An intelligent fault diagnosis model for rotating machinery based on multi-scale higher order singular spectrum analysis and GA-VPMCD

Songrong Luo, Junsheng Cheng, Ming Zeng, Yu Yang

PII: S0263-2241(16)00007-5
DOI: http://dx.doi.org/10.1016/j.measurement.2016.01.006
Reference: MEASUR 3742

To appear in: *Measurement*

Received Date: 16 December 2014
Revised Date: 30 December 2015
Accepted Date: 4 January 2016

Please cite this article as: S. Luo, J. Cheng, M. Zeng, Y. Yang, An intelligent fault diagnosis model for rotating machinery based on multi-scale higher order singular spectrum analysis and GA-VPMCD, *Measurement* (2016), doi: http://dx.doi.org/10.1016/j.measurement.2016.01.006

An intelligent fault diagnosis model for rotating machinery based on multi-scale higher order singular spectrum analysis and GA-VPMCD

Songrong Luo [a,b], Junsheng Cheng[a*], Ming Zeng [a], Yu Yang [a]

([a] College of Mechanical and Vehicle Engineering, Hunan University, Changsha 410082, China
[b] College of Mechanical Engineering, Hunan University of Arts and Science, Changde 415000, China)

Abstract

Feature extraction and class discrimination are two key problems for fault diagnosis of rotating machinery. Firstly, multi-scale higher order singular spectrum analysis（MS-HO-SSA） method is presented and the multi-scale higher order singular spectrum entropy (MSHOSSE) is defined as feature to reveal the non-Gaussian and nonlinear characteristic for the vibration signals from rotating machinery with local faults. Secondly, GA-VPMCD method is presented by combination genetic algorithm (GA) with conventional variable predictive model based class discriminate (VPMCD) approach. Lastly, an intelligent fault diagnosis model based on MS-HO-SSA and GA-VPMCD is put forward and utilized for rotor fault diagnosis. The experimental results show that MS-HO-SSA method is more effective for feature extraction and the GA-VPMCD provides better performance than conventional VPMCD and LSSVM.

Keywords: Multi-scale higher order singular spectrum analysis; Variable predictive model based class discriminate; Genetic algorithm; Rotating machinery; Fault diagnosis

1. Introduction

Vibration signals from rotating machinery with local faults are generally non-Gaussian and nonlinear time series, these signals show quadratic phase coupling[1, 2], containing much Gaussian noise too. Singular spectrum analysis (SSA) is an effective method to analysis nonlinear time series[3, 4] and has been widely used in fault diagnosis for rotating machinery [5-7]. However, SSA is the covariance matrix method based on the second order stationary hypothesis and only reflects the linear correlation of time series. Therefore, it is a linear analysis method in nature. It is difficult to describe the inherent nonlinear relation of time series using SSA. Furthermore, the analysis results of SSA can be greatly affected by reconstruction delay, embedding dimension and noise. Contrary to SSA，higher order statistics analysis (HO-SA) not only has a strong ability to restrain Gaussian noise[8], but also can reflect phase coupling feature of nonlinear time series[9-12]. HO-SA is good tool for non-Gaussian time series analysis. Combining SSA with HO-SA, higher order singular spectrum analysis (HO-SSA) is proposed as a new method for feature extraction in this paper. The simulation analysis results from Hénon map and Lorenz model show that HO-SSA is robust for embedding dimension and gives a higher tolerant to noise than SSA.

Recently, since multi-scale analysis method[12] can extract more time mode information, it has

* Corresponding author at: College of Mechanical and Vehicle Engineering, Hunan University, Changsha 410082, PR China. Tel.: +86 731 88664008.
E-mail address: signalp@tom.com