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

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GSI:    Tinghui Zhou
UC Berkeley, Fall 2016
Today

Introductions
Why Computational Photography?
Overview of the course
Administrative stuff
A bit about me

Alexei (Alyosha) Efros

Moved (back) to UC Berkeley in 2013, after decade at CMU
(alsowork 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

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

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

GSI

Tinghui Zhou (GSI)
- PhD candidate in Computer Science
- Expert in computer vision, machine learning, neural networks
- https://people.eecs.berkeley.edu/~tinghuiz/

Jun-Yan Zhu (helping out)
- PhD candidate in Computer Science
- Expert in computer graphics, computer vision, large-scale visual data, and cats
- https://people.eecs.berkeley.edu/~junyanz/
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.
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)**
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

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
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

**Computational Photography**

- Realism Manipulation Ease of capture

**Photography**

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

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.
Course objectives

2. You will get a foundation in computer vision.
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
   - Furtier Transforms
   - 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):

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

- Normalized Correlation (NCC):

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

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 Project
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:
- Matlab or Python
- 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)
• Some computer graphics, computer 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

“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/](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, waitlists clear up eventually (especially after the first few 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?