PSYC 495/971 – Introduction to the Analysis of Psychological Signals

Objectives

The objectives of this course are to (1) introduce the student to basic techniques for the quantitative analysis of time-varying signals and (2) teach the student how to apply these techniques using MATLAB, the most commonly used high-level computing language used in science and engineering. Emphasis will be placed on methods appropriate to the psychological research environment. The theoretical background for each technique will be presented briefly, but the major stress will be on the application to practical problems. This will be achieved partially by the demonstration of typical analysis procedures. More importantly, students will be required to undertake assignments involving the analysis of simulated and actual psychological data. Expertise in MATLAB or signal processing is not required.

Teaching Team

Instructor: Randy Flanagan (www.flanaganlab.com)
Matlab Instructor: Joe Nashed
Teaching/Lab Assistant: Graham Raynor

Schedule

Week	Lecture	Labs
Jan 7	Introduction	Matlab basics
Jan 14	Matlab (no lecture)	Assignment 1
Jan 21	Matlab (no lecture)	Assignment 2
Jan 28	Basic Statistical Tools	Assignment 3
Feb 4	Amplitude Structure of Signals	Assignment 4
Feb 11	Frequency Domain Representation of Signals	Assignment 5
Feb 18	Reading Week	
Feb 25	Filtering	Assignment 6
Mar 4	Sampling considerations	Assignment 7
Mar 11	Correlation functions	Assignment 8
Mar 18	Data Collection	Data Collection
Mar 25	Analysis Project	Analysis Project
Apr 1	Analysis Project	Analysis Project

Course Outline

<u>Basic Statistical Tools and Concepts</u>

Deterministic and random variables; probability distributions; realizations; range and domain; stationarity, nonstationarity, ergodicity; expected values; moments; standard deviation, coefficient of variation; median, minimum, and maximum values.

<u>Amplitude Structure of Signals</u>

Probability distributions, probability densities, joint probability distributions; statistical independence; Gaussian distribution and its properties; rectangular, exponential, Poisson, and chi-square distributions; amplitude histograms; identification of distributions.

Frequency Domain Representation of Signals

Periodic signals; Fourier series; discrete Fourier spectra; the Fourier transform; power spectra.

Filtering

Types of noise; low-pass, band-pass, high-pass and band-reject filters; Bode plots; cut-off frequency and roll-off; analog filters; digital filters: frequency domain implementations, FIR filters, recursive filters.

Sampling Considerations

Digitization, sampling, and quantization; Shannon-Nyquist sampling theorem; aliasing; Nyquist frequency; quantization theorem; analog-digital converters; digital to analog converters.

Correlation Functions

Auto-correlation, auto-covariance, and auto-correlation coefficient functions; cross-correlation, cross-covariance, and cross-correlation coefficient functions; estimation of correlation functions; relation between correlation functions and spectral densities; practical applications.

Teaching Techniques

Teaching in this course will be made up of three components: **content lectures**, **Matlab lectures**, and **assignments/projects**.

The **content lectures** will cover the topic for the week and will include a handout summarizing the material. The lectures will also review the assignments from the week before.

The **Matlab lectures** will include a basic introduction to Matlab as well as information about the functions and tools required to complete the assignments.

The **assignments** are the most important part of the course. They will be used to stress and develop further the points made in the lectures, demonstrate the applicability, strengths and weaknesses of particular methods, and test for understanding of the material. In the assignments, students will be provided with data sets that they will be responsible for analyzing and reporting (using plots, tables and text as appropriate).

In addition to the assignments, each student will complete a final **project** that will involve the collection, analysis, and evaluation of data using techniques they have learned in the course.

Evaluation

Evaluation will be based on assignments and projects. The 8 assignments will be graded out of 10 and will be worth a total of 80% of the grade. The final project will be worth 20% of the grade.

Note that the assignments for a given week are due prior to the lecture (on the Tuesday) during the following week.