Computational Photography

http://acberg.com/comp_photog

CS 590-134 (future 572) Spring 2016

M/W: 2:30-3:45 in PH0328

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office hours: after class and by appointment in Sitterson 256.

Bulletin Description
The course provides a hands on introduction to techniques in computational photography – the process of digitally recording light and then performing computational manipulations on those measurements to produce an image or other representation. The course includes an introduction to relevant concepts in computer vision and computer graphics.

Course Description
Computational Photography uses computational techniques from computer graphics and computer vision to enhance the process of recording and illustrating both the actual world around us and producing new, creative, imagery. These computational techniques allow recording and reprocessing light in ways that were not possible in traditional photography.

This is designed to be an advanced undergraduate course for students who are already familiar with programming and some mathematics including linear algebra. The course will cover the 3 Rs of computational photography: how to record, represent, and render scenes. Popular image-based algorithms will be covered in detail and implemented in a series of practical assignments.

Text
There is a very comprehensive text as a reference for this course that is also quite conveniently available for free as a PDF.

- Computer Vision: Algorithms and Applications, Richard Szeliski, 2010

There are also many other texts that can be used for further reading:

- Vision Science: Photons to Phenomenology, Stephen Palmer (for human visual perception, one of my all-time favorites)
- Digital Image Processing, 2nd edition, Gonzalez and Woods (general purpose image processing)
- The Art and Science of Digital Compositing, Ron Brinkmann
- Multiple View Geometry in Computer Vision, Hartley & Zisserman (a bible on recovering 3D geometry)
- Introductory Techniques for 3-D Computer Vision, Trucco and Verri (a more straightforward text on simpler aspects of 3D geometry)
- Fundamentals of Computer Graphics, Peter Shirley (a good computer graphics source)
- Linear Algebra and its Applications, Gilbert Strang (a great linear algebra text)

In addition there are similar versions of this course actively taught at Carnegie Mellon University, the University of California Berkeley, the University of Illinois Urbana Champaign, and Brown University. We are especially indebted to Alexei Efros who created a wonderful version of the class several years ago at CMU.

Target Audience
The course is targeted toward advanced undergraduates in computer science, or students with similar preparation. Students will be expected to be comfortable with programming, and have some background in introductory linear algebra. This complements undergraduate computer graphics although that is not a prerequisite.

Prerequisites
The course requires basic programming (COMP 401 and 410), familiarity with Matlab (e.g. from Comp 116) or the ability to quickly learn Matlab, and linear algebra (Math 349).

Course Requirements
Students will do approximately 5 homework projects and a final project. The projects will involve developing and implementing algorithms in computational photography. There will be a midterm and a final exam. Readings from the text will be assigned. Students will occasionally present their homework in class, and will all present their final project work in short class presentations as well as a web-page write-up.

Key Dates
The homework projects will generally take approximately 2 weeks, and will start at the beginning of the semester with a 1 week project. The final project will take 4-5 weeks at the end of the semester. The final exam will be on the exam day for the course.

Grading Policy
The grade will be 60% homework projects 15% midterm, 15% final, and 10% class participation. Assignments will be due at midnight on the due date, and late assignments will only be accepted after prior arrangement with the professor, and will not necessarily receive full credit. There will be optional extra credit as part of each assignment.

Honor Code
All students are expected to do their own work. Sources used and (relevant) discussions must be cited on each assignment.

Rough Schedule
A **preliminary** list of course topics and rough schedule follows:

- Weeks 1-2: Introduction cameras, color, and 2d image alignment (Assignment due in week 2.)
- Weeks 2-3: Image blending and in-painting (Assignment due in week 4.)
- Weeks 4-5: Interactive annotation and editing of photographs (Assignment due in week 6.)
- Weeks 6-7: Deformable image alignment (Assignment due in week 8.)

- Weeks 8-9: Building a camera (Assignment due in week 10.)
- Weeks 10: Begin final projects
- Weeks 10-11: Camera models and automatic alignment for reconstruction (Assignment due in week 12.)
- Weeks 12-13: High Dynamic Range and Image Based (re)Lighting (Assignment due in week 14.)
- Weeks 14-15: Final project discussion and presentations