NROSCI 1046 (graduate section 2146): *Introduction to Computational Neuroscience*

Class Meeting Location and Times: TuTh, 12:30-1:45pm, 132 Chevron Science Center.

Instructor: Dr. Chengcheng Huang

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

Office hours: Tuesdays 3-4 pm. Langley Hall, A407.

Teaching assistant: Eve Ayar, ecayar@andrew.cmu.edu. The TA will assist students with homework assignments and the final presentation, and grade homework assignments. If you have any question about the grading of assignments, please contact the TA. The TA will have office hours on Zoom weekly.
TA's office hour: Tuesdays 4-5pm, https://cmu.zoom.us/j/98494662644

Lecture: All lectures will take place in person in the assigned classroom. Lectures will be recorded. I will post lecture notes on Canvas after each lecture.

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
   Synaptic inputs; Mean-driven vs fluctuation-driven spiking
   Matlab session
   Spike train statistics; Poisson process
   Matlab session

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

3. **Population models**
   Firing rate model; Single population model
   Two-population model; Phase plane analysis
   Working memory and decision-making models
   Matlab Session
   E/I network; oscillations
   Matlab Session

4. **Learning**
   Hebbian learning
   Supervised learning; Perceptron
   Matlab Session
   Reinforcement learning
   Dimensionality reduction; Principal components analysis
   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 Textbook: *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 (60%), final project (30%), class participation (10%). 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%.

Assignments (60%): The course will have 6 assignments. 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 student's work is permitted*. Each assignment needs to be submitted on Canvas before the due dates. Late homework will not be accepted.

Assignment	Due Date
1	Sep 13
2	Sep 27
3	Oct 11
4	Oct 25
5	Nov 8
6	Nov 22

Final project (30%): The subject of the project should be a summary of one or more papers. Students will work in groups of three (undergraduate students) or two (graduate students). 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 10 minutes plus 5 minutes for questions, and all group members take turns to present. All students must attend the presentation sessions, which will be on **Dec 5 & 10** 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 15** (all group members must submit their own email).

Additional requirements for graduate students: For the final project, graduate students need to propose new research questions based on the paper chosen to present. Students need to replicate some results from the paper, analyze some parameter dependence of the published model, or modify the model. In addition to the final presentation, graduate students also need to submit a report on what they learned and did on this project. The report needs to be at least 5 pages, and needs to include a description of the paper, your results and figures and references. Graduate students can only work in groups of two. Each group submits a single report. **The report needs to be submitted by Dec 13**.

Class Participation (10%): Each week, students need to answer the questions posted on the Discussion Board on Canvas, and reply other students' questions. During the final

presentations, all students need to attend, comment on other groups' presentations and ask questions. Participation during lectures will also be considered.

MATLAB installation: The homework assignments require MATLAB. In addition, we will have hands-on MATLAB coding sessions in class throughout the course. You need to install MATLAB **before** class begins. To install, login to my.pitt.edu, navigate to"Software Download Services," and search for "MATLAB". Choose the version compatible with your computer and download and install. When it asks to select additional toolboxes, you may choose "Signal Processing Toolbox" and "Statistics and Machine Learning Toolbox" as they may have some helpful functions for our class. You don't need to install all of the toolboxes as that will take lots of memory space. You can always download additional toolboxes later if needed. If you have any problem installing MATLAB, please contact Pitt IT help desk.

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 Pittsburgh's 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.

The Pitt Concern Connection: The University of Pittsburgh strives to build and maintain a positive and healthy working, learning, and living environment. Reporting concerns and asking questions can minimize the potential negative impact of inappropriate conduct on the University and our employees, faculty, and students. Reporting can help improve our culture and operations by identifying issues that require attention. The Pitt Concern Connection is a dedicated reporting system where University members can elevate irregular or troublesome workplace, campus, and other issues so that they can be reviewed, addressed, and resolved. Report an issue or ask a question online, by telephone, or via text message. The Pitt Concern Connection is not an emergency service. Immediate, life-threatening safety

concerns should be reported to 911 or by contacting your local University police or security department.

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.