

CS 180/280A: Intro to Computer Vision and Computational Photography



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Ren Ng

GSIs: Nithin Chalapathi
Himanshu Singh
Hongsek Choi

Tutors: Aditi Mundra
Andrew Goldberg
Eric Khodorenko

Today

Introductions

Why this Course?

Administrative stuff

Project #0 out!

Brief History of Visual Data

Course Staff



Prof. Alexei Efros



Prof. Ren Ng

Course Staff

GSIs



**Nithin
Chalapathi**



Himanshu Singh



**Hongsek
Choi**

Tutors



Aditi Mundra



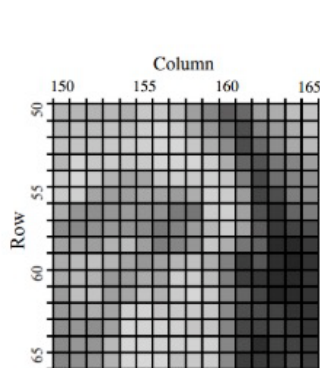
**Andrew
Goldberg**



**Eric
Khodorenko**

Why This Course?

Visual Computing in the old days...

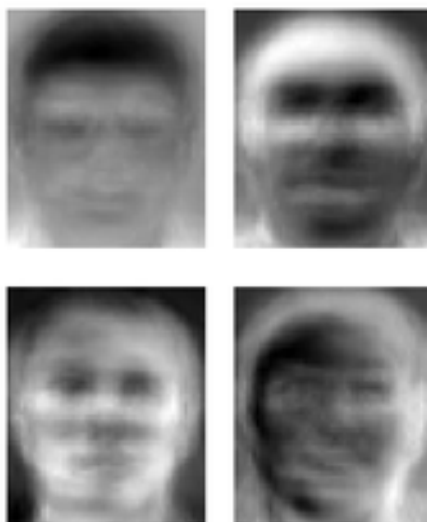


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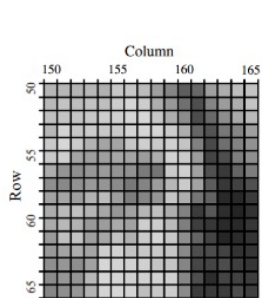
Image Processing
EECS 225B

Computer Graphics
CS 184



Computer Vision CS 280

Visual Computing gets interconnected



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Image Processing

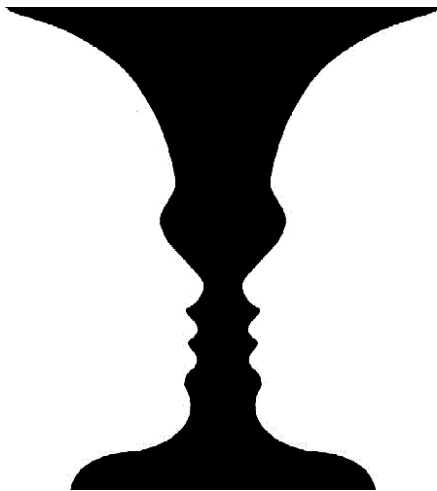
EECS 225B

Art History

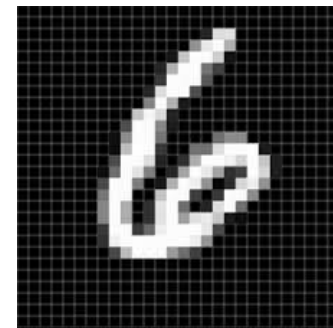
ART 10

Computer Graphics

CS 184



Computational Photography



Machine Learning

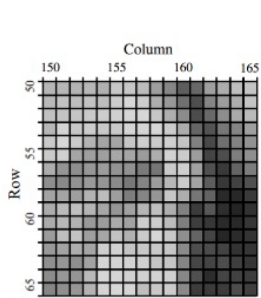
Visual Perception

PSYCH

Computer Vision

CS 280

Visual Computing gets interconnected



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Image Processing

EECS 225B

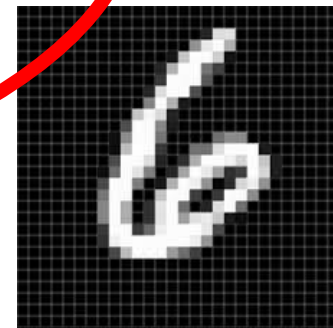
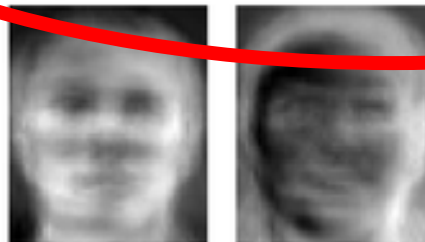
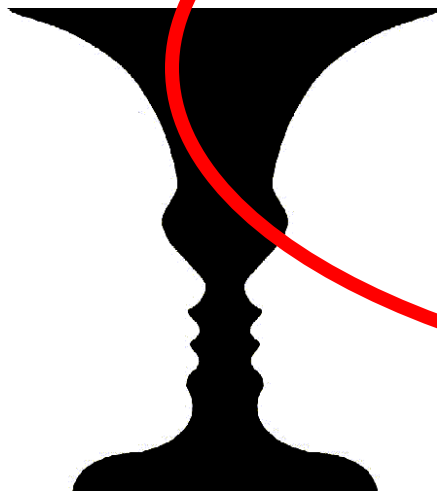
Art History

ARTH 10

Computer Graphics

CS 184

CS180



Computational Photography

Machine Learning

Visual Perception

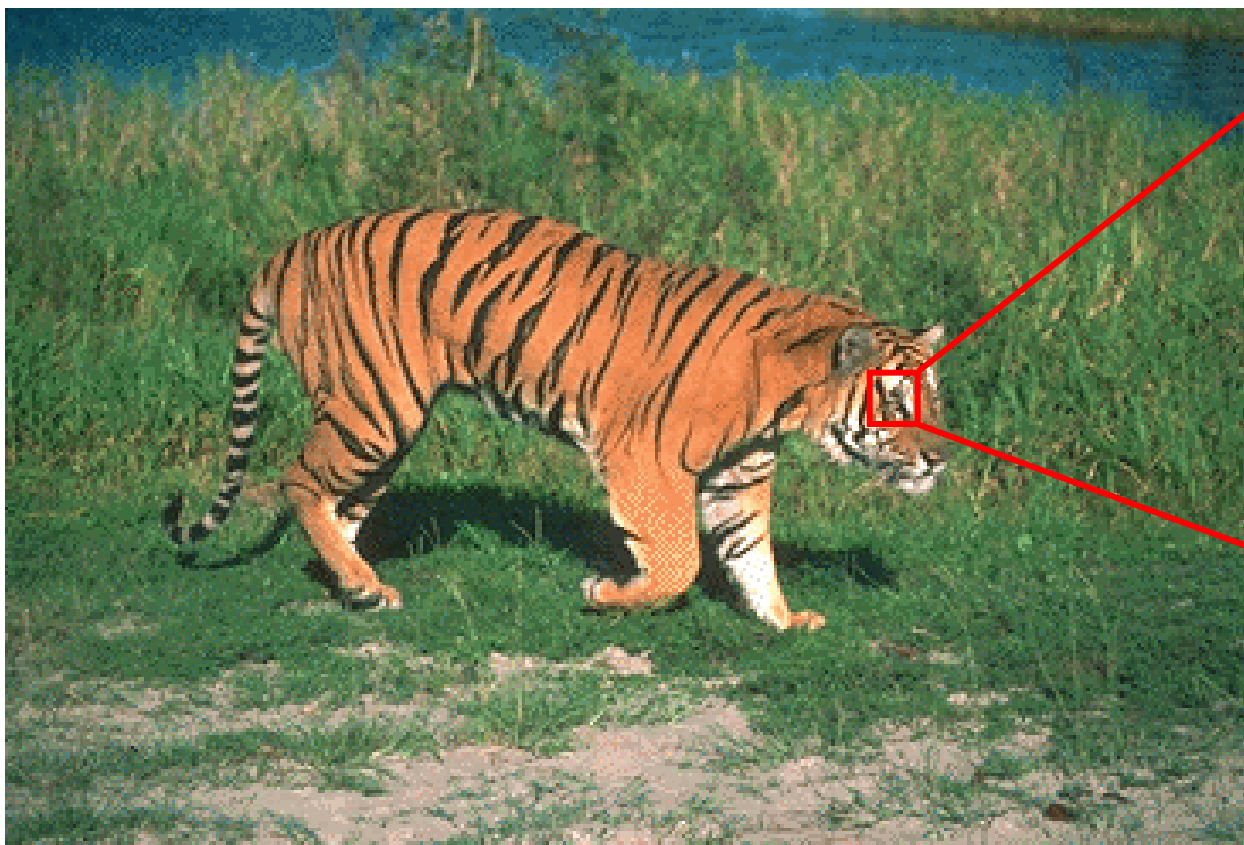
PSYCH

Computer Vision CS 280

The key objective of this class is **to become friends with every pixel!**

Course objectives

1. You will appreciate the fundamental difficulty of understanding and computing with **visual data**



Course objectives

2. You will get a foundation in image processing and computer vision, **from the ground up**:

- Camera basics, image formation
- Convolutions, filtering
- Image and Video Processing (filtering, anti-aliasing, pyramids)
- Image Manipulation (warping, morphing, mosaicing, matting, compositing)
- Projection, 3D, stereo
- Data-driven methods
- Generative Models
- ...

Course objectives

3. You will get a more intuitive understanding of important mathematical and computational concepts

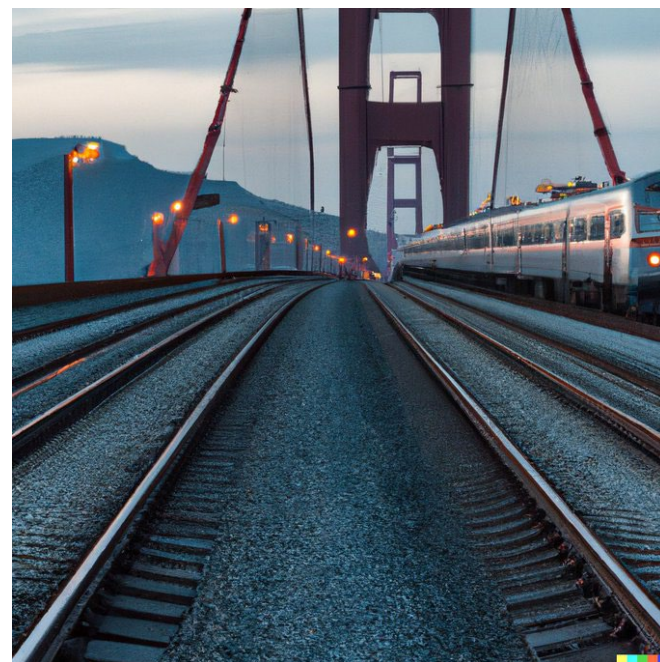
- Signal Processing
- Gradients
- Change of basis
- interpolation, extrapolation
- Furrier Transforms
- PCA
- Deep Learning
- Auto-regressive Visual Models
- Diffusion Models
- ...

Course objectives

4. You will learn approaches for **visual synthesis**



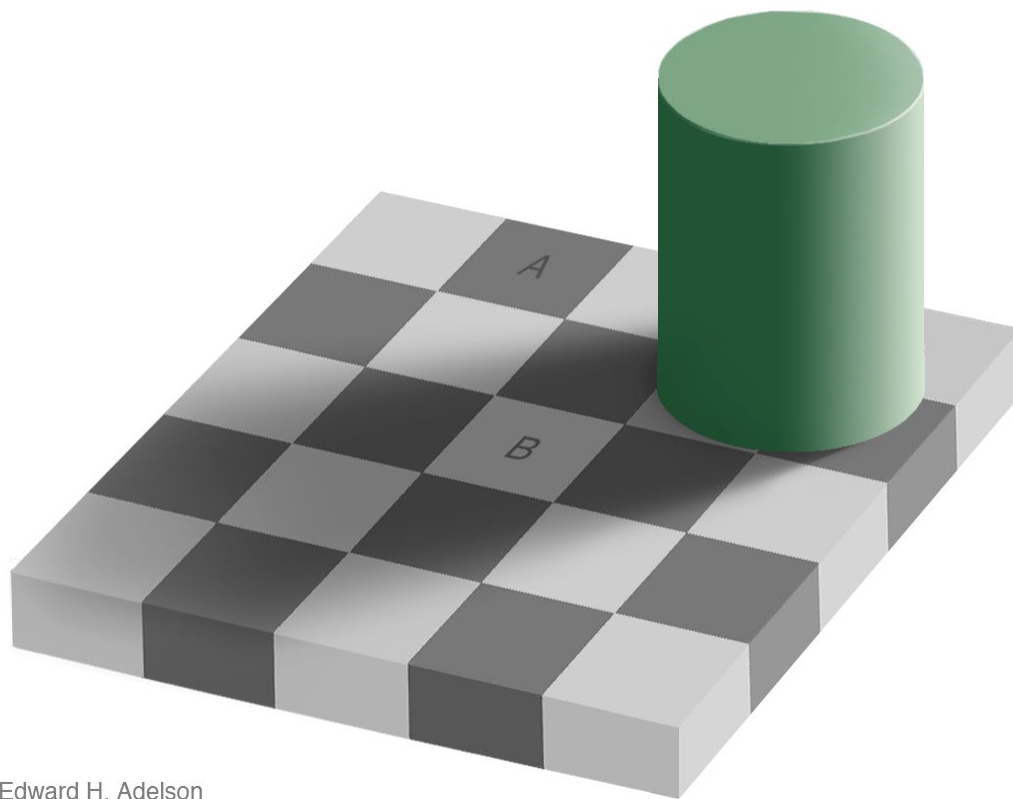
Graphic by James Hays



DALL-E + Danielle Baskin

Course objectives

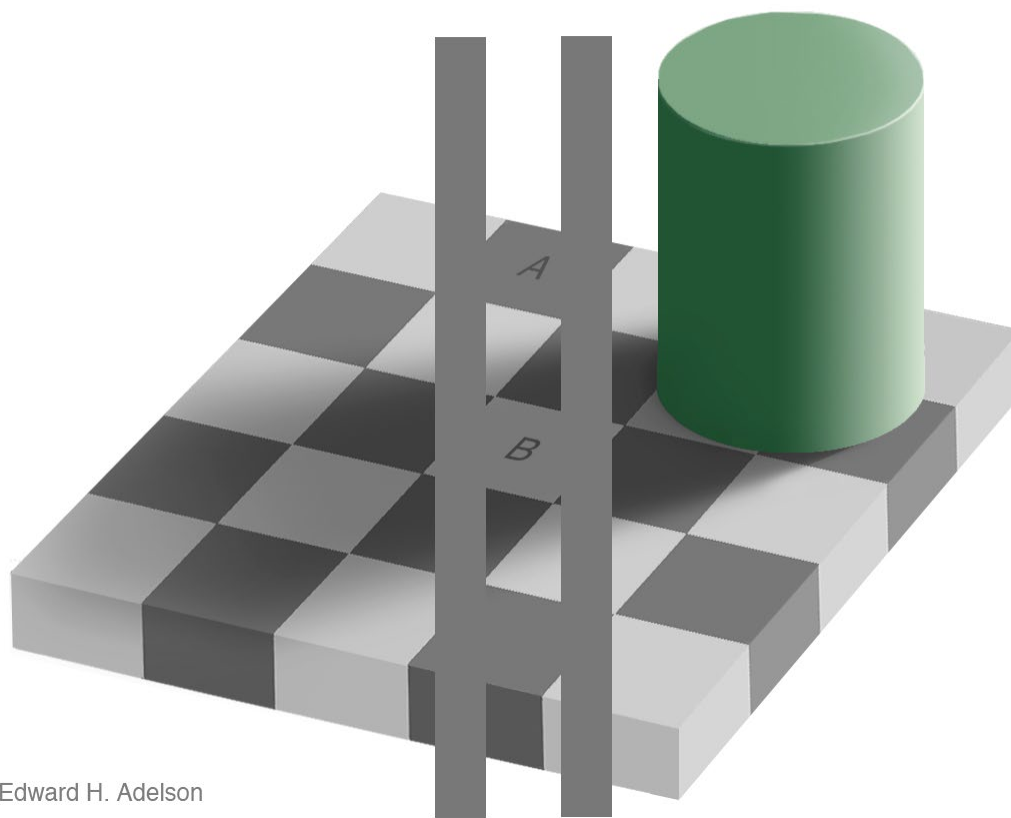
4. You'll better appreciate human visual perception



Edward H. Adelson

Course objectives

4. You'll better appreciate human visual perception



Edward H. Adelson

Different people see different things



https://en.wikipedia.org/wiki/The_dress

Course objectives

5. You will learn about the **history of ideas** in visual computing

- Did you know Large Generative Models go back to 1940s?
- Or that Deep Learning started with a Nobel Prize on Neuroscience of the Visual Cortex in the 1960s?
- ...

Course objectives

6. You'll have fun doing cool stuff, coding up a storm, largely from scratch

Programming Project #0



85mm @ 200cm

35mm @ 85cm

16mm @ 40cm

12mm @ 30cm

8mm @ 20cm

Becoming Friends with your camera:

1. Learn to take better selfies
2. Experiment with perspective compression
3. Create a **Dolly Zoom** shot

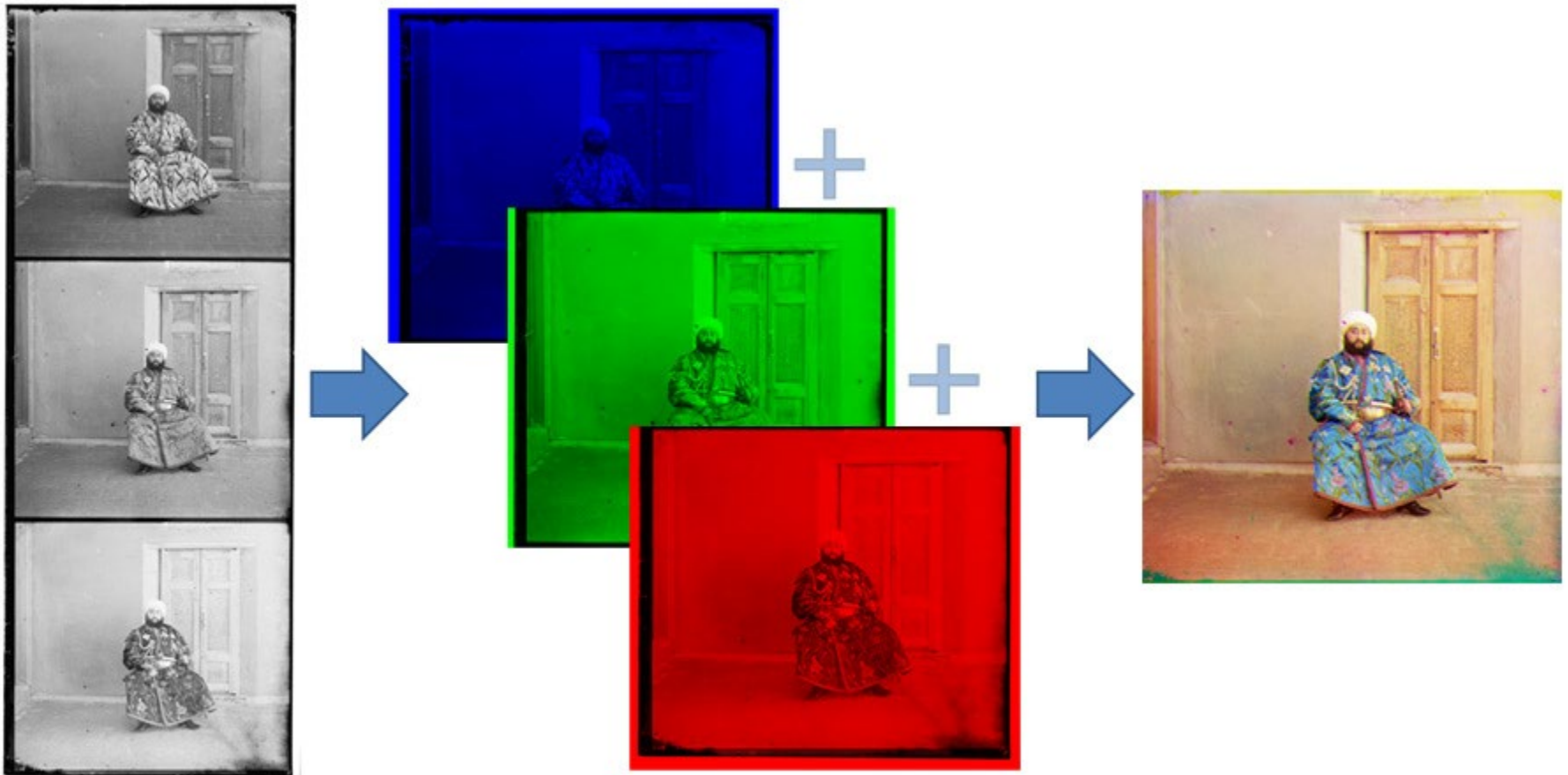
Project out TODAY, due Tuesday!

Programming Project #1

Prokudin-Gorskii's Color Photography (1907)



Programming Project #1

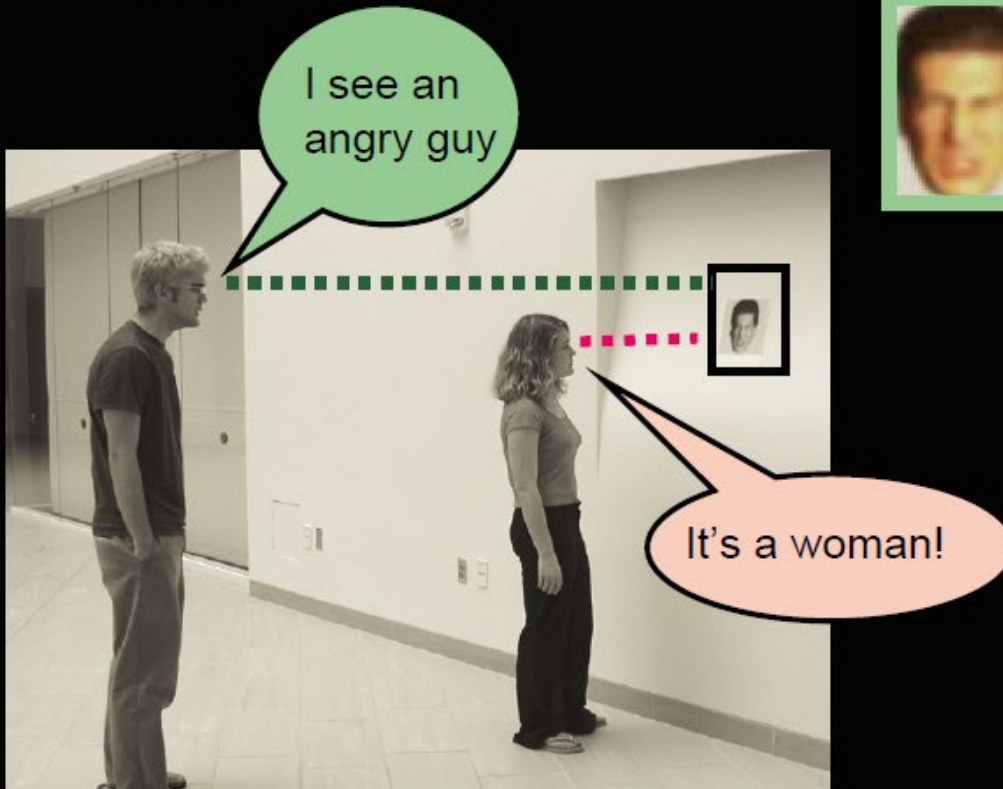


Project 2: Fun with frequencies

What you see...

From Far Away

Up Close



Project 2: Fun with Frequencies



sources/destinations



cloning



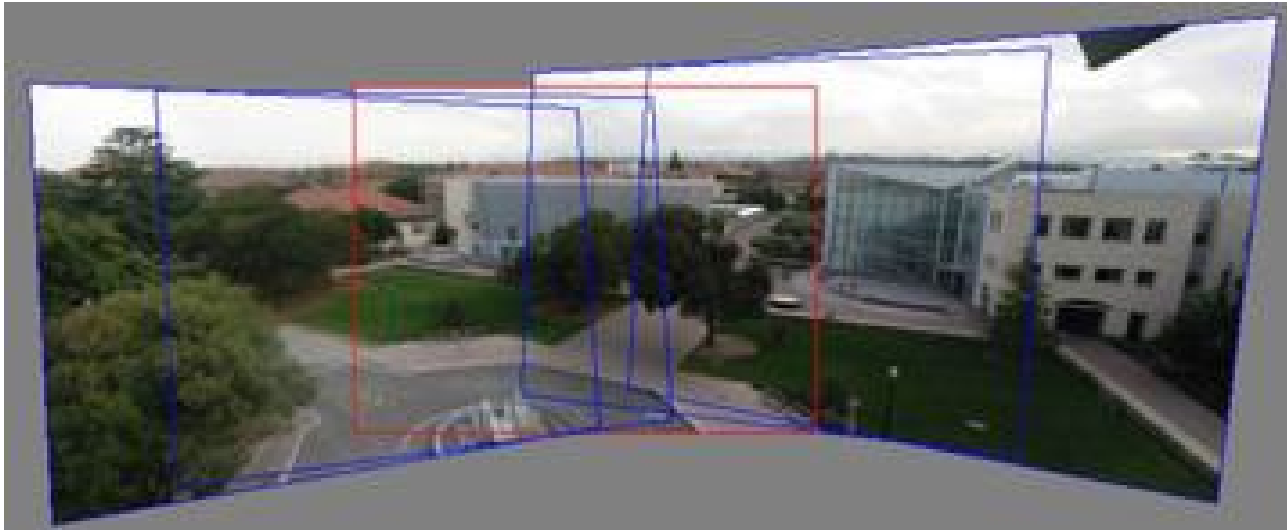
seamless cloning

Project 3: Fun with Diffusion



Project 4: Panorama Stitching

Photo Mosaics



For each project:

Derive the **math**, implement stuff **from scratch**,
and apply it to your **own** photos

Every person does their own project. **No groups!**

Reporting via web page (plus submit code)

Coding by hand (except for bells and whistles)

Our AI / LLM policy

- GPT, Claude Code, etc are wonderful tools
 - And so is calculator, Wolfram Alpha, Wikipedia, Stack Overflow, etc.
 - but before you use a calculator, it's important to learn how to do long division by hand.
- You are here to learn! The design of this course is you learning by building working assignments **from scratch**.
- Do not use LLMs to code the assignments for you, because you will **fail the class**
- Why? Exams will test your knowledge of the code you have written during the semester.
 - E.g. we might ask you to write code during exam.

Final Project

Something cool!!!

- All AI tools allowed (unlike Projects 1-4)
 - Whether from scratch or AI assisted, want you to iterate many times to develop a project that is richly your own
- Can be artistic, technical, social
 - Requirement is it **must be cool!**
- Must have a visual data aspect to project
- We will have some suggestions, cool datasets, etc
- Done in groups of ~4
- Start thinking about ideas and groups now

Sample final project from previous years



Sample final project from previous years



<https://www.youtube.com/watch?v=PCBTZh41Ris&feature=youtu.be>

Class Organization / Administtrivia

General

Prerequisites

- Linear algebra!!! (EE16A, Math 54, Math 56, or Math 110)
- Multivariable Calculus (Math 53)
- Good programming skills (at least CS61B)
- Deep Learning experience (e.g. CS189, CS182, may be concurrent)
- **Creativity**

Emphasis on programming projects!

- Building something from scratch

Graduate Version (CS280A):

- Need to do “bells & whistles” for each project
- different grading curve than CS180

Administrative Stuff

Grading

- 50% Programming Projects
- 15% Midterm (**Oct 15, in class**)
- 30% Final Exam (**Tue Dec 15, 8-11am**)
- 5% Pop Attendance Quizzes

Late Policy

- Five (5) **emergency** late days for semester. The expectation is you will never use them.
- 10% off each additional day afterwards

Rule # 1:

No lecture recordings

This is **an in-person class**. You are to come to the lecture and participate! Attendance is required.

Rule # 2:

Deadline is a deadline

In real life there are no extensions

This is a FUN but INTENSE class, projects come **one after another**

Slip days are for **emergencies**. Unless something terrible happens to you, you should have all your slip days left.

Projects are time consuming. Start early!!!

Rule # 3:

TA's don't debug code

TA's don't debug code for you.

Part of the skill is to learn how to ask questions to debug the issue without presenting the code

Visualize the results and send those to figure out what is wrong

Use the pixels – become friends with visual debugging

Getting help outside of class

Course Web Page

- <https://cal-cs180.github.io/fa26/>

Online forums:

- Ed
- **Gradescope** (add yourself via course webpage)

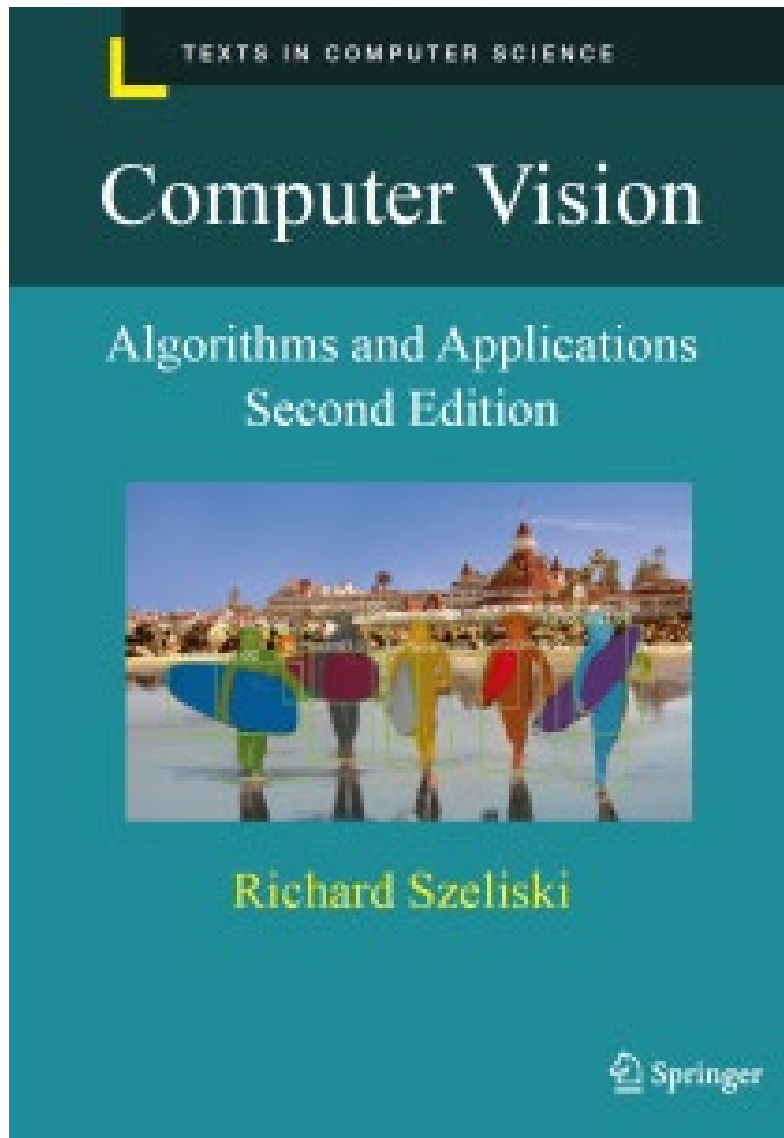
Discussion Sections:

- ~4 sections each week (watch announcements)
- Do attend, **specially first one next week!**

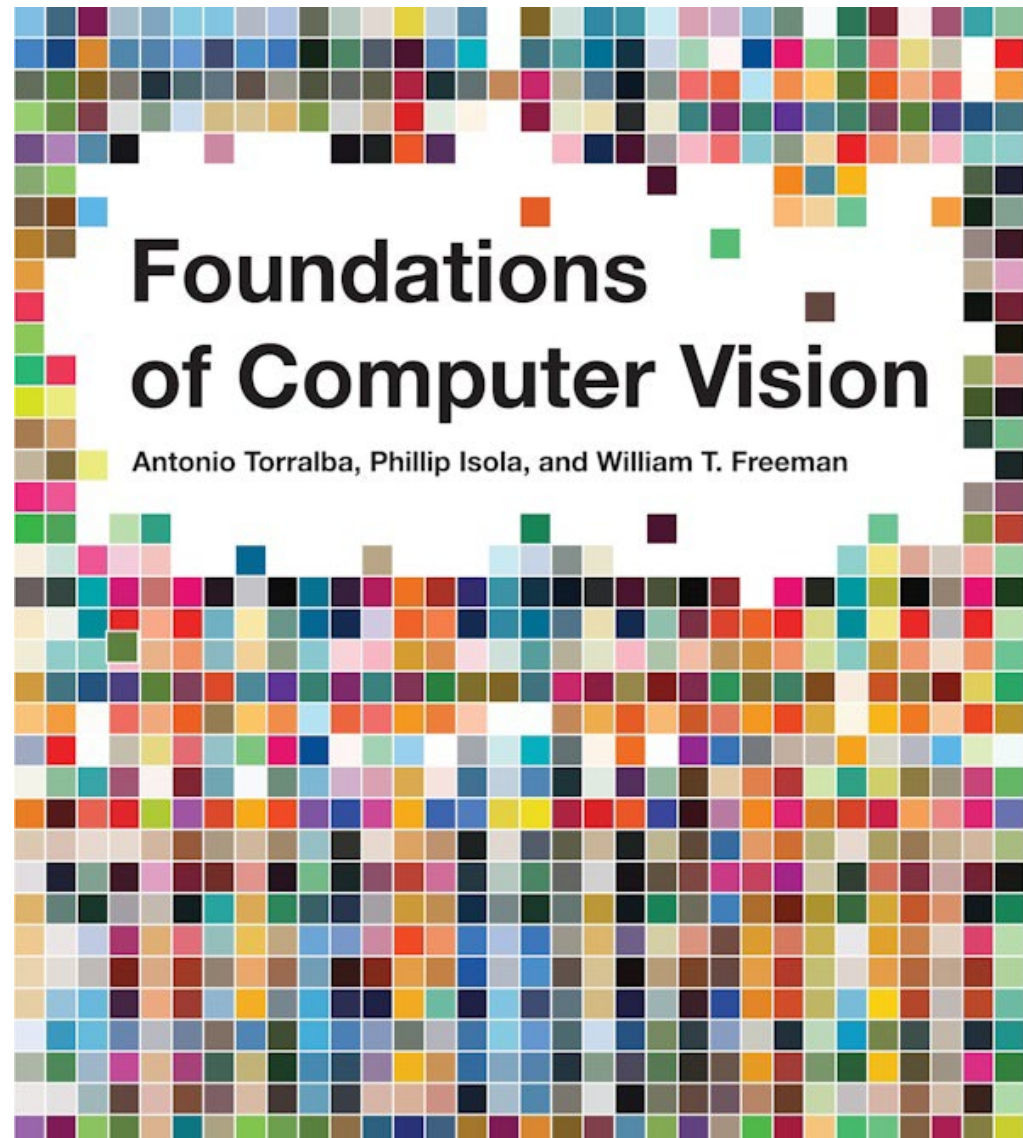
Office hours

- For profs: after each lecture
- For others, see webpage

Textbooks



<http://szeliski.org/Book/>



<https://mitpress.mit.edu/9780262048972/foundations-of-computer-vision/>

Waitlists

- We are expecting to add 10-20 seats to cs180
- Also, we expect 30-50 people to drop after the first couple of projects 😊
- So, chances are good to get in, **but you need to start doing projects**

Warning:

historically high GPA of this course

- Survivor bias
- High class GPA != easy course
- This is a FUN but INTENSE class
- Many people will drop out, switch to pass/fail.

Why you should NOT take this class

- Project-based class
 - No canned problem sets
 - No clean rubrics
 - Open-ended by design
 - Coding from scratch
 - Will try to make sure everyone understands the basics super-well, before covering advanced topics
- Need time to think, not just hack
 - **Creativity** is a class requirement Aesthetics is part of the grade.
 - We already expect you to know Deep Learning!
- Lots of work...There are easier classes if
 - you just need some units
 - you care more about the grades than about learning stuff
- Not worth it if you don't enjoy it

Now... reasons TO take this class

- It's your reward after 3 grueling years 😊
- You get to work with pictures, unleash your creative potential
- Gateway to CS280... grad school...

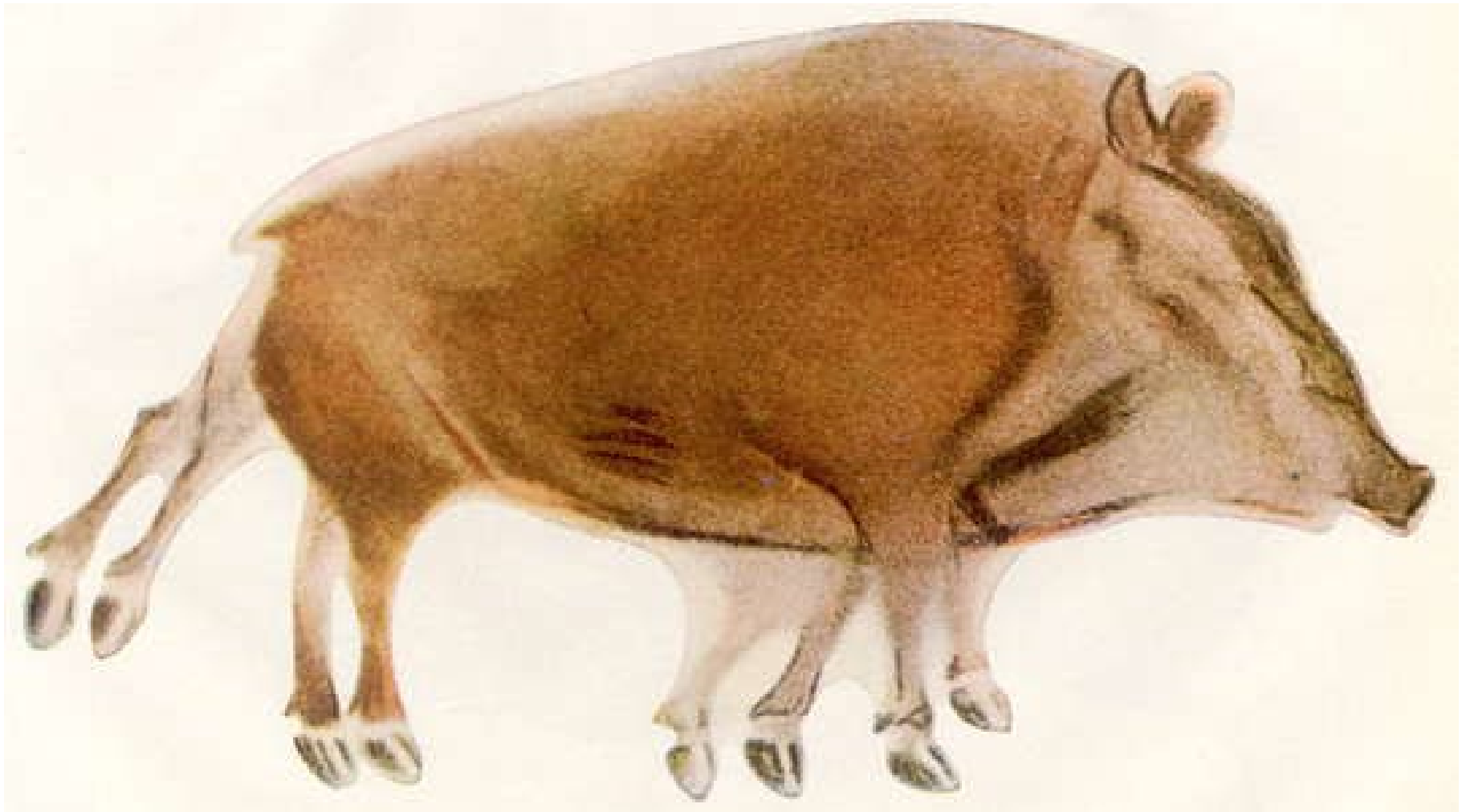


A Brief History of the Visual Data

Depicting Our World: The Beginning



Prehistoric Painting, Lascaux Cave, France
~ 13,000 -- 15,000 B.C.



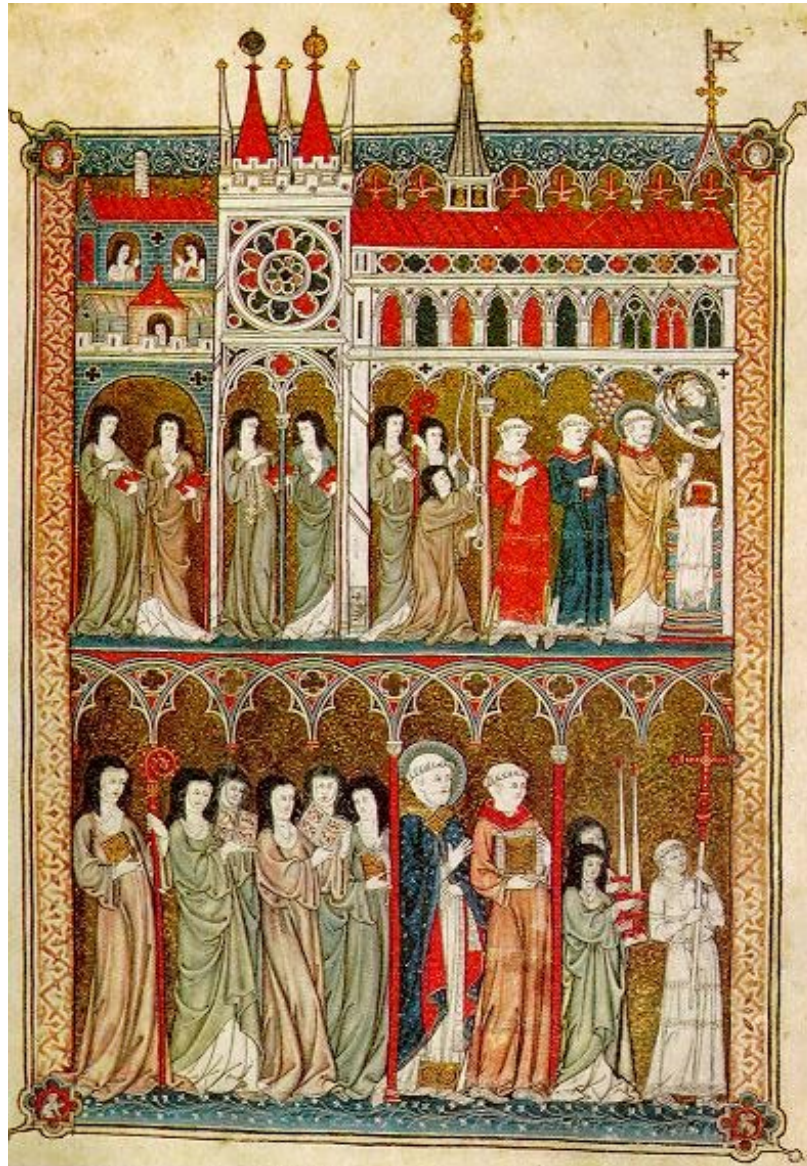
Prehistoric Cave Painting, Altamira
~ 20,000 – 15,000 B.C.

Depicting Our World: Middle Ages



The Empress Theodora with her court.
Ravenna, St. Vitale 6th c.

Depicting Our World: Middle Ages



Nuns in Procession. French ms. ca. 1300.

Beginnings of the Renaissance



Giotto, *The Mourning of Christ*, c.1305

Depicting Our World: Renaissance

North Doors (1424)



Lorenzo
Ghiberti
(1378-1455)



East Doors (1452)



Depicting Our World: Renaissance



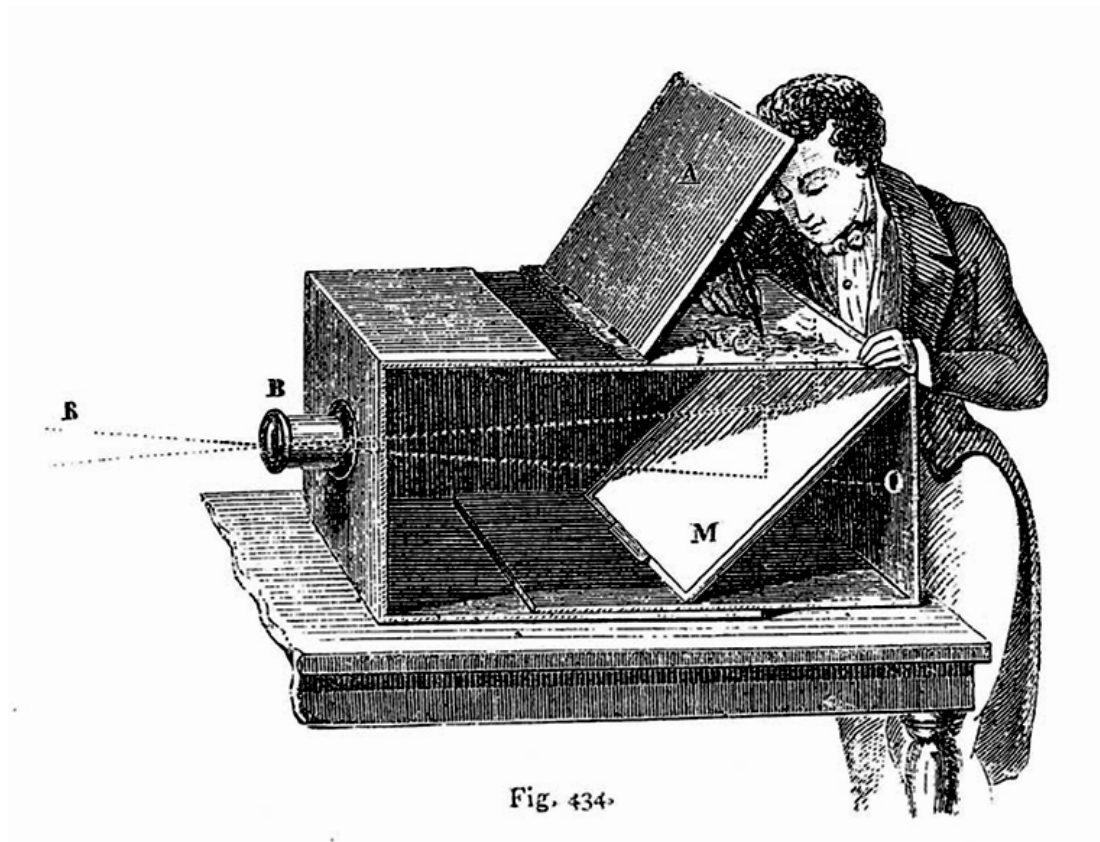
***Piero della Francesca,
The Flagellation (c.1469)***

Depicting Our World: Toward Perfection



Jan van Eyck, *The Arnolfini Marriage* (c.1434)

Depicting Our World: Toward Perfection



Lens Based Camera Obscura, 1568

Depicting Our World: Perfection!



Boulevard du Temple, Louis Daguerre, 1838

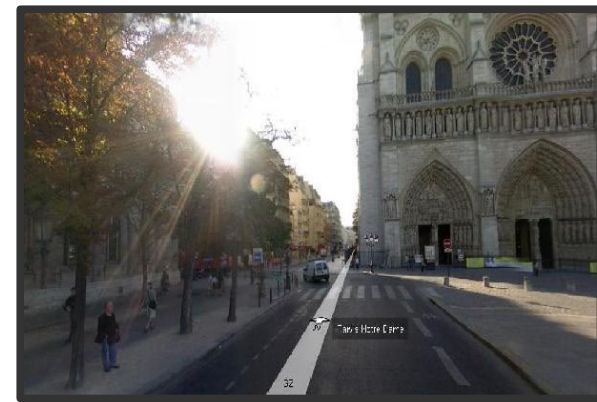
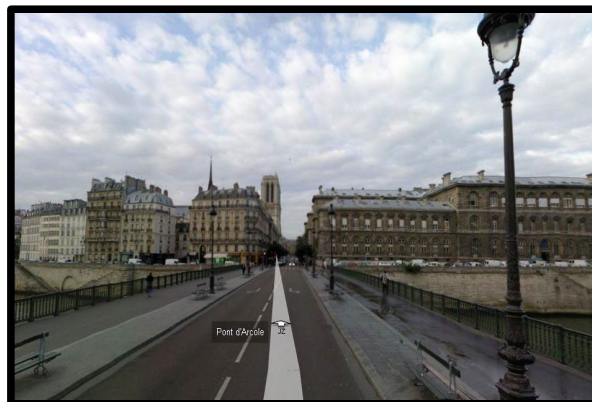
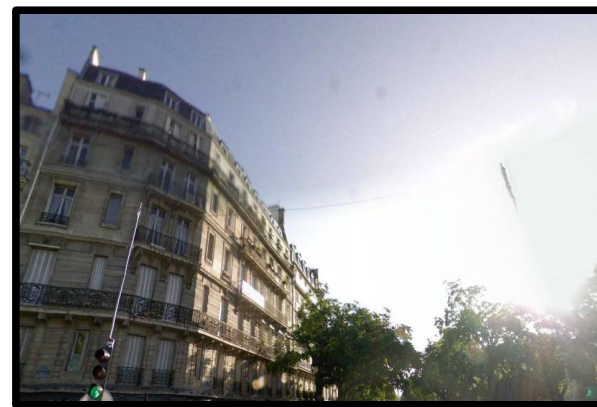
Depicting Our World: Realism?



Paris, according to Flickr



Paris, according to Google StreetView



Paris, according to me



After realism...

Monet,
La rue Montorgueil



Depicting Our World: Ongoing Quest



Pablo Picasso



David Hockney

Better than realism?



David Hockney, Place Furstenberg (1985)

Which one is right?

Multiple viewpoints



David Hockney,
Place Furstenberg,
1985

Single viewpoint



Alyosha Efros
Place Furstenberg,
2009

Depicting Our World: Ongoing Quest

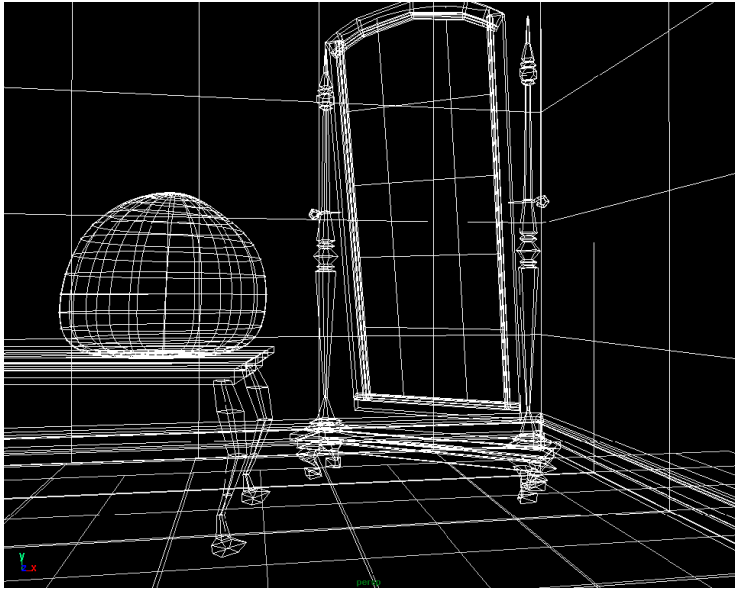


Antonio Torralba & Aude Oliva (2002)

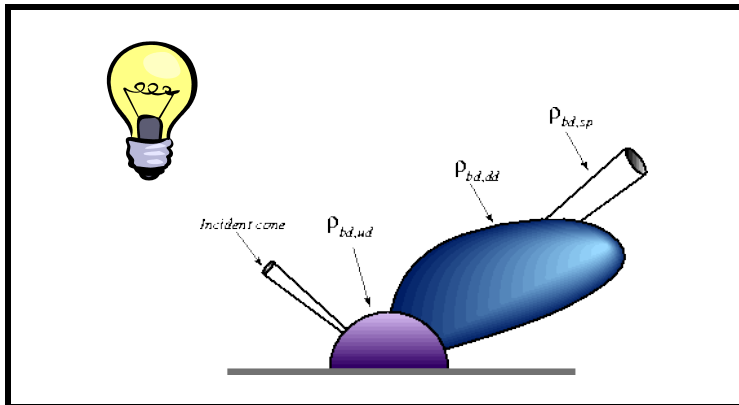


Enter Computer Graphics...

Traditional Computer Graphics



3D geometry



physics



projection

Simulation

GRAPHICS

Modern Computer Graphics



- Amazingly real
- But so sterile, lifeless, *futuristic (why?)*

The richness of our everyday world



Photo by Svetlana Lazebnik

Beauty in complexity



University Parks, Oxford

Which parts are hard to model?



Photo by Svetlana Lazebnik

Creating Realistic Imagery

Computer Graphics



- + great creative possibilities
- + easy to manipulate objects/viewpoint
- Tremendous expertise and effort to obtain realism

Computational Photography

→ Realism
Manipulation
Ease of capture
Huge Visual
Datasets ←

Photography



- + instantly realistic
- + easy to acquire
- very hard to manipulate objects/viewpoint

Pop Quiz!

- Don't worry, this time, we grade only on participation
- Quiz designed to diagnose your level of preparation for CS180
- Should take about 10-15 minutes
 - If you are DSP, you can take up to 30 minutes

