



Review

A review of stochastic resonance in rotating machine fault detection

Siliang Lu^{a,#}, Qingbo He^{b,*,#}, Jun Wang^c^a National Engineering Laboratory of Energy-Saving Motor & Control Technology, College of Electrical Engineering and Automation, Anhui University, Hefei, Anhui 230601, PR China^b State Key Laboratory of Mechanical System and Vibration, Shanghai Jiao Tong University, Shanghai 200240, PR China^c School of Rail Transportation, Soochow University, Suzhou, Jiangsu 215137, PR China

ARTICLE INFO

Article history:

Received 6 November 2017

Received in revised form 15 May 2018

Accepted 18 June 2018

Keywords:

Rotating machine fault detection

Stochastic resonance

Weak signal detection

Digital signal processing

Nonlinear filtering

ABSTRACT

Condition-based monitoring and machine fault detection play important roles in industry as they can ensure safety and reduce breakdown loss. Weak signal detection is an essential stage in many signal processing-based machine fault detection methods because the acquired machine signals are always corrupted by heavy background noise. Stochastic resonance (SR) is a nonlinear phenomenon in which the weak signal can be enhanced with the assistance of proper noise. Due to this distinct merit, SR has been extensively investigated in rotating machine fault detection. Given this, the present study is committed to providing a comprehensive review of SR from history to state-of-the-art methods and finally to research prospects, along with the applications in rotating machine fault detection. First, the classical SR theory including the history, merits and limitations is introduced and discussed, and the basic research progress of SR is reviewed. Second, the modified SR methods designed for processing the rotating machine signals are reviewed and summarized. Third, applications of SR for analyzing different kinds of rotating machine fault signals are introduced. Finally, the open problems, challenges and research prospects of SR in rotating machine fault detection are discussed.

© 2018 Elsevier Ltd. All rights reserved.

Contents

1. Introduction	231
2. Classical SR	232
2.1. SR model	232
2.2. Evaluation criterion	233
2.3. Limitations of classical SR	235
2.4. Research progress of SR theories and applications	235
3. Modified SR for machine signal processing	237
3.1. System parameters tuning	238
3.1.1. Principle	238
3.1.2. Methods review	238

* Corresponding author.

E-mail address: qbhe@sjtu.edu.cn (Q. He).

These authors contributed equally to this work.

<https://doi.org/10.1016/j.ymssp.2018.06.032>

0888-3270/© 2018 Elsevier Ltd. All rights reserved.

3.1.3.	Application example.	238
3.1.4.	Remarks.	239
3.2.	Input signal adjustment	239
3.2.1.	Principle	239
3.2.2.	Methods review	240
3.2.3.	Application example.	240
3.2.4.	Remarks.	241
3.3.	SR potential modification	241
3.3.1.	Principle	241
3.3.2.	Methods review	241
3.3.3.	Application example.	242
3.3.4.	Remarks.	242
3.4.	SR model extension.	243
3.4.1.	Principle	243
3.4.2.	Methods review	243
3.4.3.	Application example.	243
3.4.4.	Remarks.	244
3.5.	SR theory: from simple sinusoidal signal to complex multi-component signal	244
3.6.	Summary of the modified SR methods	244
4.	SR application in rotating machine fault detection: case review with a bibliography.	244
4.1.	Bearing fault detection using SR.	245
4.1.1.	Bearing signal detection in frequency-domain	245
4.1.2.	Bearing signal detection in time-domain	247
4.1.3.	Adaptive bearing signal detection	248
4.1.4.	A comparison of SR and other WSD methods in fault detection.	249
4.2.	Gearbox fault detection using SR.	250
4.3.	Fault detection of other rotating machines using SR	250
4.4.	Bibliography.	251
5.	Discussions and research prospects	252
5.1.	Realization of SR by adding noise and/or by tuning parameters	252
5.2.	SR mechanism in engineering signal processing.	252
5.3.	Multi-components signal enhancement using SR	253
5.4.	Aperiodic signal enhancement using SR	253
5.5.	Adaptive signal enhancement using SR	253
5.6.	Amplitude correction of the SR output signal.	253
5.7.	Why and how to choose SR?	254
6.	Concluding remarks	255
	Acknowledgments	256
	References	256

1. Introduction

Rotating machine condition monitoring and fault detection are essential to guarantee machine's safe operation, to reduce unscheduled maintenance, and to avoid catastrophic malfunction [1–5]. Generally, signal processing-based machine fault detection can be realized by three successive steps: signal acquisition, feature extraction, and fault identification. In the first step, vibration signal [6–11], sound signal [12,13], acoustic emission signal [14–16], and motor current signal [17,18] are acquired from sensors that are attached to or placed near to the running machines. Then, the features that can reflect machine condition are extracted using time-domain analysis [19], frequency-domain analysis [20], or time-frequency analysis [21,22] techniques. Finally, the extracted features are evaluated, compared, and fused to generate a comprehensive conclusion for fault detection.

In practice, the signal acquired from a running machine is always subjected to noise interference that comes from environment, acquisition circuit and signal transmission channel, which significantly decreases signal-to-noise ratio (SNR), affects the quality of features and further decreases the accuracy of fault detection. Thus, weak signal detection (WSD) technique is always applied on the raw acquired signal to filter out unrelated noise and to enhance the weak useful signal.

Plenty of WSD techniques have been investigated and applied in rotating machine fault detection, and some of them are briefly reviewed as follows. The first kind is the digital filters through which the out-band noise components are suppressed or eliminated while the in-band useful frequency components are retained. The typical filters include the finite impulse response (FIR) filter in which the output is the linear weighted summation of several inputs, and the infinite impulse response (IIR) filter in which the output is the linear weighted summation of several previous outputs and several inputs. Many methods have been proposed to design the optimal filters to wipe out the noise and retain the fault information in the machine signal, such as the spectral kurtosis [23] and the infogram [24].

Download English Version:

<https://daneshyari.com/en/article/6953387>

Download Persian Version:

<https://daneshyari.com/article/6953387>

[Daneshyari.com](https://daneshyari.com)