Quantitative Methods for the Brain Sciences

AS.200.318. Spring 2014. Tu/Th 1.30-2.45 pm (217 Ames)

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

The goal of this class is to train students in the methods that are commonly used in analyzing "brain data". It is designed to serve students who do not have a strong quantitative background. Therefore, rather than being a "Math" or a "Stats" class, this class is more of a guide to frequently used quantitative methods. Emphasis will be on gaining a conceptual understanding of techniques, and their use. We will focus on the analysis of brain activity data (from electrophysiology and imaging, and to some extent, fMRI). We will look at how to summarize data (normalization, comparisons, etc), how to extract the process underlying a data set (curve fitting), data visualization, etc. In order to develop expertise in the techniques and their use, you will be asked, as part of your homework assignments, to take frequent, short quizzes, to solve problem sets/critique journal articles. Knowledge of MATLAB and IMAGEJ is a plus, but not necessary, as we will go over the basics as part of the class. If time permits, we will take quick detours into labs (the "trenches") for a first hand look at neuroscientific data as they are being generated.

Target audience: Early gradual students and upper-level undergraduates (with permission).

Course benefits

By the end of the course, you can expect to:

1. Be able to apply appropriate mathematical and statistical techniques to, and draw valid conclusions from, typical (neuroscientific) 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 a personally meaningful framework.

Some topics that will be covered

1. Effective reading and concept maps
2. Basics of MATLAB.
3. Basic probability, linear algebra.
4. Correlation, independence and orthogonality from statistical, algebraic and geometric perspectives.
5. Convolution, smoothing and filtering.
6. Curve fitting, regression, generalization, model selection.
7. Dimensionality reduction (PCA etc).
8. Frequency domain analyses.
9. Basic information theory.
10. Random walk, diffusion.
11. Bootstrapping, permutation tests.
12. Normalization, modulation indices and summarizing data. Data visualization.
13. Image processing (registration, filtering, deconvolution, etc) and basics of IMAGEJ.
14. Basic analysis of spike trains and local field potentials.
15. Basic anaylsis of fMRI data.

Homework

For every class, you will be assigned homework that will have up to three components. They are indicated below with an estimate of how long it will take you to complete each component.

1. [2 hrs] Reading: Will cover new topics that will be discussed in the upcoming class. These readings will provide a framework for the in-class discussion, thereby helping to deepen understanding. They will also provide an opportunity to practice efficient reading techniques.
2. [15 min] Concept map: Your own summary of the new reading (in the form of a "concept map" or "mind map"). This is critical for consolidating what you have learned, and will allow you to practice organizing new information.
3. [~1 hr per week, when assigned] Assignment: Will test understanding of methods learned in the past week, test ability to explain analysis, or test ability to evaluate the appropriateness of analysis techniques in a paper given the conclusions the authors are trying to draw.

Completing the homework assignments in a timely fashion will be critical for maximizing what you get out of this course. You will be given a short (5-10 minute) quiz on the reading material near the start of each class. Also, you may be asked to share key points or concerns with either the homework or the reading. So, make sure to allocate and spend "quality" time on your assignments each week.

Structure of each class

Submit concept map of readings.
10': In class quiz.
45': Discussion of readings, examples and answers to quiz.
5' : break.
15': Preview of readings for next class
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.

Grading structure (tentative)

10 points for concept maps (1 point * 20 concept maps)
30 points for quizzes (1.5 points * 20 quizzes)
15 points for midterm exam
20 points for final exam
15 points (flexible), likely for 3-5 assignments (problem sets / programming assignments / paper critiques) distributed over the semester.

Course policies

1. 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. 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.
2. 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. 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.
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.