CS 194: Image Manipulation and Computational Photography

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Instructor: Alexei Efros
GSIs: Taesung Park
Shiry Ginosar
UC Berkeley, Fall 2018

Excuse the temporary disruption…

Sign up on piazza.com for the latest info

Today

Introductions

Why Computational Photography?

Overview of the course

Administrative stuff

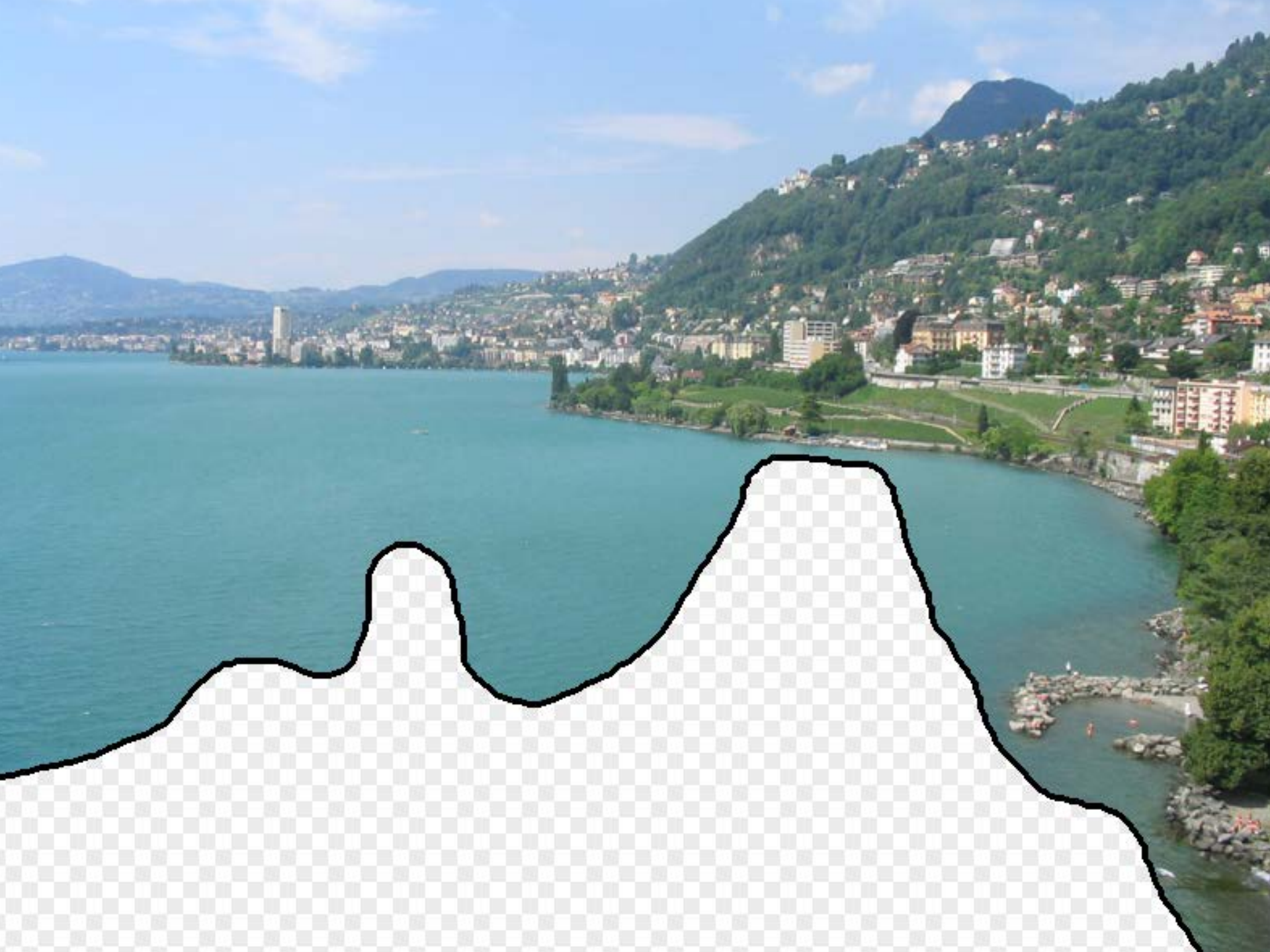
A bit about me

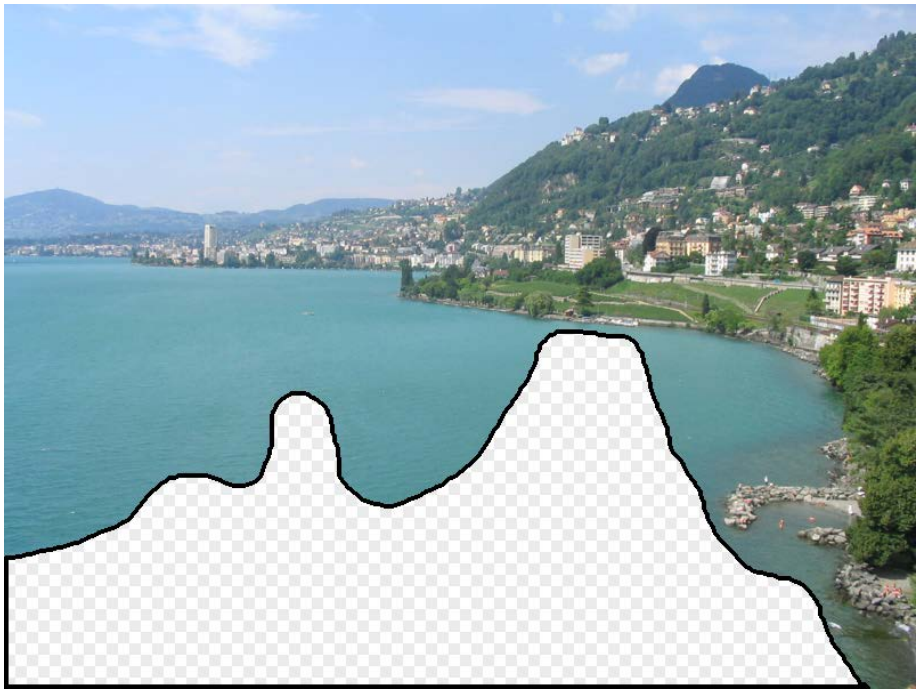
- Alexei (Alyosha) Efros
- Research
  - Computer Vision, Computer Graphics, Machine Learning, Visual Perception

PhD 2003 on Texture and Action Synthesis

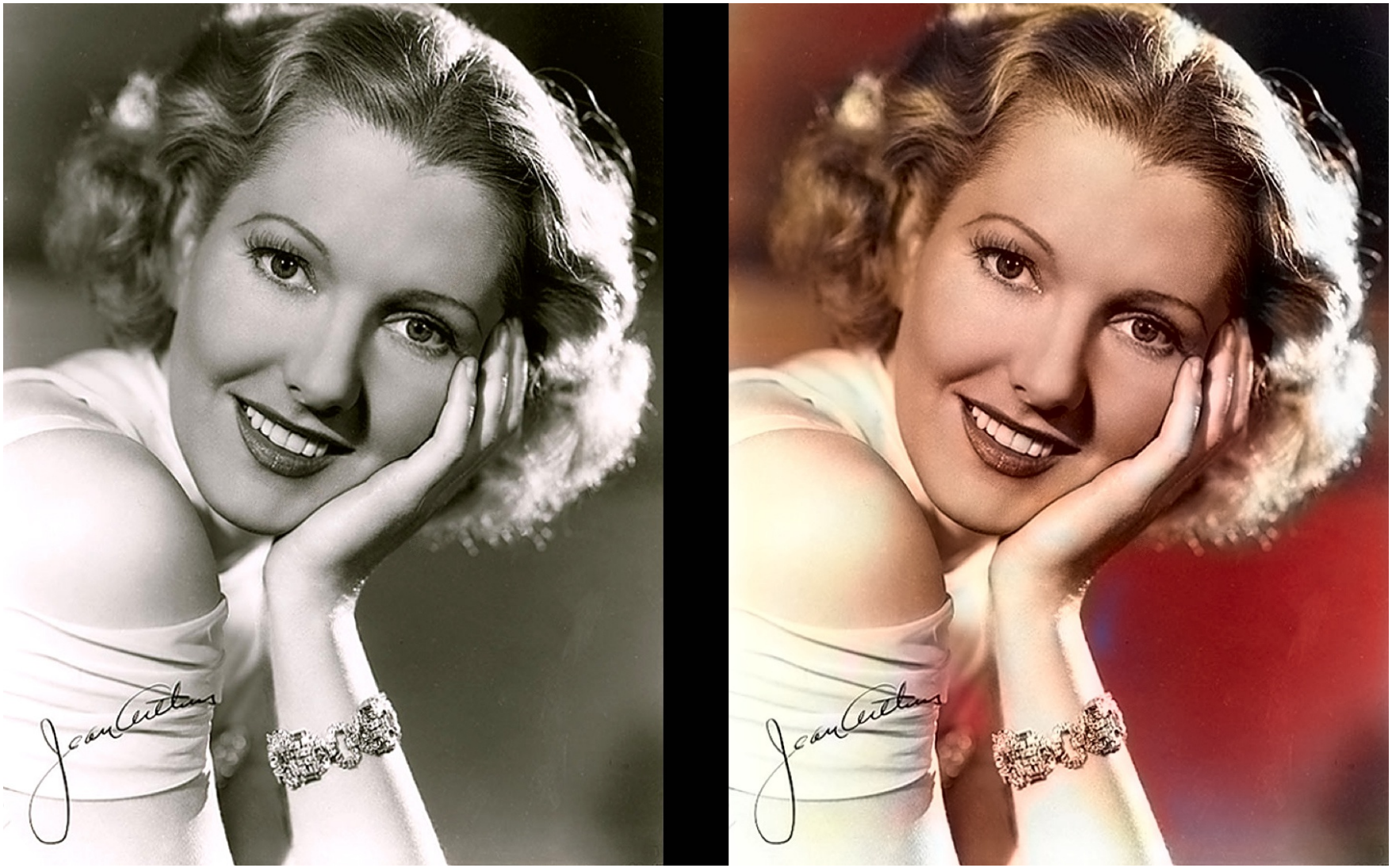
*Inspired Photoshop's **"Context-aware Fill"** and Microsoft **"Smart Erase"*** buttons:

Other works…





Colorizing Black and White Photos



Zhang et al, “Colorful Image Colorization", ECCV 2016

Amateur Photographer

Head GSI

Taesung Park

- PhD candidate in Computer Science
- Expert in computer vision, computer graphics, and deep learning
- https://taesung.me/

CycleGAN

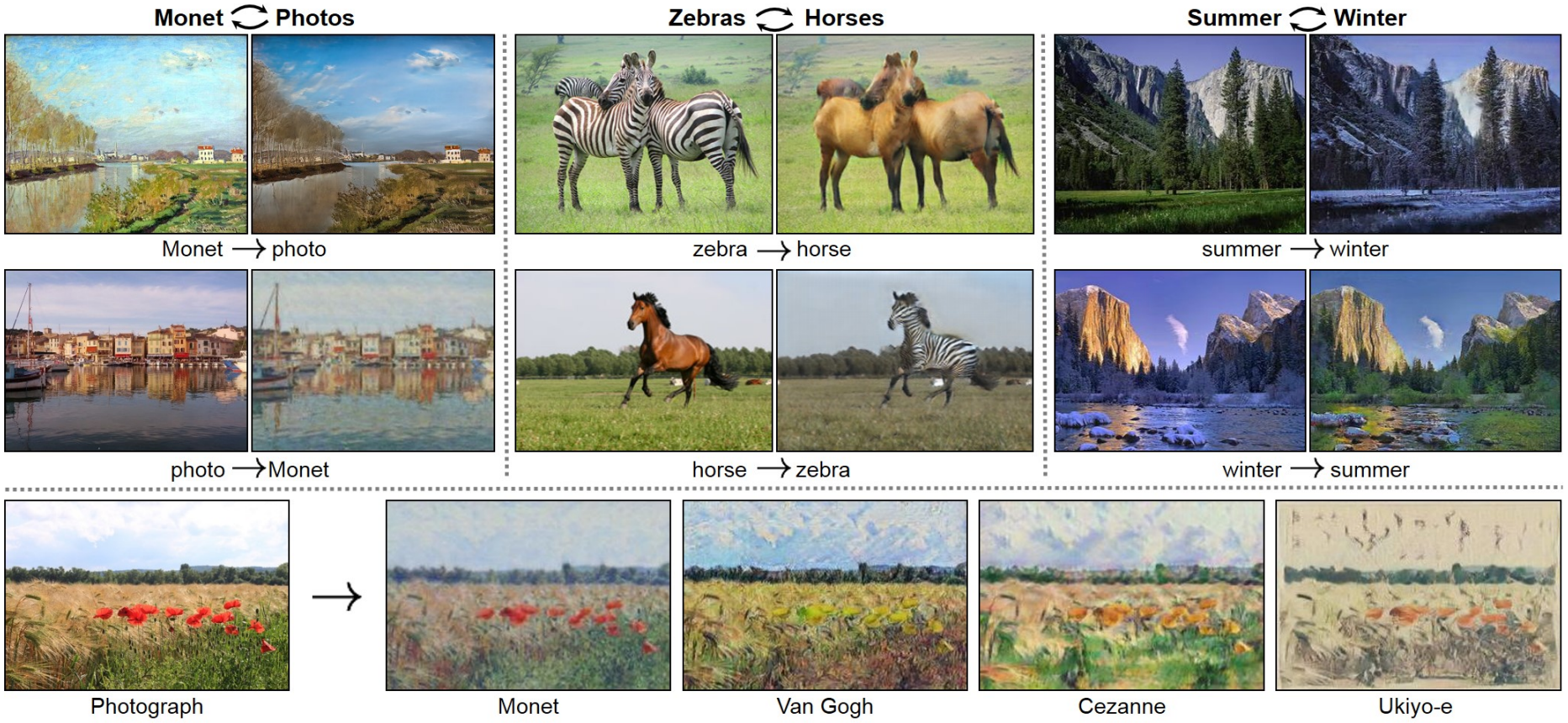

Monet ⇄ Photos
Zebras ⇄ Horses
Summer ⇄ Winter
Monet → photo
zebra → horse
summer → winter
photo → Monet
horse → zebra
winter → summer
Photograph
Monet
Van Gogh
Cezanne
Ukiyo-e

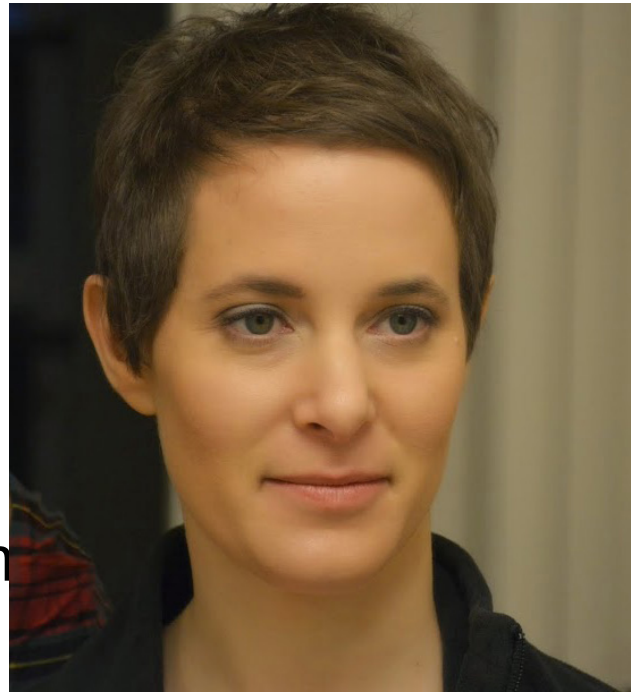
Photo to Painting

And back...

Horse to zebra

Failure case

GSI/Co-instructor



Shiry Ginosar

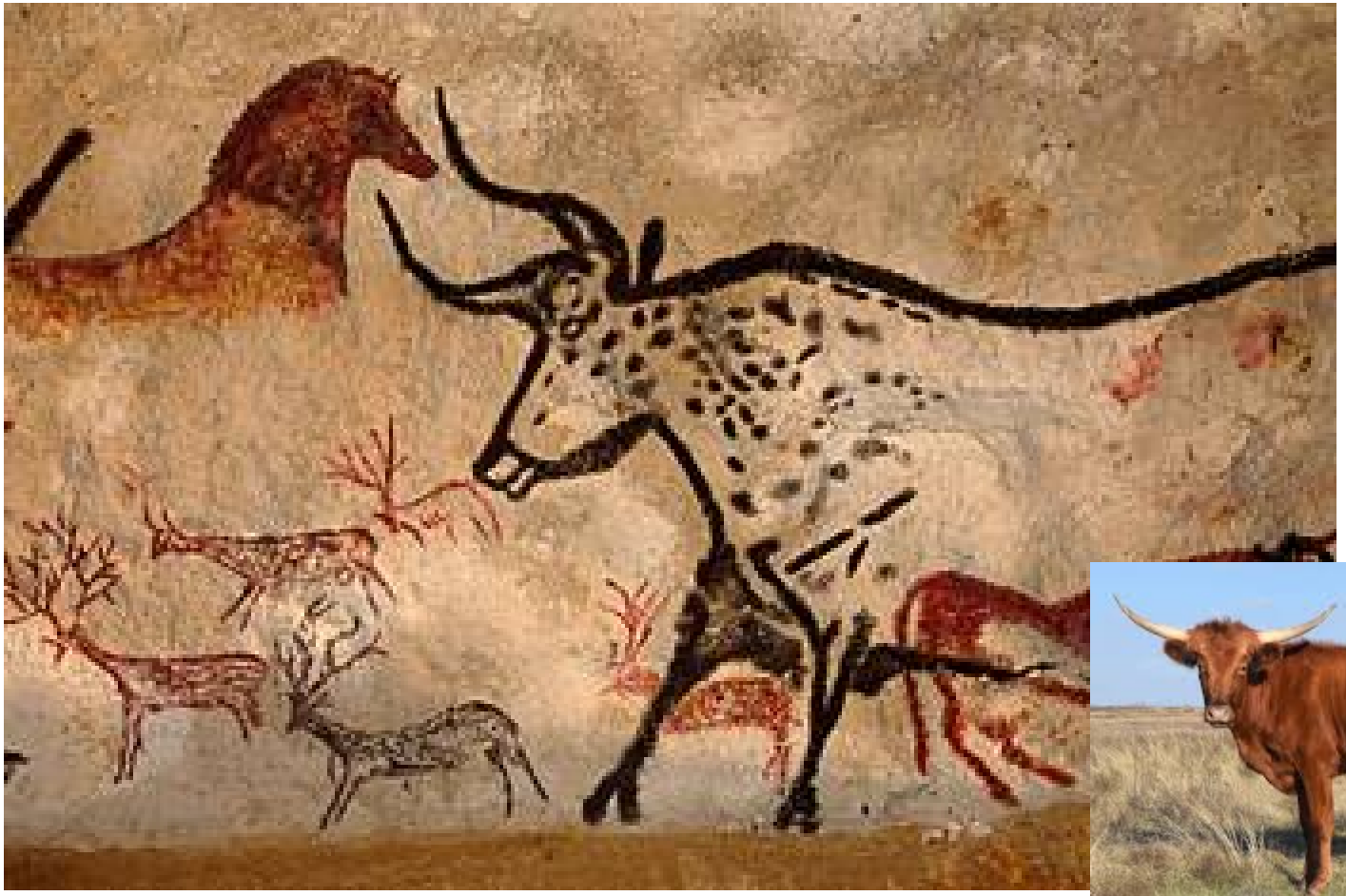
- PhD candidate in Computer Science
- Expert in computer vision, data-driven methods, deep learning, visual perception
- https://people.eecs.berkeley.edu/~shiry/

Everybody Dance Now…

Why Computational Photography?

A Brief History of the Visual Media

Depicting Our World: The Beginning

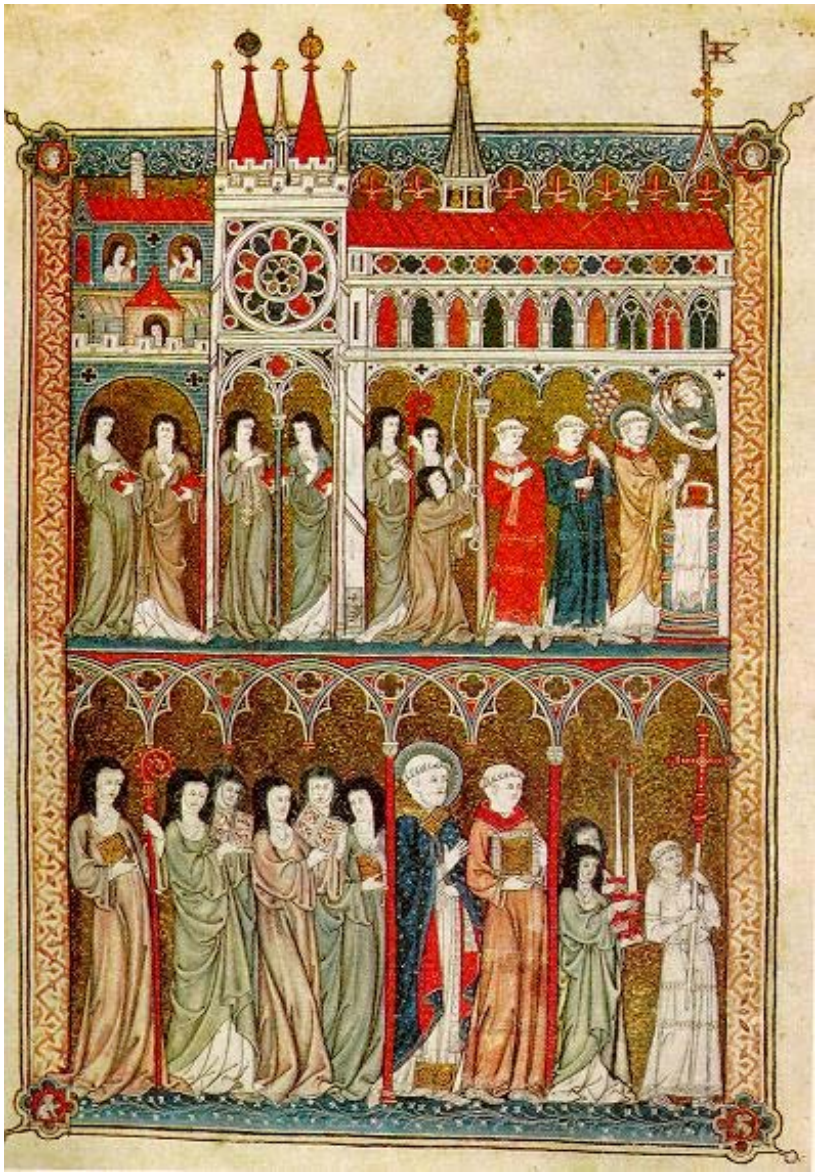


Prehistoric Painting, Lascaux Cave, France
~ 13,000 -- 15,000 B.C.

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

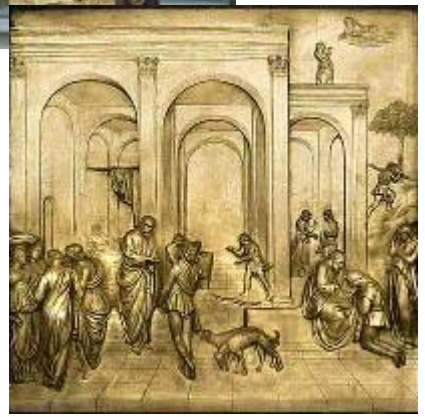
Giotto, *The Mourning of Christ*, c.1305

Depicting Our World: Renaissance

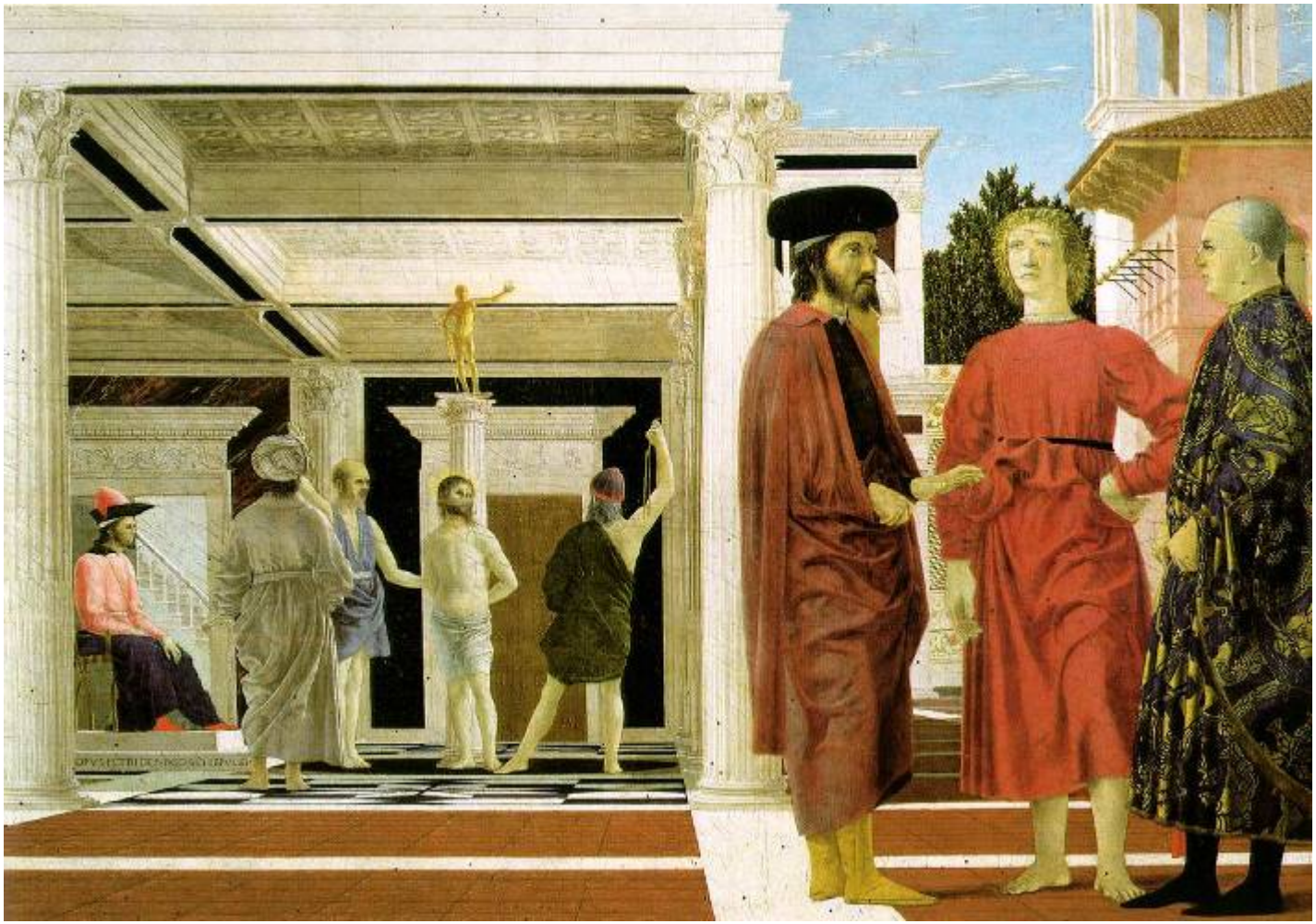
North Doors (1424)

Lorenzo Ghiberti (1378-1455)

East Doors (1452)

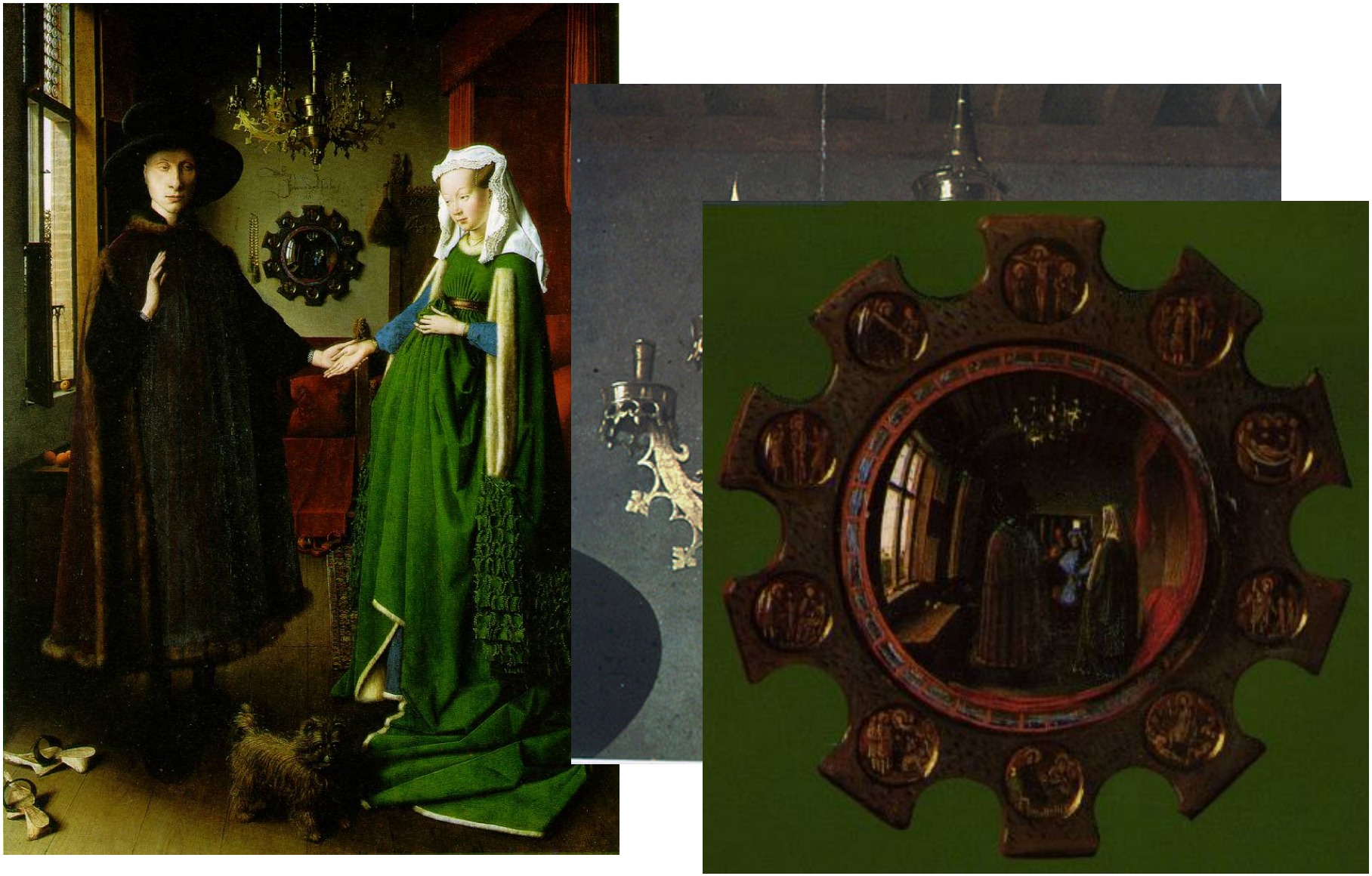


Depicting Our World: Renaissance



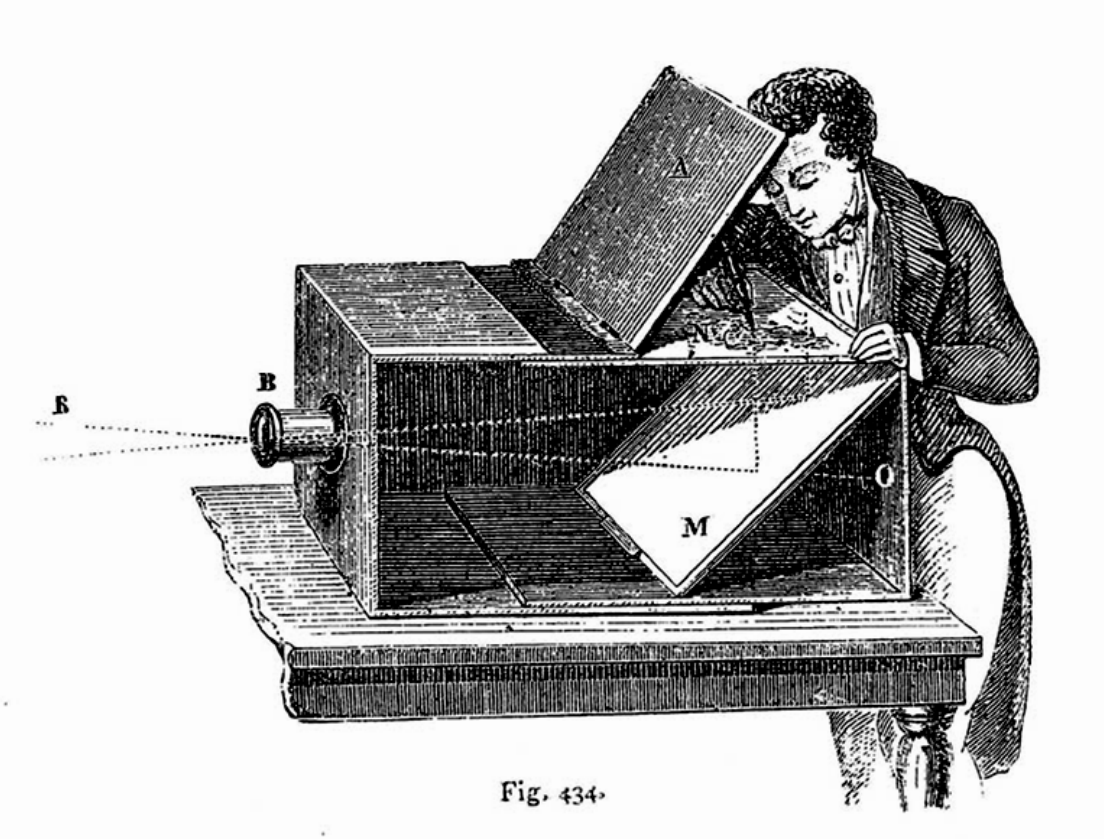
Piero della Francesca,
The Flagellation (c.1469)

Depicting Our World: Toward Perfection



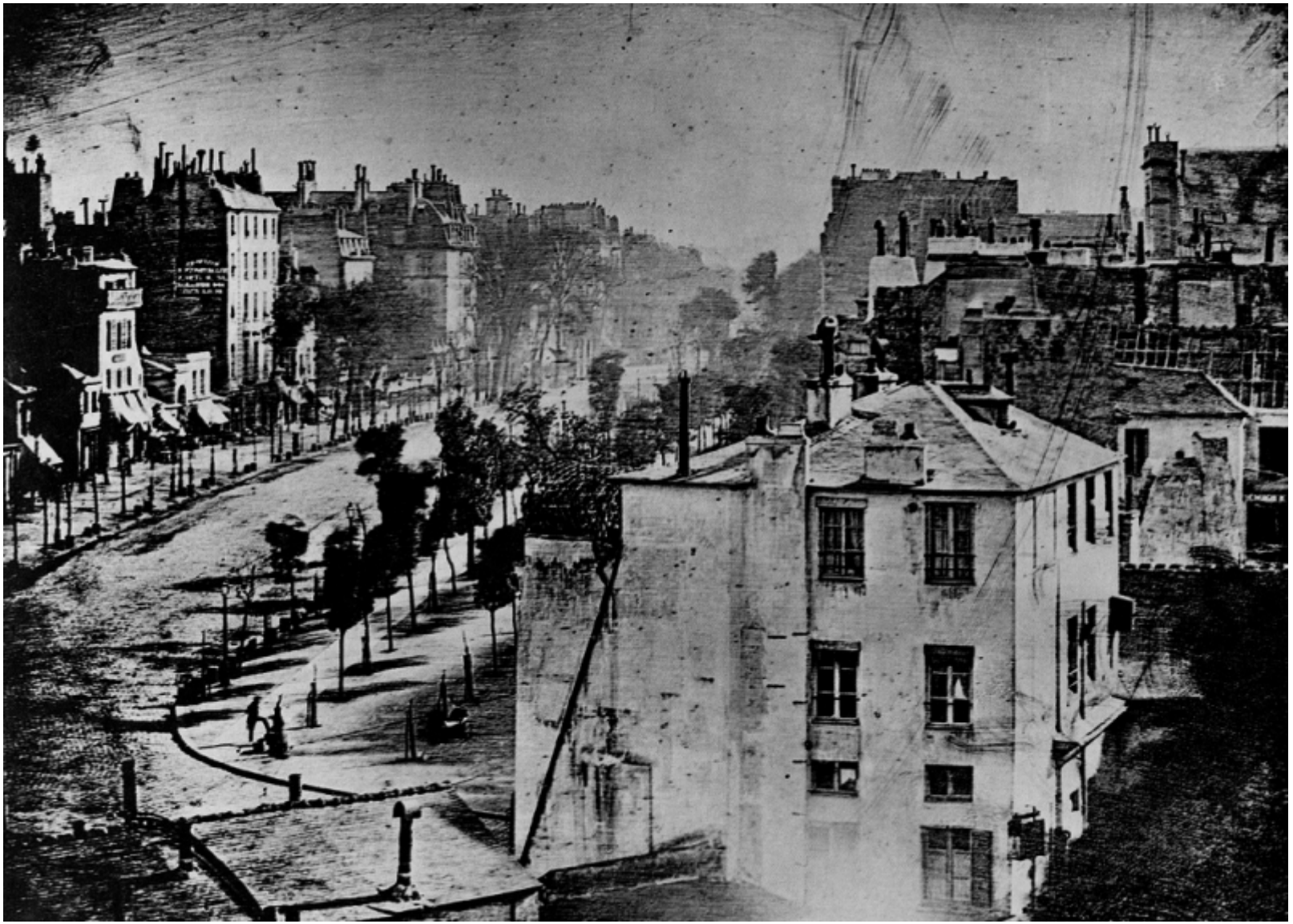
Jan van Eyck, *The Arnolfini Marriage (c.1434)*

Depicting Our World: Toward Perfection



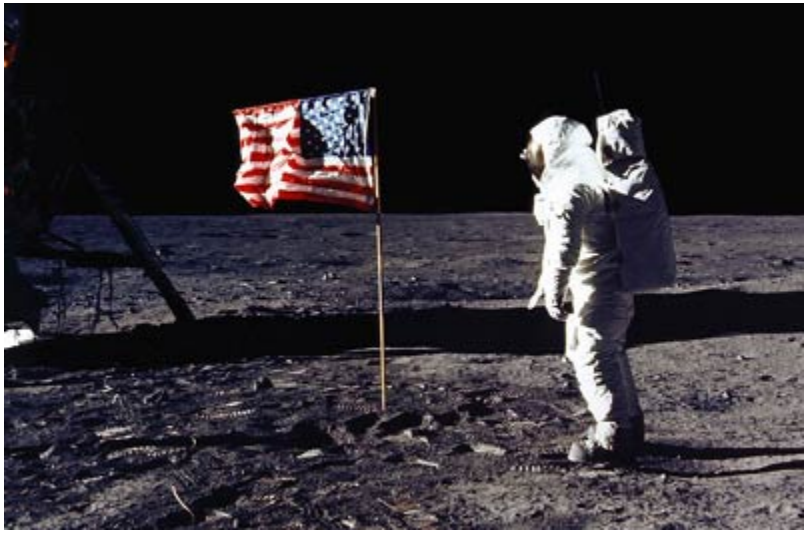
Lens Based Camera Obscura, 1568

Depicting Our World: Perfection!

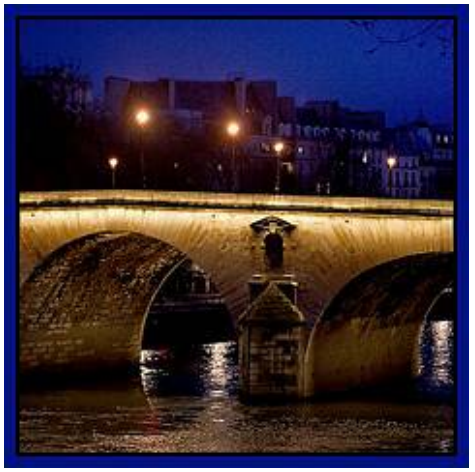


Boulevard du Temple, Louis Daguerre, 1838

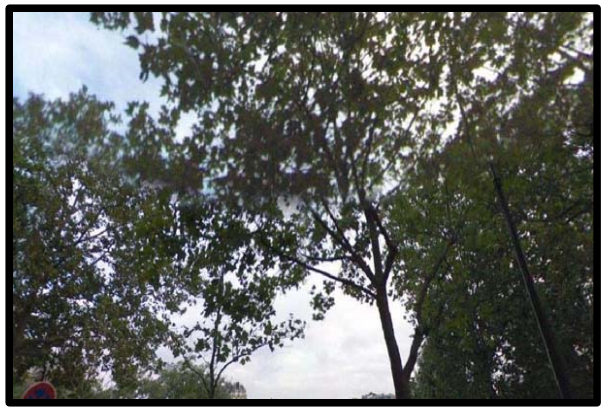
Depicting Our World: Realism?



Paris, according to Flickr



Paris, according to Google StreetView



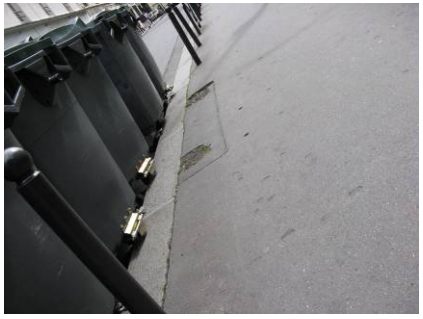


Knopp, Sivic, Pajdla, ECCV 2010

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

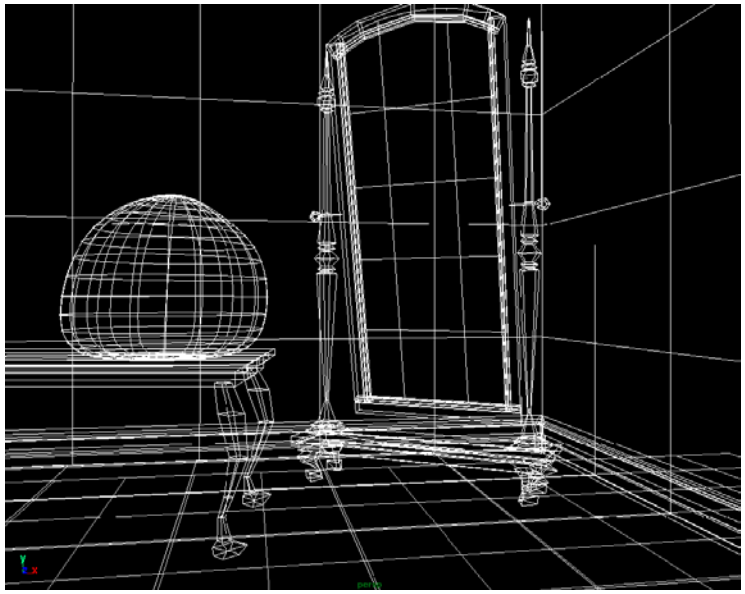
Alyosha Efros
Place Furstenberg,
2009

Depicting Our World: Ongoing Quest

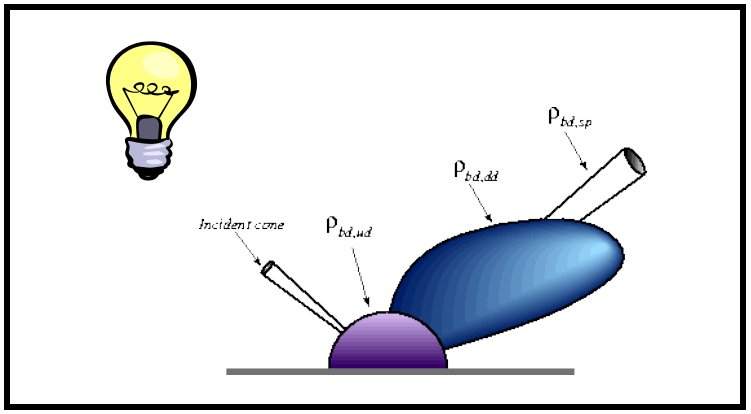
Antonio Torralba & Aude Oliva (2002)

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

Faces / Hair

From “Final Fantasy”

Photo by Joaquin Rosales Gomez

Hyper-humans

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

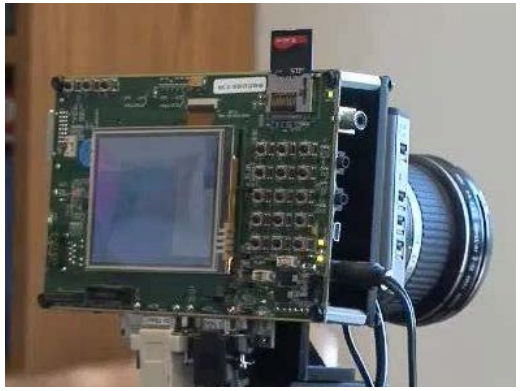
Photography

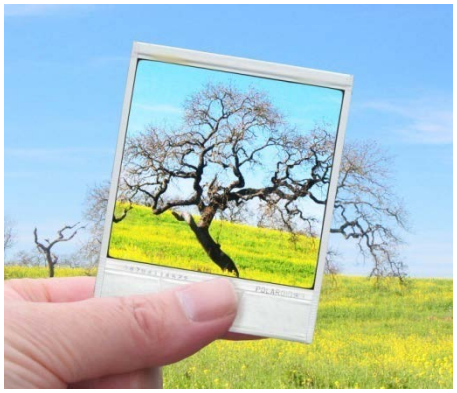
+ instantly realistic

+ easy to aquire

- very hard to manipulate objects/viewpoint

Computational Photography



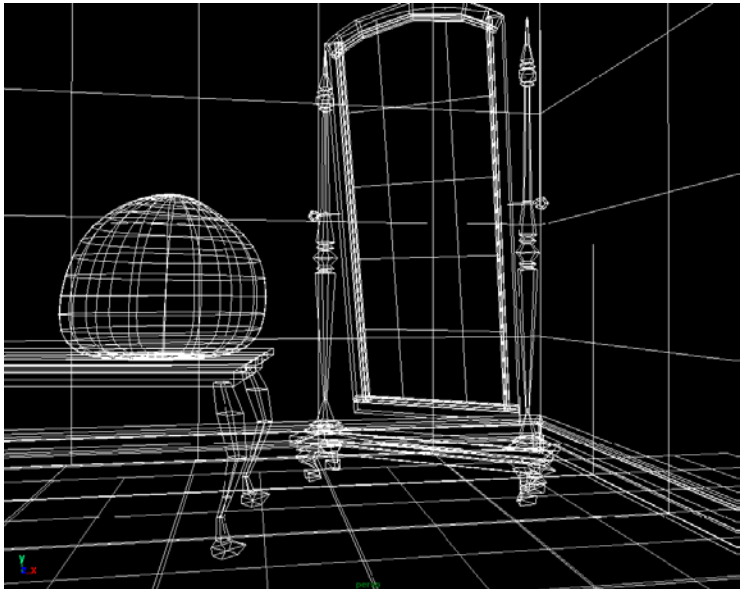


How can I use computational techniques to capture light in new ways?

How can I use computational techniques to breathe new life into the photograph?

How can I use computational techniques to visualize, organize, and navigate the captured visual world?

Relationship to Vision and Graphics



3D Model

2D image

Computer Graphics: Models to Images

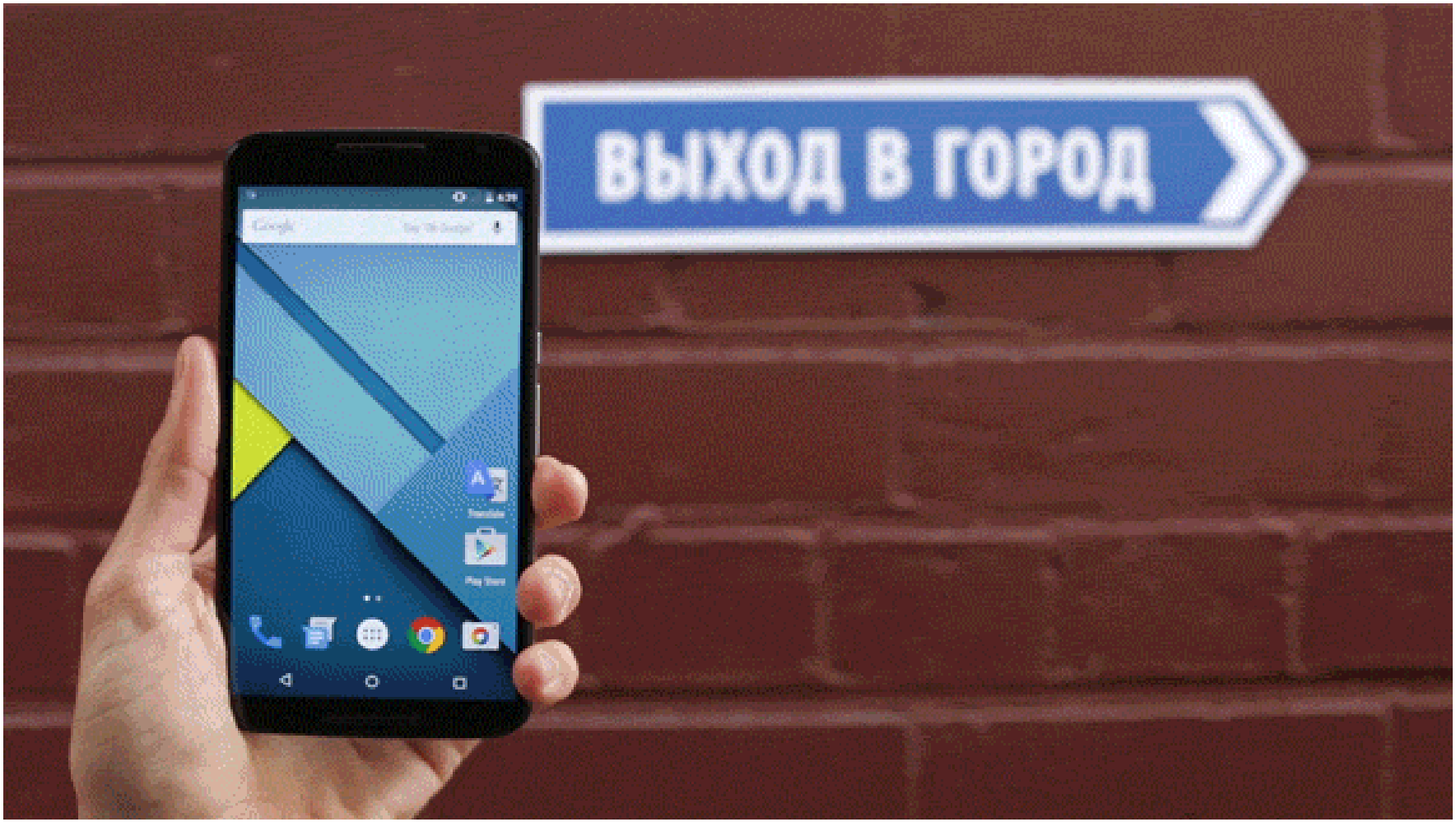
Computer Vision: Images to Models

Comp. Photography: Images to Images

Google Photosphere

https://www.youtube.com/watch?v=ZIsRPqcv0Cw

WordLens / Google Translate



Fyuse

https://www.youtube.com/watch?v=9rTjaCcwX6o

Virtual Real World

Campanile Movie

http://www.debevec.org/Campanile/

Course objectives

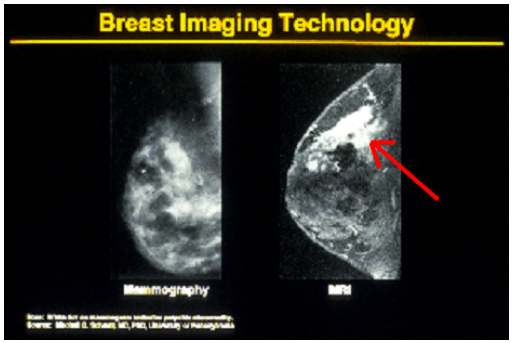
1. You will have new abilities for visual creation.

Graphic by James Hays

Course objectives

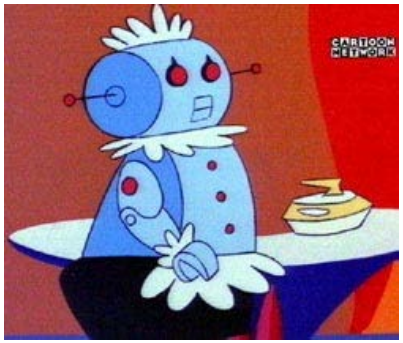
2. You will get a foundation in computer vision.

Safety



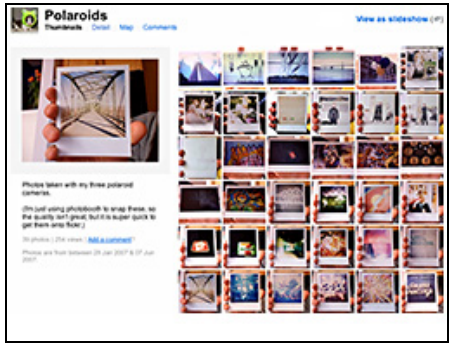
Health

Security



Comfort

Fun

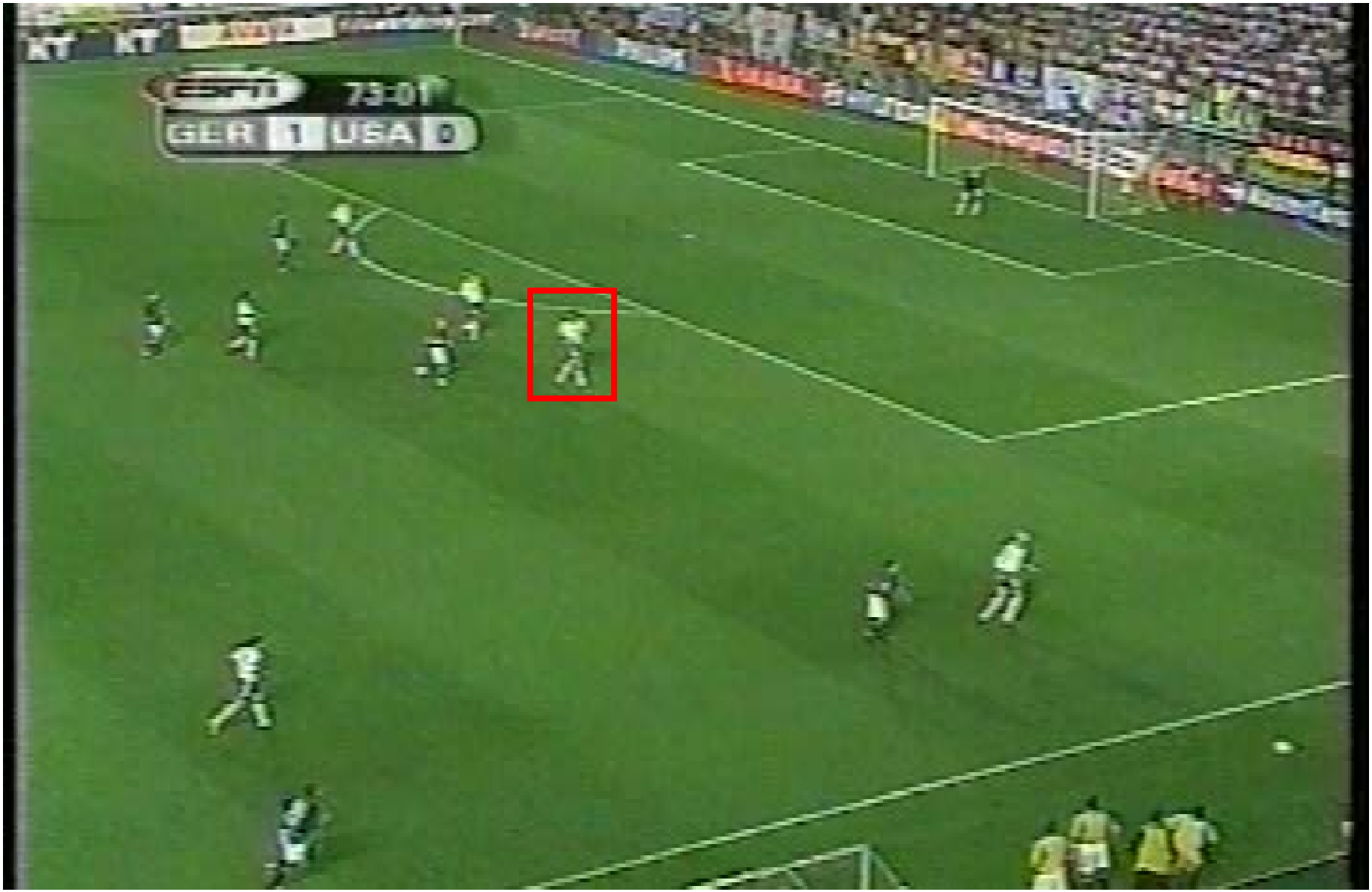


Access

Course objectives

3. You'll better appreciate your own visual ability.

Seeing less than you think…



Seeing less than you think…

Video by Antonio Torralba (starring Rob Fergus)

But actually…

Video by Antonio Torralba (starring Rob Fergus)

Course objectives

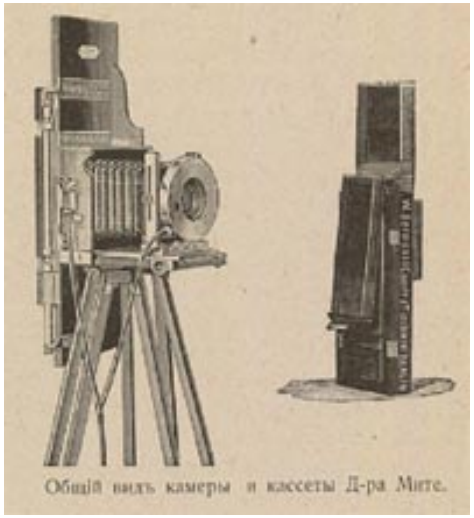
4. You will get a more intuitive understanding of important mathematical and computational concepts
   - Convolutions, filtering
   - Gradients
   - Change of basis, interpolation, extrapolation, PCA
   - FFT
   - Dynamic programming, recursion
   - …

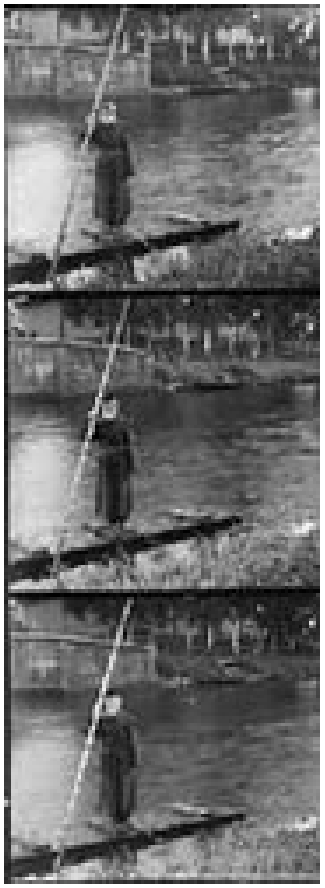
Course objectives

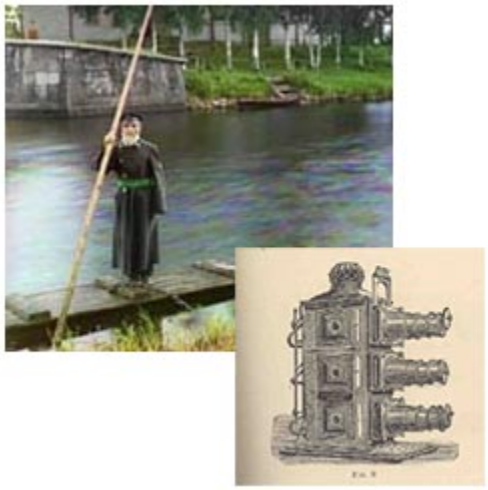
5. You'll have fun doing cool stuff!

Programming Project #1

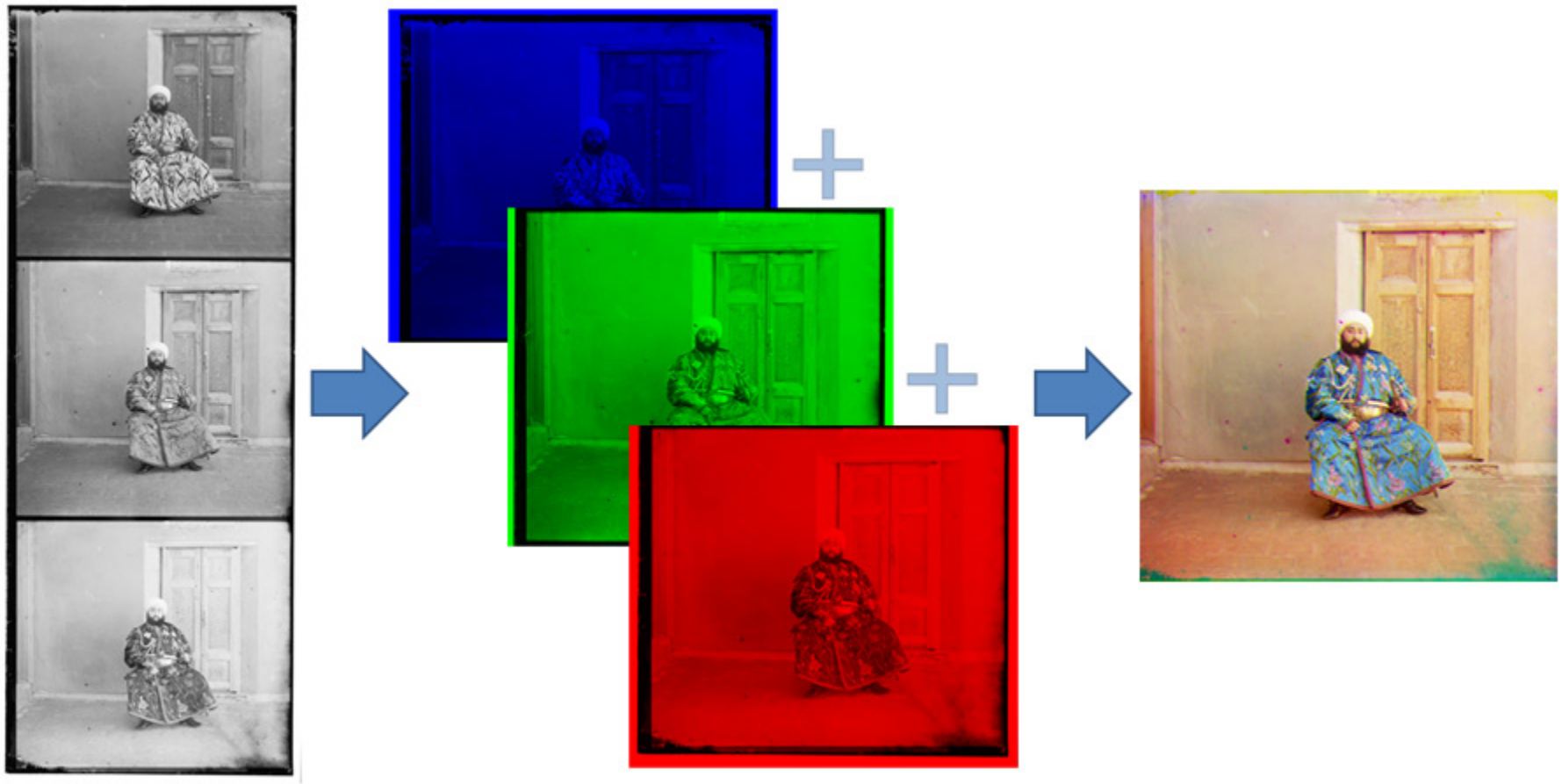
Prokudin-Gorskii's Color Photography (1907)







Programming Project #1



Programming Project #1

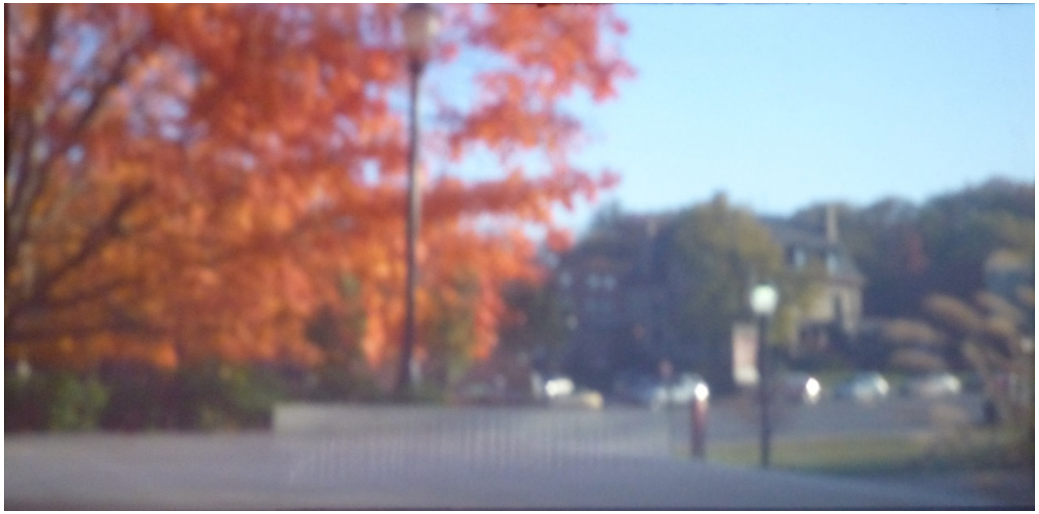
- How to compare R,G,B channels?
- No right answer
  - Sum of Squared Differences (SSD):

$$ssd(u,v) = \sum_{(x,y)\in N} \left[I(u+x, v+y) - P(x,y)\right]^2$$

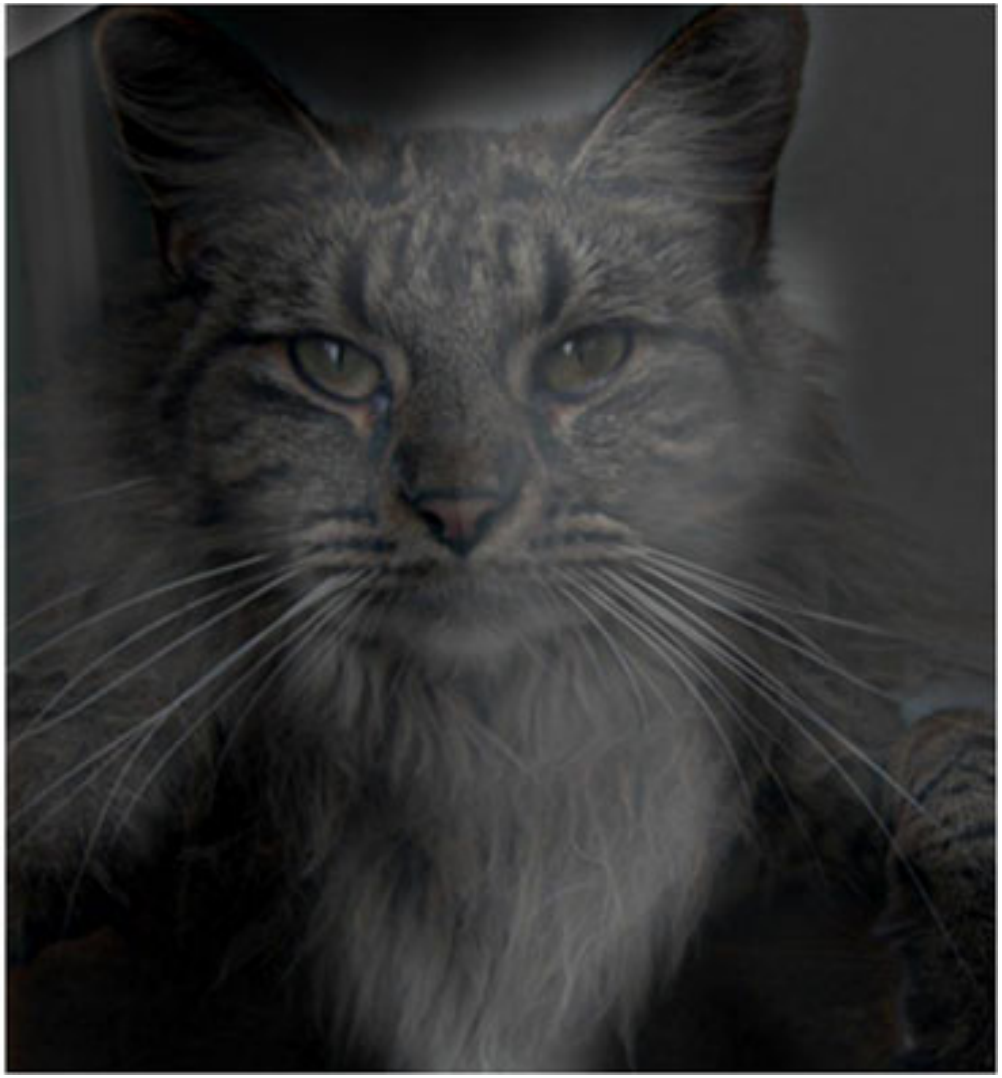
  - Normalized Correlation (NCC):

$$ncc(u,v) = \frac{\sum_{(x,y)\in N} \left[I(u+x, v+y) - \bar{I}\right]\left[P(x,y) - \bar{P}\right]}{\sqrt{\sum_{(x,y)\in N} \left[I(u+x, v+y) - \bar{I}\right]^2 \sum_{(x,y)\in N} \left[P(x,y) - \bar{P}\right]^2}}$$

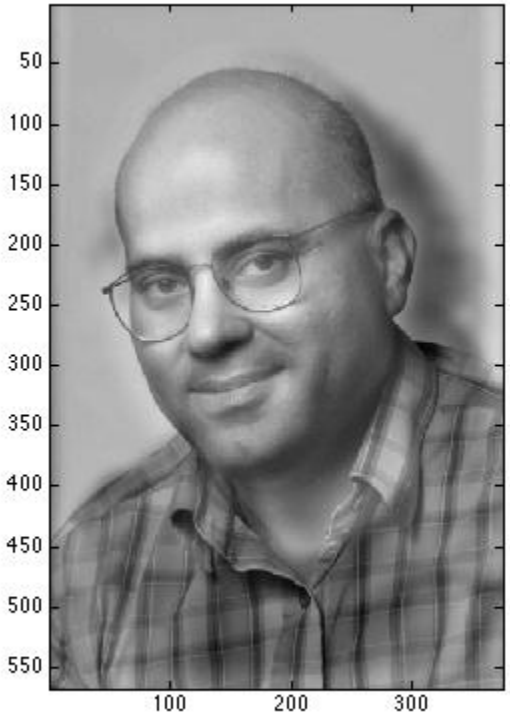
Project 2: Building a Camera Obscura



Project 3: Fun with frequencies

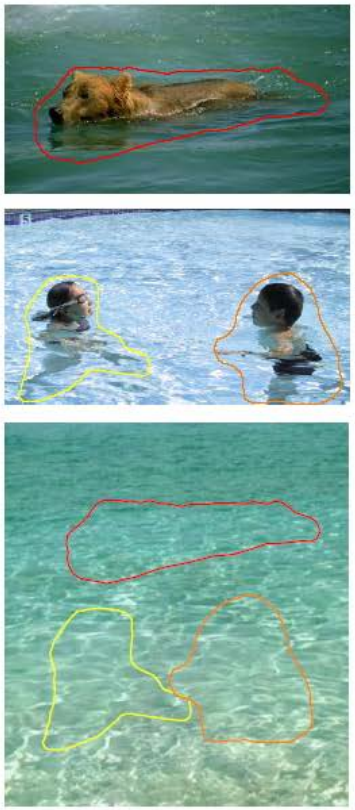


Project 3: Fun with frequencies



Prof. Christos Papadimalik

Project 4: Gradient Domain Editing



sources/destinations

cloning

seamless cloning

Project 4: Gradient Domain Editing

Project 5: Face morphing and caricatures

Project 5: Face morphing and caricatures

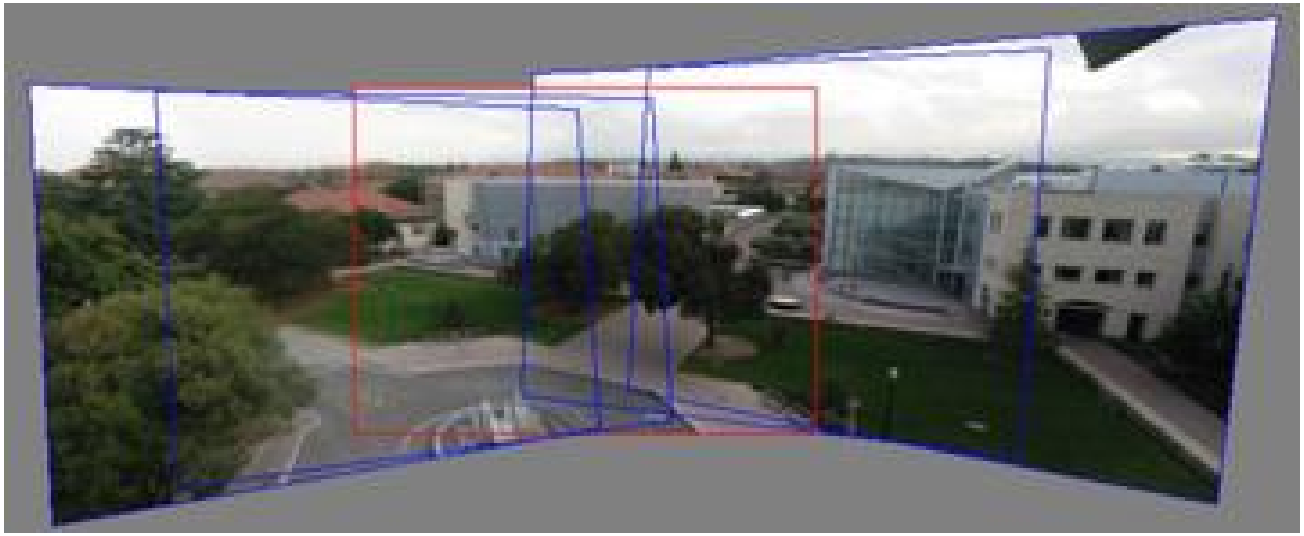
The Beatles

Polyjuice Potion

Project 6: Playing with Lightfields

Project 7: Automatic Mosaic Stitching

Photo Mosaics

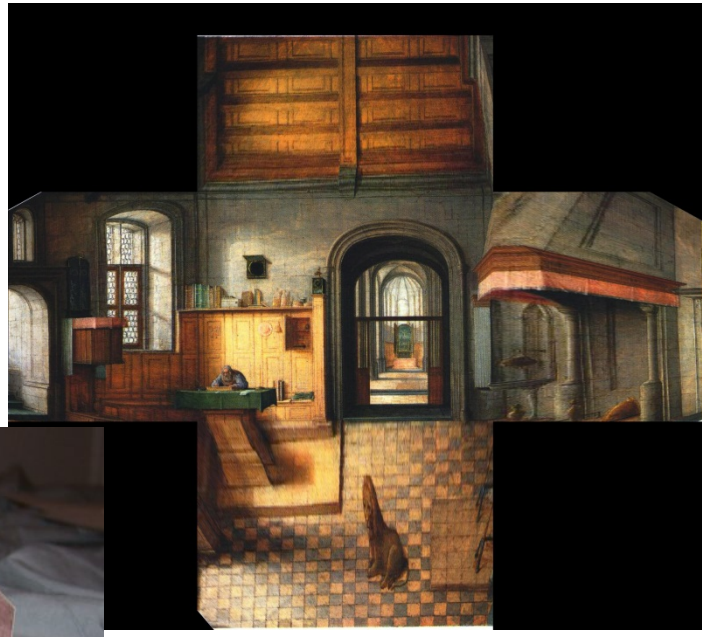


Project 7(g)

Tour Into the Picture

Paper Pop-up

Step 1: define planes



p 2: rectify each plane

Step 3: compute 3D box coords

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)

Sample final project in my class

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 and *camera obscura*)

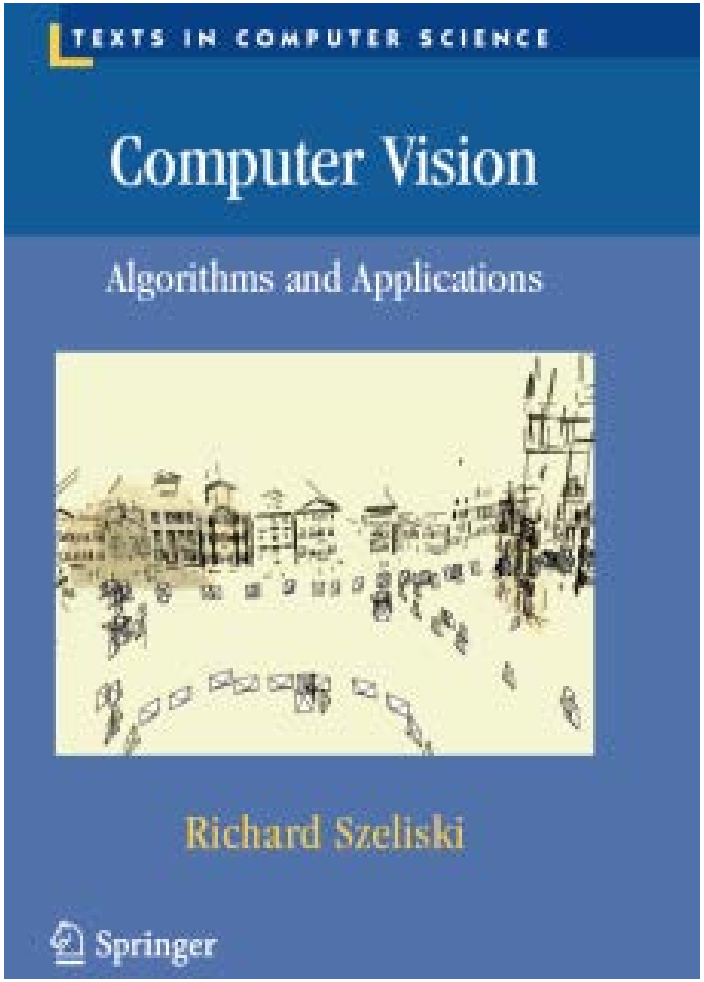
Reporting via web page (plus submit code)

Afterwards, vote for class favorite(s)!

Programming Language:

- Python or Matlab
- you can use other languages, but you are on your own

Textbook



http://szeliski.org/Book/

General Comments

Prerequisites

- Linear algebra!!! (EE16A, Math 54, or Math 110)
- Good programming skills (at least CS61B)
- Some computer graphics, computer vision, or image processing is useful, but not required.

Emphasis on programming projects!

- Building something from scratch

Graduate Version:

- No graduate version this semester…

“No Screens” Policy:

- No laptops, no cell phones, no smartphones, etc.

Getting help outside of class

Course Web Page

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

Discussion board:

- piazza.com

Office hours

- TBA… see webpage and piazza

Administrative Stuff

Grading

- Programming Project (60%)
- 2/3rd Term Exam (20%)
- Final Project (20%)
- Class Participation: priceless

Late Policy

- Five (5) emergency late days for semester, to be spent wisely
- Max 10% of full credit afterwards

Academic Integrity

- Can discuss projects, but don’t share code
- Don’t look up code or copy from a friend
- If you’re not sure if it’s allowed, ask
- Acknowledge any inspirations
- If you get stuck, come talk to us

Waitlists

- Unlikely that we will get a bigger room
- Historically, 25-30% of the class will drop after the first couple of projects

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
- Need time to think, not just hack
  - **Creativity** is a class requirement
- 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 create pictures, unleash your creative potential
- Interested in grad school? ☺

Other Questions?