Introduction and Overview

Computer Vision II
CSE 252B
CSE 252B: Computer Vision II

• CSE 252A: Computer Vision I is not a prerequisite

• Today
  – Course overview
  – Logistics
Principal Topic

- Imaging geometry
  - Single, two, three, and $n$ view geometry
  - Calibrated and uncalibrated
Feature Detection and Matching

Input Images
Feature Detection and Matching

Detected Corners
Feature Detection and Matching

Simple Matching
Feature Detection and Matching

Simple Matching
Including Outlier Rejection
Geometric Primitives

• Points
• Hyperplanes
  – 2D lines, 3D planes, $n$-D hyperplanes
• Hyperquadrics
  – 2D conics, 3D quadrics, $n$-D hyperquadrics
• Dual hyperquadrics
• 3D lines and dual lines
Geometric Transformations

• Euclidean
  – Rotation and translation

• Similarity
  – Rotation, scale, and translation

• Affine
  – Linear and translation

• Projective
Single View Geometry

• Calibrated
  – Normalized camera projection matrix
    • Rotation and translation (pose)

• Uncalibrated
  – Camera projection matrix
    • Projective space
    • Euclidean or similarity space
      – Rotation, translation, and calibration matrix
Projection and Back-Projection

• Projection
  – Same dimension
    • e.g., 2D to 2D
  – Higher dimension to lower dimension
    • e.g., 3D to 2D

• Back-projection
  – Lower dimension to higher dimension
    • e.g., 2D to 3D
    • Introduces ambiguity
Two View Geometry

• Calibrated
  – Essential matrix

• Uncalibrated
  – Fundamental matrix
Camera Rotation Only

Mosaic construction from images
Two View Triangulation
Three View Geometry
Other Topics

• $n$ view geometry
  – Triangulation
  – Bundle adjustment and 2D block adjustment

• From projective to affine and metric reconstruction

• Auto-calibration
Common Problem: Model Estimation

• Outlier rejection
  – Uses minimal solution

• Linear estimation

• Nonlinear optimization
  – Use linear estimation for initial estimate
  – Iterative process to determine global optimum
Deep learning in computer vision

• First, understand the physics of the problem, then be wise about whether to use deep learning
  – If not, then you may “learn the bitter lesson that building in how we think we think does not work in the long run” and “general methods that leverage computation are ultimately the most effective, and by a large margin”
    • Richard Sutton, “The Bitter Lesson”
  – On the other hand, you may learn “we have to take into account the total cost of any solution, and that so far they have all required substantial amounts of human ingenuity”
    • Rodney Brooks, “The Better Lesson”
Results
Results
The Syllabus

• Instructor: Ben Ochoa
• TAs: Siddharth Satyam and Honey Nikam
• Course website
  – https://cseweb.ucsd.edu/classes/wi24/cse252B-a/
• Course is on Canvas
  – Piazza for discussion
  – Gradescope for submitting assignments
• 18 lecture meetings
  – 2 university holidays (Jan 15 and Feb 19)
The Syllabus

• Grading
  – 5 homework assignments (100% of grade)
    • By hand (typed) and programming using Python
    • Significant amount of work, but rewarding
    • Start early!
    • Late policy: 15% grade reduction for each 12 hours late
      – Will not be accepted 72 hours after the due date
  – No midterm exams
  – No final exam, except for CSE graduate students taking the course-hosted comprehensive exam

• Piazza
  • Extensive, nontrivial participation could raise your grade (e.g., raise a B+ to an A-)
Textbook

• Multiple View Geometry in Computer Vision, 2nd edition
  – Richard Hartley and Andrew Zisserman

• Download the corrections and errata
Jupyter Notebook

• Used for all homework assignments
• Unless specified in the assignment, you may not use any function or method contained in any package
  – If you are unsure about using a specific function or method, then ask the instructor and instructional assistants for clarification
Collaboration Policy

• Ask and answer questions on Piazza, not email
• Post **publicly** (optionally anonymously)
  – Conceptual questions and high-level questions about assignments
• All other posts must be **private** to “Instructors” (includes instructor and instructional assistants)
  – Low-level, detailed assignment questions (e.g., implementation details)
  – Assignment-specific code
  – Results (intermediate or final; e.g., numerical values, images, figures)
  – **Posting such items publicly is an academic integrity violation**
• If you are unsure, then post privately to “Instructors”
  – If suitable, then it will be changed to a public post
• Piazza is the official, University-sanctioned discussion forum
  – **Do not use Piazza to solicit others to an alternative forum**
Collaboration Policy

It is expected that you complete your academic assignments on your own and in your own words and code. The assignments have been developed by the instructor to facilitate your learning and to provide a method for fairly evaluating your knowledge and abilities (not the knowledge and abilities of others). So, to facilitate learning, you are authorized to discuss assignments with others; however, to ensure fair evaluations, you are not authorized to use the answers developed by another, copy the work completed by others in the past or present, or write your academic assignments in collaboration with another person.
Academic Integrity Policy

Integrity of scholarship is essential for an academic community. The University expects that both faculty and students will honor this principle and in so doing protect the validity of University intellectual work. For students, this means that all academic work will be done by the individual to whom it is assigned, without unauthorized aid of any kind.
Academic Integrity Violation

If the work you submit is determined to be other than your own, you will be reported to the Academic Integrity Office for violating UC San Diego’s Policy on Integrity of Scholarship. In accordance with the CSE department academic integrity guidelines, students found committing an academic integrity violation will receive an F in the course.
Student conduct policy

UC San Diego strives to maintain a climate of fairness, cooperation, and professionalism. It is expected that you practice basic principles, including, but not limited to, mutual respect, civility, and decency, towards maintaining an atmosphere free of abusive or demeaning treatment. Non-academic student misconduct will be reported to the Center for Student Accountability, Growth, and Education for violating UC San Diego’s Principles of Community.
Wait list

• Number of enrolled students is limited by
  – Number of instructional assistants

• General advice
  – Wait for as long as you can

• UCSD policy: Extension (e.g., concurrent enrollment, UPS) students have lowest priority
Certification of Commencement of Academic Activity

• Every course at UC San Diego, per the US Department of Education, is required to certify whether students have commenced academic activity for a class to be counted towards eligibility for Title IV federal financial aid. This certification must be completed during the first two weeks of instruction.

• For this course, the requirement will be fulfilled via an ungraded prior knowledge quiz, which will assist the instructional team by providing information about your background coming into the course
  – In Canvas (https://canvas.ucsd.edu), go to the course and navigate to Quizzes, then click on First Day Survey: Prior Knowledge #FinAid
Next Lecture

• Feature detection and matching (simple)

• Reading
  – Shi and Tomasi, “Good Features to Track”