Mathematics for Signal processing

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Duration: 16 hours

Abstract: One classical problem in many applied fields of research, like Geophysics, Medicine, Engineering, Economy and Finance, is, given a signal, how to extract hidden information and features contained in it, like, for instance, quasiperiodicities and trends.

Standard methods like Fourier and Wavelet Transform, historically used in signal processing, proved to be limited when nonlinear and nonstationary phenomena are present. For this reason in the last two decades several new nonlinear methods have been developed by many research groups around the world and they have been used extensively in the applications.

In this course we will review the Empirical Mode Decomposition method and derived techniques, and introduce the Iterative Filtering technique and its generalizations. We will discuss their theoretical and numerical properties, show their limitations and discuss open problems.

During the course some applications will be presented as well as an introduction to the Matlab codes available online[1].

Lessons Plan:

- Description of the course (1/2 h)
- Empirical Mode Decomposition method
  - Review of the algorithm (1 h)
  - Alternative approaches (Ensemble EMD) (1 h)
- Iterative Filtering
  - Review of the algorithm (1 h)
  - Convergence properties in the continuous and discrete setting (1 h)
  - Pitfalls and caveats
    - Boundary Effects (1 h)
    - Jumps and spikes (1 h)
  - Acceleration of the algorithm (Fast Iterative Filtering and Direct Iterative Filtering) (1h)
  - Multidimensional and Multivariate extensions (1 h)
  - Applications (1 h)

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- Beyond Iterative Filtering
  - Adaptive Local Iterative Filtering
    - Review of the algorithm (1/2 h)
    - Numerical Analysis (1 h)
  - Resampled Iterative Filtering (1 h)
- Time frequency analysis - IMFogram (1 and 1/2 h)
- Instantaneous Frequency and Phase - JADE (1 and 1/2 h)

Final Exam: It will consists of either a short presentation on selected papers or a technical report on numerical experiments.