Lecture 1: CS574

Aug 26, 2014
Introduction

- Course name: Computer Vision, cs/ee 574
- Instructor: Prof. Ram Nevatia
  - My background, research interests…
- Today’s objective
  - Describe course content
  - Conduct of the class
  - Required work, grading
  - Pre-requisites
  - Intro to potential and problems of vision
Background

• Course web page:
  – http://den.usc.edu

• Office hours
  – Instructor, T,Th 2:00-3:30 P.M., PHE 204; other times by appointment only
  – nevatia AT usc DOT edu, 213-740-6427

• TA: Chih-Fan “Ryan” Chen; contact and office info will be posted

• Books:

• Additional reading material will be distributed electronically
Class Enrollment

• Course is fully subscribed
  – We may be able to add a few more seats; another section will **not** be added
    • Course is a “specialty” course, we have limited faculty available to teach
      – Many students do typically drop after one week
      – Those waiting are welcome to come to class if physical space permits
  – Adding a class after start of semester requires instructor approval; please do **not** bypass this system.
What is this course about?

• Study of techniques that attempt to create artificial vision capabilities for computers

• What does the term “vision” mean when applied to human vision?
  – Eyes provide images to the brain; perception happens in the brain.
  – Perception consists of computing “good” descriptions of the environment
    • Agree with other measurements
    • Example: class room scene

• Computer Vision
  – Camera is like an eye: provides images
  – Vision is really about perception
Elements of Visual Perception (Vision)

- Sensing of the environment
- Reconstruction of the 3-D environment,
- Inference of surface properties (such as, color, texture and material)
- Recognition of objects: class of objects as well as specific objects
  - A car, a “Toyota Corolla”, “John’s Corolla”
- Spatial relations between objects
- Temporal relations: events and activities
- Predictions about future state
- …
Who needs Vision?

• Biological organisms
  – Navigate: avoid obstacles, don’t get lost…
  – Recognize objects of interest: predators, food, friends…
  – Estimate motion, observe activities, predict…
  – Visual communication
  – Entertainment
  – …..

• Note: capabilities of biological vision span a broad spectrum: there are single cell organisms that can just sense presence/absence of light but still find it useful for survival

• Artificial mechanisms
  – Similar functions, depending on the environment
Application Areas

• Manufacturing:
  – Inspection, assembly...

• Mobile robots
  – For factories, construction, space and other hazardous environments, intelligent vehicles, military vehicles

• Remote Sensing
  – Cartography, change detection, crop/weather assessment

• Biomedical
  – Large population screening, assisted surgery....

• Visual surveillance, security

• Visual aids
  – Lane warnings, aid for the blind, Google Glass...

• Multi-media
  – Visual communication, enhanced reality, models for virtual environments, content based retrieval...
Why Study Computer Vision (or not)?

• Required course for some tracks
  – Easier alternatives may exist

• Many important and exciting applications
  – Number of applications has been growing rapidly; still many remain in the future
  – Good job prospects: currently yes, future?

• Exciting intellectually
  – Vision is one of few remaining mysteries of natural world
  – Vision problems seem fundamentally unsolvable, great intellectual challenge to discover methods for solving them
  – Computer vision remains a field in early stages of its evolution.
  – Solutions to many fundamental problems not designed
  – Theories are not always coherent.
  – Many advanced mathematical tools are required.
Class Difficulty

- CS 574 is not an “easy” course
  - Other options to satisfy M.S. requirements may be easier
  - Requires skills in several math topics and good programming skills
  - A coherent theory of vision does not exist; hence material is fragmented
  - Text book coverage is uneven; some parts are hard to read or lack sufficient details
  - Applications are exciting and intuitive but underlying techniques can be complex
  - Many good students find these characteristics frustrating though others thrive on the variety and the ambiguities.
  - Please make sure that the material fits your taste!
Pre-requisites: Programming and CS

• This is a graduate course in CS!
  – Proficiency in a high level programming language such as C/C++
  – Must have experience with actual programming, not just programs written on paper. If you are taking a course like CS455, you may be ready for this class by next semester.

• Data structures such as lists, trees and graphs
  – Algorithms to create and manipulate such structures

• Basic CS algorithms,
  – Sorting, searching, tree/graph traversals…. 

• Be able to take informal or mathematical descriptions of algorithms and convert them into working programs
Pre-requisites: Mathematics

• Calculus
  – Derivatives, partial derivatives, Integration

• Geometry
  – Coordinate systems (Cartesian, spherical, cylindrical…)
  – Equations of entities such as points, lines, planes, circles, spheres…;
  – Computing relations between entities (distance, intersection, angles….)

• Linear Algebra
  – Linear transformations
  – Matrix representation, inversion, eigenvectors….
  – Solutions of systems of equations

• Elementary probability theory
  – Discrete/continuous random variables
  – Joint probability distribution/density functions
  – Conditional probabilities,
  – Bayes’ theorem…

• Please take math requirements seriously! A practice assignment will be posted.
Course Objectives

• Understanding of key problems of vision
• Alternative approaches to fundamental problems
  – Basic techniques, limited discussion of state-of-art methods
• Specific applications (e.g. face detection) will be covered only to illustrate basic techniques
• To provide enough background for further study and for implementation of some practical vision systems.
• Vision has become a large field, it is not possible to cover “everything” about all topics in one semester
  – Modern research papers use mathematical and ML tools that are *not* pre-reqs to this course; we will need to omit discussion of these methods
• Not a “cookbook” or “how to do x” course
Requirements

• Assignments (~6-8)
  – 2-3 “written” (mathematical) assignments
  – 4-5 programming assignments
    • Will make extensive use of functions in the Intel OpenCV library, and other public domain software
    • Preferred language for programming is C or C++; other languages allowed but needed libraries may not be available

• Grading:
  – Assignments 30%
  – Exam1: 30%, Exam 2: 30%; note Exam 2 is not a “cumulative final”
    • Tentative dates: Exam 1, ~ Oct 14; Exam 2, Dec 4, last class day
  – Class attendance and participation 10% (not applicable to DEN students or students with special exemption; their others scores will be scaled accordingly).

• All assignments and exams are required, missing any will result in a grade of “F”. Late submissions will be accepted with prior permission only.
Academic Integrity

• Assignments and Exams are to be completed individually, unless otherwise specified.
• We encourage discussions among students but not *copying* of the answers.
• The class will be conducted on the basis of mutual trust and respect; for USC ethics code, see
• Unfortunately, there are occasional instances of gross abuse; these instances will be referred for action according to the USC Student Conduct Code, which can be found at this link:
• Grades can only be assigned based on performance, not need.
Class Schedule

• Professor needs to be on travel Sept 9, 11, 16
• No classes on Sept 9 and 11
• Additional classes on Fridays Aug 29 and Sep 5 to make up
  – Time: 7:30-8:50 A.M.; place TBD (in a DEN studio)
  – Will be recorded for those unable to attend makeup in person
• Sept 16, regular class but taught by TA
  – Will cover use of OpenCV library, a key software component
• Regular schedule resumes Sept 18
• For now, remember next class is on Aug 28, 11A.M.
Related Courses

• Artificial Intelligence (cs561)
  – Vision is part of intelligent processing in the brain.
  – Many AI techniques are used in vision.
  – However, vision must start with signal (not symbol) inputs so problems are not formulated in quite the same way.

• Probabilistic Reasoning (cs573) and Machine Learning (cs576)
  – Modern computer vision makes heavy use of these techniques;
  – However, they are not a pre-requisite,
  – We will cover needed knowledge in course but not in much depth.

• Mathematical Pattern Recognition (ee559)
  – Overlaps with 573 and 576 to some extent

• Image Processing (ee 569)
  – In image processing, goal is usual to enhance, compress or modify images for better human perception or transmission
  – In vision, goal is to extract information from images.

• Robotics and Graphics
  – Cover some major applications of vision
Next Class

• Read ch. 1 of Forsyth/Ponce book
  – Sections 1.1, 1.2.