EE 193-03: From photons to bits and back

Fall 2019
T/Th 1:30 to 2:45 Anderson 312

Welcome to EE 193-03! In this course, we will explore imaging systems: systems engineered to record, process, or display visual information.

We will investigate two overarching themes during the semester. First, since imaging systems of all kinds are created by and for humans, they operate based on peculiarities of the human visual system. During the first half of the course, we will discuss the fascinating abilities (and inabilities) of the human visual system, and see how these are exploited in cameras, displays, and other visual technologies. Second, we will examine in depth how a camera works, and untangle the complex web of tradeoffs related to the design and operation of a camera system.

In the final part of the course, we will build on these two themes to explore the cutting edge of imaging technology, looking at computational photography algorithms that attempt to sidestep limitations of traditional cameras and emerging applications such as virtual and augmented reality.

After successfully completing this course, you will be able to:

- Explain how the human visual system perceives brightness, color, depth, and motion.
- Describe how limitations of the human visual system — in terms of resolution, speed, and color perception — are exploited to build displays that mimic the real world.
- Describe the steps in a typical camera pipeline, from photons entering a lens to an image stored in memory.
- Discuss the links and tradeoffs in a camera system between noise, blur, exposure duration, gain, resolution, flash, field of view, aperture, depth of field, and more, and use these to select appropriate settings (or appropriate cameras) for various tasks.

Communication:

Steven Bell `sbell@ece.tufts.edu`

Halligan Hall 202c

Office hours:

- Mondays 10:30-12:30pm
- Tuesdays 3:00-5:00pm
- Thursdays 3:00-4:00pm (walking office hours – see my website for details)
- I'm also available other times by appointment, or just drop by my office if my door is open.

To minimize distraction, I generally only check email a few times a day. However, I will make a strong effort to answer all messages within 24 hours on weekdays.

All materials will be posted on the course website: http://www.ece.tufts.edu/ee/193HIP/

If you have a general question about the course content or course logistics, please post on Piazza rather than emailing me. That way anyone can answer the question, and everyone benefits from the response. Sign up for this course on Piazza here: http://piazza.com/tufts/fall2019/ee19303/home.

I may use Canvas for posting grades, but not much else.

Prerequisites:

There are no formal prerequisites for this course, but experience in several areas will be helpful:

- We will use MATLAB for processing image data in the homework assignments, so basic familiarity with MATLAB or another language (e.g., Python/NumPy) is important.
- Linear signals and systems (EE 23) serves as the foundation for many ideas in image processing. We will not do formal derivations based on linear systems theory, but many concepts in this course will build on the ideas of frequency space, convolution, and filtering.
- Linear algebra (at least matrix multiplication) will be used to conveniently represent many image manipulations.

If you have any questions about prerequisites or your ability to succeed in this course, please talk to me.

Textbook:

There is no textbook for the course. Readings will be assigned from a number of books and articles, which will be posted on the course website and/or distributed in class.

Homework:

There will be four homework assignments during the first half of the semester, which will include a mix of on-paper problems, short answer questions, and image processing code to be written in MATLAB.

Unless otherwise noted, homework must be submitted via `provide` by the beginning of class on the day in which it is due. Late homework will accepted for 70% credit up until I return graded work or post solutions.

You are welcome (and encouraged) to discuss approaches and solutions with other students, but each person must write up and submit their own assignment. For code-based questions, this means that it is fine to dicuss ideas and algorithms, but each person must write their own code.

Course project:

In the second half of the course, you will work with a small team to implement a project related to the ideas in the course. A list of ideas will be posted early in the quarter, and we will have some time in class to discuss possible projects.

Grading:

Grades will be assigned on an absolute scale (not curved), with the following components:

Homework: 35% One course introduction survey and four homework assignments.

Exam: 30% There will be one in-class exam roughly two-thirds of the way through the semester, which will cover all of the material up to that point.

Project: 35% The course project will have several deliverables, including a proposal, intermediate check-in, and the final code and write-up. The final write-up will be written like a conference paper, and will be an opportunity for you to practice explaining technical content in this format.

Instead of a final exam, we will use the exam time for project presentations for the whole class.

Schedule:

The tentative schedule is on the course website. It may be adjusted to meet the needs and pace of the class.