Instructor: Prof. Minh N. Do (minhdo@uiuc.edu)

Lectures: Tuesdays and Thursdays, 10:00 - 11:20 am; 252 Mechanical Eng. Bldg.
Office hours: Wednesdays 3-4 pm (115 CSL) + appointments by email.

Course description:
Wavelets have established themselves as an important tool in modern signal processing as well as in applied mathematics. The objective of this course is to establish the theory necessary to understand and use wavelets and related constructions. A particular emphasis will be put on constructions that are amenable to efficient algorithms, since ultimately these are the ones that are likely to have an impact. We thus study applications in signal processing, communications, and sensing where time-frequency transforms like wavelets play an important role. The course has computer and research projects involving independent study.

Prerequisite: ECE 551 or consent of instructor

Texts:
  OR
- Research papers.

Course Outline
1. **Introduction and background** (6 hours): why wavelets, filter banks, and multiresolution analysis? signal spaces and operators; review of Fourier theory; multirate signal processing; time-frequency analysis.
2. **Discrete-time bases and filter banks** (8 hours): series expansions of discrete-time signals; analysis and design of filter banks; orthogonal and biorthogonal filter banks; tree-structured filter banks; discrete wavelet transform.
3. **Continuous-time bases and wavelets** (8 hours): multiresolution analysis; iterated filter banks; wavelets and filter banks; wavelet series and its properties; regularity and approximation properties.
4. **Overcomplete expansions and continuous transforms** (5 hours): frame theory; oversampled filter banks; continuous wavelet and short-time Fourier transforms.
5. **Advanced topics** (9 hours): sparse representation; linear and nonlinear approximation in various bases; nonlinear signal estimation; multidimensional filter banks and wavelets; multiscale geometric signal processing; compressed sensing.
6. **Applications** (9 hours): speech, audio, image and video compression; denoising; feature extraction; inverse problems.
Grading: Homework (25%); Midterm I (25%); Midterm II (25%); Project (25%)

Course Objectives: Upon completion of this course, you should be able to:

1. understand the terminology that are used in the wavelets literature.
2. explain the concepts, theory, and algorithms behind wavelets from an interdisciplinary perspective that unifies harmonic analysis (mathematics), filter banks (signal processing), and multiresolution analysis (computer vision).
3. master the modern signal processing tools using signal spaces, bases, operators and series expansions.
4. apply wavelets, filter banks, and multiresolution techniques to a problem at hand, and justify why wavelets provide the right tool.
5. research, present, and report a selected project within a specified time.
6. think critically, ask questions, and apply problem-solving techniques.