Syllabus

9.073 Statistics for Neuroscience Research
Prereq: 9.07 or Permission of instructor
(Spring)
3-0-9
A survey statistical reasoning and statistical methods relevant to neuroscience research. Core topics include a review of basic of estimation theory, multiple regression, principal components analysis, independent components analysis, generalized linear model, point processes, time-series analysis, spectral analysis, and state-space methods. Emphasis on developing a firm conceptual understanding of the statistical paradigm and statistical methods primarily through analyses of actual experimental data.

Instructor
Professor Emery N. Brown

Teaching Assistant
Narek Dshkhunyan
Tuan LeMau

Classroom
46-3015

Lectures

February 8: Class 1 Introduction to the Statistical Paradigm of Reasoning Under Uncertainty

February 13: Class 2 Estimation I: Method of Moments, Likelihood Methods
9.07 Lectures 8, 9
KEB, p. 151-157, 200-208

*February 15: Class 3 Estimation II: Likelihood Methods, Bootstrap
9.07 Lectures 9, 11
KEB, p. 154-157, 200-208, 237-244

February 20: President's Day- No Class

*February 21: Class 4 Estimation III: Bayesian Methods
9.07 Lectures 9, 11
KEB, p. 154-157, 200-208, 237-244

February 22: Class 5 Simple Regression (Problem Set 1 due)
9.07 Lectures 14

*February 27: Class 6 Multiple Regression I
Lectures 14, 15
KEB, p. 309-360

March 1: Class 7 Multiple Regression II
Lecture 15

KEB, p. 309-360

March 6: Class 8 Multiple Regression III
9.07 Lectures 14, 15
KEB, p. 309-360

*March 8: Class 9 Principal Components Analysis
Lectures 14, 15
KEB, p. 309-360

March 13: Class 10 Independent Components Analysis
Lecture 15
KEB, p. 309-360

March 15: Class 11 Point Processes (Problem Set 2 due)

Lecture 13
KEB, p. 563-604
Brown, p. 691-726

*March 20: Class 12 Point Processes
Lecture 13
KEB, p. 563-604
Brown, p. 691-726

March 22: Class 13 Generalized Linear Model
Lecture 19
KEB, p. 391-404

March 27 and 29: Spring Vacation

April 3: Class 14 Generalized Linear Model
Lecture 19
KEB, p. 391-404

*April 5: Class 15 Generalized Linear Model
Lecture 19
KEB, p. 391-404

April 10: Class 16 Time Series Analysis
Lecture 20

April 12: Class 17 Time Series Analysis

April 17 and 18: Patriots Day Holiday

*April 19: Class 18 Time Series Analysis

April 24: Class 19 Time Series Analysis

*April 26: Class 20 Spectral Analysis
Lecture 21
KEB
May 1: Class 21 Spectral Analysis

May 3: Class 22 Spectral Analysis

*May 8: Class 23 State-Space Modeling

May 10: Class 24 State-Space Modeling
Lecture 22

May 15: Class 25 State-Space Modeling

May 17: Class 26 Advanced State-Space Modeling

May 18: Last Day of Classes

Problem Sets (approximately every two week days)
Problems Sets will be due at 5 p.m. on the day indicated. Everyone will be allowed to drop the score on one problem set in computing the final grade.

Guidelines for Writing Up Problem Sets
Collaboration on the problem sets is permitted but must be acknowledged in writing.
Each student should write his/her own solutions and own MATLAB code.
All MATLAB code must be handed in along with the outputs.
We will give partial marks for the correct portions of incomplete/incorrect solutions.

Institute Policy on Integrity
The Institute obliges us to remind you of its policy on integrity. It can be found at the website http://web.mit.edu/academicintegrity/. Please read it if you have not already done so.

Grading
Grading will be based entirely on the problem sets. There are no examinations.

Texts
The course will be presented in a set of self-contained lecture notes.

Text References
Brown EN. Theory of Point Processes for Neural Systems. In: Chow CC, Gutkin B, Hansel D, Meunier C, Dalibard J, eds. *Methods and Models in Neurophysics*. Paris, Elsevier; 2005, Chapter 14, pp. 691-726.

Bloomfield P. *Fourier Analysis of Time Series: An Introduction*. New York, NY: John Wiley & Sons, 1976.

Box GEP, Jenkins GM, & Reinsel GC. *Time Series Analysis, Forecasting and Control* 3rd edition. Upper Saddle River, NJ: Prentice Hall, 1994.

Brockwell PJ, Davis RA. *Introduction to Time Series and Forecasting*, 2nd edition. New York: Springer, 2002.

DeGroot MH, Schervish MJ. *Probability and Statistics*, 3rd edition. Boston, MA: Addison Wesley, 2002.

Fahrmeir L, & Tutz G. *Multivariate Statistical Modeling Based on Generalized Linear Models* 2nd edition. New York: Springer-Verlag, 2001.

Kass RE, Eden UT & Brown EN. *Analysis of Neural Data*. New York: Springer-Verlag, 2014

Kramer MA, Eden UT. *Case Studies in Neural Data Analysis: A Guide to the Practicing Neuroscientist,* MIT Press, 2016.

Pawitan Y. *In All Likelihood: Statistical Modeling and Inference Using Likelihood*. London: Oxford, 2001.

Percival DB, Walden AT. *Spectral Analysis for Physical Applications: Multitaper and Conventional Univariate Techniques*. Cambridge University Press, 1993.

Rosner B. *Fundamentals of Biostatistics*, 2nd edition. Boston, MA: Duxbury Press, 1986.

Shumway RH, Stoffer DS. *Time Series Analysis and its Applications*. New York, NY: Springer, 2000.

Problem Sets (approximately every two weeks)

Problem Set 1. Estimation

Problem Set 2. Regression Analysis

Problem Set 3. PCA, ICA and Point Processes

Problem Set 4. Generalized Linear Model

Problem Set 5. Time Series Analysis

Problem Set 6. Spectral Analysis and State-Space Modeling