Neuro 130 / Neuro 230
Harvard / GSAS 78454
Visual object recognition: From computational and biophysical algorithms to cognition

FALL 2020

The fall 2020 edition of Neuro 130 / Neuro 230 will be conducted via Zoom

Overview
Visual recognition is essential for most everyday tasks including navigation, reading and socialization. Visual pattern recognition is also important for many engineering applications such as automatic analysis of clinical images, face recognition by computers, security tasks and automatic navigation. In spite of the enormous increase in computational power over the last decade, humans still outperform the most sophisticated engineering algorithms in visual recognition tasks. In this course, we will examine how circuits of neurons in visual cortex represent and transform visual information. The course will cover the following topics: functional architecture of visual cortex, lesion studies, physiological experiments in humans and animals, visual consciousness, computational models of visual object recognition, computer vision algorithms.

Class web site
http://klab.tch.harvard.edu/academia/classes/hms_neuro300_vision/index.html
(can be accessed through: http://tinyurl.com/vision-class)
Lecture notes, slides, reading assignments and other information will be posted in the class web site.

Location: The fall 2020 edition of Neuro 130 / Neuro 230 will be conducted via Zoom. Links will be posted on the class web site.

Course Meeting Times and Schedule
Mondays 3:00 pm to 5:00 pm
Lectures: 60 minutes / week.
Reading assignment discussion: 60 minutes/week

Faculty: Gabriel Kreiman + invited guests

TA: Will Xiao [xiaow@fas.harvard.edu]

Contact information:
gabriel.kreiman@tch.harvard.edu
xiaow@fas.harvard.edu

Prerequisites:
Recommended:
Life Sciences 1a (or Life and Physical Sciences A) and Life Sciences 1b. [or equivalent]
Math (Maa/Mab, Math1A,1B, Math19a or equivalent). Physical Sciences 1. MCB80.

Topics:
- Introduction to pattern recognition. Why is vision difficult? Overview of key questions in the field.
- Characterization of the visual input. Natural image statistics.
- The retina, LGN and primary visual cortex. Neurophysiology and neuroanatomy.

- Lesion studies in humans and animals.
- Adventures into terra incognita: Neurophysiology beyond primary visual cortex.
- Electrical stimulation in visual cortex and causality.
- Biophysically-inspired computational models of visual object recognition.
- Computer vision. Engineering algorithms and their applications. Machine learning applications to vision.
- Human perception. Psychophysics .Visual Illusions.
- Engineering and prosthetic devices for visual recognition
- Towards understanding subjective visual perception and consciousness.

Suggested book

Kreiman G. Biological and Computer Vision. To appear, Cambridge University Press (2020)

Other great books

Ullman S (1996) High-level vision. MIT Press.
Wandell BA (1995) Foundations of vision. Sunderland Sinauer Associates.
Chalupa LM and Werner JS (editors) (2003). The Visual Neurosciences. MIT Press.
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.
Deco, G. and E.T. Rolls, Computational Neuroscience of Vision, Oxford Oxford University Press.
Dayan and Abbott (2002). Theoretical Neuroscience. MIT Press.
Horn BKP. Robot Vision. MIT Press.
Kriegeskorte N 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.

Homework, Reading assignments and writing requirements

Each week, students have to read, understand and discuss a scientific paper. The paper relates to the topics covered in the previous class and illustrates state-of-the-art research efforts in the field.
Students are required to hand in a discussion of the reading assignment including the following two points (typically half a page to one page):

1) A critic of the paper including missing controls or alternative interpretation of the findings or a critical discussion of the findings
2) Two follow up questions (computational modeling or experiments or computer vision applications)

Do not copy and paste from the paper (the instructor has already read the papers…). Homework is due (electronic format) before the beginning of each class (for the paper discussed the previous week). For a detailed schedule of reading assignments and homework, click here.

Final paper. A final paper is due at the end of the class (details to be provided in class)

Grading

Final grades are computed as follows:

Homework	50%
Comments on lecture notes	15%
Class discussion	15%
Final paper	20%

Schedule

CLASS	Date	Title	Comment
1	09/02/20	Introduction to visual pattern recognition. Why is vision difficult?	No reading assignment
	09/07/20	**No class: Labor Day**	
2	09/14/20	Natural image statistics and the retina	Discussion Reading 1
3	09/21/20	The phenomenology of vision	HW1 due. Discussion Reading 2
4	09/28/20	Learning from lesions	HW2 due. Discussion Reading 3
5	10/05/20	Primary visual cortex	HW3 Due. Discussion reading 4
	10/12/19	**No class: Columbus Day**	
5	10/19/20	Adventures into terra incognita: probing the neurophysiological responses along the ventral visual stream	HW4 Due. Discussion Reading 5
6	10/26/20	First steps into computational neuroscience	HW5 due. Discussion Reading 6
7	11/02/20	Teaching computers how to see	HW6 due. Discussion Reading 7
8	11/09/20	The three levels of understanding vision	HW7 due. Discussion Reading 8
9	11/16/20	Computer Vision	HW8 due. Discussion Reading 9
10	11/23/20	Connecting vision to the rest of cognition	HW9 due. Discussion Reading 10
11	11/30/20	Visual consciousness	HW9 due. Discussion Reading 11
		Reading period: 12/04/20 – 12/09/20	
		Final exam period: 12/10/20 – 12/19/20	**Final exam due 12/14/20**