Goals of Computer Vision

Get a computer to understand
Goal: Naming
Goal: Naming

The picture shows a building with many windows and grass in front of it. There is a person walking on the right...
Goal: 3D
Goal: Actions

What can I do here?
Seems Obvious, Right?

• Key concept to keep in mind throughout the course: you see with both your eyes and your brain.
Why is it Hard?
Why is it Hard?
Goal of computer vision
Despite This, We’ve Made Progress

• Few of these problems are **solved** *(and there are lots of dangers to pretending things are solved when they aren’t)*

• But we do have systems with performance ranging from non-embarrassing to super-human *(with the right caveats)*
Look at Your Phone

Graphics

https://affinelayer.com/pixsrxv/

Isola et al. *Image-to-Image Translation with Conditional Adversarial Networks*. CVPR 2017
Humans

Real-time Multi-Person 2D Pose Estimation Using Part Affinity Fields

Zhe Cao, Tomas Simon, Shih-En Wei, Yaser Sheikh
Carnegie Mellon University
Recognition

Video Credit: Karol Majek (https://www.youtube.com/watch?v=OOT3UIXZztE)
3D

Left input image

Vision Assisting Things

Owens et al. Audio-Visual Scene Analysis with Self-Supervised Multisensory Features. ECCV 2018
Why is Computer Vision Difficult?
Viewpoint Variation
Illumination Variation

Image Credit: J. Koenderink
Scale Variation
Deformation

Image Credit: Peng et al., SIGGRAPH ASIA 2018
Intra-Object Class Variation
Occlusion, Clutter
Ambiguity
Ambiguity
Ambiguity
Why is it Possible?

The World

Has regularity

Has rules

Has rules and regularity

Imaging
Our Job

Sift through: evidence (the image) and past experience (knowledge) to interpret the image correctly.
Cues: Perspective
Cues: Shading
Cues: Texture Gradient
Cues: Common Fate

Course overview

1. Image formation and processing
2. Learning and deep learning
3. Transformations and motion
4. 3D reconstruction
5. Advanced topics
Part 1: Formation and Processing

Camera Models

Linear Filtering

Feature Detection

Image Credit: Hartley and Zisserman 04, Leung and Malik IJCV 01, Brown and Lowe ICCV 03,
Part 2: Transformations and Fitting

Transformations

Robust Fitting

Part 3: Learning and Deep Learning

1. Input image
2. Extract region proposals (~2k)
3. Compute CNN features
4. Classify regions

Part 4: 3D Reconstruction

Multiview Stereo and Structure From Motion

Stereo Vision
Part 5: Advanced Topics

**Vision & Language**

- CNN
- LSTM
- Recognition

**Video**

- Video Understanding
- Temporal Reasoning

**Learning and Geometry**

- Scene Understanding
- 3D Reconstruction

Image Credit: Karpathy et al. CVPR 2015, Wang et al. ECCV 2018, Tulsiani et al. CVPR 2018
Textbooks

No textbook, but Szeliski, *Computer Vision: Algorithms and Applications*, is a good reference and available online.

http://szeliski.org/Book/
Administrivia

- Websites / Staff
- Prerequisites
- Waitlist etc.
- Evaluation
- Classes/Discussions/Piazza/Office Hours
Websites

• Course website: [http://web.eecs.umich.edu/~fouhey/teaching/ECS442_W19/](http://web.eecs.umich.edu/~fouhey/teaching/ECS442_W19/)

• Piazza: You should have access via canvas

• We’ll use Piazza to make announcements/discussions, and things like homework will appear on the website.
Piazza

• Please ask questions on Piazza so we can answer the question once, officially, and quickly
• We will monitor Piazza in a systematic way, but we cannot guarantee instant response times
• Same goes for email
Staff

• Professor: (me) David Fouhey
• GSIs / IAs:
  • Linyi Jin,
  • Richard Higgins
  • Shengyi Qian
  • Yi Wen
Prerequisites

You **absolutely** need: EECS 281 and corresponding programming ability.

You will **struggle continuously** without: Basic knowledge of linear algebra, calculus.

You’ll have to learn: Numpy+PyTorch, a little tiny bit of continuous optimization
Prerequisites

Suppose $K$ in $\mathbb{R}^{3 \times 3}$, $x$ in $\mathbb{R}^3$. Should know:

• How do I calculate $Kx$?
• When is $K$ invertible?
• What is $x$ if $Kx = \lambda x$ for some $\lambda$?
• What’s the set $\{y: x^Ty = 0\}$ geometrically?

You should also be able to remember some notion of a derivative.
Waitlist Policies

1. Waitlist right now is huge
2. I will move as many people off as possible
3. I will not reorder the waitlist
4. If you are dropping, please drop quickly so others can be added quickly
Evaluation

- Mid-term Exam: 15%
- Homeworks: 5 x 10%
- Project: 35%
Evaluation: Mid-term

• 15% of grade
• Thursday before Spring Break (2/28) in class
  • Please do not schedule things.
• Will cover:
  • Images and image processing
  • Fitting and matching
  • Basics of Learning
Evaluation: Homework

• 5 Homeworks, 10% Each
• Submit a tiny project (code) + write-up (pdf)
• You should discuss, but your implementations should be your own.
• No: copying off the Internet or your classmates, asking reddit / stackoverflow, over-the-shoulder debugging
• Overall: should not know the code for how others solved it.
Evaluation: Homework Late Days

• 3 late days in *The Ann Arbor Bank of Late HW*
• Spend these as you choose. No loans!
• No need to announce you’re taking a late day – we’ll just deduct it automatically.
Evaluation: Homework Late Policy

- Penalty: 1% per hour, round to nearest hour
- Example:
  - Due: Midnight Mon. (1s after 11:59:59pm Mon)
  - Submitted at 12:15am Tue: No penalty!
  - Submitted at 6:50am Tue: 7% penalty
- Exceptions only for exceptional circumstances (talk to us)
- Questions?
Evaluation: Homework Advice

• Start early: vision often takes a while to run. Think of both computer time and your time. They’re different.

• Vision code often “works” a little, but poorly, with bugs. Build in time for two full screwups.

• Make things modular: visualize and test on smaller data.

All three interact – bugs are expensive since they may require lengthy reruns.
Evaluation: Term Project

• Work in a team of 2+ to do something cool
• There will be a piazza thread for pairing up
• Could be:
  • Independent re-implementation of a paper
  • Applying vision to a problem you care about
  • Trying to build and extend an approach
• Should be 3 homeworks worth of work per person
Evaluation: Term Project

Think outside the box!

Evaluation: Term Project

• Proposal due between Feb 14 – March 19. We will provide some inspiration. You can turn it in at any point and we will give you feedback quickly.

• Progress Report due April 4: what have you done, what is left?

• Final Project (code + report) due April 23 at the earliest (may give an extension).

• Poster Session during Exams.

• Questions?
Meetings

• Class:
  • Tue/Thu 10:30am – Noon, 1571 GGBL

• Discussion Section
  • Wed 5PM-6PM, 1571 GGBL
  • Mon 12:30PM – 1:30PM, 1200 EECS

• Office Hours
  • Professor: 10:30am-Noon Fridays (BBB 3777)
  • GSI/IAs: 3:00-4:30pm Tuesday, 2:30-4:00pm Thursday (BBB Learning Center)
## Meetings

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<thead>
<tr>
<th>Day</th>
<th>Activity</th>
<th>Time</th>
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<tbody>
<tr>
<td>Mon</td>
<td>Discussion</td>
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<td>Tue</td>
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<td>Wed</td>
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<td>Fri</td>
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Questions?
Slide Credit: L. Lazebnik