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Application of Dispersion Entropy to Status Characterization of Rotary Machines

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Abstract: Nonlinear techniques have been widely and successfully used to analyze the vibration signals in rotary machines due to the nonlinear nature of such times series. We have recently introduced dispersion entropy (DisEn) as a powerful and fast nonlinear method to quantify the uncertainty of signals. This study investigates the usefulness of DisEn for the condition monitoring of rotary machines. We inspect the effect of the parameters of DisEn, namely embedding dimension, number of classes, and time delay as well as the length of signals, on its performance to characterize the dynamics of time series. Next, several straight-forward concepts in signal processing using a set of time series are used to show the advantages of DisEn over permutation entropy (PerEn) and approximate entropy (ApEn) in terms of detection of the dynamical variability of signals. The results suggest that DisEn, compared with PerEn and ApEn, leads to more stable results when dealing with a high signal-to-noise-ratio. We also show that DisEn is noticeably faster than ApEn, and thus, it is more appropriate for real-time applications. DisEn is also assessed by three experimental tests for the detection of different gear faults, fault diagnosis of rolling element bearings, and characterization of bearing degradation. The results show that DisEn, compared with PerEn and ApEn, yields more stable results for the status characterization of rotary machines.

Keywords: Dispersion entropy, Nonlinear dynamics, Condition monitoring, Rotary machines.

1. Introduction

Rotating machinery, as one of the most common type of machines, plays a key role in industrial and mechanical applications [1, 2]. If the faults of the rotating machinery are diagnosed soon, it will be possible to fix or replace them immediately. Therefore, its repair costs are reduced and its reliability increases [1, 2].

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