Lecture 1:

Introduction

Computer Graphics and Imaging
UC Berkeley CS184/284A

Welcome to CS184 / 284A!

Prof. Angjoo Kanazawa

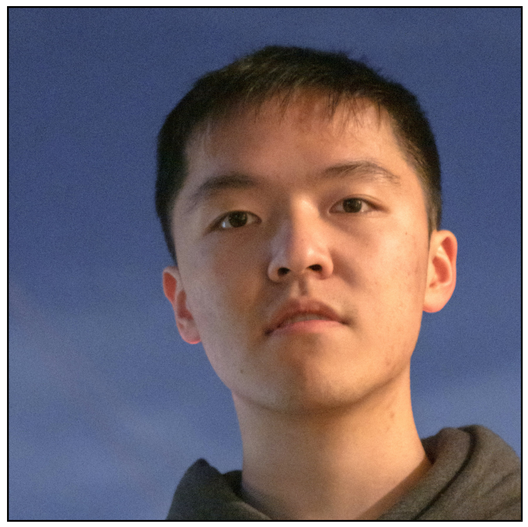
- Ph.D. 2017 on Single-View 3D Reconstruction of Animals (including cats!)
- This is my second semester :)! Prev @ Google Research, BAIR postdoc
- Research Interest: Computer Vision—3D Vision, Inverse Graphics, Computer Graphics, Machine Learning
- Fun fact: From Kobe, Japan. Currently into one-wheel/euc

Welcome to CS184 / 284A!

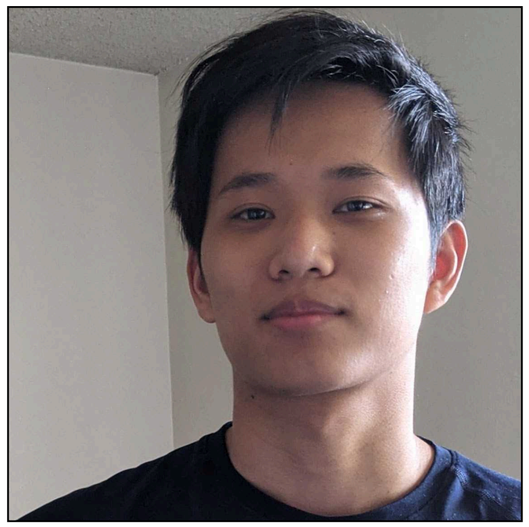
Prof. Ren Ng

- Ph.D. 2006 on Digital Light Field Photography (evolving camera design using graphics technology)
- Founder of Lytro, a light field camera company
- Research interests: computational imaging systems, computer graphics, computer vision, human vision
- Fun fact: born Malaysian, became Australian, naturalized American

Welcome to CS184 / 284A!



Cheng (Bob) Cao



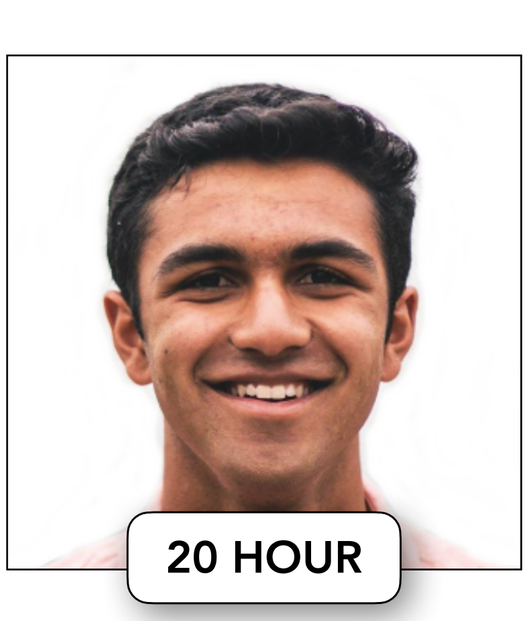
Kenny Chen

Divi Schmidt

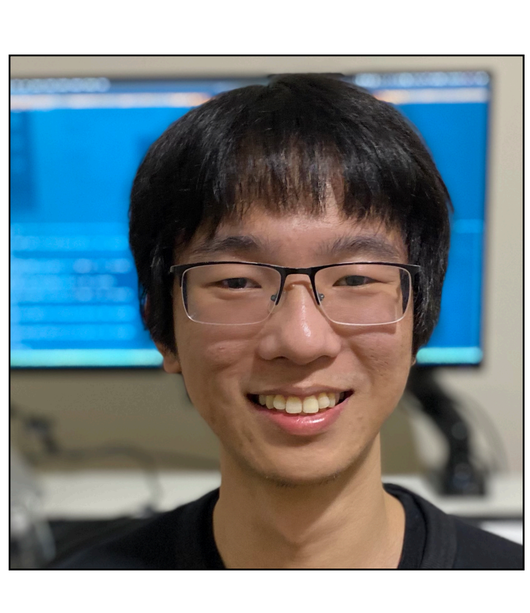
Jade Singh

Utkarsh Singhal

Matt Tancik



Rishi Upadhyay



Ziyao (Mark) Zhang

CS184/284A: Computer Graphics & Imaging

Why Study Computer Graphics?

Course Overview

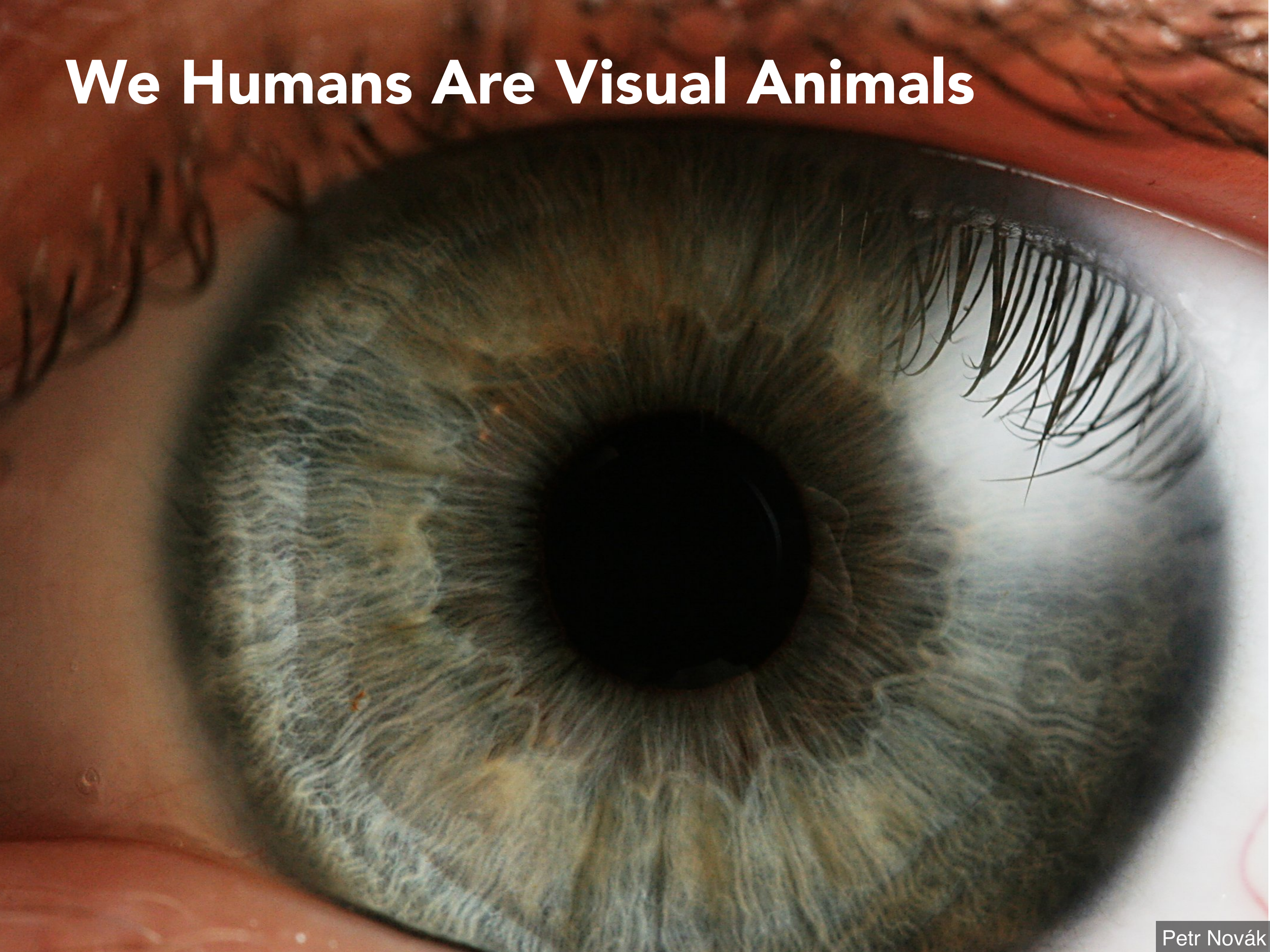
Logistics

What is Computer Graphics?

com•put•er graph•ics /kəmˈpyo͞odər ˈgrafiks/ n.
The use of computers to synthesize and manipulate visual information.

Why Visual Information?

We Humans Are Visual Animals



Petr Novák

Discussion

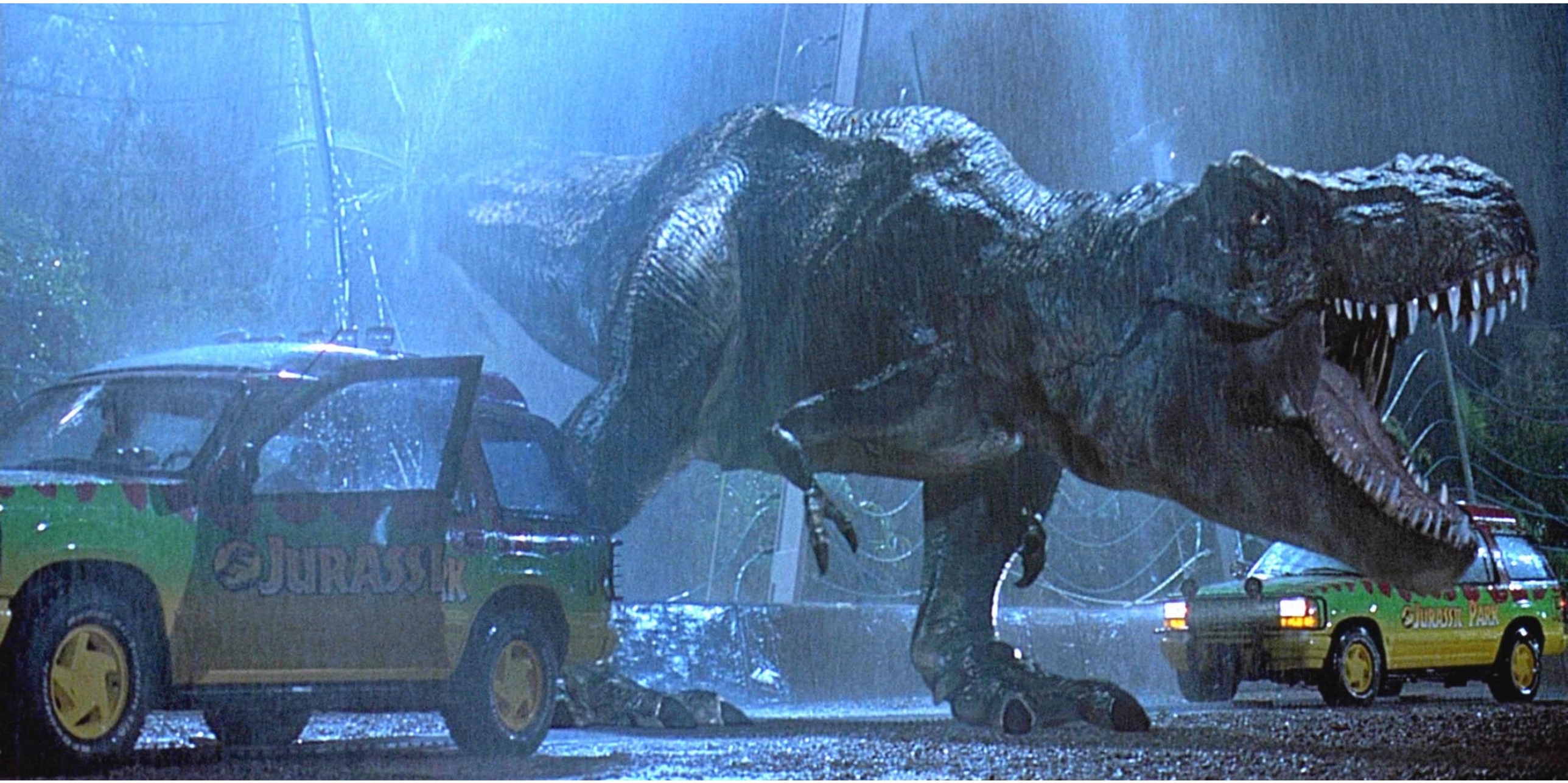
Why are you interested in this course?

What do you want to learn about graphics & imaging?

Tell us @ https://tinyurl.com/cs184-intro-survey
(link also in chat)

Why Study Computer Graphics and Imaging?

Movies



Jurassic Park (1993)

Moments That Changed The Movies: Jurassic Park
https://www.youtube.com/watch?v=KWsbcBvYqN8

Movies

The Matrix (1999)

Movies

The Matrix (1999)

The Campanile

Debevec, Taylor and Malik SIGGRAPH 1996

https://www.pauldebevec.com/Campanile/

Motion Capture

Andy Serkis in The Two Towers

CS184/284A

Kanazawa + Ng

Indie VFX

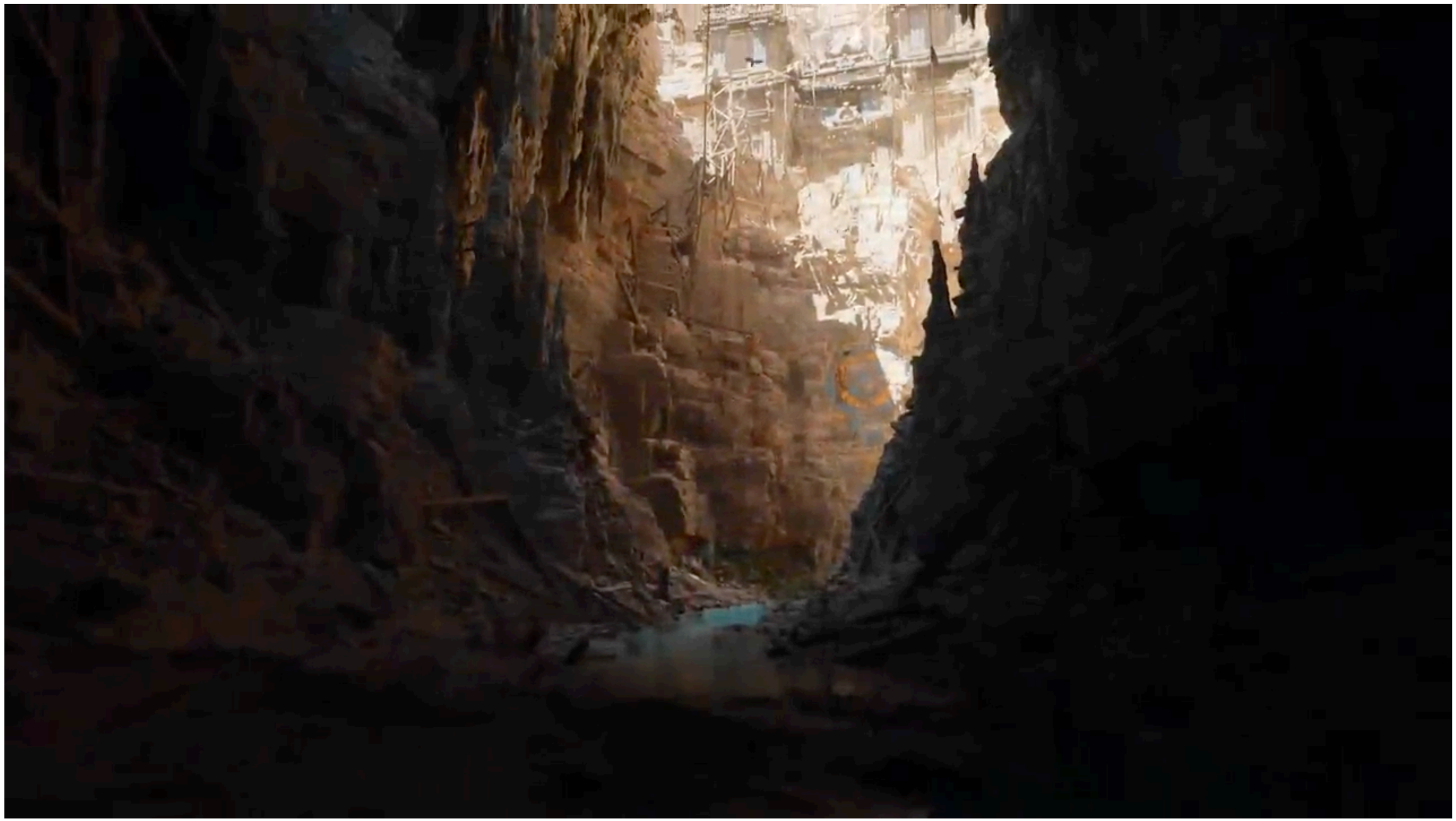
Memories of Australia (2020)

CS184/284A **Kanazawa + Ng**

Games

Crysis 3 (2013)

Games



Unreal Engine 5 Demo Realtime in PS5 (2020)

Product Design and Visualization

Ikea - 75% of catalog is rendered imagery

Product Design and Visualization

Tesla Model X concept (2012)

Product Design and Visualization

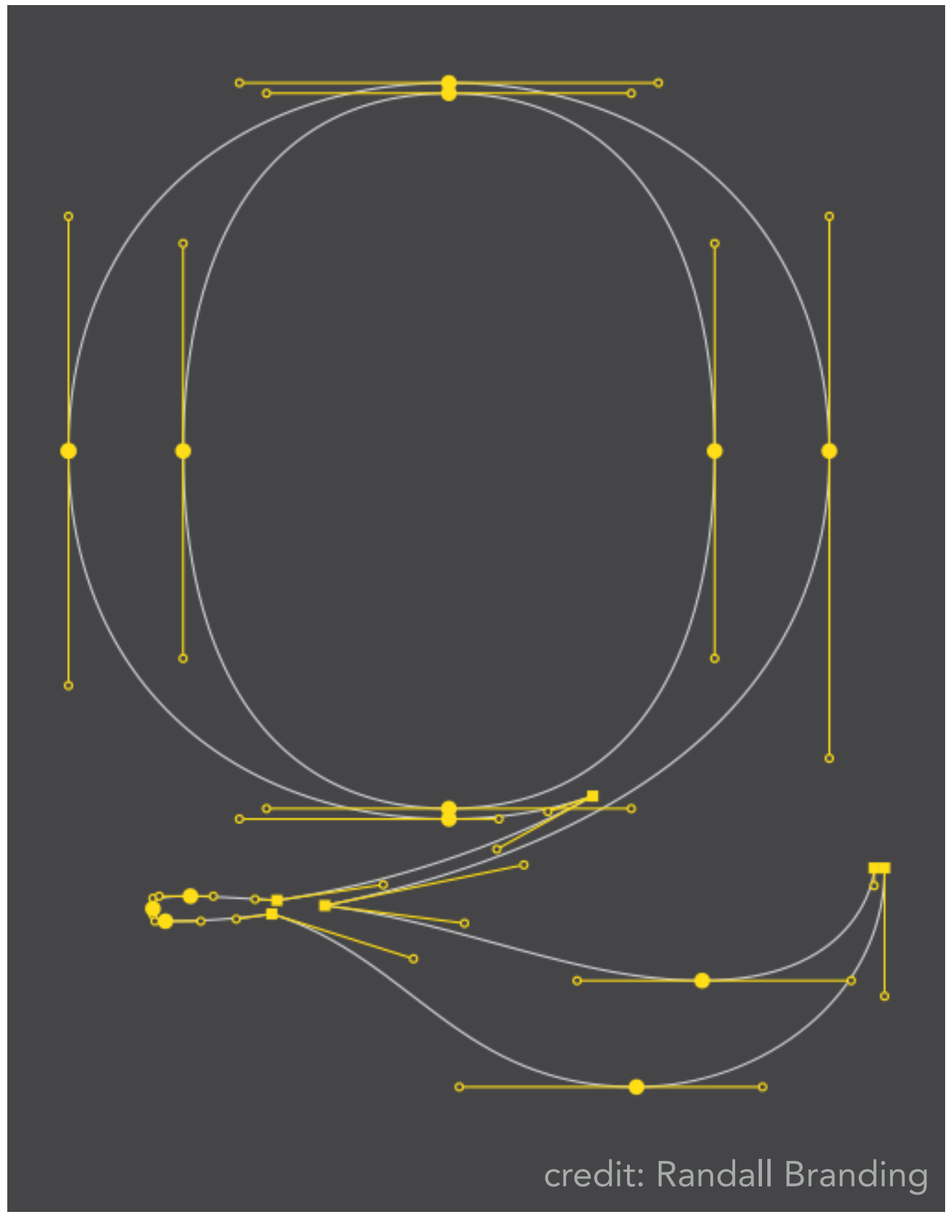
Credit: EV obsession.com, James Ayre

Tesla Model X review

Typography

The Quick Brown Fox Jumps Over The Lazy Dog

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 0123456789



credit: Randall Branding

Baskerville

Illustration

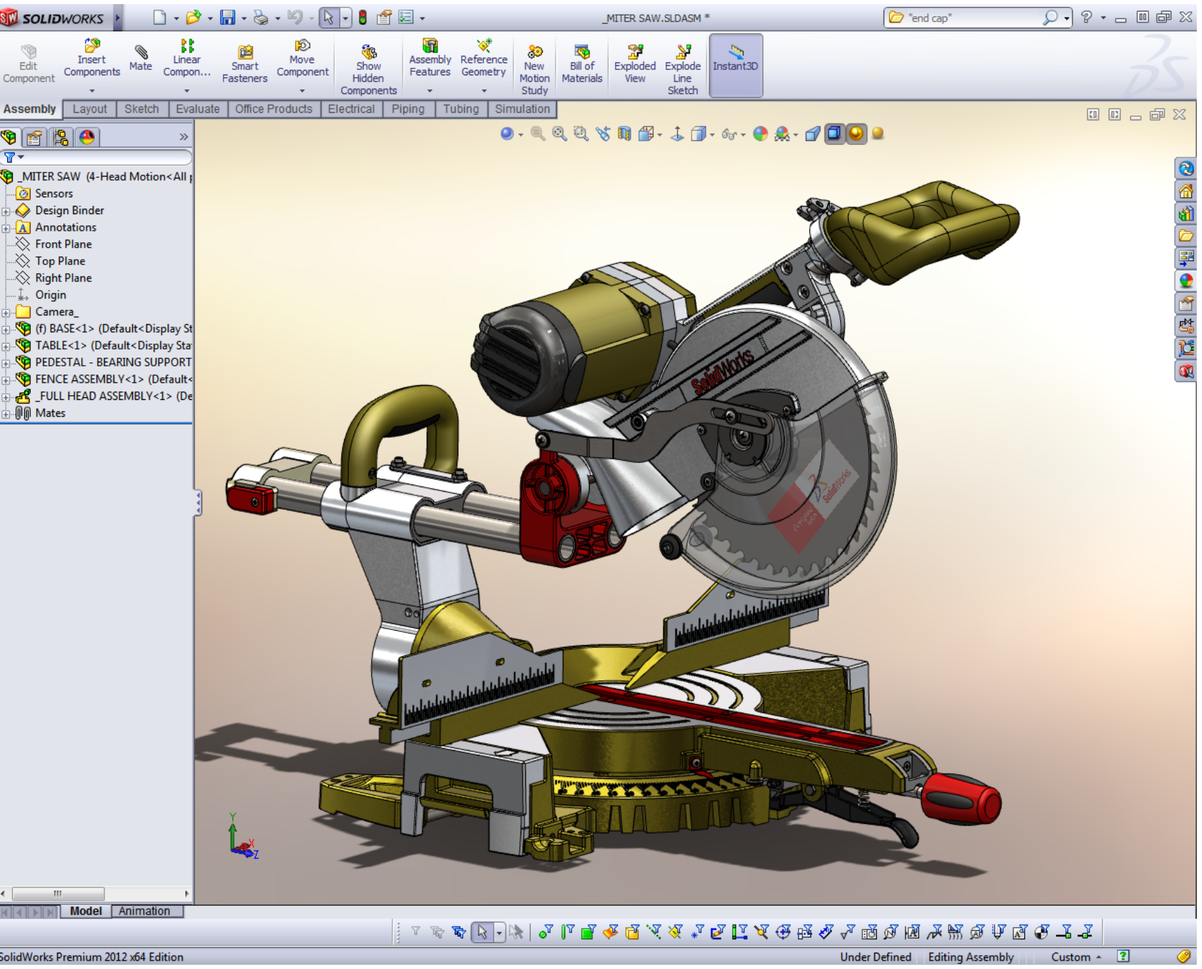
Cave painting c. 36,000 B.C.

Digital Illustration

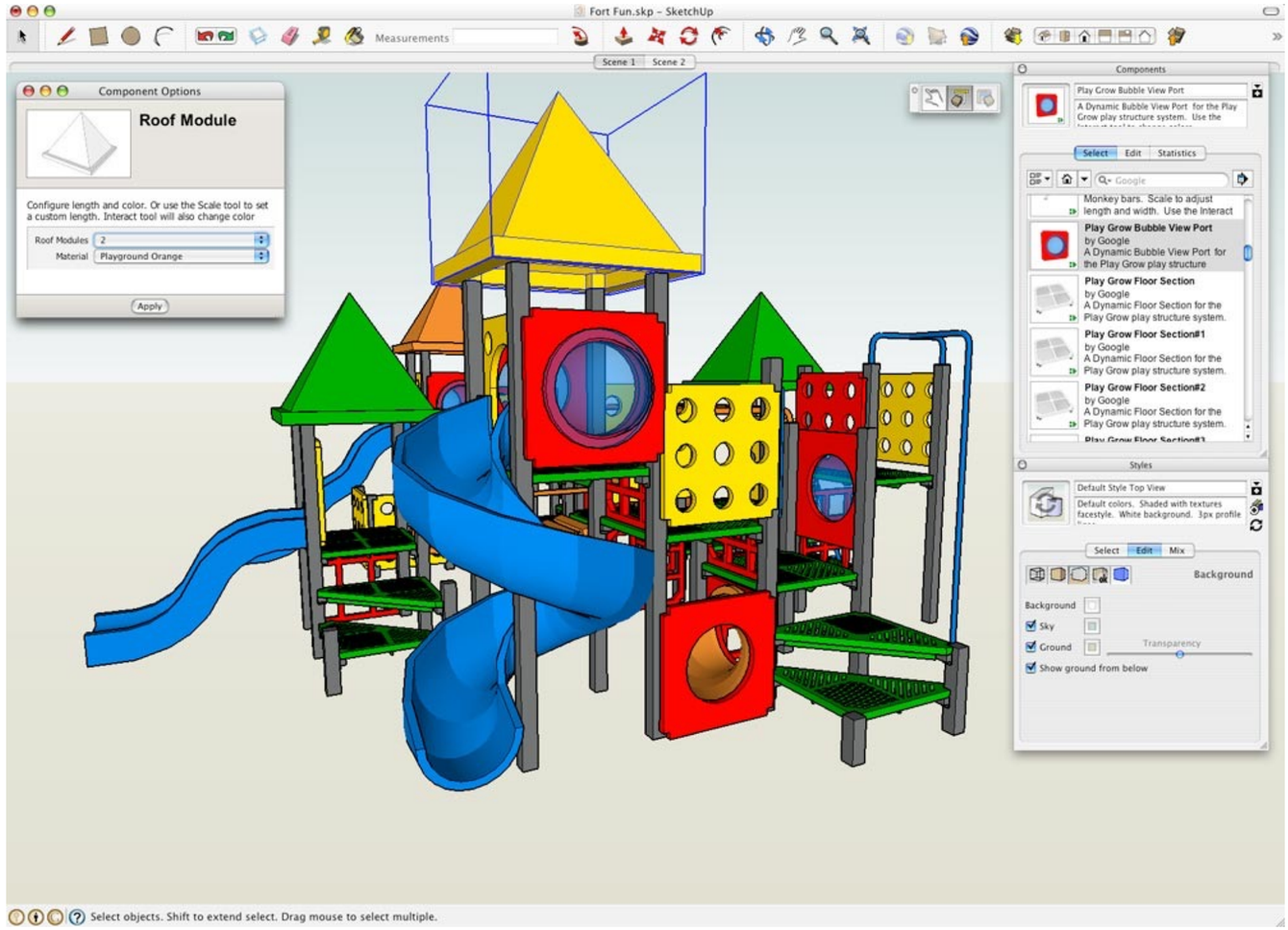
Meike Hakkart

http://maquenda.deviantart.com/art/Lion-done-in-illustrator-327715059

Computer-Aided Design



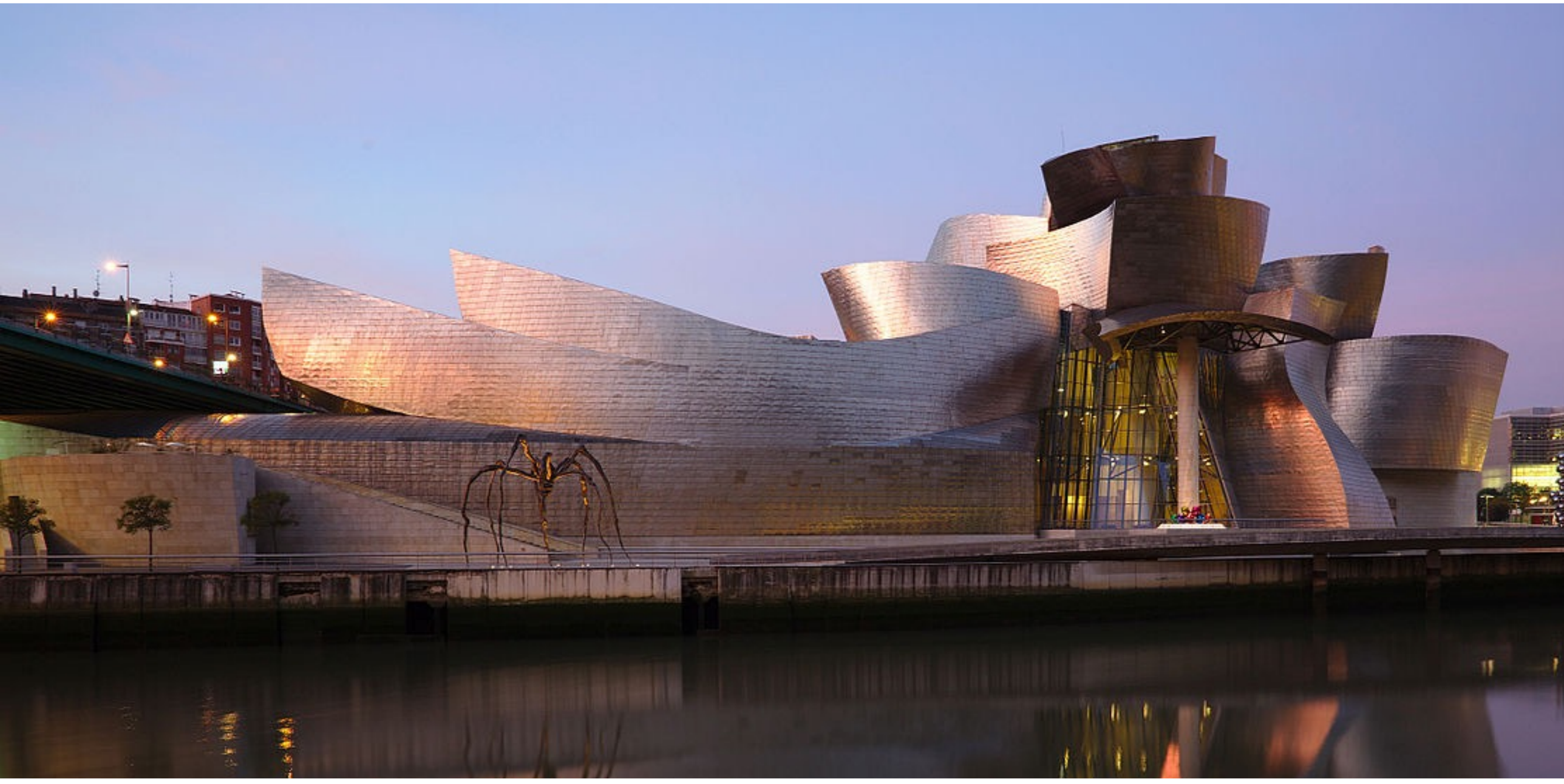
SolidWorks



SketchUp

For mechanical, architectural, electronic, optical, ...

Architectural Design

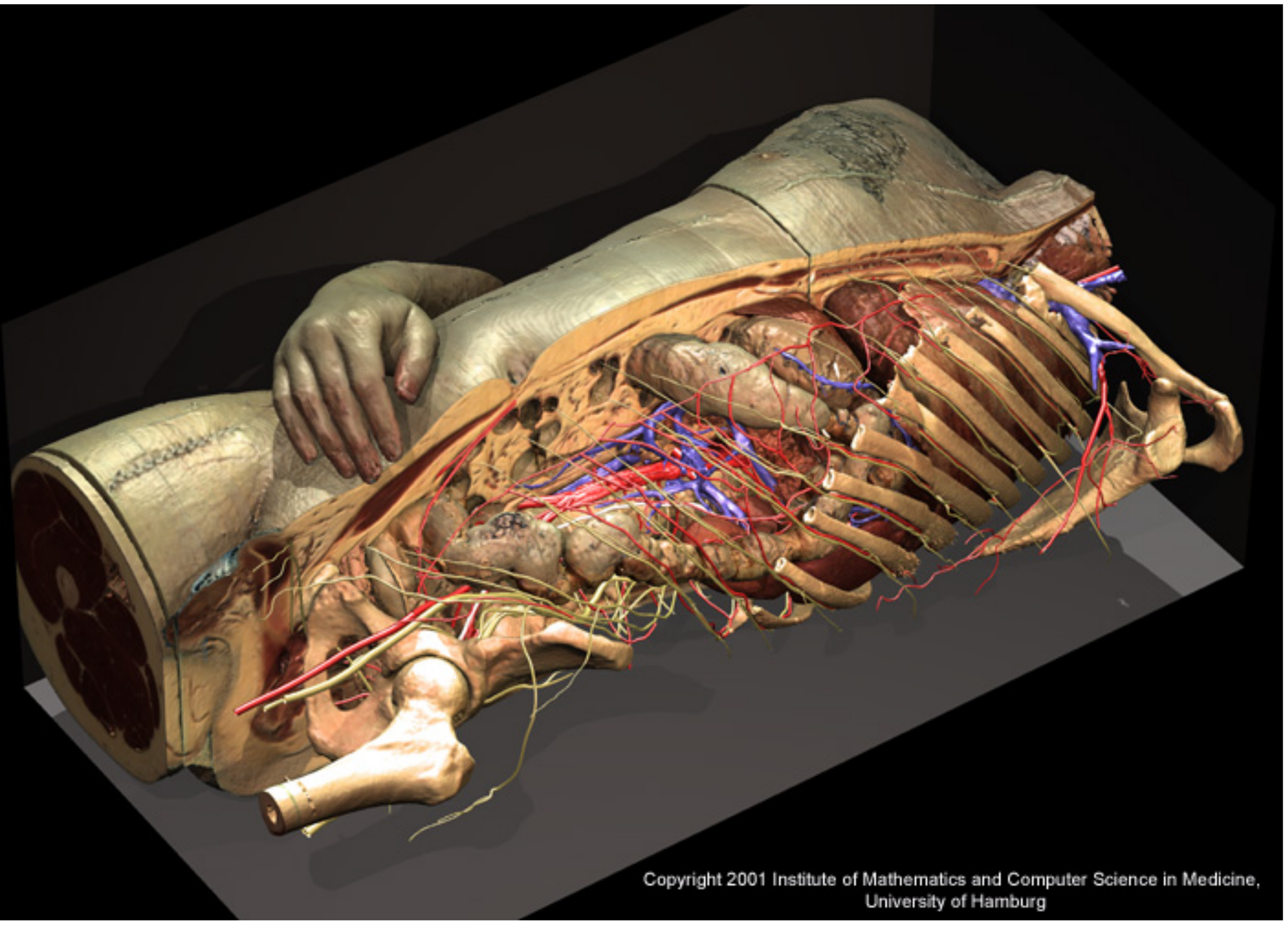


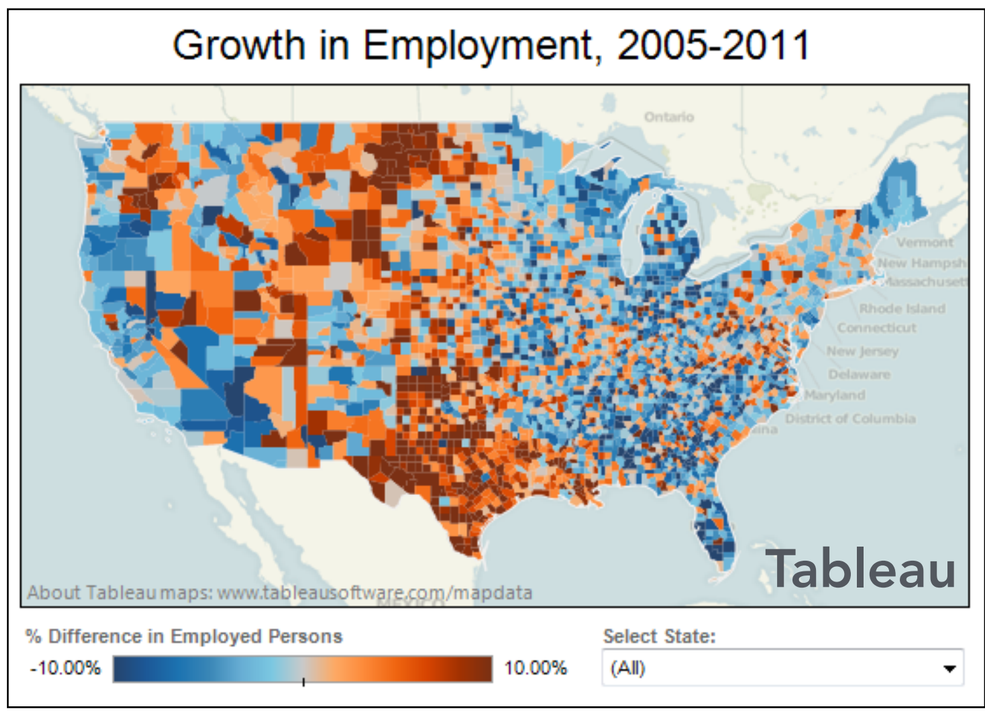
Bilbao Guggenheim, Frank Gehry

Architectural Design

Heydar Aliyev Center, Zaha Hadid Architects

Visualization





Science, engineering, medicine, journalism, …

Visual Simulation

Driving simulator
Toyota Higashifuji Technical Center

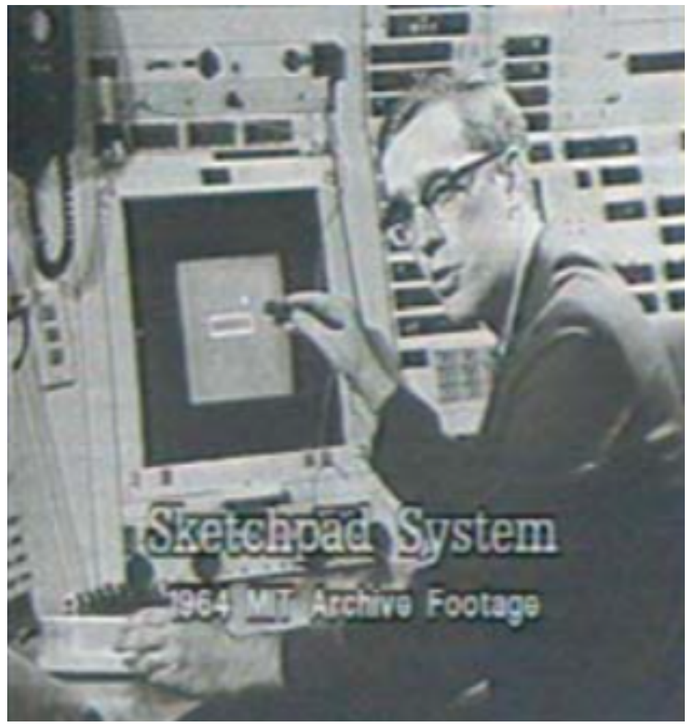
da Vinci surgical robot
Intuitive Surgical

Flight simulator, driving simulator, surgical simulator, …

Graphical User Interfaces

Desktop metaphor

- Input: Keyboard, mouse
- Ouput: Cathode-ray tube



Ivan Sutherland, Sketchpad
Light pen, vector display

Doug Engelbart
Mouse

Graphical User Interfaces

2D drawing and animation are ubiquitous in computing.
Typography, icons, images, transitions, transparency, ...

Graphical User Interfaces

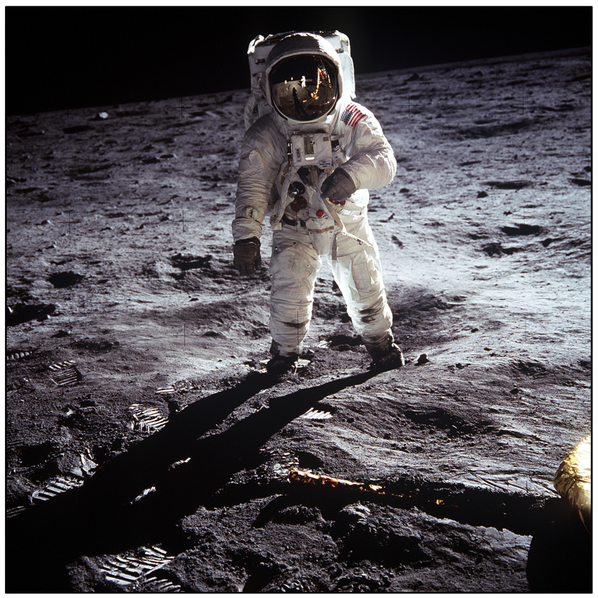
2D drawing and animation are ubiquitous in computing.

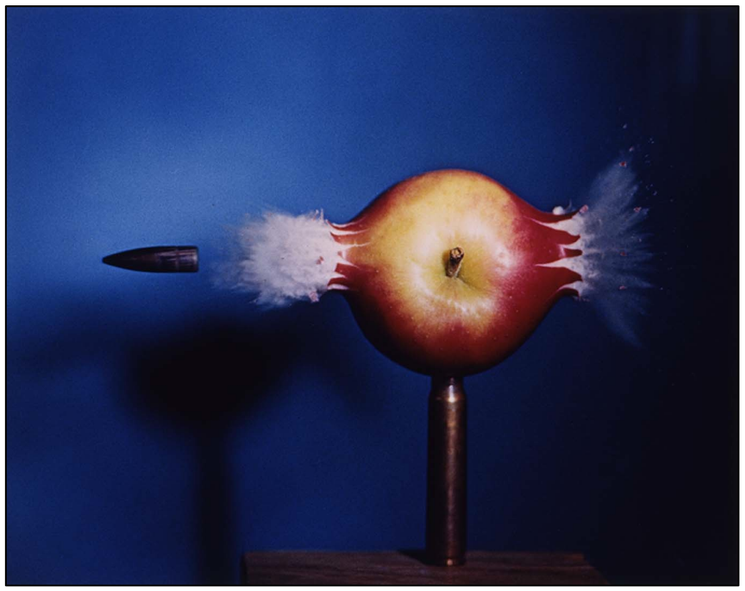
Typography, icons, images, transitions, transparency, ...

Graphical User Interfaces

https://www.youtube.com/watch?v=YndL315tQq8

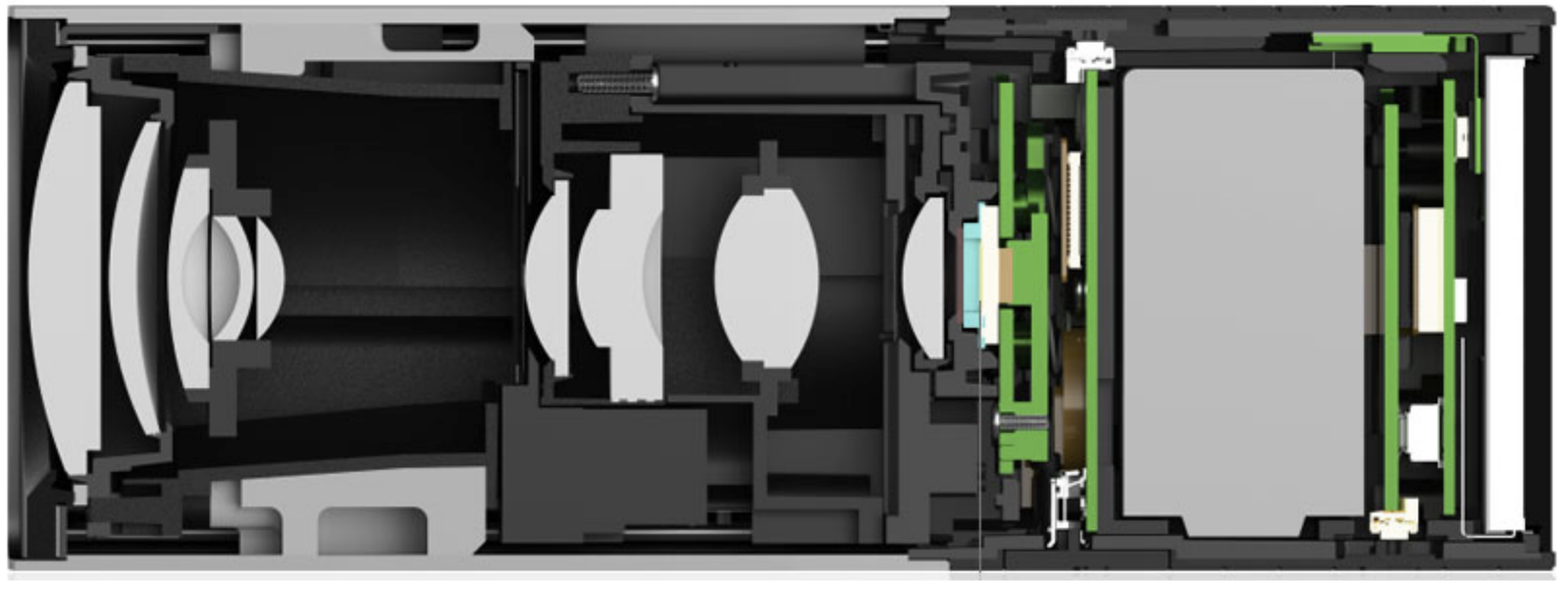
Photography





NASA | Walter Iooss | Steve McCurry
Harold Edgerton | NASA | National Geographic

Digital and Computational Cameras

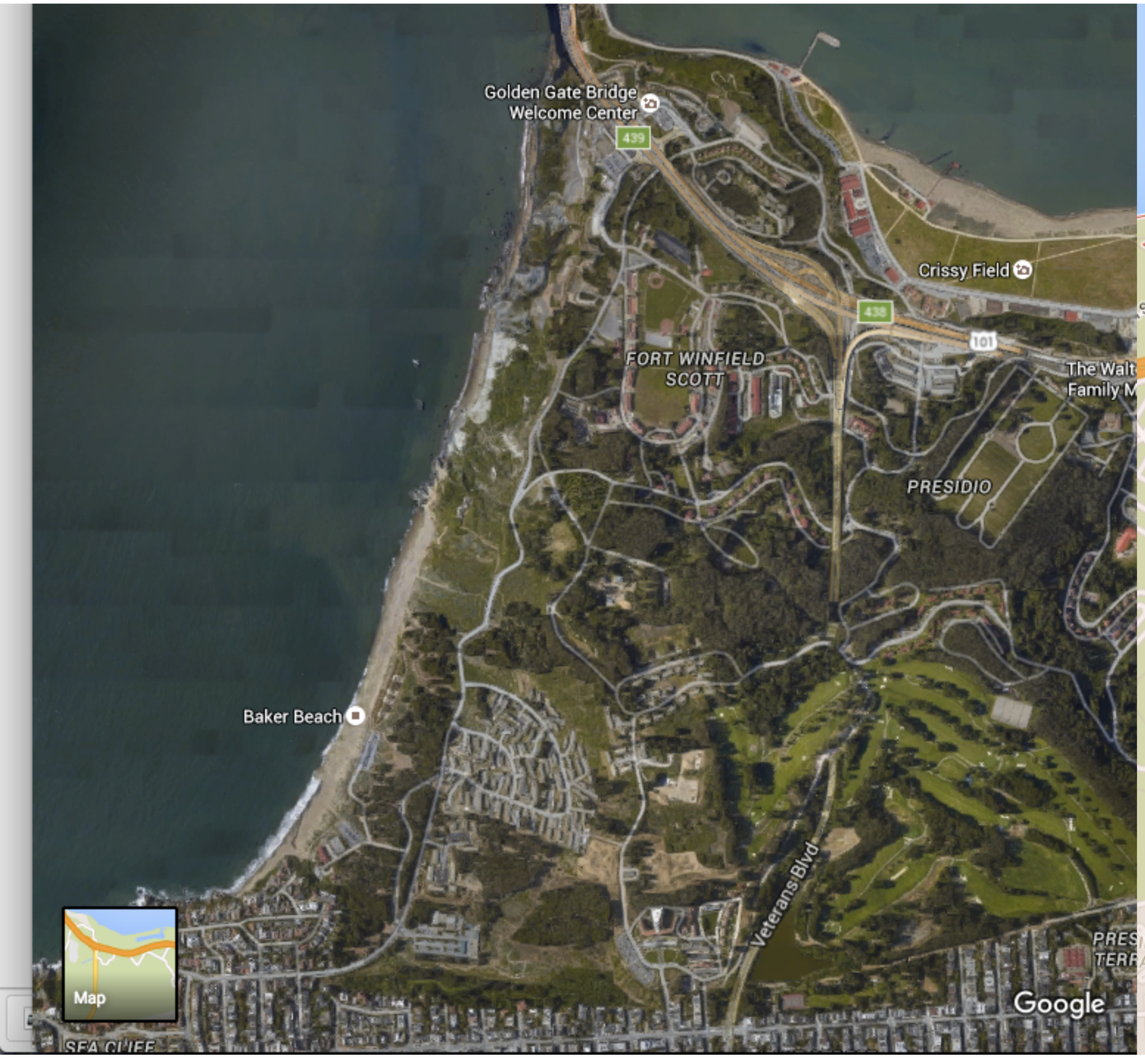


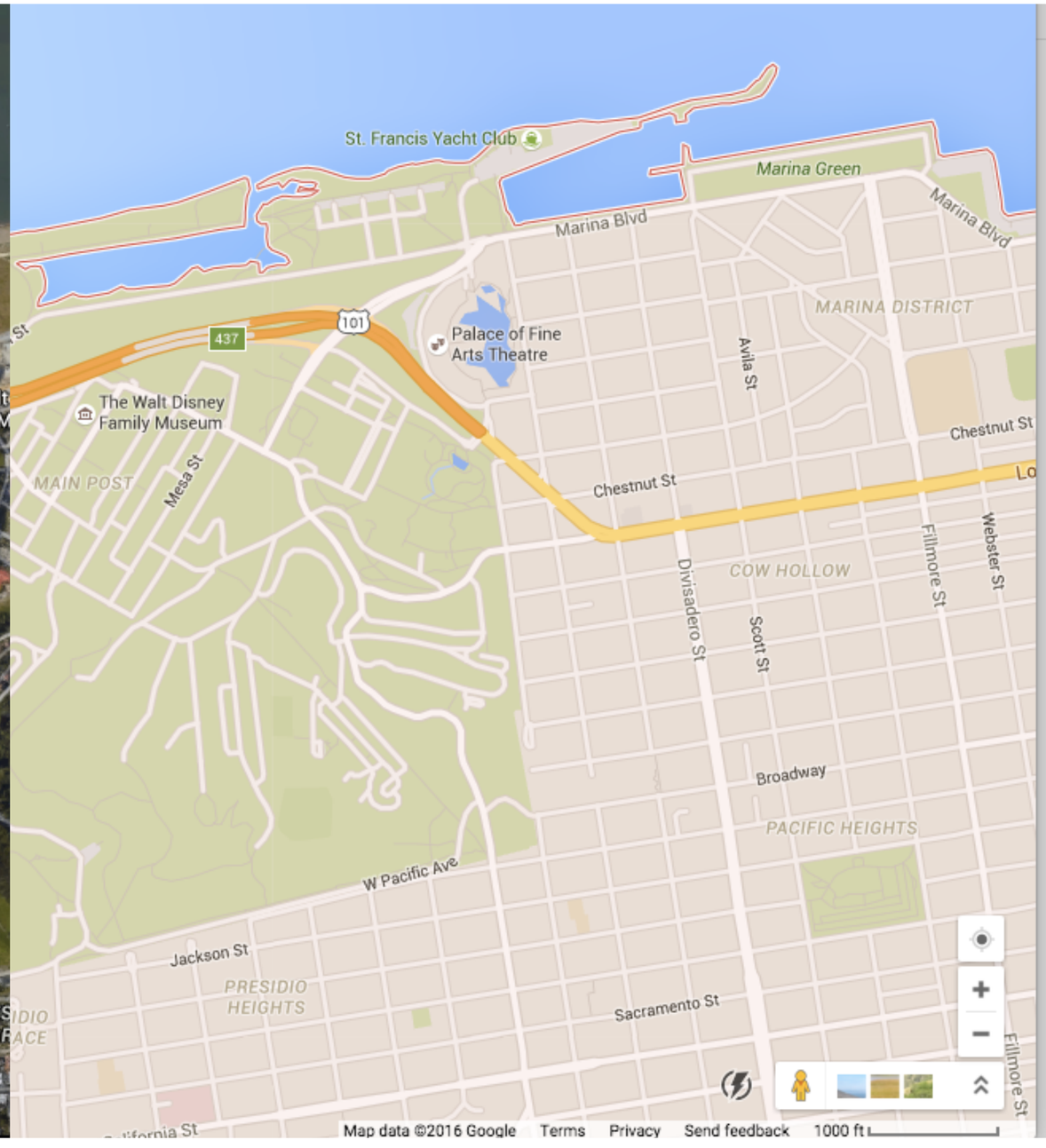
Panaromic stitching, HDR photos, light field cameras, …

Ubiquitous Imaging

Cameras everywhere

Imaging in Mapping





Maps, satellite imagery, street-level imaging,...

Imaging in Mapping

Maps, satellite imagery, street-level imaging,...

Imaging for Computer Vision

ImageNet: 15M images, 22K categories

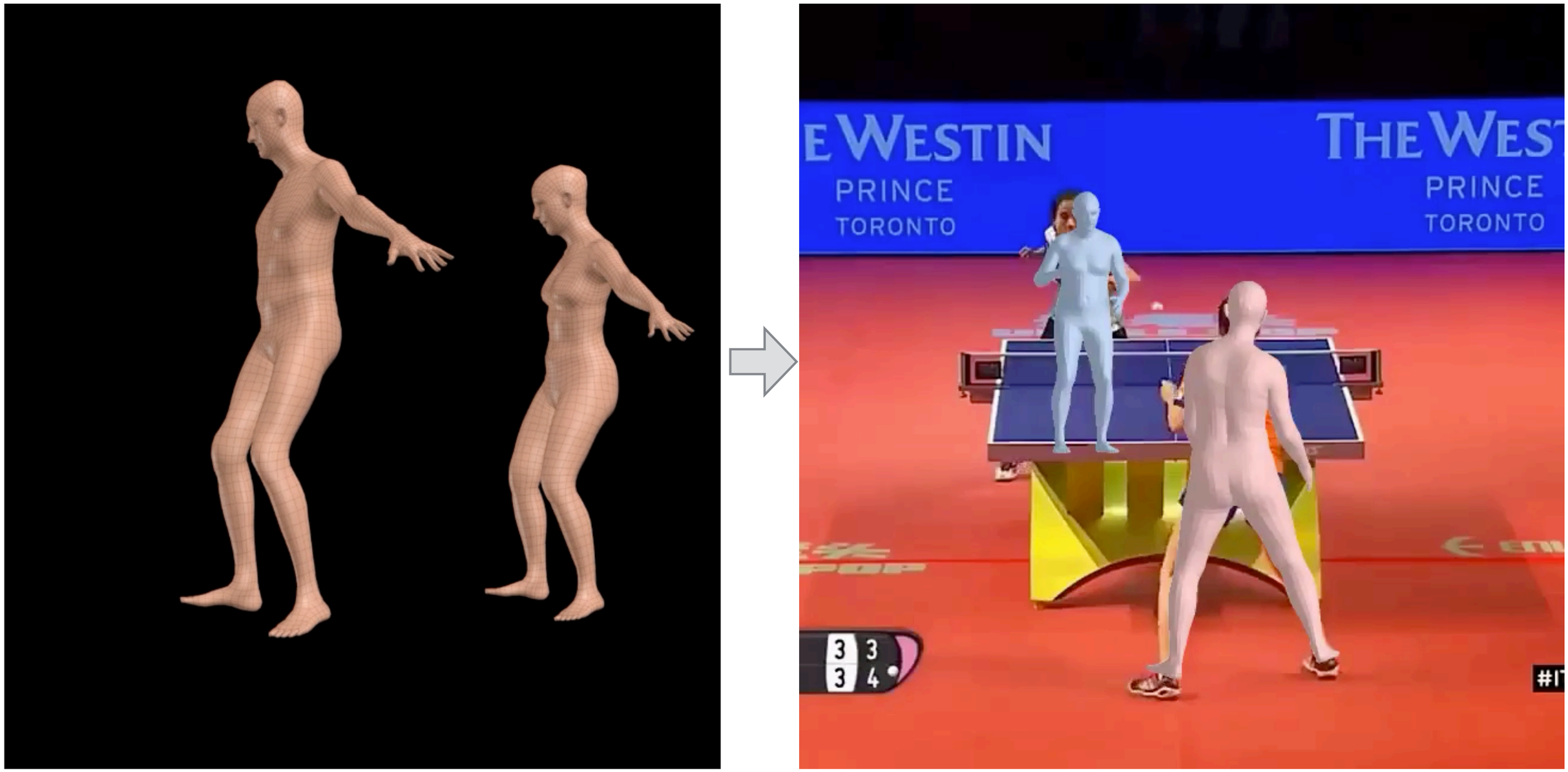
http://image-net.org

Inverse Graphics

Recovering the underlying 3D components from Image(s)

CS184/284A **Kanazawa + Ng**

Inverse Graphics

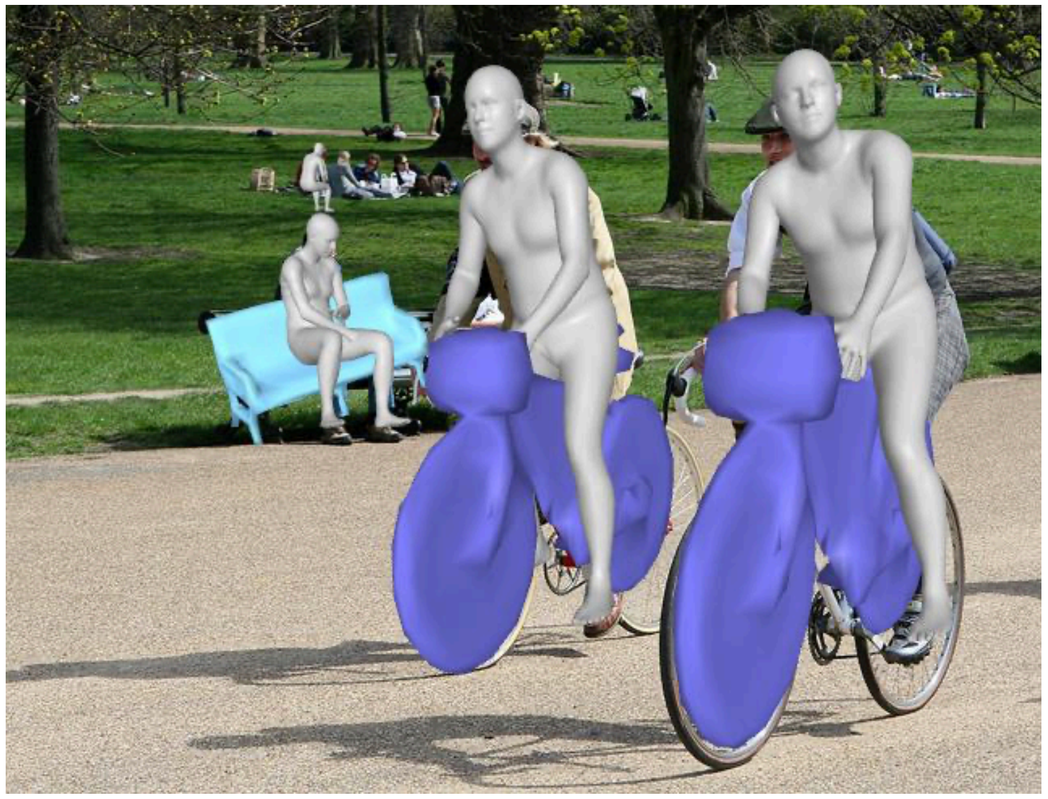


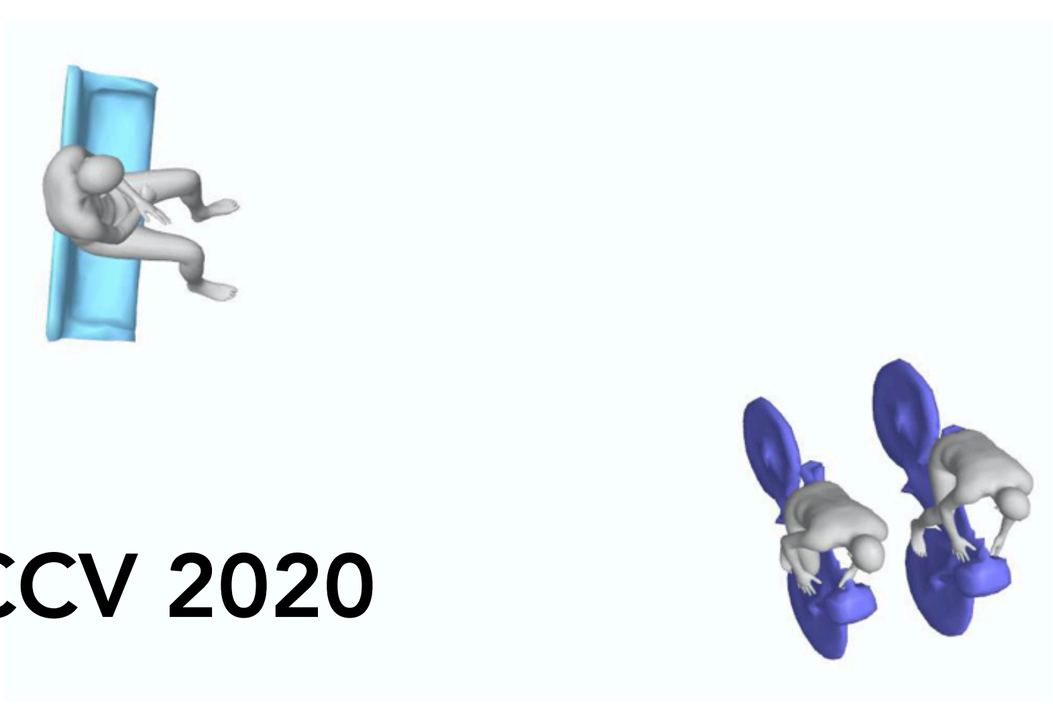
Markerless Motion Capture from a single image/video

CS184/284A

Kanazawa + Ng

Mocap of the world in-the-wild!

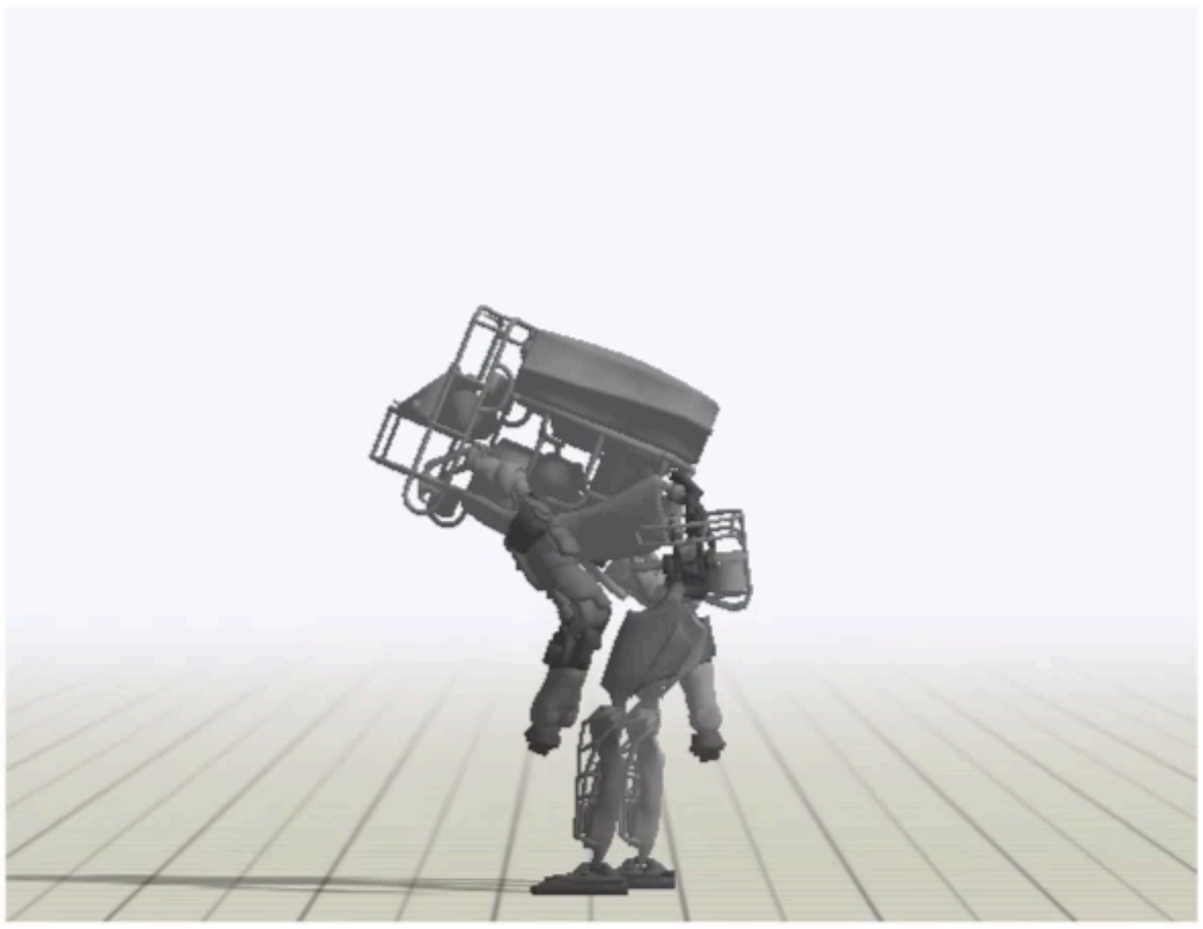




Zhang et al. ECCV 2020

Inverse Graphics

Video: Handspring A



Policy

Learn to Animate Characters from Video!
Peng et al. SIGGRAPH Asia 2018

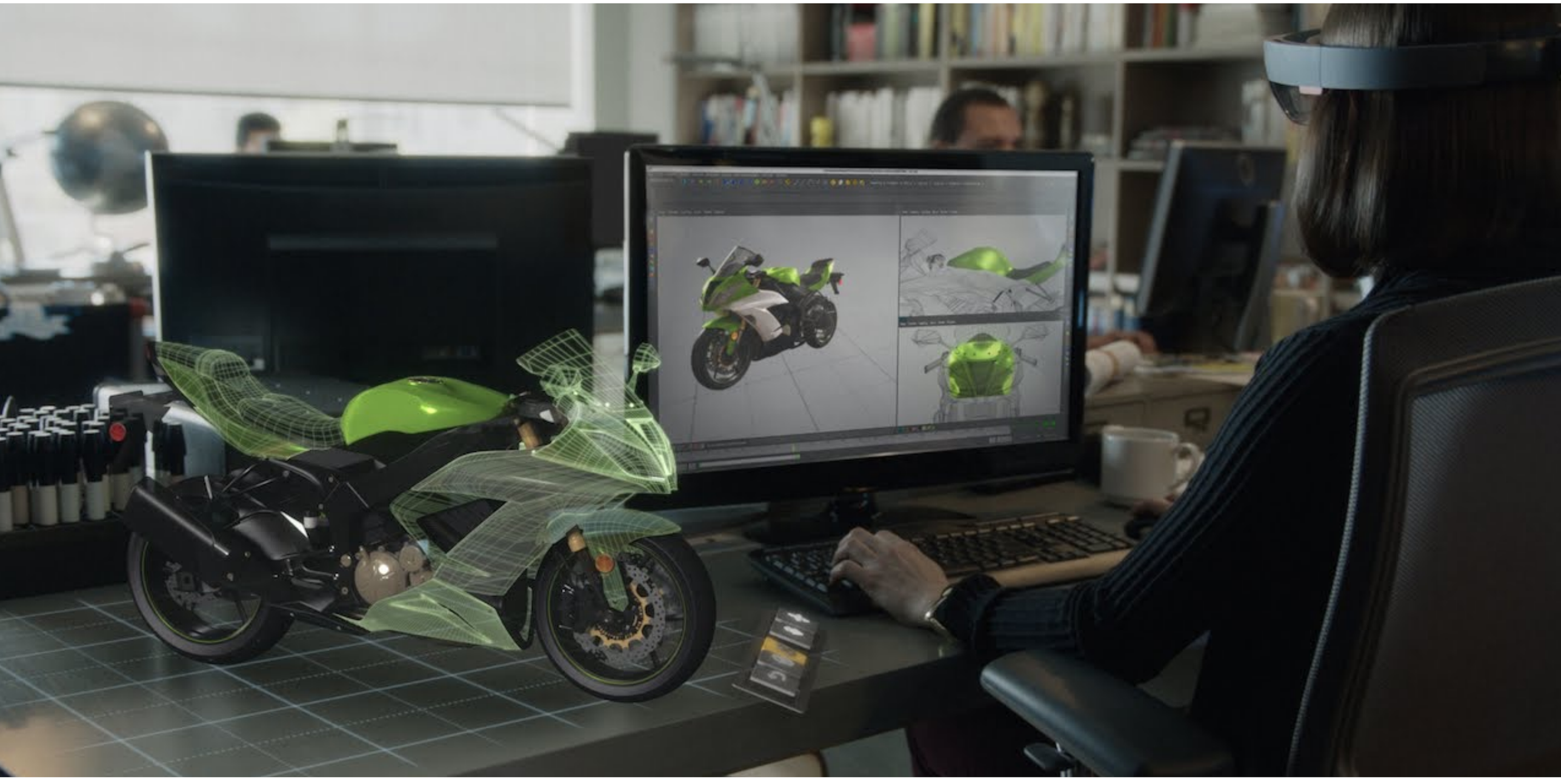
Imaging for Robotics

Google's "Arm Farm"

Virtual Reality

HTC Vive headset and controllers

Augmented Reality



Microsoft Hololens augmented reality headset concept

3D Printing

3D Self-portraits Omote3D Shashin Kan

CS184/284A

Kanazawa + Ng

Single-image 3D self-portraits

Saito et al. PIFu ICCV 2019

Foundations of Graphics and Imaging

These applications require sophisticated theory and systems

Science and Mathematics

- Physics of light, color, optics, …
- Math of curves, surfaces, geometry, perspective, …

Technology and Systems

- Input devices, GPUs, displays, …
- Cameras, lenses, sensors, …

Art and Psychology

- Perception: color, stereo, motion, image quality, …
- Art and design: composition, form, lighting, …

Course Goals

Overview of core ideas in graphics and imaging

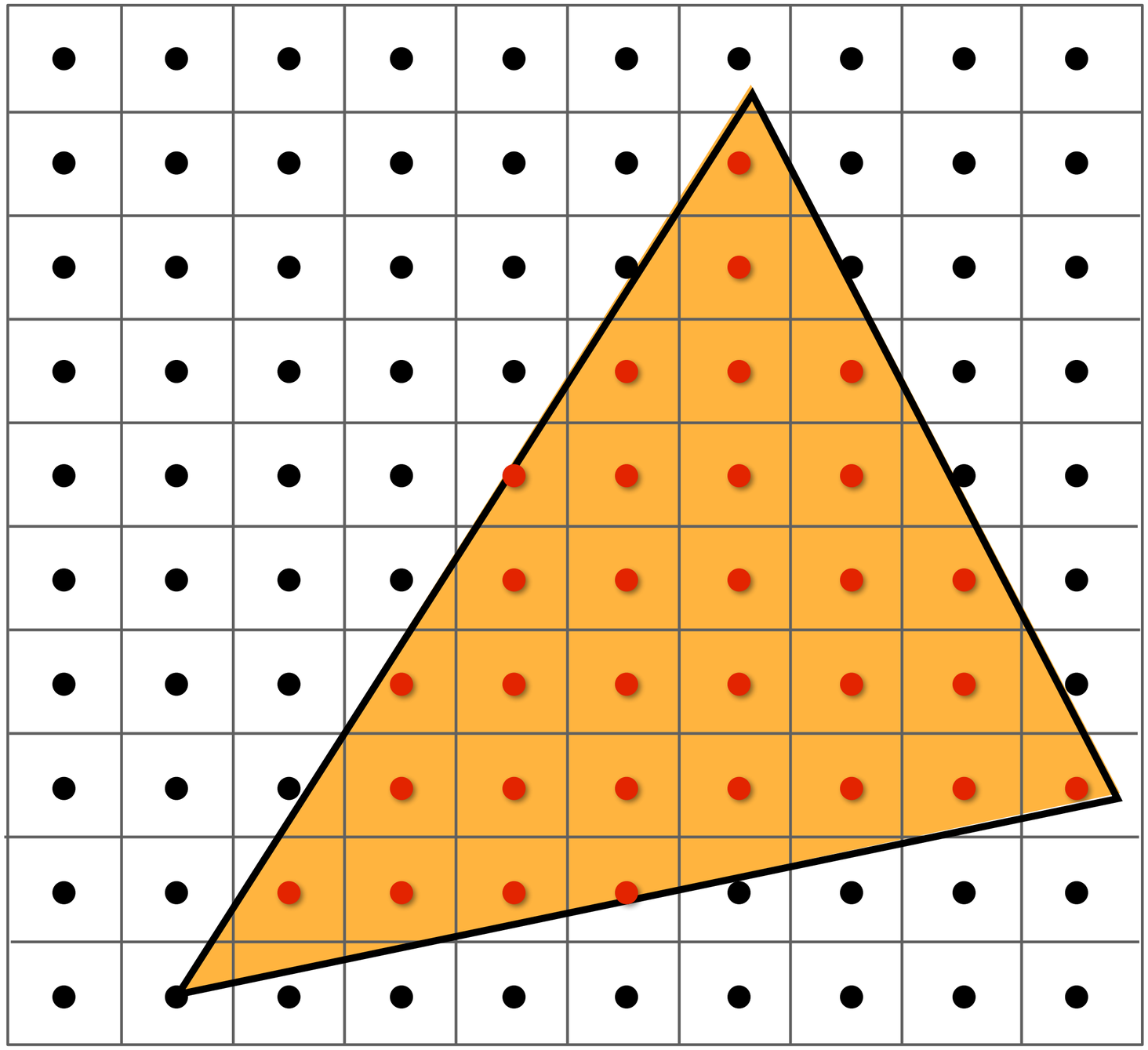
- Modeling the world, image synthesis
- 3D graphics: geometry, rendering, animation
- Image capture, manipulation and display

Acquire core concepts and skills

- Representations (geometry, images, transforms, …)
- Algorithms (sampling, subdivision, ray-tracing, …)
- Technology (GPUs, displays, cameras, …)

Course Topics

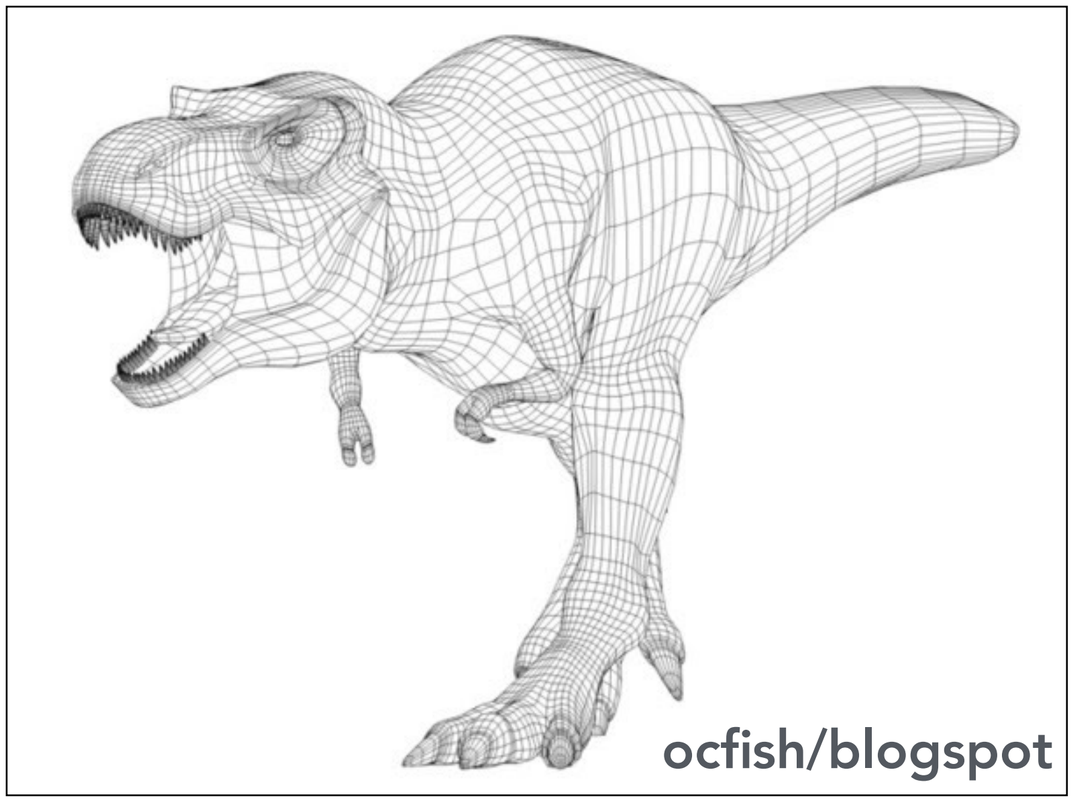
Drawing Digital Images (Rasterization)

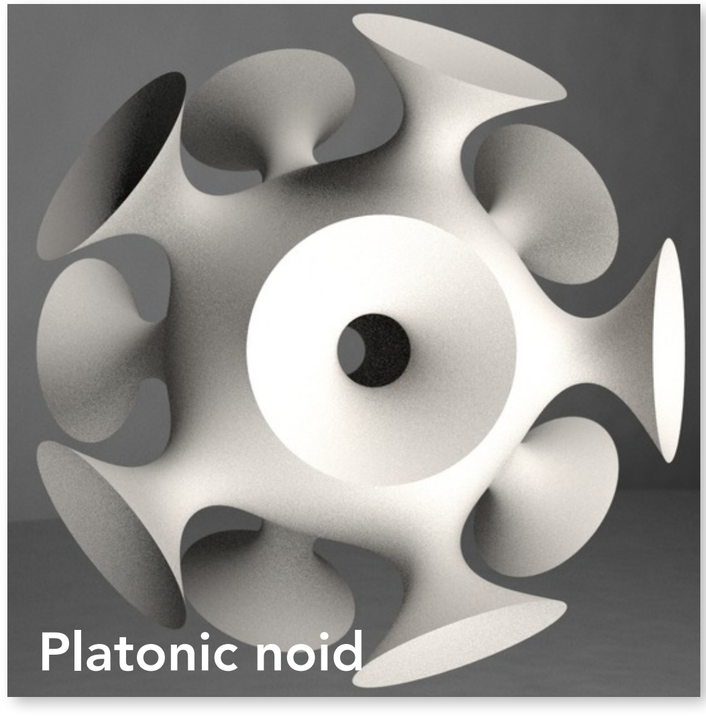


Filtering and Sampling

No Jaggies

Modeling Geometry

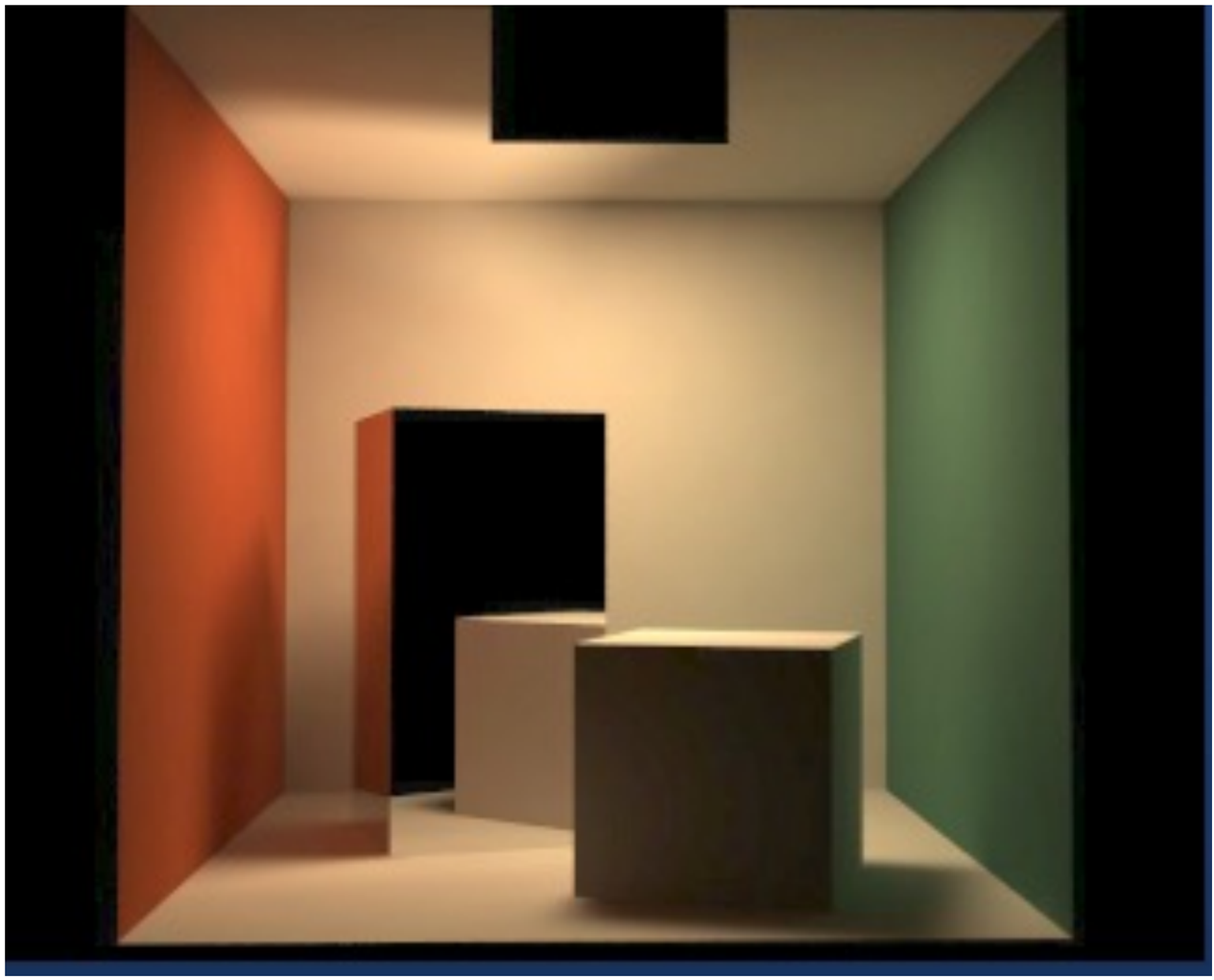




Modeling Material Properties

Modeling Lighting

Light Transport and Image Synthesis



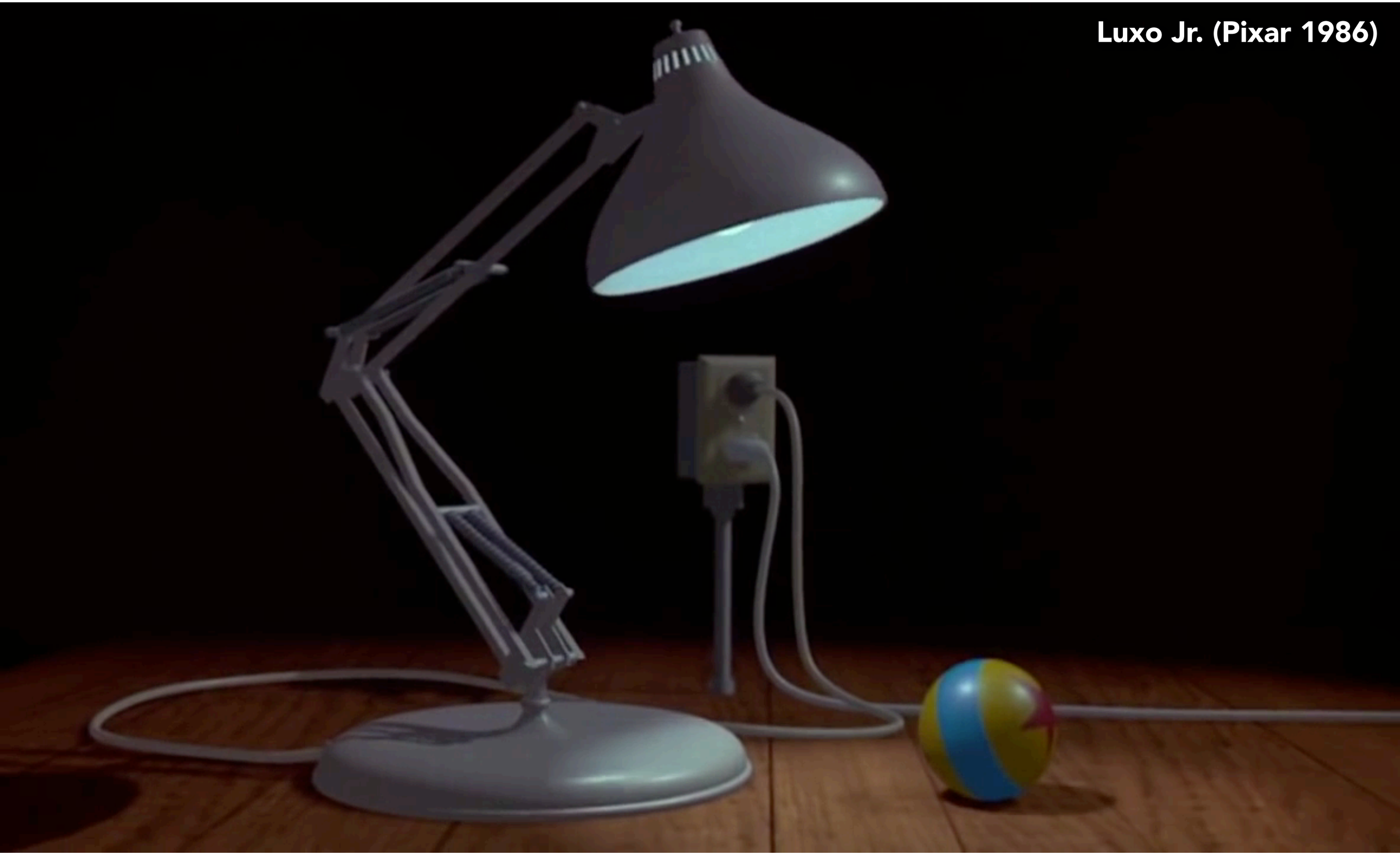
Photograph (CCD) vs. computer rendering

How Do Cameras Work?

Glenn Derene, Popular Mechanics

CS184/284A **Kanazawa + Ng**

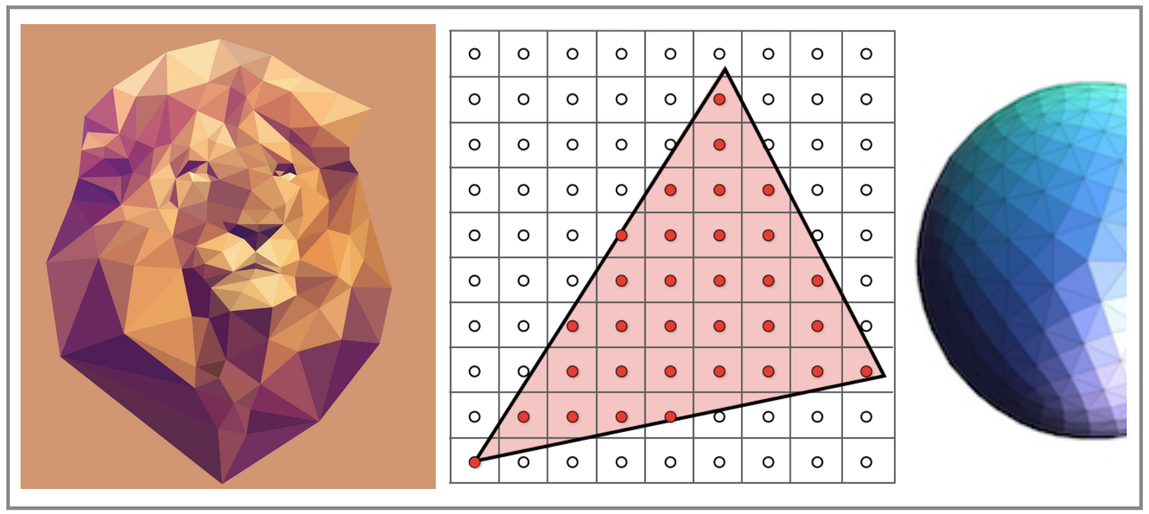
Animation and Physical Simulation



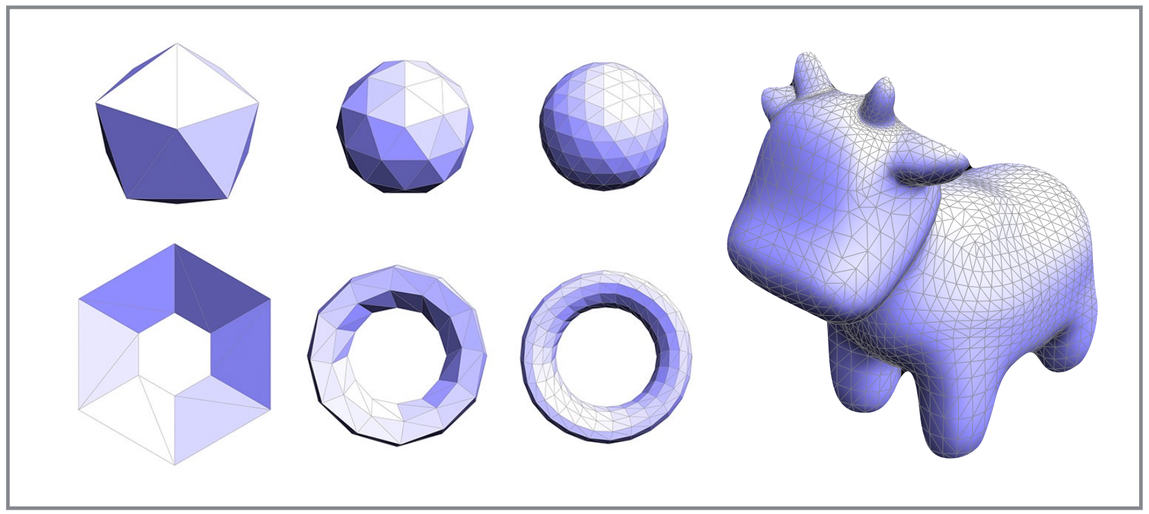
Virtual Reality

Hands-On Learning

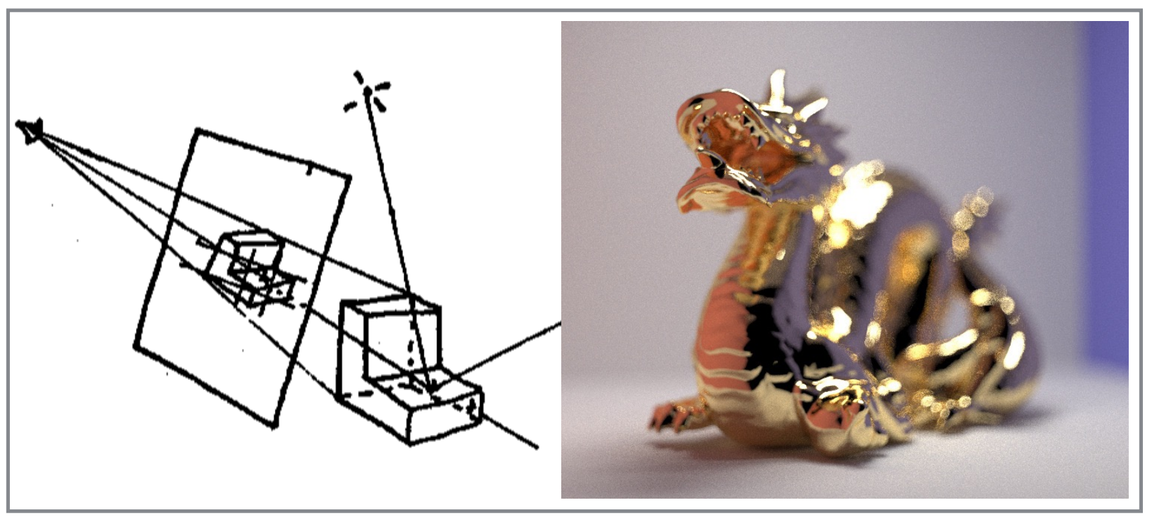
Course Assignments



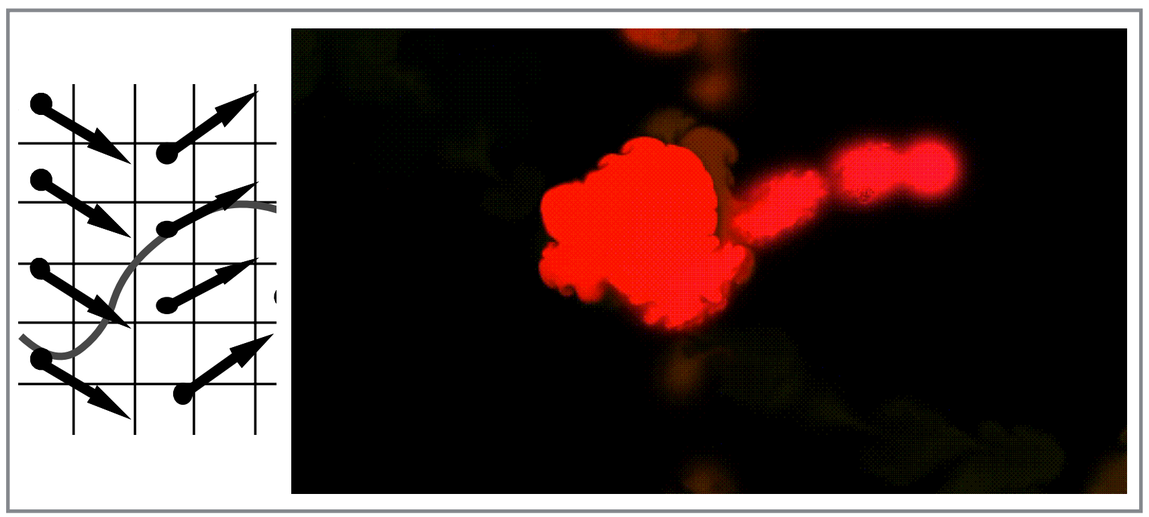
1. Digital Drawing (2 weeks)



2. Geometry (2 weeks)



3. Ray-Tracing (4 weeks)



4. Animation (2 weeks)

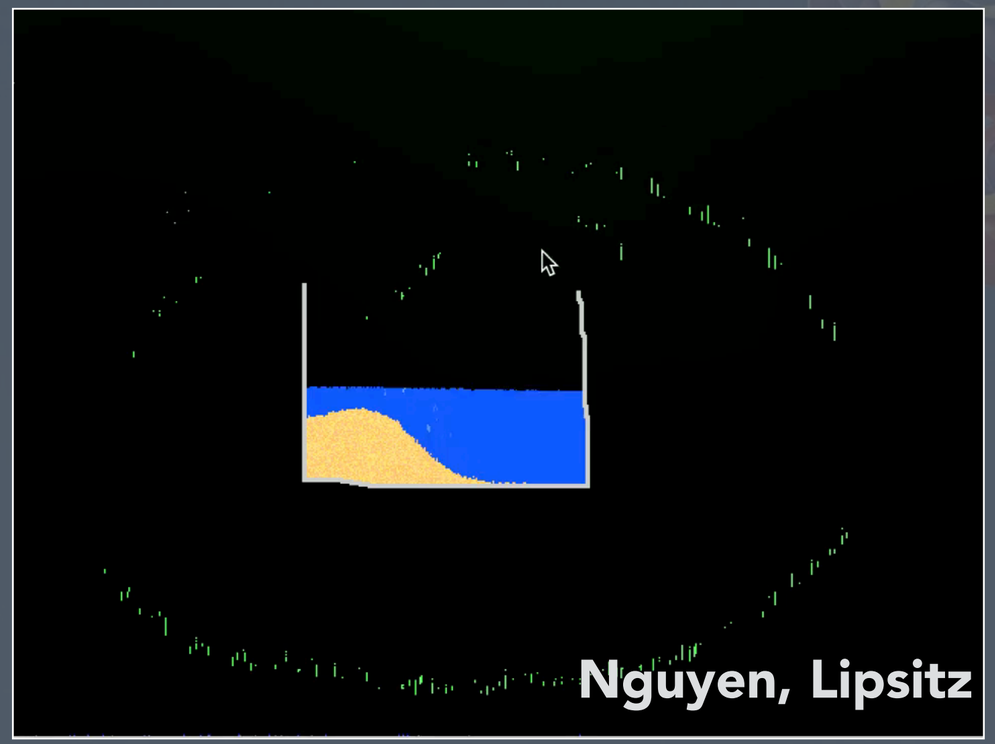
Final Project

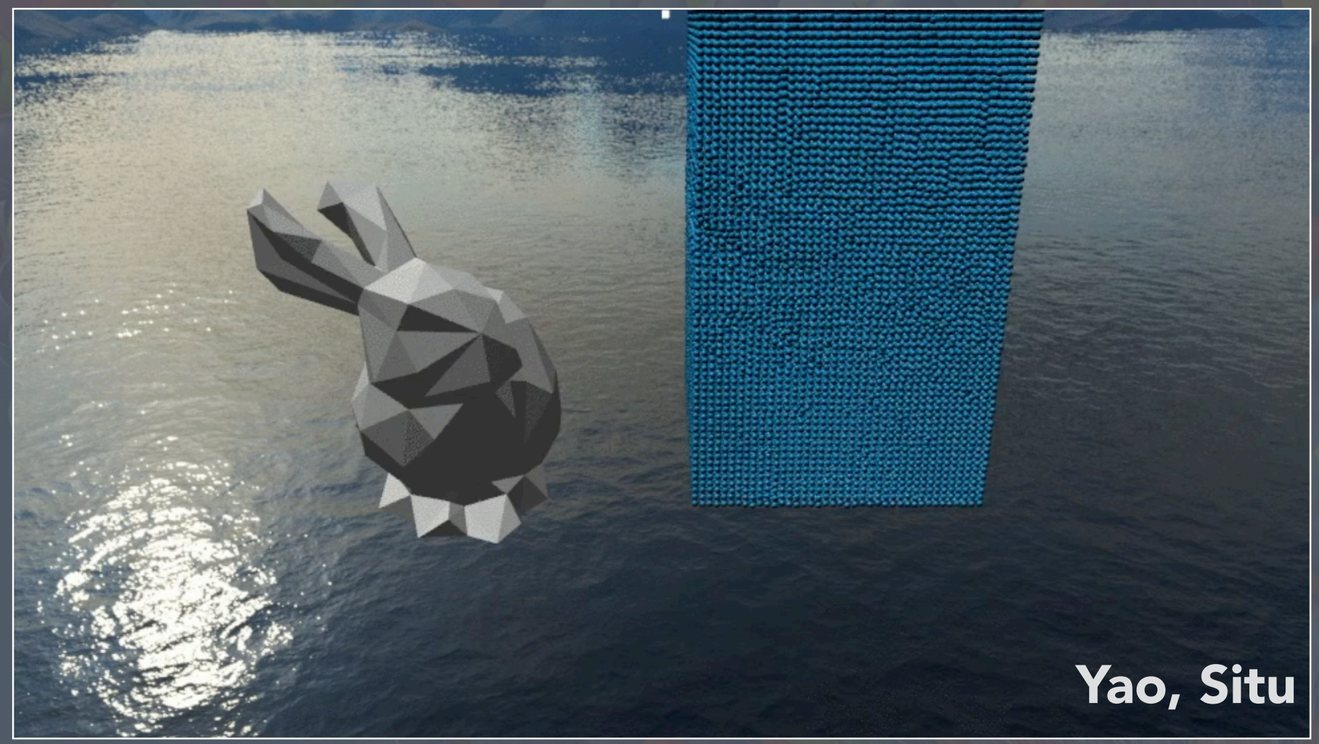
Project Competition

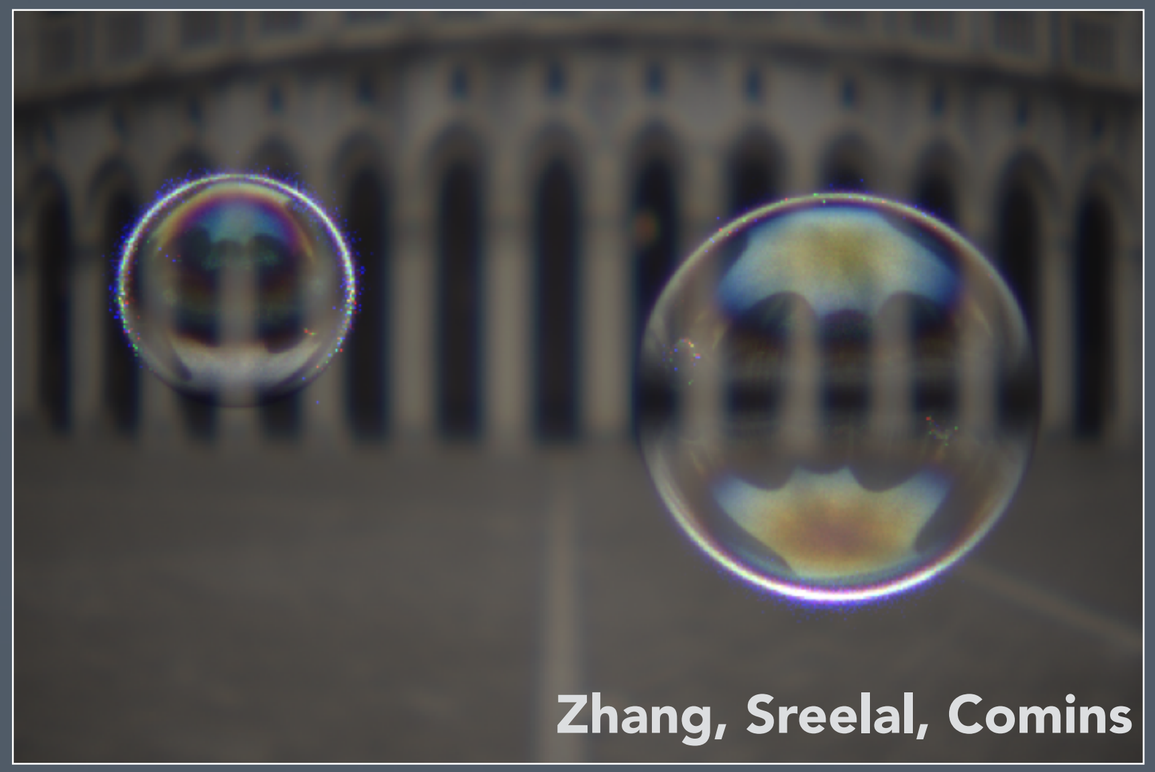
- 4 weeks, let your creativity take flight!
  (we will have suggested projects)
- Proposal; checkpoint; presentation, video, report

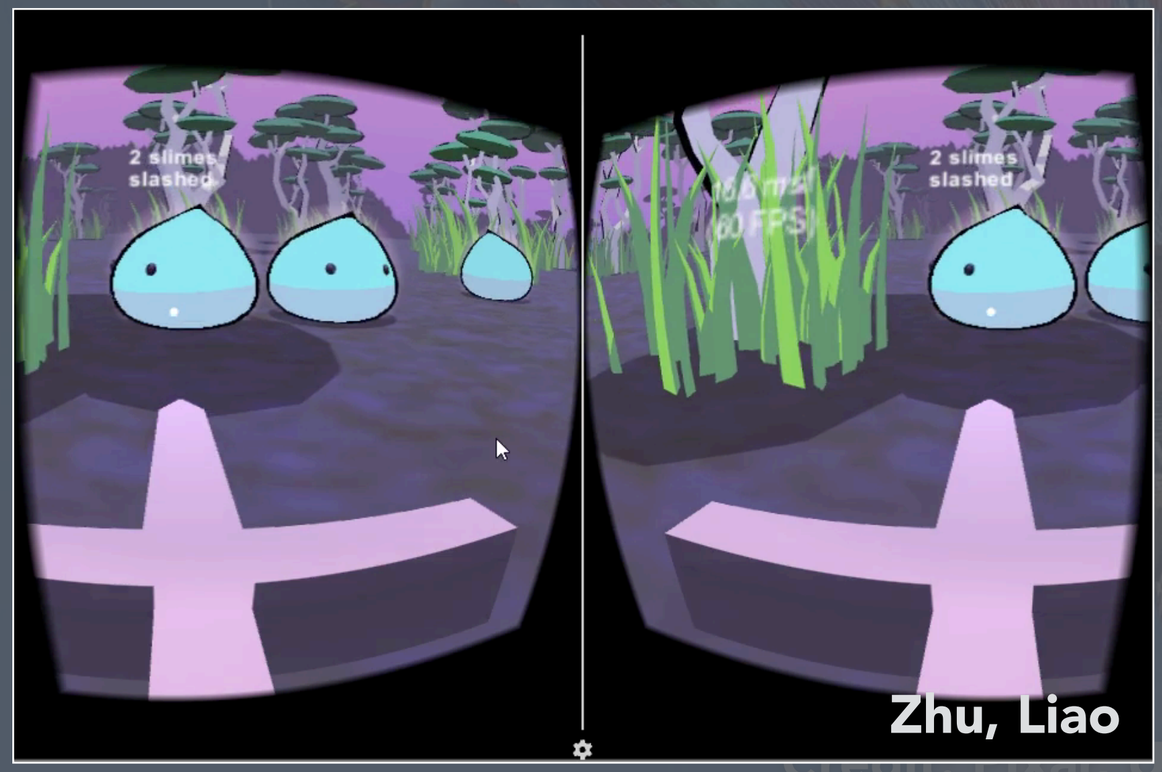
Credit: Pixar, Up

Final Project - Examples

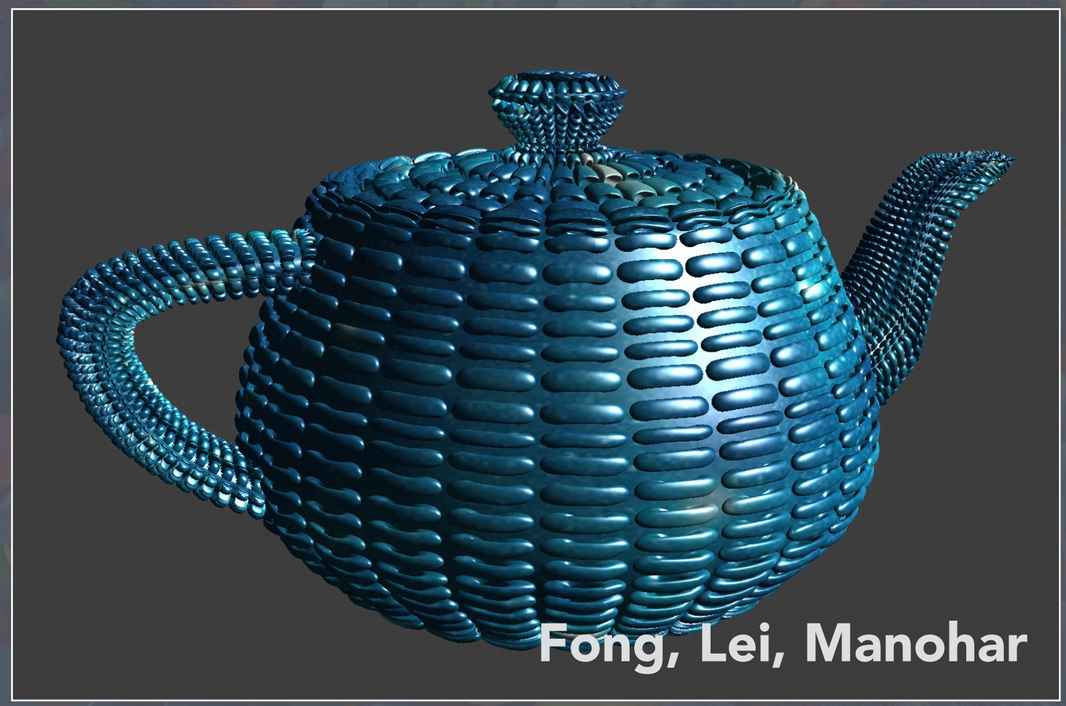


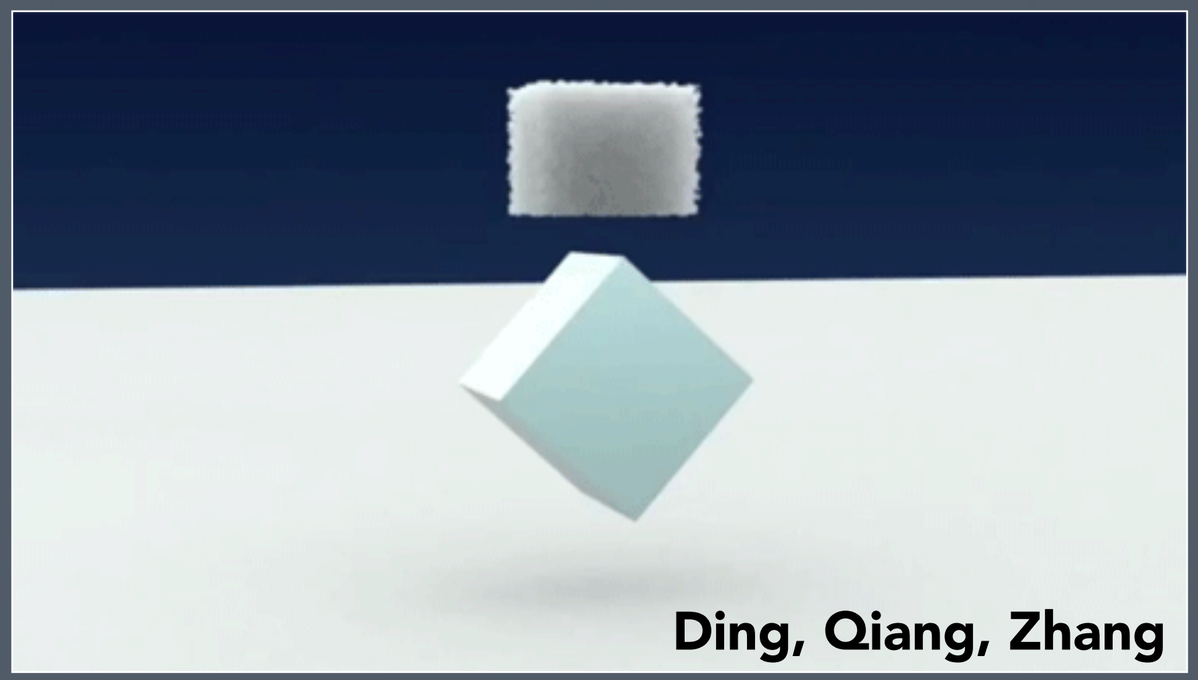


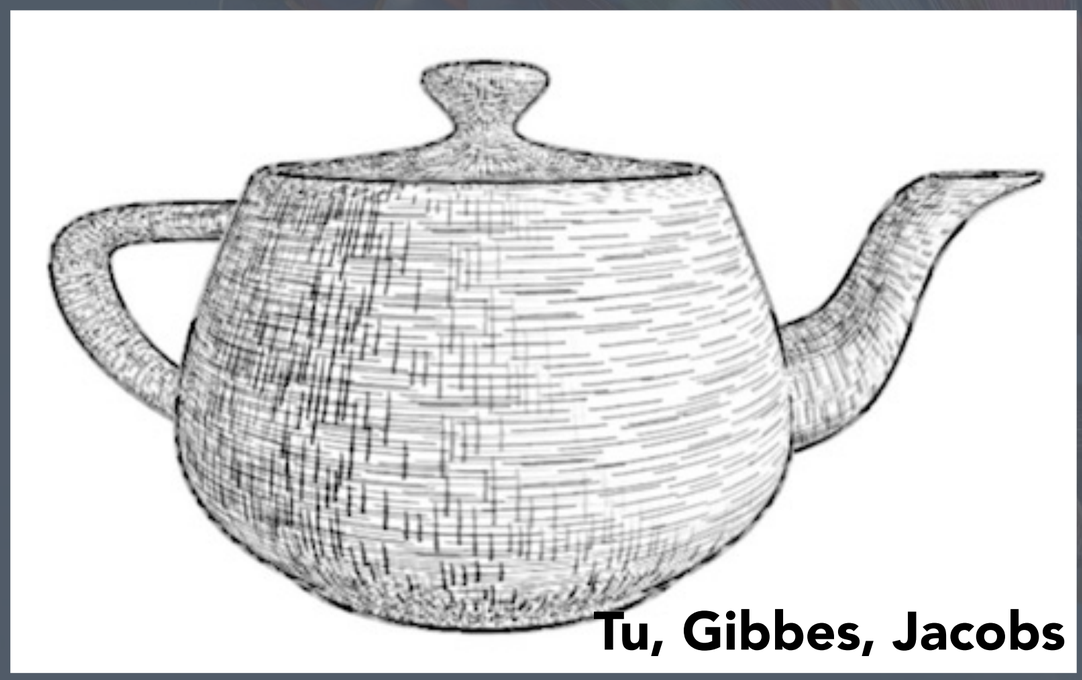




Final Project - Examples







Credit: Pixar, Up

Course Logistics

Prerequisites

Math

- Vectors, matrices, basic linear algebra
- Helpful: exposure to statistics, signal processing, Fourier transform

Programming

- Data structures (CS61B)
- Fluent with C and C++
- Fluent with development environment, debugging, etc.

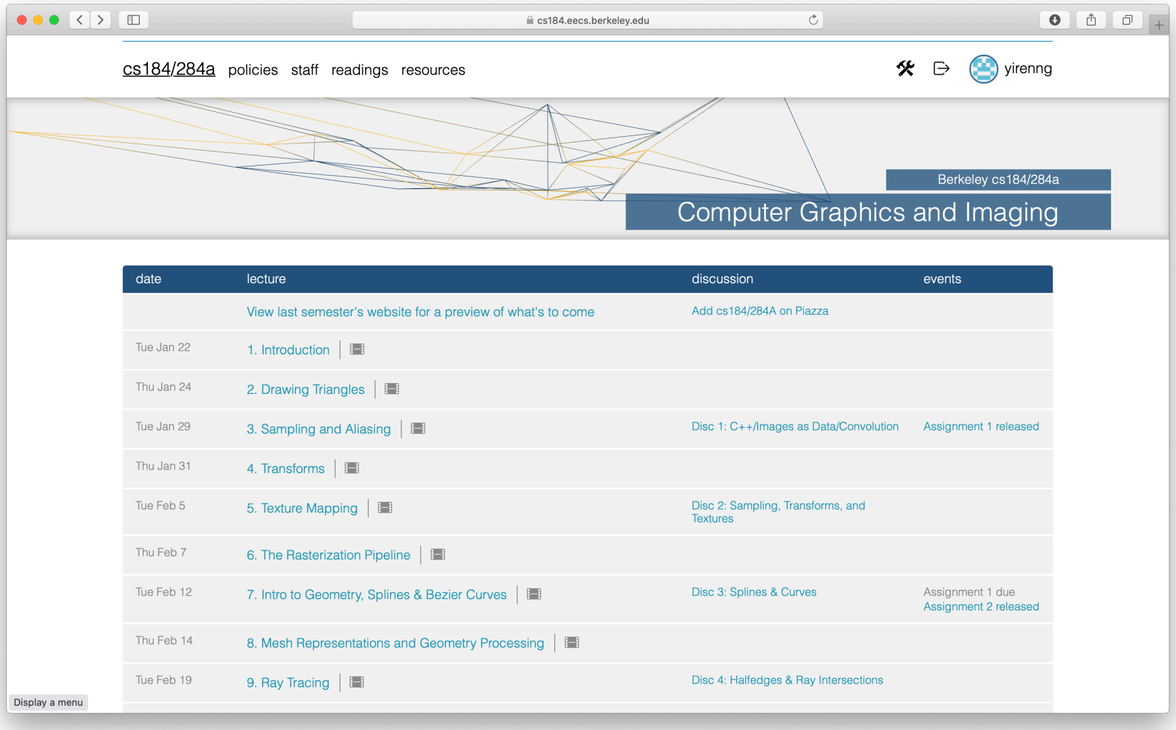
Enrollment

- Last year, high turnover from wait list
- Questions about enrollment:
  - CS184: ask scheduler
    Cindy Conners, csconners@cs
  - CS284A: contact instructors on Piazza
  - Concurrent enrollment: send note to instructors on Piazza about your prerequisites for the class

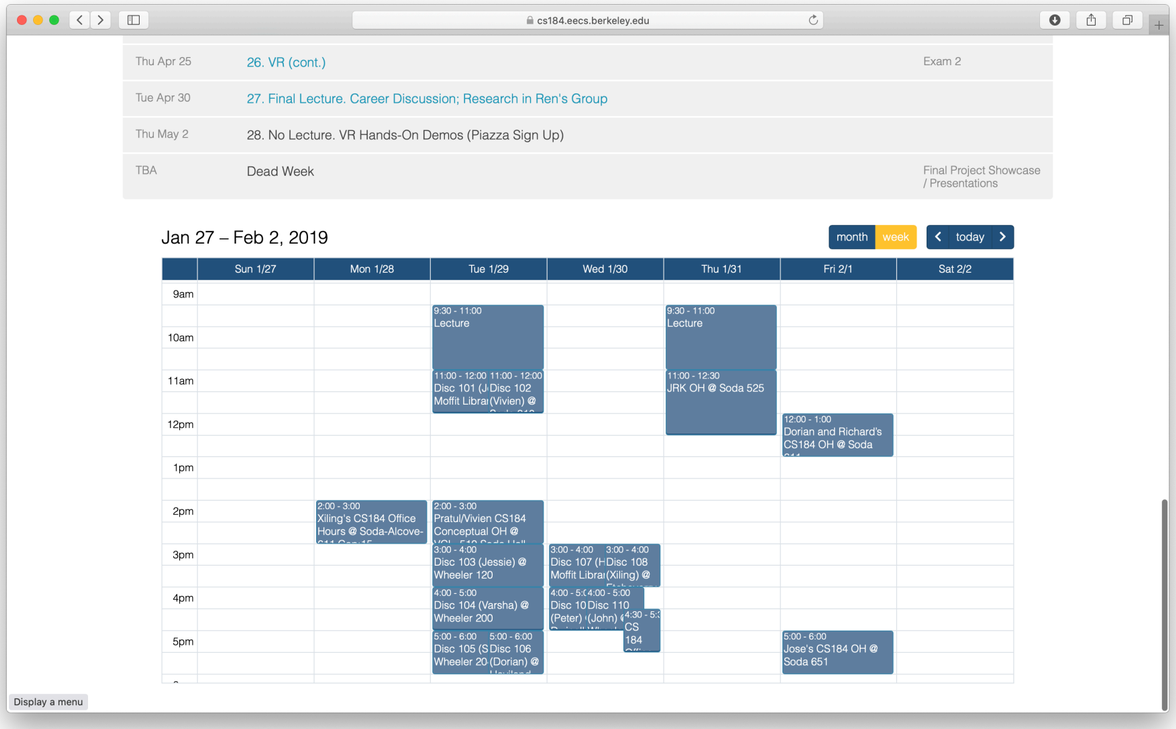
Course Schedule

[cs184.org](cs184.org) or
cs184.eecs.berkeley.edu

Full schedule for class will be on website soon



Note class calendar at bottom for office hours, homework, parties, etc.



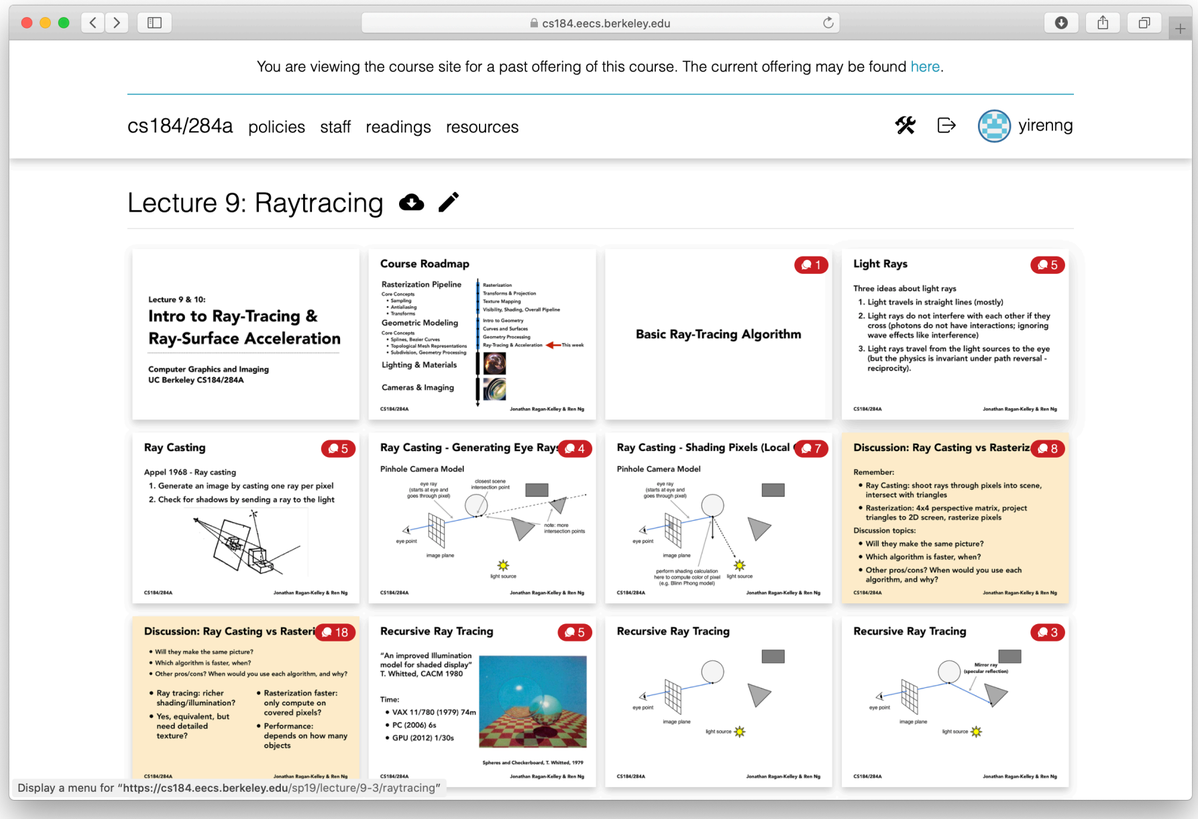
CS184/284A

Kanazawa + Ng

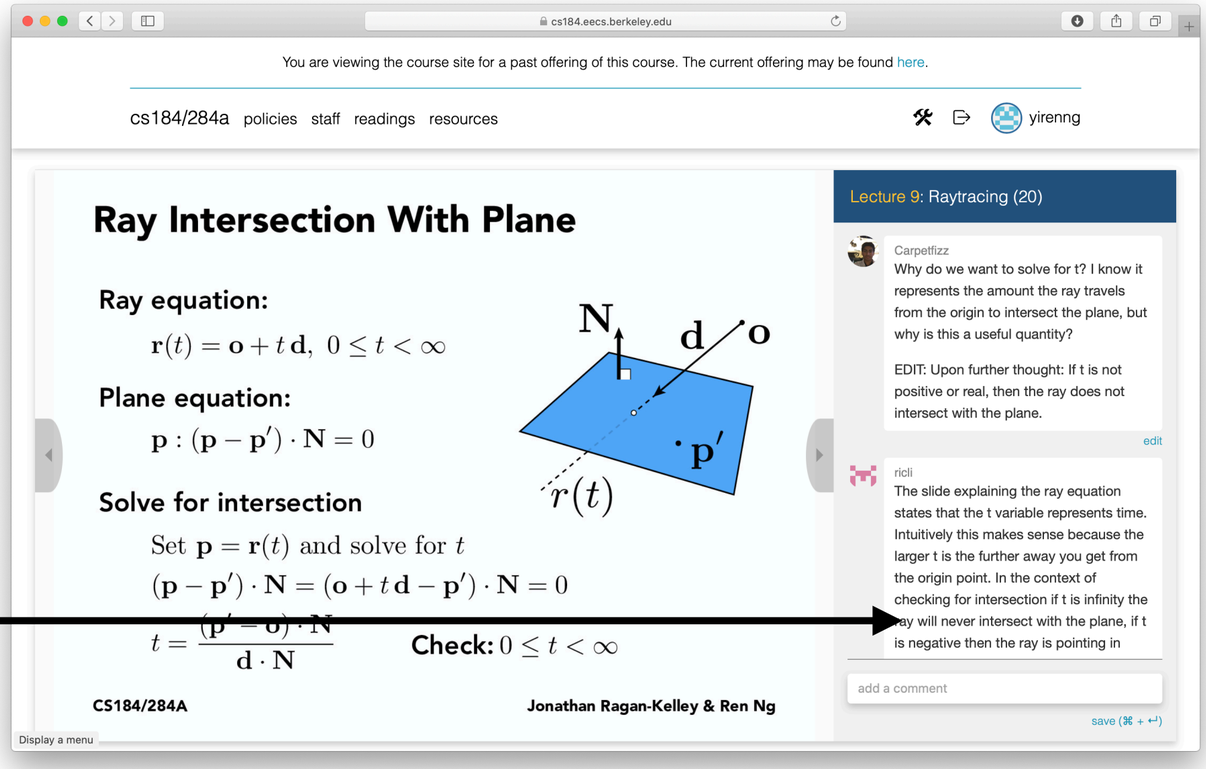
Lecture Slides

[cs184.org](cs184.org) or
cs184.eecs.berkeley.edu

Lecture slides and instructor/TA/ student discussions on the web are the primary course reference materials



Slide comments and discussion



CS184/284A

Kanazawa + Ng

Piazza

piazza.com/berkeley/spring2021/cs184

Please sign up!

For logistics and general communication / discussion

- Use Piazza instead of email
- But intellectual discussions about content should primarily go on website as slide comments

Webcasting

Zoom lecture will be recorded this semester

- Videos will be linked from the class website

Section

Sections start next week, and TAs will give a primer on C++ and building class projects

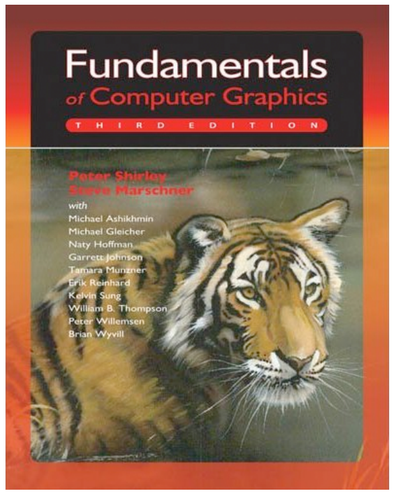
Resources

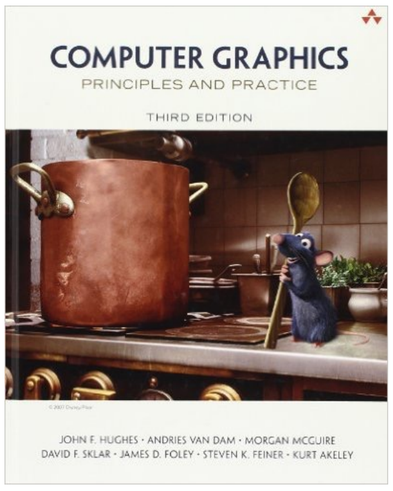
Lectures will be primary source

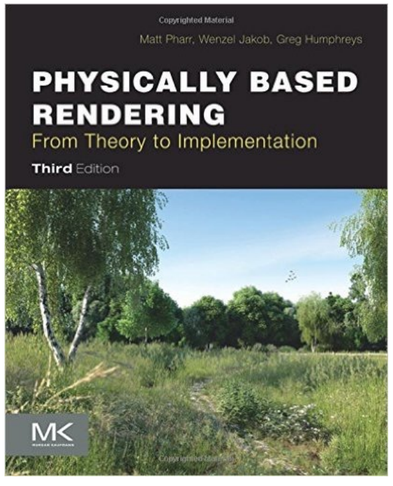
Textbook reference material:

- Fundamentals of Computer Graphics by P. Shirley, S. Marschner, et al.
- Computer Graphics: Principles and Practice (3rd Edition) by Hughes, van Dam, et al.
- Physically Based Rendering, Third Edition: From Theory to Implementation by Pharr, Jakob and Humphreys

Other resources on class website







Learning, Grading, Collaboration & Culture

- New for 2021!
- Significant evolution in course grading and collaboration policies.

Goals:

- Enable you to increase focus on learning rather than assessment
- Further encourage your learning through collaboration
- Further entrust you with maintaining academic integrity

Main Changes:

- Collaboration in pairs encouraged on programming assignments.
- The class will not be graded on a curve.
- Exams will be take-home, with honor code, no proctoring.

Course Deliverables and Assessment

CS184: your course grade is out of 100 total points

- Five homework assignments, 10 points each
  - Pair projects encouraged. Programming and written reports.
- Two exams, 10 points each
  - Check dates on website schedule. No final exam.
- Final project, 25 points
  - In groups of four, with final presentation, video, report.
- Participation, 5 points
  - Attend lectures, and/or write comments online on lecture slides.

CS284A students: Project is 40% of grade, remainder normalized.

Late Days Policy

Assignments are late after 11:59pm on due date.

You have 5 late days for assignments (not final project)

- Extend a homework assignment deadline by 24 hours using one late day.
- If you do not have remaining late days, 1 point penalty per day.
- Please use this flexibility to manage your exceptional circumstances.

What We Are Looking For In Slide Comments

Try to explain the slide (as if teaching your classmate to study for an exam)

- "Ren said this, but if you think about it this way it is much clearer"

Explain what is confusing you

- "What I was totally confused about here was…"

Challenge classmates with a question

- For example, make up a question you think might be on an exam

Provide a link to an alternative explanation

- "This site has a really good animation of pre-filtering to avoid aliasing"

Mention real-world examples

- For example, describe what default interpolation functions are used in iOS.

Constructively respond to another student's question

- "@nojaggies, are you sure that is correct? I thought that Ren said…"

It is OK, and even encouraged, to address the same topic (or repeat someone else's summary, explanation or idea) in your own words

- "@cornellbox's point is that subdivision is also used to…"

Website Comments in Markdown

You are encouraged to write your comments in Markdown, which enables working hyperlinks, typeset equations, and more. There is an article on Markdown linked on the website.

Class Philosophy

We want a very active class.

Come to class, participate in lecture, discussion, office hours, homeworks parties.

Practice cooperative, supportive learning.

Contribute on the website.

Uphold academic honor individually and collectively.

Inclusive Classroom

Projects = great way to meet new people and make friends!

Respect each other as an individual and try to create a safe space.

Ask people how they would like to be referred to.

Look through common micro-aggressions and how to intervene if you see them.

“Please” and "thank you” are the magic words.

Make the best effort to have a positive outcome for the group you are in.

Questions?

Acknowledgments

Thanks to Pat Hanrahan, Kayvon Fatahalian, Keenan Crane, and Mark Pauly for presentation resources.