NROSCI 1046: *Introduction to Computational Neuroscience*

Class Meeting Location and Times: TuTh, 1:00-2:15pm, A214 Langley Hall.

Instructor: Dr. Chengcheng Huang

Office: Langley Hall, A407; E-mail: huangc@pitt.edu

Office hours: Thursdays 4-5 pm. Langley Hall, A407.

Teaching assistant: TBD. The TA will assist students with homework assignments and the final presentation, grade homework assignments and deliver recitations. Students can email TA to ask questions or set up Zoom meetings for office hours. Students can also ask questions in the Discussion board on Canvas.

Lecture: All lectures will take place in person in the assigned classroom. Lectures will not be recorded. I will post some lecture notes on Canvas after each lecture.

Recitation: The TA will deliver recitations once a week, which will cover basic programming skills that are relevant for homework assignments and lectures, as well as supplementary mathematics and clarifications for the lectures. The delivery method of recitations is to be determined.

Course description:

Computational neuroscience applies theoretical and numerical techniques to understand brain functions and neural coding. In this course, students will learn how to simulate and analyze model neurons and networks of neurons, and how simple neuronal networks perform computations. Students will also learn how to analyze spike train data and decode information from neural responses. We will have hands-on MATLAB practice sessions throughout the course. By the end of the course, students will be familiar with the mathematical formulations to study neural coding and network dynamics, and acquire programming skills in MATLAB. Knowledge of linear algebra, probability and differential equations is recommended, but not required.

Tentative course outline:

1. **Single neuron models**
   Integrate-and-fire neuron models; Adaptation
   Matlab session
   Mean-driven vs fluctuation-driven spiking

Spike train statistics; Poisson process
Matlab session

2. **Neural encoding and decoding**
   Firing rates; tuning curves
   Spike-triggered average, receptive field
   Matlab Session
   Single neuron decoding, signal detection theory
   Population decoding
   Matlab Session

3. **Population models**
   Firing rate model; Bistable systems
   Phase plane analysis
   Working memory and decision-making models
   Matlab Session
   E/I network; oscillations
   Inhibition-stabilized network
   Hopfield model/ attractive networks
   Matlab Session

4. **Learning**
   Hebbian learning
   Supervised learning; Perceptron
   Reinforcement learning
   Matlab Session

Prerequisites: Intro to Neuroscience (NROSCI 1000, 1003) with a minimum grade of B-. Calculus I (MATH 0220 or equivalent) with a minimum grade of C.

Primary Text: *Theoretical neuroscience.* Peter Dayan and Larry Abbott, MIT Press, 2005 (https://mitpress.mit.edu/books/theoretical-neuroscience)

Additional Recommended Texts:
Neuronal dynamics: From single neurons to networks and models of cognition, Wulfram Gerstner, Werner M. Kistler, Richard Naud, and Liam Paninski, Cambridge University Pres, 2014 (Online: https://neuronaldynamics.epfl.ch/online/index.html)

MATLAB for neuroscientists: an introduction to scientific computing in MATLAB, Pascal Wallisch, Michael E. Lusignan, Marc D. Benayoun, Tanya I. Baker, Adam S. Dickey and

Nicholas G. Hatsopoulos, Academic Press, 2014 (https://www.sciencedirect.com/book/9780123838360/matlab-for-neuroscientists)

Grading: Six assignments (50%), final presentation (30%), class participation (20%). There is *no* final exam during the finals week. Grading scale: A/A±: 90-100%, B/B±: 80-89%, C/C±: 70-79%, D/D±: 60-69%, F: <60%. The grading policy does not depend on the risk posture of the university.

Assignments (50%): The course will have 6 assignments. The best 5 assignments will be counted toward the final score. Each assignment will involve a significant MATLAB component and further analysis to be done by the student. For each assignment, students need to submit a write-up to describe the results, and the associated MATLAB code that can be run successfully and generates relevant figures. Students are welcome to work together on homework. However, each student must turn in his or her own assignments, and *no copying from another students work is permitted*. Each assignment needs to be submitted on Canvas before the due dates. Late homework will not be accepted.

Assignment	Assigned Date	Due Date
1	Aug 31	Sep 9
2	Sep 13	Sep 23
3	Sep 27	Oct 7
4	Oct 11	Oct 21
5	Oct 24	Nov 4
6	Nov 8	Nov 18

Final presentation (30%): The subject of the project should be a summary of one or more papers. Students will work in groups of two or three. I will post a list of papers on Canvas, from which students can choose to present. Students can also choose other papers outside the list. Each presentation should be about 10 minutes, and all group members take turns to present. All students must attend the presentation sessions, which will be on **Dec 7 & 9** during the lecture time. Students need to email me the paper chosen to present and the names of other group members no later than **Nov 19** (all group members must submit their own email).

Class Participation (20%): Each week, students need to post questions and/or answer other students' questions on the Discussion Board on Canvas. During the final presentations, all students need to attend, comment on other groups presentations and ask questions. Participation during lectures will also be considered.

Disability concerns: If you have a disability for which you are or may be requesting accommodation, you are encouraged to contact both me and Disability Resources and Services

(DRS), 216 William Pitt Union, (412) 648-7890, drsrecep@pitt.edu, (412) 228-5347 for P3 ASL users, as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.

Academic integrity: Students in this course will be expected to comply with the University of Pittsburghs Policy on Academic Integrity. Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process, initiated at the instructor level, as outlined in the University Guidelines on Academic Integrity. This may include, but is not limited to, the confiscation of the examination of any individual suspected of violating University Policy. Furthermore, no student may bring any unauthorized materials to an exam, including dictionaries and programmable calculators. To learn more about Academic Integrity, visit the Academic Integrity Guide for an overview of the topic. For hands-on practice, complete the Understanding and Avoiding Plagiarism tutorial.

Health and Safety : In the midst of this pandemic, it is extremely important that you abide by public health regulations and University of Pittsburgh health standards and guidelines. While in class, at a minimum this means that you must wear a face covering and comply with physical distancing requirements; other requirements may be added by the University during the semester. These rules have been developed to protect the health and safety of all community members. Failure to comply with these requirements will result in you not being permitted to attend class in person and could result in a Student Conduct violation. For the most up-to-date information and guidance, please visit `coronavirus.pitt.edu` and check your Pitt email for updates before each class.