Biological and Artificial Intelligence

Neuro 140
Harvard College/Graduate School of Arts and Sciences
Spring 2022

Overview

This is a seminar-style course which provides a foundational overview of the fundamental ideas in computational neuroscience and the study of Biological and Artificial Intelligence. The course will connect the study of brains to the blossoming and rapid development of ideas in Artificial Intelligence. Topics covered include the biophysics of computation, neural networks, machine learning, Bayesian models, theory of learning, deep convolutional networks, generative adversarial networks, neural coding, control and dynamics of neural activity, applications to brain- machine interfaces, connectomics, among others. Lectures will be taught by leading Harvard experts in the field.

Lectures presented by: **Amin**, **Ba, Born, Drugowitsch, Gershman, Janson, Kreiman, Nelson, Pehlevan, Serre, Sompolinsky, Ullman**

Class website

http://klab.tch.harvard.edu/academia/classes/BAI/bai.html

https://canvas.harvard.edu/courses/96019 (login required)

Lecture notes, slides, reading assignments, and other information will be posted in the class web site.

Location: Northwest B108

Meeting Times

Tuesdays: 3:00 pm to 5:00 pm

FIRST CLASS: January 25, 2022

Contact information and office hours

Main faculty: Gabriel Kreiman

gabriel.kreiman@tch.harvard.edu
Longwood campus: 3 Blackfan Circle, CLS 18047. Boston, MA

Office hours: Office hours will be held remotely via zoom. By appointment only. Please email Prof. Kreiman to coordinate.

Teaching assistants:

Spandan Madan

spandan_madan@g.harvard.edu

Zoom: https://harvard.zoom.us/my/spandanmadan

Prerequisites:

<u>Recommended:</u>

- Math (Maa/Mab, Math1A,1B, Math19a or equivalent).
- CS 50, CS107 [or equivalent]
- Experience with Machine Learning or Data Science through below mentioned classes, or related projects.

<u>Great to Have, but not necessary:</u>

- CS 96, CS 109A/B, or CS 181, or experience with Machine Learning or Data Science through projects.
- MCB80, Physical Sciences 1, Life Sciences 1a (or Life and Physical Sciences A), Life Sciences 1b. [or equivalent]

Topics:

- Introduction to artificial intelligence
- Introduction to computational neuroscience
- Machine learning
- Reinforcement learning
- Visual recognition
- Computer vision

- Deep convolutional networks
- Neural networks
- Neural coding
- Learning and memory
- Animal intelligence
- Collective intelligence

Suggested books

There won't be an official book for the class. This is a seminar-style class that will not be following any one specific book. Here are some interesting books that touch upon some of the topics covered in class.

- Kreiman G. Biological and Computer Vision (2021). Cambridge University Press.
- Ullman S (1996) High-level vision. MIT Press.
- Wandell BA (1995) Foundations of vision. Sunderland Sinauer Associates.
- Ripley. Pattern recognition and neural networks (1996). Cambridge University Press.
- Rao, Olshausen and Lewicki (eds) (2002). Probabilistic models of the brain. MIT Press.
- Koch C (2005) The quest for consciousness. Roberts & Company Publishers.
- Dayan and Abbott (2002). Theoretical Neuroscience. MIT Press.
- Horn BKP. (1986) Robot Vision. MIT Press.
- Kriegeskorte and Kreiman G. (2011) Understanding visual population codes. MIT Press.
- Davies ER. (2005). Machine Vision, Third Edition: Theory, Algorithms, Practicalities (Signal Processing and its Applications). Elsevier.
- Sutton RS, Barto AG. (2018) Reinforcement Learning: An Introduction. MIT Press.
- Vapnik, V. (1998). The Nature of Statistical Learning Theory. Springer.
- Tegmark M (2017) Life 3.0: Being Human in the Age of Artificial Intelligence. Random House.
- Poole D, Mackworth, A. (2017) Artificial Intelligence: foundations of computational agents, 2nd edition, Cambridge University Press.
- Poggio TA, Anselmi F. Visual Cortex and Deep Networks (2016). MIT Press

Projects

A highlight of the course will be hands-on direct exposure to projects in the field:

- A list of projects will be provided, students have to choose one and only one project.
- With approval from the TA and Faculty, students can propose a variation of one of the proposed projects or a project of their own.
- Students work on their projects throughout the course. There will be office hours and consultation with the TAs via email request
- There will be multiple deliverables and check-ins throughout the semester. See schedule and credits here.
- At the end of the course (see schedule), students must hand-in a final report on their project.

Grading

Final grades will be computed according to the details given in the project timeline and credits document. Summary of grading:

Deliverable 1:	10 points
Deliverable 2:	5 points
Deliverable 3, Midterm report:	20 points
Deliverable 4:	7.5 points
Deliverable 5:	7.5 points
Deliverable 6, Final project report:	50 points

Schedule

Schedule posted on class web site