Quantitative Methods for the Brain Sciences

AS.200.318 Spring 2016. Tu/Th 1.30-2.45 pm (217 Ames)

Professor	**Teaching Assistant**
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Office hours: By appt.	Office hours: TBA

The goal of this class is to train students in key quantitative methods that are commonly by brain scientists (neuroscientists, psychologists, cognitive scientists) to analyze data. It is designed to serve students who do not have a strong quantitative background. This is not a "stats" class. Rather, it serves as a guide to powerful quantitative techniques, along with some exposure to their underlying math. Topics covered will include dimensionality reduction, information theory, frequency domain analyses, curve fitting, and clustering, and will be applied to "brain activity" datasets (obtained with electrophysiology, imaging, and to some extent fMRI). Emphasis will be on gaining a conceptual understanding of techniques and their practical application, rather than on proofs. In order to develop expertise in the techniques and their use, students will work on problem sets, take short quizzes, and critique journal articles. Knowledge of MATLAB is a plus, but not necessary (we will go over MATLAB basics).
Target audience: Early graduate students and seniors (with permission).

Course benefits
By the end of the course, you can expect to:
1. Be able to apply appropriate mathematical techniques to, and draw valid conclusions from, typical "brain science" datasets.
2. Be able to justify and explain the use of analyses (this will help with writing methods sections in your own papers); be able to view quantitative methods used in publications with a critical eye.
3. Be exposed to "meta" skills: use of MATLAB, and organization of new information into personally meaningful frameworks.

Lesson plan

Date	Week#	Topic
26-Jan	1	Snow day
28-Jan		Intro (learning goals), Examples, Concept maps, MATLAB basics
2-Feb	2	Random variables, correlation and independence
4-Feb		
9-Feb	3	Linear algebra (Coordinate systems and bases; Types/properties of vectors)
11-Jan		Linear algebra (Matrices; Diagonalizability; Covariance matrices
16-Feb	4	Dimensionality reduction - Linear
18-Feb		
23-Feb	5	Dimensionality reduction - nonlinear
25-Feb		
1-Mar	6	Clustering and Classification
3-Mar		
8-Mar	7	Optimization, Curve fitting, and Model Selection
10-Mar		
Spring break		
22-Mar	8	Cross validation, Bootstrapping, and Permutation testing
24-Mar		
29-Mar	9	Information theory
31-Mar		
5-Apr	10	Time-domain, frequency domain analyses
7-Apr		
12-Apr	11	Time-frequency analyses
14-Apr		
19-Apr	12	Flex Week
21-Apr		
26-Apr	13	Issues in designing experiments and reporting results (w/common errors)
28-Apr		(**Student presentations**)
A few other topics of interest of which we may only have time for one (during Flex Week): (a) Bayesian Inference, (b) GLM, (c) State space analysis and Random walks, (d) Computational modeling basics, (e) Overview of analysis of spike, continuous signal (EEG, LFP), and fMRI data, (f &onwards) Coherence, Image Processing / Calcium Imaging, Graph theory, Granger causality.		

Each week = 2.5 hrs = 150 min
[90] Theory (Lecture)
[30] Problem solving in class (in groups)
[15] Caveats, thumb rules & relevance of technique, critique of methods section of paper.
[15] Quiz

Homework
Assignments will include
1. Reading assignments
2. Problem sets
3. Concept map (for the first few week)

Grading structure (tentative)
(Weekly, take-home) Problem sets (7.5 points * 9 sets; lowest one dropped)
(Weekly, in class) Quizzes (2 points *9; lowest one dropped)
Concept maps for the first 3 weeks (1 point * 3 concept maps)
(Once, in class) Presentation (10 points)
(Final, take-home) A final project?

Course policies
1. The reading assignments, concept maps and problem sets/paper critiques will all form an integral part of the in-class discussion on the day they are due. Completing the homework assignments in a timely fashion will be critical for successful interaction in class, and more importantly, for maximizing what you get out of this course. So, not working on them or not turning them in on time will adversely affect what you get out of class. For this reason, I typically will not allow late submissions. Please contact me if there are extenuating circumstances preventing you from turning in homework, and we can work something out on a case-by-case basis.
2. Students must abide by the JHU code of academic ethics: The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Ethical violations include cheating on exams, plagiarism, reuse of assignments, improper use of the internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition. In this course, quizzes and exams are to be done without discussion or collaborations (questions about them should always be brought to your professor or TA). Discussion of the homework assignments among students is allowed; however, each student must turn in their own work (as directed by the instructor). Report any violations you witness to the instructor. You may consult the associate dean of students and/or the chair of the Ethics Board beforehand. See the guide on "Academic Ethics for Undergraduates" and the Ethics Board Website (**http://ethics.jhu.edu**) for more information.
3. Bring questions to the TA's office hours (TBA). You may also email me or the TA with questions. Typically, I will pool questions related to class material and discuss them in class. Any emails on administrative or other personal concerns, I will respond to individually.