Fall 2019 Edition

Meeting Time: Tuesday and Thursday noon-1:15pm in Pierce 209

Instructor: Prof. Todd Zickler (zickler@seas.harvard.edu). Office hours: Mon 1-2pm, MD 341

Teaching Fellows:
Mia Polansky (miapolansky@g.harvard.edu). Office hours: Monday 4-5pm, MD second floor lobby
Dor Verbin (dorverbin@g.harvard.edu). Office hours: Tuesday 3-4pm, MD second floor lobby

---

Course Description. The goal of computer vision is to create artificial vision systems that produce useful information from images. Addressing the vision problem requires an understanding of light transport (radiometry, optics, projective and differential geometry) and of mathematical and computational tools for image analysis and inference. This course is designed to be a first course in computer vision, so it covers some of all of these. It also blends theory and practice.

Pre-requisites. At a bare minimum, CS283 requires calculus and linear algebra at the level of Math 21a/b and some programming experience (e.g., CS50). Background in probability (e.g., ES150, Stat 110), machine learning (e.g., CS181), and signal processing (e.g., ES156) is highly recommended, but having experience in only two of these three is generally OK if you are willing to work hard.

Evaluation. Your deliverables for this class include weekly assignments, an in-class exam, and a written report on an individual final project. Final grades are computed as follows:

40%	Assignments
25%	In-class exam (mid-November)
35%	Final project report

Assignments. The assignments are combinations of mathematical analysis and Python code. They are distributed and submitted electronically using Jupyter notebooks.

Late policy. No assignment can be submitted more than 24 hours after the declared deadline. Each student has a budget of three "late days" that can be used during the course of the semester. Only one "late day" can be used for any one assignment. "Late days" cannot be applied to the final project report.

Textbooks. There is no required textbook for this class, although selected readings from the textbooks listed below are required. The most relevant of these are on reserve in the library. The textbook used most is Szeliski, which is available for free online.

The book by Hartley & Zisserman covers geometrical aspects of Computer Vision very well. The book by Bishop and the book by Duda, Hart & Stork are good for probabilistic and statistical matters, and the book by Gonzalez & Woods provides an introduction to signal and image processing. Forsyth & Ponce provide a broad overview of the field---it is a good place to start if you are looking for pointers to literature on a particular topic. It is also a good learning tool for color and radiometry. Horn is a great learning tool for radiometry, shape from shading, and optical flow.

- R. Szeliski, *Computer Vision: Algorithms and Applications*, Springer, 2010. (Available here.)
- R. Hartley and A. Zisserman, *Multiple View Geometry in Computer Vision*, 2nd Ed., Cambridge University Press, 2003.
- D. Forsyth, and J. Ponce, *Computer Vision: A Modern Approach*, Prentice Hall, 2003. (Online draft copy.)
- R.O. Duda, P.E. Hart and D.G. Stork, *Pattern Classification*. 2nd Ed., John Wiley & Sons, 2001.
- C. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2007.
- R.C. Gonzalez and R.E. Woods, *Digital Image Processing*. 2nd Ed., Prentice Hall, 2002.
- B.K.P. Horn, *Robot Vision*. MIT Press, 1986.

Online Resources. These may be useful at various points in the course.

- OpenCV: Documentation for open source computer vision library.
- CVonline: Community-contributed tutorials and information on many topics.

Schedule

No.	Date	Title

1	Tu 9/3	Computer vision: past and future
2	Th 9/5	Projective geometry and model-fitting I
3	Tu 9/10	Projective geometry and model-fitting II
4	Th 9/12	Projective geometry and model-fitting III
5	Tu 9/17	Single-view measurement
6	Th 9/19	Cameras I
7	Tu 9/24	Cameras II
8	Th 9/26	Epipolar geometry
9	Tu 10/1	Structure from motion
10	Th 10/3	Filtering and Fourier Transform
11	Tu 10/8	Edges, blobs, corners
12	Th 10/10	Interest points
13	Tu 10/15	Multi-resolution representations
14	Th 10/17	Radiometry and reflection
15	Tu 10/22	Lighting
16	Th 10/24	Color; initial project proposal due
17	Tu 10/29	Texture
18	Th 10/31	Segmentation I
19	Tu 11/5	Segmentation II
20	Th 11/7	Stereo and regularization
	Tu 11/12	In-class exam
21	Th 11/14	Stereo and regularization
22	Tu 11/19	Optical Flow
23	Th 11/21	Tracking
24	Tu 11/26	Object Detection & Recognition
	Th 11/28	Holiday, class does not meet
25	Tu 12/3	How to write about your work
	We 12/11	Final project reports due at 11:59pm