Course Project Outline

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CS231A
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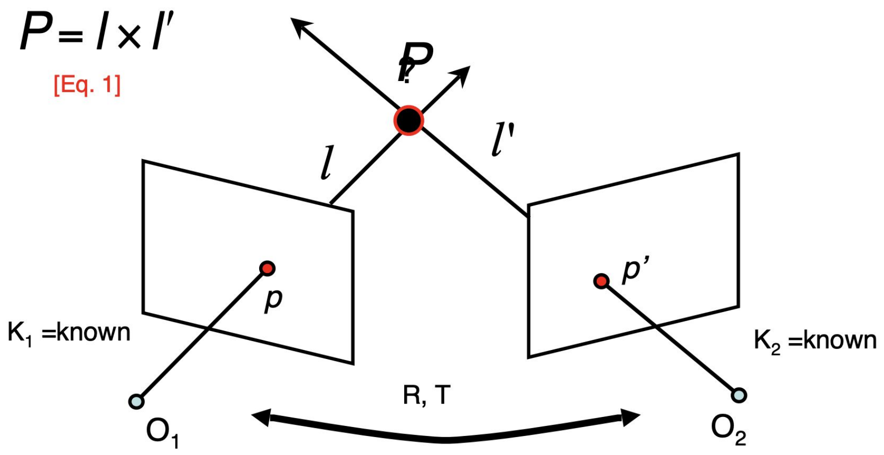
Overview

- Camera & world reference frames
- Project Logistics
- Types of Projects
- Class Coverage and Ideas
- Where to Get Projects
- Helpful Resources

World to Camera Frame

- To move between camera reference systems:
  - Assume one of them, O1, to be world coordinates
  - Let l and l' lie in the same plane
  - Using Eq. 9 from Course Notes 1 (pg 8):



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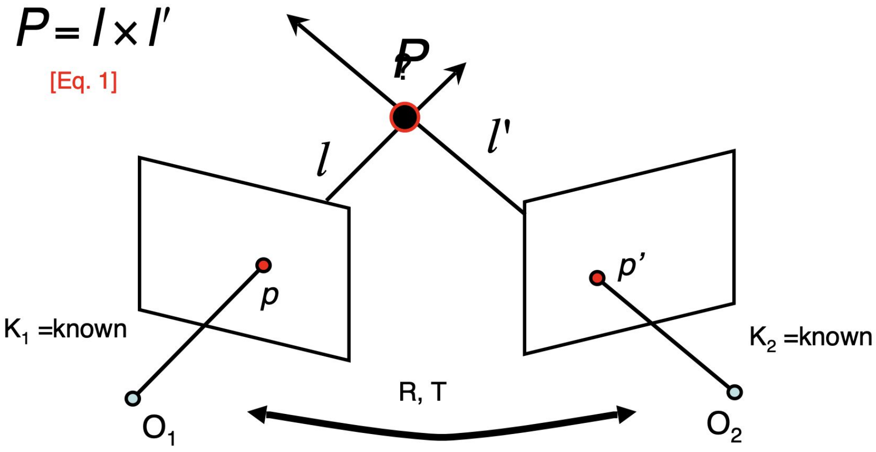
$$O_2 = \begin{bmatrix} R & T \\ 0 & 1 \end{bmatrix} O_1$$

- To get p’ in O1 (world) coordinates, multiply with rotation matrix:
  - $p'_{O1} = Rp'$



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- To get p' in O1 (world) coordinates, multiply with rotation matrix:
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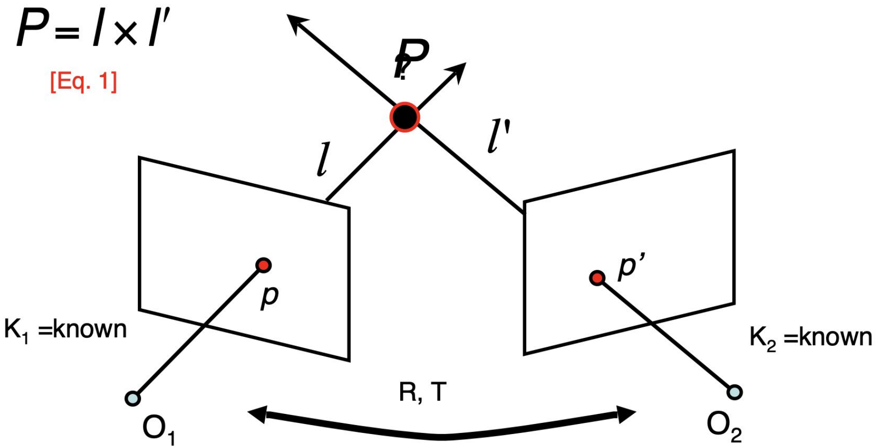
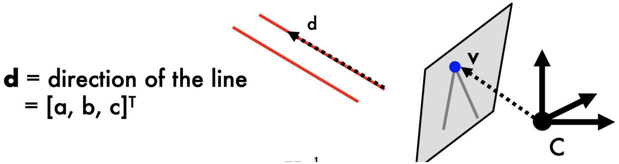
- To get lines **l** and **l'**: use the 3D direction vectors **d** and **d'** in terms world reference system (intersecting p and p')





World to camera frame

- If Camera and World reference systems are the same, the camera projection matrix **M** is:
  - $M = K\,[I \;\; 0]$
- If Camera (c) and World (w) reference systems are related by rotation and translation **R** and **T**:
  - Going from world to camera frame: $P_c = R_{wc}^{-1}\,(P_w - T_{wc}) = R_{wc}^T\,P_w - R_{wc}^T T_{wc}$
- This means camera projection matrix from world to camera image coordinates:
  - $M = K\,[R_{wc}^T \quad -R_{wc}^T T_{wc}]$
- Going from camera to world frame is the reverse operation:
  - $P_w = R_{wc} P_c + T_{wc}$
- Going from camera 1 (c) to camera 2 (c') involves the same operations, taking into account the rotation and translation from 1 to 2: $R_{cc'}$, $T_{cc'}$

Project Logistics

- Overview here
- Teams of **1-3**: Number of people is taken into account when grading project
  - More members → More work
- Suggestions for project direction
  - Replicate an interesting paper
  - Compare different methods to a benchmark
  - Use a new approach to an existing problem
  - Implement an interesting system
  - Original research

Sharing a Project with Another Class

- Sharing projects is generally allowed
- Specify in reports
- Must be approved by both our staff and the other course staff
- Project must be profound enough that you can clarify which parts of the project were done for which class
  - Each part must be substantial enough to hold as a single project
  - Technical parts and experiments should sufficient and different
  - If using CNN for flower classification include some other components related to this course (e.g. geometry, …)
- Will need a separate write-up for each class

Project Grading - Important Dates

- Course project: 38%
  - Project proposal 1% (due Jan 27)
  - Midterm milestone 5% (due Feb 20)
  - Presentation 7% (due March 14)
  - Final report 25% (due March 18, 11:59 pm)

Project Proposal

- Maximum of 2 pages
- Submit the report as a PDF document through Gradescope
- Include the following:
  - Title and authors
  - Sec. Introduction: Problem you want to solve and why
  - Sec. Technical Approach: How do you propose to solve it?
  - Sec. Milestones (dates and sub-goals)
  - References
- You will be assigned a project mentor

Project Milestone Report

- Maximum of 4 pages
- Submit the report as a PDF document through Gradescope
- Include the following:
  - Title and authors
  - Sec. Introduction: Problem you want to solve and why
  - Sec. Technical Approach: How do you propose to solve it?
  - Sec. Milestones achieved so far
  - Sec. Remaining Milestones (dates and sub-goals)
  - References

Project Presentations

- Short presentation with time for a brief Q&A
- Include the following:
  - Problem Motivation/Description
  - Technical Approach
  - Results
  - Maybe demo (+)!

Project Final Report

- Length of 6-8 pages
- Submit the report as a PDF document through Gradescope
- Email your code to TBA.
- Include the following:
  - Title and authors
  - Abstract
  - Sec. Introduction
  - Sec. Previous work
  - Sec. Technical Approach
  - Sec. Experiments
  - Sec. Conclusions
  - References

Class Coverage:

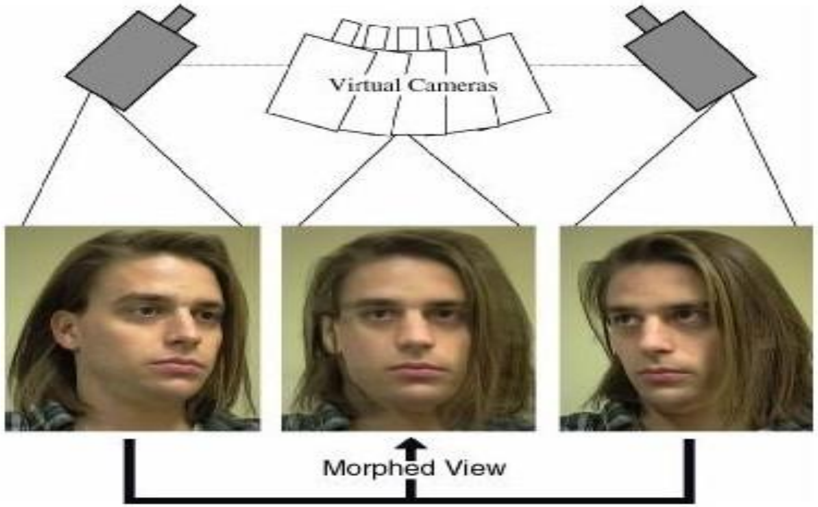
- Camera models and calibration
  - Single camera and how we model it
- Single view metrology
  - Estimating geometry from a single view
- Epipolar Geometry (Stereo Vision)
  - Estimating geometry from two viewpoints
- Structure from Motion
  - Using motion/several viewpoints to estimate structure
- Volumetric Stereo
  - Using multiple views to map 3D points

Class Coverage:

- Low Level Representations
  - Extracting features from 2D images for downstream applications
- Depth Estimation, Low Level Tracking
  - Estimating depth in images, tracking of pixels in videos
- 6d Pose Estimation, Object Tracking
  - Estimating translation and rotation of objects, tracking of movement of objects
- SLAM
  - Simultaneous localization and mapping

View Morphing

Image morphing techniques can generate compelling 2D transitions between images.



S. M. Seitz and C. R. Dyer, *Proc. SIGGRAPH 96*, 1996, 21-30

View Morphing

Automatic Photo Pop-Up

A fully automatic method for creating a 3D model from a single photograph

Hoiem, D., Efros, A. A., and Herbert, M, “Automatic Photo Pop-Up”, SIGGRAPH 2005.

Photo Tourism

(a) (b) (c)

Browsing and exploring large unstructured collections of photographs of a scene using a novel 3D interface

Snavely, N., Seitz, S. M., Szeliski, R. “Photo Tourism: Exploring Photo Collections in 3D”, SIGGRAPH 2006.

Novel Hardware

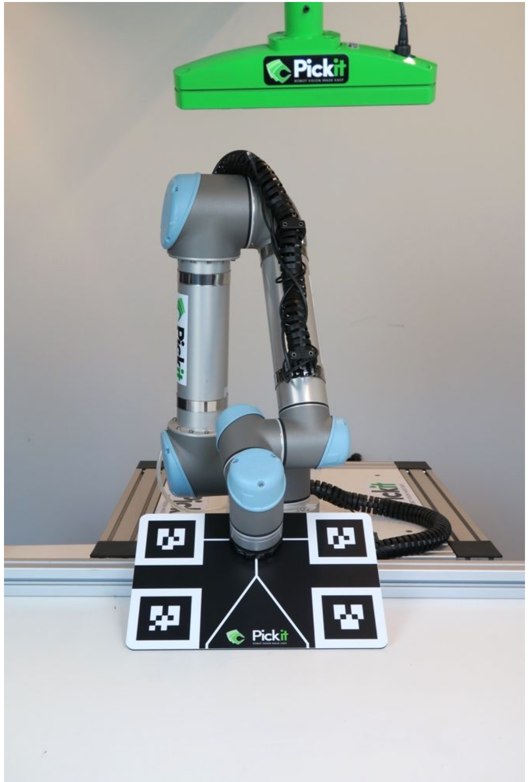
Mobile Devices

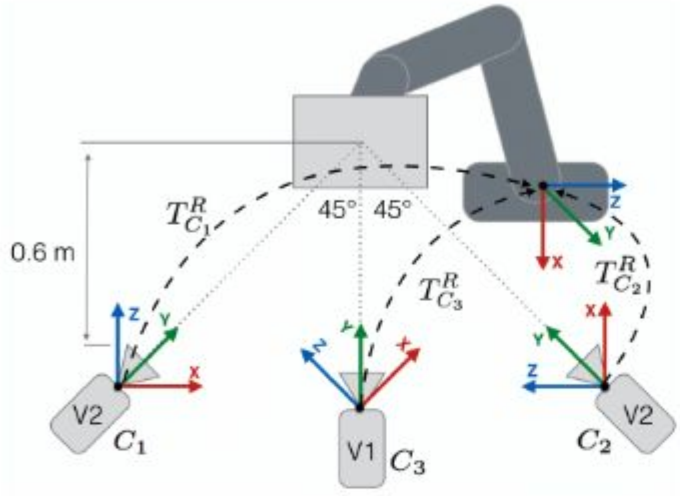
Can you take an existing vision algorithm and adapt it to a mobile device to make it more useful?

Monocular Depth estimation

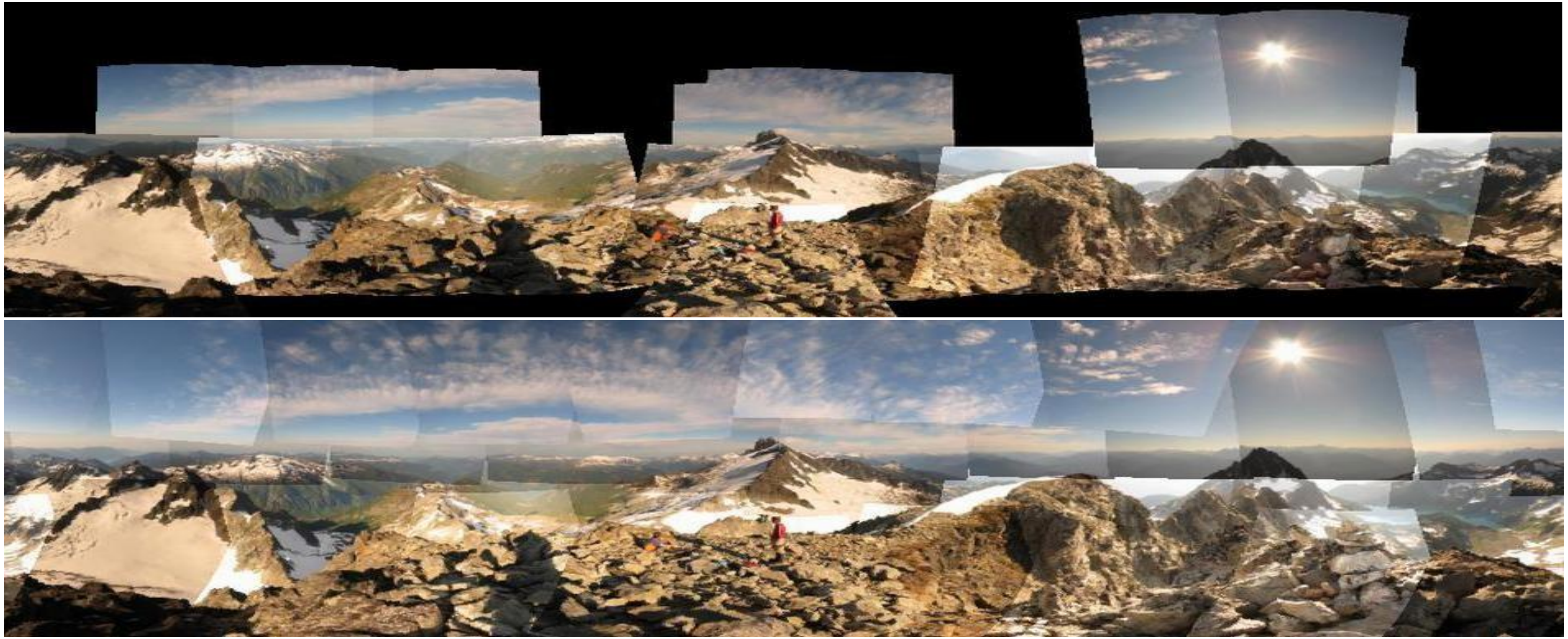
Figure 10. Snapcode of publicly available community lens

Camera Calibration for Robots





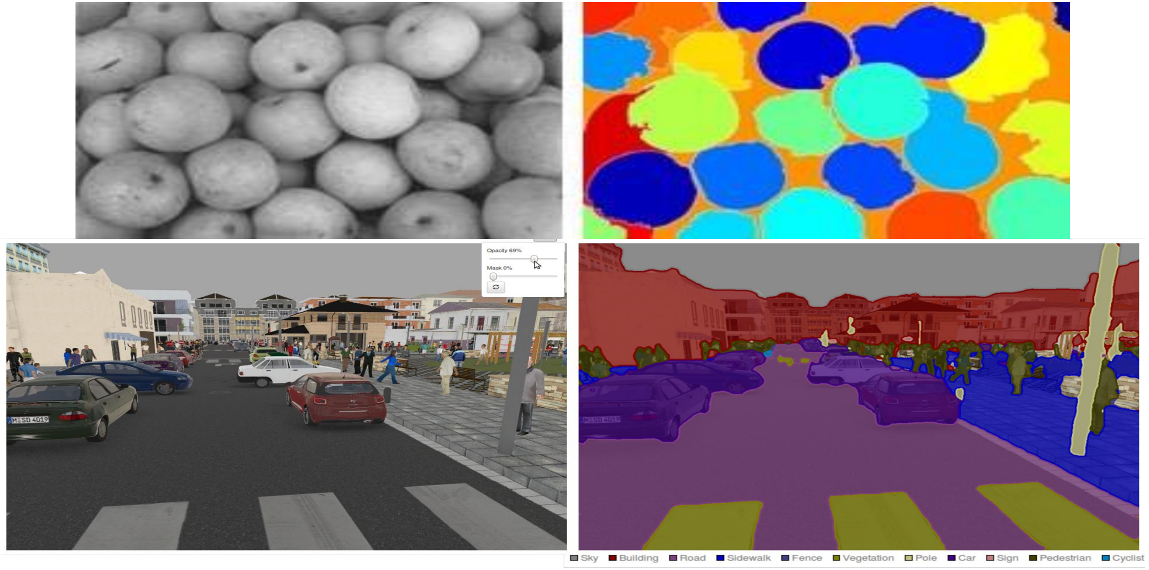
Recognizing Panoramas



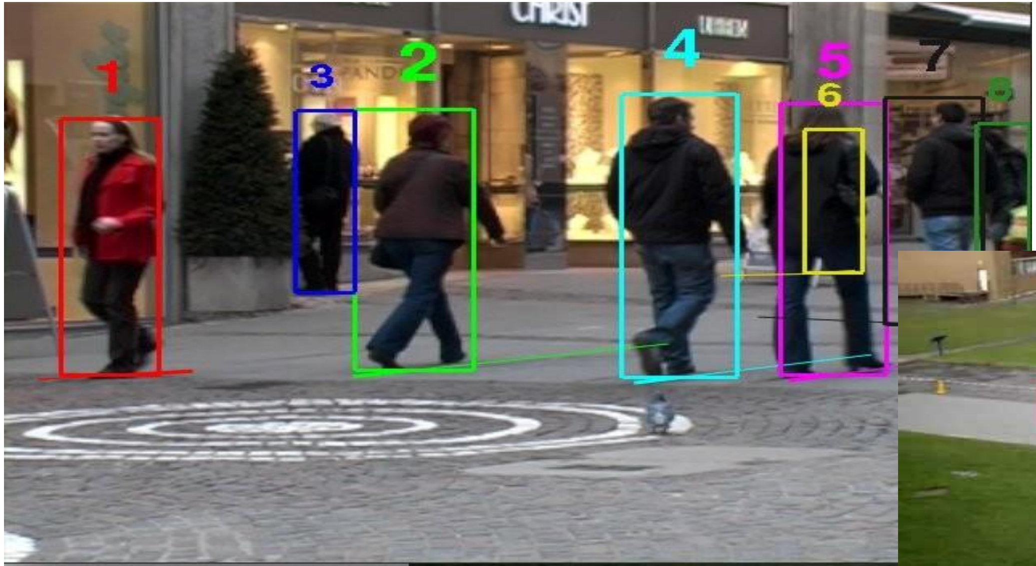
Brown, M. and Lowe, D. G., “Recognizing Panoramas”, ICCV 2003.

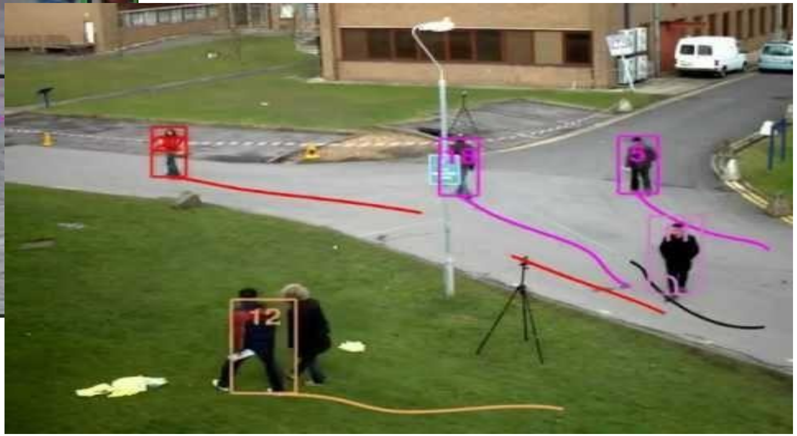
Image Segmentation

Partition an image into multiple segments (sets of pixels) in order to make it easier to analyze

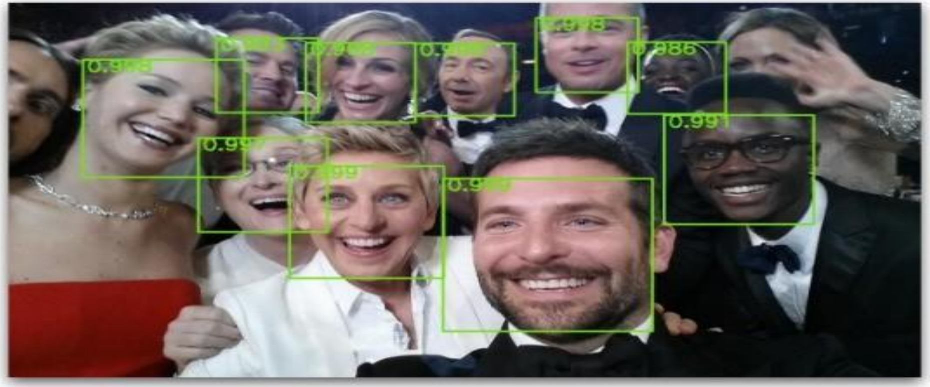


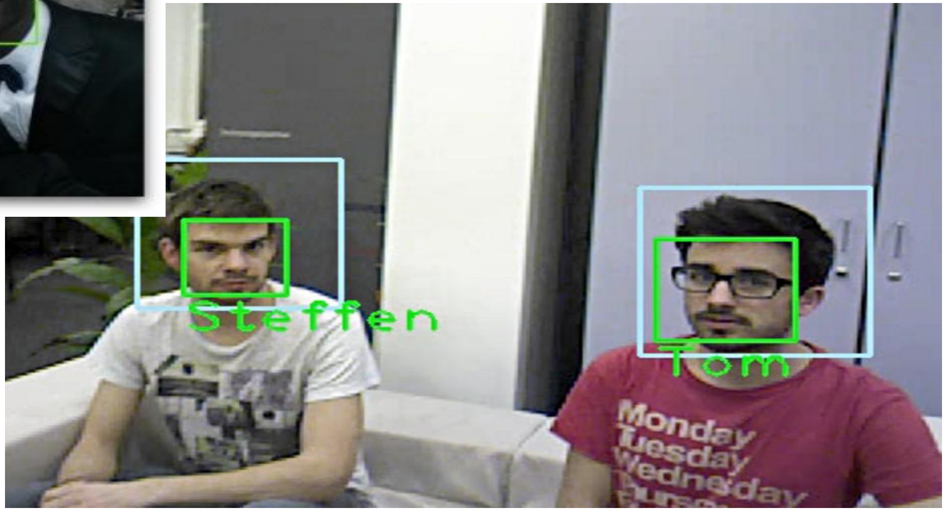
Tracking





Face Detection – Face Identification





Other Topics

- Pose Estimation: Estimate the skeleton angles for a person from an image/video
- Action and Gesture Recognition: Is a person standing, walking, or sitting in an image/video? Is he/she waving?
- Scene Understanding: Can you classify a scene? Can you recognize and/or segment each component of the scene?
- Trajectory Forecasting
- ...

Negative project examples

- Projects without components related to the course
- Applying Alexnet for image classification
- Finding and running an existing Github code
- Only running OpenCV libraries for a task
- …

Where to get Project Ideas

- Course Staff: Office hours, ideas posted on website
- Computer vision papers and conferences
  - CVPR
  - ICCV
  - ECCV
- Computer vision research groups at Stanford
  - Silvio Savarese
  - Fei-Fei Li
  - Juan Carlos Niebles
- Last years' projects: See course website
- Papers with Code: Computer Vision
- Come up with your own!

Datasets

- Many are available on the web
- See the following aggregators:
  - CV Datasets on the Web
  - Yet Another Computer Vision Index To Datasets (YACVID)
- References found in papers
- Course CA's

Project Advice

- Choose your team well
- Make sure the scope of your project fits a quarter
  - Set a minimum goal, desired goal, and a moonshot
- Constrain your problem smartly
- See what datasets are available if you are doing a recognition project
  - Specially for deep learning projects
- You may need to plan ahead/learn outside materials
- Use software when available
  - OpenCV, MATLAB, Deep learning frameworks
- Come ask questions – We're happy to talk!

Thank You