Syllabus for CS 677: Advanced Computer Vision, Fall 2022

Instructor
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ON-CAMPUS or ONLINE?
Even though USC if fully open and classes are held in-person, on-campus, due to continuing high COVID-19 transmission rate in Los Angeles, there is a possibility that this class maybe held online; a final decision may be delayed until close to the start of the Fall semester. In any case, students registered in on-campus session will have the option of attending in the assigned classroom. All exams will be conducted on-campus (except for students in locations outside the Los Angeles area).

Brief Course Description
The course will provide an overview of the challenges of vision, the common approaches and current techniques. While specific examples and applications may be used to illustrate, the focus will be on fundamental techniques and algorithms. We assume no prior knowledge of computer vision but still aim to study many modern, state-of-art techniques.

Course Availability
CS677 is available for CS PhD credit but is also open to CS and ECE MS students. In exceptional cases, undergraduate students may also be admitted. PhD students will be given priority in enrollment; however, MS students are expected to be the large majority of enrollment.

Prerequisites
1. Mathematics: Knowledge of and ability to use calculus, analytical geometry, linear algebra and probability theory.

2. Programming: Ability to program in Python.

3. Other Courses: There are no specific pre-requisite courses. In particular, courses in AI, Machine Learning, Deep Learning, Computer Vision and Image Processing are not required.

4. Entrance Exam: No exam will be given to assess pre-requisites. However, GPA may be used to screen students for preparedness.
Textbooks
There is, unfortunately, not a single, modern textbook available to cover the topics in this course. We will use published papers and tutorials extensively. Nonetheless, following books will be helpful for study.

Required:


Recommended:


Grading Breakdown
There will be two exams: Exam1 and Exam2, each counting for 25% of the grade (for a total of 50%). There will be one mathematical assignments and five or six programming assignments. Large scale “projects” are not planned. Total assignments will count for 30% of the grade. 10% of the grade will be assigned to attendance (does not apply to remote DEN students). Lastly, an end of the term, “term paper”, will count for the remaining 10% of the grade. We aim to waive the last requirement but this requires university-level approval; if granted, no term paper will be required and the weights given to the two exams will increase to 30% each.

Programming Assignments
The assignments must be completed using the Python language. We will use OpenCV library for the traditional part of the course and PyTorch for the deep learning component. It is expected that some cloud resources will be made available for assignments requiring use of GPUs; students are not required to have GPU-enabled personal computers of their own.

Detailed Course Syllabus:
The topic of computer vision is evolving very rapidly. Recent advances have come largely from “data-driven” deep learning and neural network approaches. However, traditional, “model-based” methods continue to be of interest and use in practice and continues to be taught at major universities active in vision research. This course will cover both traditional and deep-learning approaches with an emphasis on the latter category.
Following is a list of topics expected to be covered, in anticipated order, and with expected time to be spent on them. However, this list should be taken as being only indicative and actual topics, the order and the time devoted to them may vary depending on various factors including student interests and preparation, and new developments in the field.

1. **Introduction (1 week)**
   - Background, requirements and issues, human vision
2. **Image formation: geometry and photometry (1.5 weeks)**
   - Geometry, photometry (brightness and color), quantization, camera calibration
3. **Image segmentation and Feature Extraction (1 week)**
   - Various methods of image segmentation, edge detection, object proposals, SIFT features
4. **Multi-view Geometry (2 weeks)**
   - Shape from stereo and motion, feature matching, surface fitting, Active ranging
5. **Introduction to Neural Networks (1 week)**
   - Artificial neural networks, loss functions, backpropagation and SGD, Batch Normalization
6. **Object Recognition: Deep Learning Methods (3 weeks)**
   - Image classification, object detection and semantic segmentation, adversarial attacks.
   - Various neural network architectures, visualization techniques.
7. **Motion analysis and Activity Recognition (1 week)**
   - Motion detection and tracking, Inference of human activity from image sequences
8. **Selected Topics (1 week)**
   - Examples: Face recognition, Image grounding, Visual question answering