Computational Vision PSY5036F2019

University of Minnesota, Fall Semester, 2019

Instructor:

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≡ Abstract

The visual perception of what is in the world is accomplished continually, instantaneously, and usually without conscious thought. The very effortlessness of perception disguises the underlying richness of the problem. We can gain insight into the processes and functions of human vision by studying the relationship between neural mechanisms and visual behavior through computer analysis and simulation. Students will learn about the anatomy and neurophysiology of vision and how they relate to the phenomona of perception. An underlying theme will be to treat vision as a process of statistical inference. There will be in-class programming exercises using the language Mathematica. No prior programming experience is required; however, some familiarity with probability, vector calculus and linear algebra is helpful.

Readings

Main

- Lecture notes, Main Readings & Supplementary Material are all available online.

Additional readings

MATH AND VISION

- (**EV**) Early Vision. Yuille and Kersten. In *From Neuron to Cognition via Computational Neuroscience*, M.A. Arbib, James J. Bonaiuto Editors, Cambridge MA: The MIT Press, in 2016 (preprint pdf)

- Understanding Vision: Theory, Models, and Data. Li Zhaoping. 2014. (publisher page) (author's web outline)

FUNCTIONAL HUMAN VISION

- (**FV**) *Foundations of Vision*. Wandell ([web](web))

NEUROPHYSIOLOGY

- (**NVN**) *The New Visual Neurosciences*. John S. Werner and Leo M. Chalupa, edts. 2014.

Software

Mathematica

Mathematica is the primary programming environment for this course. Students who have registered for the course will have access through the Psychology Department's site license.

Alternatives: Mathematica is available in several labs on campus, go to http://www.oit.umn.edu/computer-labs/software/index.htm You may wish to purchase *Mathematica for Students* see http://www.wolfram.com/products/student/mathforstudents/index.html.

For help using Mathematica, see: http://mathematica.stackexchange.com

Python/IPython

http://ipython.org http://jupyter-notebook-beginner-guide.readthedocs.org/en/latest/index.html http://www.scipy.org

For an online course in using Python and PsychoPy for research in human vision see: http://nbviewer.ipython.org/github/gestaltrevision/python_for_visres/blob/master/index.ipynb

Writing

- Gopen, G. D., & Swan, J. A., 1990. The Science of Scientific Writing. <u> American Scientist </u> , <u> 78 </u> , 550-558.

- **Supplementary:**
  - The Sense of Style: The Thinking Person's Guide to Writing in the 21st Century (2014), Pinker, Steven. (amazon link)
  - Penrose, A. M., & Katz, S. B. (1998). `<u>` Writing in the Sciences: Exploring Conventions of Scientific Discourse `</u>` . New York: St. Martin's Press, Inc.
  - American Psychological Association. (2009). `<u>` Publication manual of the American Psychological Association `</u>` (6th ed.). Washington, DC: American Psychological Association

- **Writing assistance.** THE CENTER FOR WRITING offers free one-to-one writing assistance to undergraduate and graduate students, with appointments up to 45 minutes. Nonnative speaker specialists are available. For more information, see http://writing.umn.edu.

- Psychology department resources: http://writing.psych.umn.edu/student-resources

Grade Requirements

There will be programming assignments and a final project.

The grade weights are:

- Exercise/programming assignments: 55%
- Final project in-class presentations: 5 %
- Final project : 40% (five parts: 2% (title and outline) +5%(first draft) +5% (peer commentary) +8% (cover letter response) + 20% (final draft))

The programming assignments will use the *Mathematica* programming environment. No prior experience with *Mathematica* is necessary.

Assignment due By the 6 am on the day after the nominal due date. *Late Policy: Assignments turned in within 24 hours following the due date will have 15% deducted from the assignment score. Assignments turned in between 24 and 48 hours following the due date will have 30% deducted from the score. Assignments more than 48 hours late will receive a score of zero.*

Lectures

Check this section before each class for recent additions and revisions.

> **ⓘ Info**
>
> Lecture notes are in Mathematica Notebook and pdf format. You can download the Mathematica notebook files below to view with Mathematica or Wolfram CDF Player (whichis free).

Final Project Assignment

Goal: This course integrates the behavioral, neural and computational principles of perception. Students often find the interdisciplinary integration to be the most challenging aspect of the course. Through writing, you will learn to synthesize results from diverse and typically isolated disciplines. By writing about your project work, you will learn to think through the broader implications of your project, and to effectively communicate the rationale and results of your contribution in words. You will do a final page research report in which you will describe, in the form of a scientific paper, the results of an original computer program on a topic in computational vision.

Your final project will involve: 1) a computer program and; 2) a 2000-3000 word final paper describing your project. For your computer project, you will do one of the following: 1) Write a program to simulate a model from the computer vision literature ; 2) Design and program a method for solving some problem in perception. 3) Design and program a psychophysical experiment to study an aspect of human visual perception. The results of your final project should be written up in the form of a short scientific paper or Mathematica Notebook, describing the motivation, methods, results, and interpretation.

If you choose to write your program in Mathematica, your paper and program can be combined can be formated as a Mathematica notebook.

See: Books and Tutorials on Notebooks. If you do your final project using Python, you can turn your paper in as a Jupyter notebook.

Your paper will be critiqued and returned for you to revise and resubmit in final form. You should write for an audience consisting of your class peers.

Completing the final paper involves 4 steps. Each step requires that you email a document to the teaching assistant.

1. **Outline (2% of grade).** You will submit a working title and paragraph outline by the deadline noted in the syllabus. These outlines will be critiqued in order to help you find an appropriate focus for your papers. (Consult with the instructor or TA for ideas well ahead of time).

2. **Complete draft (5% of grade).** A double-spaced, complete draft of the paper must be turned in by the deadline noted in the syllabus. Papers should be between **2000** and **3000** words. In addition to the title, author and date lines, papers must include the following sections: Abstract, Introduction, Methods, Results, Discussion, and Bibliography. Use citations to motivate your problem and to justify your claims. Cite authors by name and date, e.g. (Marr & Poggio, 1979). *Citations should be original sources, not wikipedia.* Use a standard citation format, such as APA. (The UM library has information on style guides, and in particular APA style.) Papers must be typed, with a page number on each page. Figures should be numbered and have figure captions. This draft will be reviewed by your instructor and one of you class peers. **The point break down for the total 5% is: 2 pts for completing Introduction, 2 pts for completing Methods, 1 pt for completing Discussion)**

3. **Peer commentary (5% of grade)**. You will submit a written commentary **(200** to **500** words) on a complete draft of one of your class peers. The project drafts and commentaries will be anonymous. The commentary should provide feedback to improve the quality and clarity of the writing.

4. **Final draft (20% of grade) and "Cover letter" (8% of grade).** The final draft must be turned in by the date noted on the syllabus. The "Cover letter" should describe how your revision addressed comments from your peer evaluator and from your instructor. It should itemize key

criticisms together with a brief description of the changes you made to your draft manuscript.