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

Class Meeting Location and Times: TuTh, 2:30-3:45pm, 132 Chevron Science Center.

Instructor: Dr. Chengcheng Huang

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

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

Teaching assistant: TBD.

Lecture: All lectures will take place in person in the assigned classroom. Lectures will be recorded. Recordings will be available on Panopto accessed through Canvas. Zoom meetings will be set up on Canvas during lecture times. These are used for recording purpose only and questions on the Zoom will not be monitored. Lecture slides will be posted on Canvas.

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; f-I curve; Adaptation
   Matlab session
   Exponential integrate-and-fire model
   Variability in neuronal responses; Spike train statistics; Poisson process
   Neuronal responses to noisy inputs; Mean-driven vs. fluctuation-driven spiking; Balanced E & I
   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; Single population model
   Two-population model; Phase plane analysis
   Working memory and decision-making models
   Matlab Session
   Hopfield model/ attractive networks

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 12
2	Sep 26
3	Oct 14
4	Oct 24
5	Nov 7
6	Nov 21

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 2 & 4** 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 7** (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 12**.

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 Services: 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),140 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 Academic Integrity Modules.

No Use of Generative AI Permitted: Intellectual integrity is vital to an academic community and for my fair evaluation of your work. All work completed and/or submitted in this course must be your own, completed in accordance with the University's Guidelines on Academic Integrity. You may not engage in unauthorized collaboration or make use of ChatGPT or any other generative AI applications at any time.

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 Office of Compliance, Investigations and Ethics 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. This 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.

Civil Rights and Title IX: The University of Pittsburgh does not tolerate any form of discrimination, harassment, or retaliation based on disability, race, color, religion, national origin, ancestry, genetic information, marital status, familial status, sex, age, sexual orientation, veteran status or gender identity or other factors as stated in the University's Title IX policy. The University is committed to taking prompt action to end a hostile environment that interferes with the University's mission. For more information about policies, procedures, and practices, visit the Civil Rights & Title IX Compliance web page.

I ask that everyone in the class strive to help ensure that other members of this class can learn in a supportive and respectful environment. If there are instances of the aforementioned issues, please contact the Title IX Coordinator, by calling 412-648-7860, or e-mailing titleix-coordinator@pitt.edu. Reports can also be filed online. You may also choose to report this to a faculty/staff member; they are required to communicate this to the University's Office of Institutional Engagement and Wellbeing. If you wish to maintain complete confidentiality, you may also contact the University Counseling Center (412-648-7930).

Your Well-being Matters: College/Graduate school can be an exciting and challenging time for students. Taking time to maintain your well-being and seek appropriate support can help you achieve your goals and lead a fulfilling life. It can be helpful to remember that we all benefit from assistance and guidance at times, and there are many resources available to support your well-being while you are at Pitt. You are encouraged to visit Thrive@Pitt to learn more about well-being and the many campus resources available to help you thrive.

If you or anyone you know experiences overwhelming academic stress, persistent difficult feelings and/or challenging life events, you are strongly encouraged to seek support. In addition to reaching out to friends and loved ones, consider connecting with a faculty member you trust for assistance connecting to helpful resources.

The University Counseling Center is also here for you. You can call 412-648-7930 at any time to connect with a clinician. If you or someone you know is feeling suicidal, please call the University Counseling Center at any time at 412-648-7930. You can also contact Resolve Crisis Network at 888-796-8226. If the situation is life threatening, call Pitt Police at 412-624-2121 or dial 911.