Title: Computational Modeling & Analysis in Neuroscience

Description: Quantitative methods for exploring and understanding data are becoming increasingly common in neuroscience. The aim of this course is to introduce students to state-of-the-art methods that are used for data analysis and computational modeling of behavior and neural activity. Classes will combine discussions of primary research papers with coding tutorials to facilitate focused, hands-on exploration of quantitative methods of interest. Students will need their own computers and access to MATLAB. Minimal programming experience is helpful but not required.

Schedule: The class will meet for two 90-minute sessions per week on Monday and Wednesday. Monday's meetings will be a combined lecture and student-led discussion, and Wednesday's meetings will be a hands-on tutorial exploring concepts from Monday's lecture. *Exceptions*: No class on Labor Day (Sept 7th)—instead, class will meet the **Friday** before Labor Day, Sept 4th. Dr. Chang and Dr. Levy are giving their lectures on the Wednesdays of their respective weeks.

Date	*Topic*	*Lecturer*
Sept. 2nd	Introduction to MATLAB	N/A
Sept. **4th** & 9th	Behavioral Data Analysis: Visualization of Choices	Steve Chang
Sept. 14th & 16th	Behavioral Data Analysis: Basic Model Fitting and Selection	Ifat Levy
Sept. 21st & 23rd	Neural Activity Analysis: Spectral Analysis and Filtering	Alex Kwan
Sept. 28th & 30th	Neural Activity Analysis: Time-Frequency Analysis	George Dragoi
Oct. 5th & 7th	Neural Activity Analysis: Spike-Triggered Averaging	Damon Clark
Oct. 12th & 14th	Generative Models of Neural Activity	Jamie Mazer
Oct. 26th & 28th	Behavioral Modeling: Reinforcement Learning	Daeyeol Lee
Nov. 2nd & 4th	Behavioral Modeling: Reaction Times	Bart Massi
Nov. 9th & 11th	Modeling Single-Neuron Activity	John Murray
Nov. 16th & 18th	Modeling Populations of Neurons	Genevieve Yang
Nov. 30th & Dec. 2nd	Project Preparation Week (no class)	N/A
Dec. 7th & 9th	Student Presentations	N/A

Grading: Each week, students will be required to write an original abstract for each of the assigned readings. Students will be expected to participate during discussions and to complete in-class tutorials. At the end of the course, students will present an original project based on the material covered during the semester. This assignment is relatively open-ended, and can consist of a novel computational analysis of one's own data, an analysis a detailed analysis of a model discussed in class or development and analysis of a new model.

Breakdown of Final Grade:

<u>Class Participation & Attendance (60%)</u>
Students will be expected to attend all tutorials and lecture/discussion sections, and notify the TAs when attendance is not possible. Students will be expected to participate during paper discussions. Although tutorials will not be collected or graded, students will be expected to make a strong effort to complete them.

<u>Abstracts (10%)</u>
Students will be expected to write an abstract (~150-300 words) for the assigned paper each week, as though they were the authors of the paper. This abstract should not be identical to the paper's actual abstract. Abstracts are due on the day of lectures/discussions (typically Mondays).

<u>Final Project (30%)</u>
Students will apply what they have learned throughout the semester to prepare a brief presentation about an original quantitative analysis of their own data using methods discussed during class, a more detailed analysis of a model or data that was discussed in class, or the development and analysis of a new model.

Reading List

Week 2, Behavioral Data Analysis: Visualization of Choices:
Britten, K. H., Shadlen, M. N., Newsome, W. T., & Movshon, J. A. (1992). The analysis of visual motion: a comparison of neuronal and psychophysical performance. *The Journal of Neuroscience*, *12*(12), 4745-4765.

Week 3, Behavioral Data Analysis: Basic Model Fitting & Selection:
Park, S. Q., Kahnt, T., Rieskamp, J., & Heekeren, H. R. (2011). Neurobiology of value integration: when value impacts valuation. *The Journal of neuroscience*, *31*(25), 9307-9314.

Supplement:
Kable, J. W., & Glimcher, P. W. (2007). The neural correlates of subjective value during intertemporal choice. *Nature neuroscience*, *10*(12), 1625-1633.

Week 4, Neural Activity Analysis: Spectral analysis & Filtering:
Sigurdsson, T., Stark, K. L., Karayiorgou, M., Gogos, J. A., & Gordon, J. A. (2010). Impaired hippocampal–prefrontal synchrony in a genetic mouse model of schizophrenia. *Nature*, *464*(7289), 763-767.

Week 5, Neural Activity Analysis: Time-Frequency Analysis:
Fujisawa, S., & Buzsáki, G. (2011). A 4 Hz oscillation adaptively synchronizes prefrontal, VTA, and hippocampal activities. *Neuron*, *72*(1), 153-165.

Week 6, Neural Activity Analysis: Spike-Triggered Averaging:
Chichilnisky, E. J. (2001). A simple white noise analysis of neuronal light responses. *Network: Computation in Neural Systems*, *12*(2), 199-213.

Week 7, Generative Models of Neural Activity:
Baccus, S. A., & Meister, M. (2002). Fast and slow contrast adaptation in retinal circuitry. *Neuron*, *36*(5), 909-919.

Week 8, Behavioral Modeling: Reinforcement Learning:
Daw, N. D., O'Doherty, J. P., Dayan, P., Seymour, B., & Dolan, R. J. (2006). Cortical substrates for exploratory decisions in humans. *Nature*, *441*(7095), 876-879.

Supplement:
Schultz, W., Dayan, P., & Montague, P. R. (1997). A neural substrate of prediction and reward. *Science*, *275*(5306), 1593-1599.

Week 9, Behavioral Modeling: Reaction Times:
Roitman, J. D., & Shadlen, M. N. (2002). Response of neurons in the lateral intraparietal area during a combined visual discrimination reaction time task. *The Journal of neuroscience*, *22*(21), 9475-9489.

Supplement:
Gold, J. I., & Shadlen, M. N. (2002). Banburismus and the brain: decoding the relationship between sensory stimuli, decisions, and reward. *Neuron*, *36*(2), 299-308.

Week 10, Modeling Single-Neuron Activity:
Rossant, C., Leijon, S., Magnusson, A. K., & Brette, R. (2011). Sensitivity of noisy neurons to coincident inputs. *The Journal of Neuroscience*, *31*(47), 17193-17206.

Week 11, Modeling Populations of Neurons:
Wong, K. F., & Wang, X. J. (2006). A recurrent network mechanism of time integration in perceptual decisions. *The Journal of neuroscience*, *26*(4), 1314-1328.