ES/STAT 251: SIGNAL & IMAGE PROCESSING AND INFERENCE USING WAVELETS (Fall 2005)

Teaching Staff

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Additional Instructors:

- Prof. Xiao-Li Meng (Statistics)
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Logistics

Location: Maxwell-Dworkin G-115
Meeting Time: Tu., Th., 1-2:30pm
Catalog Numbers: 3211 (ES 251), 3506 (STAT 251)
Website: http://www.courses.fas.harvard.edu/∼es251 and /∼stat251

Course Content

This interdisciplinary course will treat theory and applications of time-frequency/time-scale methods as motivated by statistical inference and missing-data problems, along with a significant project component tailored to participants' interests. Graduate-level researchers from all science and engineering disciplines are welcome; examples will be drawn from signal & image processing, computer graphics and vision, astronomy, biological signal analysis, and multiscale modeling of complex systems.

On successful completion of this course, a student will ideally have gained:

- a basic understanding of the general formulation and foundation of time-frequency/time-scale methods, including their theoretical properties and associated computational algorithms;
- a clear sense of the current state-of-the-art of the use of such methodologies in signal and image processing, and in statistical inference (e.g., non-parametric regression);
- a significant hands-on experience, via a term project involving the actual implementation of a wavelet-based method to address a problem in inference for signal or image processing.

Prerequisites

Engineering Sciences 156 or equivalent, knowledge of probability theory and/or statistics at the level of Statistics 110/111 or above, and programming experience; or permission of instructor.

Aims and Objectives

Many students and researchers in statistics and its various fields of application employ wavelets and other time-frequency/time-scale methods with only limited understanding of their origins. On the other hand, engineers and applied scientists who use such methods only as transforms may be unaware of the powerful associated techniques of semi- and non-parametric modeling and inference.

This course aims to bridge this gap by providing a strong foundation in wavelet methods applied to problems in statistical signal and image processing, and as such will provide useful and unique training for scientists and engineers across disciplines. Furthermore, the course aims to provide an effective introduction for statistics students to engineering applications, as well as for engineering and applied mathematics students to relevant statistical theory and methodologies, including computational algorithms.

Texts and Readings

S. Mallat, *A Wavelet Tour of Signal Processing* (Academic Press, second ed., ISBN 0-124-66606-X). Handouts and research articles will be given to supplement the reading. Additionally, a number of textbooks covering various aspects of the course and/or background material (e.g., Ogden's *Essential wavelets for statistical applications and data analysis*) will be placed on reserve in the Cabot and/or McKay Libraries.

Course Organization

The course will devote roughly 1/3 of its full duration to each of the three components outlined on the preceding page. The first 1/3 of the semester will primarily consist of lectures on the basic formulation and properties of wavelet methods. With that as the necessary background, the second 1/3 of the semester will focus on introducing students to the current methodological research literature on wavelets, particularly those from statistical literature on efficient wavelets methods in the presence of noise and/or incomplete data. Through application of the fundamentals and methods studied in the first 2/3 of the semester, the last 1/3 of the course will be devoted to ongoing research projects by the instructors and students, with the aim of providing fruitful directions for future research and exploration, particularly those of an interdisciplinary nature.

Tentative Evaluation Scheme

- Class participation and problem sets (prior to midterm) - 25%
- Midterm examination (in class) - 25%.
- Final project (proposal, presentation, and report) - 50%.

NB: While the grading breakdown above is indicative of relative weights, the instructors do reserve the right to rescale grades based on the performance of the class. Naturally, this will be done only in the event that it raises grades, and will not lower "raw" scores.