Exploring Our Visual System
KHC NE 103

(Spring 2017)

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Office hours TBD
Office/Laboratory location: 677 Beacon Street, Room 203/215

Course Description

The course approaches human visual system through multiple datasets, including physiological, imaging, and psychophysical to review present and past neural models, theories and the controversies related to them. Further, we review journal articles which are representative of notable findings in the field of visual neuroscience. In the beginning of each session, a one-page written journal summarizing the key points of the suggested journals are required. Besides the lectures, there are discussion sessions to consolidate the ideas in the suggested articles. In the vision laboratory, students replicate and modify a selection of the presented neural models for learning how to put together model neurons and their connectivities. The practice of neural modeling at multiple levels provides the opportunity of evaluating dynamics, similarities, and differences in models and in physiology.

Course Objectives

Upon completion of this course you should be able to:
1. Generate visual stimuli
2. Gathering data about our visual system
3. Analyze the data we gathered
4. Developing neural models based on the data and their analysis
5. Summarizing the suggestions and predictions of the developed neural models
6. Testing the neural models suggestions in the vision lab by running the experiments which can test the model predictions
7. Comparing the model predictions with the experimental results
8. Improving the models based on the above comparison
9. Looping back to 4 and getting hands on with the data/model paradigm

Required Texts


Attendance
Attendance in class is required.

Academic Dishonesty
http://www.bu.edu/academics/resources/academic-conduct-code/

Grading

- Assignment 1 (due on the 1st session of W 3) 14%
- Assignment 2 (due on the 1st session of W 9) 14%
- Assignment 3 (due on the 1st session of W12) 14%
- Midterm exam 18%
- Final Report (due 2 days prior to the last day of final exam period) 20%
- Discussion meeting 10%
- 13 one-page (per week) written journals (due on the first day of each week lecture) 10%

Course Outline & Readings
Week 1.  Key topics in human vision

Date:
- Seeing and recognizing
- Visual grouping and segregation
- Detectors in primate visual system
- Reflectance and ratio
- Signal and noise in our visual system

Readings:

- KSJ, Ch. 25 (Constructing the visual image)
- Palmer, Ch. 1 (till section 1.3)

Week 2.  Neural models in vision

Date
- Retinal physiology
- Weber Law
- Fechner Law
- Shift property
- Brightness constancy and simultaneous contrast
- Physiology of retina

Readings:

- Palmer, the rest of Ch. 1, Ch. 2, and Ch. 4, Sec. 3.
- KSJ. Ch. 26 and an overview of Ch. 27. Also, skim Ch. 21 if you have had no undergraduate introduction to perception or cognition.

Week 3.  Brain visual pathways

Date
- Eyeball is not flat
- Retinal structure as the image plane on a non-flat surface
- Anatomy and physiology of visual system
- Functions of ON and OFF channels
- Primary visual cortex and the concept of receptive field
- Beyond the primary visual cortex

Readings:
Week 4.  Spatial scales and contrast in vision
Date
- More on receptive fields
- Lateral inhibition
- Detectors and filters, linear systems approach to vision
- Are there definite feature set for probing a visual area?
- Percept and neural representation homeomorphism?

Readings:
- Palmer, Ch. 4.
- KSJ Ch. 27, pp 529-533

Week 5.  Perception of brightness and lightness
Date
- Achromatic Watercolor Effect (WCE)
- Contrast sensitivity of WCE and the polarity effect
- A prelude for contours and surfaces
- Brightness assimilation
- A few neural models for brightness perception
- Challenges to brightness models

Readings:
- Palmer, skim Ch. 3. Read Sec. 3.3 carefully

Week 6.  Constructing the visual image: visual perception is a creative process
Date
- Transparency and neon color spreading
- Diffusion models and time
- Scales again: alternative approaches to diffusion?
- Edge detection
- Hyperacuity
- Prelude to border-ownership approach

Readings:

- KSJ Ch. 25
- Palmer Ch. 6

Week 7. The concept of representation in human visual system

Date

- Grouping cells
- Spatial and cross-orientation competition
- How thin is thin
- Border-ownership signals within the visual cortex
- Thin and thick, grouping across scales

Readings:

- KSJ. Ch. 28.

Week 8. Motion perception and representation

Date

- What is motion?
- Apparent motion and real motion
- Long- and short-range motion
- Traveling Gaussian waves
- Aperture problem
- Neural models of motion processing

Readings:
- Palmer Ch. 10

Week 9. The frames of reference in vision

Date

- Perceptive fields
- Diversity of reference frames for space perception
- Induced motion and depth
- Vector subtraction model

Readings:


Week 10. In class midterm examination

Date

topics:
- The midterm exam will cover the topics in the readings, lecture, discussion, models and experiments from the first 9 weeks

Week 11. Color and color perception

Date

- Opponent and non-opponent chromaticity space
- The effect of complementary chromatic induction in grouping
- The contribution of neon color spreading to generate impossible colors
- Revisiting classic color space

Readings:

- KSJ Ch. 29
- Palmer Ch. 3

Week 12.  Seeing with two eyes: binocular vision, stereopsis, and binocular rivalry

Date

- The correspondence problem
- Matching algorithms
- Disparity and depth
- Monocular depth cues
- Binocular rivalry

Readings:

- Palmer Ch. 5, Sections 1-3
- KSJ Ch. 28, pp 581-561

Week 13.  Our eyes constantly move: eye movements and eye tracking

Date

- Saccade
- Microsaccade
- Drift
- Tremor
- Eye movement measures obtained in different labs

Readings:

- KSJ Ch. 39
- Palmer Ch. 11, Section 11.1

Week 14.  Visual attention

Date

- Change blindness
- Features for attention
- Bottom-up and top-down
- Attentional modulation of receptive fields
- Pop-out and slow search
Readings:

- Palmer Ch. 11, from Section 11.2 to the end of Chapter
- KSJ Ch. 28 pp 565-568