Lecture 1:

Introduction

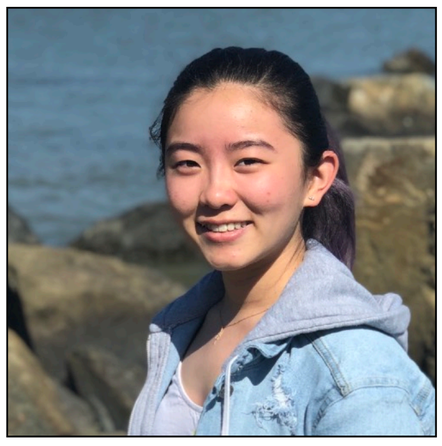
Computer Graphics and Imaging
UC Berkeley CS184/284A

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. Had all speaking accents!

Welcome to CS184 / 284A!



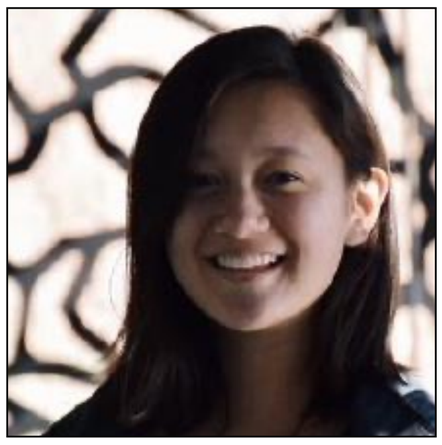
Xinyun Cao

Hang Gao

Ajay Jain

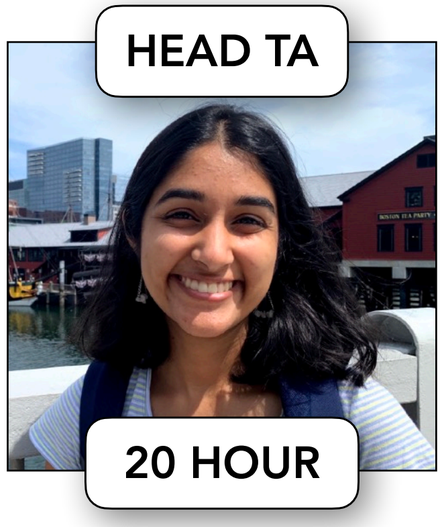
Emily Ma

Michael Ren

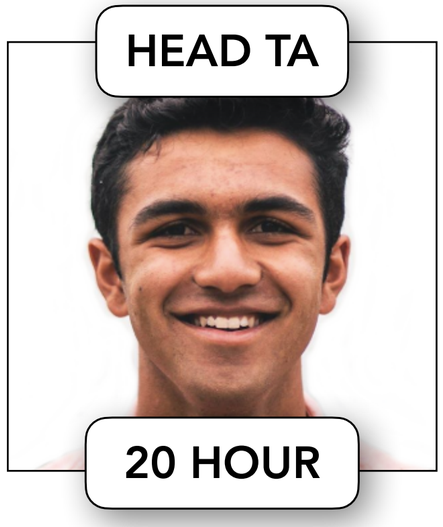


Divi Schmidt

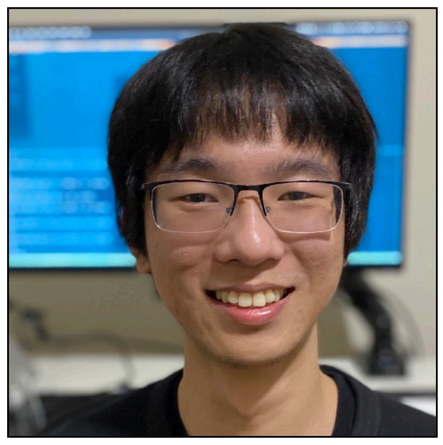
Matt Tancik



Anjali Thakrar



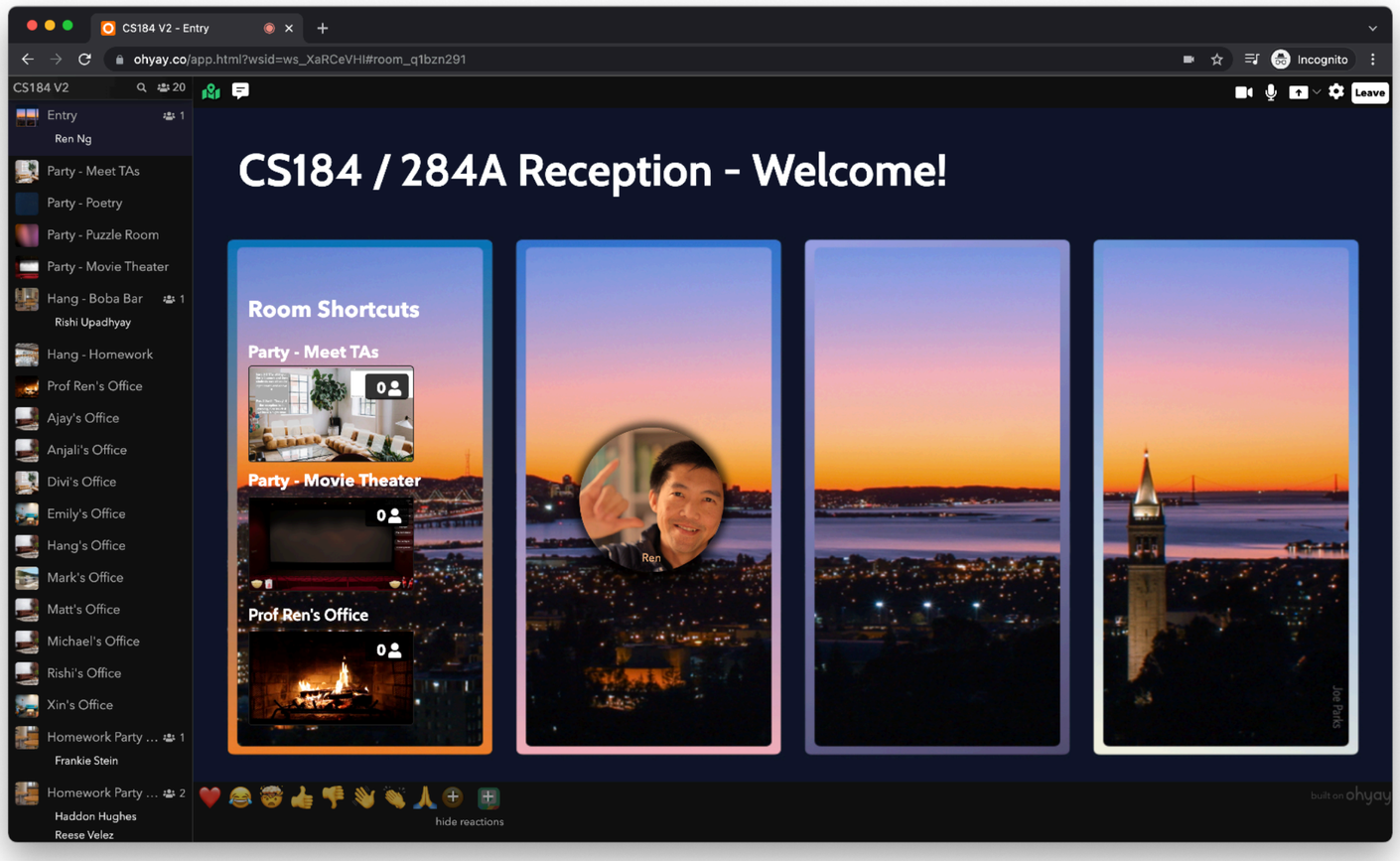
Rishi Upadhyay



Ziyao (Mark) Zhang

Evening Receptions in Ohyay

- Wed (1/19) and Thu (1/20) from 6:30-7:30pm
- Come chat with Ren, TAs, other students
- Details / URL to follow in Piazza
- Custom CS184 ohyay space



CS184/284A: Computer Graphics & Imaging

Why Study Computer Graphics?

Course Overview

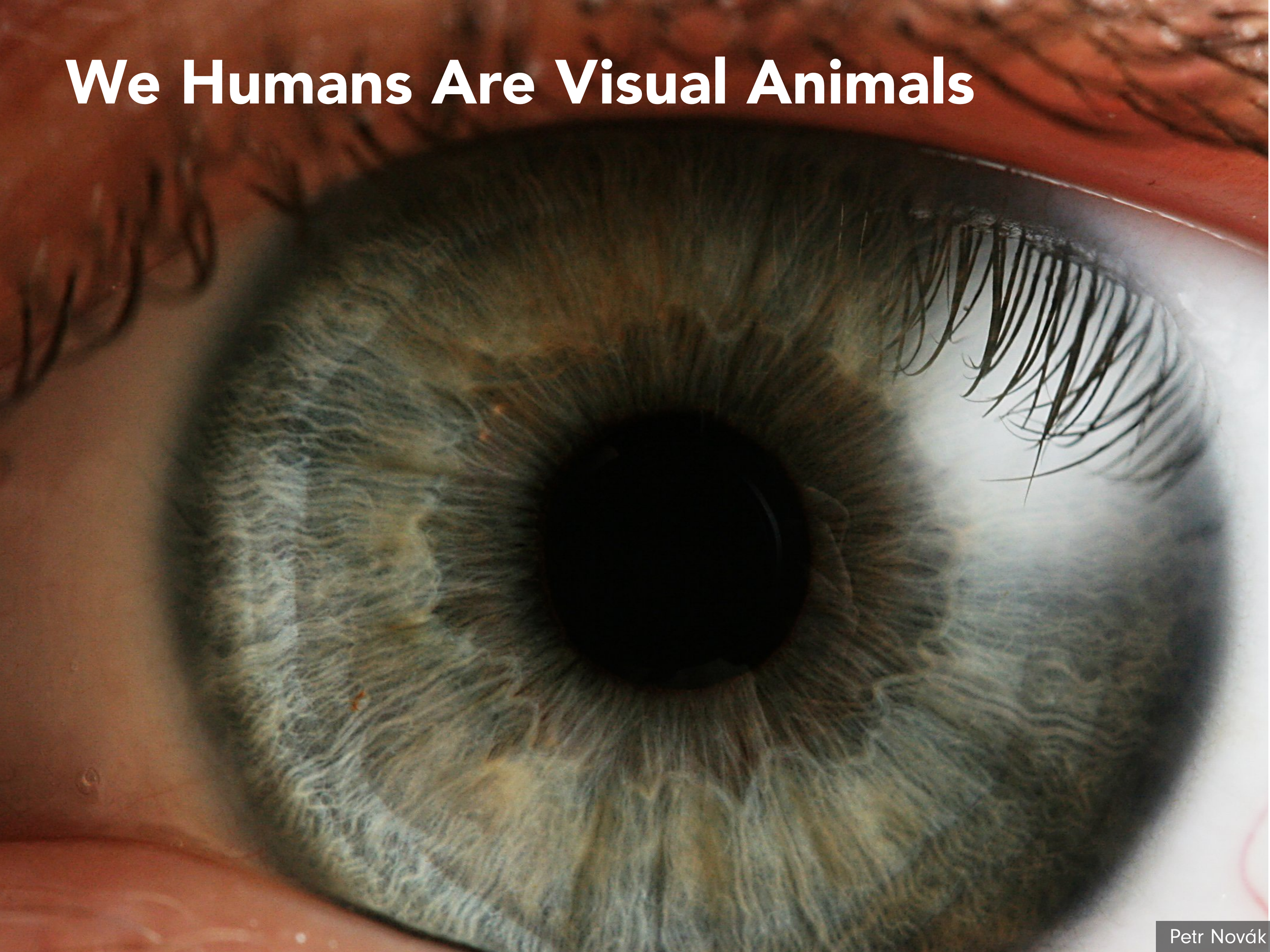
Logistics

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

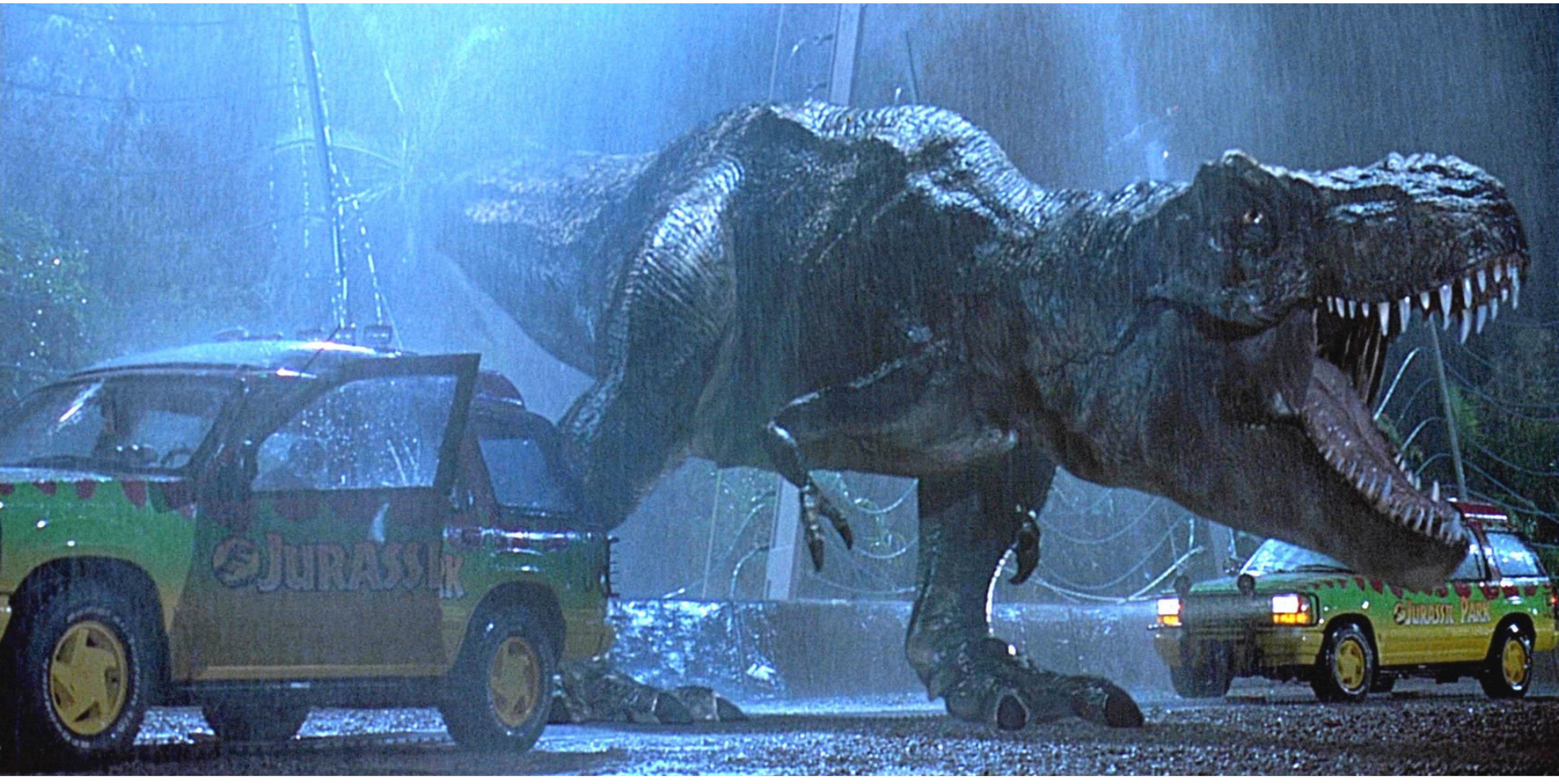
Discussion

Why are you interested in this course?

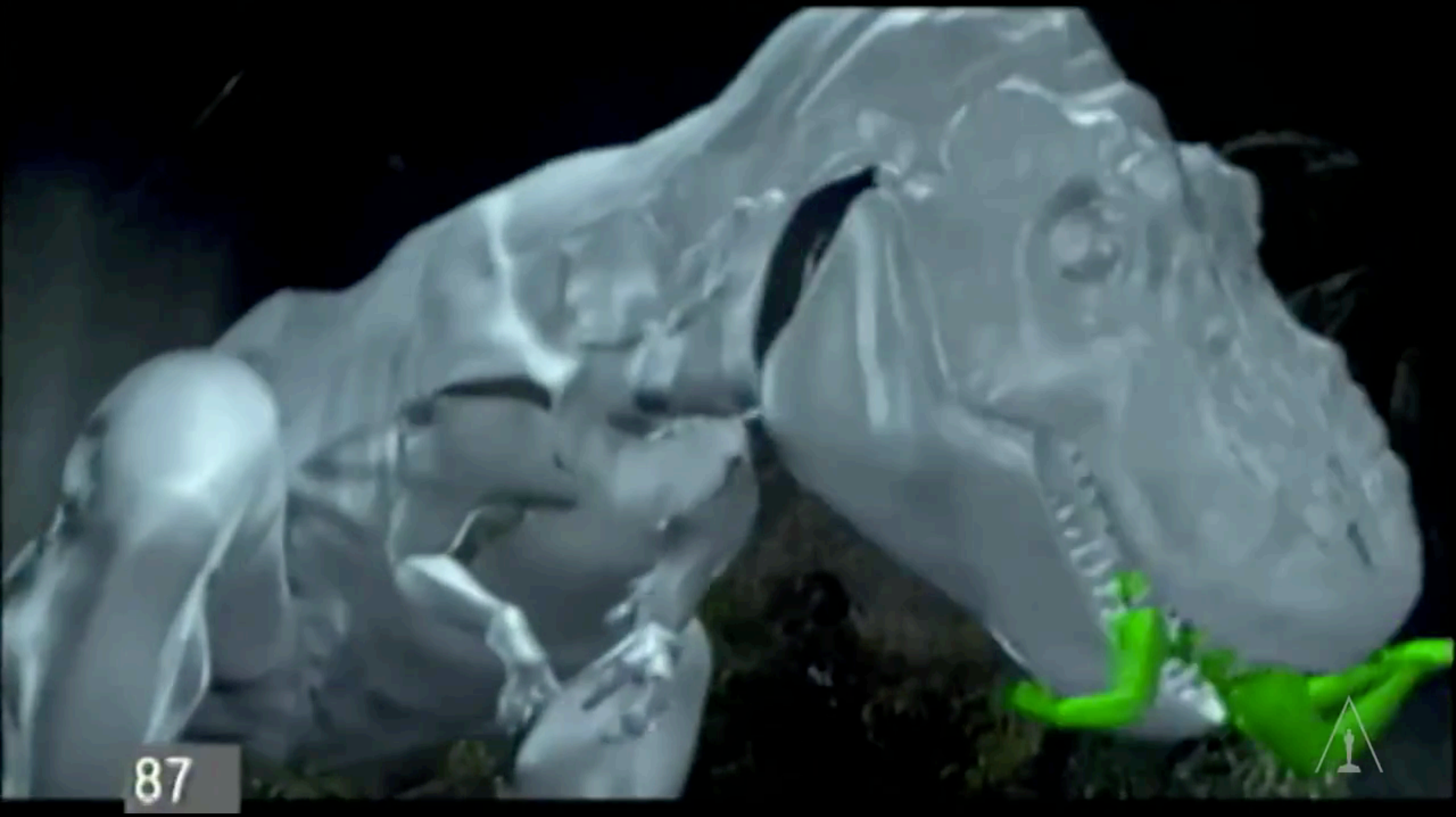
What do you want to learn about graphics & imaging?

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

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Indie VFX

https://www.fxguide.com/fxfeatured/indie-series-1-memories-of-australia/

Games

Crysis 3 (2013)

Product Design and Visualization

Ikea - 75% of catalog is rendered imagery

Product Design and Visualization

Tesla Model X concept (2012)

Product Design and Visualization

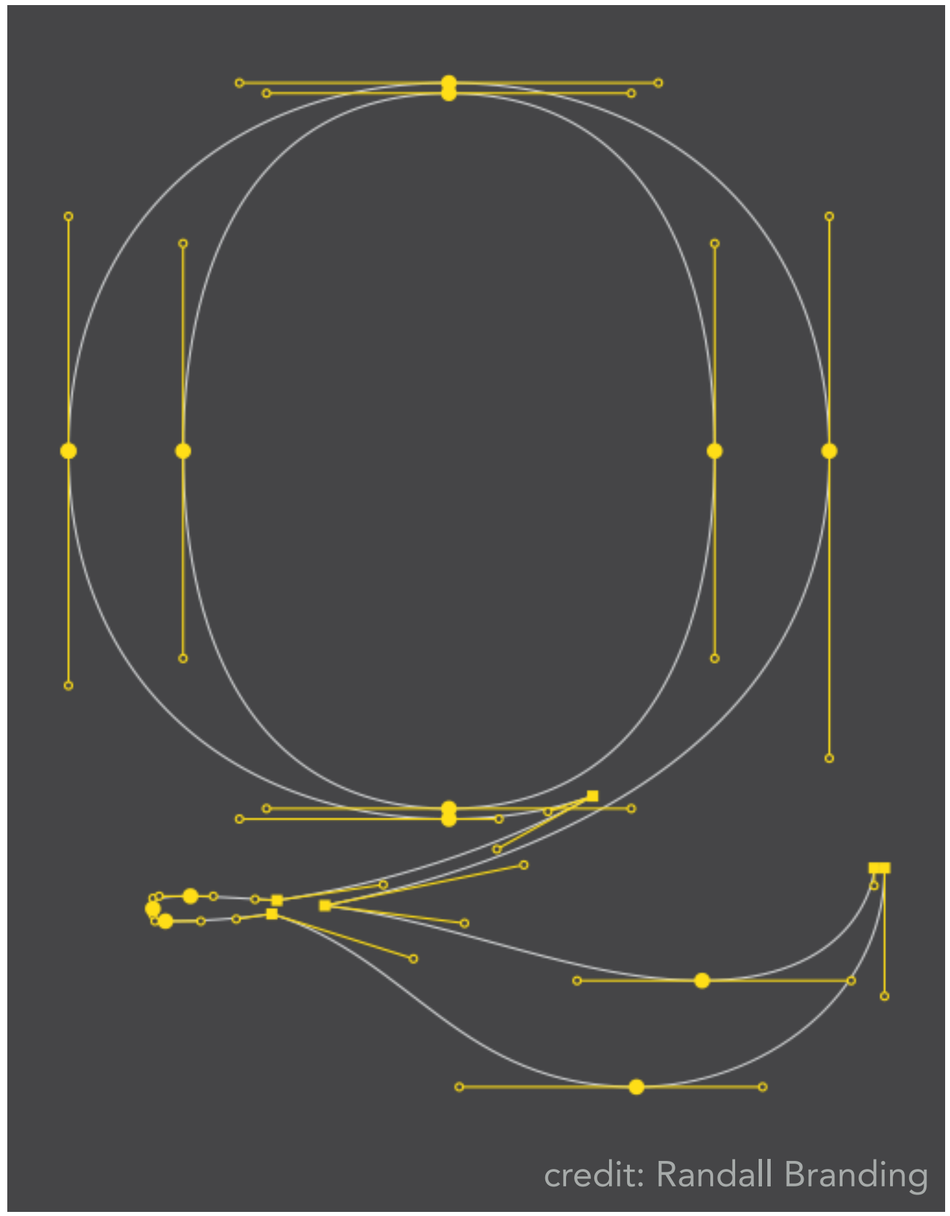
Credit: EV obsession.com, James Ayre

Tesla Model X production

Typography

The Quick Brown Fox Jumps Over The Lazy Dog

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 0123456789



credit: Randall Branding

Baskerville

Illustration

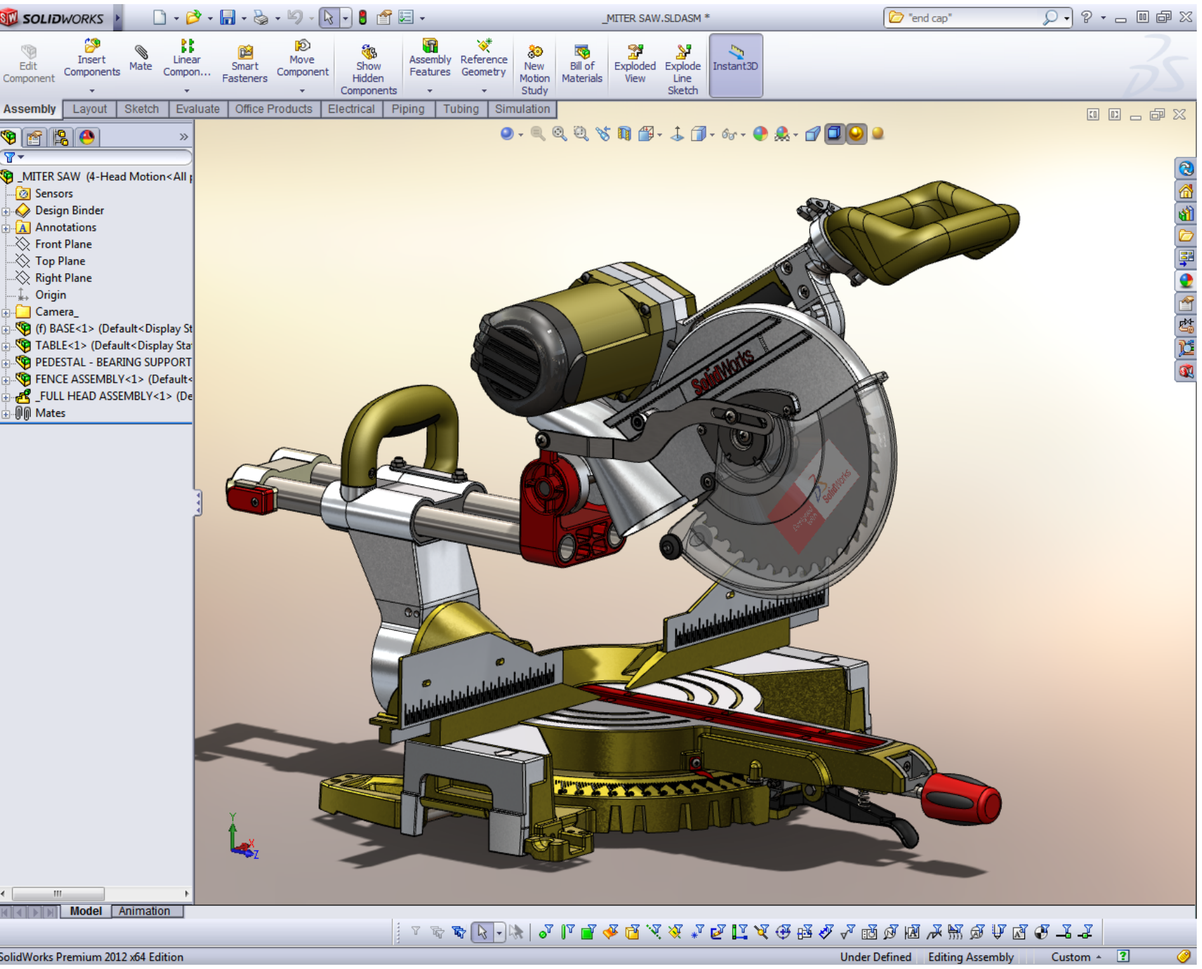
Cave painting c. 36,000 B.C.

Digital Illustration

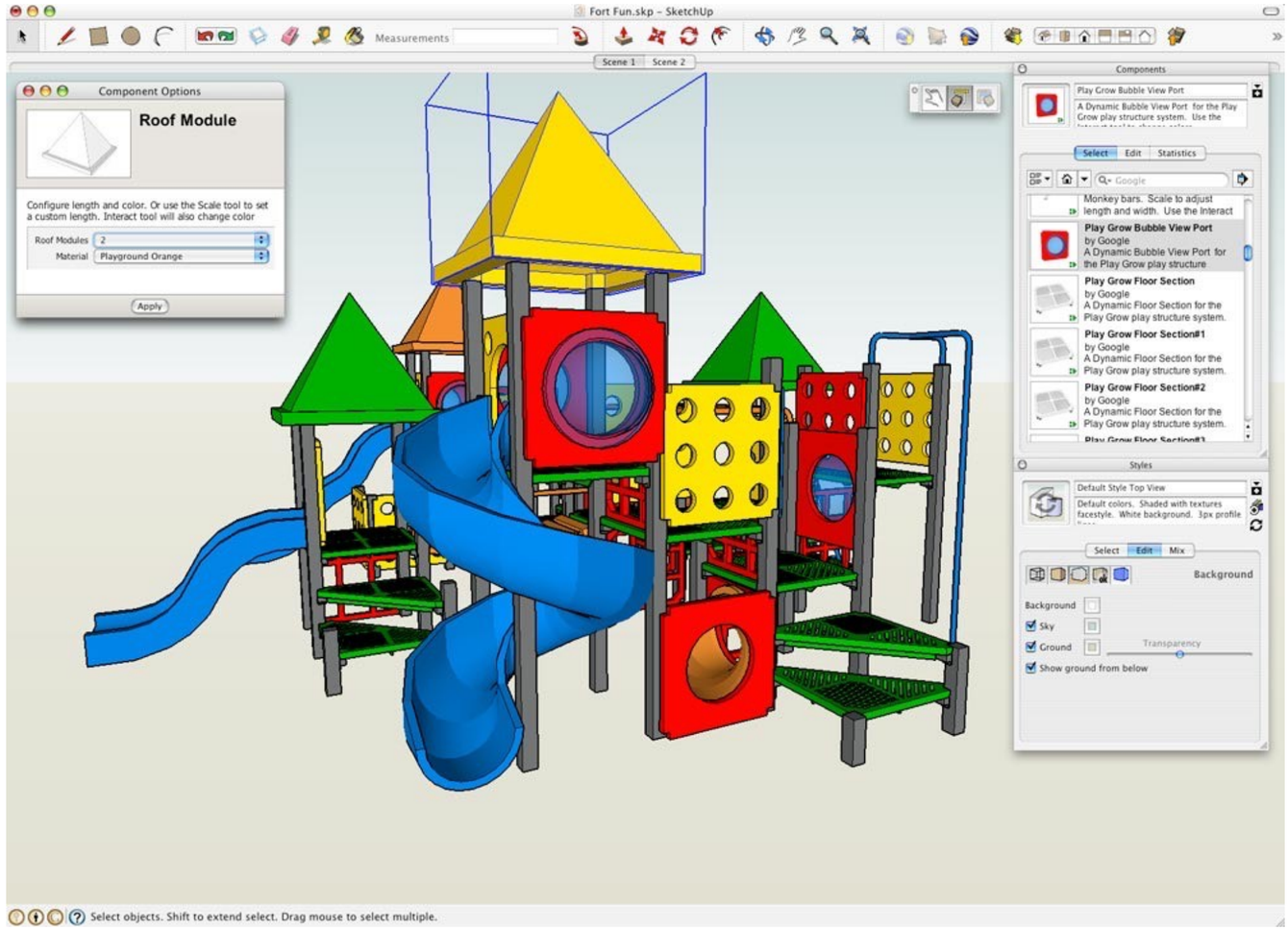
Meike Hakkart

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

Computer-Aided Design



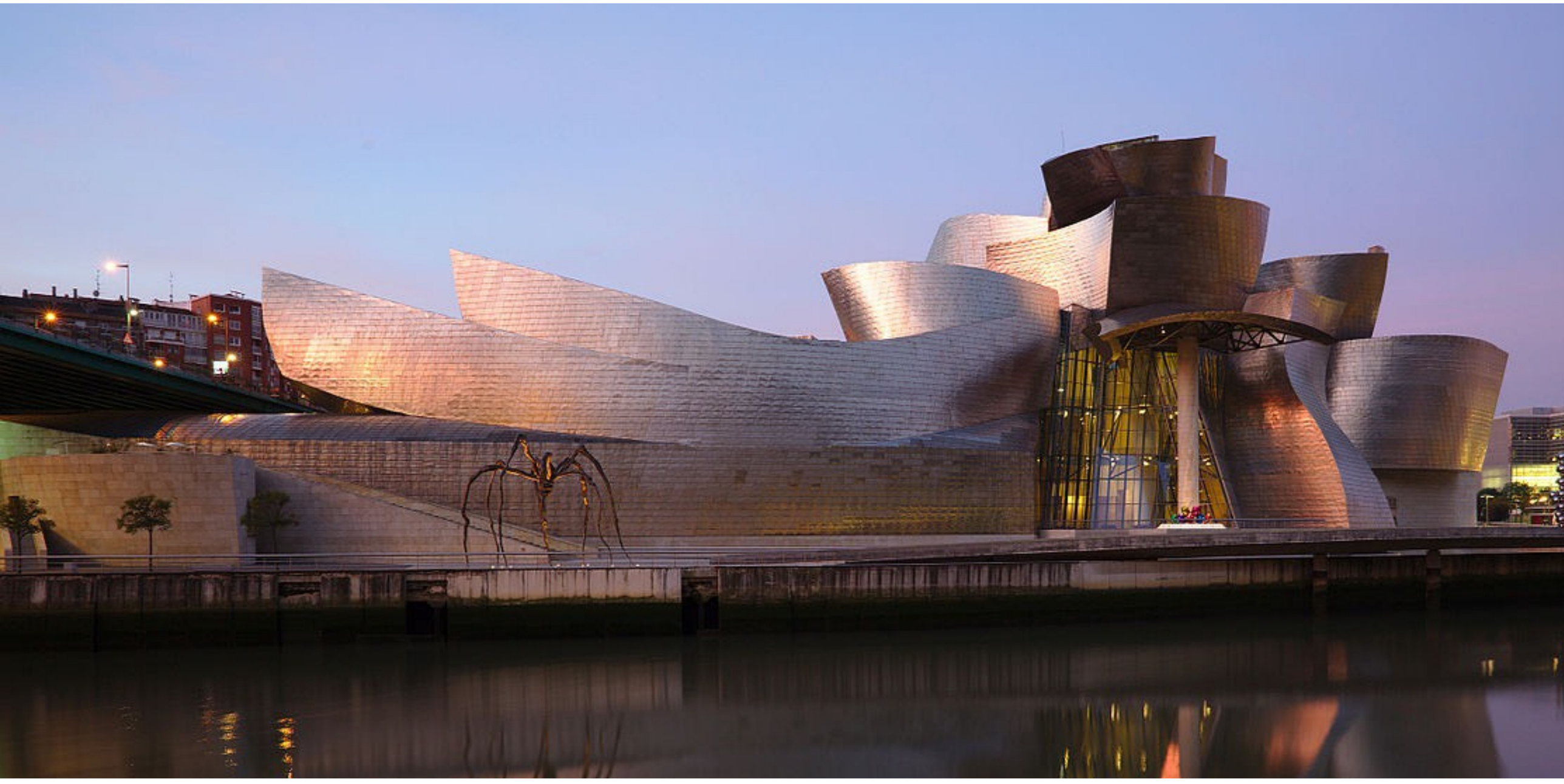
SolidWorks



SketchUp

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

Architectural Design

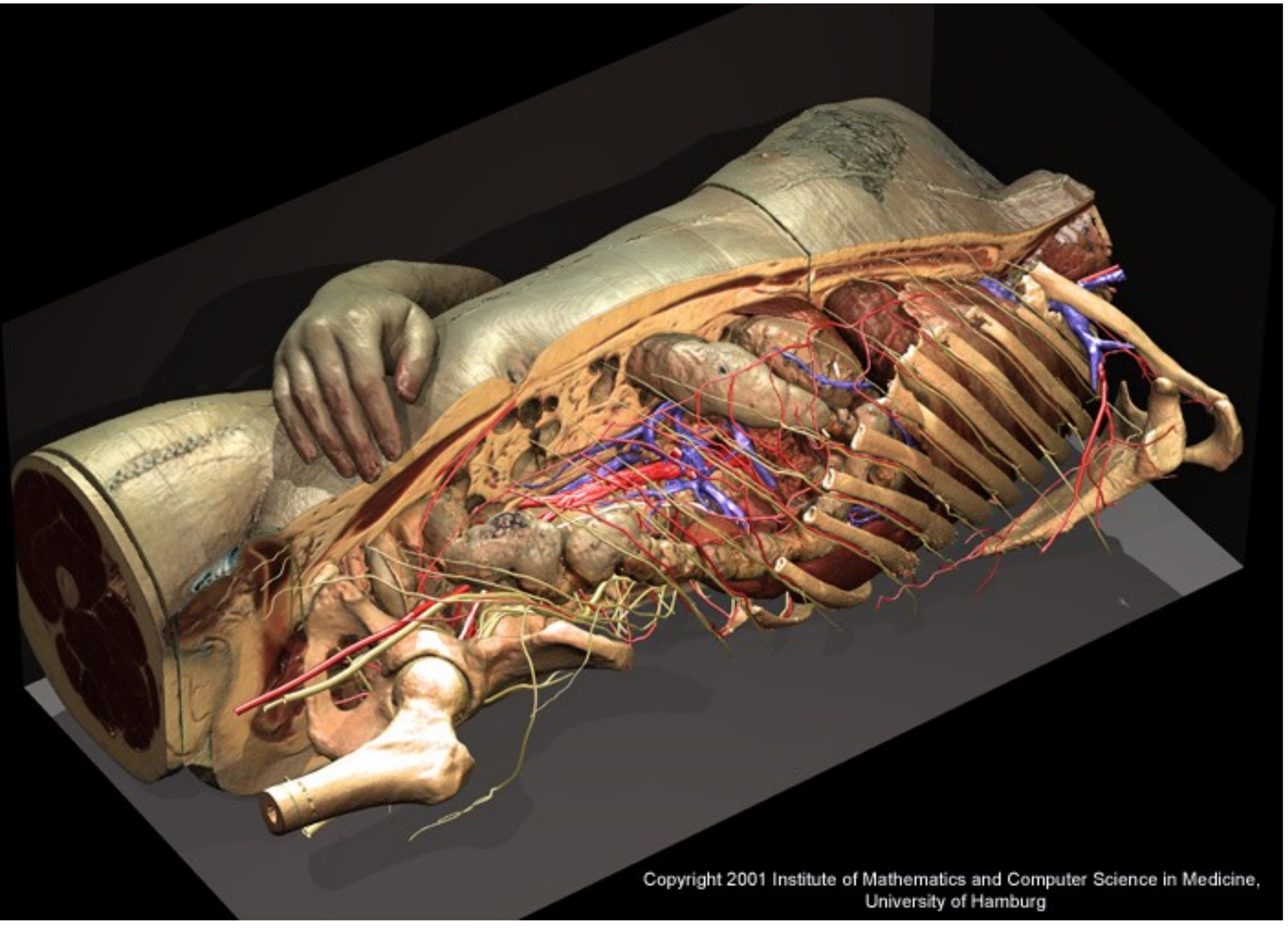


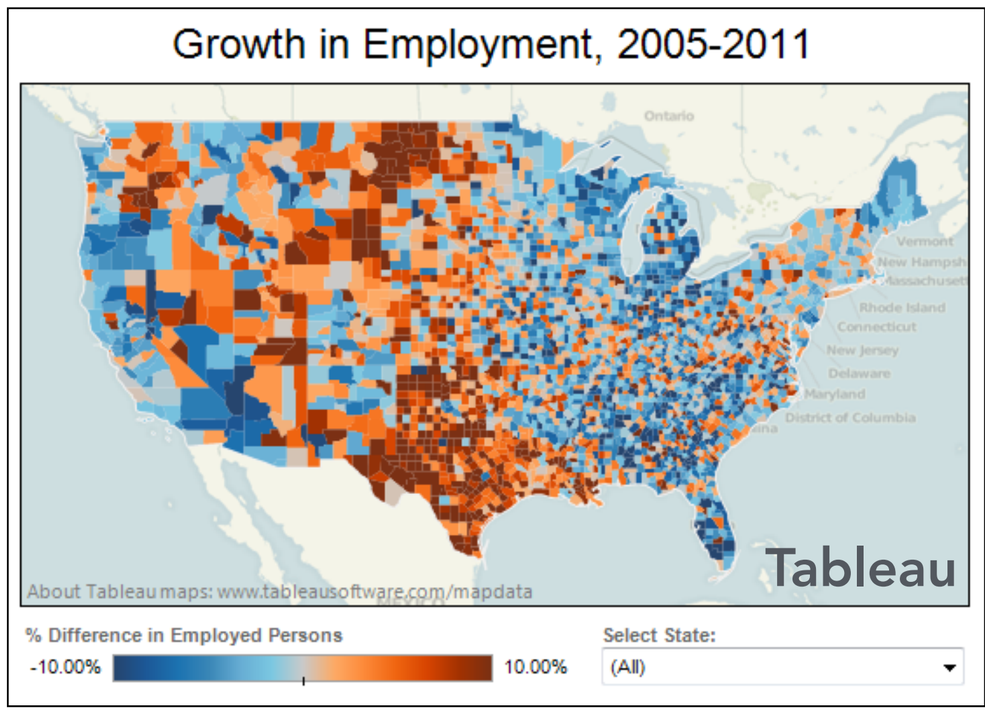
Bilbao Guggenheim, Frank Gehry

Architectural Design

Heydar Aliyev Center, Zaha Hadid Architects

Visualization





Science, engineering, medicine, journalism, ...

Visual Simulation

Driving simulator
Toyota Higashifuji Technical Center

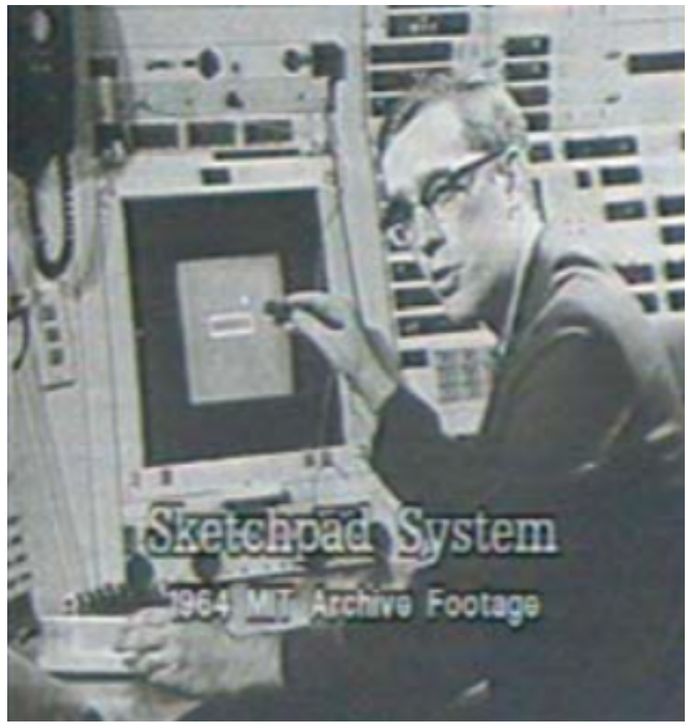
da Vinci surgical robot
Intuitive Surgical

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

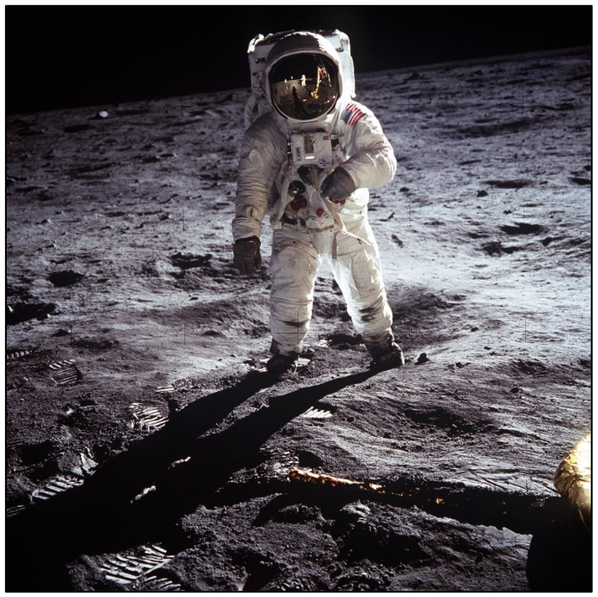
2D drawing and animation are ubiquitous in computing.

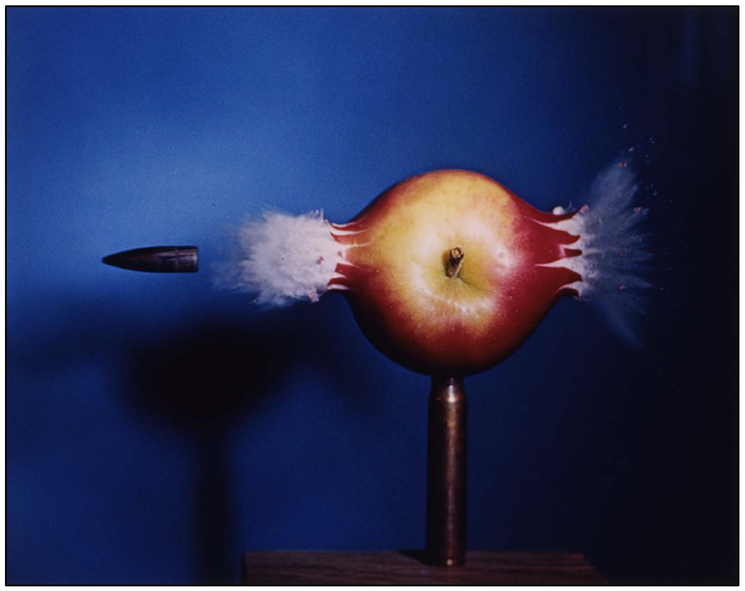
Typography, icons, images, transitions, transparency, ...

Graphical User Interfaces

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

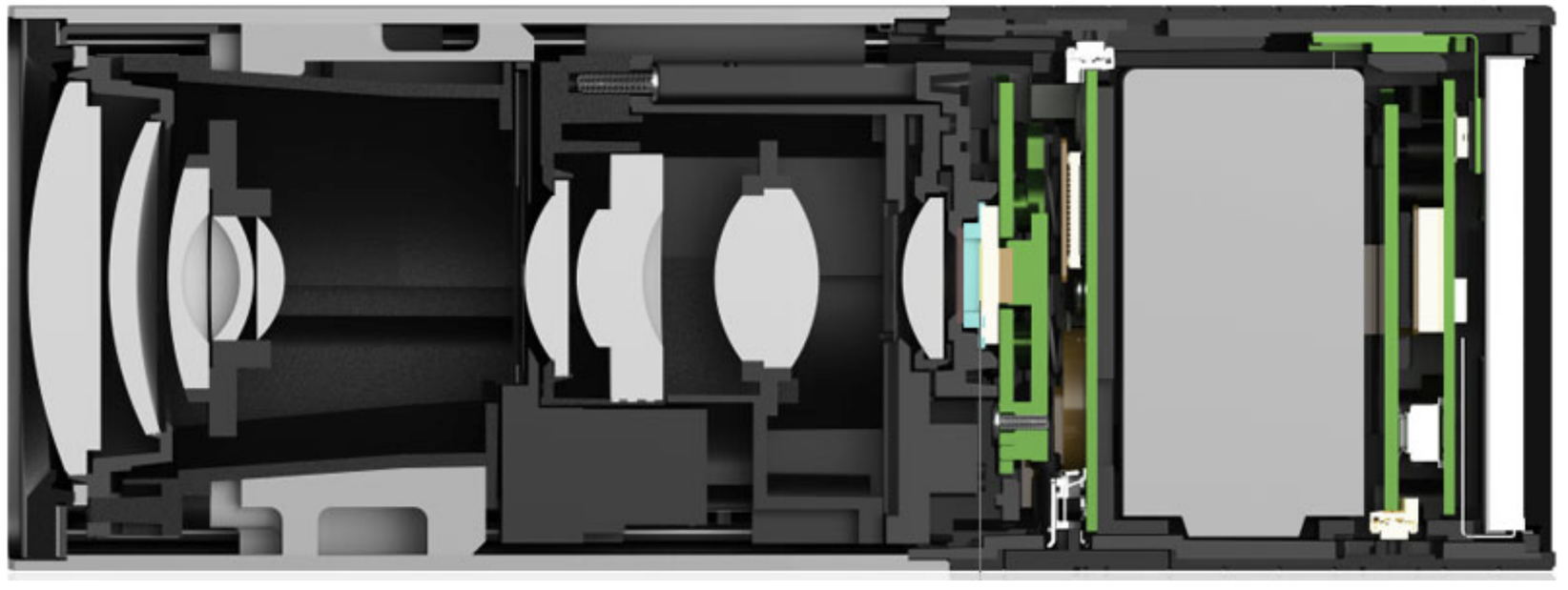
Photography





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

Digital and Computational Cameras

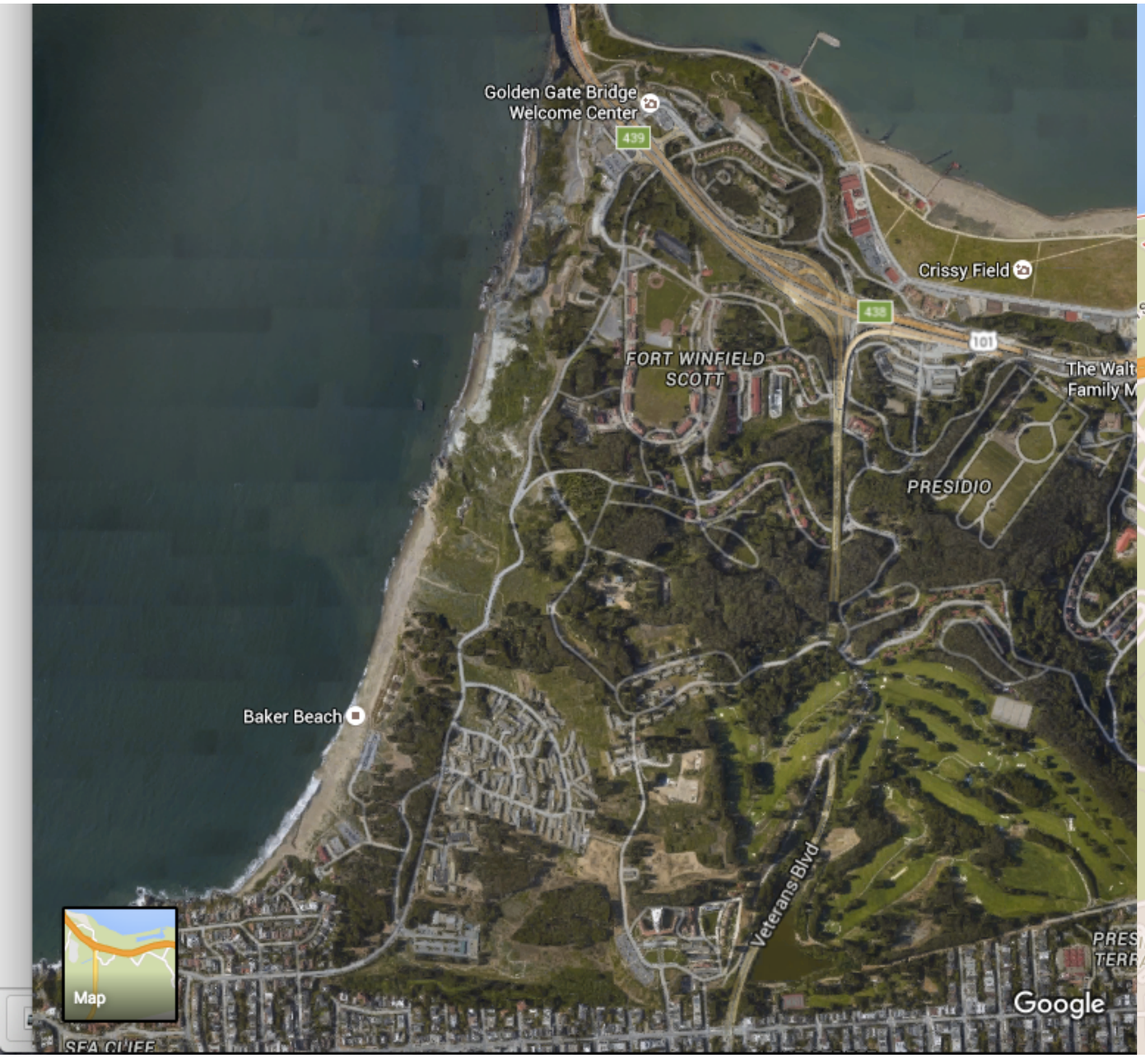


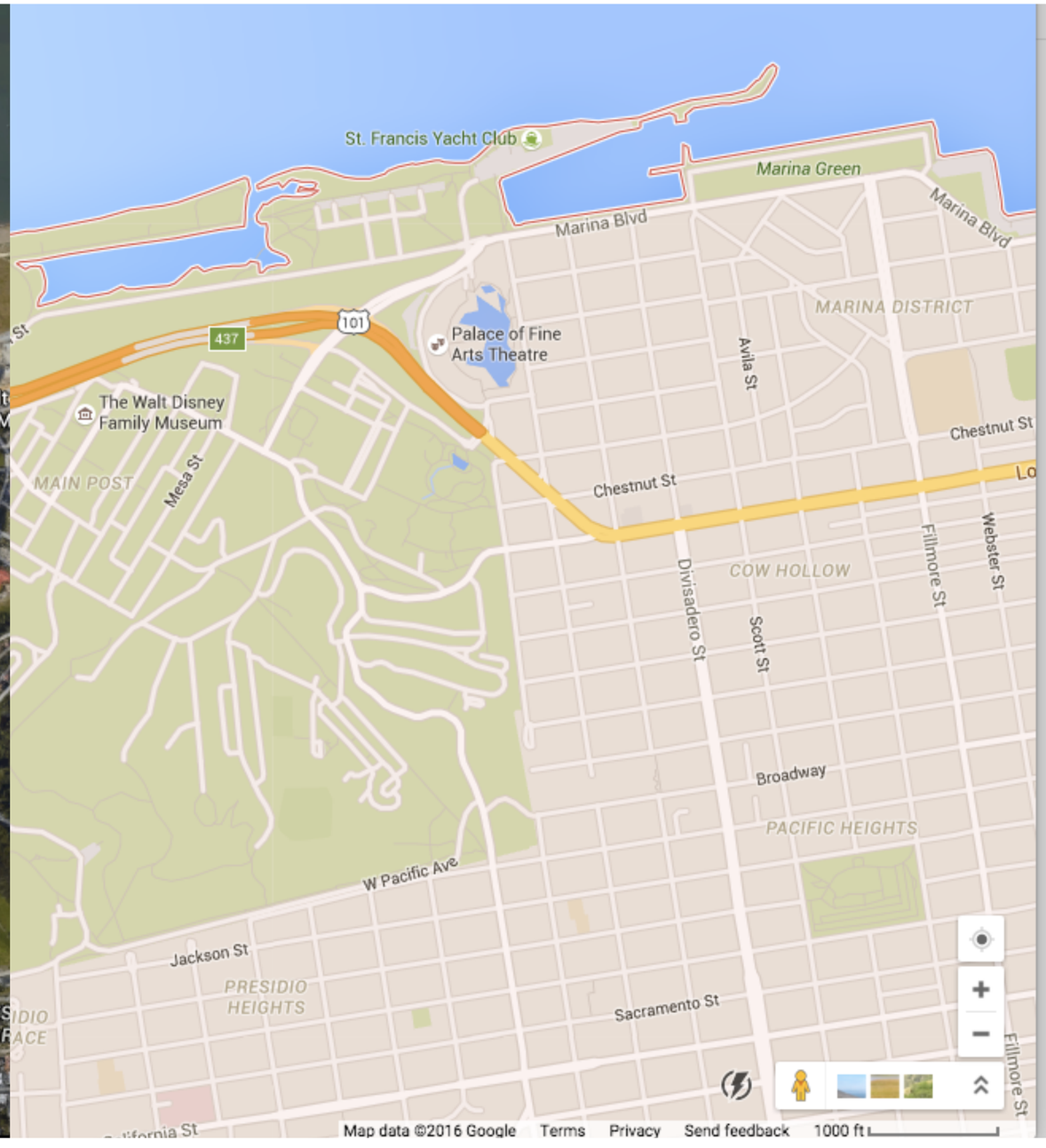
Panaromic stitching, HDR photos, light field cameras, …

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)

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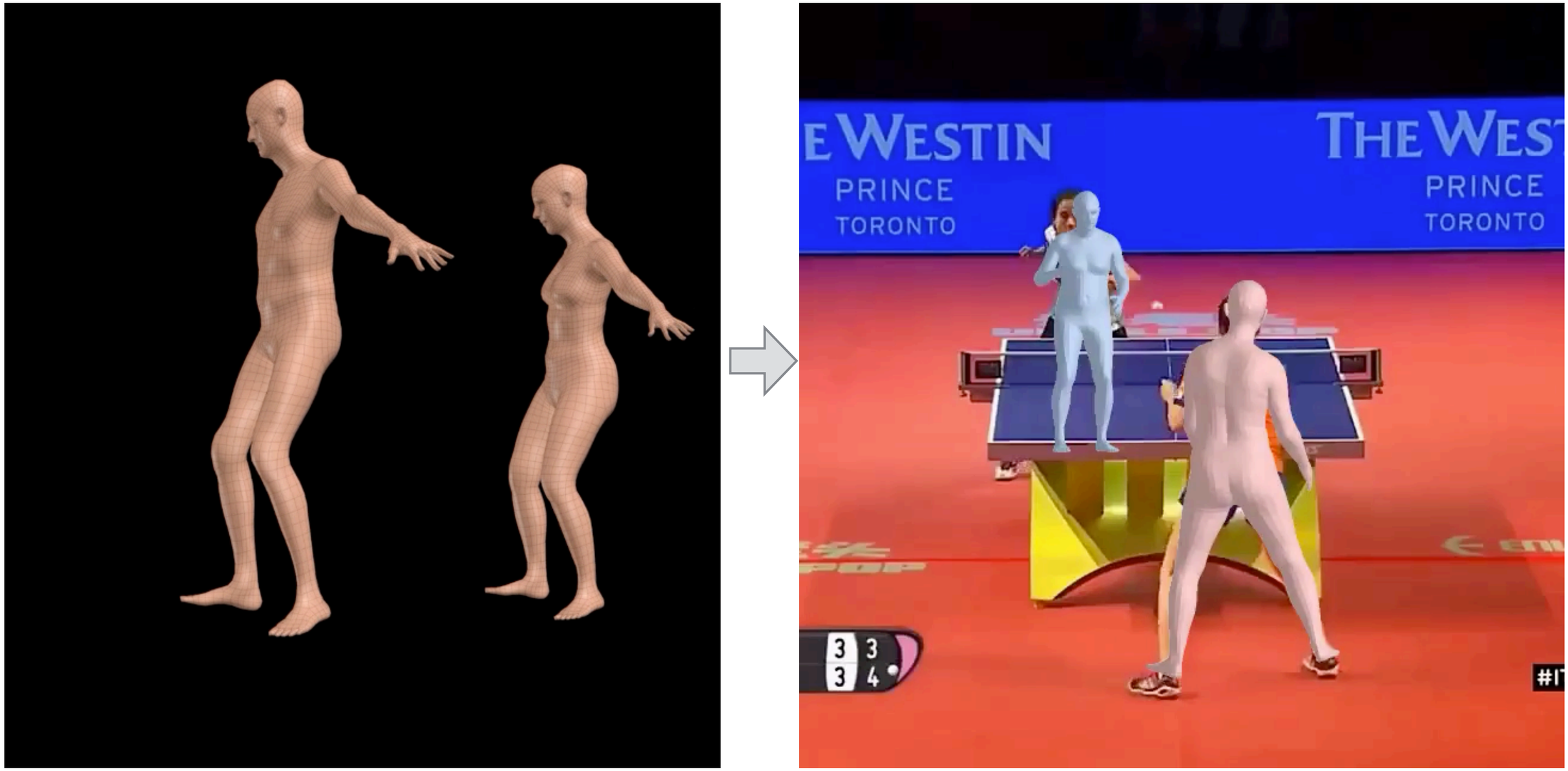
Inverse Graphics



Markerless Motion Capture from a single image/video

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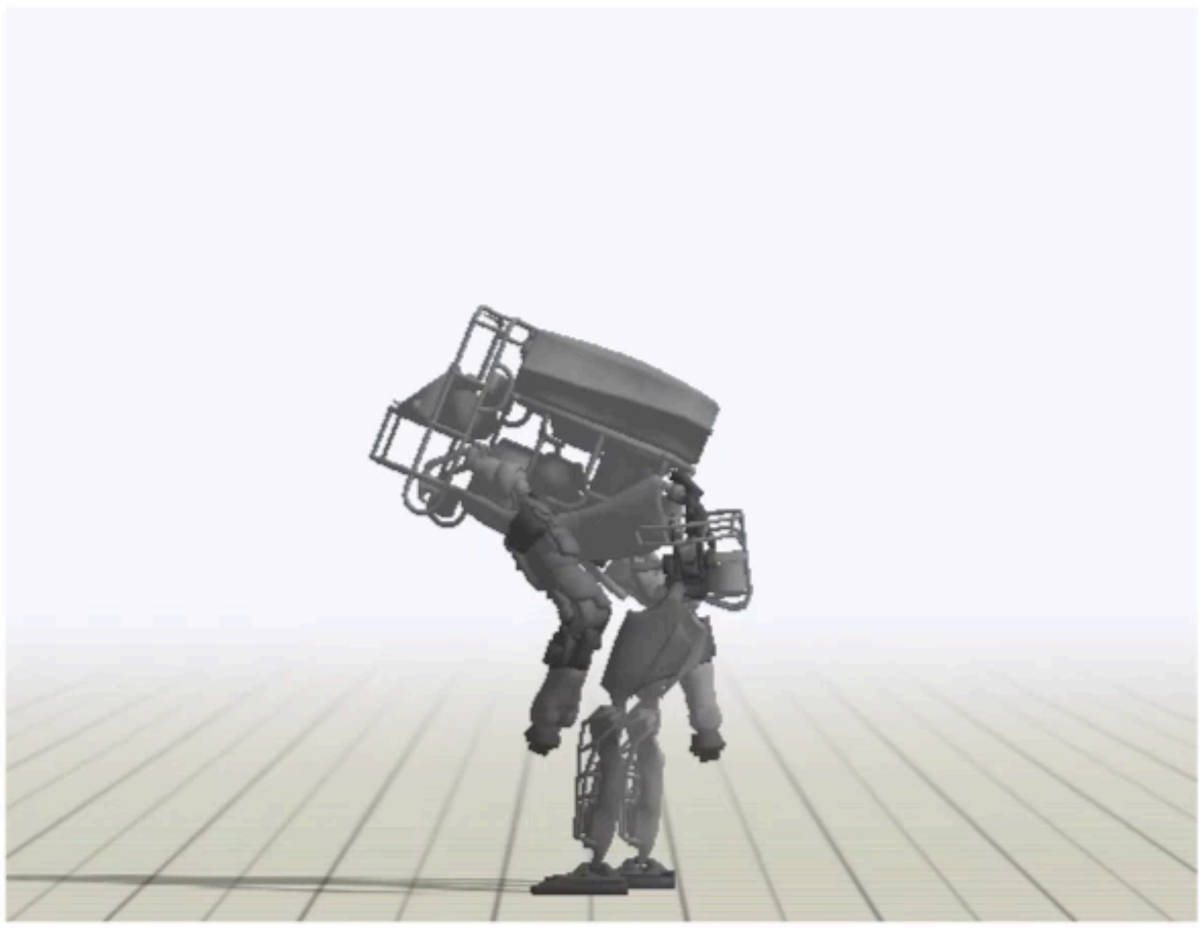
Inverse Graphics

Video: Handspring A



Policy

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

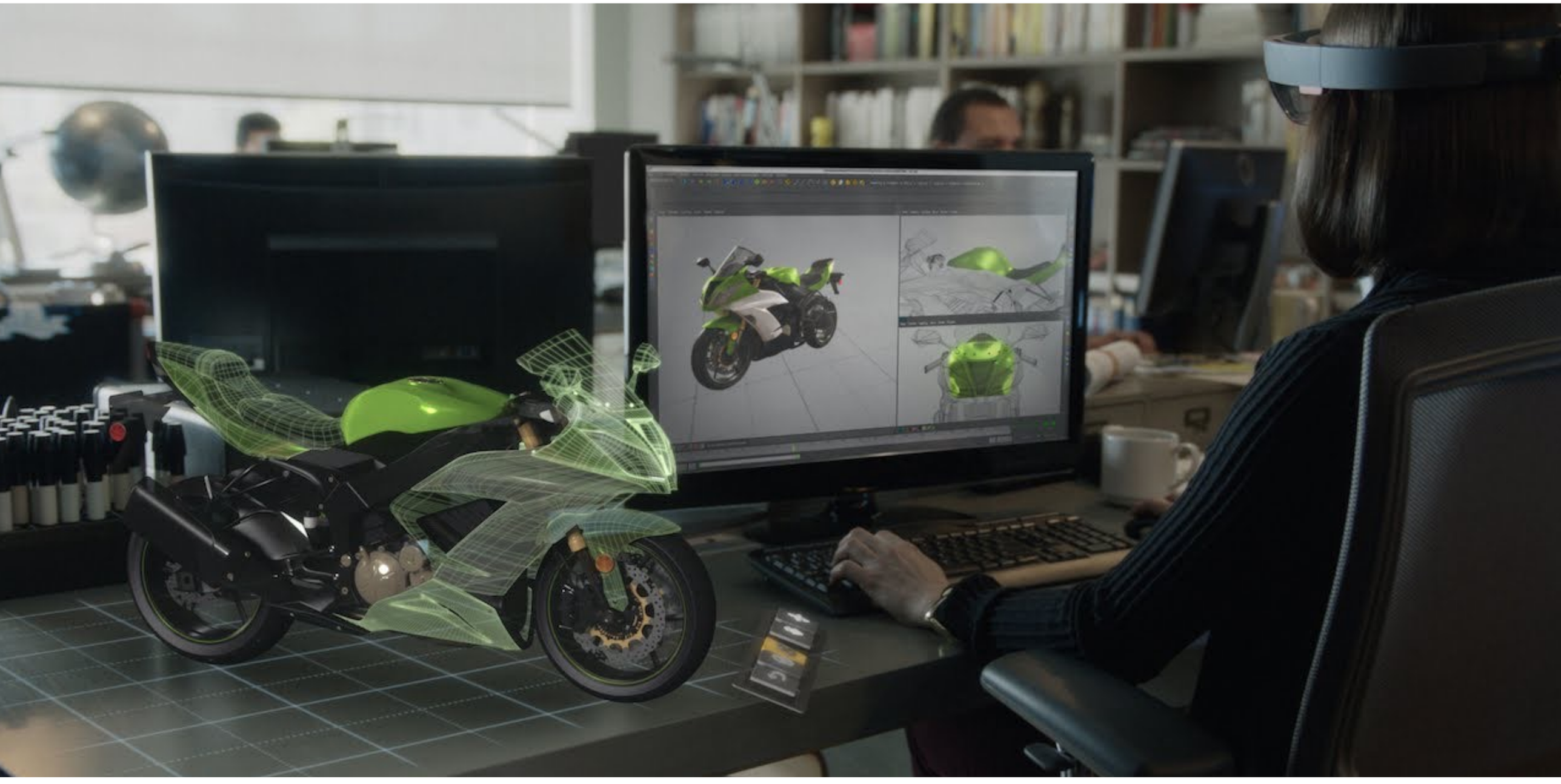
Imaging for Robotics

Google's "Arm Farm"

Virtual Reality

HTC Vive headset and controllers

Augmented Reality



Microsoft Hololens augmented reality headset concept

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

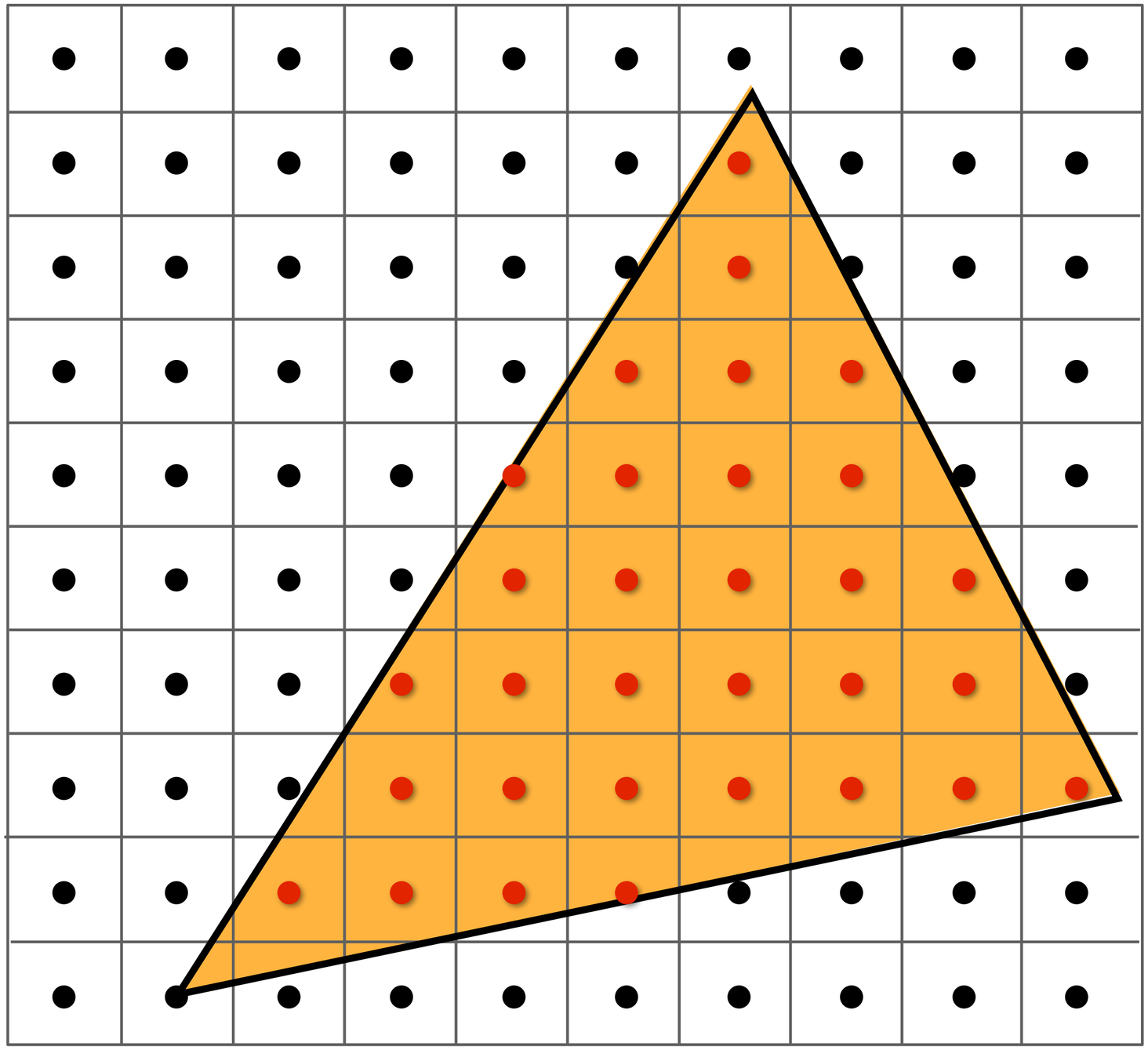
- Modeling the world, image synthesis
- 3D graphics: geometry, rendering, animation
- Image capture, manipulation and display

Acquire core concepts and skills

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

Course Topics

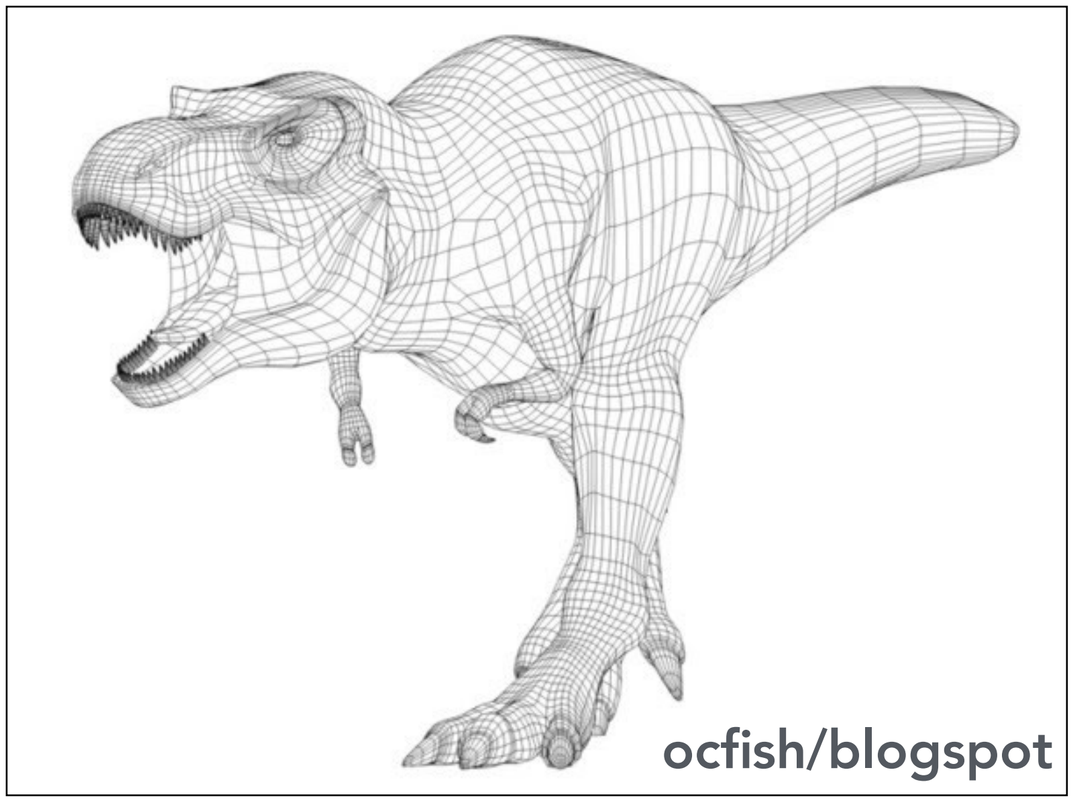
Drawing Digital Images (Rasterization)

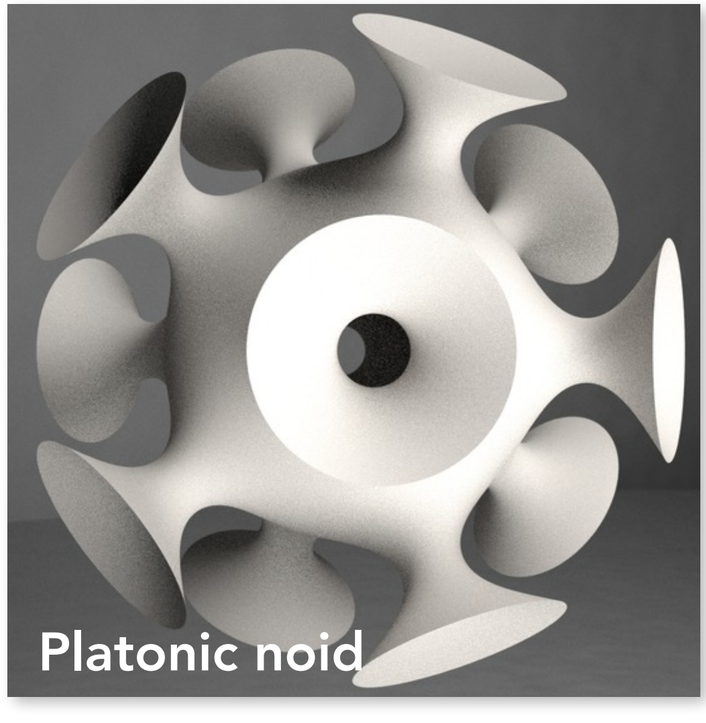


Filtering and Sampling

No Jaggies

Modeling Geometry

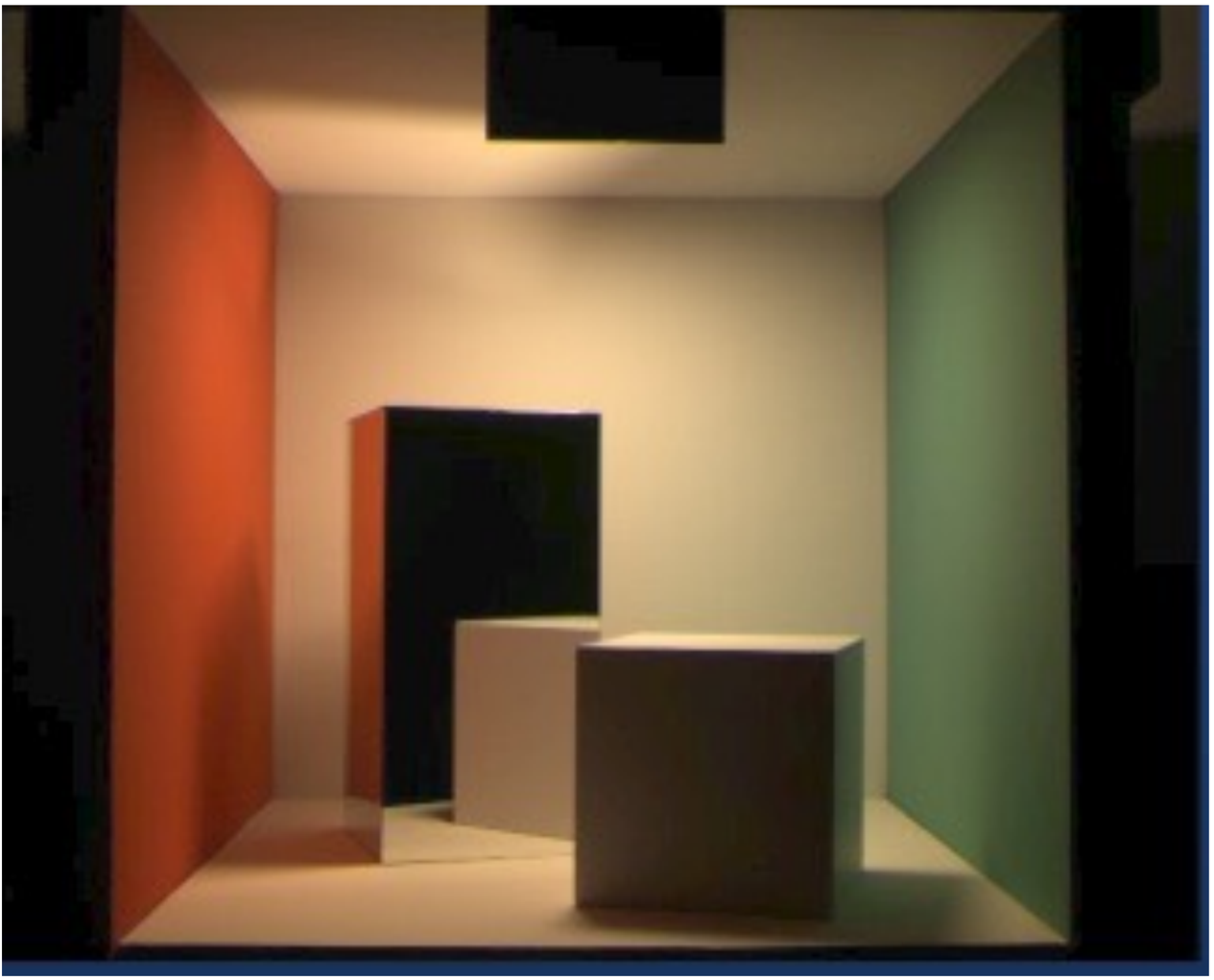




Modeling Material Properties

Modeling Lighting

Light Transport and Image Synthesis



Photograph (CCD) vs. computer rendering

How Do Cameras Work?

Glenn Derene, Popular Mechanics

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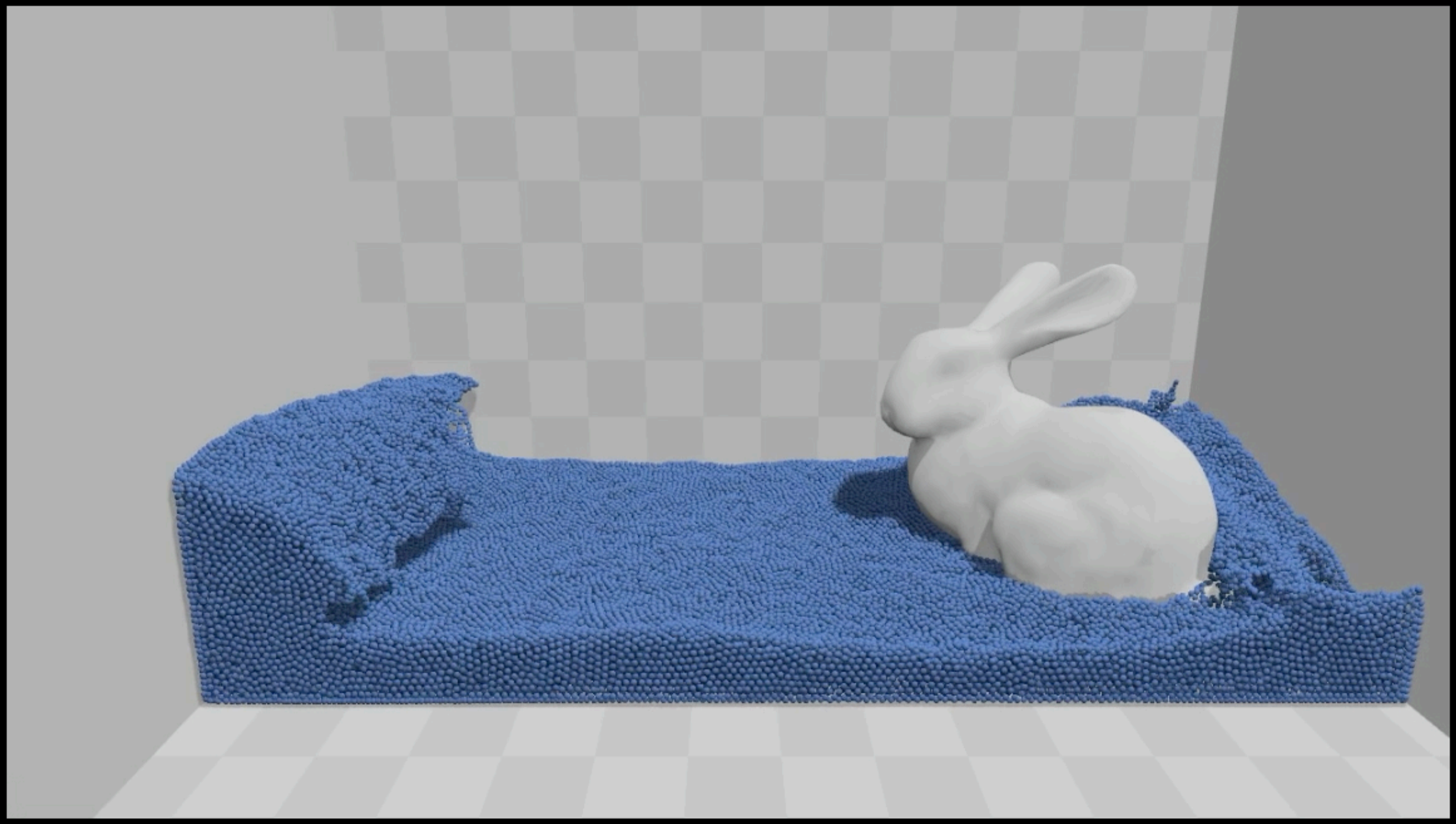
Animation and Physical Simulation

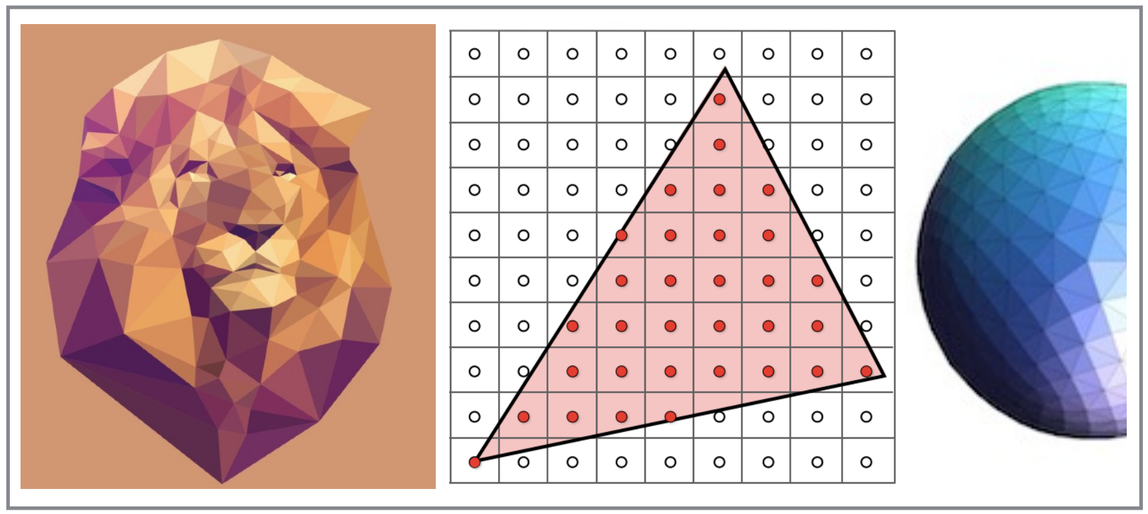


Position Based Fluids, Macklin and Müller

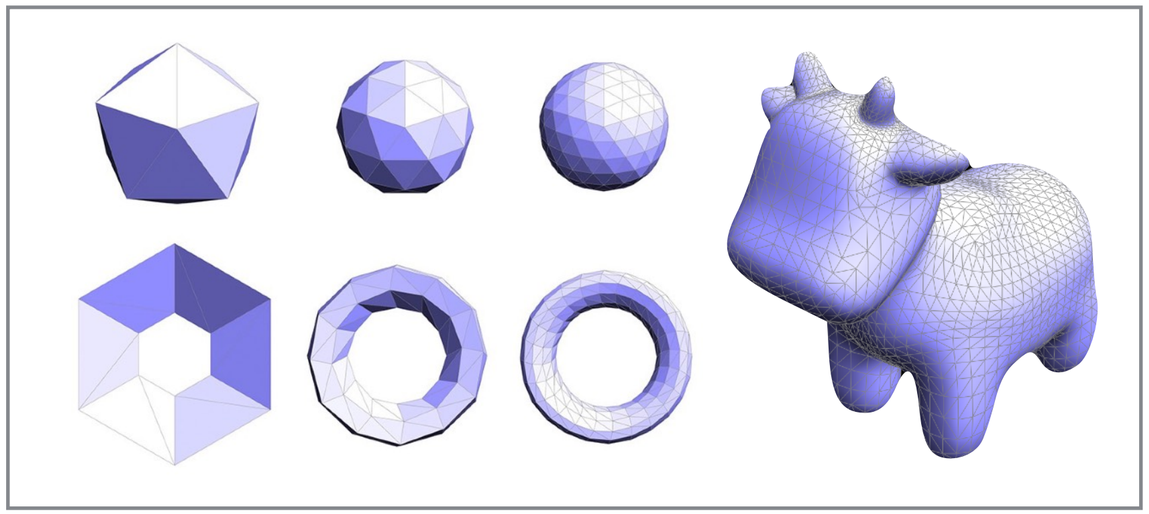
Virtual Reality

Hands-On Learning

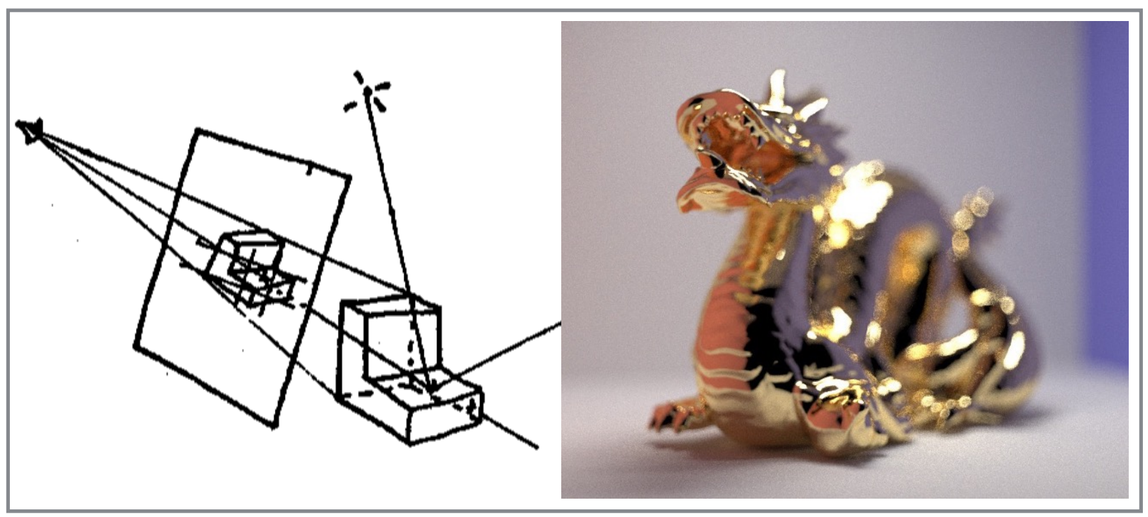
Course Assignments



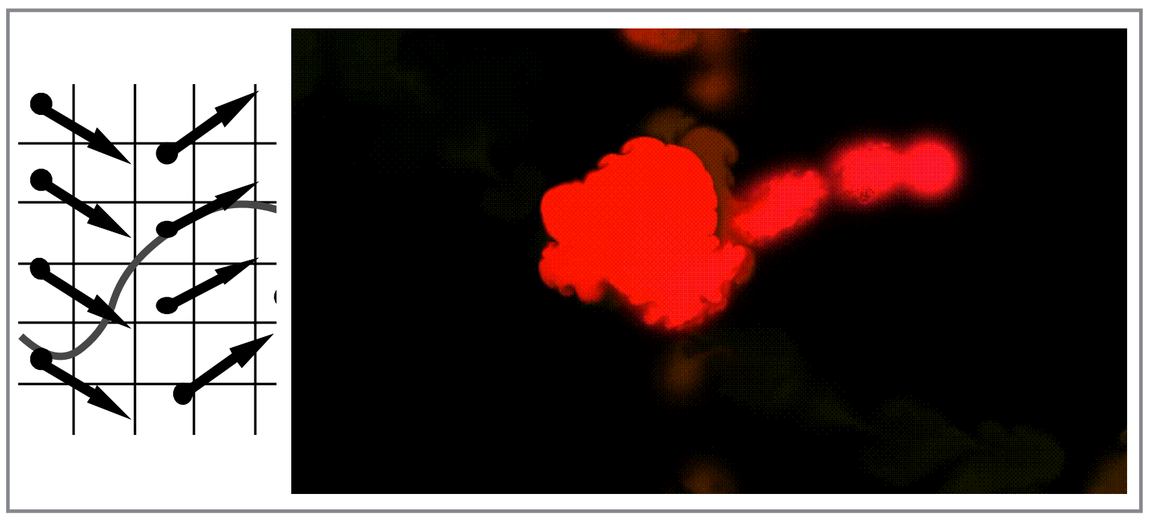
1. Digital Drawing (2 weeks)



2. Geometry (2 weeks)



3. Ray-Tracing (4 weeks)



4. Animation (2 weeks)

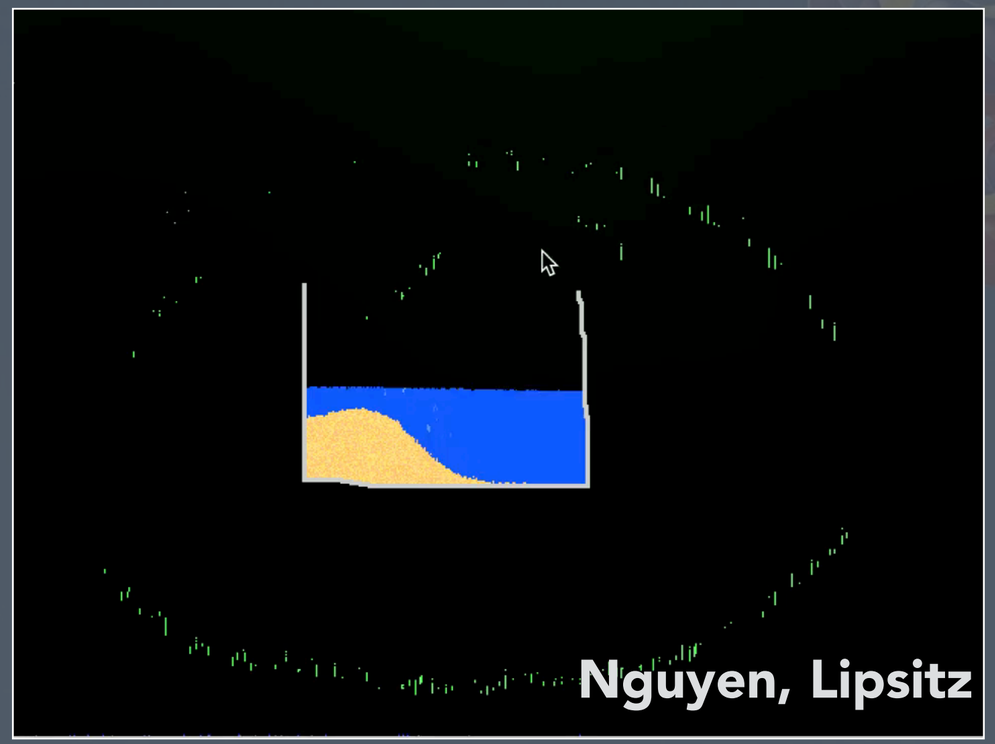
Final Project

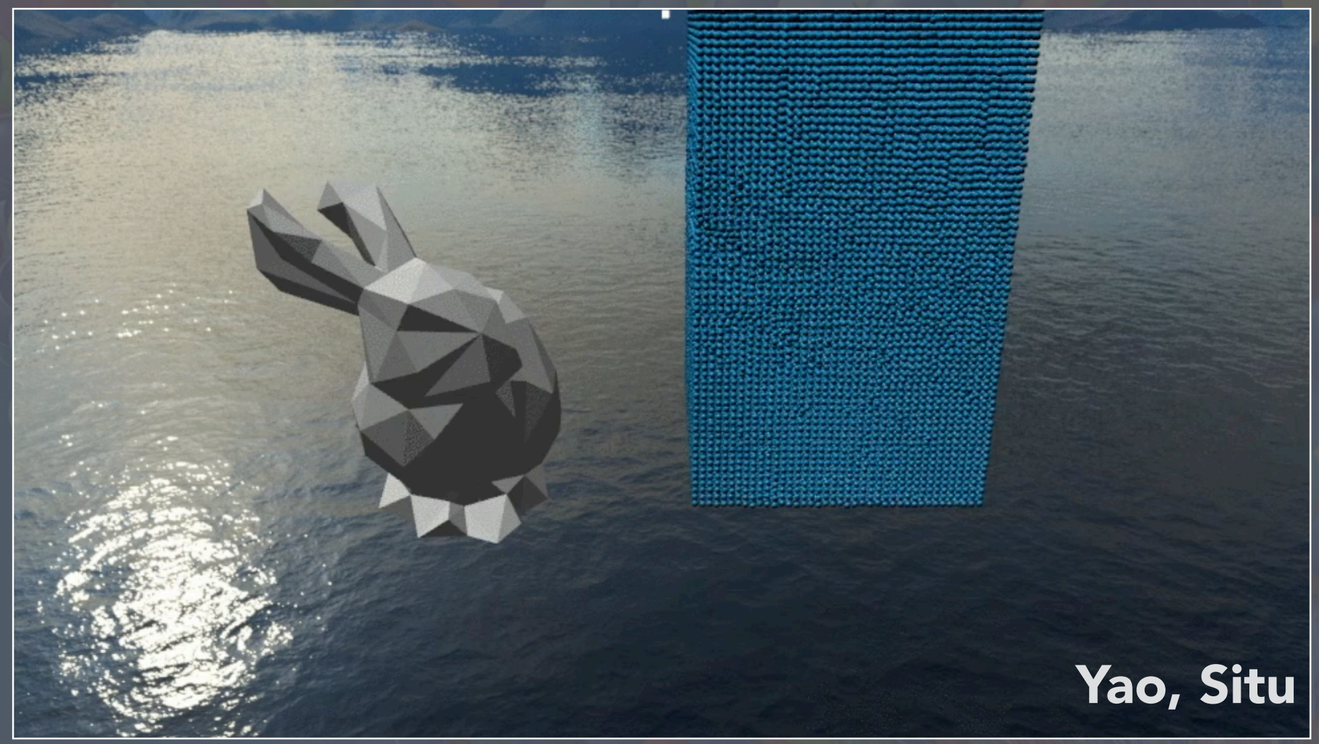
Project Competition

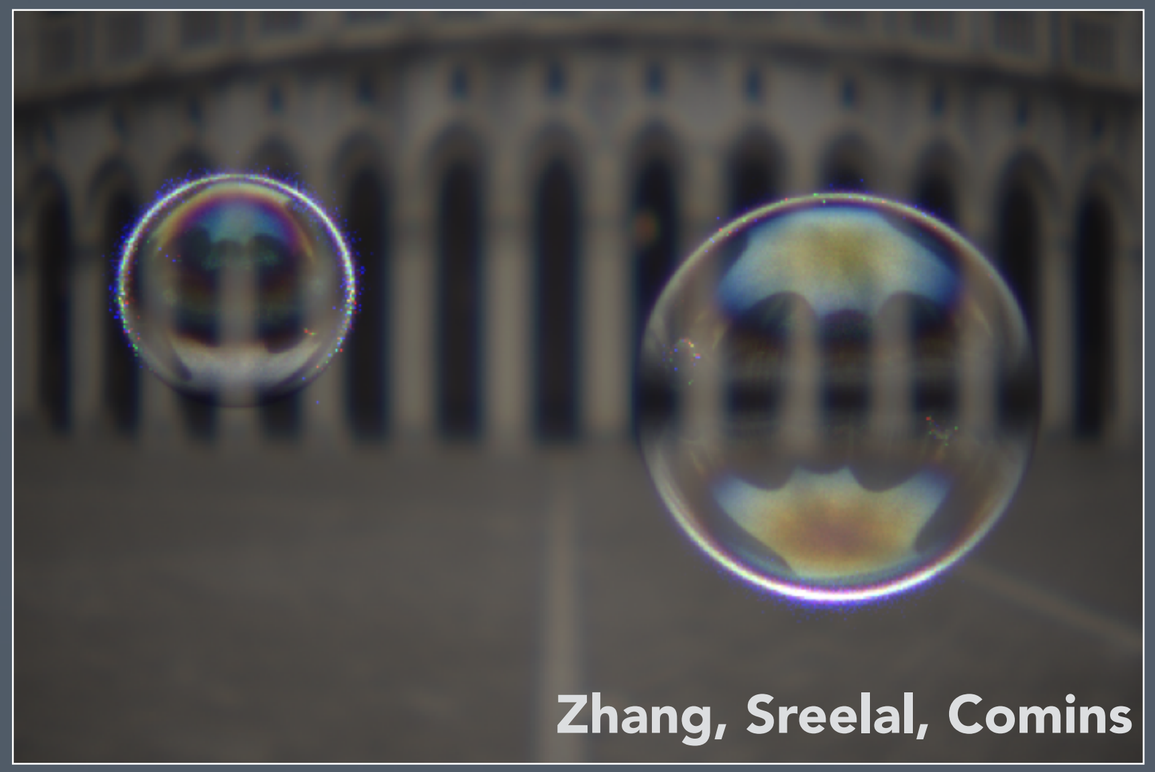
- 4 weeks, let your creativity take flight!
  (we will have suggested projects)
- Proposal; checkpoint; presentation, video, report

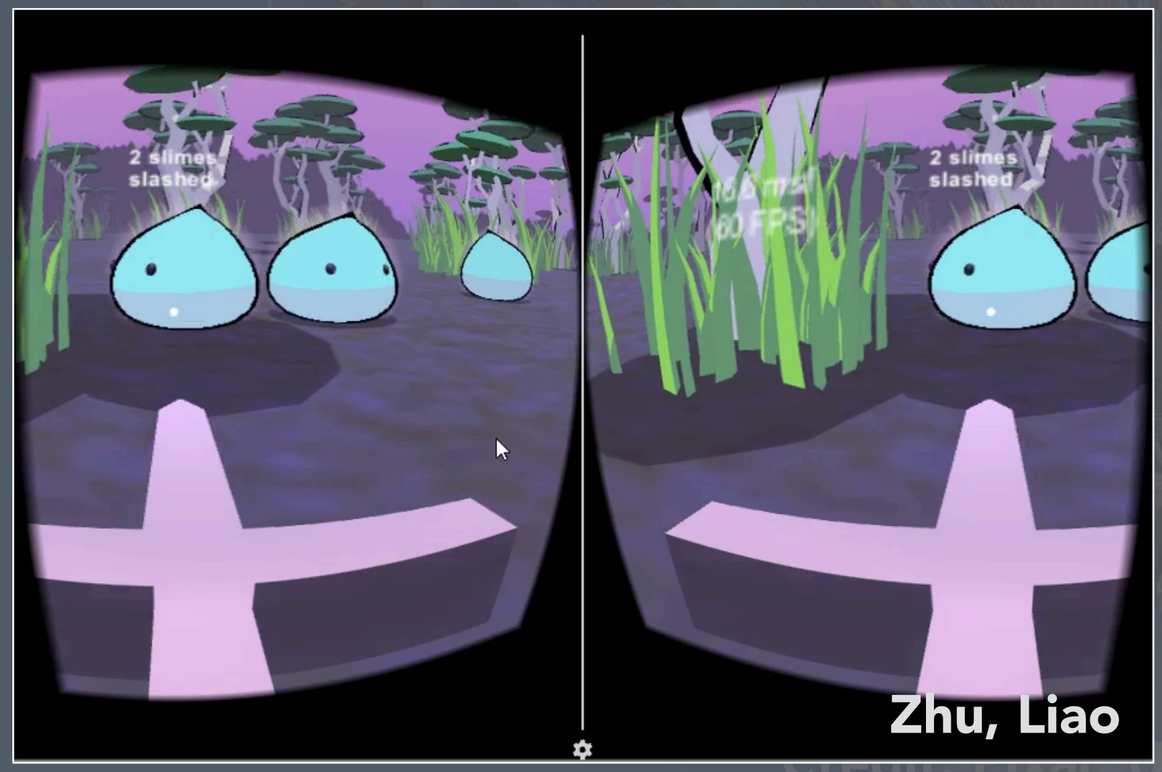
Credit: Pixar, Up

Final Project - Examples

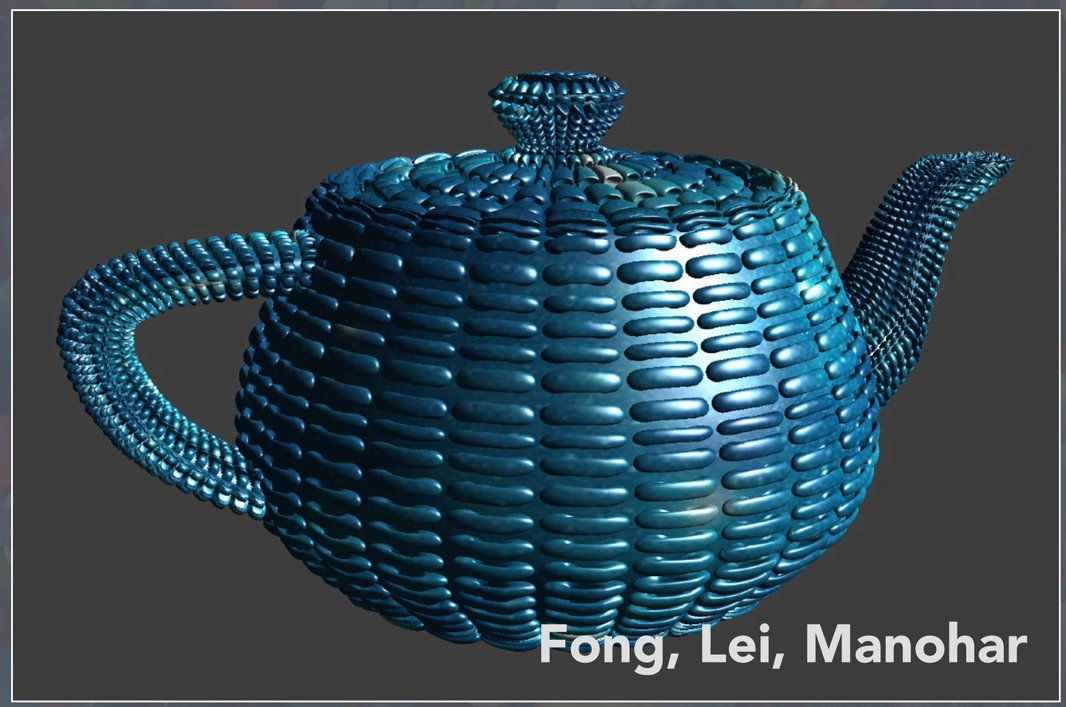


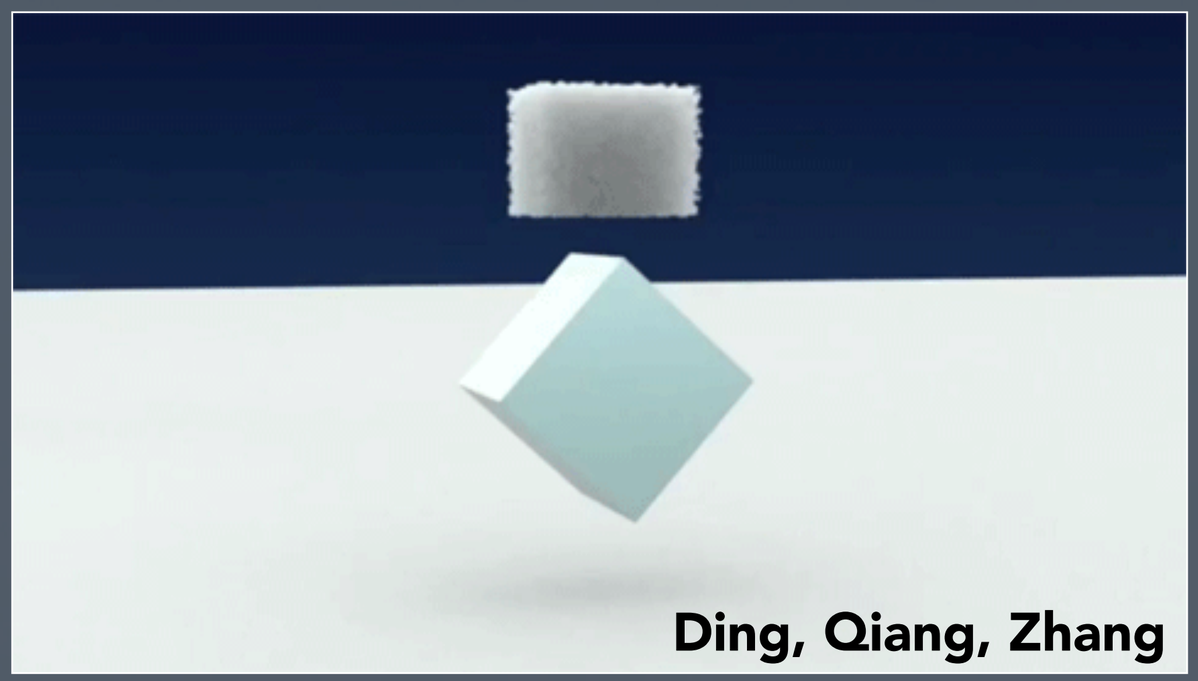


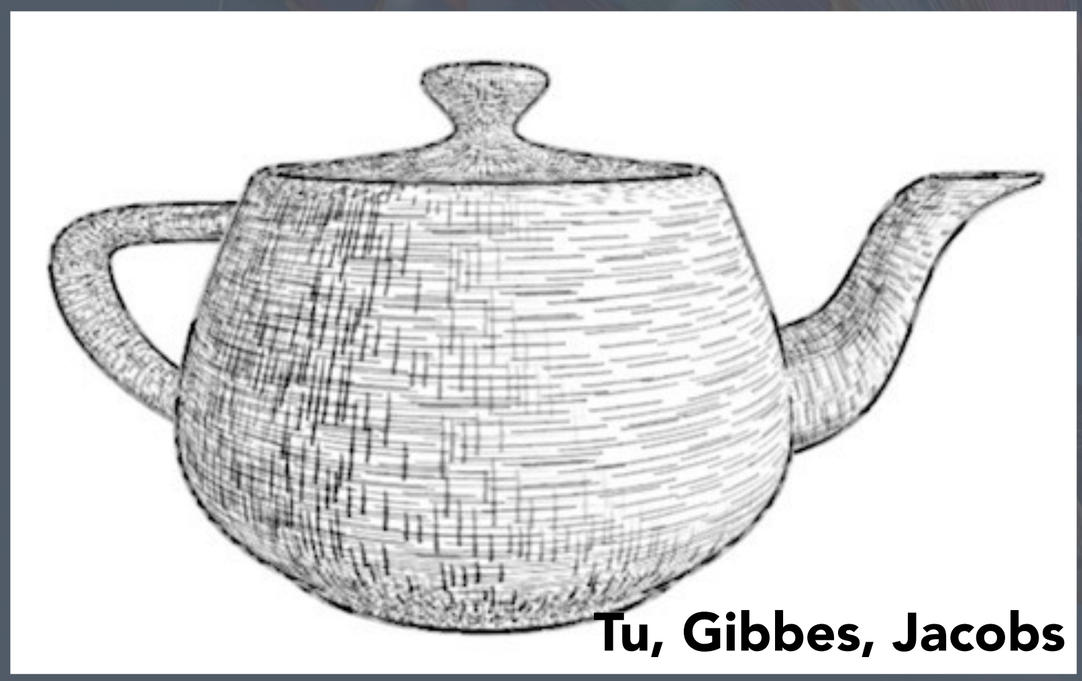




Final Project - Examples







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

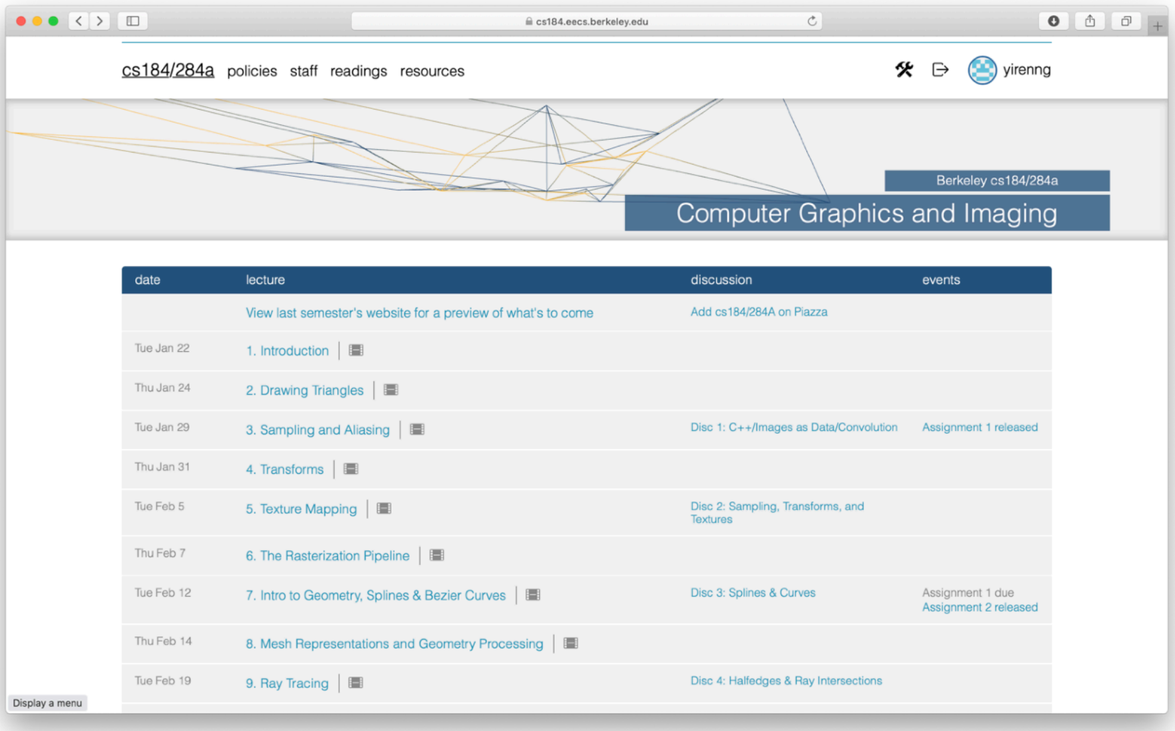
- Past years, high turnover from wait list
- Questions about enrollment:
  - CS184: ask scheduler
    Cindy Conners, csconners@cs
  - CS284A: contact instructors on Piazza
  - Concurrent enrollment: send note to Head TAs on Piazza about your prerequisites for the class

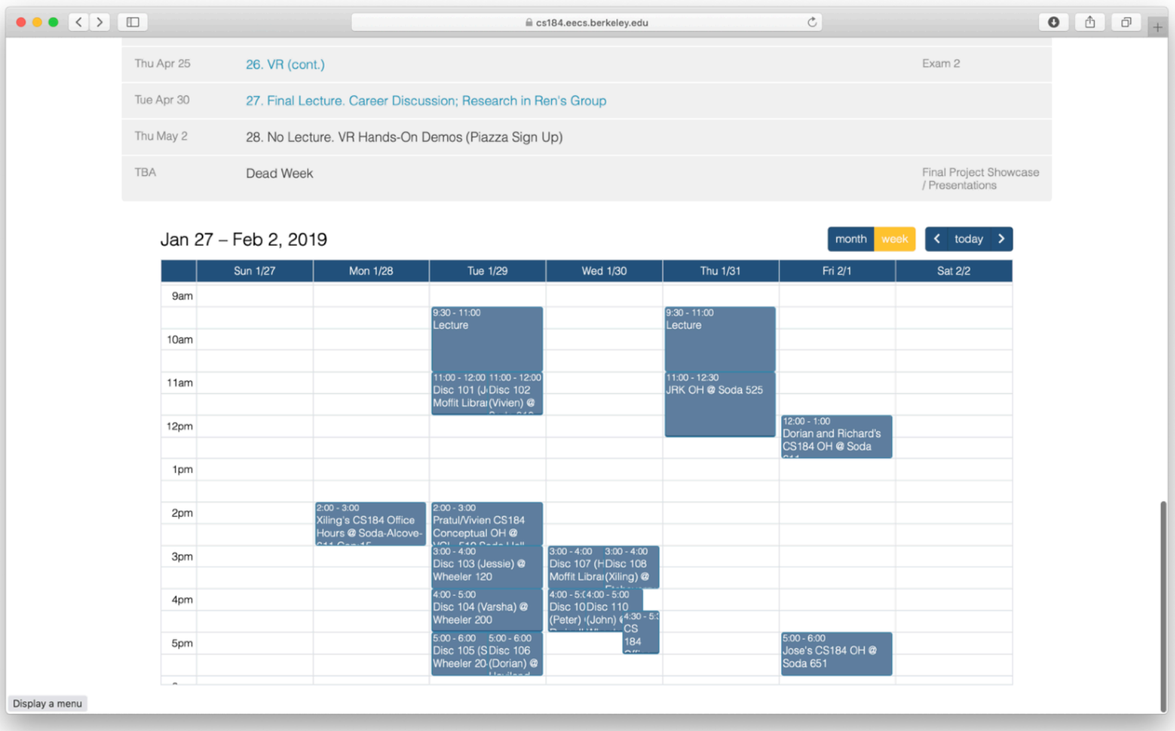
Course Schedule

cs184.eecs.berkeley.edu

Full schedule for class will be on website soon

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





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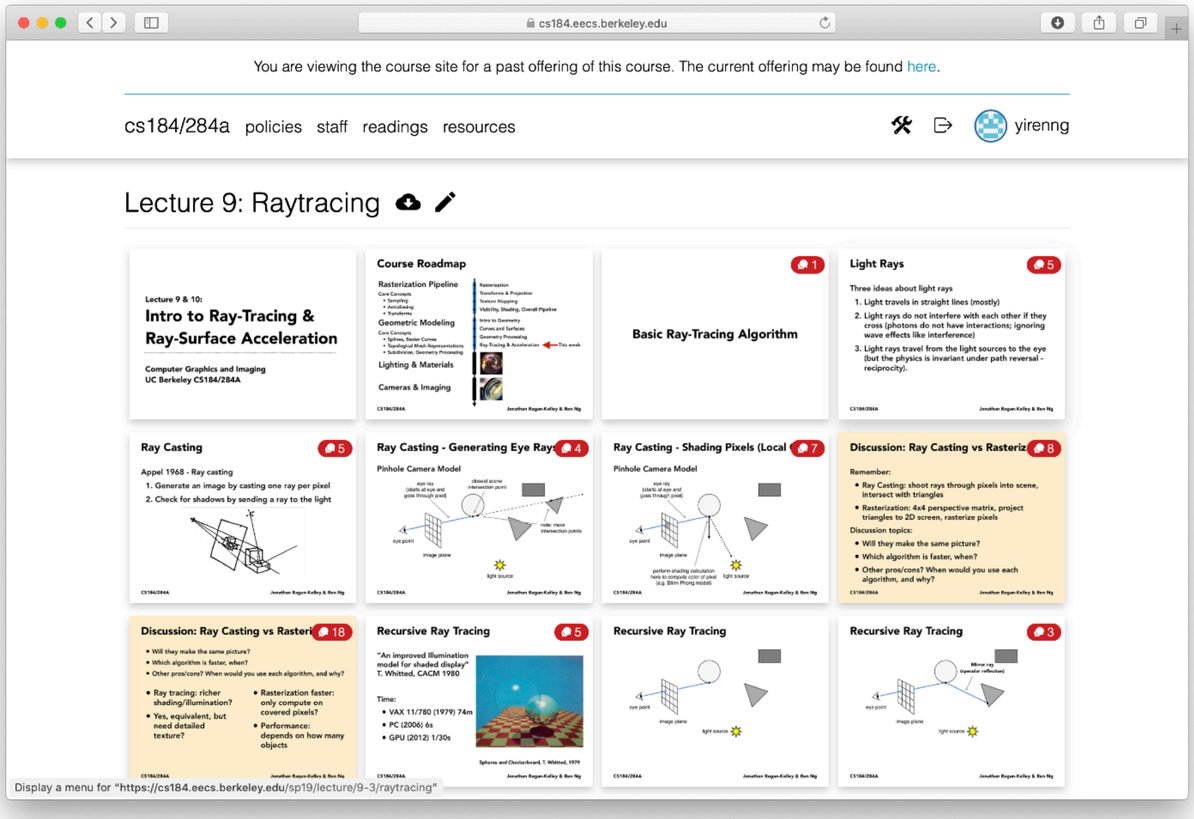
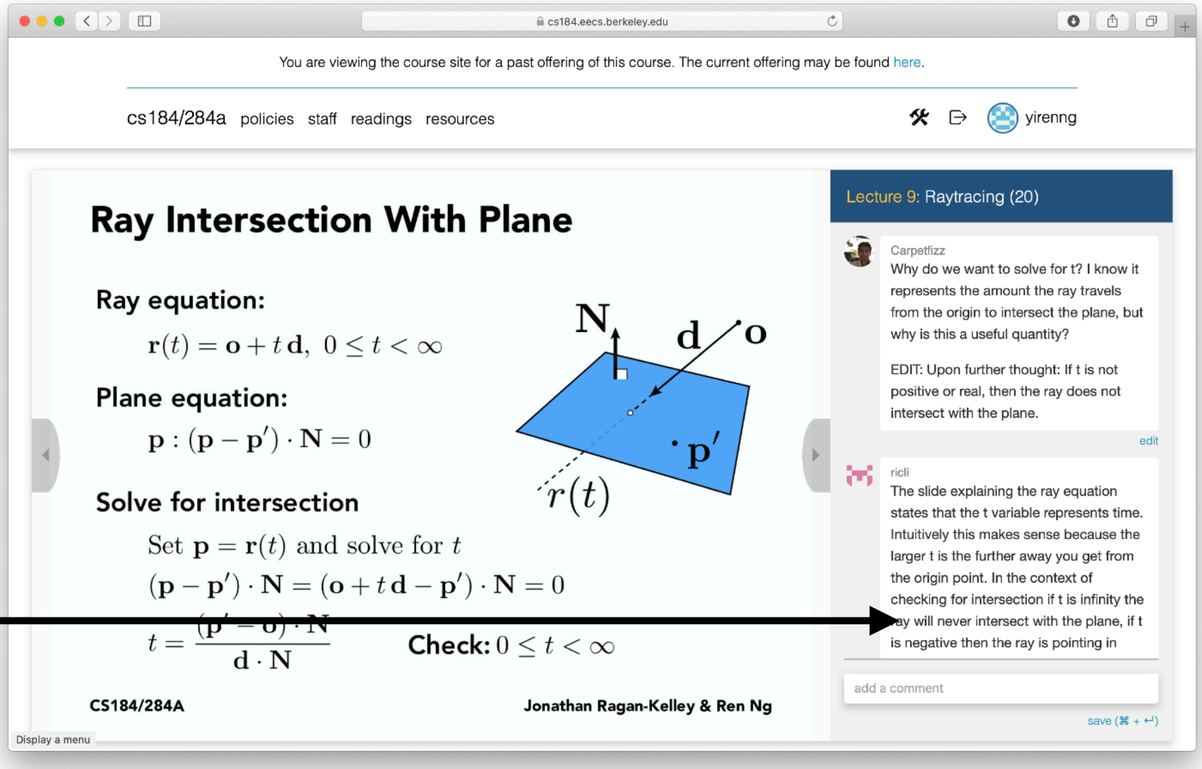
Lecture Slides

cs184.eecs.berkeley.edu

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



Slide comments and discussion



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Piazza

piazza.com/berkeley/spring2022/cs184

You should be added already (if not, 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

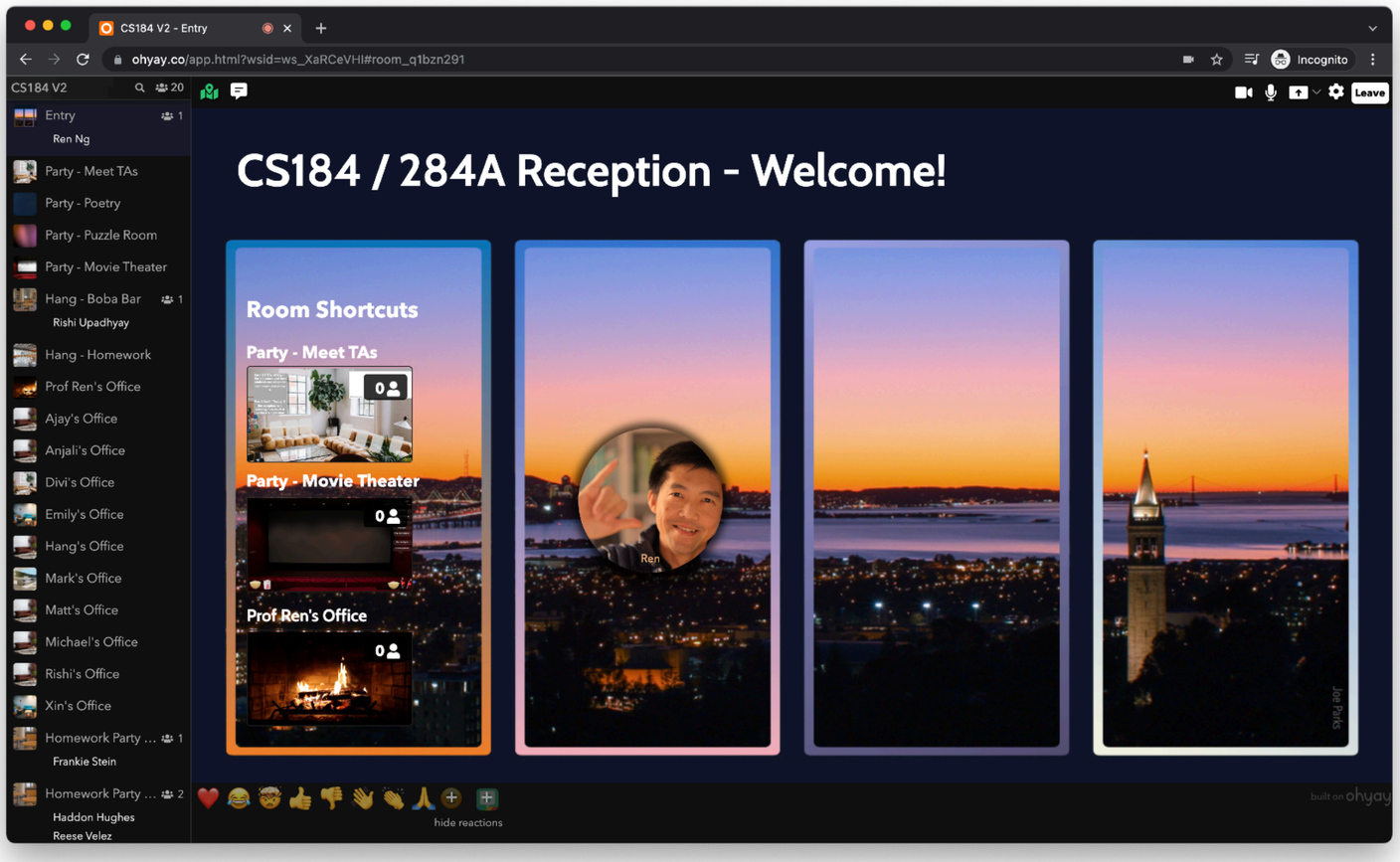
Webcasting

Zoom lecture will be recorded while virtual this semester

- Videos will be linked from the class website

Ohyay - 24/7 Virtual Space for Class

- Receptions on Wed (1/19) and Thu (1/20) from 6:30-7:30pm
- Custom CS184 ohyay space - open 24/7
- Meet or bump into other students to study & collaborate
- Office hours, section and homework parties will also be held in this space



Section

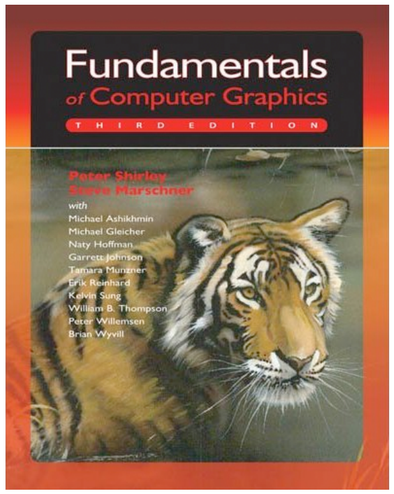
Sections start next week, and TAs will give a primer on C++ and building class projects

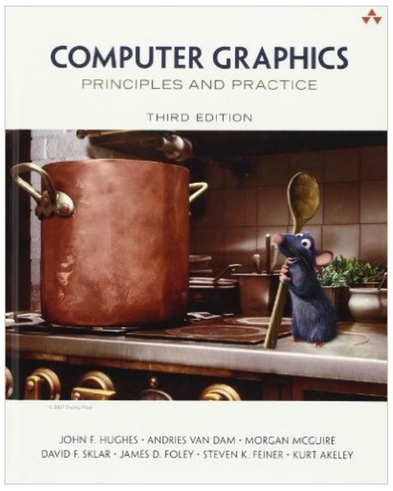
Resources

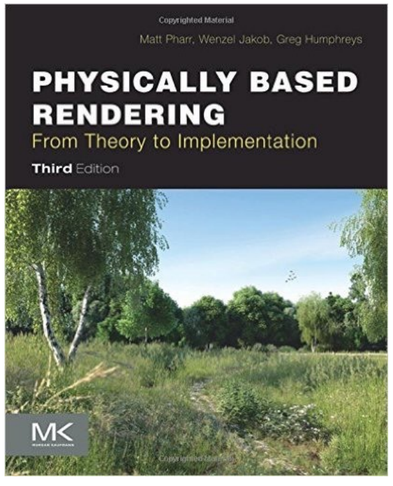
Lectures will be primary source

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

Goals:

- Enable you to increase focus on learning rather than assessment
- Encourage your learning through collaboration
- Entrust you with maintaining academic integrity

Main Ideas (details on course website — please review):

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

Details

- Please read the Policies page on the course website and ask questions on Piazza.

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 exam during Finals Week.
- 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.

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…"

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.

Class Philosophy

We want to build an active, engaged class community.

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

Practice cooperative, supportive learning.

Contribute on the website.

Uphold academic honor individually and collectively.

Inclusive Classroom

Respect each other as individuals with unique identities and backgrounds.

Help create a welcoming community for our full diversity of perspectives and experiences.

Collaboration and team learning are encouraged, and will be supported through class staff and resources.

Projects are a great way to meet new people and make friends; work on building trust and leveraging each other's unique strengths.

Questions?

Acknowledgments

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