ECE 498DLJ: Principles of Signal Analysis

Fall 2012

http://courses.engr.illinois.edu/ece498dlj/

Lectures: Mondays, Wednesdays and Fridays 10-11 AM and Fridays 11-12AM, 170 Everitt Lab.

Instructor: Prof. Mark Hasegawa-Johnson (jhasegaw@illinois.edu; 2011 Beckman Institute).

Course Description:
This course is intended as an advanced introduction to signal processing and analysis methods for advanced undergraduate and graduate students in the biological, physical, and social, and engineering sciences. Many researchers in these areas collect, process, and analyze signals and need a sophisticated understanding of processing methods and their capabilities, weaknesses, and artifacts. ECE 498-MJ will serve as a required course for neuroscientists in the graduate Neuro-Engineering concentration being developed as a requirement of the NSF-funded IGERT training grant, and will hopefully attract students from other areas whose research requires substantial signal analysis. The course material overlaps much of ECE 410 and small portions of ECE 537, 547, and 551, but will also involve significant hands-on processing and interpretation of real biological data using Matlab or Labview and will be paced at a level typical for graduate courses, thus requiring an advanced undergraduate or graduate-level sophistication in a relevant application domain. The course meets 4 hours per week, with one of those hours being a discussion session oriented toward the Matlab-based software laboratory assignments. These assignments require considerable work outside of class.

Prerequisites: Differential and integral calculus.

Grading:

- Written Homework: 15%
- Matlab Assignments: 15%
- Midterm Exams (2): 20%
- Final Exam: 30%

Scheduled Lectures: Lecture topics are subject to change as necessary; homework, etc. will change as necessary in response to changes in lectures.

- M 8/27 - Continuous and discrete time; click, buzz and hiss
- W 8/29 - Orthonormality of sines and cosines
- F 8/31 - Fourier series, quadrature form
- F 8/31 - MATLAB: introduction to matlab
- M 9/3 - Complex numbers
- W 9/5 - Fourier series, complex exponential form

- F 9/7 - Magnitude and phase spectrum
- F 9/7 - MATLAB: Fourier spectral analysis
- M 9/10 - no lecture
- W 9/12 - no lecture
- F 9/14 - no lecture
- M 9/17 - Continuous-time Fourier transform (CTFT)
- W 9/19 - CTFT properties
- F 9/21 - Frequency response of linear shift-invariant operators
- F 9/21 - MATLAB: additive music synthesis
- M 9/24 - Linearity, shift-invariance, stability
- W 9/26 - Impulse response and convolution
- F 9/28 - Frequency response again
- F 9/28 - MATLAB: reverberation
- M 10/1 - ***MIDTERM EXAM***
- W 10/3 - Discrete-time Fourier transform (DTFT)
- F 10/5 - Discrete Fourier transform (DFT)
- F 10/5 - MATLAB: DFT spectral analysis
- M 10/8 - DTFT and DFT properties
- W 10/10 - Overlap-add filtering of long signals
- F 10/12 - Short-time Fourier transform (STFT)
- F 10/12 - MATLAB: STFT analysis of biological data
- M 10/15 - Sampling: A/D and D/A
- W 10/17 - Ideal A/D: Nyquist sampling rate
- F 10/19 - Ideal D/A: sinc interpolation
- F 10/19 - MATLAB: Aliasing
- M 10/22 - Difference equations
- W 10/24 - Z-transform and Freq. response
- F 10/26 - Stability and causality; lowpass, highpass, bandpass
- F 10/26 - MATLAB: Filtering and frequency masking
- M 10/29 - Notch filters; IIR filtering

- W 10/31 - Windowing; FIR filters
- F 11/2 - Generalized linear phase; Min-Max filters
- F 11/2 - MATLAB: Notch, Windowed, and Min-Max filter design
- M 11/5 - ***MIDTERM EXAM***
- W 11/7 - Random signals: autocorrelation, power spectrum
- F 11/9 - Random signals: cross-correlation, cross-power spectrum, TDOA
- F 11/9 - MATLAB: array processing, TDOA estimation, beamforming
- M 11/12 - Image processing: 2D signals, human visual system, color histogram
- W 11/14 - 2DFT and Image filtering
- F 11/16 - Image formation: projection-slice theorem and CT
- F 11/16 - MATLAB: CT image formation, filtering, enhancement
- M 11/26 - Random signals: Wiener filtering, denoising
- W 11/28 - Image features: PCA, DCT, image patches and histograms, HOG
- F 11/30 - Classification: KNN
- F 11/30 - MATLAB: Image denoising and classification
- M 12/3 - Image formation: MRI
- W 12/5 - Matched filtering
- F 12/7 - Signal detection theory; D-prime; ROC
- F 12/7 - MATLAB: Image object detection using matched filters
- M 12/10 - Review
- W 12/12 - Review