Decomposition of non-stationary signals into varying time scales: Some aspects of the EMD and HVD methods

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ABSTRACT

The Empirical Mode Decomposition has become very popular since its first introduction. Its suitability and expected performance for specific signal processing task is however somewhat open ended.

Addressed are basic questions concerning the decomposition of signals according to different time scales, from noise sensitivity to frequency resolution. Comparing it to the recently introduced Hilbert Vibration Decomposition, signals simulating moving mechanical systems are analyzed. It is argued that in spite of signal adaptive properties, a universal fully automatic decomposition is still beyond our capabilities.

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1. Introduction—the problem of time scales

Signal processing tasks are usually performed as part of a more comprehensive project. The scope of applications is enormous. To mention just a few typical to Mechanical Engineering these encompass pattern recognition geared towards diagnostics, system identification, classification, vibration/noise abatement, modeling and control.

Often the aim is to recognize patterns. A meta-review of works dealing with such signal processing task results in an interesting observation. The majority of the techniques used for such tasks attempt to decompose the acquired signal into components of different time scales. In simplified terms, the decomposition attempts to separate "slow" and "fast" components.

We list some of the most popular tools—from Filters and Fourier Transforms to Joint Time–Frequency ones. These later ones may be looked upon as having two basic foundations

(1) linear decompositions, e.g. Fourier, Gabor, etc. upon, which Short Time Fourier Transform (STFT), Wavelets and others are based;
(2) quadratic or energetic methods, e.g. Wigner–Ville, etc.

All of these can be considered of performing the above separation.

In can be noted that some major tools are not listed in this general discussion. These include for example Blind Source Separation (BSS), as we limit ourselves to the analysis of a single signal, Independent Component Analysis (ICA), where statistical

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