was often

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doi:10.1016/j.ymssp.2011.01.013