Accepted Manuscript

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PII: S0263-2241(17)30800-X
DOI: https://doi.org/10.1016/j.measurement.2017.12.029
Reference: MEASUR 5160

To appear in: *Measurement*

Received Date: 10 July 2017
Revised Date: 6 September 2017
Accepted Date: 19 December 2017

Please cite this article as: Y. Song, S. Zeng, J. Ma, J. Guo, A Fault Diagnosis Method for Roller Bearing Based on Empirical Wavelet Transform Decomposition with Adaptive Empirical Mode Segmentation, *Measurement* (2017), doi: https://doi.org/10.1016/j.measurement.2017.12.029

A Fault Diagnosis Method for Roller Bearing Based on Empirical Wavelet Transform Decomposition with Adaptive Empirical Mode Segmentation

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ABSTRACT

This paper proposes a fault diagnosis method for roller bearings based on the decomposition of vibration signals using the empirical wavelet transform (EWT) with adaptive empirical mode segmentation and the merging of redundant empirical modes. The proposed method employs scale-space histogram segmentation to determine the boundaries of the empirical modes adaptively, which helps to eliminate the effect of noise and obtain meaningful empirical modes that are more reflective of fault characteristics. In addition, the method merges similar empirical modes to rectify the tendency of conventional EWT to overly decompose empirical modes for fault feature extraction. To this end, an effective merging algorithm based on Pearson's correlation coefficient is developed to divide the empirical modes into groups according to their similarity prior to merging, which avoids a large increase in the amplitude of the signal after merging, and ensures the accuracy of the final result. The performance of the proposed method is first tested using an analytically derived signal. Then, the method is tested using actual vibration signals of roller bearings collected by NASA. The results demonstrate that the proposed method can identify fault information effectively and accurately.

Keywords: Fault diagnosis, Empirical wavelet transform, Scale-space histogram segmentation, roller bearing.

1. INTRODUCTION

Rotating machinery is a common and widely used component in mechanical systems. Rotating machines often operate in severe environments, and are subject to failure, which critically affects the reliability of the overall mechanical system. It is therefore necessary to monitor the state of rotating machinery in real time, and to diagnose possible faults. As a result, the diagnosis and analysis of rotating machinery faults has attracted considerable interest in recent years.

The most commonly employed method of fault diagnosis involves adapting signal processing techniques to the vibration signals of rotating machinery to extract fault features [1]. Because most vibration signals obtained from rotating machinery are nonlinear and non-stationary, time-frequency analyses are the most suitable signal processing techniques employed to this end. Among these techniques, empirical mode decomposition (EMD) proposed by Huang et al. in 1998 [2] has been widely employed for the fault diagnosis of rotating machinery. EMD is a self-adaptive signal processing technique that can decompose any complicated data set into a finite and typically small number of intrinsic mode functions (IMFs), which are well-suited to analysis via the Hilbert transform. The IMFs represent the inherent oscillatory modes of the vibration signal, and are determined only by the signal itself. The instantaneous frequency of each mode in a complicated data set has a physical significance.