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Multiwavelet denoising with improved neighboring coefficients for application on rolling bearing fault diagnosis

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ABSTRACT

The characteristic signal of a rolling bearing with a defect acts as a series of periodic impulses. These features are usually immersed in heavy noise and then difficult to extract. It is feasible to make the features distinct through wavelet denoising. Scalar wavelet thresholding has been used to extract features. However, scalar wavelet might not extract the feature available due to its limitation in some important properties, and conventional term-by-term thresholding does not consider the effect of neighboring coefficients. Since multiwavelets have been formulated recently and they might offer good properties in signal processing, a novel denoising method — multiwavelet denoising with improved neighboring coefficients (neighboring coefficients dependent on level, DLNeighCoeff for short) — is proposed in this article. The method proposed is applied to a simulated signal and fault diagnosis of locomotive rolling bearings, obtaining performance superior to conventional methods.

1. Introduction

Safety, reliability and efficiency of a mechanical system are important for industry. Rolling bearings are used in various rotating machinery as the major parts. Failure detection of rolling bearing has therefore received considerable attentions. Vibration-based analysis has been the most popular approach to the detection of the localized bearing defect. The vibration of the normal bearing is usually generated by low frequency components caused by shaft-rotation, load fluctuation, etc. When a defect is induced, periodic impulses will be generated due to the pass of the rolling elements over the defect. The frequency of the impulse is the 'characteristic frequency' [1]. However, this frequency is often immersed in heavy noise. Thus, extracting the characteristic frequency is the main task for the diagnosis of the defect. There are many approaches that are adopted to analyze the signal of the bearing with defects, such as envelope analysis method [2], empirical mode decomposition [3], singular value decomposition [4], spectral kurtosis [5–7] and denoising with thresholding [8].

Frequency spectrum and envelope analysis are useful tools to detect periodic features. They encounter difficulties in detecting transient features. Furthermore, they are usually integrated with other methods to diagnose the faults. Empirical mode decomposition (EMD) is a self-adaptive signal processing method that can be applied to non-linear and non-stationary processes perfectly. One of the most important characters of EMD is that the IMFs are calculated using the cubic spline function. Then it is effective to extract the harmonic features. For the transient features, spline functions cannot match them exactly. Singular value decomposition (SVD) is a denoising method based on matrix decomposition. It has been proved effective in many cases. SVD is regarded as a non-linear filter which suppresses the noise with different

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