

# CS 194/294-26: Image Manipulation and Computational Photography

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Instructor: Alexei Efros  
GSIs: Shiry Ginosar  
Shubham Tulsiani  
UC Berkeley, Fall 2014

# Today

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Introductions

Why Computational Photography?

Overview of the course

Administrative stuff

# A bit about me

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## Alexei (Alyosha) Efros

Moved to UC Berkeley in 2013, after decade at CMU  
(also work with colleagues in Paris)

## Teaching

The plan is to have fun and learn cool things, both  
you and me!

Social warning: I don't see well

## Research

Computer Vision, Computer Graphics, Machine  
Learning, Visual Perception

# PhD 2003 on Texture and Action Synthesis

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



© Antonio Criminisi

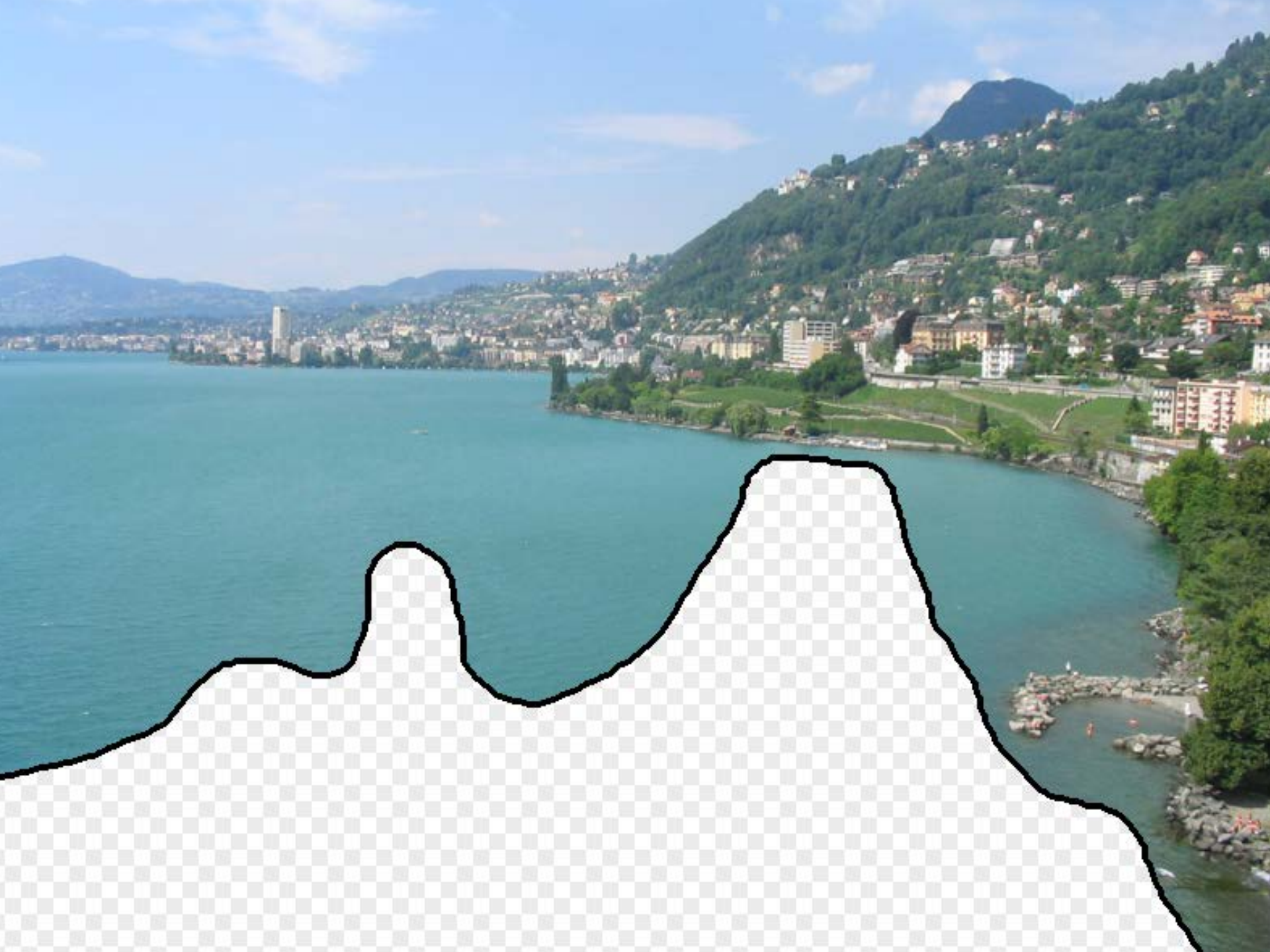
# Other work

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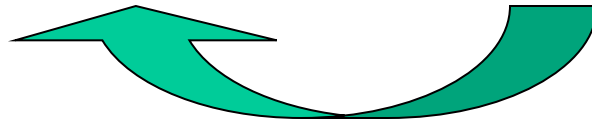
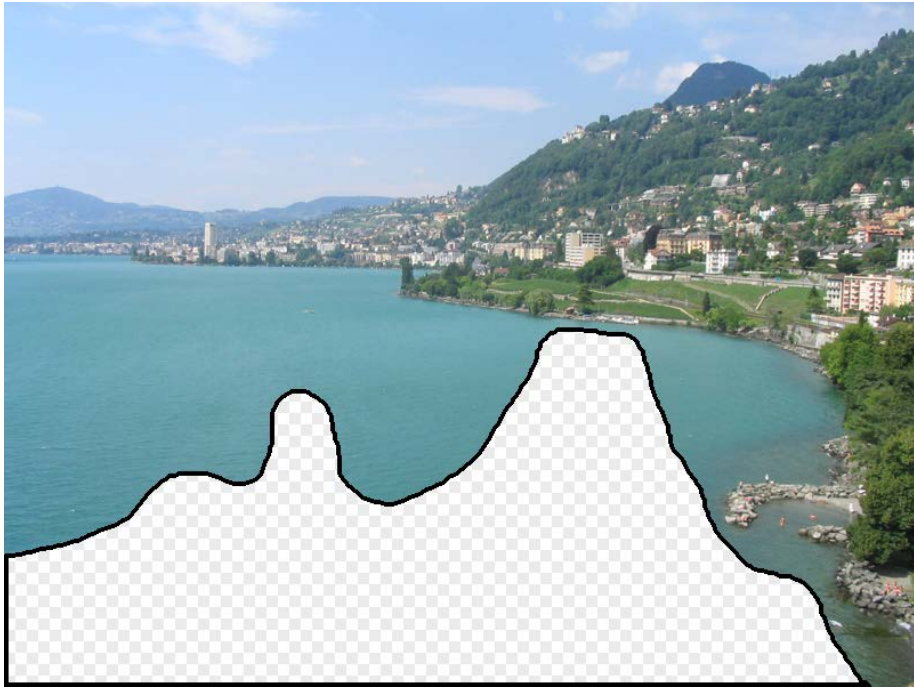
Automatic Photo Pop-Up (SIGGRAPH 2005)













# im2GPS

(using 6 million GPS-tagged Flickr images)



Query Photograph

# Amateur Photographer

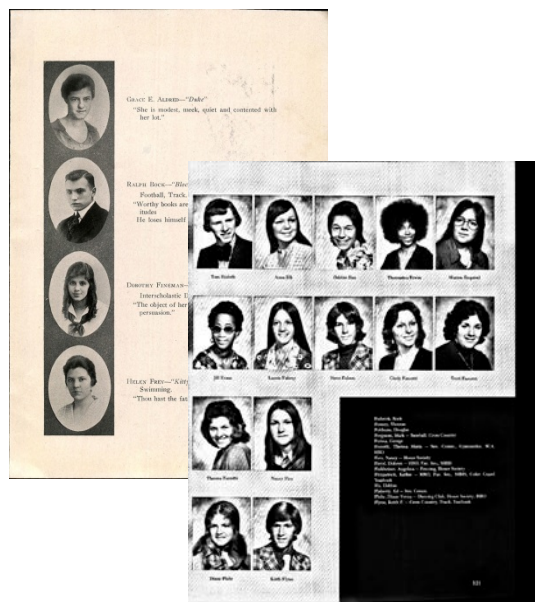
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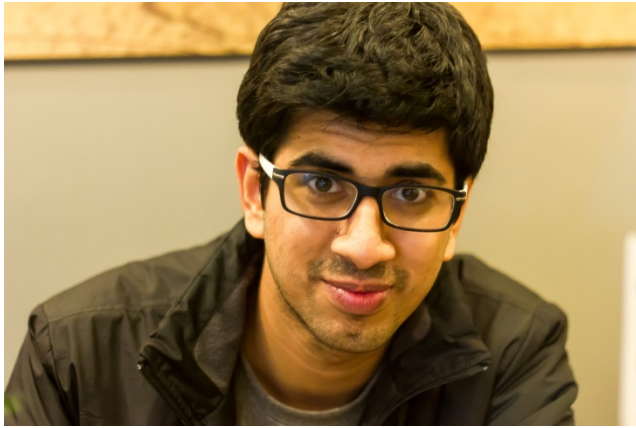
# Where is Shiry?



## GSI: Shiry Ginosar

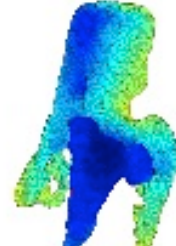
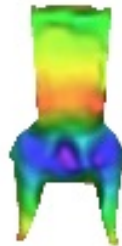


# Where is Shubham?



Here ! [He's terrible at playing fiddle so they kicked him out of the group ☹ ]

## GSI: Shubham Tulsiani



(Random pictures for reconstructions of random objects. Any correlation with actual research is purely coincidental !)

# Why Computational Photography?

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A Brief History of Visual Media

# Depicting Our World: The Beginning

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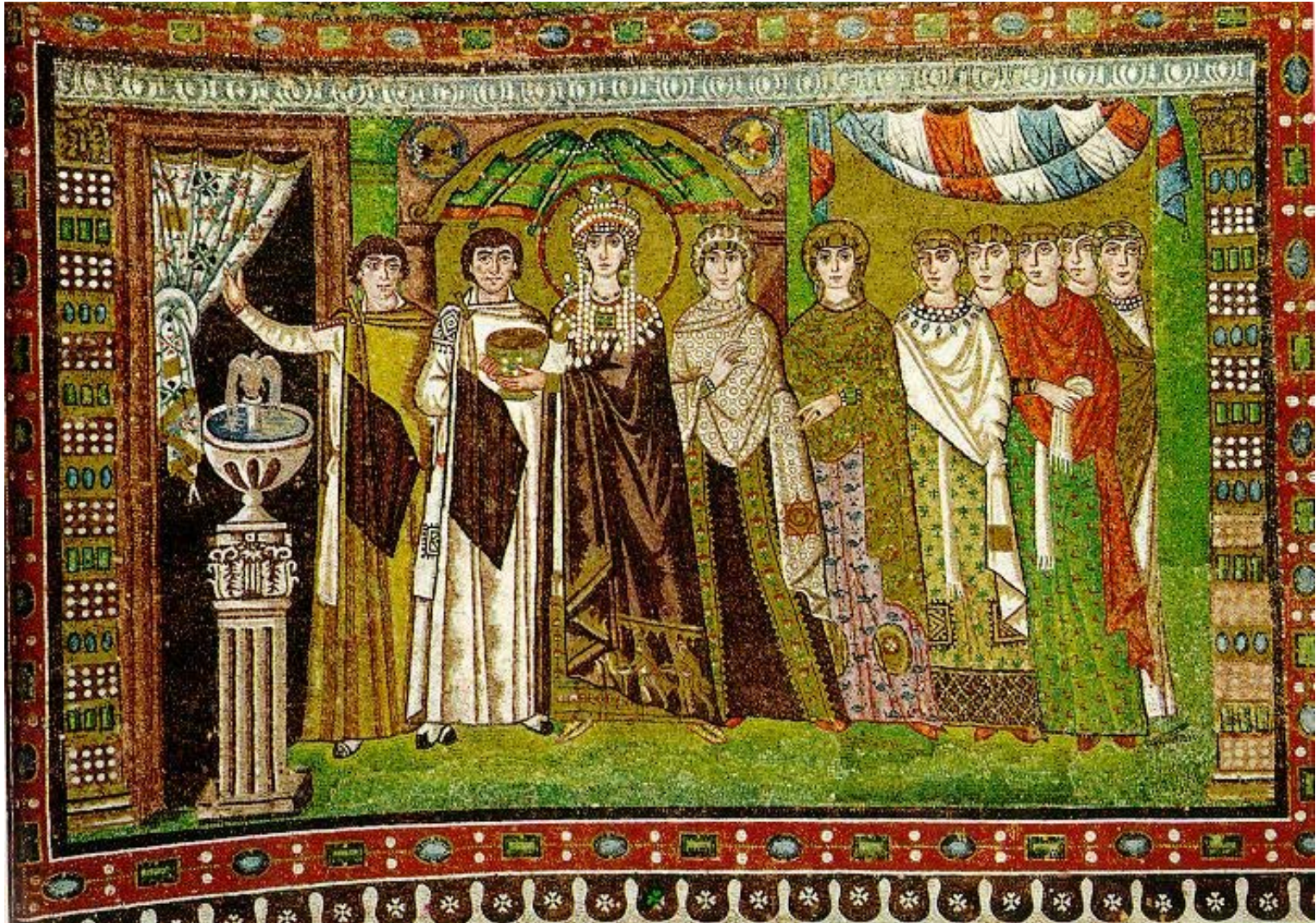


Prehistoric Painting, Lascaux Cave, France  
~ 13,000 -- 15,000 B.C.



# Depicting Our World: Middle Ages

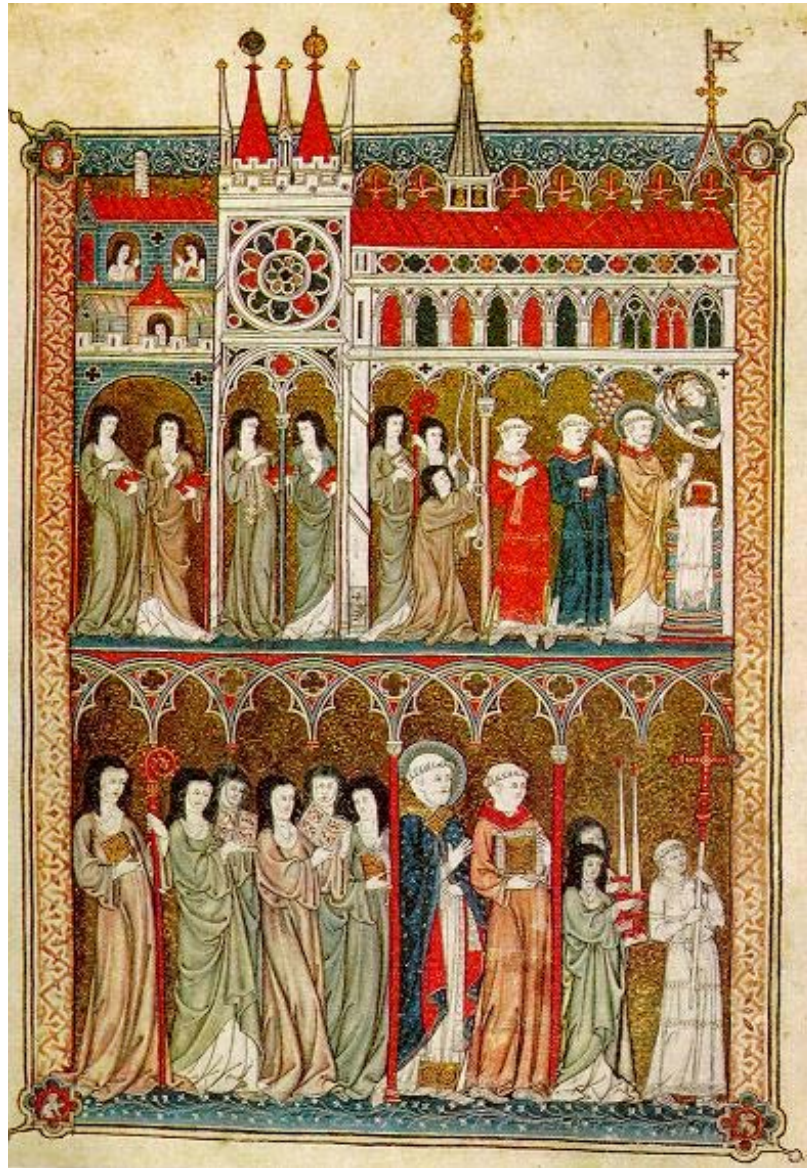
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The Empress Theodora with her court.  
Ravenna, St. Vitale 6th c.

# Depicting Our World: Middle Ages

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Nuns in Procession. French ms. ca. 1300.

# Beginnings of the Renaissance

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**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

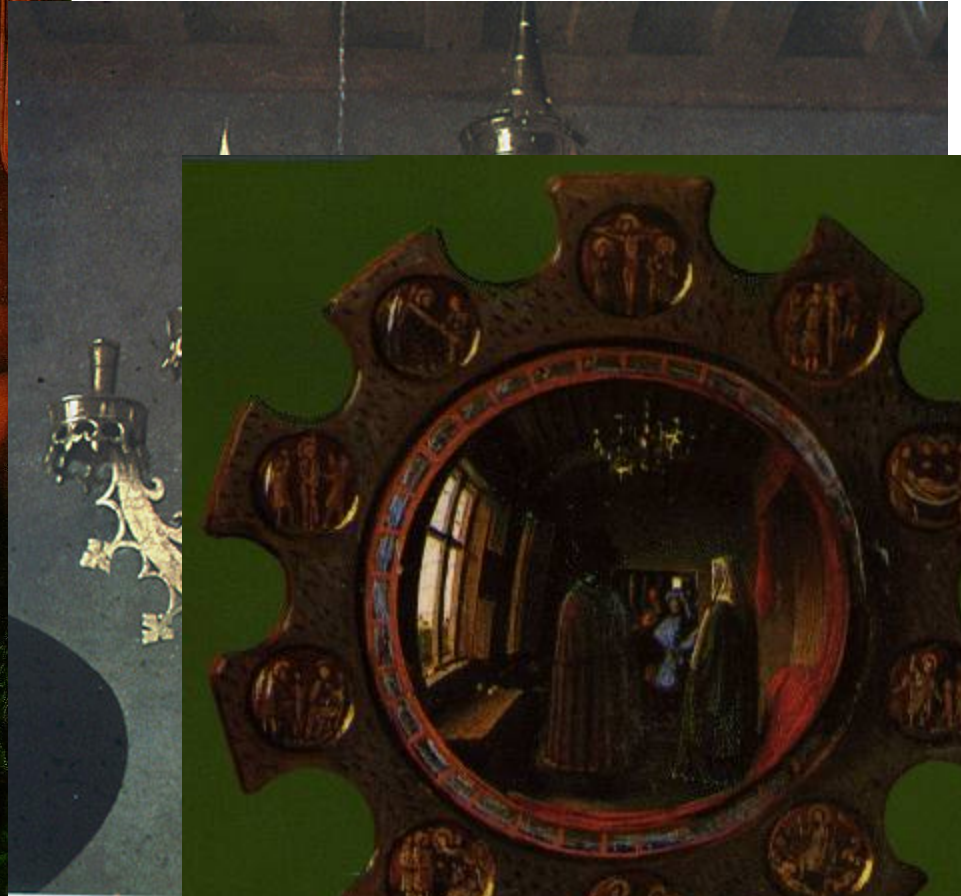
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***Piero della Francesca,  
The Flagellation (c.1469)***

# Depicting Our World: Toward Perfection

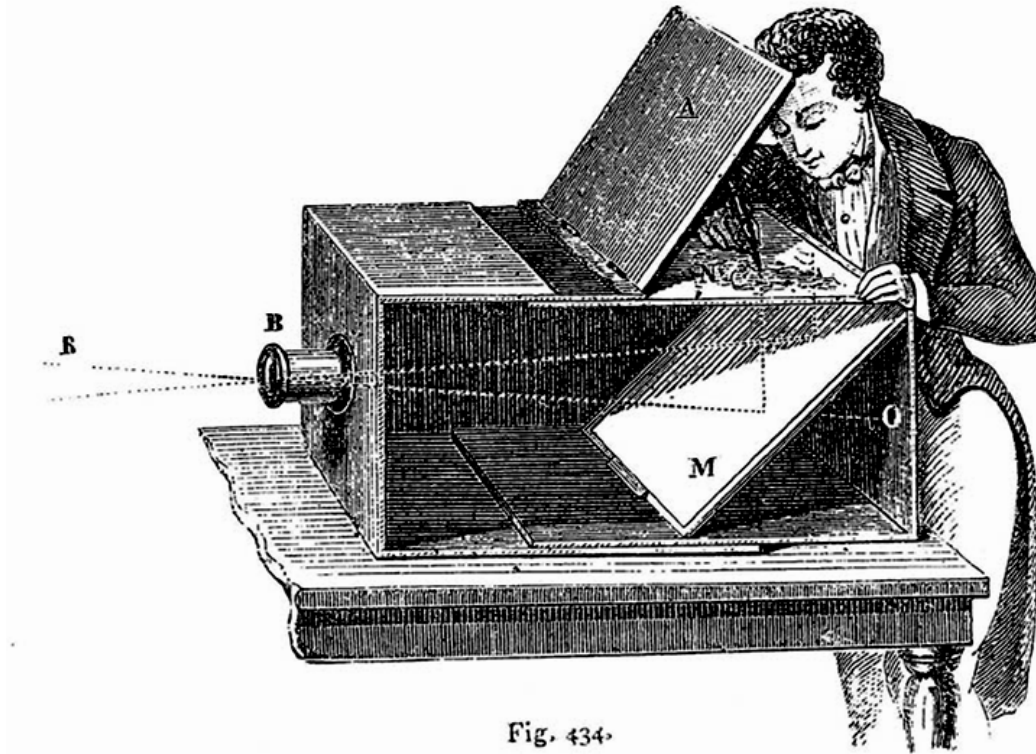
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**Jan van Eyck, *The Arnolfini Marriage* (c.1434)**

# Depicting Our World: Toward Perfection

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Lens Based Camera Obscura, 1568

# Depicting Our World: Perfection!

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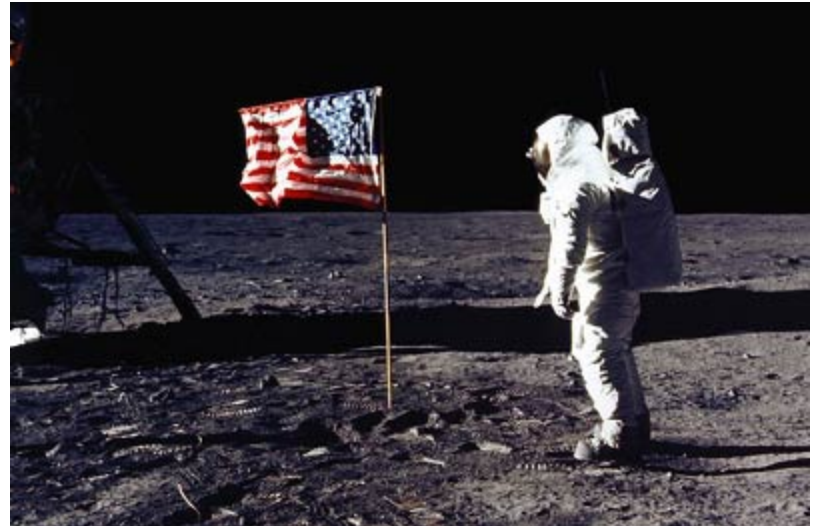


*Still Life*, Louis Jaques Mande Daguerre, 1837

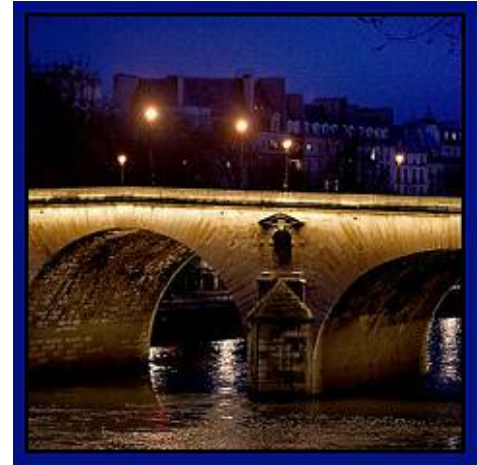


# Depicting Our World: Realism?

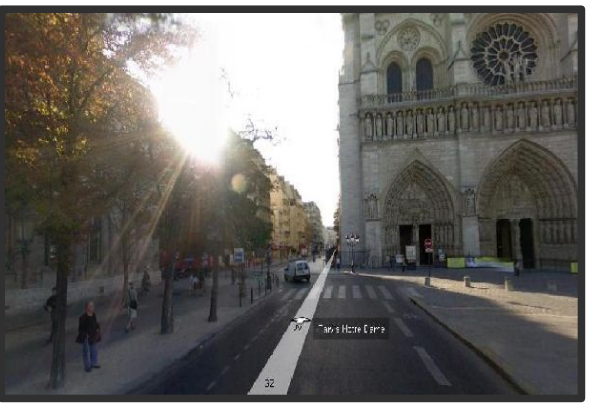
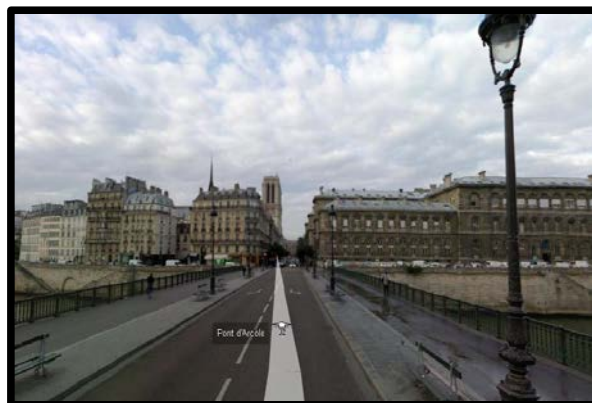
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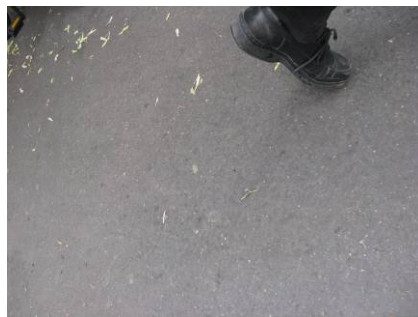
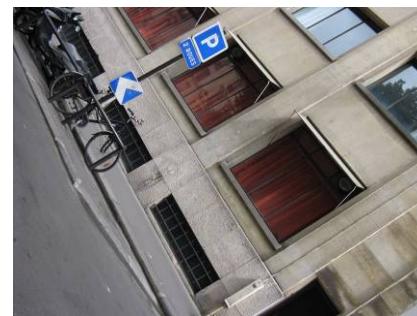
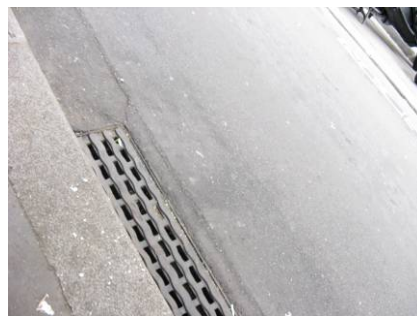
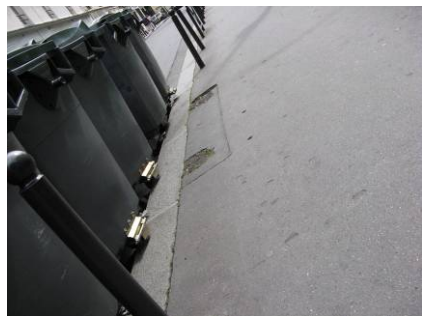
# Paris, according to Flickr



# Paris, according to Google StreetView



# Paris, according to me



**After realism...**

Monet,  
La rue Montorgueil



# Depicting Our World: Ongoing Quest

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Pablo Picasso



David Hockney

# Better than realism?

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**David Hockney, Place Furstenberg, (1985)**

# Which one is right?

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## Multiple viewpoints



**David Hockney,  
Place Furstenberg, 1985**

## Single viewpoint



**Alyosha Efros  
Place Furstenberg, 2009**



# Depicting Our World: Ongoing Quest

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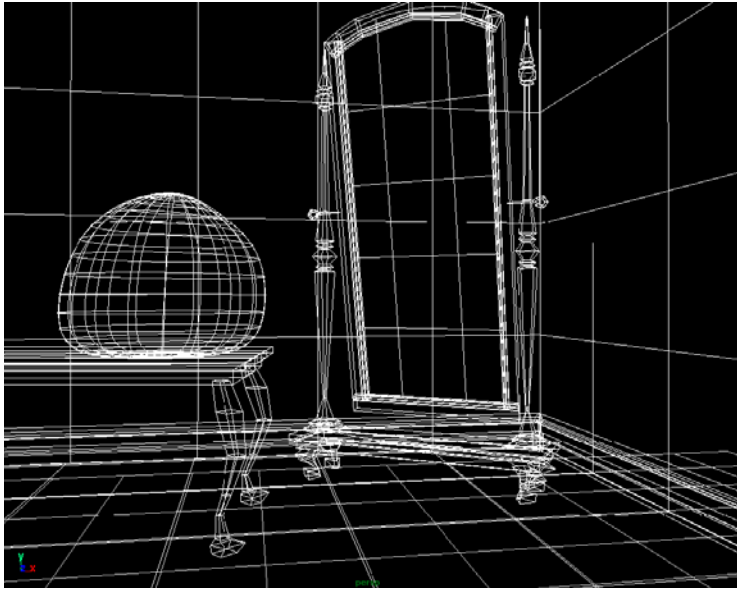


Antonio Torralba & Aude Oliva (2002)

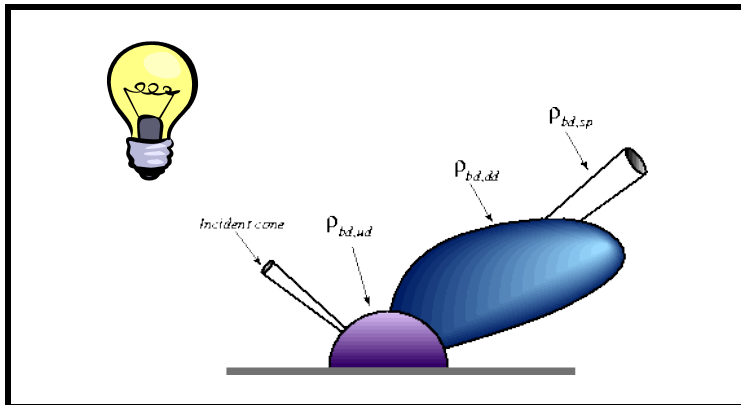


Enter Computer Graphics...

# Traditional Computer Graphics



3D geometry



physics



projection



**GRAPHICS**

# Modern Computer Graphics

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

# The richness of our everyday world

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Photo by Svetlana Lazebnik

# Beauty in complexity

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University Parks, Oxford

# Which parts are hard to model?

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Photo by Svetlana Lazebnik

# People

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From "Final Fantasy"

On the Tube, London





# Faces / Hair

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From "Final Fantasy"



Photo by Joaquin Rosales Gomez

# Hyper-humans

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# Creating Realistic Imagery

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## 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 acquire
- very hard to manipulate objects/viewpoint

# Computational Photography

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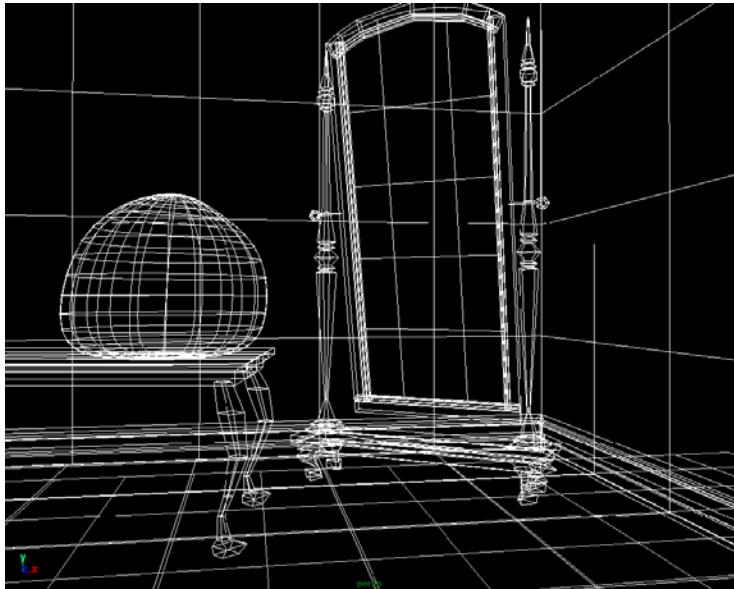
How can I use computational techniques to capture light in new ways?

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

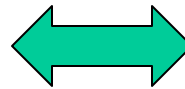
How can I use computational techniques to visualize, organize, and navigate the captured visual world?

# Relationship to Vision and Graphics

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3D Model



2D image

**Computer Graphics:** Models to Images

**Computer Vision:** Images to Models

**Comp. Photography:** Images to Images

# Virtual Real World

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Campanile Movie

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

# Course objectives

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1. You will have new abilities for visual creation.



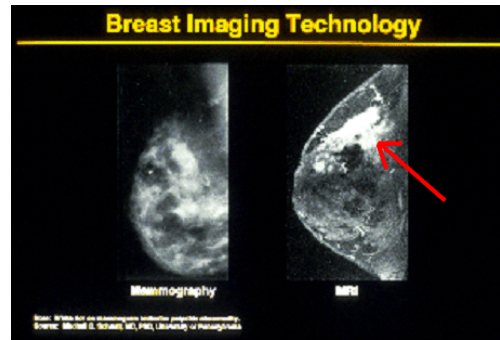
# Course objectives

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2. You will get a foundation in computer vision.



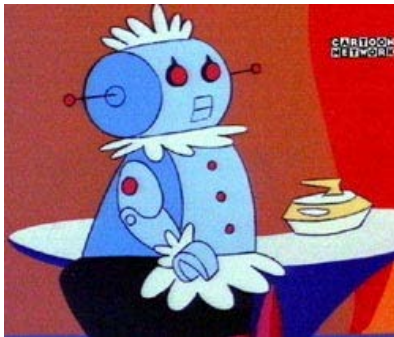
Safety



Health



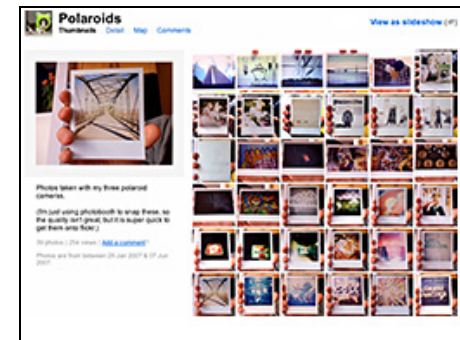
Security



Comfort



Fun



Access



# Course objectives

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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

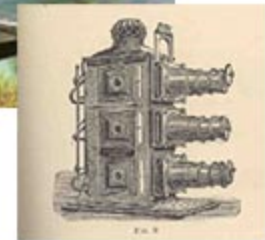
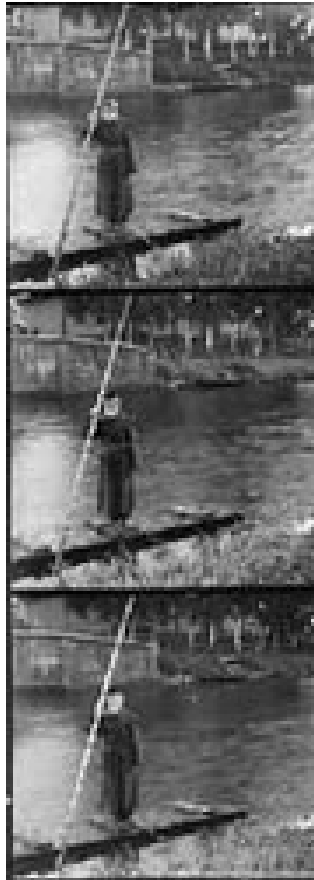
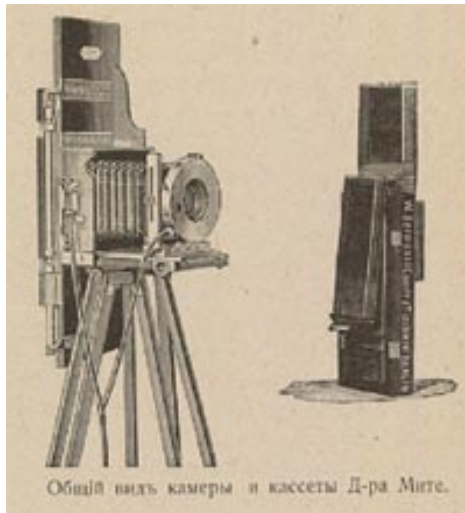
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4. You'll have fun doing cool stuff!

# Programming Project #1

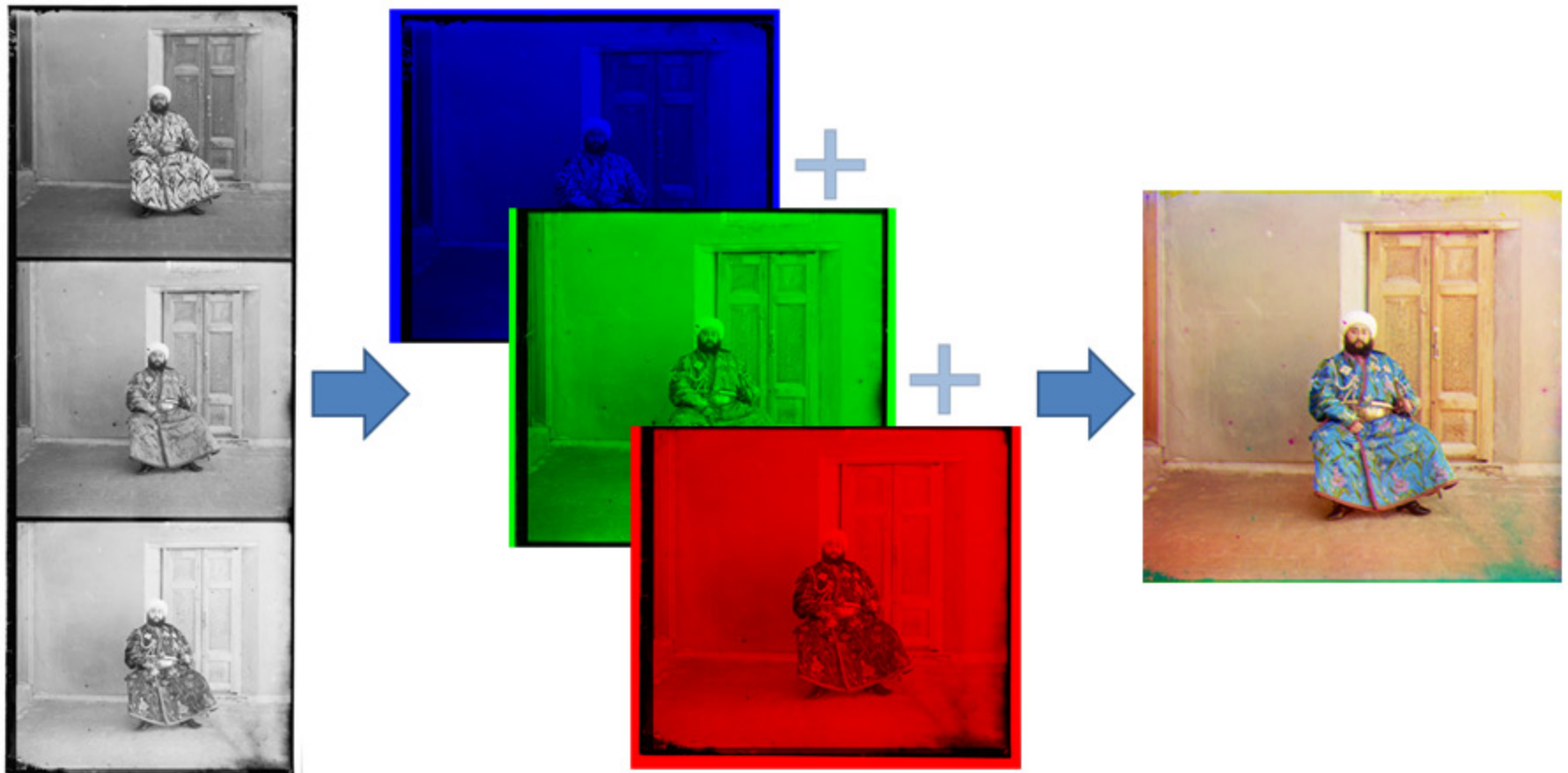
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## Prokudin-Gorskii's Color Photography (1907)



# Programming Project #1

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# Programming Project #1

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

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

- Normalized Correlation (NCC):

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



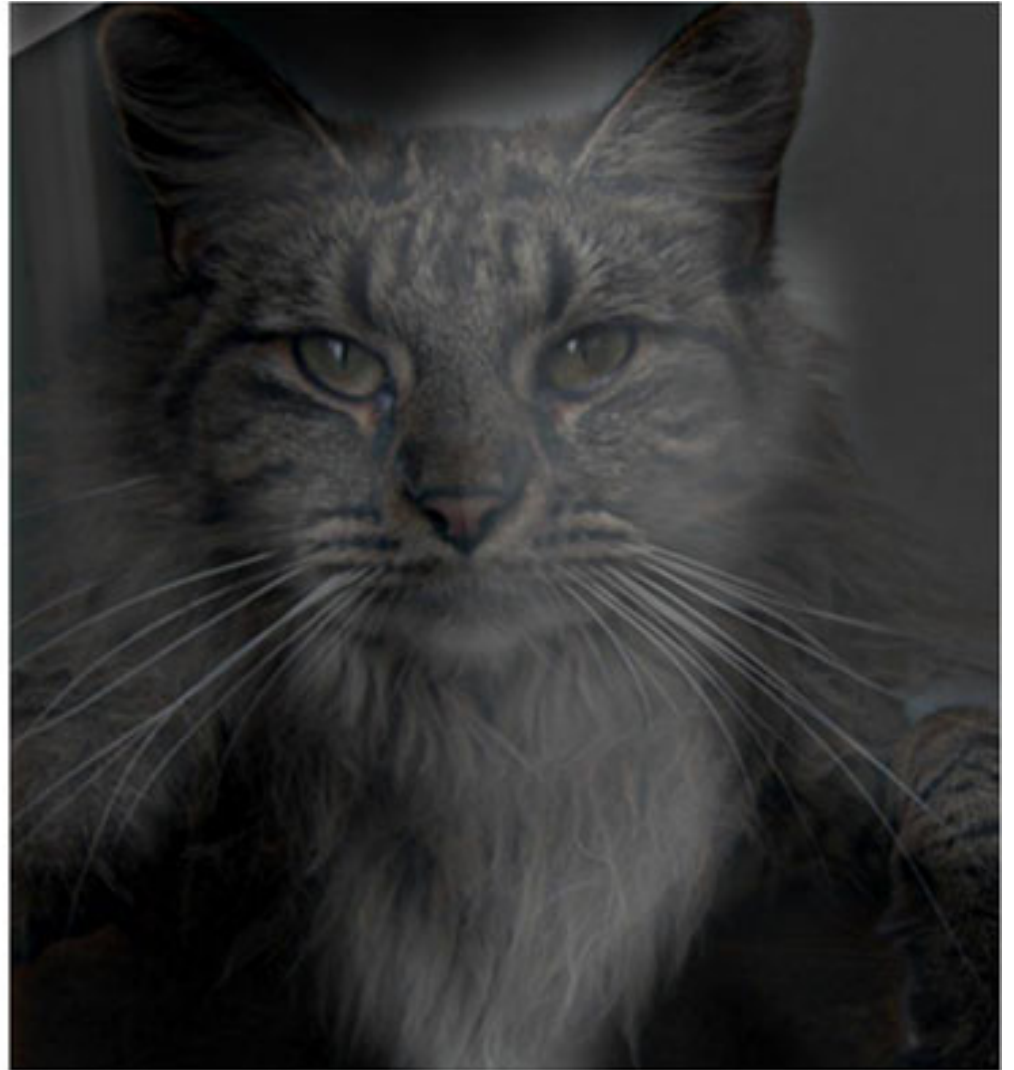
# Project 2: Building a Camera Obscura

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# Project 3: Hybrid Images

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# Project 4: Gradient Domain Editing

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sources/destinations



cloning



seamless cloning

# Project 5: Face morphing and caricatures

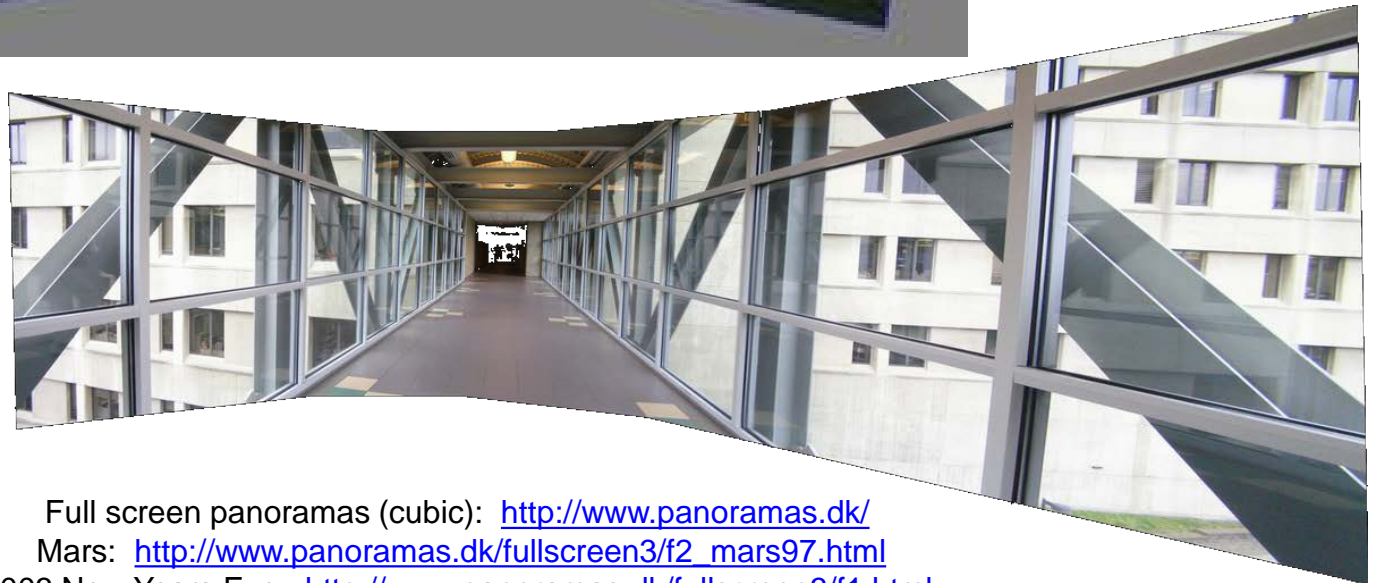
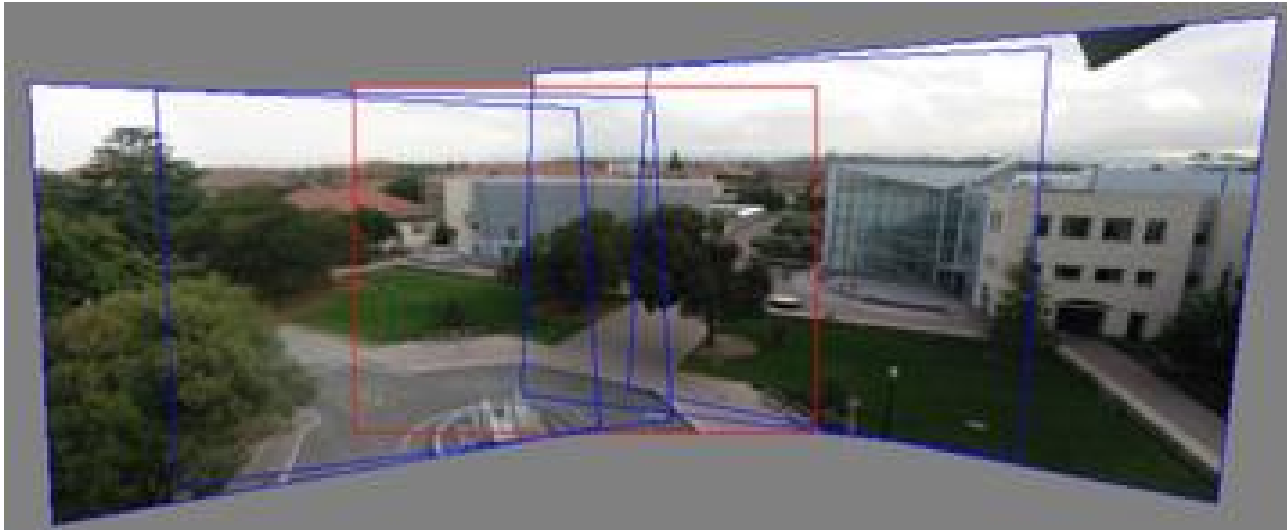
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# Project 6: Automatic Mosaic Stitching

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## Photo Mosaics



Full screen panoramas (cubic): <http://www.panoramas.dk/>  
Mars: [http://www.panoramas.dk/fullscreen3/f2\\_mars97.html](http://www.panoramas.dk/fullscreen3/f2_mars97.html)  
2003 New Years Eve: <http://www.panoramas.dk/fullscreen3/f1.html>

# Image warping with homographies

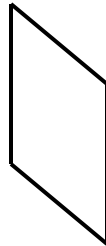
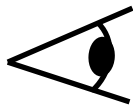
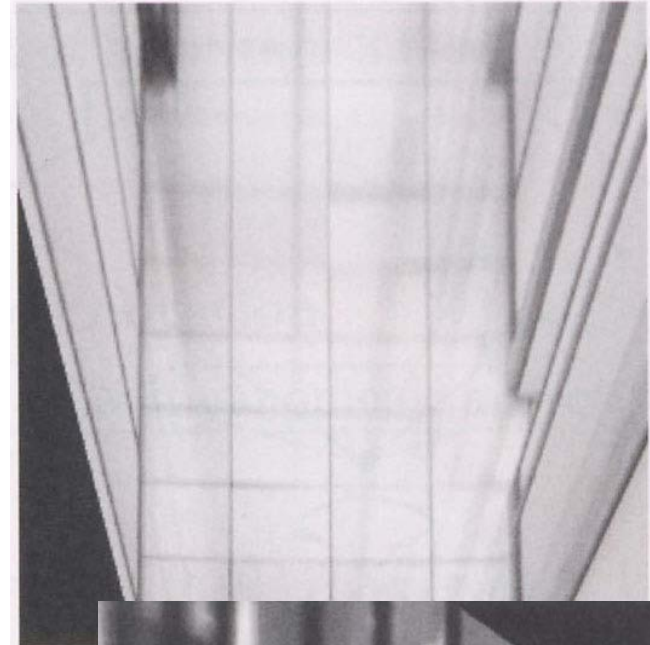


image plane in front



black area  
where no pixel  
maps to



# Project 6'

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## Tour Into the Picture



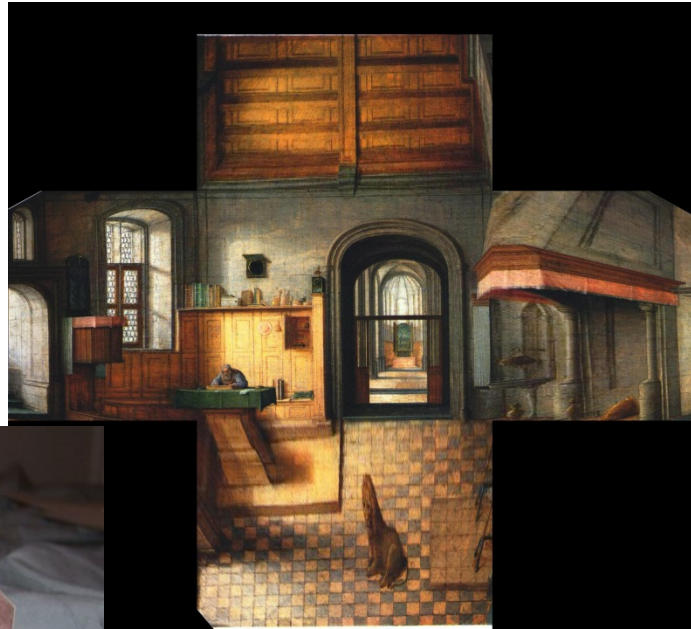


# Paper Pop-up

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Step 1: define planes



Step 2: rectify each plane



Step 3: compute 3D box coords

# Project 7: post-capture focus

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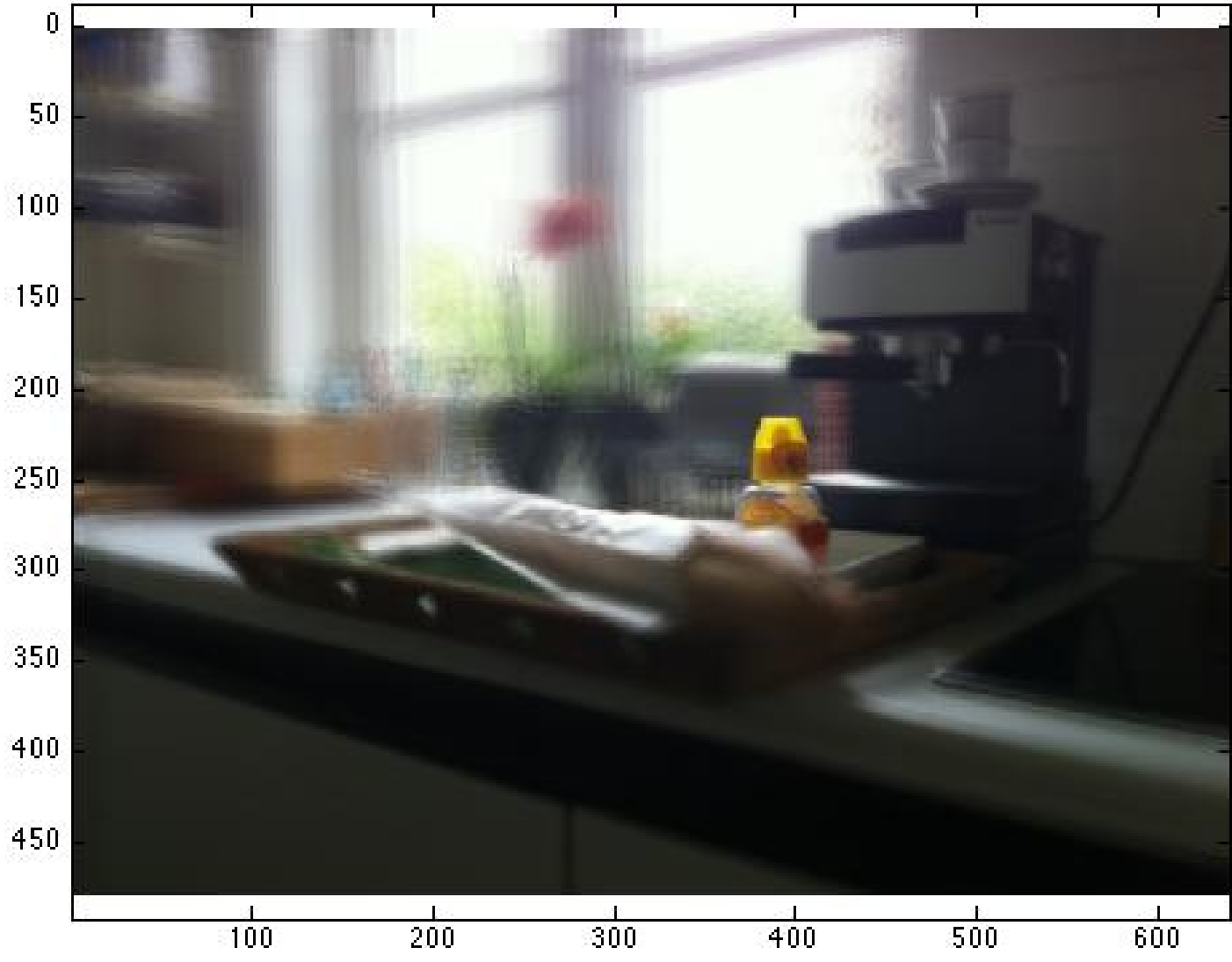




# Results

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# Final Project

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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 up to 3)

# Sample Project

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# Project details

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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)

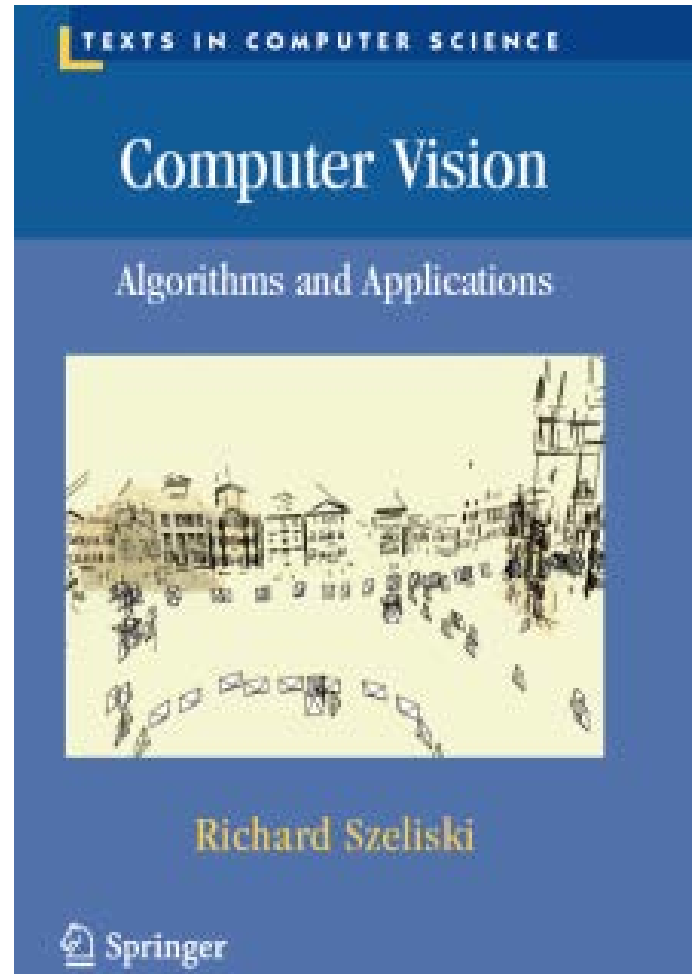
Afterwards, vote for class favorite(s)!

## Software

- Matlab!
- (you can use other languages, but expect no help from GSIs).

# Textbook

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

# General Comments

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## Prerequisites

- Linear algebra!!!
- Good programming skills (at least 61B?)
- Some computer graphics, vision, or image processing is useful, but not required.

## Emphasis on programming projects!

- Building something from scratch

## Graduate Version:

- Need to do more on each project, plus a final paper

## Misc:

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

# Getting help outside of class

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## Course Web Page

- <http://inst.eecs.berkeley.edu/~cs194-26/fa14/>

## Discussion board:

- piazza.com

## Office hours

- TBA... see webpage and piazza

## Matlab

- Tentitively: 6-7pm Tuesday, Sept 2



# Administrative Stuff

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## Grading

- Programming Project (60%)
- Exam (20%)
- Final Project (20%)
- Class Participation: priceless

## Late Policy

- Five late days total, to be spent wisely
- 20% off from each extra late day

## Cheating

- Let's not embarrass ourselves

# Academic Integrity

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Can discuss projects, but don't share code

Don't look up code (even to get hints) 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

# Why you should NOT take this class

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- 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

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

# Questions?

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