ECE 497-MD: Wavelets in Signal Processing  
Spring 2004  
http://www.ifp.uiuc.edu/~minhdo/teaching/ECE497.html

Instructor: Prof. Minh N. Do (115 CSL, minhdo@uiuc.edu)  
Lecture times: Tuesdays 3-4:50 pm and Thursdays 3-4 pm (163 Everitt Lab)  
Office hours: Tuesdays 5-6 pm (115 CSL) plus appointments by email.

Overview  
Wavelets have established themselves as an important tool in modern signal processing as well as in applied mathematics. It is the purpose of this course to establish the theory necessary to understand 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 and communications where time-frequency transforms like wavelets play an important role. Computer and research projects involving independent study will be assigned.

Prerequisite: ECE 451 or consent of instructor

Texts:  
• M. Vetterli and J. Kovacevic, Wavelets and Subband Coding, Prentice Hall, 1995. (Required)  

Course Outline  
1. Introduction and Background (6 hours): Why wavelets and multiresolution analysis? Signal spaces and operators; Review of Fourier theory; Time-frequency analysis; Multirate signal processing.
2. Discrete-Time Bases and Filter Banks (8 hours): Elementary filter banks; 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; Construction of compactly supported wavelet bases; 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. Applications (9 hours): Subband coding and wavelet compression; Applications to speech, audio, image and video compression; Denoising; Feature extraction; and others.
6. Advanced Topics (9 hours): Linear and nonlinear approximation in various bases; Nonlinear signal estimation; Multidimensional filter banks and wavelets; Multiscale geometric image processing.

Grading: Homework (20%); Midterm I (25%); Midterm II (25%); Project (30%)
Course Objectives: Upon completion of the course, you should be able to:

1. understand the terminology that are used in the wavelets literature.
2. understand the concepts and theory behind wavelets constructions from an interdisciplinary perspective that unifies harmonic analysis (mathematics), filter banks (signal processing), and multiresolution analysis (computer vision).
3. be familiar with the modern signal processing using signal spaces, bases, operators and series expansions
4. apply wavelets 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.