Tutorial Title: Wavelet Signal Processing

Instructor(s):
Prof. Hemant Patil

Affiliation: Dhirubhai Ambani Institute of Information and Communication Technology (DA-IICT),
Near Indroda Circle, Gandhinagar -382 007, Gujarat, India.

Email: hemant_patil@daiict.ac.in

Tel: +91-79-30510650

Content (180 minutes)

- Introduction and historical background of Wavelet Signal Processing
- Review of Mathematical Background
- Regularity analysis using Fourier transform
- Gabor Transform (STFT) vs Wavelet Transform
- Frequency Estimation using Wavelets
- Wavelet Zoom and Singularity Analysis
- Multiresoultion Analysis (MRA) concept and filter bank
- Wavelet Design Issues
- Spline Wavelet Design

About Wavelet Signal Processing

After a few minutes in a restaurant we cease to notice the annoying sound of surrounding conversations, but a sudden silence reminds us of the presence of neighbors. Our attention is clearly attracted by transients and movements as opposed to stationary stimuli, which we beautifully ignore in our perception. Concentrating on transients is probably a strategy for selecting important information from the overwhelming amount of data recorded by our senses. The world of transients is considerably larger and more sophisticated than the world of stationary of signals. The search for an ideal Fourier-like basis that would simplify most signal processing task is therefore a hopeless exercise. Instead a series of different transforms and bases have proliferated, among which wavelets are just one example. Wavelet means a wave for short duration. Recently, for past two decades it has got keen attention for analysis of transients in the signals especially after introduction by oil exploration engineer, Jean Morlet, working in French oil company Elf Acuatine. This tutorial gives a guided tour in this jungle of new mathematical and algorithmic results, while trying to provide an intuitive sense of orientation.

The main objective of this tutorial is to conduct a study on wavelet theory from both theoretical and application perspective (such as signal compression, denoising, and pattern recognition) in a *coherence* manner. The course first builds up background on LTI operators and Fourier analysis (including *Shannon's* sampling theory) and its short comings. Windowed Fourier Transform (WFT) and Continuous Wavelet Transform (CWT) are introduced along with analysis of *admissibility* condition for mother wavelet. . One of most important aspect in wavelet theory, i.e., *regularity* analysis and vanishing moments of wavelets along with detection of singularity and zeros-crossing using WT is discussed. DWT is introduced from Multiresolution Analysis (MRA) point of view. Mallat's algorithm (which relates MRA and WT with QMF banks) is studied. Different factors affecting wavelet design are studied and spline wavelets (e.g., quadratic spline, cubic-spline) are designed.

Why/how knowledge of Wavelet Signal Processing is important for a communication professional?

The theoretical beauty of wavelet analysis is also brought to industry by proposal of new coding standards such as JPEG, MPEG-1, MPEG-2, and ongoing MPEG-4. JPEG standard is also used by forensic agencies to compress millions fingerprint images. Hence knowledge of this field will certainly benefit communication professional.

Pre-requisites (for participants)
Signals and Systems or Digital Signal Processing

Lab Component
MATLAB exercise will be discussed during tutorial and tutorial on matlab containing introduction to programming will be given in CD.

Infrastructure Requirements
- LCD projection system for **powerpoint presentation.**
- Good Quality Acoustics in the room with at least some degree of isolation (sound-proofing with external environment)

Media of Tutorial Material
Presentation (PPT/PDF) and Demo material will be packaged on a CD-ROM