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

Instructor: Alexei Efros

GSIs: Hang Gao
Vongani Maluleke

Tutors: Daniel George
Ryan Tabrizi
Max Vogel
Bill Zheng

UC Berkeley, Fall 2024

Today

Introductions

Why this Course?

Administrative stuff

- Project #1 out!

Brief History of Visual Data

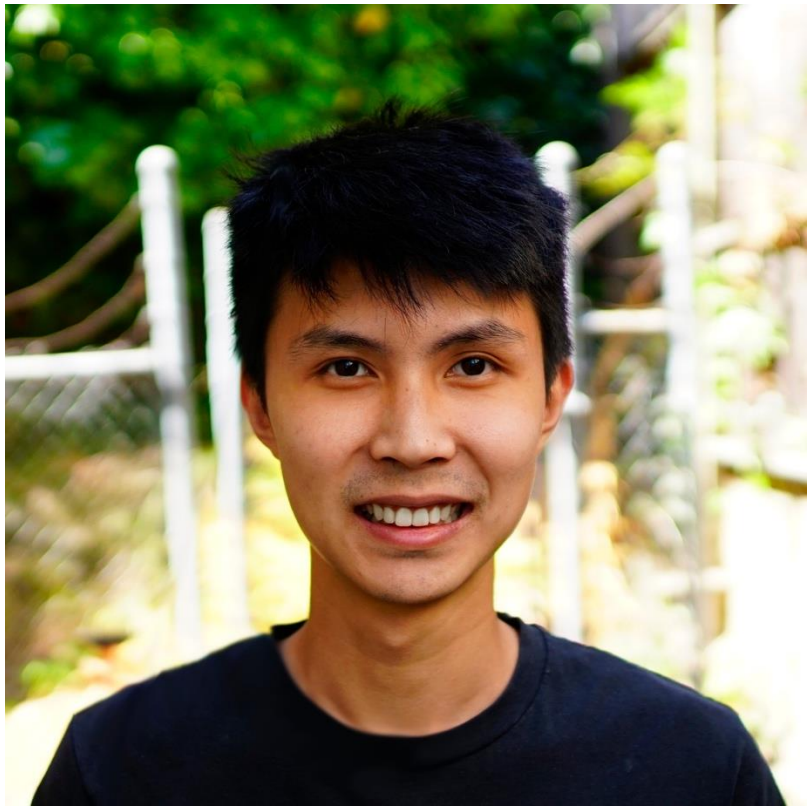
Teaching team: Instructor

Social warning –
I don't see well

Alexei Efros

Professor in BAIR, focus on Computer Vision and Machine Learning

Teaching Team: GSIs



Hang Gao

Vongani Maluleke

PhD students in BAIR, expertise in Computer Vision

Teaching Team: Tutors

Daniel George

Max Vogel

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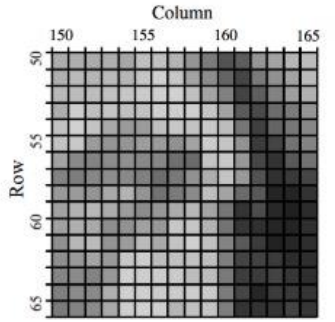
Why This Course?

Visual Computing in the old days…



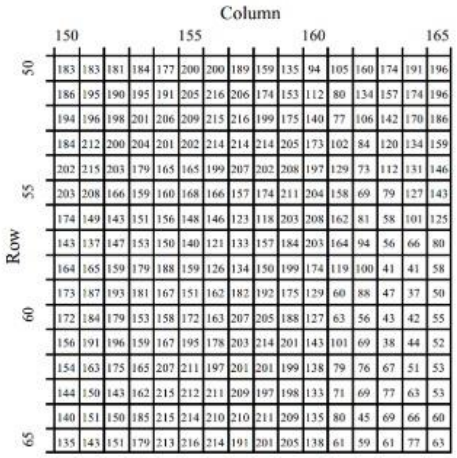
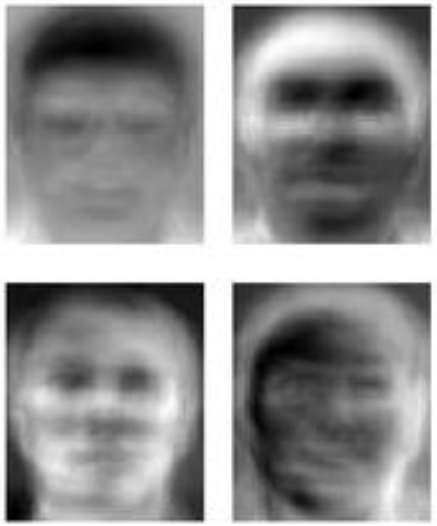


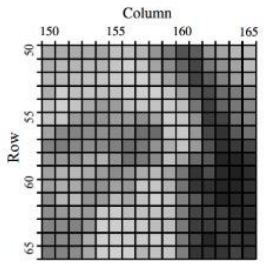
Image Processing
EECS 225B

Computer Graphics
CS 184



Computer Vision CS 280

Visual Computing gets interconnected



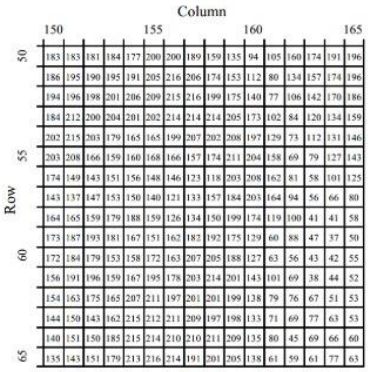
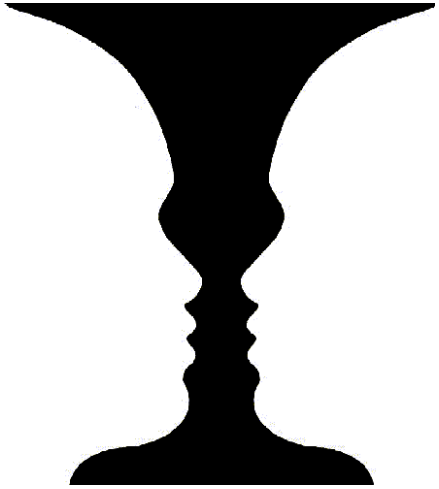


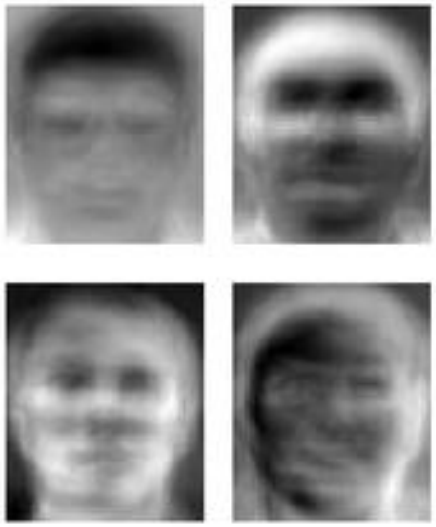
Image Processing
EECS 225B

Art History
ART 10

Computer Graphics
CS 184

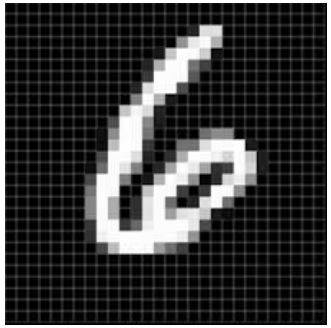


Visual Perception
PSYCH



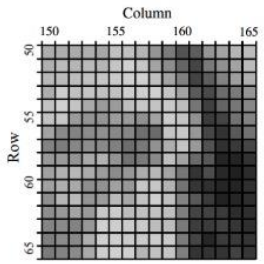
Computer Vision CS 280

Computational Photography



Machine Learning

Visual Computing gets interconnected



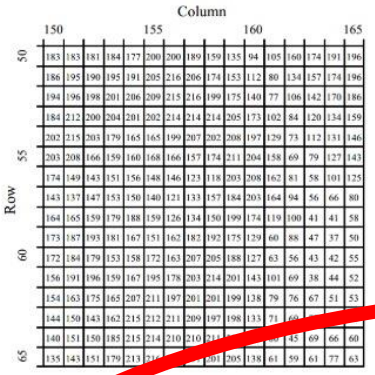


Image Processing
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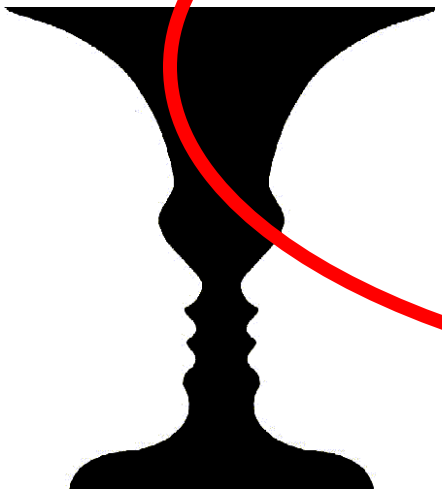
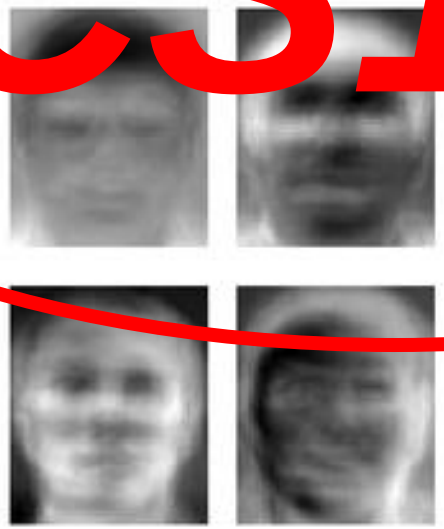
Art History
AR 10

Computer Graphics
CS 184

CS180





Computational Photography

Machine Learning

Visual Perception
PSYCH

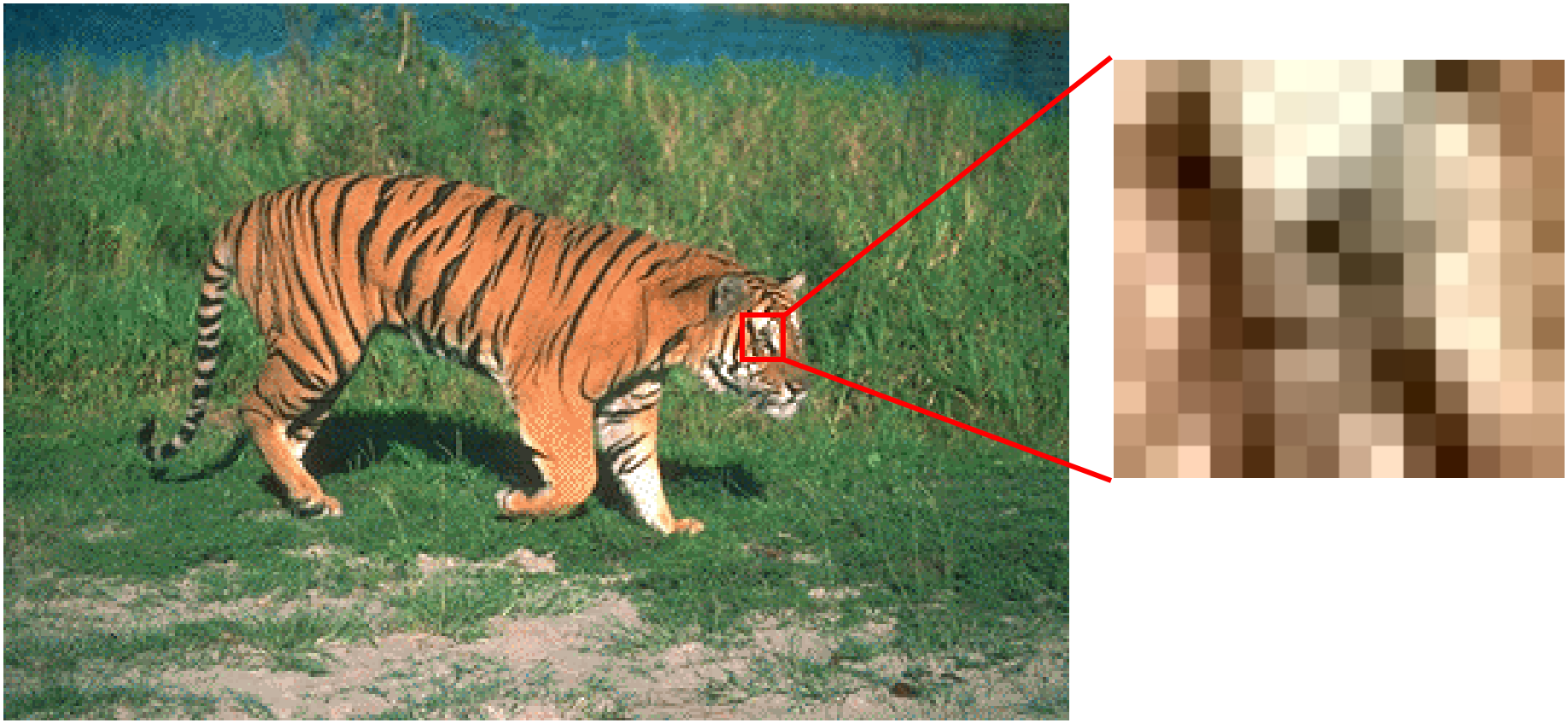
Computer Vision CS 280

CS180: 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, **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
- …

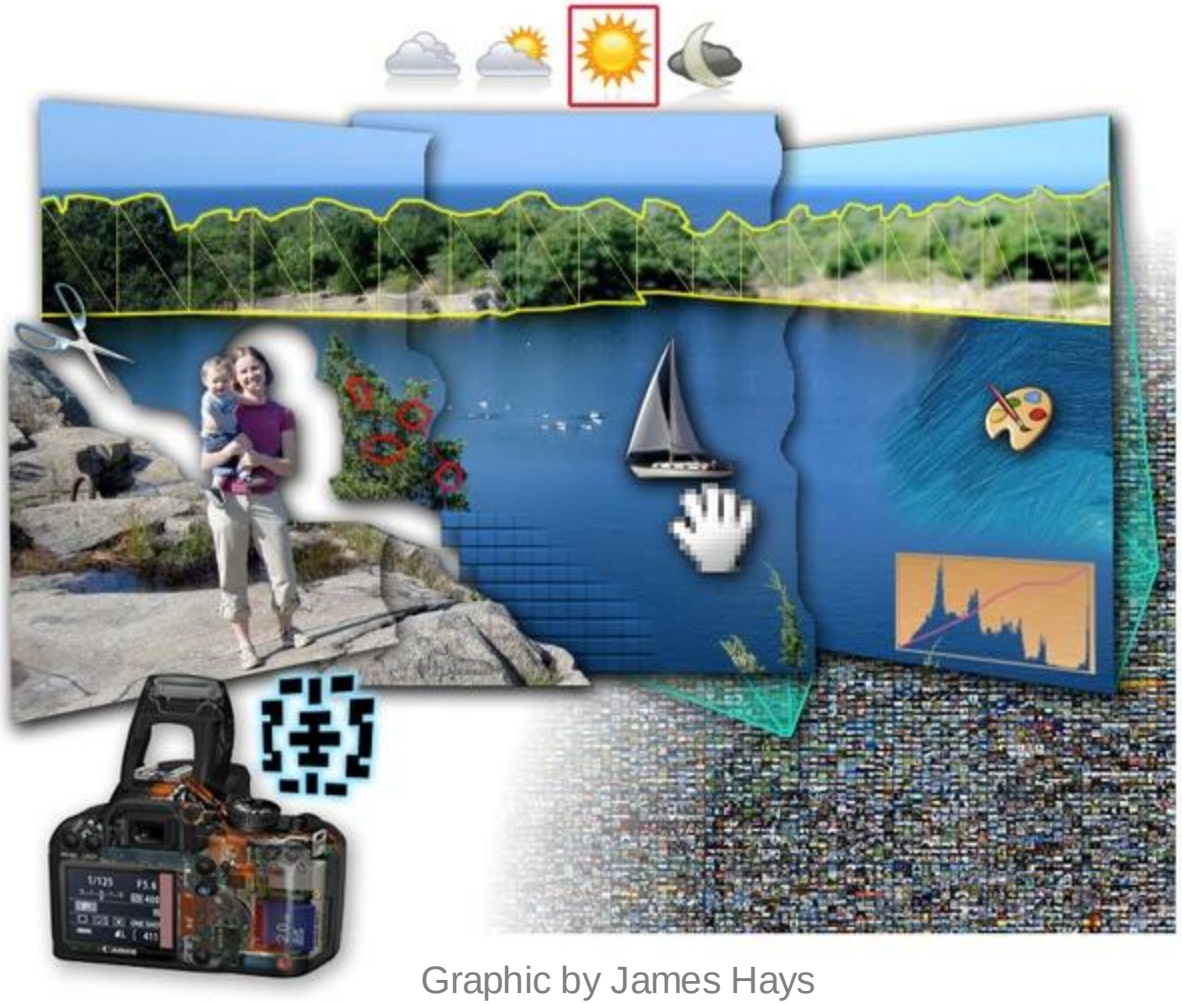
Course objectives

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

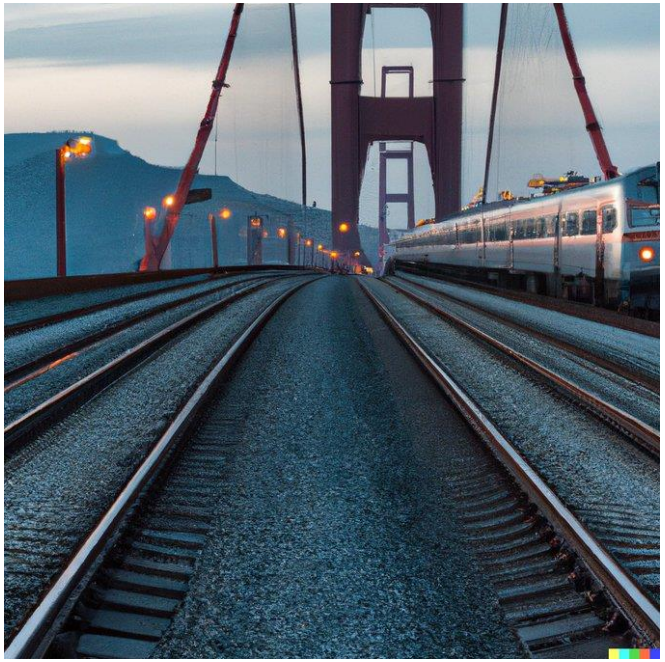
- Gradients
- Change of basis
- interpolation, extrapolation
- Furrier Transforms
- PCA
- Deep Learning
- Auto-regressive Models
- Diffusion Models
- …

Course objectives

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



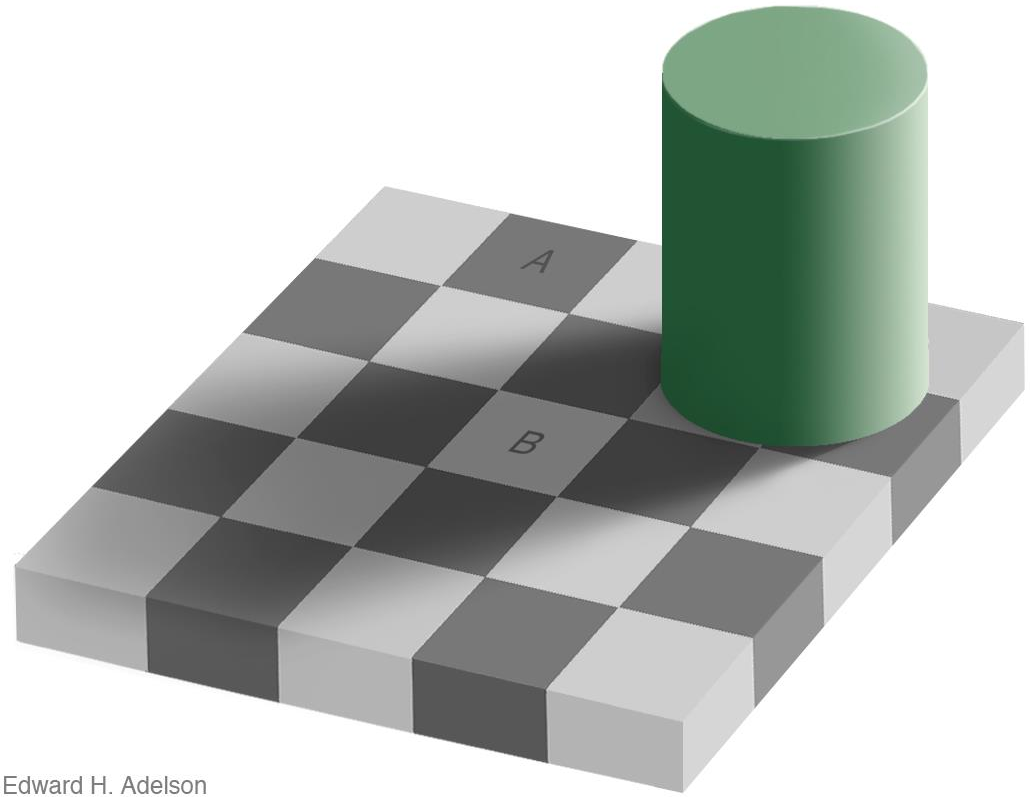
Graphic by James Hays



DALL-E + Danielle Baskin

Course objectives

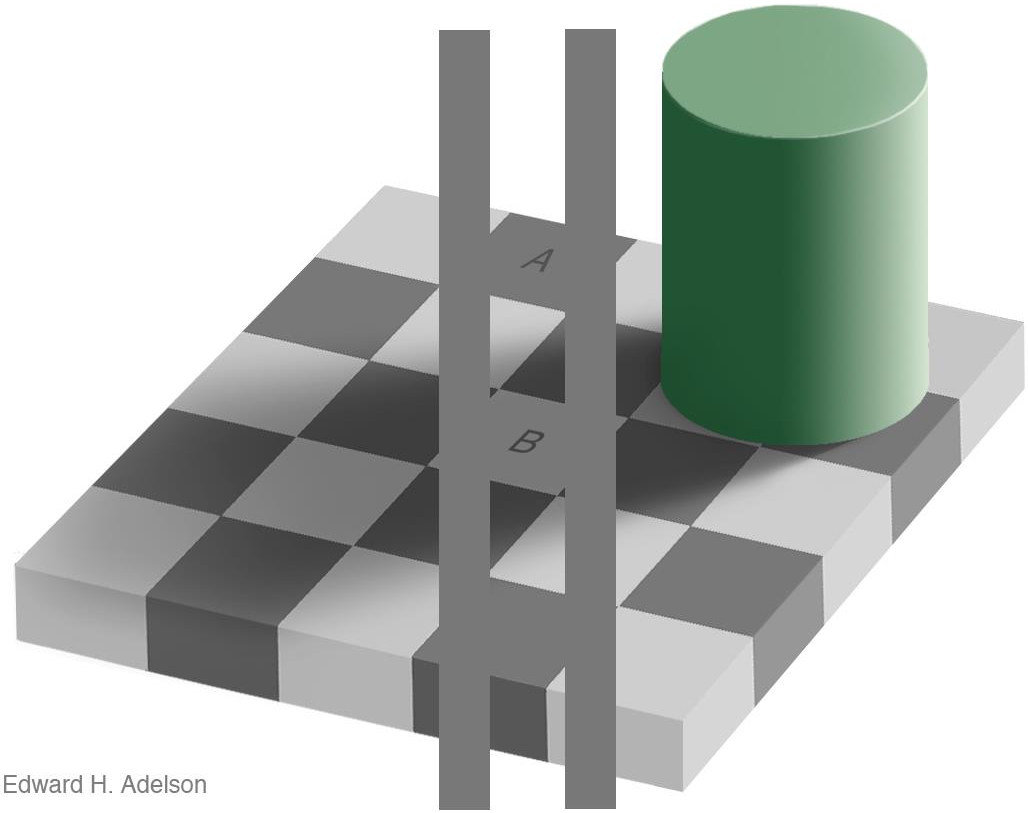
4. You'll better appreciate human visual perception



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

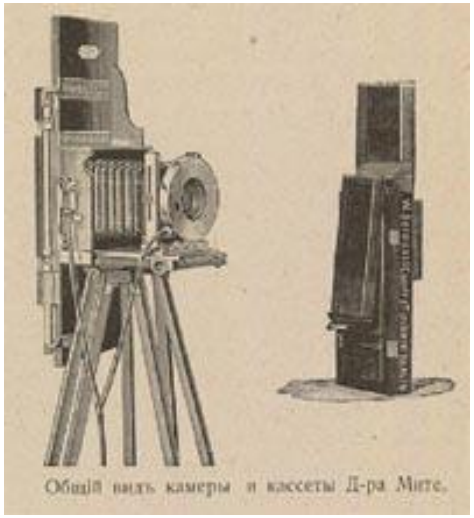
5. You will learn about the **history of ideas** in visual computing
   - Did you know Large Generative Models go back to 1940s?
   - Or that Deep Learning started with a Nobel Prize on Neuroscience of the Visual Cortex in the 1960s?
   - …

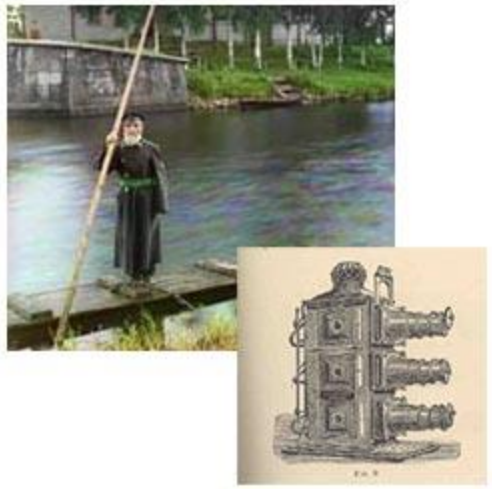
Course objectives

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

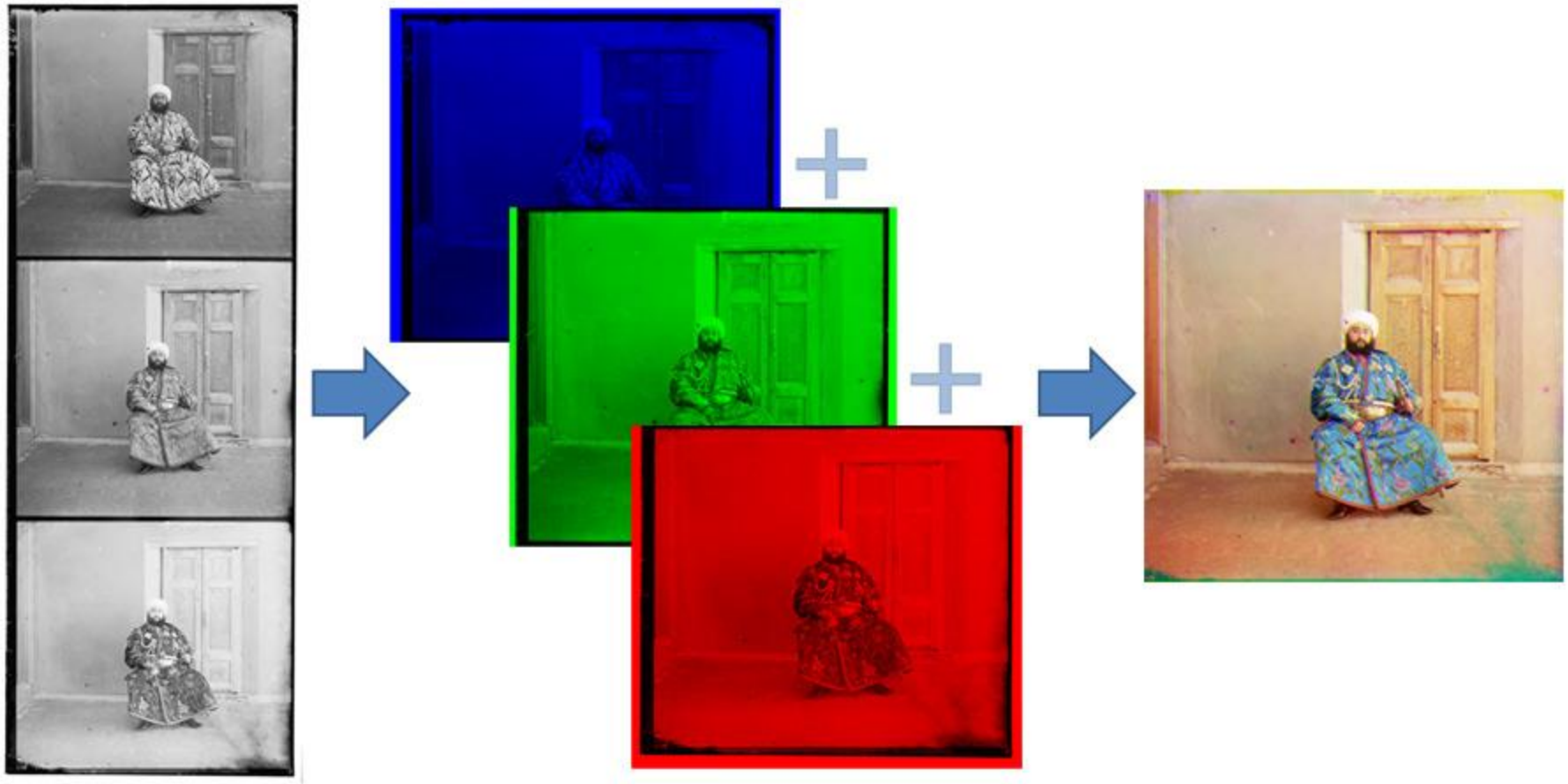
Programming Project #1

Prokudin-Gorskii's Color Photography (1907)



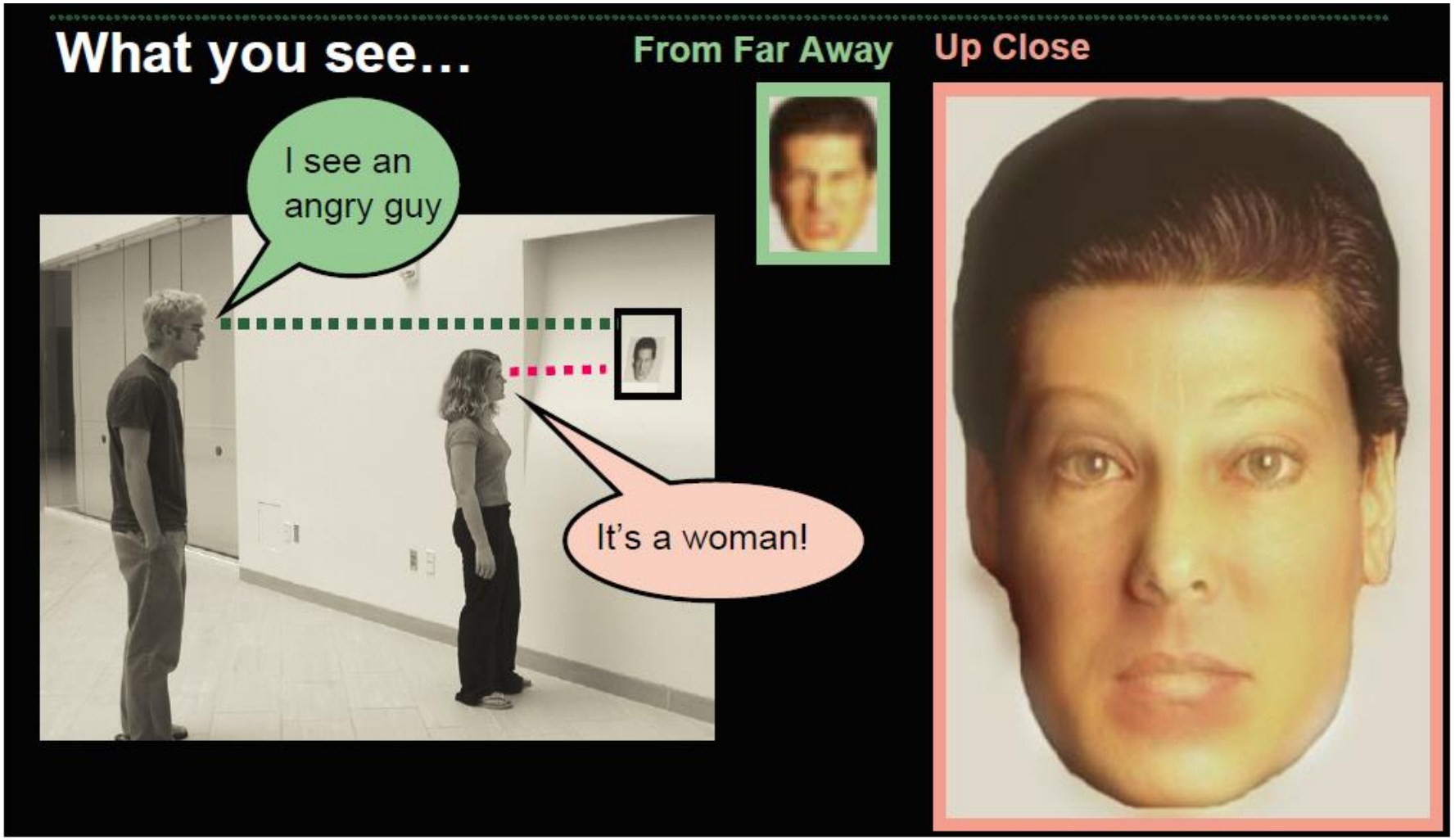


Programming Project #1

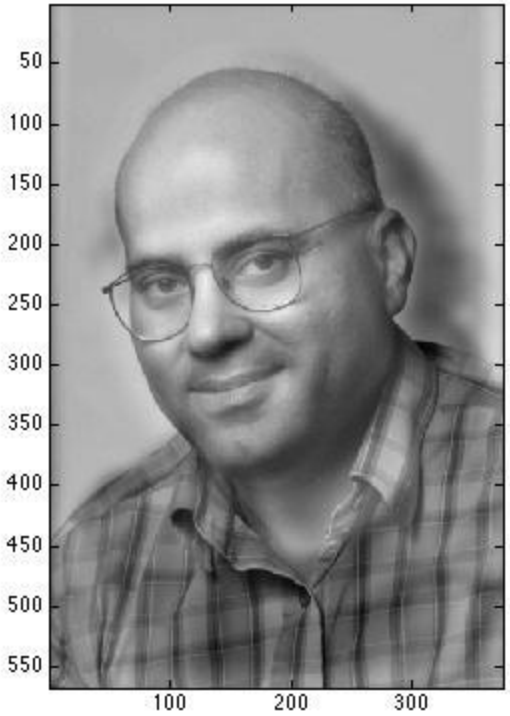


Project out TODAY!

Project 2: Fun with frequencies

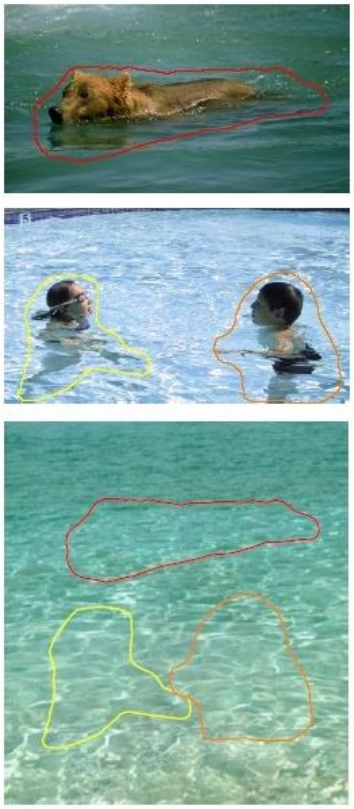


Project 2: Fun with frequencies



Prof. Christos Papadimalik

Project 2: Fun with Frequencies

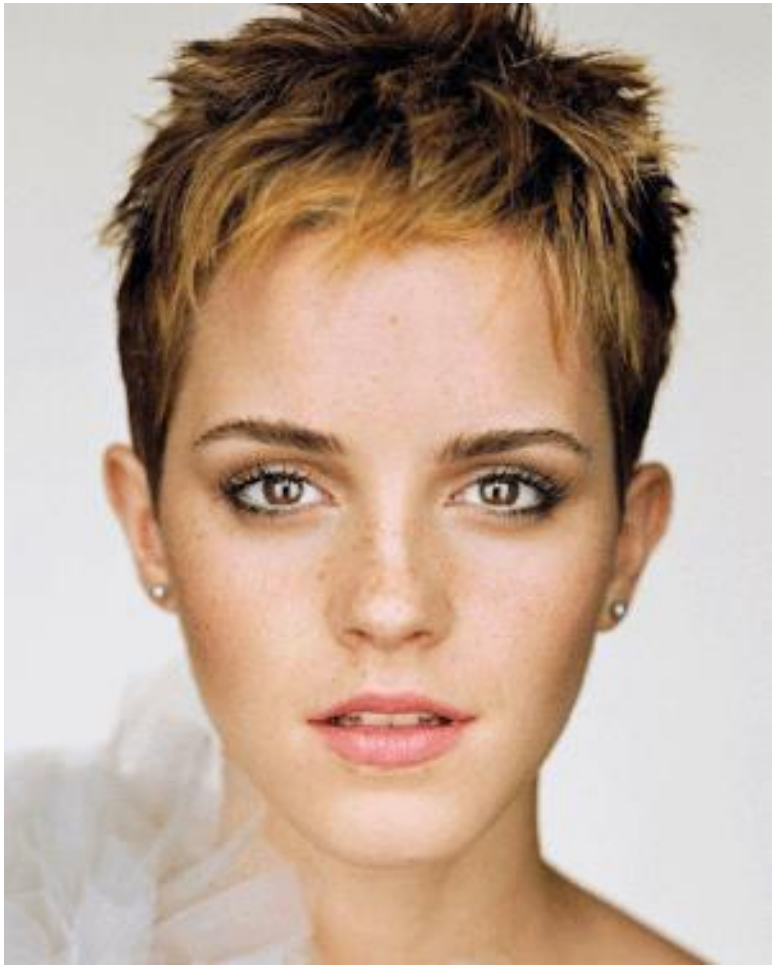


sources/destinations

cloning

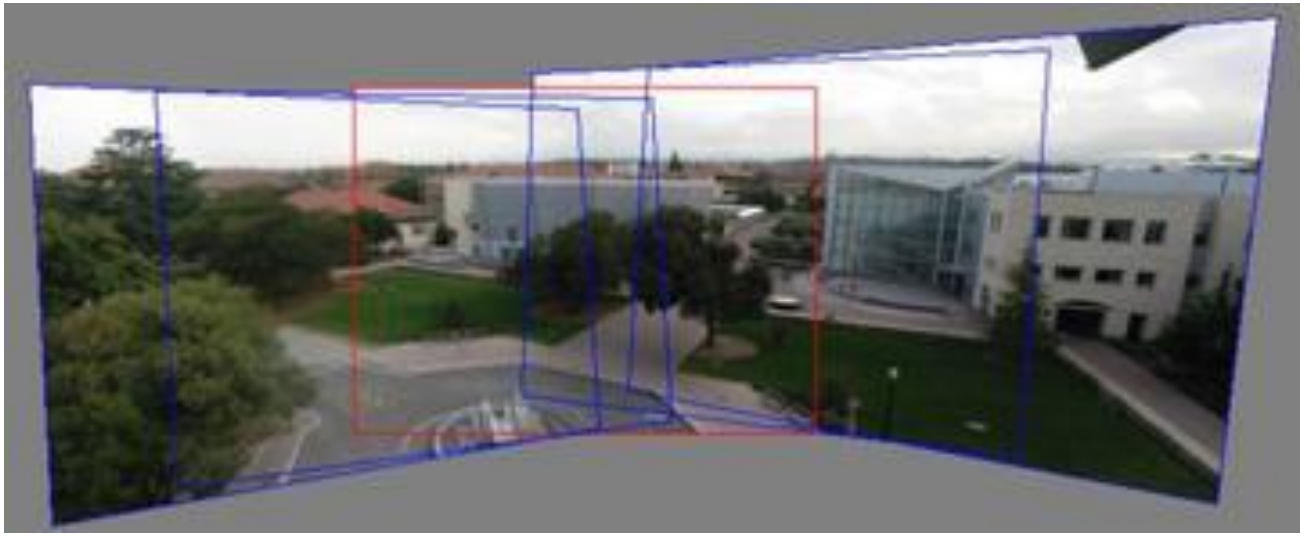
seamless cloning

Project 3: Face modeling and morphing



Project 4: Panorama Stitching

Photo Mosaics



Project 5: Diffusion and Visual Anagrams

a photo of an old woman

a painting of a deer

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!

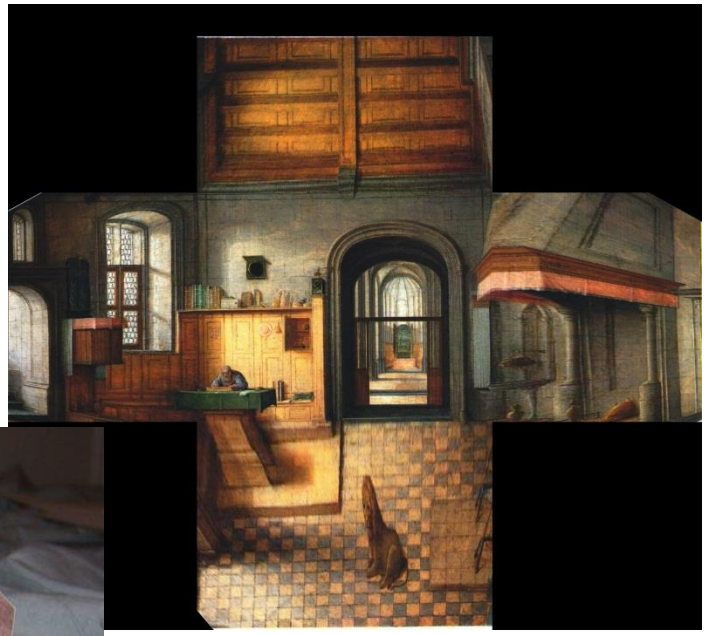
(can be done in groups of 2 or 3)

Example Pre-canned Project

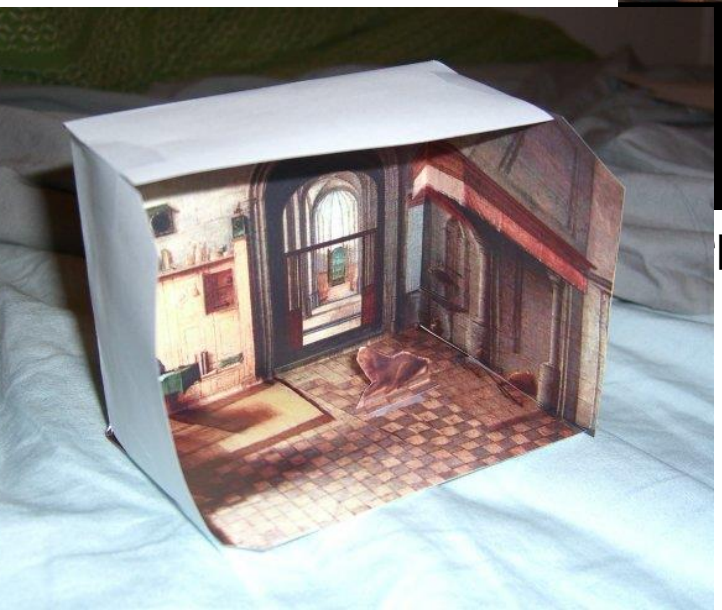
Tour Into the Picture

Paper Pop-up

Step 1: define planes



p 2: rectify each plane



Step 3: compute 3D box coords

Sample final project from previous years

Sample final project from previous years

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)

Class Organization / Administrivia

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):

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

Administrative Stuff

Grading

- 60% Programming Projects (5 in total)
- 20% Final Exam (Last Lecture**, Wednesday 12/04/24**)
- 15% Final Project
- 5% Pop Quizzes
- Class Participation: *priceless*

Late Policy

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

Extra Points

- Most projects will have optional “bells & whistles”
- These extra points could be used to **drop one or two quizzes**

Rule # 1:
No lecture recordings

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

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

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.** If nothing dramatic happened to you during the semester, 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

- http://inst.eecs.berkeley.edu/~cs180

Online forums:

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

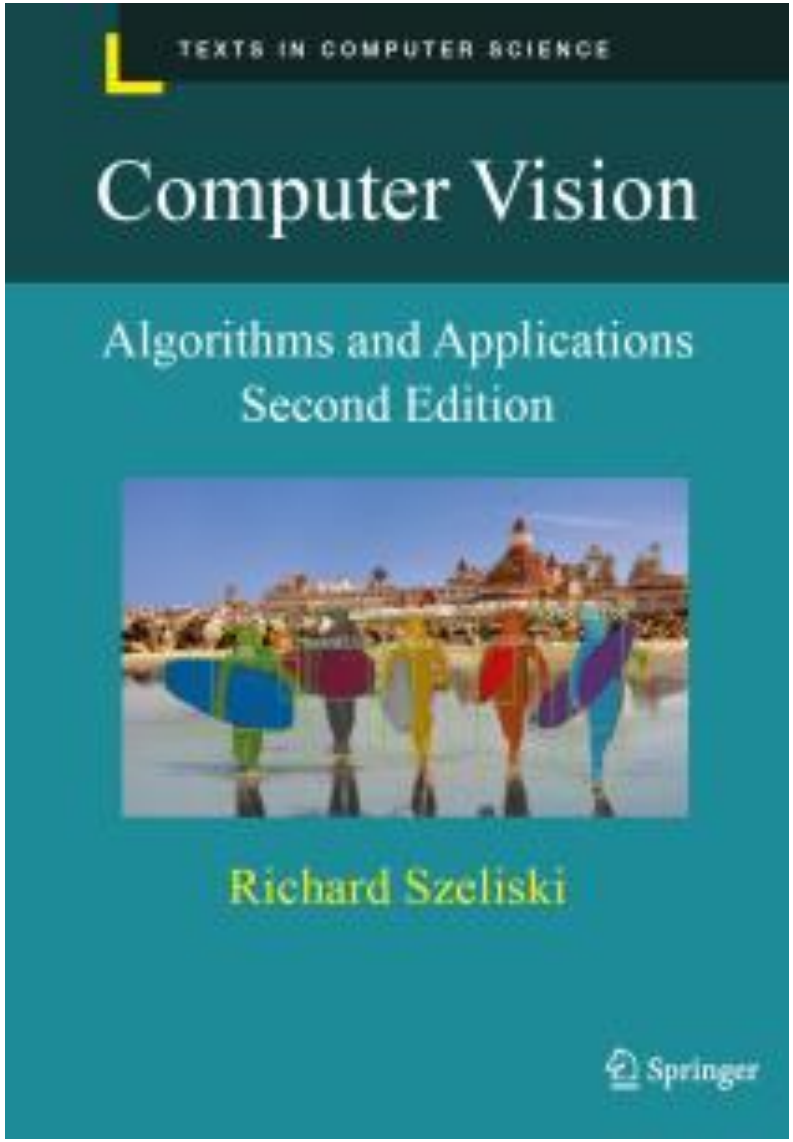
Discussion Sections:

- Two each week
- see webpage for times

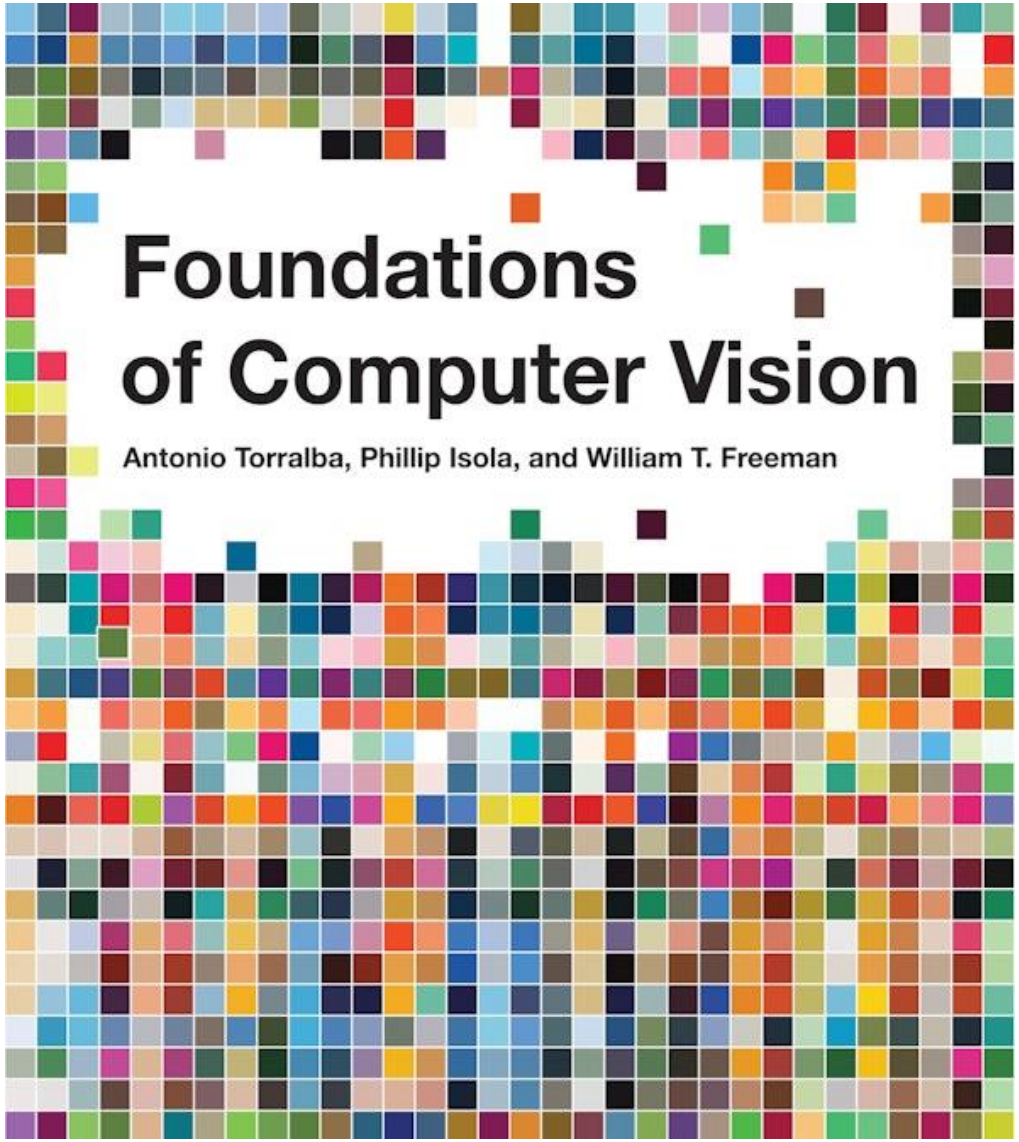
Office hours

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

Textbooks



http://szeliski.org/Book/



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

Academic Integrity

- Can discuss projects, but **never share code**
  - You must type every character yourself
- Don’t search for code or copy from a friend
- If you’re not sure if it’s allowed, ask
- Cite any sources and inspirations

Our GPT policy

- GPT is a wonderful tool
  - 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.
- In this course, we want you to do things **from scratch**.
  - So, no Stack Overflow, no searching for code, no fancy libraries, and no GPT
- You can use GPT (sparingly) to **debug** your code, but you must acknowledge and submit transcript of your GPT sessions

Waitlists

- We are limited by room size (~300 people)
- However, we expect 50-70 people to drop after the first couple of projects ☺
- So, chances are good to get in, but you need to start doing projects

- For CS280A, everyone is on the waitlist
  - Fill in this form, if you haven't already: https://forms.gle/DDBFWN6D1CH5uec58
- For Concurrent Enrollment (CE):
  - Fill in this form, if you haven't already: https://forms.gle/5cjKzgSoRVjSf9uW8

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

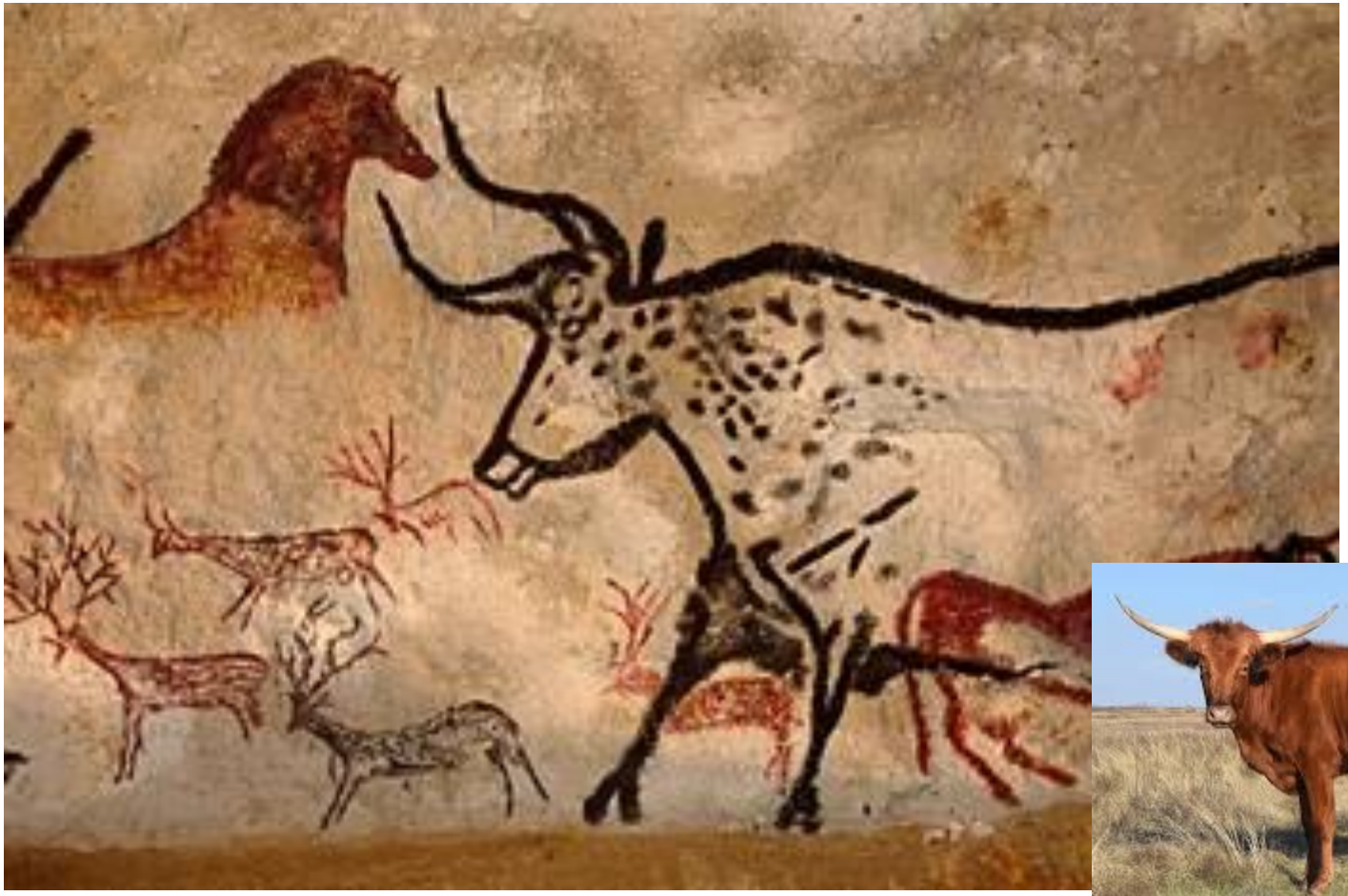
- Project-based class
  - No canned problem sets
  - No clean rubrics
  - Open-ended by design
  - Coding from scratch
  - Will try to make sure everyone understands the basics super-well, before covering advanced topics
- Need time to think, not just hack
  - **Creativity** is a class requirement
  - 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 grade than about learning stuff
- Not worth it if you don't enjoy it

Now… reasons TO take this class

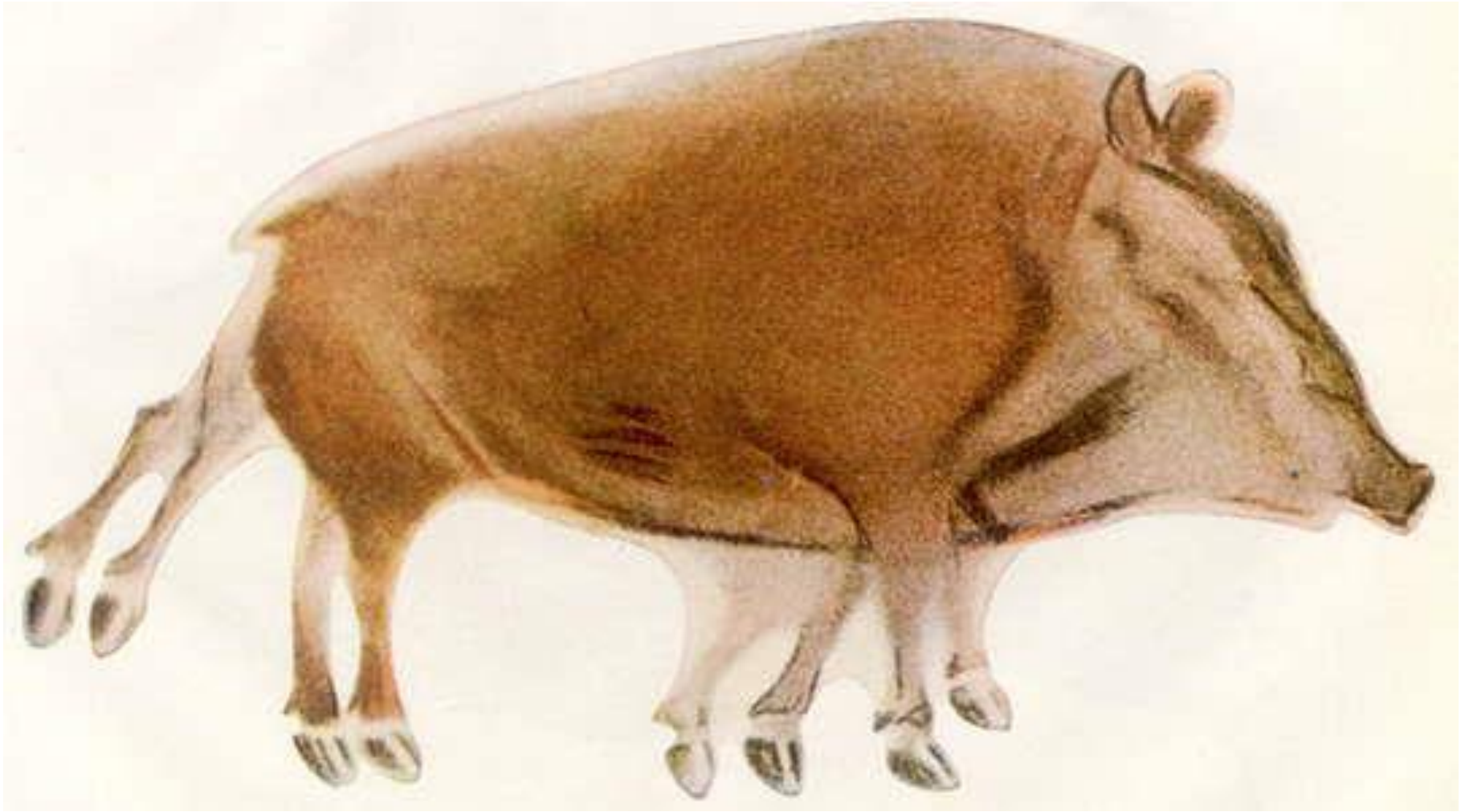
- It's your reward after 3 grueling years ☺
- You get to work with pictures, unleash your creative potential
- Interested in grad school? ☺

A Brief History of the Visual Data

Depicting Our World: The Beginning

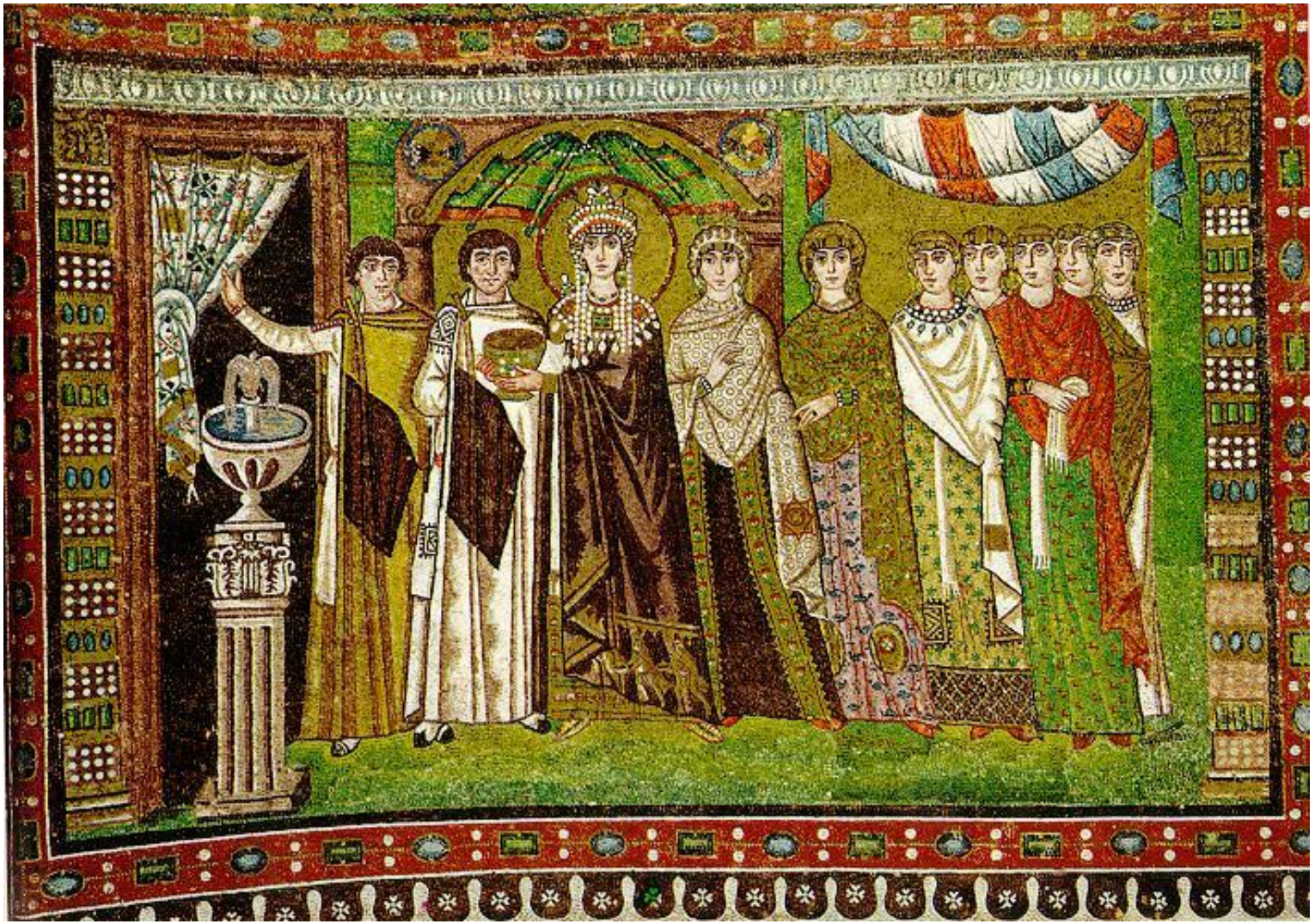


Prehistoric Painting, Lascaux Cave, France
~ 13,000 -- 15,000 B.C.



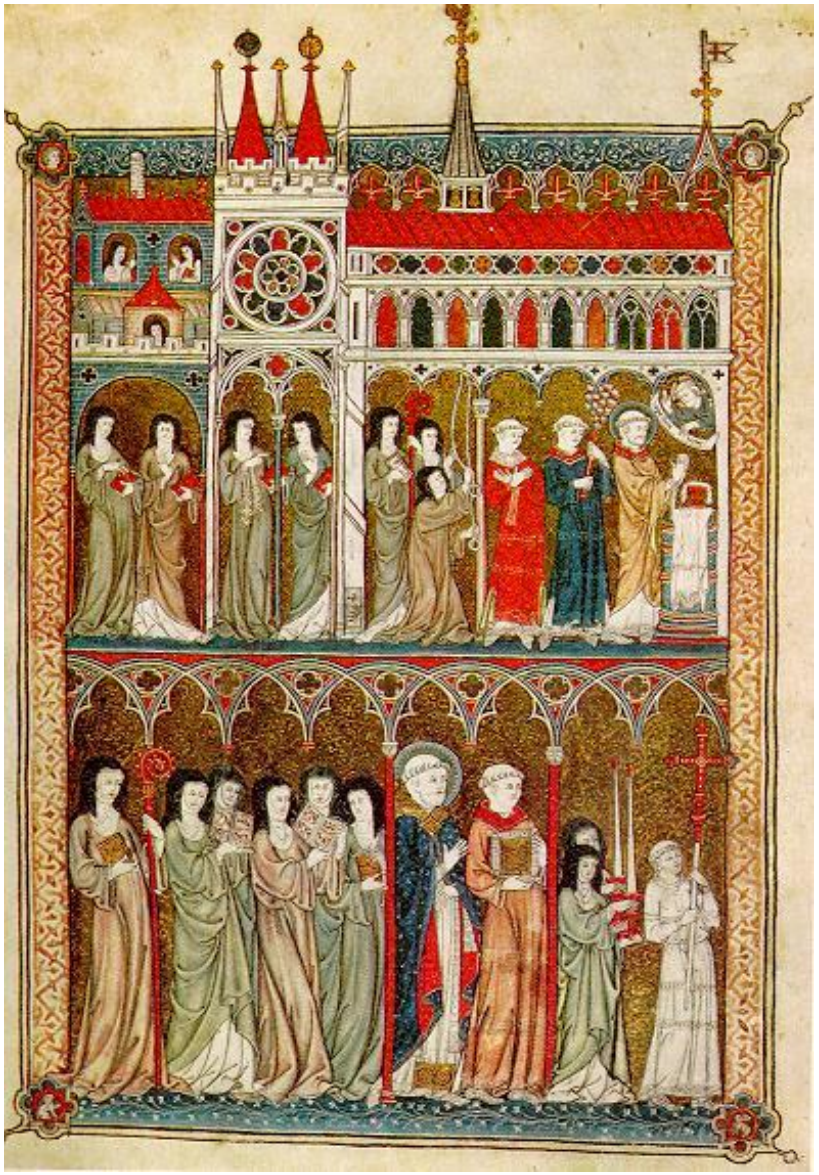
Prehistoric Cave Painting, Altamira
~ 20,000 – 15,000 B.C.

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

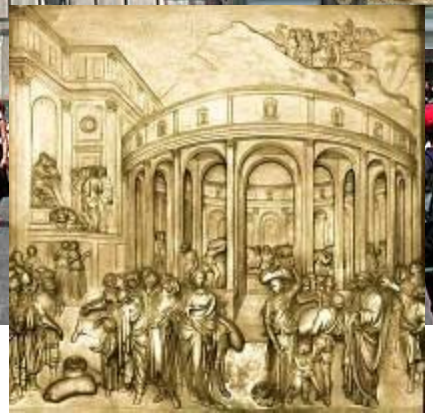
Giotto, *The Mourning of Christ*, c.1305

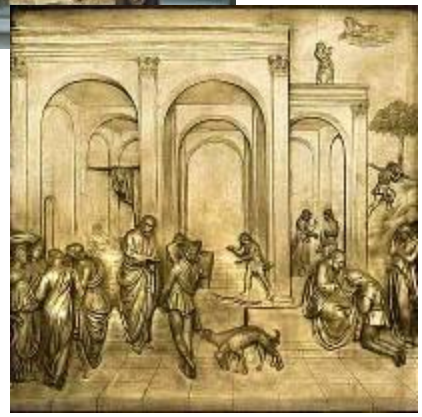
Depicting Our World: Renaissance

North Doors (1424)

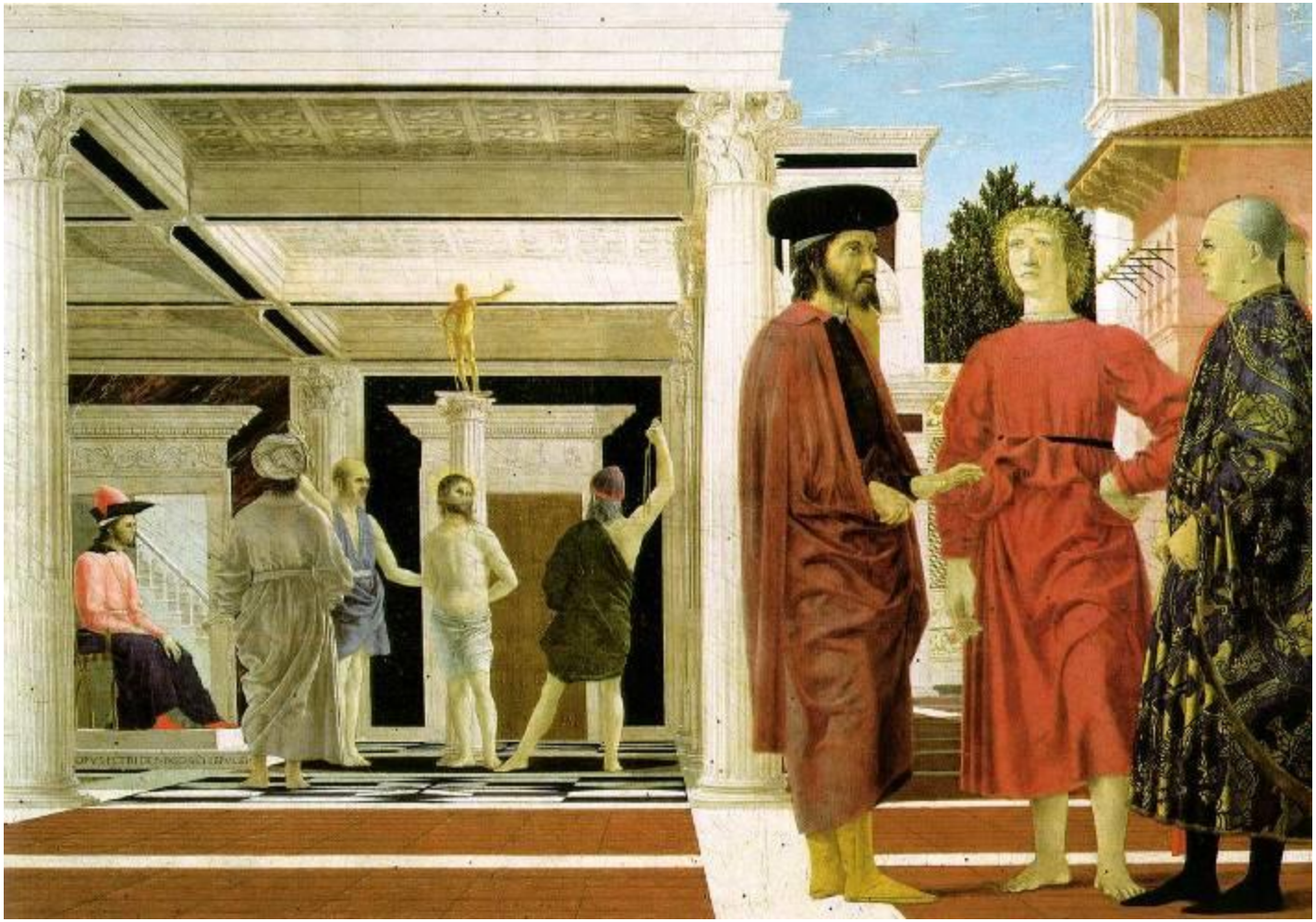
Lorenzo Ghiberti (1378-1455)

East Doors (1452)



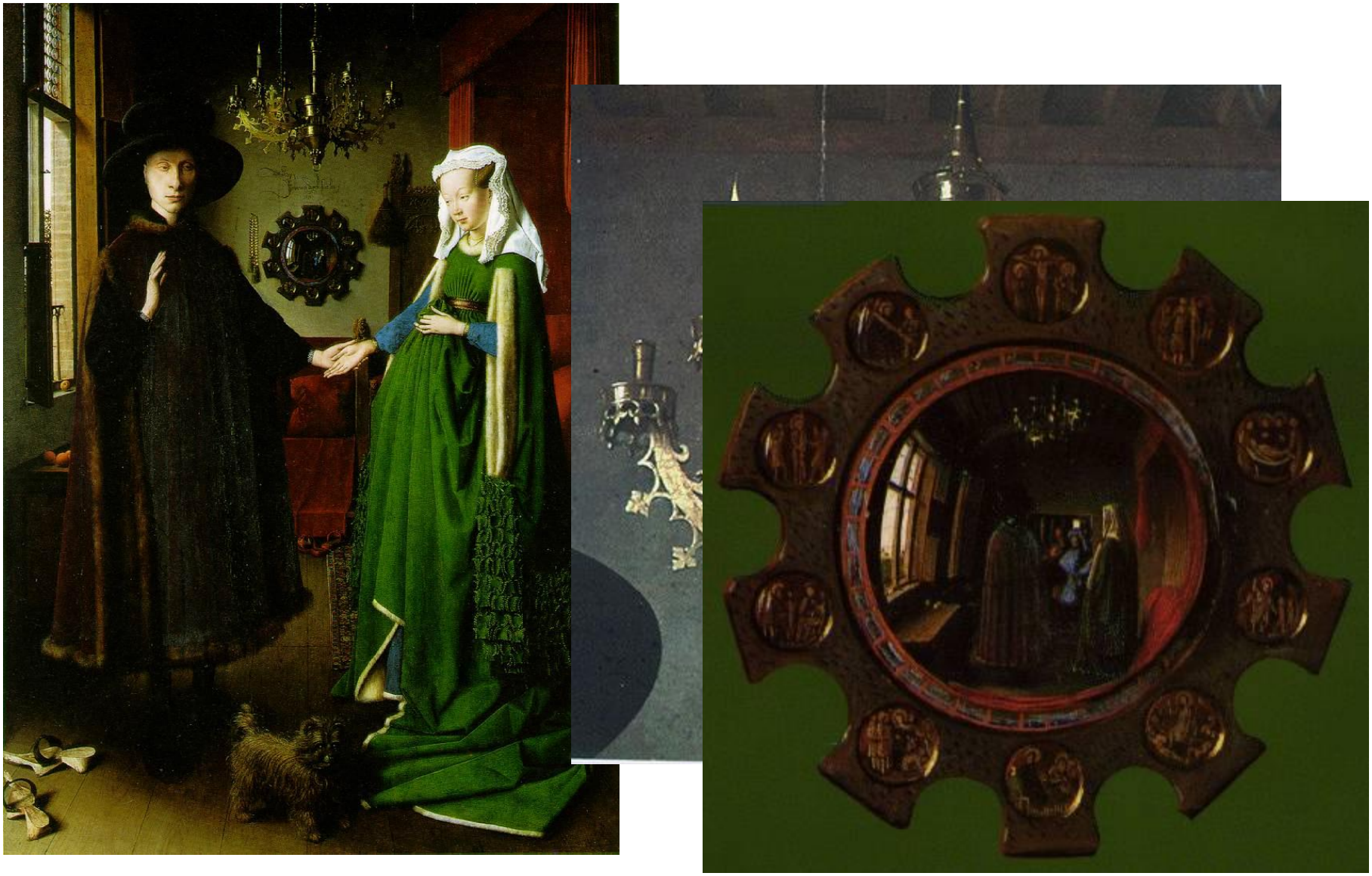


Depicting Our World: Renaissance



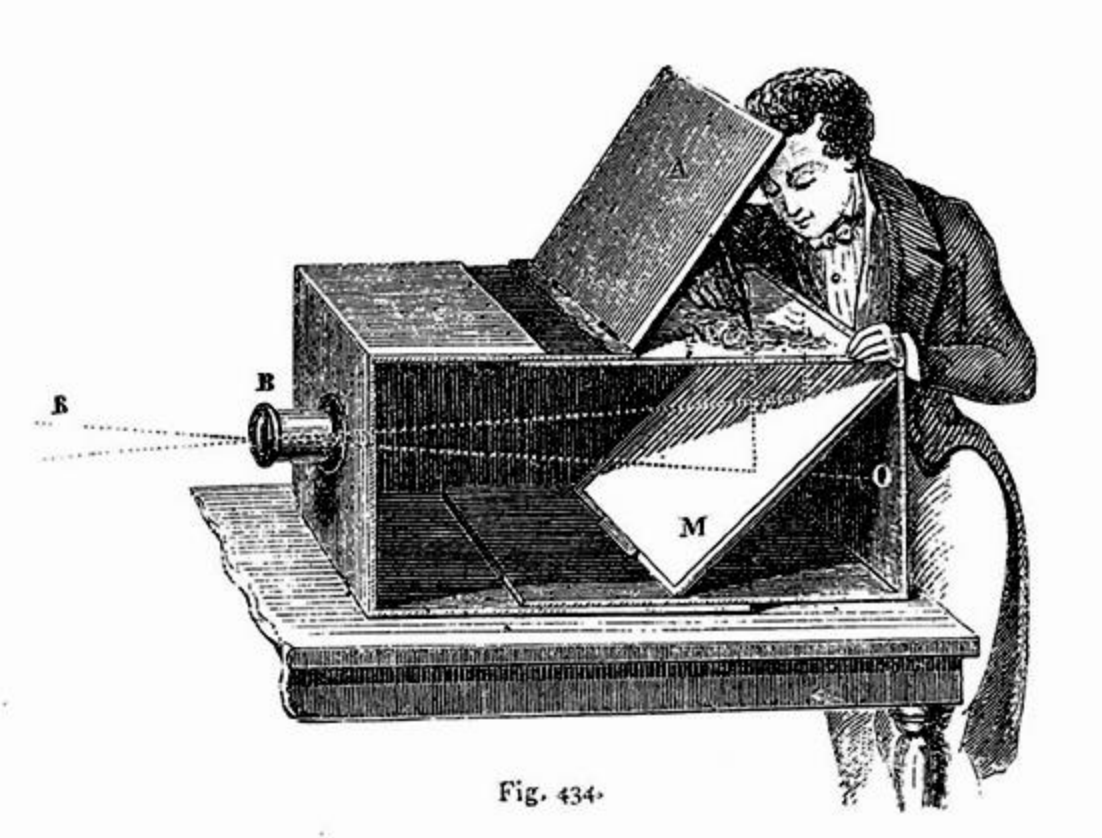
Piero della Francesca,
The Flagellation (c.1469)

Depicting Our World: Toward Perfection



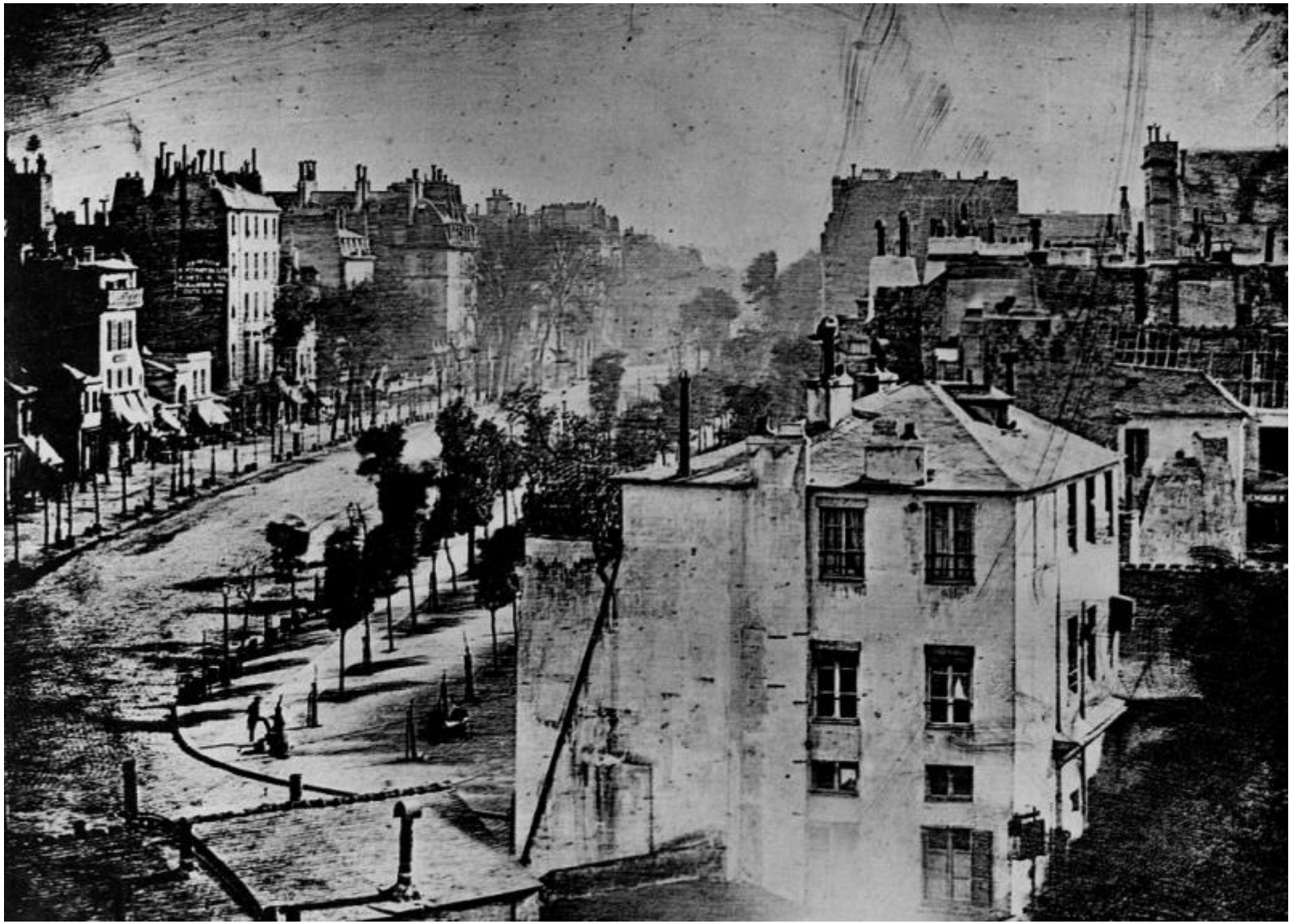
Jan van Eyck, *The Arnolfini Marriage (c.1434)*

Depicting Our World: Toward Perfection



Lens Based Camera Obscura, 1568

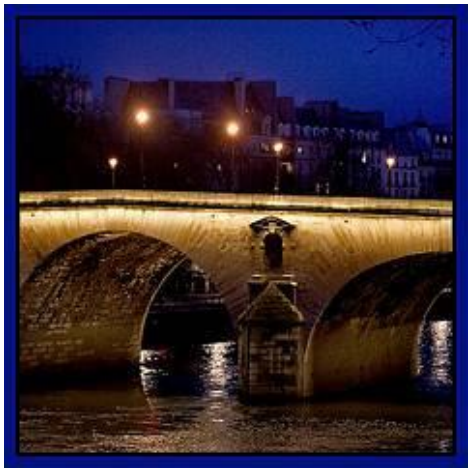
Depicting Our World: Perfection!



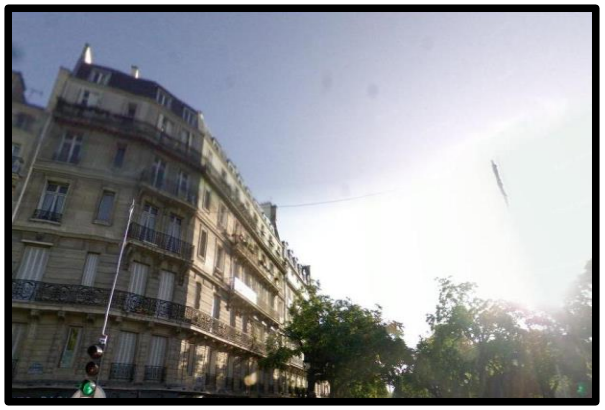
Boulevard du Temple, Louis Daguerre, 1838

Depicting Our World: Realism?

Paris, according to Flickr



Paris, according to Google StreetView

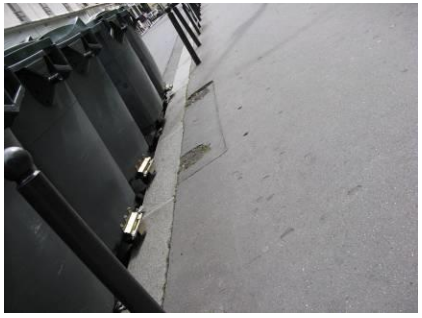




Knopp, Sivic, Pajdla, ECCV 2010

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

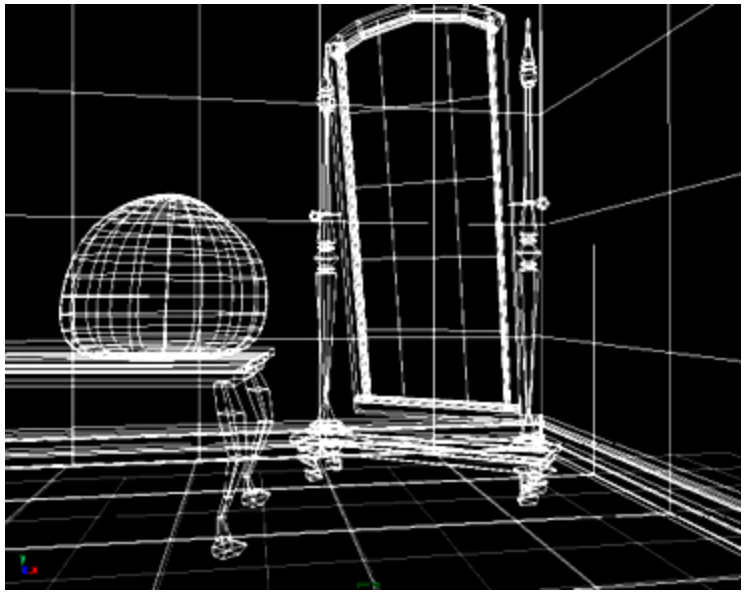
Alyosha Efros
Place Furstenberg,
2009

Depicting Our World: Ongoing Quest

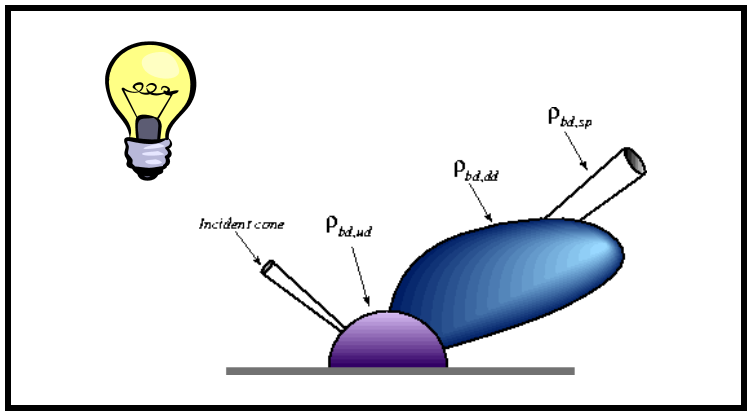
Antonio Torralba & Aude Oliva (2002)

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

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

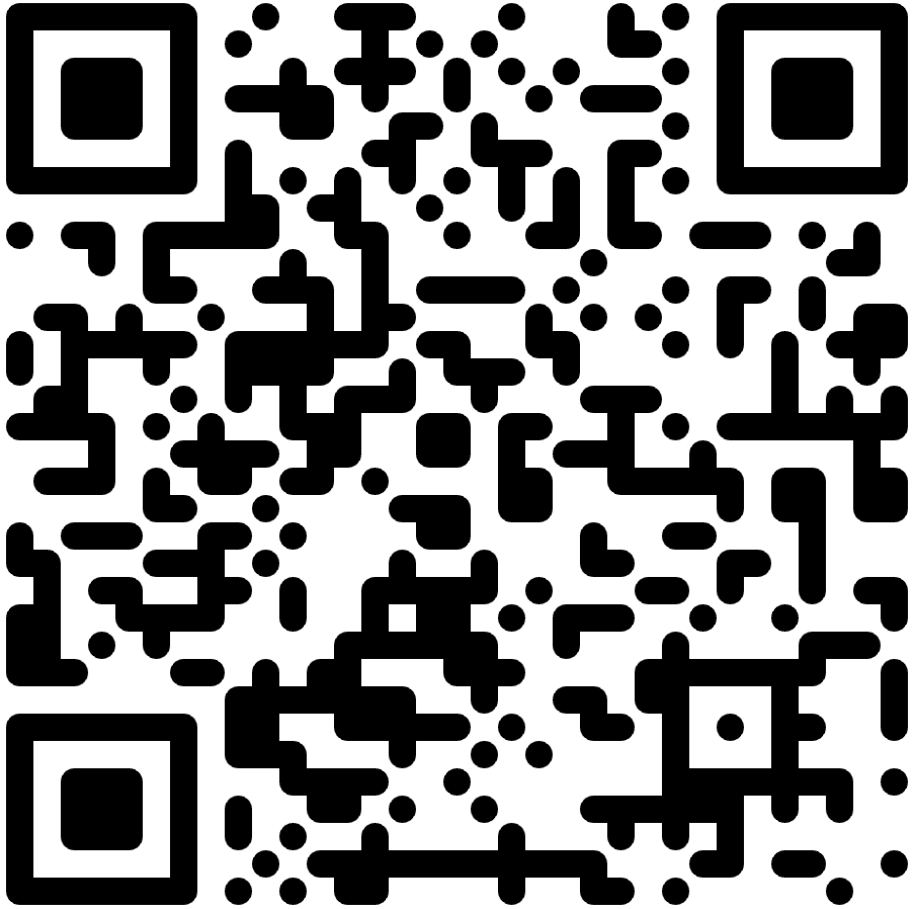
+ instantly realistic

+ easy to aquire

- very hard to manipulate objects/viewpoint

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



https://forms.gle/17c6YUfNaStgJpcM9