CS 194/294-26: Image Manipulation, Computer Vision and Computational Photography

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Today

Introductions
Why this Course?
Brief History of Visual Data
Administrative stuff
A bit about me

Alexei (Alyosha) Efros

Research

PhD 2003 on Texture and Action Synthesis

Inspired Photoshop’s “Context-aware Fill” and Microsoft “Smart Erase” buttons:

© Antonio Criminisi
Other works...
Colorizing Black and White Photos

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
Amateur Photographer
Why This Course?
Visual Computing in the old days…
Visual Computing in the old days...

Image Processing

Computer Graphics

Computer Vision

Computational Photography
Visual Computing in the old days…

Image Processing

Computer Graphics

Computer Vision

This Class
Excuse the temporary disruption…

Sign up on piazza.com for the latest info
Course objectives

1. 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
   - …
2. You will get a more intuitive understanding of important mathematical and computational concepts

- Gradients
- Change of basis, interpolation, extrapolation, PCA
- FFT
- Dynamic programming, recursion
- Convolutional Neural Networks
- ...
Course objectives

3. You will have new abilities for visual creation.
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’ll have fun doing cool stuff!
A Brief History of the Visual Data
Depicting Our World: The Beginning

Prehistoric Painting, Lascaux Cave, France
~ 13,000 -- 15,000 B.C.
The Empress Theodora with her court. Ravenna, St. Vitale 6th c.
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)
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

Single viewpoint

David Hockney, Place Furstenberg, 1985

Alyosha Efros, Place Furstenberg, 2009
Depicting Our World: Ongoing Quest

Enter Computer Graphics...
Traditional Computer Graphics

3D geometry

Physics

Simulation

Projection
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?
People

From “Final Fantasy”

On the Tube, London
Faces / Hair

From “Final Fantasy”
Hyper-humans
Creating Realistic Imagery

**Computer Graphics**

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

**Photography**

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

**Computational Photography**

Realism
Manipulation
Ease of capture
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?
Mechanical creation of a perspective image,
Albrecht Dürer, 1525
“What does it mean, to see? The plain man's answer (and Aristotle's, too). would be, to know what is where by looking... “

“In other words, vision is the process of discovering from images what is present in the world, and where it is.”
Computer Vision: a split personality

...as measurement

**Goals:** **Objective** (depth, distance, etc)

Represented by: meters, angles, 3D meshes, etc.

Related fields: mathematics, optics, physics, etc.

...as understanding

**Goals:** **Subjective** (objects, parts, affordances)

Represented by: words, human annotations, etc.

Related fields: statistics, learning, psychology, philosophy, etc.
Measurement vs. Understanding
Measurement vs. Understanding

Pablo Picasso
The Guitar Player (1911)
Ridiculously brief history of computer vision

• 1966: Minsky assigns computer vision as an undergrad summer project
• 1960’s: interpretation of synthetic worlds
• 1970’s: some progress on interpreting selected images
• 1980’s: ANNs come and go; shift toward geometry and increased mathematical rigor
• 1990’s: face recognition; statistical analysis in vogue
• 2000’s: broader recognition; large annotated datasets available; video processing starts
• 2010’s: Deep learning with ConvNets
• 2020’s: Widespread autonomous vehicles?
• 2030’s: robot uprising?
Class Organization / Administrivia
Programming Project #1

Prokudin-Gorskii’s Color Photography (1907)
Programming Project #1
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: Mystery ConvNet Project
Project 4: Face modeling and morphing
Project 5: Panorama Stitching

Photo Mosaics
Project 6: Mystery 3D project

Tour Into the Picture
Step 1: define planes

Step 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
Everybody Dance Now
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)!

Programming Language:
- Python or Matlab
- you can use other languages, but you are on your own
General Comments

Prerequisites

• Linear algebra!!! (EE16A, Math 54, or Math 110)
• Good programming skills (at least CS61B)
• Machine Learning experience helpful

Emphasis on programming projects!

• Building something from scratch

Graduate Version:

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

“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%)
- Exam + popup quizzes (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

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 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

- It seems there is plenty of room.
- GSIs/readers are the main problem.
- I expect we could get everyone off the waitlist.
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 work with pictures, unleash your creative potential
• Interested in grad school? 😊
Other Questions?