NEW EMPIRICAL MODE DECOMPOSITIONS AND THEIR APPLICATIONS IN SIGNAL AND IMAGE PROCESSING

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To analyze or process a signal, reliably, one of the best-known solutions is to decompose the signal into levels of resolution or frequency. Many studies have been devoted to this topic and various techniques have been introduced for signal decomposition, among which two of the most popular ones are Fourier analysis and wavelet transforms. These approaches, however, either require a predefined basis function or are not adapted for nonlinear non-stationary signals. They, therefore, will not perform well when analyzing the natural signals, due to the fact that most of the natural signals do not behave linearly or are not stationary. Empirical Mode Decomposition (EMD), unlike Fourier and wavelet transforms, is a data driven algorithm. It is a relatively new promising tool, which was intended to allow perfect analysis of nonlinear non-stationary data by extracting the local features and time-frequency distribution. The EMD reduces the time signal into a set of basis functions known as Intrinsic Mode Functions (IMFs), each representing the behavior of the signal at a particular time scale. Despite being featured as a very powerful algorithm, the traditional EMD approach suffers from a few limitations. The major ones are (i) mode mixing problem, (ii) high computational cost and (iii) distortion generation at signal/image boundaries.

In many signal/image processing applications such as object detection or recognition applications, it is essentially important to have a high quality data to make reliable decisions. Most of the recorded natural signals/images suffer from lack of decent quality and thus, will present many challenges if used in the original form. For instance, a captured image from an indoor/outdoor scene can be remarkably noisy, hazy, dark or bright. Even, in worse cases the distribution of the illumination may not be uniform over the entire image. Thus, in order to maintain the accuracy of the

outputs, it is critical to preprocess the input signal to provide an acceptable level of quality. In this thesis, we will show that by incorporating the EMD technique, we will obtain more promising results compared to the current existing preprocessing approaches. We start by addressing the shortcomings of the traditional EMD method and introducing its extensions and modifications. Later, we introduce our new EMD based techniques developed to mitigate the weaknesses of the EMD approach. Subsequently, we present our established methods for image de-noising, image enhancement, time series forecasting and fingerprint preprocessing.