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Constrained independent component analysis and its application to machine fault diagnosis

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ABSTRACT

For machine fault diagnosis the signals from working machine are always numerous, even uncountable, but there contains only a little useful information. Hence how to find out the useful signal from numerous signals, including noises, that is, how to only extract the desired fault signal is very attractive. This paper shows that the constrained independent component analysis (cICA) can solely extract desired faulty signal using some prior mechanical information. The methods of creating reference of cICA for machine diagnostics are discussed, and the effectiveness of the method is successfully verified by simulations and experiments.

1. Introduction

Independent component analysis (ICA) is a technique that separates statistically independent components (ICs) from a set of measured signals. The technique enjoys numerous applications in biomedical engineering [1,2], communication [3,4], and speech process [3,5,6]. Some researchers also show that ICA can be used as a preprocessing tool of support vector machines [7,8] or factorial hidden Markov model [9] and illustrate some successful applications in machine fault diagnosis, but ICA algorithm must firstly resolve source number estimation problem in machine diagnostics. Furthermore, for machine fault diagnosis the number of signals meeting with the requirement of statistical independence from operating equipment is too many, even uncountable. The common ICA algorithms estimate the number of sources by estimating the number of the eigenvalues which are greater than the specified threshold. But it is difficult to ascertain the threshold in machine fault diagnostics. Though some supplemental ICA algorithms can order independent components according to singular-eigenvalue, kurtosis, skewness, sparsity, hurst exponent, etc. [10], the implementation of the methods still needs to know the number of sources and sensors in advance, as it orders the "separated" ICs. Principal Component Analysis (PCA) technique, which can be a preprocessing tool of ICA, can reduce data dimensions, but it cannot completely solve source number estimation problem, as PCA also orders the "separated" ICs that are reserved according a specified threshold. These methods risk useful information lost unless reserved ICs carried the desired signals or faulty signals.

For machine fault diagnosis the signals from working machine are numerous, but there contains only a little useful information. Hence how to find out useful signals from numeral signals, including noises, that is, how to only extract the interested signals are very attractive. Recently constrained independent component analysis (cICA) technique [11–15] has

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