PSYC 315 – Introduction to the Analysis of Psychological Signals – Winter 2023

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.

Schedule

Week	Labs	Dates	Lecture	Date
Week 1	No labs	Jan 8, Jan 10	Introduction	Jan 11
Week 2	Matlab basics	Jan 15, Jan 17	1st Matlab lecture	Jan 18
Week 3	Matlab Assignment 1 (Due Feb 2)	Jan 22, Jan 24	2nd Matlab Lecture	Jan 25
Week 4	Matlab Assignment 2 (Due Feb 9)	Jan 29, Jan 31	Basic Statistical Tools	Feb 1
Week 5	Basic Statistical Tools Assignment 3 (Due Feb 16)	Feb 5, Feb 7	Amplitude Structure of Signals	Feb 8
Week 6	Amplitude Structure of Signals Assignment 4 (Due Mar 1)	Feb 12, Feb 14	Frequency Representation of Signals	Feb 15

Week 7	Frequency Representation of Signals Assignment 5 (Due Mar 8)	Feb 26, Feb 28	Filtering	Feb 29
Week 8	Filtering Assignment 6 (Due Mar 15)	Mar 4, Mar 6	Sampling Considerations	Mar 7
Week 9	Sampling Considerations Assignment 7 (Due Mar 17)	Mar 11, Mar 13	Correlation functions	Mar 14
Week 10	Correlation Functions Assignment 8 (Due Mar 22)	Mar 18, Mar 20	Data Collection for Analysis Project	Mar 21
Week 11	Analysis Project (Due Apr 12)	Mar 25, Mar 27	Final Project Consultation	Mar 28
Week 12	Analysis Project	Mar 1, Apr 3	Final Project Consultation	Apr 4

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.