Neurobiology HMS230
Harvard / GSAS 78454
Visual object recognition:
From computational and biophysical algorithms to cognition

FALL 2013

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: Biolabs 1075

Course Meeting Times and Schedule
Mondays 3:30 pm to 5:30 pm
Lectures: 60 minutes / week.
Reading assignment discussion: 60 minutes/week

Faculty: Gabriel Kreiman

Contact information:
617-919-2530
gabriel.kreiman@tch.harvard.edu

Prerequisites:
Life Sciences 1a (or Life and Physical Sciences A) and Life Sciences 1b. [or equivalent]
Recommended: 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.
• Engineering and prosthetic devices for visual recognition
• Towards understanding subjective visual perception.

Suggested Books

University Press.
Horn BKP. Robot Vision. MIT Press.
Press.
(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 one of
the following (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.

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

Final grades are computed as follows:
- Homework: 60%
- Class discussion: 20%
- Final paper: 20%

Schedule

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<thead>
<tr>
<th>CLASS</th>
<th>Date</th>
<th>Title</th>
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<tbody>
<tr>
<td>1</td>
<td>09/09/13 [Mon]</td>
<td>Introduction to visual pattern recognition.</td>
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<td>2</td>
<td>09/16/13 [Mon]</td>
<td>Why is vision difficult? Natural image statistics and the retina.</td>
<td>Discussion, Reading 1</td>
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<td>3</td>
<td>09/23/13 [Mon]</td>
<td>Primary visual cortex</td>
<td>HW1 due, Discussion Reading 2.</td>
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<td>4</td>
<td>09/30/13 [Mon]</td>
<td>Psychophysical studies of visual object recognition</td>
<td>HW2 due, Discussion Reading 3. <em>Lecture by Jed Singer</em></td>
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<td>5</td>
<td>10/07/13 [Mon]</td>
<td>Lesions and neurological examination of extrastriate visual cortex</td>
<td>HW3 due. Discussion Reading 4. <em>Lecture by Hanlin Tang</em></td>
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<td>10/14/13 [Mon]</td>
<td>NO CLASS: Columbus Day</td>
<td><strong>Note: HW4 due via e-mail on 10/15</strong></td>
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<td>7</td>
<td>10/21/13 [Mon]</td>
<td>Adventures into terra incognita: probing the neurophysiological</td>
<td>Discussion Reading 5.</td>
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<td>responses along the ventral visual stream</td>
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<td>9</td>
<td>11/04/13 [Mon]</td>
<td>From the highest echelons of visual processing to cognition</td>
<td>HW6 due. Discussion Reading 7.</td>
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<td>11/18/13 [Mon]</td>
<td>First steps towards in silico vision</td>
<td>HW8 due. Discussion</td>
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<td>13</td>
<td>12/09/13 [Mon]</td>
<td>Neural correlates of visual consciousness</td>
<td>HW 11 due 12/04/12</td>
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<td>12/19/13 [Th]</td>
<td>Final paper due</td>
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