9.49/9.490: Neural circuits for cognition

MIT
Fall 2019
Tu/Th 2:30 pm – 4pm
46-3015

Instructors:

Ila Fiete
fiete@mit.edu
Office hours: Tue noon-1 @ 46-5065, or by appointment

TA:

Sugandha (Su) Sharma
susharma@mit.edu
Office hours: Wed 4-5 PM @ 46-5065

Daniel Zysman
dzysman@mit.edu
Office hours: by appointment

Course content and aims
This class takes a computational approach to examine circuits in the brain that perform elemental cognitive tasks: tasks that are neither directly sensory nor directly motor in function, but are essential to bridging from perception to action. Covers circuits and circuit motifs in the brain that underlie computations like integration, decision-making, spatial navigation, inference, and other cognitive elements. Students study empirical results, build dynamical models of neural circuits, and examine the mathematical theory of representations and computation in such circuits. Considers noise, stability, plasticity, and learning rules for these systems. Students taking the graduate version complete additional assignments.

We will study the following topics:

- Sensory perception
- Attention
- Memory
- Cognition in motor control
- Decision making
- Spatial navigation
- Neural coding
- Learning and development, pattern formation

Prerequisites
9.40, 18.06, or permission of instructor.

Textbook
We have no single text, and you are not required to acquire one. However, the course will draw on material from original papers and pieces of texts including Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems, by Dayan, P., and Abbott, L.F. 1st edition. (MIT Press, 2005; available free online and via a link on our course website), and Principles of Cognitive Neuroscience, by D. Purves, K.S. LaBar, M.L. Platt, M. Woldorff, R. Cabeza, S.A. Huettel. 2nd edition. (Sinauer Associates, an imprint of Oxford University Press, 2012; available for purchase at major online booksellers).

Communication and discussion
We will use Piazza for class discussion. The system allows for general discussion between classmates, the TA, and myself. If you have questions or contributions related to class content, it is best to do it via Piazza so that all your peers can also benefit. To avoid redundancy, please adhere to Piazza etiquette: Before submitting a new thread check that the question you intend to ask has not been previously addressed.
Find our class page at: https://piazza.com/mit/fall2019/949/home

Email should be only used for private communications regarding extension requests, scheduling/class conflicts, sickness or similar inquiries.

Course-related materials including this syllabus will be posted on the Stellar course website: https://stellar.mit.edu/S/course/9/fa19/9.49/

Software
I will use the mathematical programming languages Matlab or Python (SciPy) for in-class demonstrations. You may do your homework programming in Python or Matlab; Python is preferred and encouraged. If you have only used Matlab, this might be an excellent time to learn Python.

SciPy is available for free download in various install packages online.

The Course instructors and TA will help to get you up and running through a tutorial session (TBA).

Grading
There are three components to your grade: problem sets, participation in presenting papers in class, and a final project. The breakdown will be as follows:

Problem sets 1/2
Class paper presentations 1/6
Final project, presentation, and report 1/3

Grades are based on individual performance on these three components, and are not curved. The following score thresholds are guaranteed to earn you at a minimum the following grades:

>=90%	A-
>=80	B-
>=70	C-
>=60	D-

Depending on the difficulty of the material, we may adjust these thresholds *downwards*. We will in no case adjust them *upwards*.

Active participation in the class is also encouraged and taken into account in borderline grade cases!

Homework policy

You are free to collaborate on homework in small groups, and even encouraged to do so. However, there are three requirements: 1) You must do your own programming, from scratch, and turn in code developed yourself (we will check for copied code), 2) For non-coding portions of the assignment, write/type out your own version of the response, even if the solutions were discussed together in a group. Writing it down yourself helps to ensure that you understand something well. 3) Write the name of your collaborators at the top of your submitted assignment.

Code should be submitted as Jupyter notebooks (these are compatible with both Matlab and SciPy), with fully executable code, figures, and added textual commentary. Submissions of code will be via Stellar, on the class Stellar website:
https://learning-modules.mit.edu/gradebook/index.html?uuid=/course/9/fa19/9.49#assignments

Non-coding parts may be handwritten, typewritten, or submitted as part of the Jupyter notebook (which supports LaTeX formatting). If you do not use the Jupyter notebook for this portion, please submit *printed* versions of the non-coding pieces to facilitate written feedback/comments.

There will be 6 homework assignments. Release and due dates will be indicated on the class schedule. Assignments will be due on **Fridays by 5:00 pm.**

You will be allowed **4** free days of **unexcused extensions** on homework assignments to flexibly manage scheduling difficulties across the semester. Once these free days have been used, late work will be penalized at 20% per day.