PSYC 315/971 – Introduction to the Analysis of Psychological Signals – Winter 2019

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, flanagan@queensu.ca)
Matlab Instructor: Joe Nashed (jnashed@gmail.com)
Teaching Assistant: Josh Moskowitz (j.moskowitz@queensu.ca)

Schedule

Date	Lecture	Date	Labs
Sep 6	Introduction	Sep 9, 11	Matlab basics
Sep 13	Matlab	Sep 16, 19	Matlab I *Assignment 1*
Sep 20	Matlab *Assignment 1 Due*	Sep 23, 26	Matlab II *Assignment 2*
Sep 27	Basic Statistical Tools *Assignment 2 Due*	Sep 30, Oct 3	Basic Statistical Tools *Assignment 3*
Oct 4	Amplitude Structure of Signals *Assignment 3 Due*	Oct 7, 10	Amplitude Structure of Signals *Assignment 4*
Oct 11	Matlab Drop-in	Oct 17, 21	Amplitude Structure of Signals *Assignment 4* (cont'd)
Oct 18	Frequency Representation of Signals *Assignment 4 Due*	Oct 21, 28, 30	Frequency Representation of Signals *Assignment 5*
Nov 1	Filtering *Assignment 5 Due*	Nov 4, 7	Filtering *Assignment 6*
Nov 8	Sampling considerations *Assignment 6 Due*	Nov 11, 14	Sampling Considerations *Assignment 7*
Nov 15	Correlation Functions *Assignment 7 Due*	Nov 18, 21	Correlation functions *Assignment 8*
Nov 22	Data Collection Final Project *Assignment 8 Due*	Nov 25, 28	Analysis Project
Nov 29	Final Project Consultation	Dec 2, 5	Analysis Project *Final Project Due Dec 6*

Course Outline

Matlab Basics

Basic of the Matlab programming language; programming environment; scalars, vectors and matrices; matrix operations and relational operators; program control and flow.

Basic Statistical Tools and Concepts

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.

Amplitude Structure of Signals

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

This course consists of a single **lecture** each week and two **labs**. This year, the lecture is on Monday morning and the labs are on Monday and Thursday afternoons.

The **lectures** will cover the topic for the *current* week and will include a handout summarizing the material. The assignment from the previous week is due at the start of the lectures; this assignment will be reviewed in the lecture.

The **labs** will go over the Matlab functions and tools required to complete the assignments. Most of the time will be spent working on the assignment due at the start of the next week.

The assignments are 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 analyze and report (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 at the start of the lecture the following week. The assignment for the coming week will be given out in the lecture.