

Course Syllabus: CptSci475b
Computational Vision and Biological Perception

Instructor: Steven Zucker

Goal: To provide an introduction to biological perception for computer science and engineering students; to provide an introduction to computational vision for mathematics, psychology, and physiology students; and to present steps toward a unified approach to vision.

Rationale: The biological metaphor is common within computer vision, and the computational metaphor is common within psychology and neuroscience. However, few attempts have been made to cross these interdisciplinary boundaries in a coherent, unified manner. This is a highly interdisciplinary course intended to broaden the appreciation of vision for students with different backgrounds.

Prerequisites:

- A basic curiosity about vision, computation, and the brain.
- Some previous understanding of vision from one perspective; e.g., a computer vision or a perceptual psychology course, is helpful. Although the course touches on several mathematical issues, the presentations are informal. No advanced mathematical background is required beyond introductory calculus. Introductory programming skills (e.g. matlab) are necessary to build simple displays (see below).

Text:

xeroxed notes; research papers.

Grading:

Homework: 30 percent
term project 35
final exam 35

Organization: Two lectures/week, 1.5 hrs duration.

1. - Introduction: playing 20 questions against Nature.
 - Elementary visual behaviours and modeling: visual trophisms and molluscs; neurons and synapses.
2. - Elementary visual behaviours and modeling (cont): Limulus and lateral inhibition; simple neural networks; artificial neural nets.
 - Frogs, food, and feature detectors.
3. - Cats, Primates, and simple cells, complex cells.
 - the Hubel-Wiesel hierarchy; First Paradigm Computer Vision (FPCV)
4. - Edge detection in computer vision; differential calculus; continuity.
 - Organization of visual cortex; endstopping; critique of FPCV.
5. - Introduction to Second Paradigm Computer Vision (SPCV); the shape-from-shading problem; "inverse optics"; multiple primate visual areas
 - Introduction to partial differential equations; characteristics; geometry.
6. - Structure from Motion; the Rigidity of the Rigidity constraint; regularization; critique of SPCV.
 - "Edges" as Tangents; boundaries as curves: intro. to differential geometry;
7. - Logical/linear operators; the tangent bundle and orientation hypercolumns; Frenet equations.
 - Visual cortical local circuits; curvature estimation.
8. - Relaxation labeling and intercolumnar interactions.
 - Co-circularity and layer 2/3 local circuits; pyramidal cells.
9. - Texture and shading flow fields; scenel bundles; 2D vs. 3D representations.
 - Segmentation via complexity analysis of the tangent field.
- 10.- Color and cytochrome oxidase blobs (what can't be represented in the tangent field).
 - Local-to-global transitions; Perceptual grouping and integral curves.
- 11.- Visual shape analysis: generic vs. specific; visual areas V4/IT; grandmother cells (FPCV) revisited.
 - Curve evolution equations and their shocks.
- 12.- Fragment linking.
 - Summary.