EECS 442
Computer Vision
Justin Johnson & David Fouhey
Winter 2021
https://web.eecs.umich.edu/~justincj/teaching/eecs442/WI2021/
Lecture 1: Introduction
Goals of Computer Vision

Get a computer to understand
Goals of Computer Vision

Goal: Naming
Goals of Computer Vision

Goal: Naming

Bob and Betty Beyster Building

Justin Johnson

Lawngress
Goals of Computer Vision

Goal: Naming

The picture shows a building with many windows and grass in front of it. There is a person walking on the right...
Goals of Computer Vision

Goal: 3D Structure
Goals of Computer Vision

Goal: Actions

What can I do here?
Goals of Computer Vision

Goal: Matching
Something I’m excited about...
Generating Images

Karras et al, “Progressive Growing of GANs for Improved Quality, Stability, and Variation”, ICLR 2018
Generating Images from Language

**Text Prompt**
an illustration of a baby daikon radish in a tutu walking a dog

**AI-Generated Images**

**Text Prompt**
an armchair in the shape of an avocado, an armchair imitating an avocado.

**AI-Generated Images**

Generating Images from Language

**TEXT PROMPT**

an illustration of a baby daikon radish in a tutu walking a dog

**AI-GENERATED IMAGES**

![Generated Images](https://openai.com/blog/dall-e/)

**TEXT PROMPT**

an armchair in the shape of a peach, an armchair imitating a peach.

**AI-GENERATED IMAGES**

![Generated Images](https://openai.com/blog/dall-e/)
Reconstructing the 3D World

[Images of a room and its 3D model]

Justin Johnson & David Fouhey  EECS 442 WI 2021: Lecture 1 - 14  January 19, 2021
Giving People Tools

Roughly: as magnetic as MRI machine and as big as Venus

Traditional Technique: 30 min/image

Neural Network: ~4s / image
Why is this hard?

All of this stuff seems obvious and effortless!

Why do we need a whole subfield of CS for this?

**Key Concept**: We see with both our eyes and our brain
Why is this hard?
Why is this hard?
Why is this hard?

Problem: Semantic Gap
Why is it important?

Understand Web Data

Instagram: 100 million photos and videos uploaded per day

YouTube: 300 hours of video uploaded every minute

Looking at all content created in one day would take >50 years
Why is it important?

Autonomous Vehicles
Why is it important?

Robotics
Why is it important?

Augmented / Virtual Reality
Why is it important?
Science and Medicine

Medical Imaging

Levy et al, 2016

Galaxy Classification

Dieleman et al, 2014

Whale recognition

Kaggle Challenge

From left to right: public domain by NASA, usage permitted by ESA/Hubble, public domain by NASA, and public domain.

This image by Christin Khan is in the public domain and originally came from the U.S. NOAA.
We have made great progress

![ImageNet Large Scale Visual Recognition Challenge](chart)

Enter Deep Learning

- **2010**: Lin et al.
- **2011**: Sanchez & Perronnin
- **2012**: Krizhevsky et al. (AlexNet)
- **2013**: Zeiler & Fergus
- **2014**: Simonyan & Zisserman (VGG)
- **2014**: Szegedy et al. (GoogleLeNet)
- **2015**: He et al. (ResNet)
- **2016**: Shao et al.
- **2017**: Hu et al. (SENet)
- **Human**: 5.1
Explosion of Computer Vision

Publications at top Computer Vision conference:
Number of submitted and accepted papers at CVPR
Despite our success, computer vision still has a long way to go.

Computer vision is far from solved!
“The Elephant in the Room”

Modern object detectors seem to work well!

Rosenfeld et al, “The Elephant in the Room”, arXiv 2018
“The Elephant in the Room”

“Unusual” objects are often missed!

Computer Vision systems “see” very differently than we do.

Rosenfeld et al, “The Elephant in the Room”, arXiv 2018
Course Logistics
Meeting Times

• Lecture:
  • Section 1: Tue / Thu 10:30am – 12:00pm on Zoom
  • Section 2: Tue / Thu 12:00pm – 1:30pm on Zoom

• Office Hours
  • Lots of office hours! Schedule TBD
  • GSI Office Hours: Questions about homework, code
  • Faculty Office Hours: Prefer conceptual questions
Prerequisites

You **absolutely** need:

- **Programming**: EECS 281
- **Linear Algebra** (new): Math 214, 217, 296 or 417
  - Reach out to us if you have equivalent experience
  - We will have a one-lecture math refresher

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 $\{y : x^T y = 0\}$ geometrically?

You should also be able to remember some notion of a derivative
Websites

- Course website: https://web.eecs.umich.edu/~justincj/teaching/eecs442/WI2021/
- Piazza: https://piazza.com/class/umich/winter2021/eecs442
- Canvas / Autograder for code submission
- Gradescope for writeup submission
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 do not guarantee instant response times

• Please don’t ask questions about course material, homework, or logistics over email – those should all go to Piazza

• If you have a sensitive or private issue, then email me / David directly
Textbooks

No required textbook.

Szeliski, *Computer Vision: Algorithms and Applications*, is a good reference and available online.

http://szeliski.org/Book/
Evaluation

- Homework (76%)
  - Programming assignments in Python / numpy / Pytorch
  - HW0 is a numpy crash course (6%)
  - HW1-6 are guided mini-projects
  - HW1-5 are 12% each
  - HW6 is 10%

- Project (24%)
  - Project Proposal (2%)
  - Virtual Project Showcase (8%)
  - Project Report (14%)
Homework Late Policy

• Penalty: 1% per hour, rounded to nearest
• Example:
  • Due: Midnight Mon. (1s after 11:59:59pm Mon)
  • Submitted at 12:15am Tue: No penalty!
  • Submitted at 6:50am Tue: 7% penalty (specifically 90% - > 83%)
• Exceptions only for exceptional circumstances.
• Everyone gets 72 free late hours, applied automatically
Copying: There are better options

- Read the syllabus
- Copying is usually *painfully* obvious and I don’t have many options
- Submit it late (*that’s why we have late days*), half-working (*that’s why we have partial credit*), or take the zero on the homework – I guarantee you won’t care about one bad homework in a year
- If you’re overwhelmed, talk to us
Course Project

• Work in a team of 3-5 to do *something cool*
• There will be a piazza thread for pairing up
• Could be:
  • Applying vision to a problem you care about
  • Independent re-implementation of a paper
  • Trying to build and extend an approach
• Should be 2 homeworks worth of work per person
First Homework: Numpy warmup

First homework is meant as an introduction / refresher to array programming with numpy

Will be released tomorrow, due in one week on Wednesday 1/27 11:59pm
And now to David: Camera Models