Neurobiology HMS230  
Harvard / GSAS 78454  
Visual object recognition:  
From computational and biophysical algorithms to cognition  
FALL 2012

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  
TA: Hanlin Tang  

Contact information:  
617-919-2530  
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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.
• Engineering and prosthetic devices for visual recognition
• Towards understanding subjective visual perception.

Suggested Books

Horn BKP. Robot Vision. MIT Press.

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

<table>
<thead>
<tr>
<th>CLASS</th>
<th>Date</th>
<th>Title</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>09/05/12</td>
<td>Introduction to visual pattern recognition. Why is vision difficult?</td>
<td>Note: Special Wednesday Class</td>
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<tr>
<td>2</td>
<td>09/10/12</td>
<td>Natural image statistics and the retina.</td>
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<tr>
<td>3</td>
<td>09/17/12</td>
<td>Primary visual cortex</td>
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<td>4</td>
<td>09/24/12</td>
<td>Lesions and neurological examination of extrastriate visual cortex</td>
<td>HW1 due</td>
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<td>5</td>
<td>10/01/12</td>
<td>Adventures into terra incognita: probing the neurophysiological responses along the ventral visual stream</td>
<td>HW2 due</td>
</tr>
<tr>
<td>6</td>
<td>10/15/12</td>
<td>Psychophysical studies of visual object recognition</td>
<td>HW3 due 10/10 Note: HW due via e-mail on 10/10</td>
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<tr>
<td>7</td>
<td>10/22/12</td>
<td>First steps into inferior temporal cortex</td>
<td>HW4 due</td>
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<tr>
<td>8</td>
<td>10/29/12</td>
<td>From the highest echelons of visual processing to cognition</td>
<td>HW5 due</td>
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<tr>
<td>9</td>
<td>11/05/12</td>
<td>From correlation to causation: electrical stimulation of visual cortex</td>
<td>HW6 due</td>
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<tr>
<td>10</td>
<td>11/12/12</td>
<td>First steps towards in silico vision</td>
<td>HW7 due</td>
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<td>11</td>
<td>11/19/12</td>
<td>Computational models of the ventral visual stream</td>
<td>HW8 due</td>
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<td>12</td>
<td>11/26/12</td>
<td>Computer vision</td>
<td>HW9 due</td>
</tr>
<tr>
<td>13</td>
<td>12/03/12</td>
<td>Neural correlates of visual consciousness</td>
<td>HW10 due 12/10 Note: HW due via e-mail on 12/10</td>
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<td></td>
<td>12/14/2012</td>
<td>Final paper due</td>
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