Empirical Mode Decomposition, Hilbert Huang Transform and their Applications in Controller Performance Monitoring ; An Overview

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Empirical Mode Decomposition (EMD) and Hilbert Huang Transform (HHT) are recent additions to the adaptive signal and data processing techniques. The power of these methods stem form their adaptive and data driven nature and ability to deal both non-linear and non stationary time series. Due to the peculiar characteristics both HHT and EMD are finding their ways in many technological areas like sensor fusion, communication systems, seismic and biological data analysis, fault diagnosis etc. In this brief an overview of these techniques is presented with a summary of current and probable future applications with regards to the modern performance monitoring paradigm.

EMD is an iterative sifting process that adaptively sifts out high frequency (fast) modes from the slower ones in a fully data driven way. The modes so extracted are orthogonal to each other and are called Intrinsic Mode Functions or IMFs. The IMFs are the functions with zero mean where number of extrema and zero crossing at most differ by one. The IMFs can then be used to calculate the meaningful instantaneous frequency by the application of Hilbert transform to reveal the time-frequency spectrum of the signal. The procedure to generate instantaneous frequency from the combination of EMD and Hilbert transform is termed as Hilbert Huang Transform or HHT.

Controller performance monitoring (CPM) has attracted lots of interest in the past decade owing to the fact that only third of industrial control loops are reported to be giving satisfactory performance. The increased level of complexity and automation in industry necessitates the provision of adaptive and data driven performance monitoring tools. The research community has therefore started exploring the data driven nature of HHT from the perspective of control loop performance assessment. The EMD has been used for the detection of multiple oscillations and related characteristics in process control loops without any pre-filtering or *a priori* knowledge about the underlying plant dynamics.

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The HHT is also successfully applied for the detection of non-linearity induced oscillation both in qualitative and quantitative terms. Though these are early days of HHT in performance monitoring business yet it has potential to cater for the future needs.