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Adaptive Data Analysis Methods: with some biomedical applications

By
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Abstract

Traditionally, data analysis methods are based on a priori basis, which forces us to make the critical linear and stationary assumption even before we look at any data. But the world we live in is neither stationary nor linear. Facing with such reality, we have to change our approaches. The existing methods of probability theory and spectral analysis are certainly inadequate. For example, spectral analysis is synonymous with the Fourier based analysis. As Fourier spectrum can only give meaningful interpretation to linear and stationary process, its application to data from nonlinear and nonstationary processes is problematical. To break away from this limitation, we should let data speak for themselves. We should develop adaptive data analysis techniques.

New methods, from categorization to Hilbert-Huang Transform (HHT), are developed for analyzing nonlinear and nonstationary data. These methods could be applied to a wide variety of problems from literature to engineering and biomedical problems. An introduction to the radically different method, the HHT, will be introduced. The key part of it is the Empirical Mode Decomposition method with which any complicated data set can be decomposed into a finite and often small number of Intrinsic Mode Functions (IMF). With the Hilbert transform, the Intrinsic Mode Functions yield instantaneous frequencies as functions of time that give sharp identifications of imbedded structures. The final presentation of the results is an energy-frequency-time distribution, designated as the Hilbert Spectrum. Classical nonlinear system models are used to illustrate the roles played by the nonlinear and nonstationary effects in the energy-frequency-time distribution.

Some examples will be presented to illustrate the prowess of the new adaptive data analysis methods that would include biomedical and other applications. Specific applications include electroencephalography, dynamics of cerebral auto-regulation and other heart rate variability studies.

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Biography

Prof. Norden Eh Huang, a TSMC Chair Professor and the Director of the Research Center for Adaptive Data Analysis at the National Central University, Taiwan. He held a doctoral degree (1967) in Fluid Mechanics and Mathematics from the Johns Hopkins University. In the past, he has been working on nonlinear random ocean waves. Recently, he has devoted all his time in data analysis, specifically in a new method, the Hilbert-Huang Transform, to process nonstationary and nonlinear time series. Over the last few years, he has applied this method to analyze data in the following areas: nonlinear ocean wave evolution data; earthquake signals and structure responses; bridge and structural health monitoring; biomedical signals such as blood pressure fluctuations; long term environmental data such as global temperature variations, Antarctic ice extents records, and solar irradiance variance; hydro-machinery design and machine vibration data. For this invention, he was awarded the 1998, 2003, 2004 NASA Special Space Act Awards. He was also the winner of the 1999 Federal Government Technical Leadership Award; the 2001 Federal Laboratory Development Award, 2006 Service to America Medal for Science and Environment, and, for his contribution in the filed of nonstationary and nonlinear data analysis, elected as a member of the National Academy of Engineering, 2000.

Dr. Huang serves as an Associate editor for Journal of Physical Oceanography, and Journal of Geophysical Research. He has published extensively on subjects covering data analysis method and its applications to natural science, engineering, biomedical and financial problems.

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