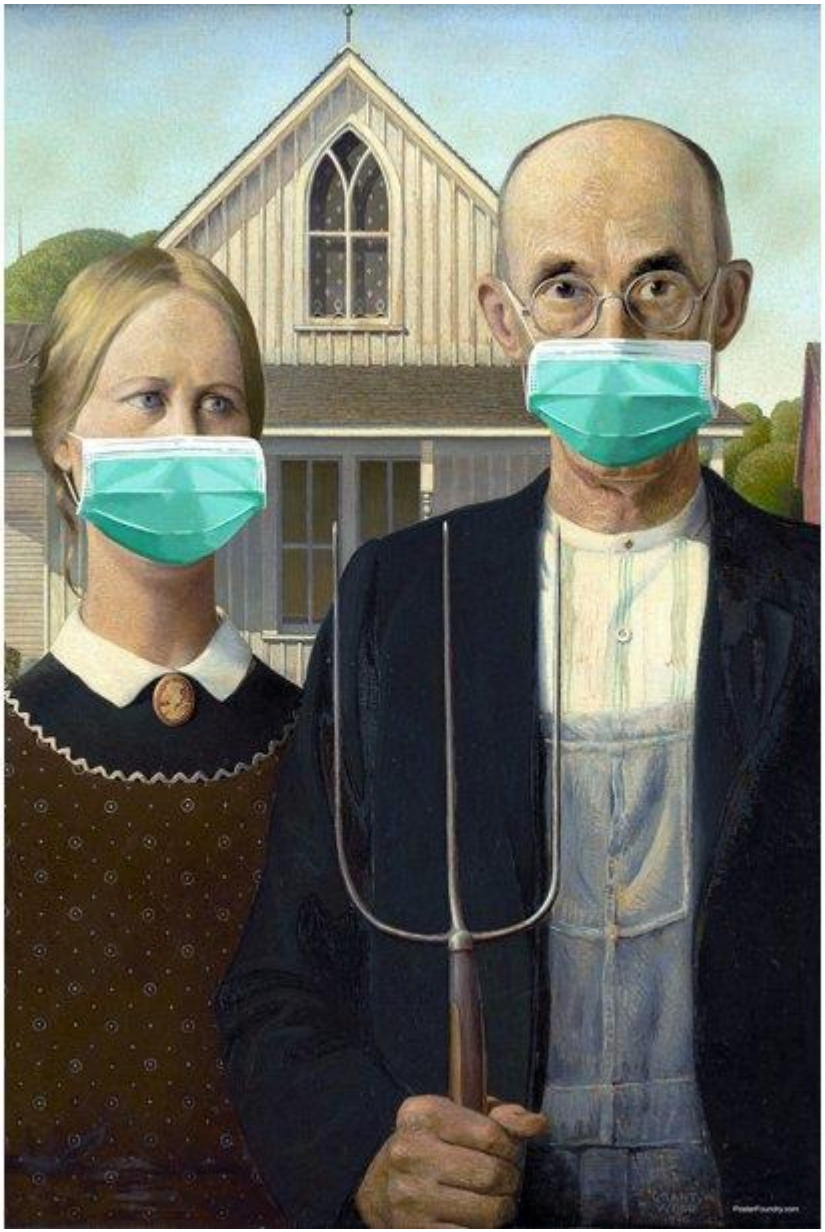
CS 194/294-26: Intro to Computer Vision and Computational Photography

Instructors: Alexei Efros
Angjoo Kanazawa
GSIs: Ruilong Li
Evonne Ng
Readers: Jason Ding
Boyuan Ma
Kamyar Salahi
Jeffrey Shen

UC Berkeley, Fall 2022, in person

Covid Precautions



Today

Introductions

Why this Course?

Administrative stuff

Brief History of Visual Data

Teaching Team: professors

Angjoo Kanazawa

Alexei Efros

Teaching Team: GSIs

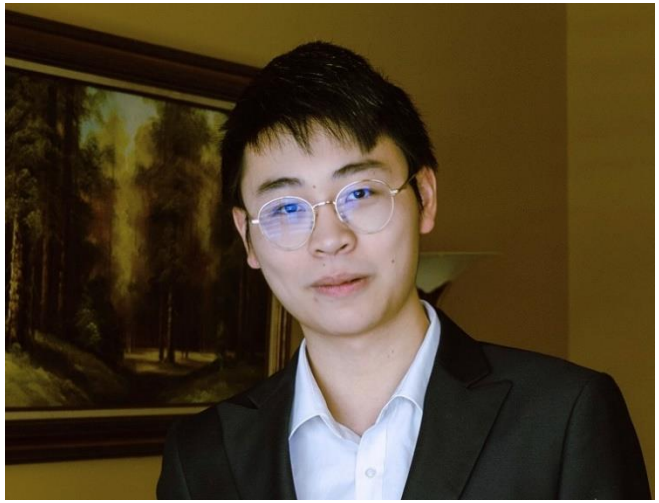
Ruilong Li

Evonne Ng

Teaching Team: Readers/Tutors

Kamyar Salahi

Boyuan Ma

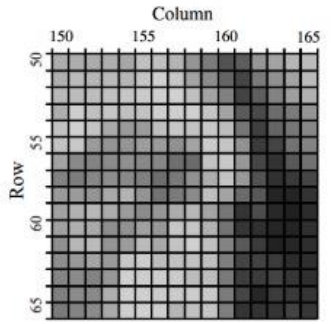


Jason Ding

Jeffrey Shen

Why This Course?

Visual Computing in the old days…



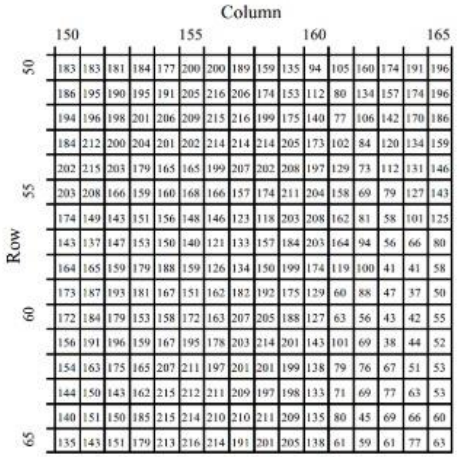
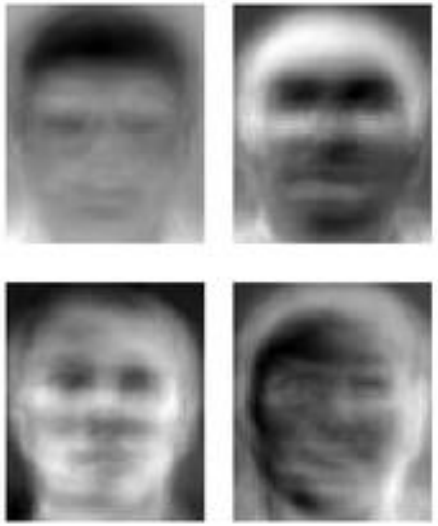


Image Processing
EECS 225B

Computer Graphics
CS 184



Computer Vision CS 280

Visual Computing gets interconnected

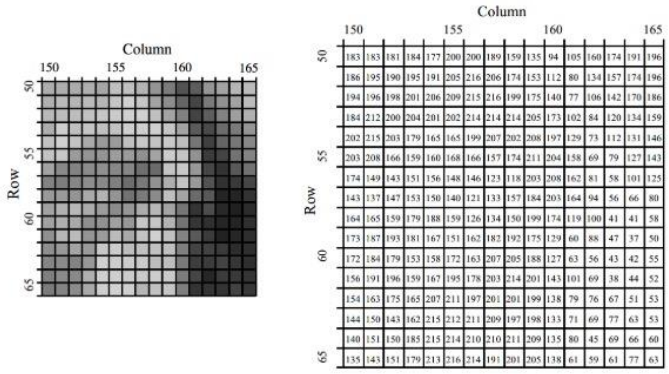
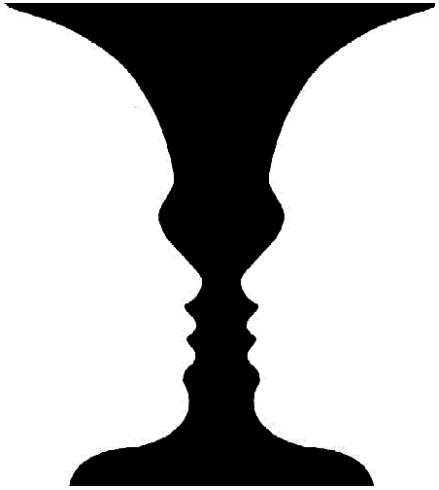


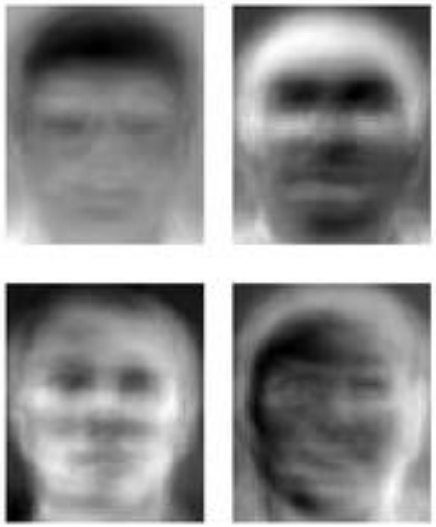
Image Processing
EECS 225B

Art History
ART 10

Computer Graphics
CS 184

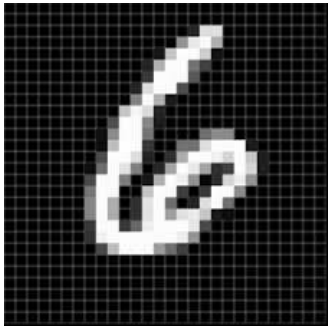


Visual Perception
PSYCH



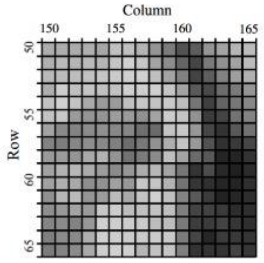
Computer Vision CS 280

Computational Photography



Machine Learning

Visual Computing gets interconnected



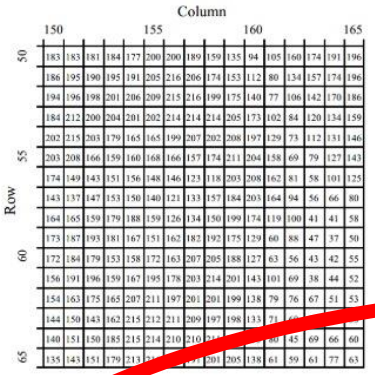
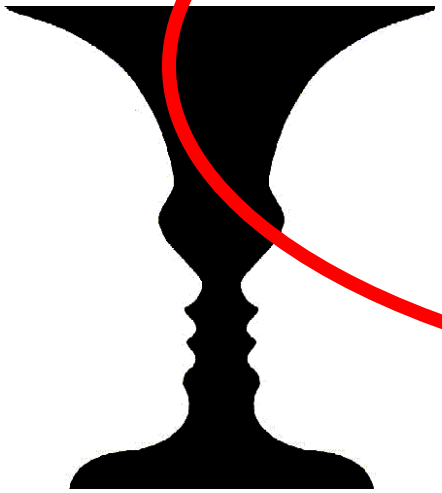


Image Processing
EECS 225B

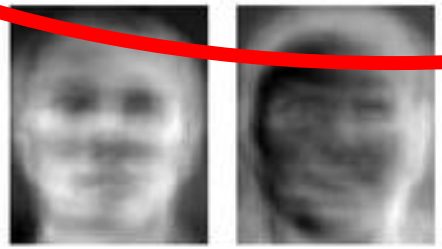
Art History
ART 10

Computer Graphics
CS 184

THIS CLASS



Visual Perception
PSYCH



Computer Vision CS 280

Computational Photography

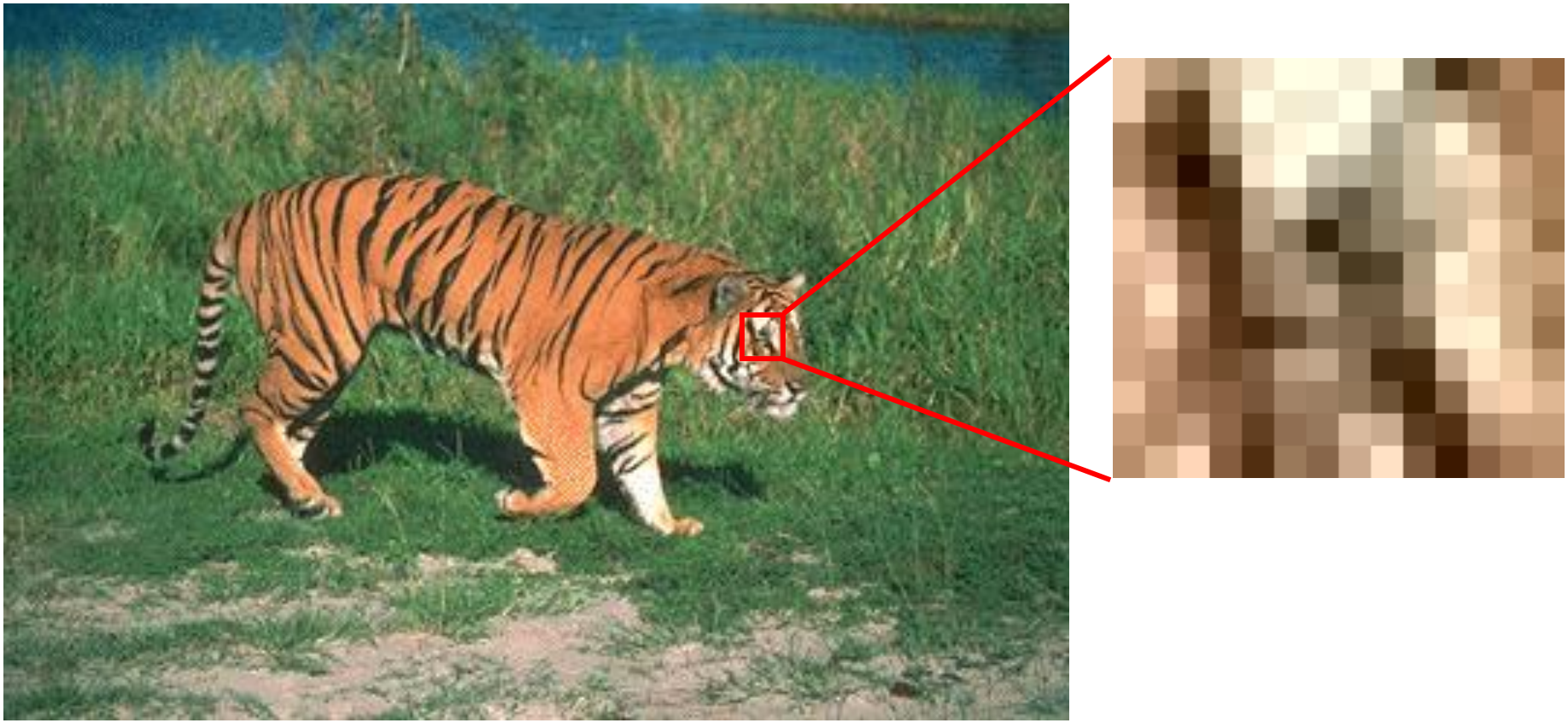
Machine Learning

CS194-26: Focus on Visual Data

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

- Camera basics, image formation
- Convolutions, filtering
- Image and Video Processing (filtering, anti-aliasing, pyramids)
- Image Manipulation (warping, morphing, mosaicing, matting, compositing)
- Projection, 3D, stereo
- Basics of recognition
- …

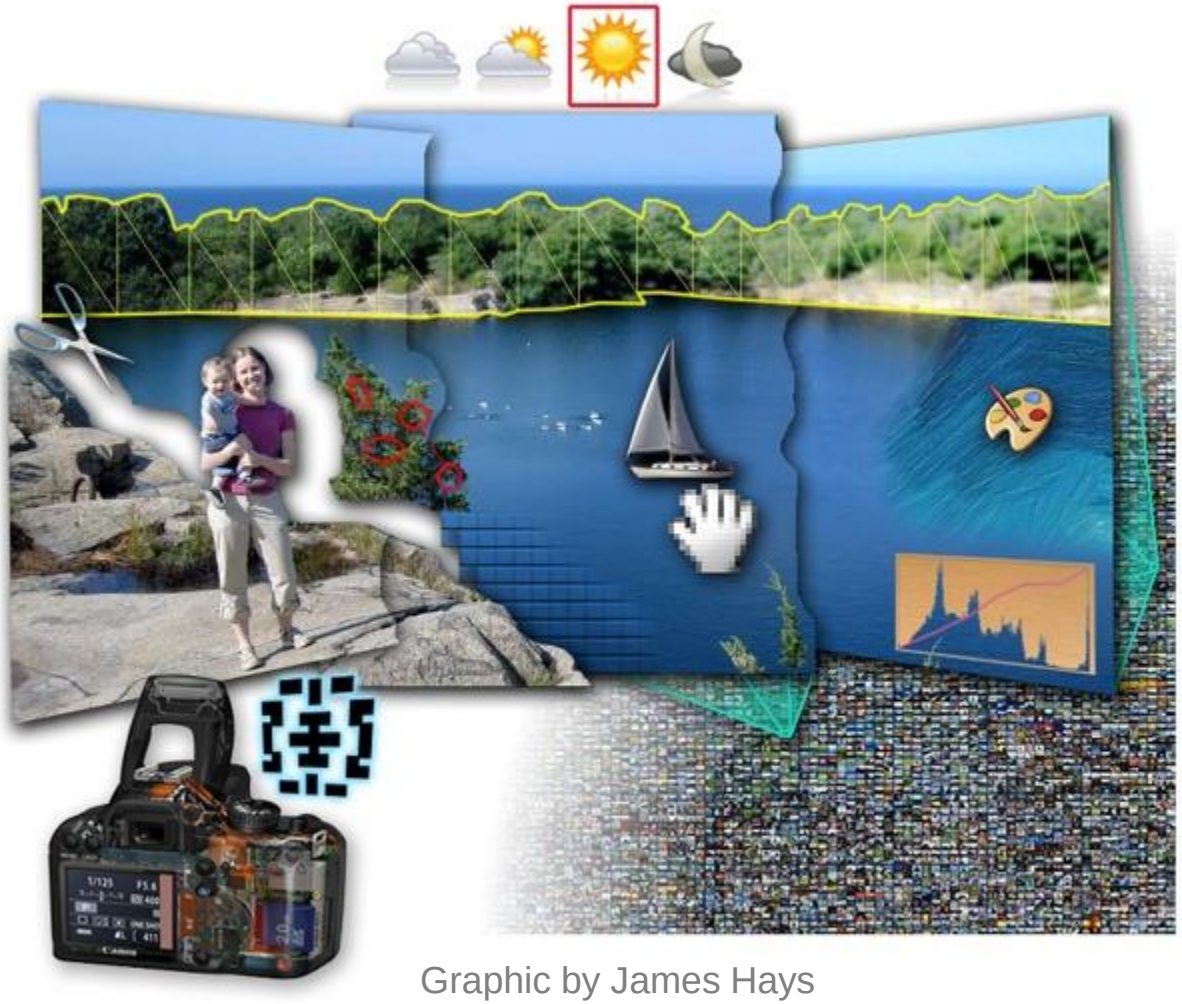
Course objectives

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

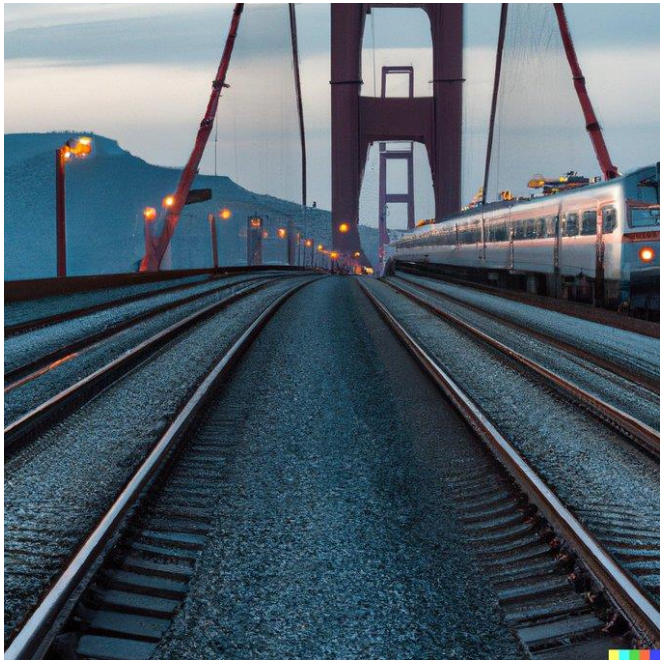
- Gradients
- Change of basis, interpolation, extrapolation, PCA
- FFT
- Dynamic programming, recursion
- Machine learning, Convolutional Neural Networks
- Large-data Approaches
- …

Course objectives

4. You will learn approaches for visual synthesis



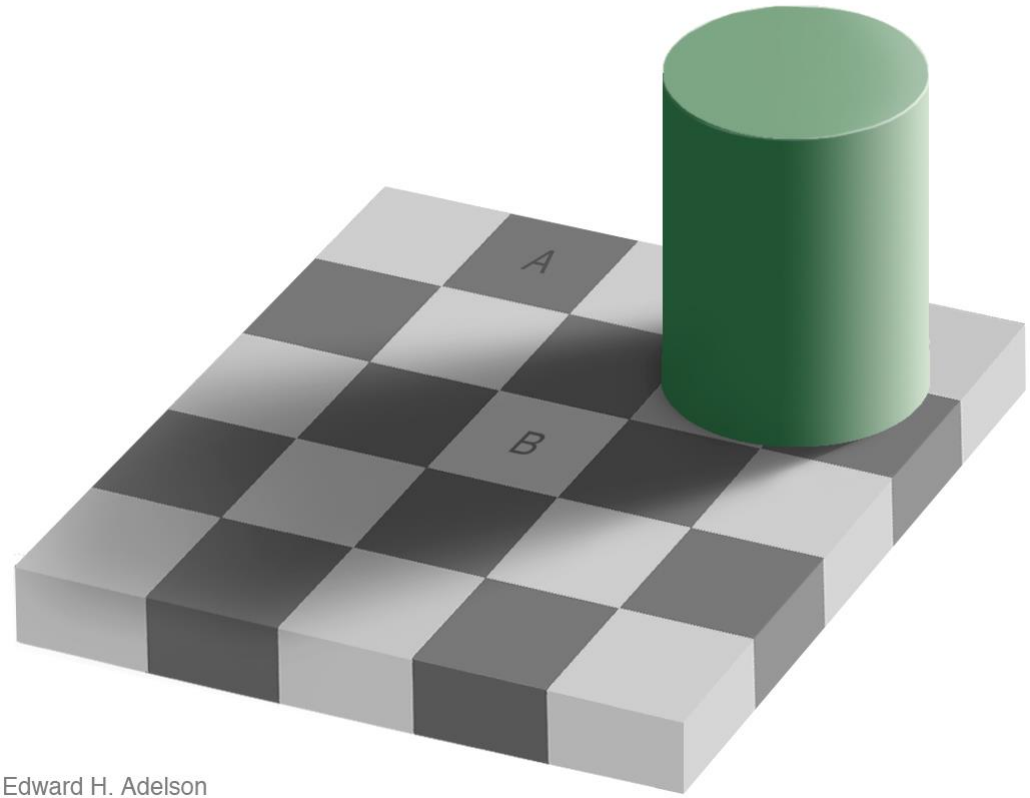
Graphic by James Hays



DALL-E + Danielle Baskin

Course objectives

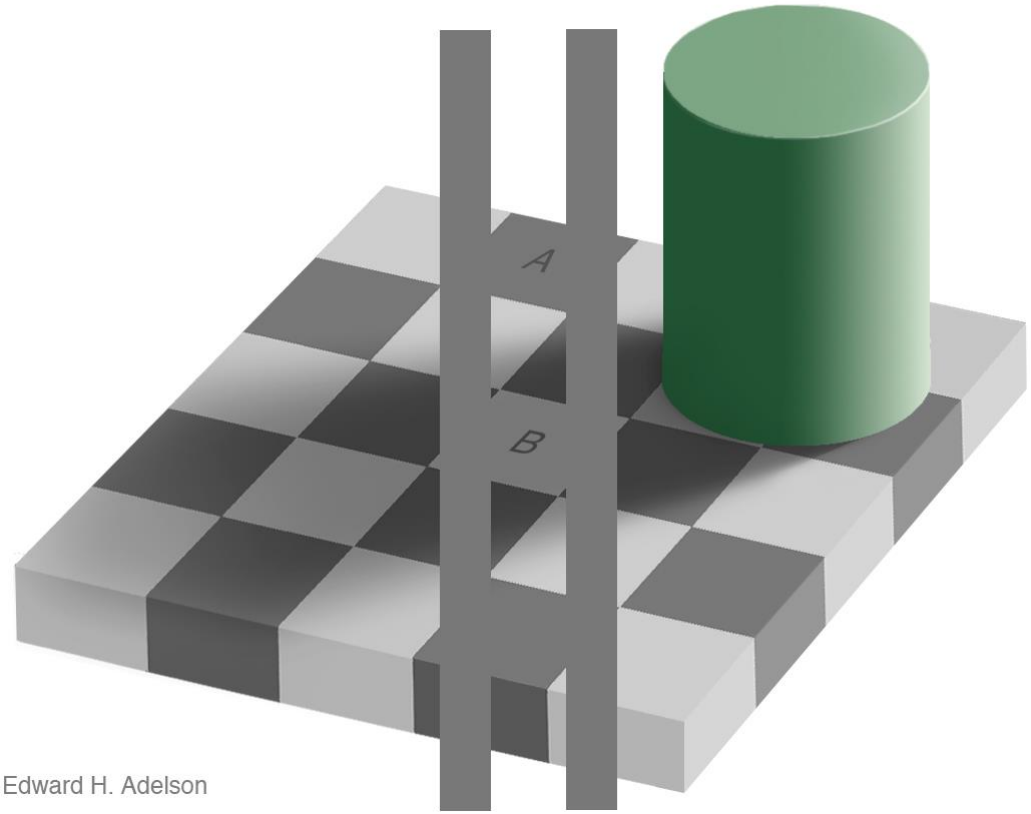
4. You'll better appreciate human visual perception



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

Seeing vs. experience

Seeing less than you think…

Video by Antonio Torralba (starring Rob Fergus)

But actually…

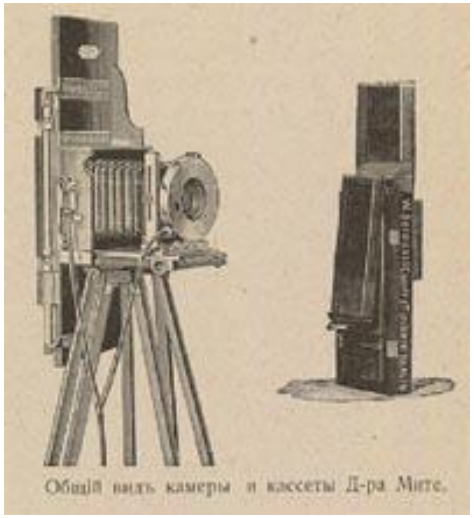
Video by Antonio Torralba (starring Rob Fergus)

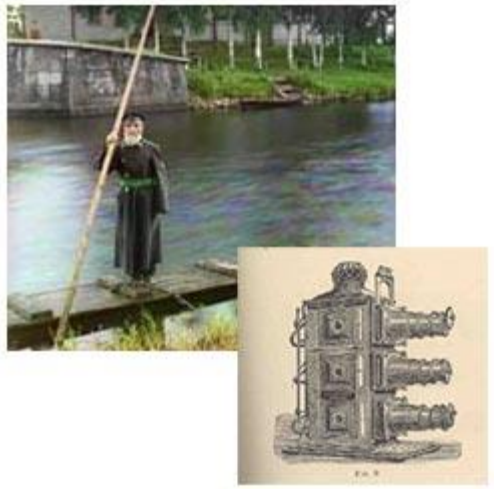
Course objectives

5. You'll have fun doing cool stuff, coding up a storm, while you befriend the pixels

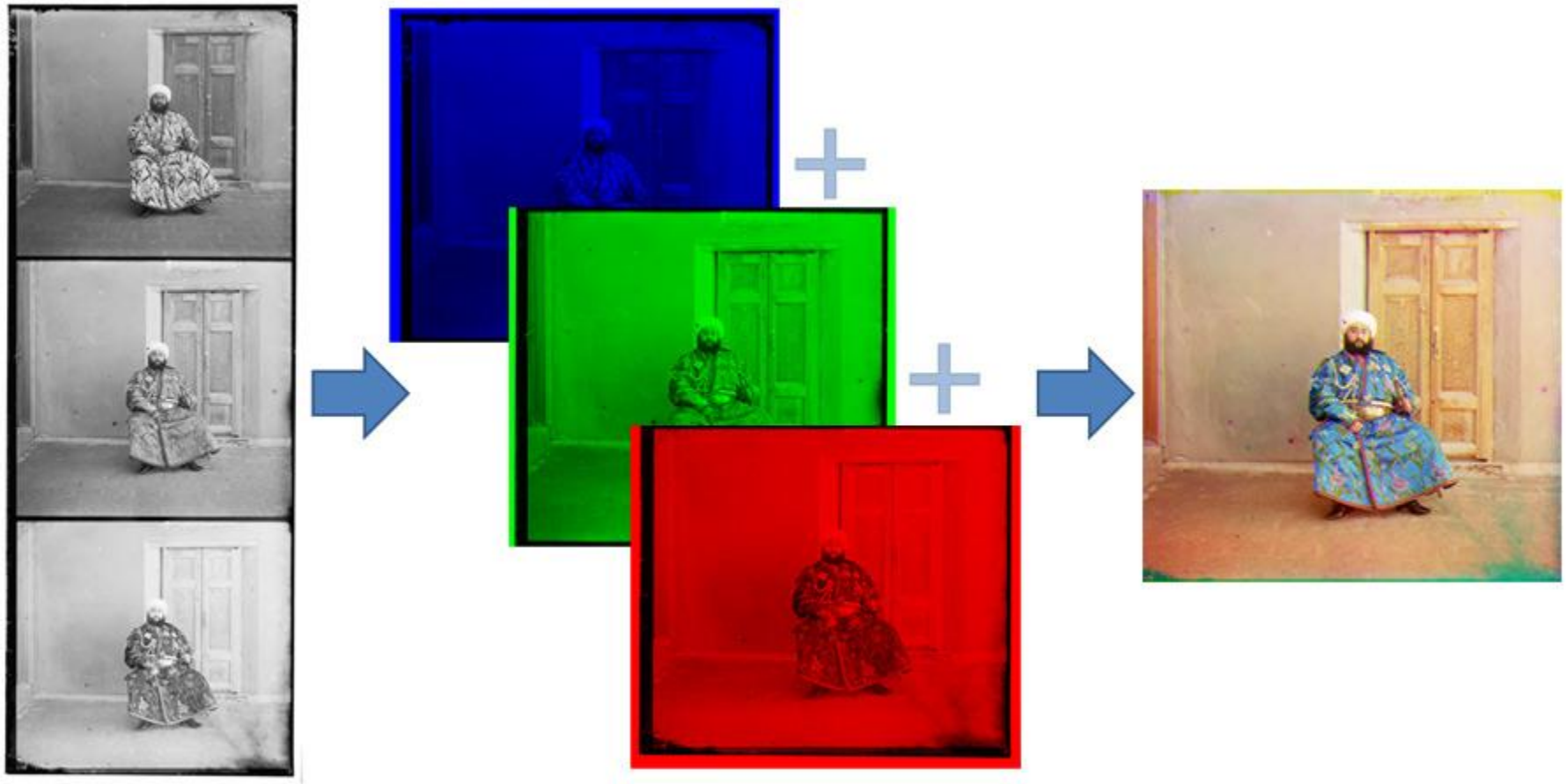
Programming Project #1

Prokudin-Gorskii's Color Photography (1907)





Programming Project #1



Project 2: Fun with frequencies

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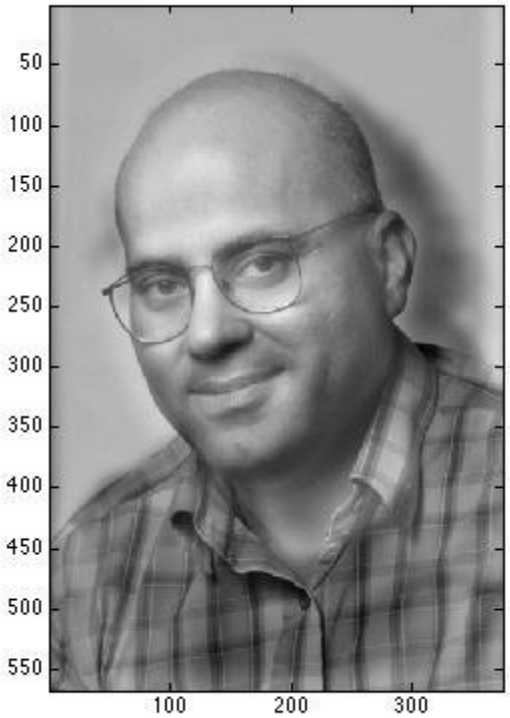
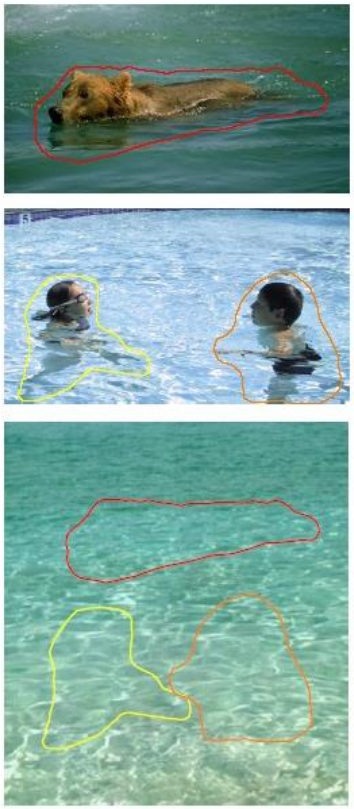


Prof. Christos Papadimalik

Project 2: Fun with Frequencies

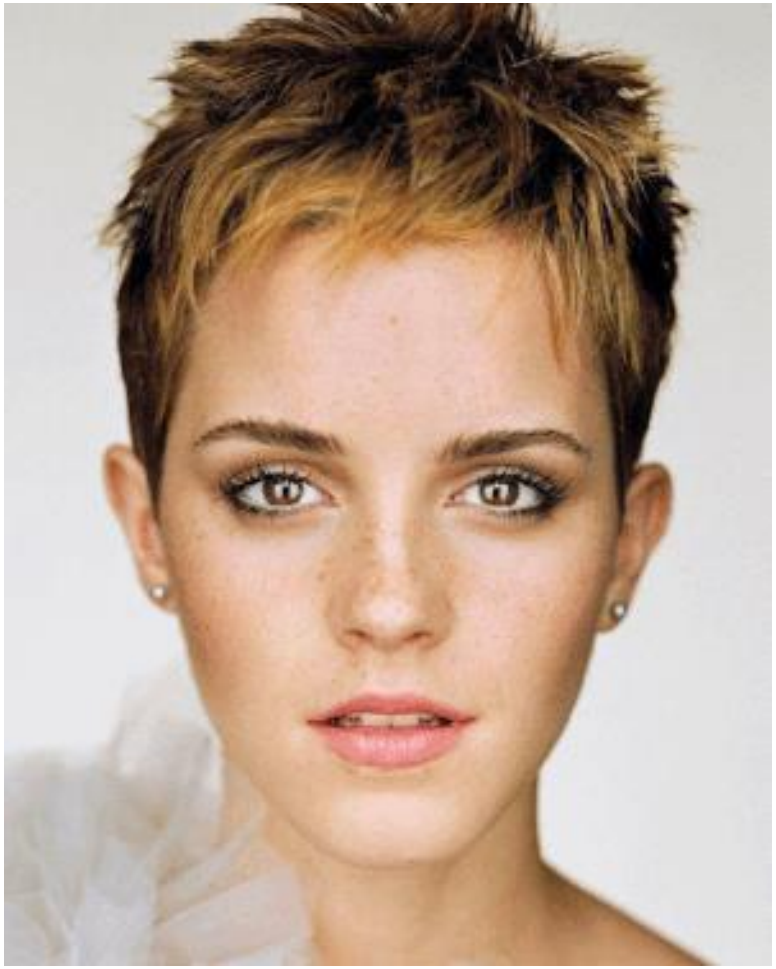


sources/destinations

cloning

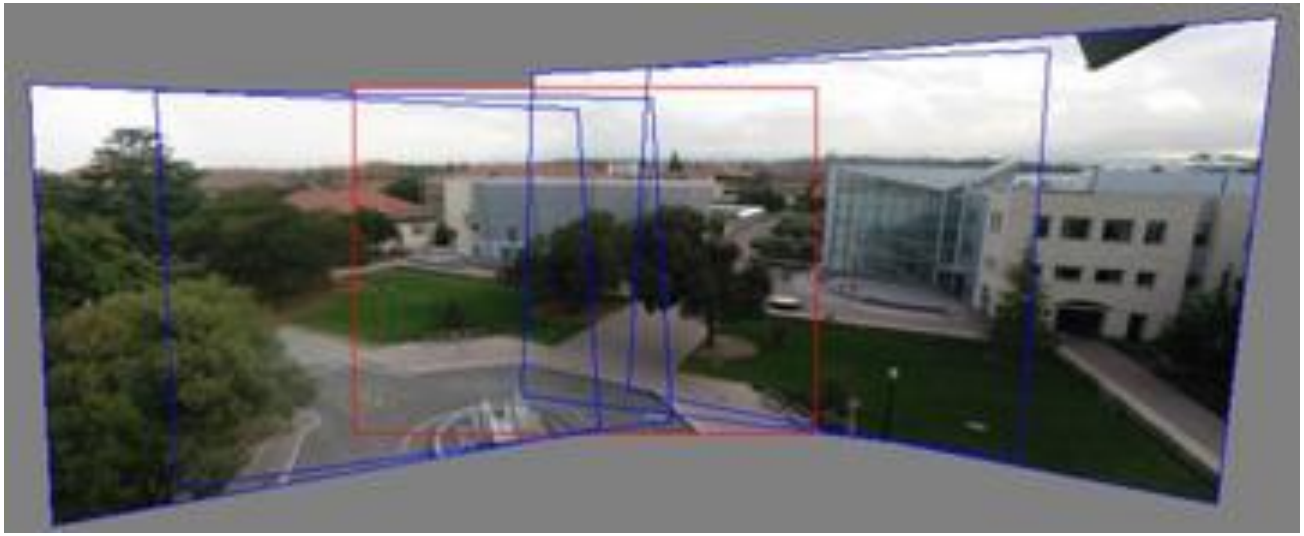
seamless cloning

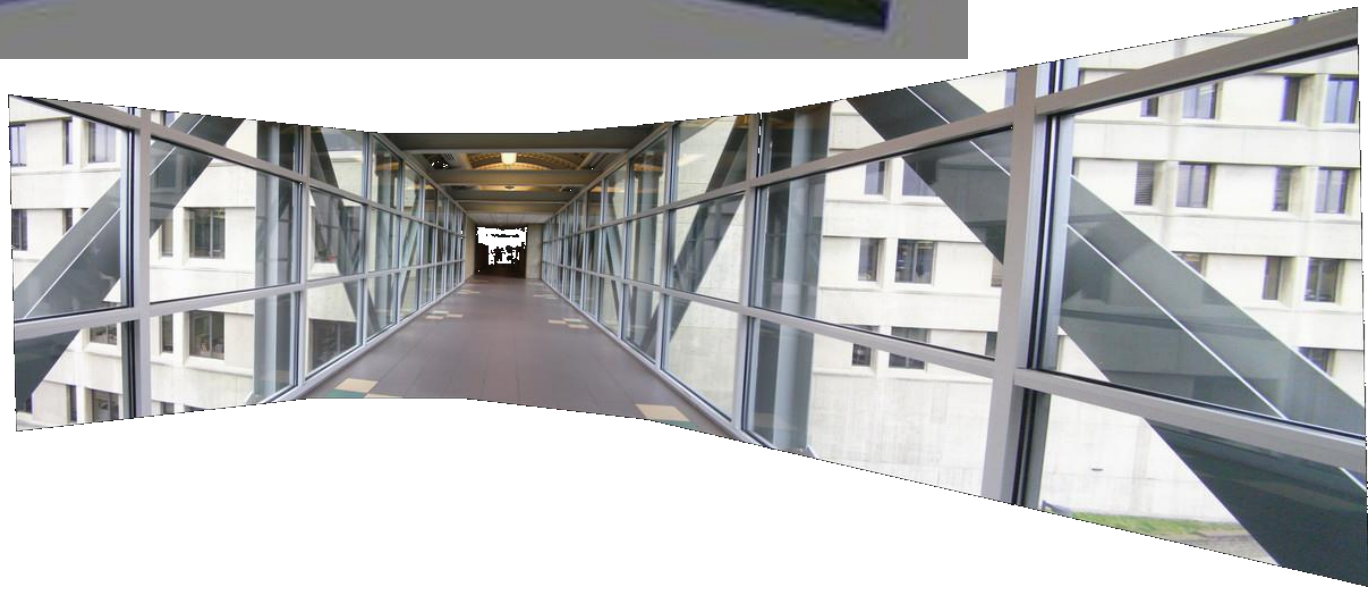
Project 3: Face modeling and morphing



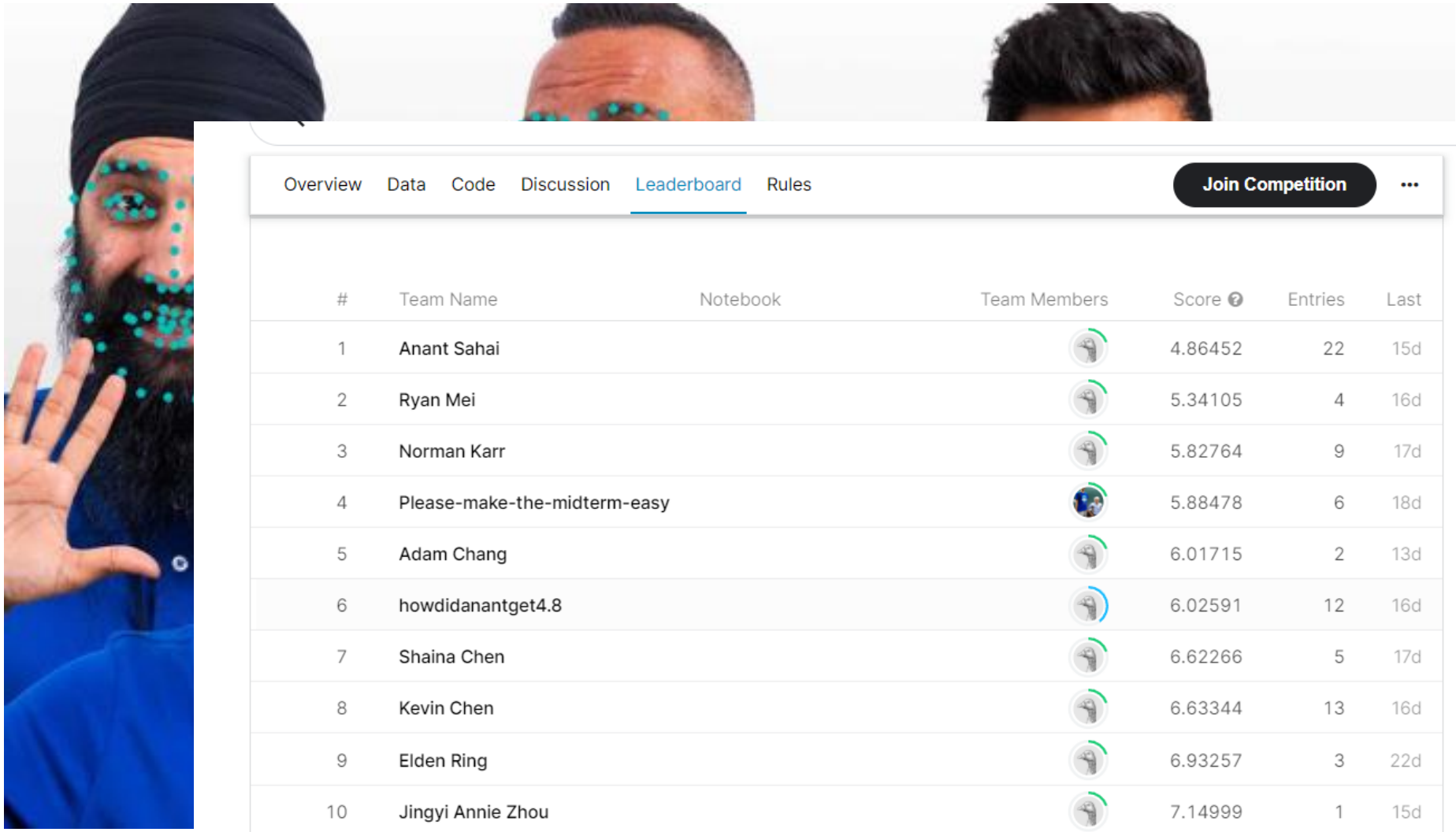
Project 4: Panorama Stitching

Photo Mosaics





Project 5: Deep Facial Keypoint Detection



Overview Data Code Discussion Leaderboard Rules Join Competition ...

#	Team Name	Notebook	Team Members	Score	Entries	Last
1	Anant Sahai			4.86452	22	15d
2	Ryan Mei			5.34105	4	16d
3	Norman Karr			5.82764	9	17d
4	Please-make-the-midterm-easy			5.88478	6	18d
5	Adam Chang			6.01715	2	13d
6	howdidanantget4.8			6.02591	12	16d
7	Shaina Chen			6.62266	5	17d
8	Kevin Chen			6.63344	13	16d
9	Elden Ring			6.93257	3	22d
10	Jingyi Annie Zhou			7.14999	1	15d
11	Zhibo Fan			7.16965	3	20d
12	Jason Ding			7.24119	12	11d

Final Project

Something cool!!!

- We will have some pre-canned projects
- Will also have some suggestions, cool datasets, etc
- Or you can do whatever you want!

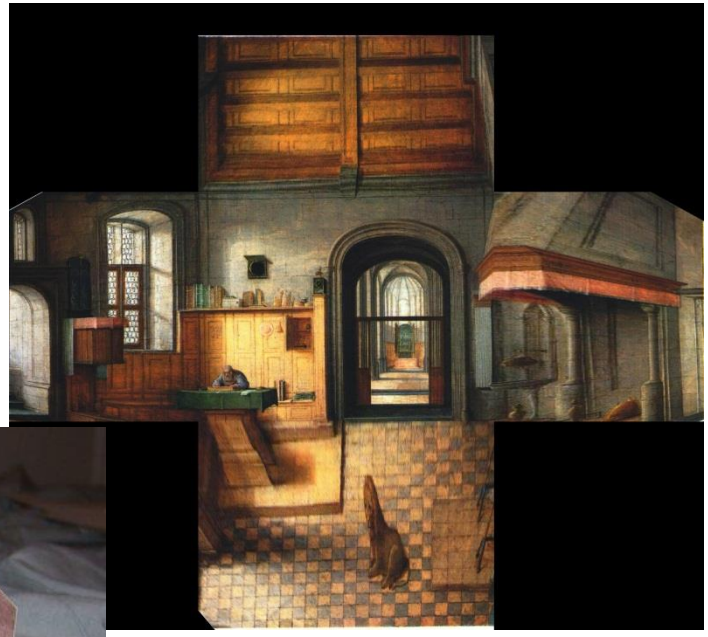
(can be done in groups of 2 or 3)

Example Pre-canned Project

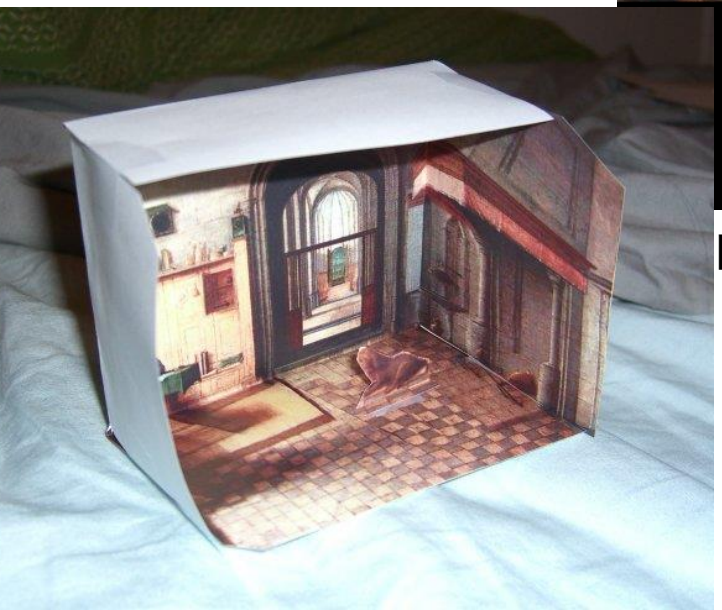
Tour Into the Picture

Paper Pop-up

Step 1: define planes



p 2: rectify each plane



Step 3: compute 3D box coords

Sample final project in my class

Everybody Dance Now

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

For each project:

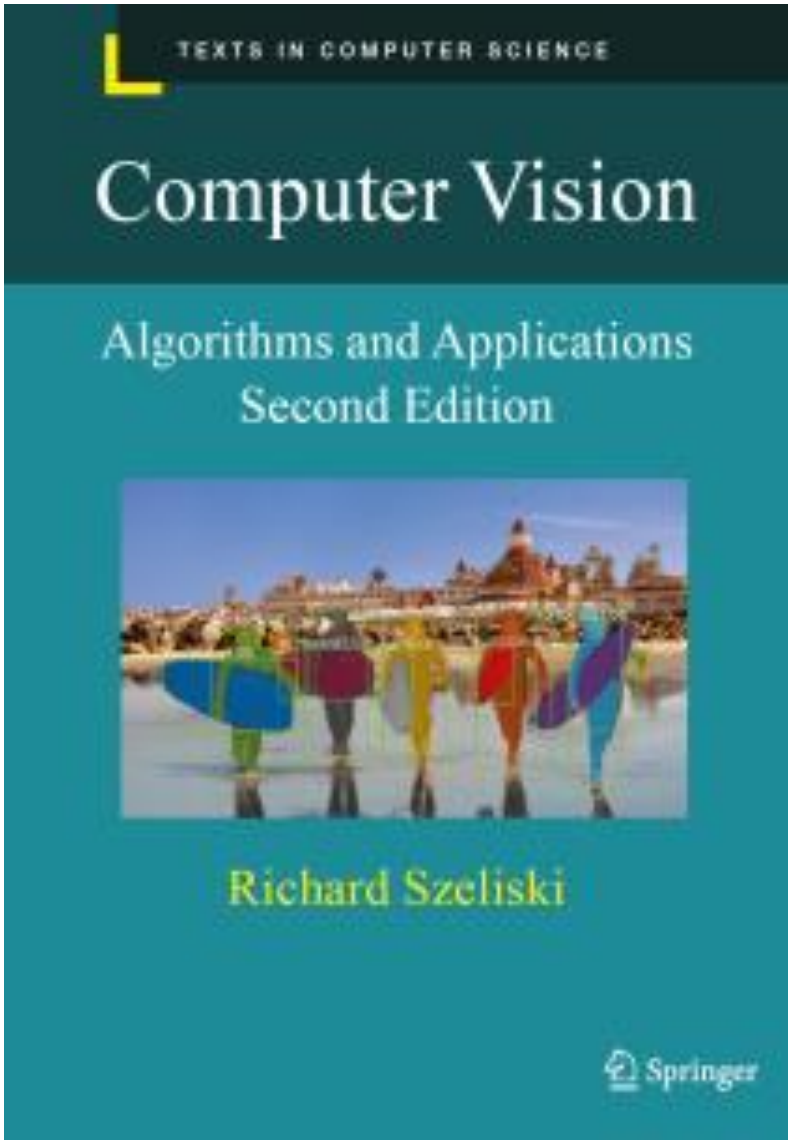
Derive the **math**, implement stuff **from scratch**, and apply it to your **own** photos

Every person does their own project (except final projects)

Reporting via web page (plus submit code)

Afterwards, vote for class favorite(s)!

Textbook



http://szeliski.org/Book/

Class Organization / Administrivia

General

Prerequisites

- Linear algebra!!! (EE16A, Math 54, or Math 110)
- Good programming skills (at least CS61B)
- Deep Learning experience strongly recommended!

Emphasis on programming projects!

- Building something from scratch

Graduate Version:

- Final project required (not pre-canned), including conference-style report paper

This will be a “live” class:

- Attendance is required

Rule # 1:
No lecture recordings

This is an in-person class. You are come to the lecture and ask questions!

Only available by request for truly exceptional circumstances, e.g. severe illness

Rule # 2:
Deadline is a deadline

In real life there's no slip days

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

Know that more slip days you use, the tougher next project gets. They are for **emergencies.**

Projects are time consuming. Part of it is to create a website, which also takes a lot of time.

Rule # 3:
TA’s don’t read 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

- http://inst.eecs.berkeley.edu/~cs194-26/

Discussion board:

- piazza

Office hours

- TBA… see webpage and piazza

Administrative Stuff

Grading

- Programming Project (60%)
- Exam + possible popup quizzes (20%)
- Final Project (20%)
- Class Participation: priceless

Late Policy

- Five (5) **emergency** late days for semester. The expectation is you will never use them.
- Max 10% of full credit afterwards

Extra Points

- Most projects will have optional “bells & whistles”
- These extra points could be used to pad scores on other projects (but not exams!)

Academic Integrity

- Can discuss projects, but **never share code**
- Don’t look up code or copy from a friend
- If you’re not sure if it’s allowed, ask
- Cite any sources and inspirations

Waitlists

- To keep this course live, we are limited by room size (217 people)
- However, we expect 50-70 people to drop after the first two projects ☺
  - So, if you are on waitlist, etc, you have good chance to get into class
  - But 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
- You write the code from scratch, that’s the point.
- Rubrics are fuzzy, goals are ill-defined, that’s the point.

Why you should NOT take this class

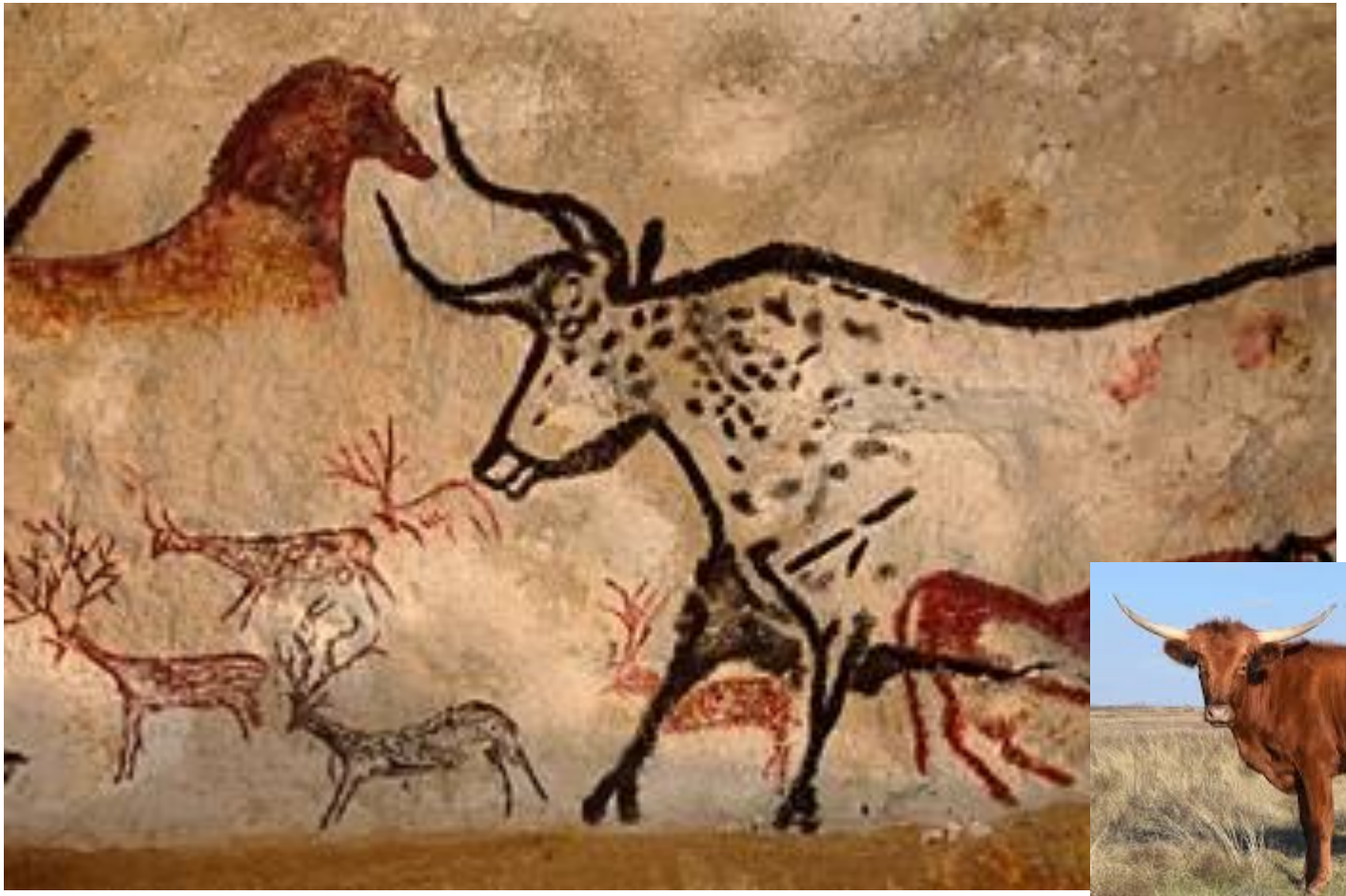
- Project-based class
  - No canned problem sets
  - Not theory-heavy (but will read a few research papers)
  - No clean rubrics
  - Open-ended by design
  - Will not copy advanced topics, but will try to make sure everyone understands the basics super-well
- Need time to think, not just hack
  - **Creativity** is a class requirement
  - Not a class to learn about Deep Learning!
- Lots of work…There are easier classes if
  - you just need some units
  - you care more about the grade than about learning stuff
- Not worth it if you don’t enjoy it

Now… reasons TO take this class

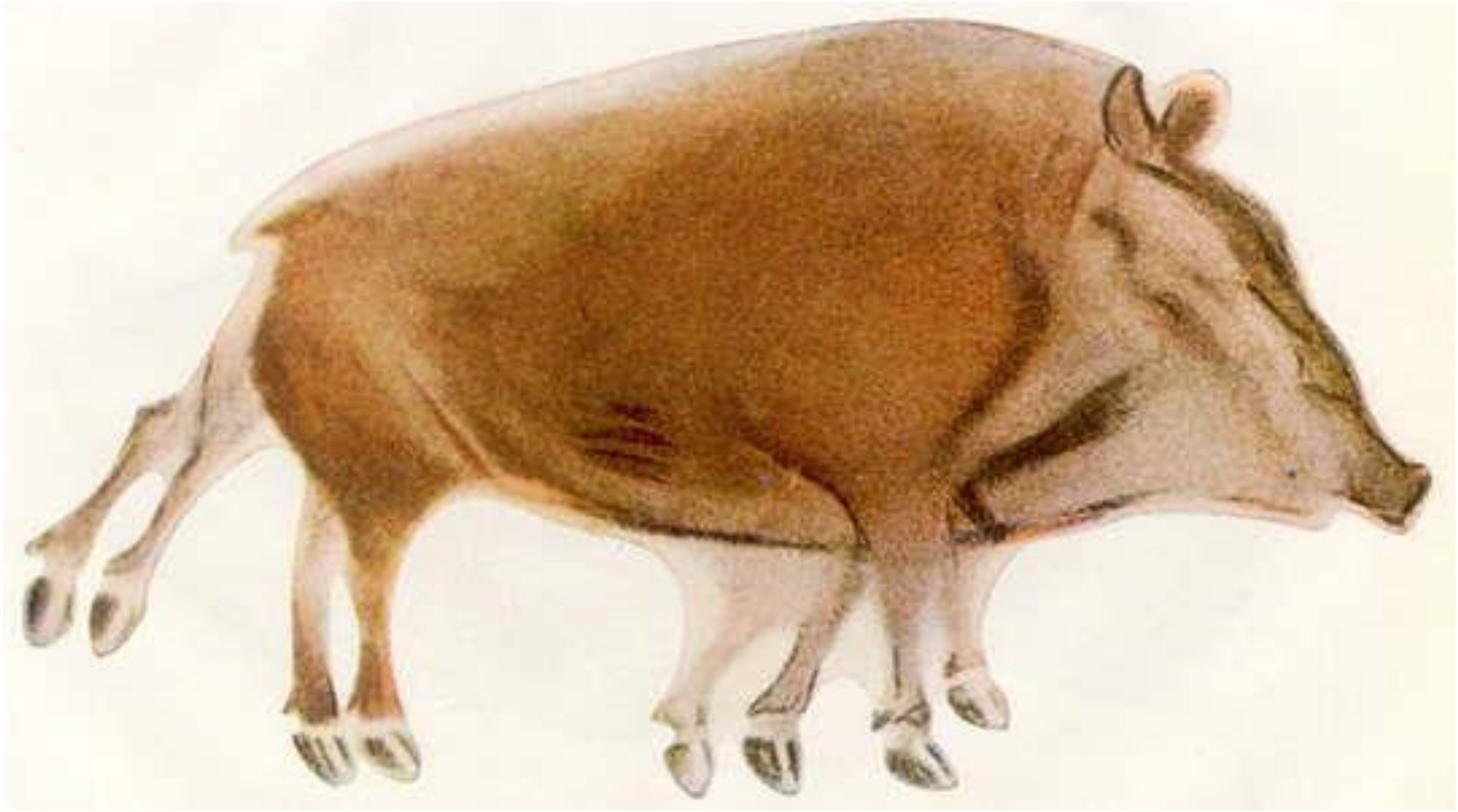
- It's your reward after 3 grueling years ☺
- You get to work with pictures, unleash your creative potential
- Interested in grad school? ☺

A Brief History of the Visual Data

Depicting Our World: The Beginning



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

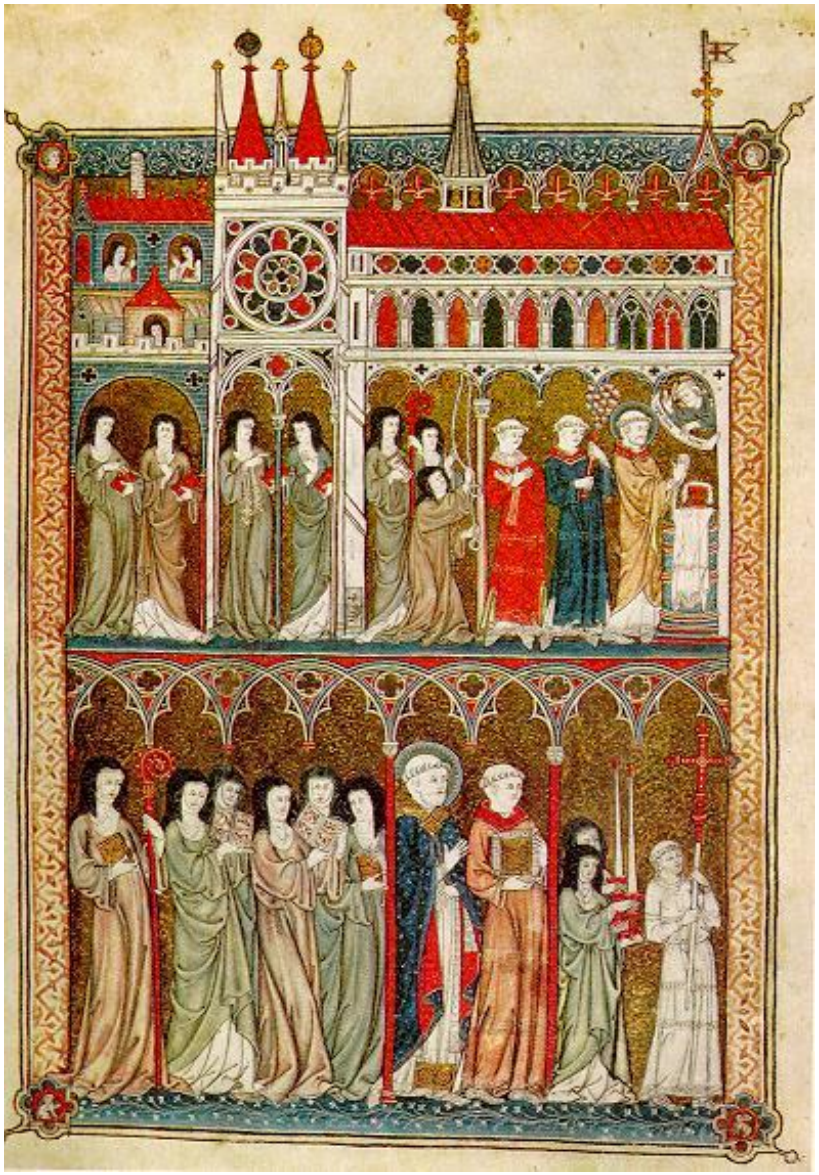


Prehistoric Cave Painting, Altamira
~ 20,000 – 15,000 B.C.

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

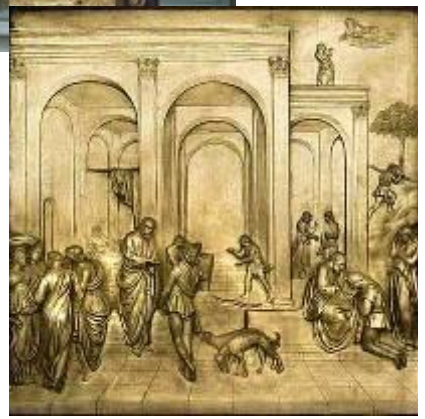
Giotto, *The Mourning of Christ*, c.1305

Depicting Our World: Renaissance

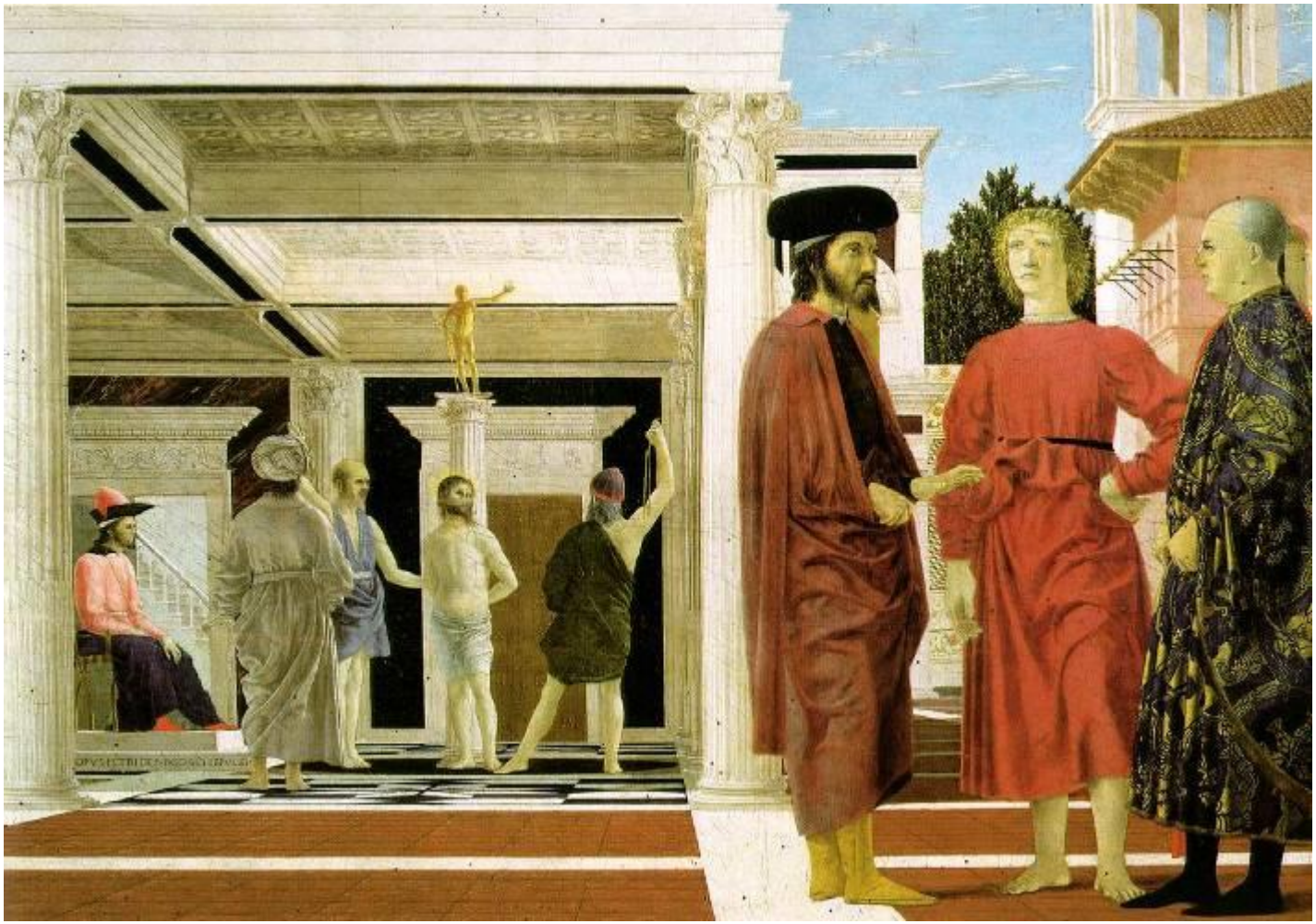
North Doors (1424)

Lorenzo Ghiberti (1378-1455)

East Doors (1452)

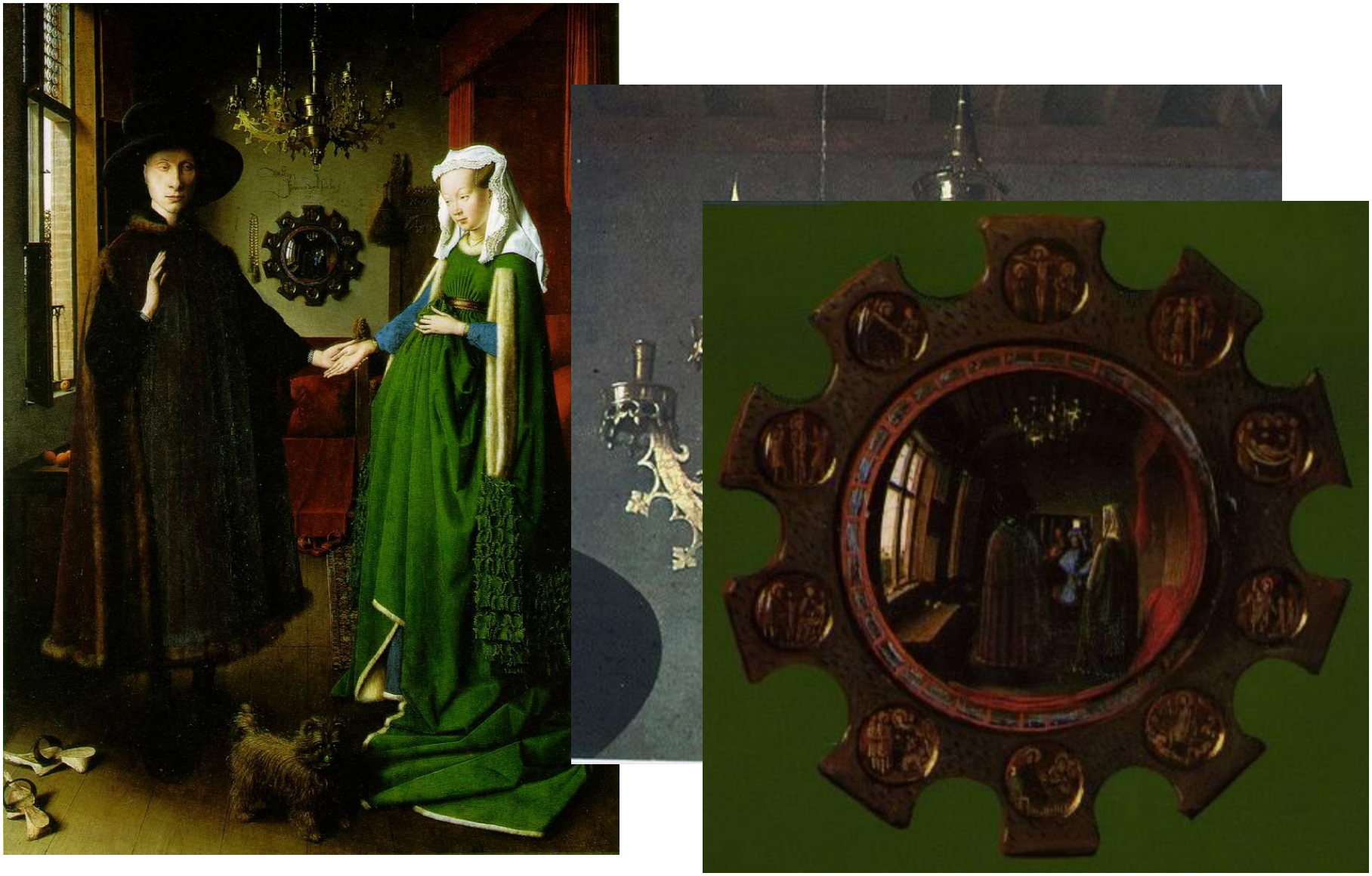


Depicting Our World: Renaissance



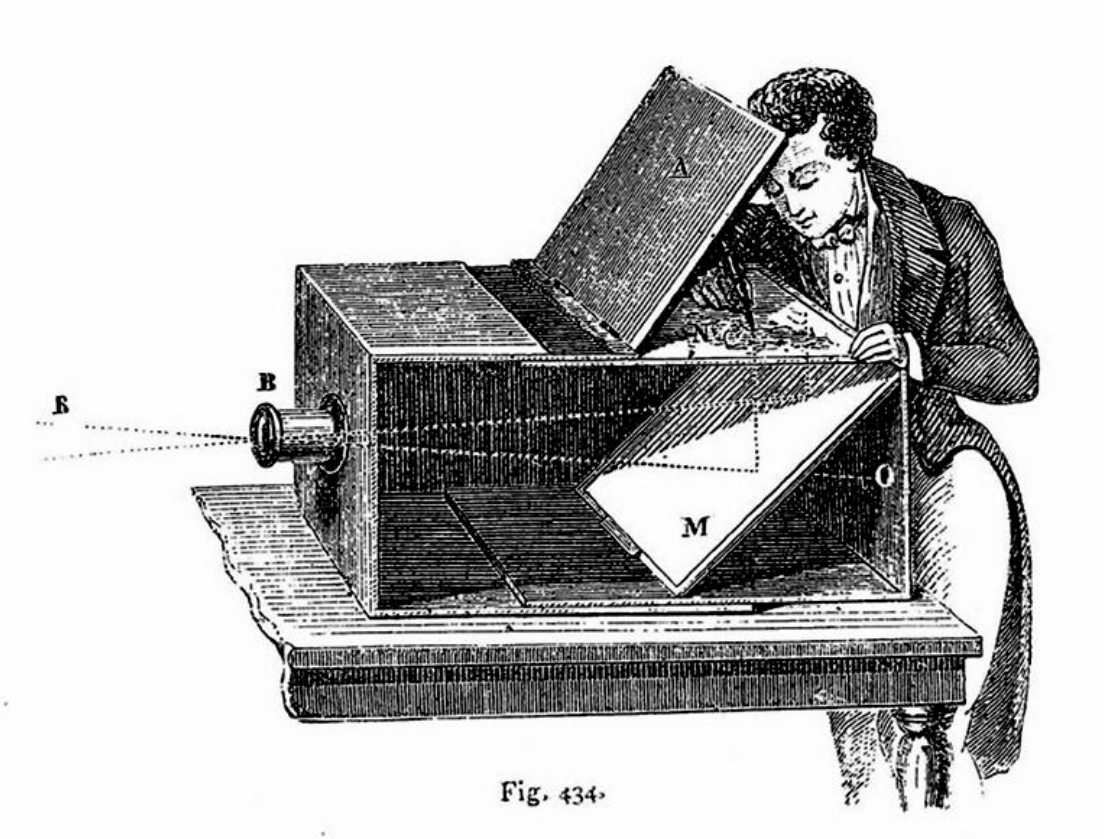
Piero della Francesca,
The Flagellation (c.1469)

Depicting Our World: Toward Perfection



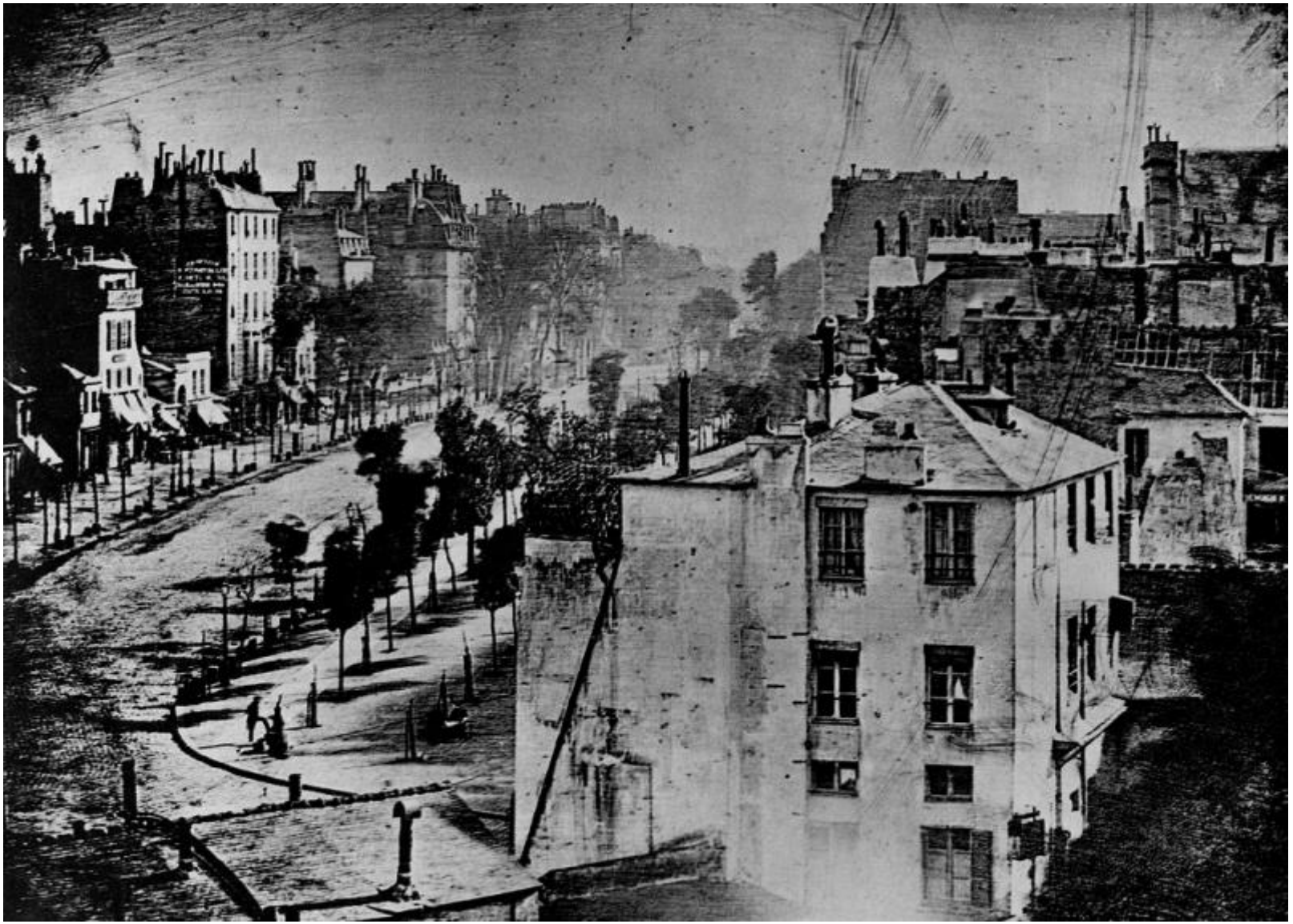
Jan van Eyck, *The Arnolfini Marriage (c.1434)*

Depicting Our World: Toward Perfection



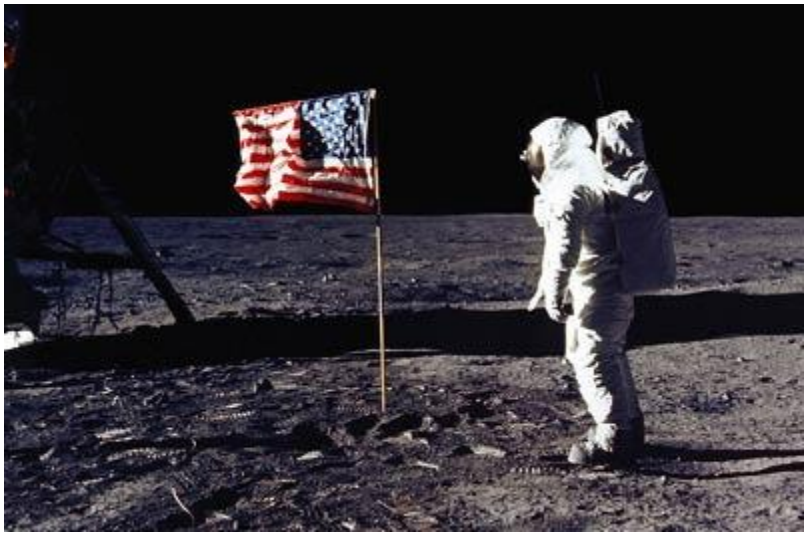
Lens Based Camera Obscura, 1568

Depicting Our World: Perfection!

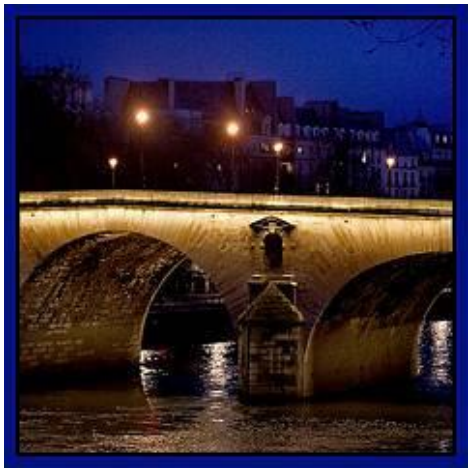


Boulevard du Temple, Louis Daguerre, 1838

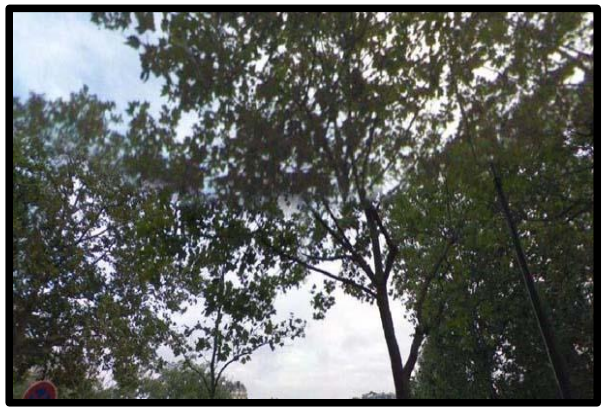
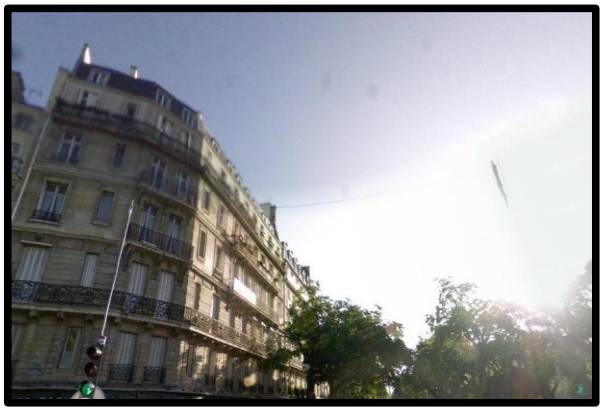
Depicting Our World: Realism?

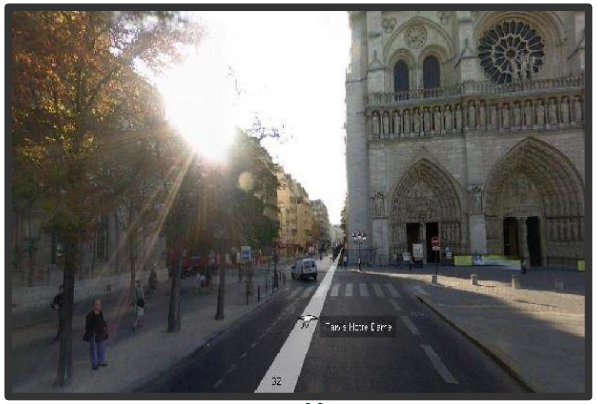


Paris, according to Flickr



Paris, according to Google StreetView

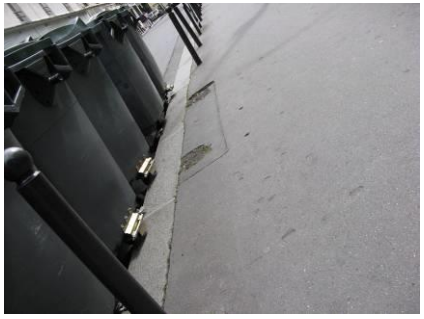



Knopp, Sivic, Pajdla, ECCV 2010

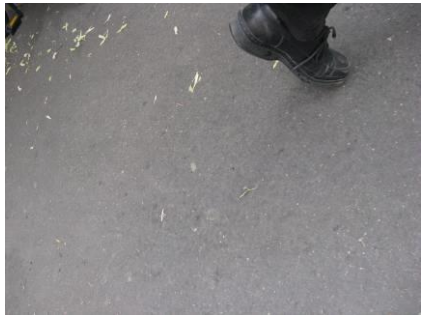
Paris, according to me









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

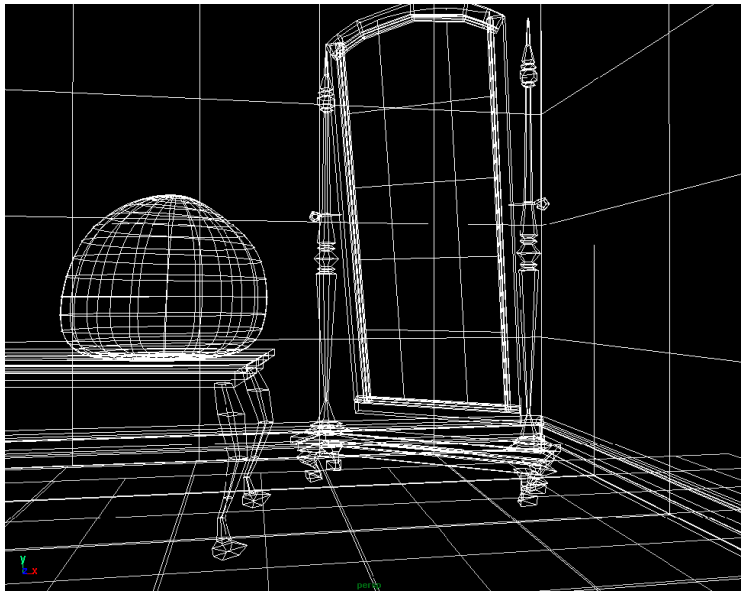
Alyosha Efros
Place Furstenberg,
2009

Depicting Our World: Ongoing Quest

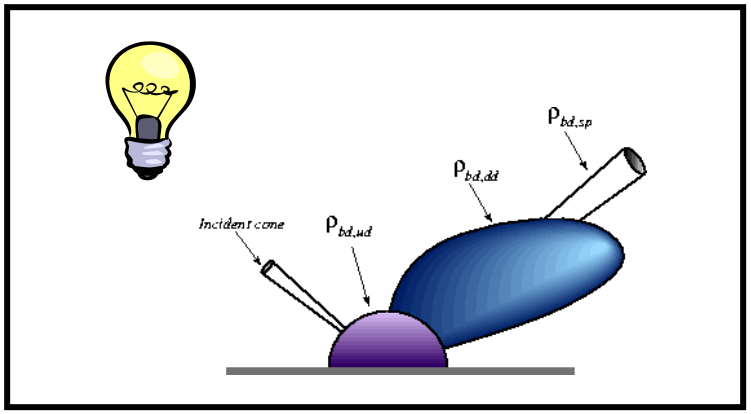
Antonio Torralba & Aude Oliva (2002)

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

People

From “Final Fantasy”

On the Tube, London

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

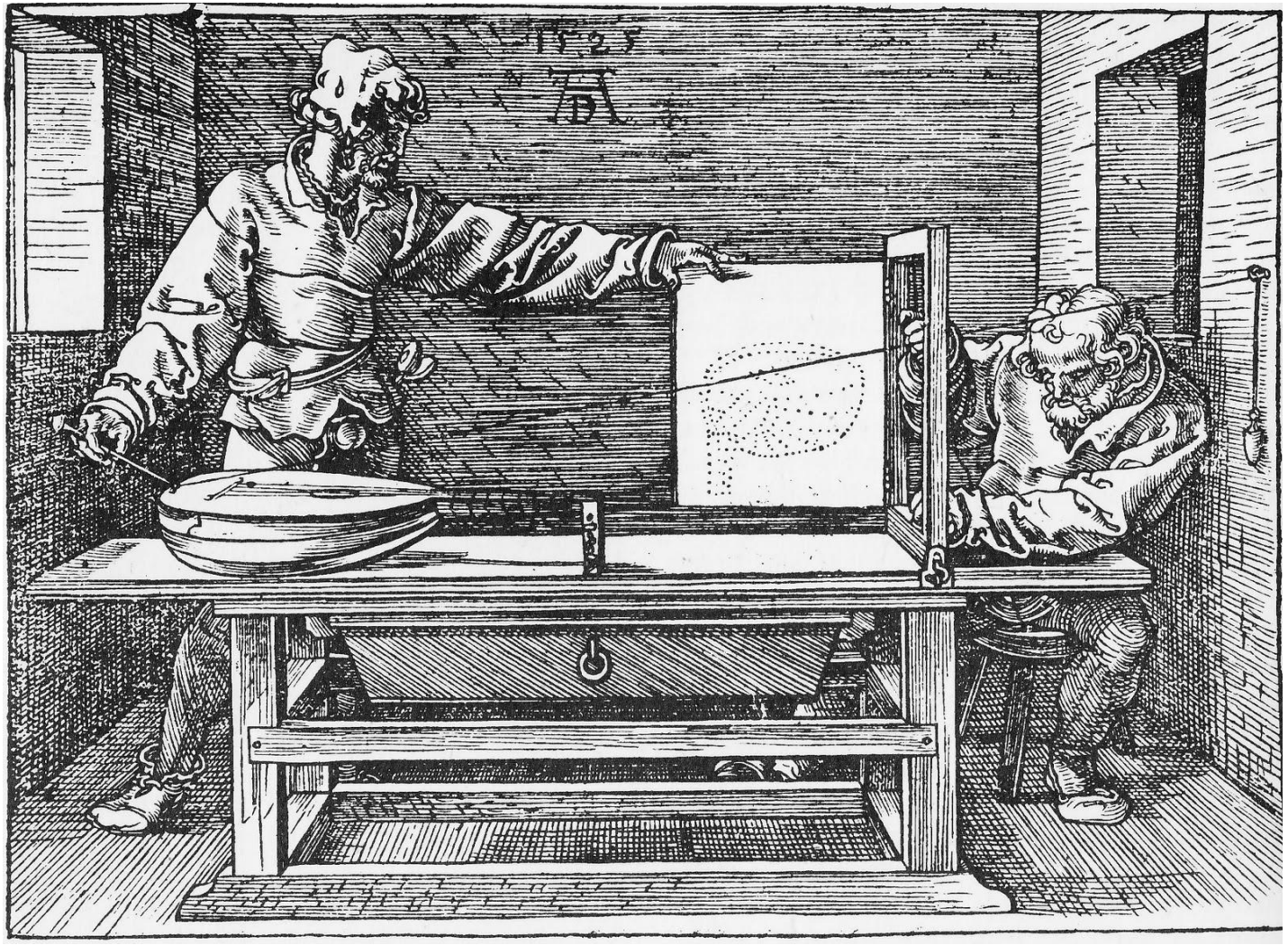
Photography

+ instantly realistic

+ easy to aquire

- very hard to manipulate objects/viewpoint

Computer Vision



Mechanical creation of a perspective image,
Albrecht Dürer, 1525

Happy Independence Day, Ukraine!