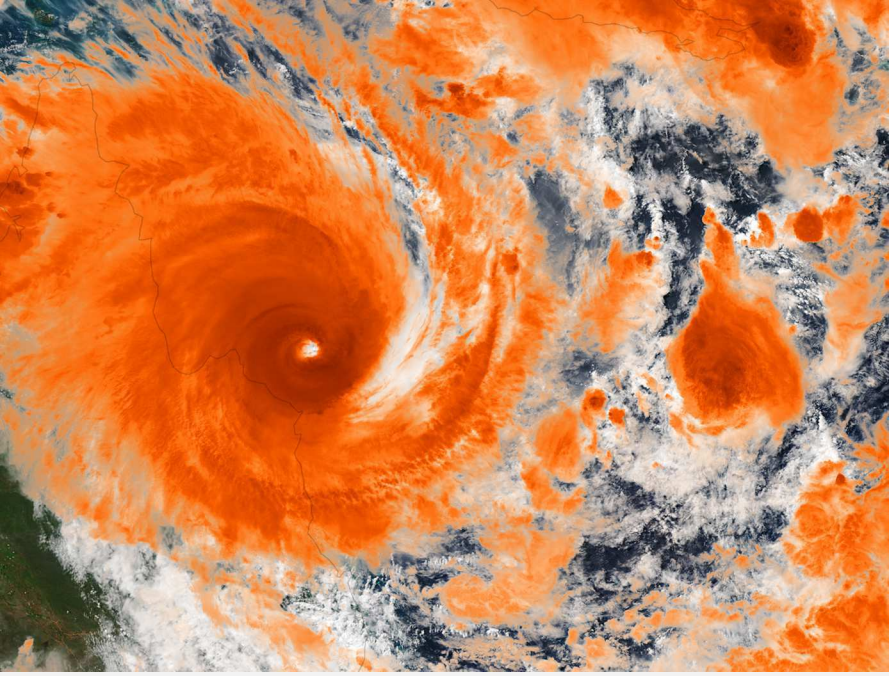

National Aeronautics and Space Administration

Information Technology and Software

The Hilbert-Huang Transform Real-Time Data Processing System

Analyzing nonlinear and nonstationary signals

One of the main heritage tools used in scientific and engineering data spectrum analysis is the Fourier Integral Transform and its high performance digital equivalent - the Fast Fourier Transform (FFT). The Fourier view of nonlinear mechanics that had existed for a long time and the associated FFT carry strong a-priori assumptions about the source data, such as linearity and being stationary. Natural phenomena measurements are essentially nonlinear and nonstationary.

A recent development at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC), known as the Hilbert-Huang Transform (HHT) proposes a novel approach to the solution for the nonlinear class of spectrum analysis problems.

BENEFITS

- Unlike other signal processing techniques such as the Fast Fourier Transform (FFT1 and FFT2), HHT does not assume signal linearity and stationarity
- HHT utilizes relationships between arbitrary signals and local extrema to find the signal instantaneous spectral representation

technology solution

THE TECHNOLOGY

The present innovation is an engineering tool known as the HHT Data Processing System (HHTDPS). The HHTDPS allows applying the Transform, or 'T,' to a data vector in a fashion similar to the heritage FFT. It is a generic, low cost, high performance personal computer (PC) based system that implements the HHT computational algorithms in a user friendly, file driven environment. Unlike other signal processing techniques such as the Fast Fourier Transform (FFT1 and FFT2) that assume signal linearity and stationarity, the Hilbert-Huang Transform (HHT) utilizes relationships between arbitrary signals and local extrema to find the signal instantaneous spectral representation.

Using the Empirical Mode Decomposition (EMD) followed by the Hilbert Transform of the empirical decomposition data, the HHT allows spectrum analysis of nonlinear and nonstationary data by using an engineering a-posteriori data processing, based on the EMD algorithm. This results in a non-constrained decomposition of a source real value data vector into a finite set of Intrinsic Mode Functions (IMF) that can be further analyzed for spectrum interpretation by the classical Hilbert Transform.

The HHTDPS has a large variety of applications and has been used in several NASA science missions.

NASA cosmology science missions, such as Joint Dark Energy Mission (JDEM/WFIRST), carry instruments with multiple focal planes populated with many large sensor detector arrays with sensor readout electronics circuitry that must perform at extremely low noise levels.

A new methodology and implementation platform using the HHTDPS for readout noise reduction in large IR/CMOS hybrid sensors was developed at NASA Goddard Space Flight Center (GSFC). Scientists at NASA GSFC have also used the algorithm to produce the first known Hilbert-Transform based wide-field broadband data cube constructed from actual interferometric data.

Furthermore, HHT has been used to improve signal reception capability in radio frequency (RF) communications.

This NASA technology is currently available to the medical community to help in the diagnosis and prediction of syndromes that affect the brain, such as stroke, dementia, and traumatic brain injury.

The HHTDPS is available for non-exclusive and partial field of use licenses.

APPLICATIONS

The technology has several potential applications:

- The HHT Data Processing System is broadly applicable to analyzing nonlinear and nonstationary signals while improving the accuracy of linear- and stationary-signal analysis
- Structural damage detection
- Analyzing dynamic and earthquake motion recordings in studies of seismology and engineering
- Pitch determination in speech recognition
- Geometrical Signal Processing
- Biological Signal Processing
- Geophysical Signal Processing
- Analyzing nonstationary financial time series

PUBLICATIONS

Patent No: 9013490; 8,144,331; 8913844

Kizhner, S., Flatley, T., Huang, N., Blank, K., & Conwell, E. (2004). On the Hilbert-Huang transform data processing system development. 2004 IEEE Aerospace Conference Proceedings (IEEE Cat. No.04TH8720).

More Information

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