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Mode Mixing Suppression Algorithm for Empirical Mode Decomposition Based on Self-Filtering Method[1]

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Abstract—The Hilbert-Huang transform (HHT) is a classic method in time-frequency analysis field which was proposed in 1998. Since it is not limited by signal type, it is generally applied in medicine, target detection and so on. Empirical mode decomposition (EMD) is a pre-processing part of HHT. However, EMD still has many imperfect aspects, such as envelope fitting, the endpoint effect, mode mixing and other issues, of which the most important issue is the mode mixing. This paper proposes a mode mixing suppression algorithm based on self-filtering method using frequency conversion. The proposed algorithm focuses on the instantaneous frequency estimation and the false components removing procedures, which help the proposed algorithm to update or purify the designated intrinsic mode function (IMF). According the simulation results, the proposed algorithm can effectively suppress the mode mixing. Comparing with ensemble empirical mode decomposition (EEMD) and mask method, the suppression performance is increased by 26%.

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1. INTRODUCTION

In order to obtain the time-frequency characteristics, the commonly used methods are short-time Fourier transform [1], fractional Fourier transform [2], wavelet transform [3] and Wigner-Ville distribution (WVD) [4–6]. Comparing with other methods, WVD has been widely used for its high time-frequency concentration. And based on the WVD, smoothing pseudo Wigner-Ville distribution (SPWVD) was proposed to eliminate cross-terms of signal time intervals in dealing with multi-component signals [7, 8].

Actually WVD can be regarded as the Fourier transform of the signal autocorrelation function, and it has high time-frequency concentration. However, when dealing with multi-component signals or non-linear frequency modulated signals, WVD always generates serious cross-terms, which may overlap with auto-terms. That is to say, WVD has a strong advantage in dealing with a single component signal, but not in dealing with the multi-component signals or non-linear frequency modulated signals [9, 10].

In order to eliminate cross-terms of signal intervals, some scholars tried to filter the signal with some designed window before using WVD. One of those methods is well known as pseudo Wigner-Ville distribution (PWVD). Since PWVD only filters signal in time domain, PWVD is not an ideal choice for suppressing cross-terms. SPWVD can eliminate cross-terms much better, because SPWVD filters signal both in time and frequency domain [11–14]. Although these smoothing versions of WVD can eliminate the effect of cross-terms in some sense, they reduce the time-frequency concentration at the same time.

It is well known that Fourier transform is suitable for linear systems and the data must be strictly periodic or stationary. However real systems are always nonlinear. When Fourier transform is directly used to analysis these data, the result makes little physical sense. Then Huang et al. proposed an analysis method named empirical mode decomposition (EMD) to decompose signal into a group of multiple one-component signals [15, 16]. After EMD, the original signal can be decomposed into multiple intrinsic mode functions (IMFs) and a residual component which characterizes the signal's time domain trend. The frequencies

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ADDITIONAL INFORMATION

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