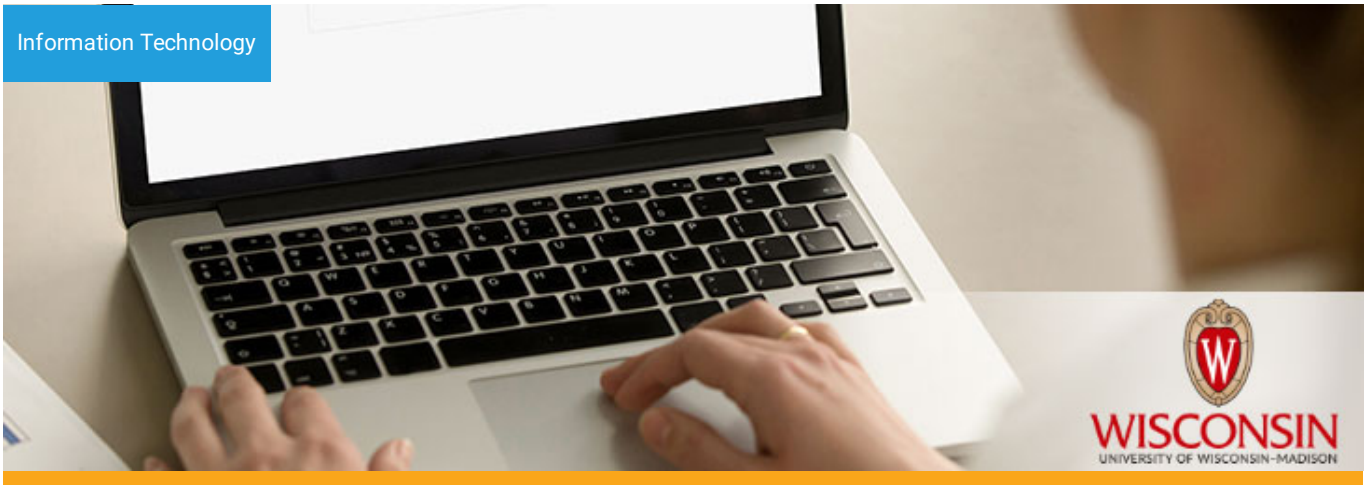
Information Technology



Algorithm Improves Resolution of Time-Frequency Analysis for Medical Diagnostics, Telecommunications

View U.S. Patent No. 9,687,198 in PDF format.

WARF: P100227US01

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The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing a system and method for time-frequency analysis with improved temporal and spectral resolution.

Overview

Time-frequency analysis involves detecting when oscillations of certain frequencies turn on and off. This kind of analysis is useful in nearly every field of science and engineering. The traditional approach for frequency analysis, the fast Fourier transform (FFT), can be adapted for time-frequency analysis by segmenting data into short time windows. The FFT algorithm is applied to each time window separately, and frequency spectra are then generated, one for every time window. The time resolution of such time-windowed FFT is limited by the well-known uncertainty principle that any attempt to improve time resolution (e.g., by segmenting data into shorter time windows) results in degradation of frequency resolution.

Wavelet transforms have found widespread application in time-frequency analysis. A wavelet consists of an oscillatory waveform that has a fairly well-defined frequency and exists only for a brief period of time. Time-frequency analysis using wavelets has become popular because, in some ways, wavelet transforms are more convenient and less susceptible to certain kinds of artifacts than time-windowed FFT.

All true wavelets have to meet certain mathematical criteria, which have useful properties. A further generalization of wavelet transforms is possible whereby these criteria are loosened. The resulting waveforms are called pseudo-wavelets. An infinite variety of wavelets and pseudo-wavelets is available, each with its own strengths and weaknesses. Currently, FFT, wavelet and pseudo-wavelet approaches vie with one another for dominance in time-frequency analysis. A need remains for a system and method for time-frequency analysis that not only yields high performance over a large domain of applications, but also is convenient and easy to use.

The Invention

UW-Madison researchers have developed a pseudo-wavelet algorithm known as the “damped-oscillator oscillator detector” (DOOD). This algorithm is unique among all wavelet and pseudo-wavelet algorithms in that it is the only algorithm that is explicitly based on modeling data as a “driving force” that interacts with a hypothetical set of mathematical oscillators. In the DOOD algorithm, an entirely new spectral density can be defined as the time rate of change in the energy specifically due to interaction with the data driving force, referred to as the data power. The data power measure is more sensitive to the presence or absence of data oscillators than traditional energy measures.

The DOOD algorithm allows an enormous frequency range to be spanned over as many orders of magnitude as desired. The instantaneous phase of oscillation and relationships between oscillators easily. The inverse of the DOOD transform is accomplished readily, which means that the DOOD algorithm also can be used to compress data. Any time-frequency or correlation

analysis that can be accomplished by conventional means also can be accomplished using the DOOD algorithm, with the advantages of greater flexibility in defining the frequency range and better time resolution.

Applications

- Software for detecting electrical brain oscillations for use in epilepsy surgery planning and basic neuroscience applications
- Software for detecting low frequency brain oscillations as determined by functional MRI
- General purpose time-frequency analyzer for engineering applications
- Telecommunications and digital television data compression and recovery
- Analysis of climate patterns, business and financial market cycles, stability of architectural structures and turbulent fluid flow

Key Benefits

- High time resolution with minimal frequency degradation
- Flexible definition of frequency range(s) to be covered
- Low computational burden

Additional Information

For More Information About the Inventors

- David Hsu

Publications

- Hsu D., Hsu M., Grabenstatter H.L., Worrell G.A. and Sutula T.P. 2010. Time-Frequency Analysis Using Damped-Oscillator Pseudo-Wavelets: Application to Electrophysiological Recordings. J. Neurosci. Meth. 194, 179-192.

Tech Fields

- Information Technology : Networking & telecommunications
- Medical Devices : Diagnostics & monitoring tools

For current licensing status, please contact Jeanine Burmania at jeanine@warf.org or 608-960-9846