CAP 6411 Foundations of Vision

Credits: 3 credits

Textbook, title, author, and year: None

Reference materials:

- Book: **Seeing: The Computational Approach to Biological Vision, 2nd ed**., by John P. Frisby and James V. Stone (MIT Press 2010, ISBN: 9780262514279)
- Book: **Vision Science: Photons to Phenomenology**, by Stephen E. Palmer, Bradford Books, MIT Press, Cambridge, MA: 1999.

Additional books and papers whose details will be provided during the semester.

Specific course information

Catalog description: Catalog description: Study of the interdisciplinary science of vision, combining psychological, neurophysiological, and computational aspects of vision research. Research paper and project topics will be chosen from a list of latest developments in the field.

Prerequisites: Graduate-level status or permission from instructor.
Elective graduate-level course for Computer Science, Electrical Engineering, and Computer Engineering students. Open to graduate-level students from other majors/colleges.

Specific goals for the course: Upon successful completion of this course, students will be able to:

- Demonstrate a solid conceptual understanding of how visual information can be processed by humans and machines.
- Identify the challenges involved in understanding, modeling, and simulating human vision mechanisms.
- Compare and contrast the human vision system and computer vision systems designed to achieve comparable functionality.
- Interpret, summarize and critique scientific papers in the field of vision science, analyzing the implications and applications of their research findings.
- Contextualize the latest advances in computer vision, artificial intelligence, and deep learning and their impact on the advancement of vision science.

Brief list of topics to be covered:

1. **Introduction to vision science**: history, methods, theories, approaches, visual perception
2. **The human visual system**: the human eye, the retina, receptive fields, brain cells, the visual cortex, brain maps, physiological mechanisms, psychophysical channels
3. **Psychophysical methods in vision science**: thresholds, sensitivity, bias, just noticeable difference, signal detection theory, two-alternative forced choice (2AFC) methods, Weber's, Fechner's and Stevens's laws
4. **Spatial vision**: edge detection, depth perception, size and distance estimation, the figure/ground problem, lightness perception (brightness, contrast), texture analysis, shape from texture, stereoscopic information, aftereffects

5. **Color vision**: physics of light and color, theories of color vision, physiological mechanisms, color constancy, color blindness, color naming
6. **Object detection, recognition, and categorization**: object properties and parts, representation of shape and structure, perception of function, theories of object categorization
7. **Organizing objects and scenes**: scene analysis, scene classification, objects in context
8. **Visual dynamics**: image motion, object motion, self-motion and optical flow
9. **Visual selection, attention, search, and saliency**: eye movements, bottom-up versus top-down visual attention, feature integration theory, visual search, computational models of visual saliency, applications
10. **Visual memory and imagery**: iconic, short- and long-term memory, visual imagery
11. **Visual awareness**: philosophical foundations, neuropsychology of visual awareness, famous patients (and what can be learned from them), theories of consciousness
12. **Art and the brain**: using works of art to learn more about the neurophysiology and psychology of vision
13. **Deep Learning**: basics of neural networks, fundamentals of deep learning techniques and algorithms, deep learning frameworks
14. **Recent advances in computer vision using deep learning techniques**: the end of the AI winter, deep learning everywhere, solved problems, open problems, achievements, promising directions for future research.

The course uses Canvas for notes, assignments, announcements, and all course information (restricted to enrolled students).