Identification of rotational speed using stochastic resonance

Goal

In this master thesis project at Viking Analytics AB, you will investigate alternatives to identify the rotational speed of a rotating machine component (rolling element bearing) using vibration signals. In particular, you will explore the suitability of stochastic resonance as mechanism to boost low-energy content signals in conjunction of a signal decomposition method.

Background

Rotating machinery use rolling element bearings to facilitate the rotational motion. Bearing failures are a common cause of machine faults. Typical machine diagnostics is carried out using vibration analysis. However, fault identification requires knowledge of the rotational speed of the rotating machine component. The rotational speed acts as a weak modulating signal component, which affects the overall vibration signal of the machine element. Figure 1 below shows an example of a spectral diagram of a vibration signal. The main BPFI (Ball-Pass Frequency Inner-ring) peak is a fundamental bearing defect frequency and its location on the frequency spectra is a product of the bearing geometry and the rotational speed. Meanwhile, the sideband frequency distance is entirely dependent on the rotational speed (RPM). However, when there is no defect present, the major peak is not observable, and the rotational speed signal component is buried within the noise of the vibration signal.

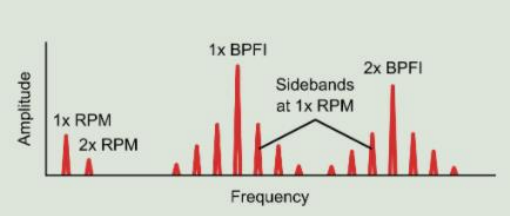

Figure 1. Example of signal modulation where rotational speed (RPM) is appreciated as sideband distance.

The aim of this project is to investigate the possibility to detect the rotational speed of a rolling machine component. One of the elements of this detection framework is to use stochastic resonance[1] as a method to extract the weak vibration component. However, given that vibration signals usually contain strong noise interference, we will explore diverse signal decomposition methods to eliminate the interference occasioned by coupled signals. This project intends to enable an alternative for fault detection of rotating machines where external data shall not be incorporated.

Deliverables

- Literature study on signal decomposition methods.
- Software implementation and code of identification framework.
- Procedure description of implementation (comments) and use (user guide).
- Comparative study of stochastic resonance among decomposition methods.

Requirements

- Background in Engineering Physics and Electrical Engineering.
- Knowledge of Python is necessary.
- General interest in mathematics, scientific computation, machine learning or AI is beneficial.
- Participation in writing of a scientific paper summarizing the results of the project is encouraged.

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[1] http://www.scholarpedia.org/article/Stochastic_resonance