CS 4476 / 6476 Computer Vision

Fall 2016, MWF 11:05 to 12:55, College of Computing room 16

Instructor: **James Hays**

TAs: Shray Bansal, Zhaoyang Lv, Huda Alamri, Varun Agrawal, Mahita Mahesh, Amit Raj, Cusuh Ham.

Course Description

This course provides an introduction to computer vision including fundamentals of image formation, camera imaging geometry, feature detection and matching, stereo, motion estimation and tracking, image classification and scene understanding. We'll develop basic methods for applications that include finding known models in images, depth recovery from stereo, camera calibration, image stabilization, automated alignment, tracking, boundary detection, and recognition. The focus of the course is to develop the intuitions and mathematics of the methods in lecture, and then to learn about the difference between theory and practice in the projects.

The difference between the undergraduate version of the class (CS4476) and the graduate version (CS6476) will be the requirements on the projects. In particular, more challenging extensions of the projects will be extra credit for CS4476 but required for CS6476.

The Advanced Computer Vision course (CS7476) in spring will build on this course and deal with advanced and research related topics in Computer Vision, including Machine Learning, Graphics, and Robotics topics that impact Computer Vision.

Learning Objectives

Upon completion of this course, students will:

- 1. Become familiar with both the theoretical and practical aspects of computing with images building on image processing approaches
- 2. Describe the foundation of image formation and image analysis.
- 3. Become familiar with theoretical foundations of the major technical approaches involved in computer vision based image analysis.
- 4. Understand basics of measurements and robust detection of features in images.
- 5. Describe various methods used for registration, alignment, and matching in images.
- 6. Understand the basics of 2D and 3D Computer Vision.
- 7. Get an exposure to advanced concepts leading to object and scene categorization from images.
- 8. Be able to connect issues from Computer Vision to Human Vision
- 9. Develop practical skills that are necessary for building computer vision applications.

Prerequisites

No prior experience with computer vision is assumed, although previous knowledge of visual computing or signal processing will be helpful. The following skills are necessary for this class:

- Data structures: You'll be writing code that builds representations of images, features, and geometric constructions.
- Programming: A good working knowledge of programming environments that support image and video analysis. All lecture code and project starter code will be in MATLAB. Students are strongly encouraged to use MATLAB and the TA's will support questions about MATLAB. If you've never used MATLAB that is OK.
- Math: Linear algebra, vector calculus, and probability. Linear algebra is the most important and students who have not taken a linear algebra course have struggled in the past.

Grading

Your final grade will be made up from

- 80% 6 programming projects
- 20% 2 written quizzes

You will lose 10% each day for late projects. However, you have three "late days" for the whole course. That is to say, the first 24 hours after the due date and time counts as 1 day, up to 48 hours is two and 72 for the third late day. This will not be reflected in the initial grade reports for your assignment, but they will be factored in and distributed at the end of the semester so that you get the most points possible.

These late days are intended to cover unexpected clustering of due dates, travel commitments, interviews, hackathons, etc. Don't ask for extensions to due dates because we are already giving you a pool of late days to manage yourself.

Graduate Credit

If you are enrolled in the graduate section CS 6476 then you will be expected to do additional work on each project. Each project will list several extra credit opportunities available and CS 6476 students will be required to do at least 10 points worth of extra credit (for which you will not get extra credit, unless you do more than 10 points worth).

Academic Integrity

Academic dishonesty will not be tolerated. This includes cheating, lying about course matters, plagiarism, or helping others commit a violation of the Honor Code. Plagiarism includes reproducing the words of others without both the use of quotation marks and citation. Students are reminded of the obligations and expectations associated with the Georgia Tech Academic Honor Code and Student Code of Conduct, available online at **www.honor.gatech.edu**. For quizzes, no supporting materials are allowed (notes, calculators, phones, etc).

You are expected to implement the core components of each project on your own, but the extra credit opportunties often build on third party data sets or code. That's fine. Feel free to include results built on other software, as long as you are clear in your handin that it is not your own work.

Learning Accommodations

If needed, we will make classroom accommodations for students with documented disabilities. These accommodations must be arranged in advance and in accordance with the ADAPTS office (**www.adapts.gatech.edu**).

Important Links:

- **Piazza for CS 4476 / 6476**. This should be your first stop for questions and announcements.
- **t-square.gatech.edu** will be used to hand in assignments.
- **Matlab Tutorial**
- **Get Matlab from software.oit.gatech.edu**

Contact Info and Office Hours:

If possible, please use Piazza to ask questions and seek clarifications before emailing the instructor or staff.

- James: hays[at]gatech.edu
- GTA Huda Alamri: halamri3[at]gatech.edu
- GTA Shray Bansal: sbansal34[at]gatech.edu
- GTA Zhaoyang Lv: zhaoyang.lv[at]gatech.edu
- GTA Varun Agrawal: varunagrawal[at]gatech.edu
- GTA Mahita Mahesh: mahitamahesh[at]gatech.edu
- GTA Amit Raj: amit.raj[at]gatech.edu
- TA Cusuh Ham: cusuh[at]gatech.edu

Office Hours

- James, Monday and Wednesday, 1 to 2 (CCB 315).
- TA hours: Monday 12 to 3 (CCB 360), Tuesday 11 to 1 (CCB 360), Thursday 11 to 1 (TBD).

Tentative Assignments Highlighted projects All Results

Image Filtering and Hybrid images

Local Feature Matching

Camera Calibration and Fundamental Matrix Estimation with RANSAC

Scene Recognition with Bag of Words

Face Detection with a Sliding Window

Deep Learning

It is strongly recommended that all projects be completed in Matlab. All starter code will be provided for Matlab. Students may implement projects through other means but it will generally be more difficult.

Textbook

Readings will be assigned in **"Computer Vision: Algorithms and Applications"** by **Richard Szeliski**. The book is available for free online or available for purchase.

Tentative Syllabus

Class Date	**Topic**	**Slides**	**Reading**	**Projects**
Mon, Aug 22	Introduction to computer vision	**pptx**, **pdf**	Szeliski 1	
Image Formation and Filtering (Szeliski chapters 2 and 3)				
Wed, Aug 24	Cameras and Optics	**pptx**, **pdf**	Szeliski 2.1, especially 2.1.5	Project 1 out
Fri, Aug 26	Light and Color	**pptx**, **pdf**	Szeliski 2.2 and 2.3	
Mon, Aug 29	Image Filtering	**pptx**, **pdf**	Szeliski 3.2	
Wed, Aug 31	Thinking in frequency	**pptx**, **pdf**	Szeliski 3.4	

Fri, Sept 2	Thinking in frequency part 2	**pptx**, **pdf**	Szeliski 3.5.2 and 8.1.1	
Feature Detection and Matching				
Mon, Sept 5	No classes, Institute holiday			
Wed, Sept 7	Edge detection	**pptx**, **pdf**	Szeliski 4.2	Project 1 due
Fri, Sept 9	Interest points and corners		Szeliski 4.1.1	Project 2 out
Mon, Sept 12	Local image features		Szeliski 4.1.2	
Wed, Sept 14	Feature matching and hough transform		Szeliski 4.1.3 and 4.3.2	
Fri, Sept 16	Model fitting and RANSAC		Szeliski 6.1 and 2.1	
Multiple Views and Motion				
Mon, Sept 19	Stereo intro		Szeliski 11	
Wed, Sept 21	Camera Calibration		Szeliski 6.2.1	Project 2 due
Fri, Sept 23	Epipolar Geometry and Structure from Motion		Szeliski 7	Project 3 out
Mon, Sept 26	Feature Tracking and Optical Flow		Szeliski 8.1 and 8.4	
Wed, Sept 28				
Machine Learning Crash Course				
Fri, Sept 30	Machine learning: unsupervised learning		Szeliski 5.3	
Mon, Oct 3	Machine learning: Supervised learning		Szeliski 5.3	
Wed, Oct 5	Quiz 1			
Fri, Oct 7				
Mon, Oct 10	No classes, Institute holiday			Project 3 due
Recognition				
Wed, Oct 12	Guest lecture			Project 3 due
Fri, Oct 14	Recognition overview and bag of features		Szeliski 14	Project 4 out
Mon, Oct 17	Large-scale instance recognition		Szeliski 14.3.2	
Wed, Oct 19	Large-scale category recognition			
Fri, Oct 21	Advanced feature encoding			
Mon, Oct 24	Detection with sliding windows: Viola Jones		Szeliski 14.1 and 14.2	
Wed, Oct 26	Detection with sliding windows: Dalal Triggs and Deformable Parts Models		Szeliski 14.1	Project 4 due
Fri, Oct 28	Internet scale vision		Szeliski 14.5	Project 5 out
Mon, Oct 31	Internet scale vision 2			
Wed, Nov 2	Human computation and crowdsourcing			
Fri, Nov 4	Attributes and more crowdsourcing			
Mon, Nov 7	Modern boundary detection: Pb and sketch tokens		Szeliski 4.2	

Wed, Nov 9	Context, Spatial Layout, and scene parsing			
Fri, Nov 11				
Deep Learning				
Mon, Nov 14	Neural networks			Project 5 due
Wed, Nov 16	Convolutional networks for recognition			Project 6 out
Fri, Nov 18	"Fully" convolutional networks			
Mon, Nov 21	Unsupervised or weakly supervised networks			
Wed, Nov 23	No classes, Institute holiday			
Fri, Nov 25	No classes, Institute holiday			
Mon, Nov 28	Generative Networks			
Wed, Nov 30	Recurrent Networks and Language			
Fri, Dec 2	Guest lecture			
Mon, Dec 5	Quiz 2			
Wed, Dec 7	No classes, reading period			
Fri, Dec 9	No classes, reading period			Project 6 due
Wed, Dec 14	Final Exam Period - not used			

Acknowledgements

The materials from this class rely significantly on slides prepared by other instructors, especially Derek Hoiem and Svetlana Lazebnik. Each slide set and assignment contains acknowledgements. Feel free to use these slides for academic or research purposes, but please maintain all acknowledgements.

Comments, questions to **James Hays**.