A dynamic multi-scale Markov model based methodology for remaining life prediction

Jihong Yan *, Chaozhong Guo, Xing Wang

Department of Industrial Engineering, Center for Advanced Production Technology, Harbin Institute of Technology, Harbin Institute of Technology, Mailbox 204, Harbin, China

ABSTRACT

The ability to accurately predict the remaining life of partially degraded components is crucial in prognostics. In this paper, a performance degradation index is designed using multi-feature fusion techniques to represent deterioration severities of facilities. Based on this indicator, an improved Markov model is proposed for remaining life prediction. Fuzzy C-Means (FCM) algorithm is employed to perform state division for Markov model in order to avoid the uncertainty of state division caused by the hard division approach. Considering the influence of both historical and real time data, a dynamic prediction method is introduced into Markov model by a weighted coefficient. Multi-scale theory is employed to solve the state division problem of multi-sample prediction. Consequently, a dynamic multi-scale Markov model is constructed. An experiment is designed based on a Bently-RK4 rotor testbed to validate the dynamic multi-scale Markov model, experimental results illustrate the effectiveness of the methodology.

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1. Introduction

Equipment degradation and unexpected failures impact the three key elements of competitiveness—quality, cost and productivity [1]. Maintenance has been introduced to help to reduce downtime and rework and to increase consistency and an overall business efficiency. However, traditional maintenance costs constitute a large portion of the operating and overhead expenses in many industries [2]. More efficient maintenance strategies such as condition based maintenance (CBM) are being implemented to handle the situation. It says CBM can reduce the maintenance costs by 25% approximately [3]. In order to achieve this efficient maintenance strategy, prognostics is employed which is built upon diagnostic and is the process of estimating remaining useful life (RUL) of a machine by predicting the progression of a diagnosed anomaly. Since, generally, machines go through degradation before failure occurs, monitoring the trend of machine degradation and assessing performance allow the degraded behavior or faults to be corrected before they cause failure and machine breakdowns. Therefore, advanced prognostics focuses on performance degradation monitoring and assessment, so that the failures can be predicted and prevented [4].

In order to implement prognostics, three main steps are needed. (1) Feature extraction and selection: feature exaction is the process of transforming the raw input data acquired from mounted or build-in sensors into a concise representation that contains the relevant information of health condition. Feature selection is to select typical features which reflect an overall degradation trend from the extracted features. (2) Performance assessment: how to effectively evaluate the performance based on the selected features is crucial to prognostics. A good performance assessment method ought to be capable of fusing

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* Corresponding author. Tel./fax: +86 451 86402972.
  E-mail address: jyan@hit.edu.cn (J. Yan).