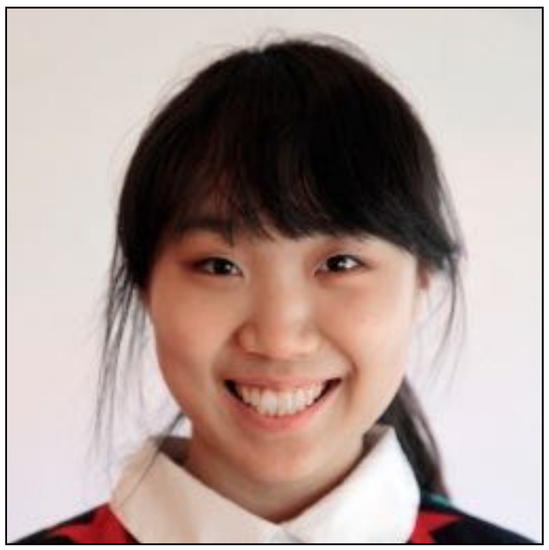
Lecture 1:

Introduction

Computer Graphics and Imaging
UC Berkeley CS184/284A

Welcome to CS184 - Instructors

Ben Mildenhall



Cecilia Zhang

Vivien Nguyen

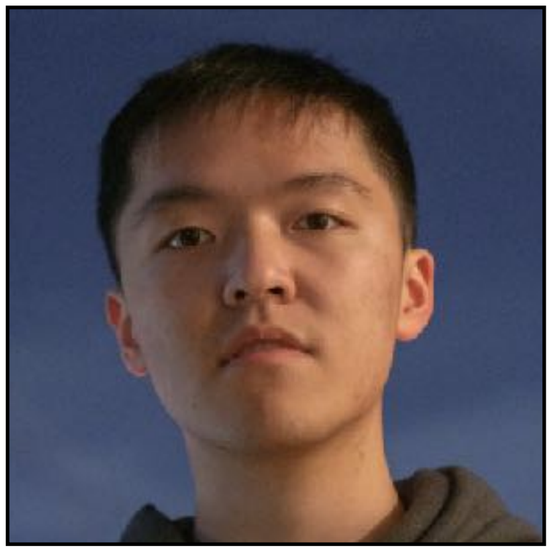
Welcome to CS184 - Course Staff

Susan Lin

Reid Johnson

John Xiang

Rishi Upadhyay



Bob Cao

Matt Tancik

Shoutout to Ren!

Prof. Ren Ng

- Ph.D. 2006 on Digital Light Field Photography (evolving camera design using graphics know-how)
- Founder of Lytro, a light field camera company
- Became a professor at Berkeley in 2015
- Research interests: computational imaging systems, computer graphics and computer vision

Engagement and Interaction

- We want to interact!
- Class will be better for it - if you have a question, likely someone else does too
- Don’t be shy to speak up (Zoom, Piazza, Discord)
- If possible, use consistent name across platforms

CS184/284A: Computer Graphics & Imaging

Why Study Computer Graphics?

Course Overview

Logistics

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What is Computer Graphics?

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

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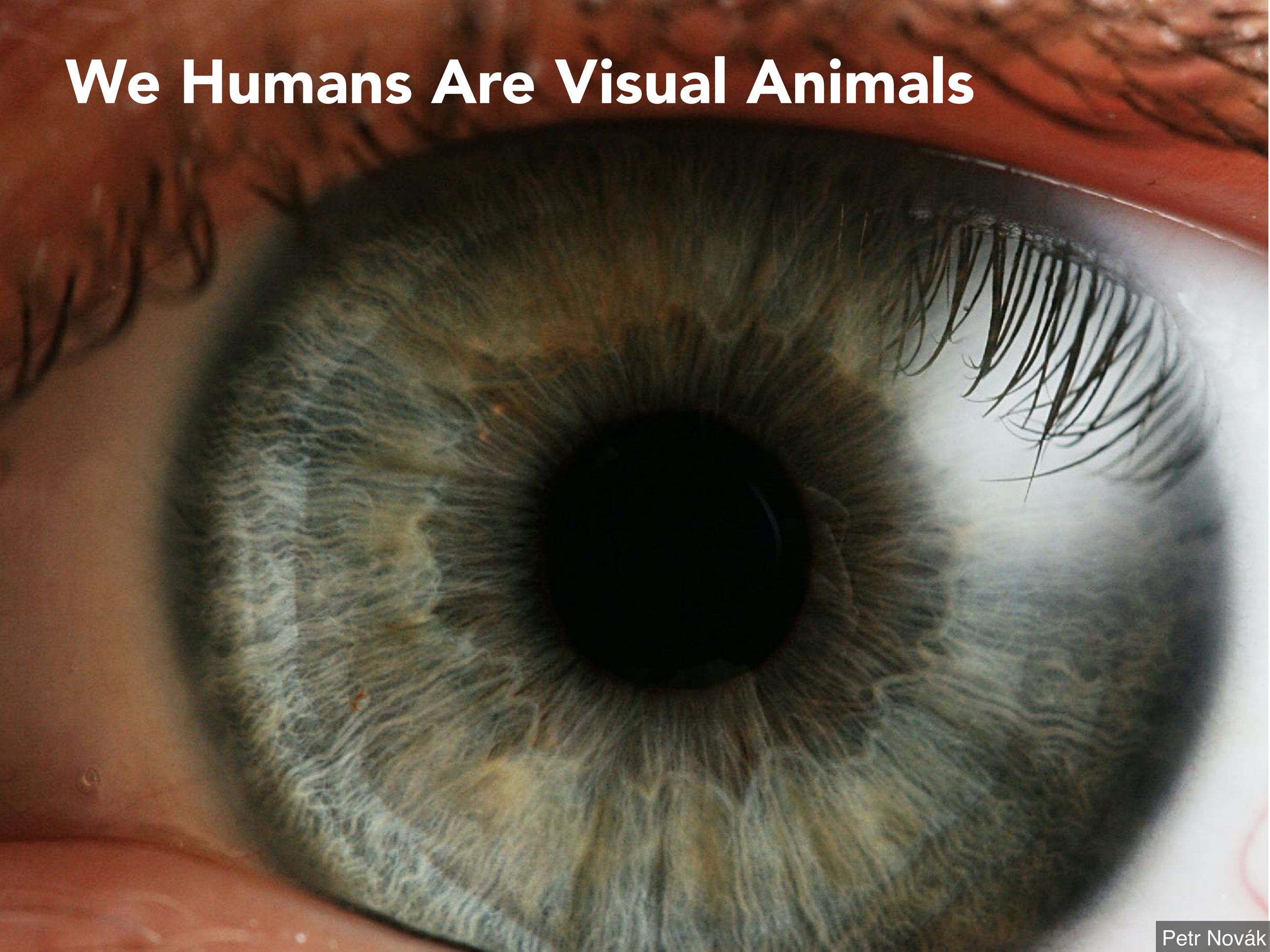
Why Visual Information?

We Humans Are Visual Animals



Petr Novák

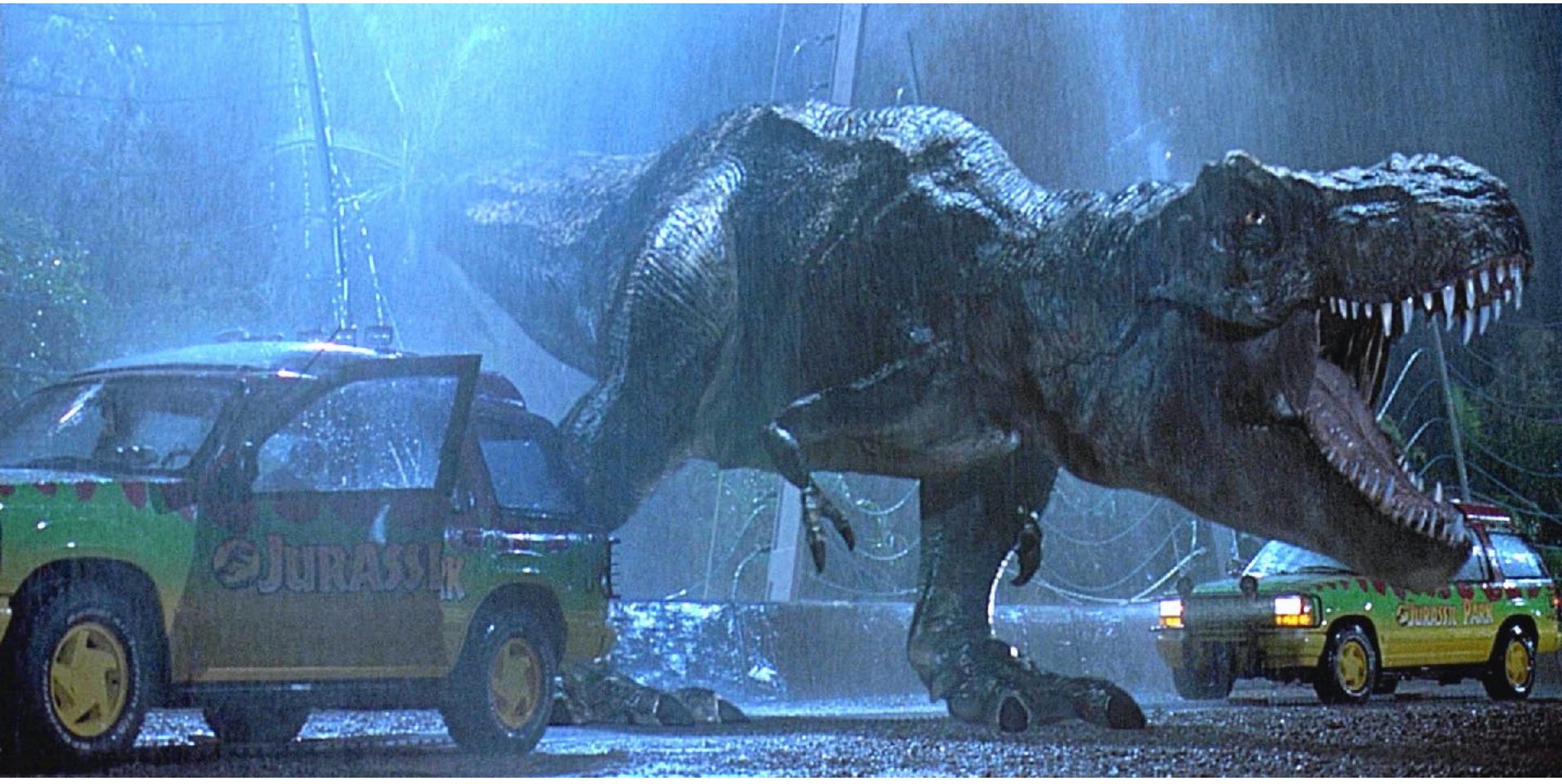
Discussion

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)

Movies

Monsters University (2013)

Games

PlayStation 5 Unreal Engine Demo

Product Design and Visualization

Ikea - 75% of catalog is rendered imagery

Product Design and Visualization

Tesla Model X concept (2012)

Product Design and Visualization

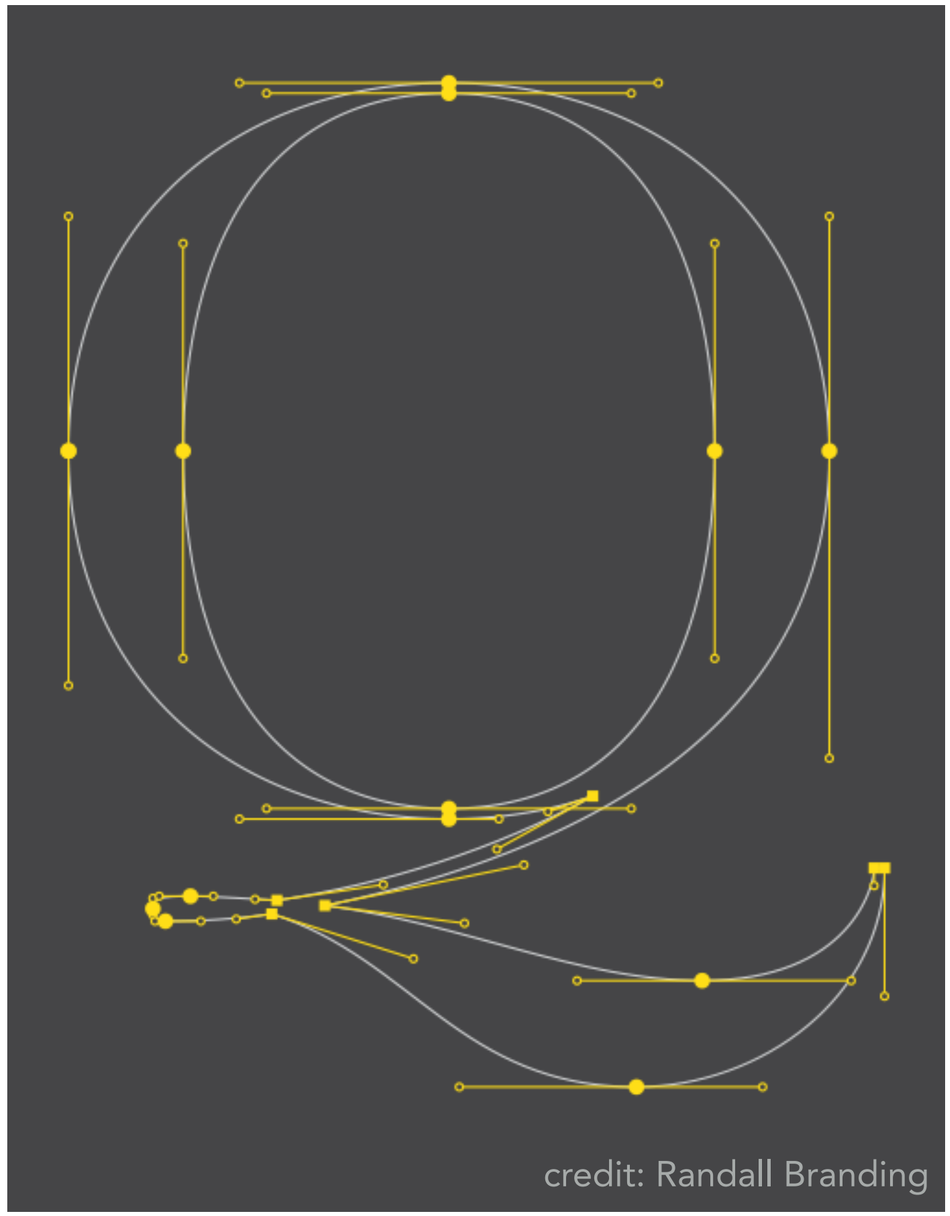
Credit: EV obsession.com, James Ayre

Tesla Model X review

Typography

The Quick Brown Fox Jumps Over The Lazy Dog

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 0123456789



credit: Randall Branding

Baskerville

Illustration

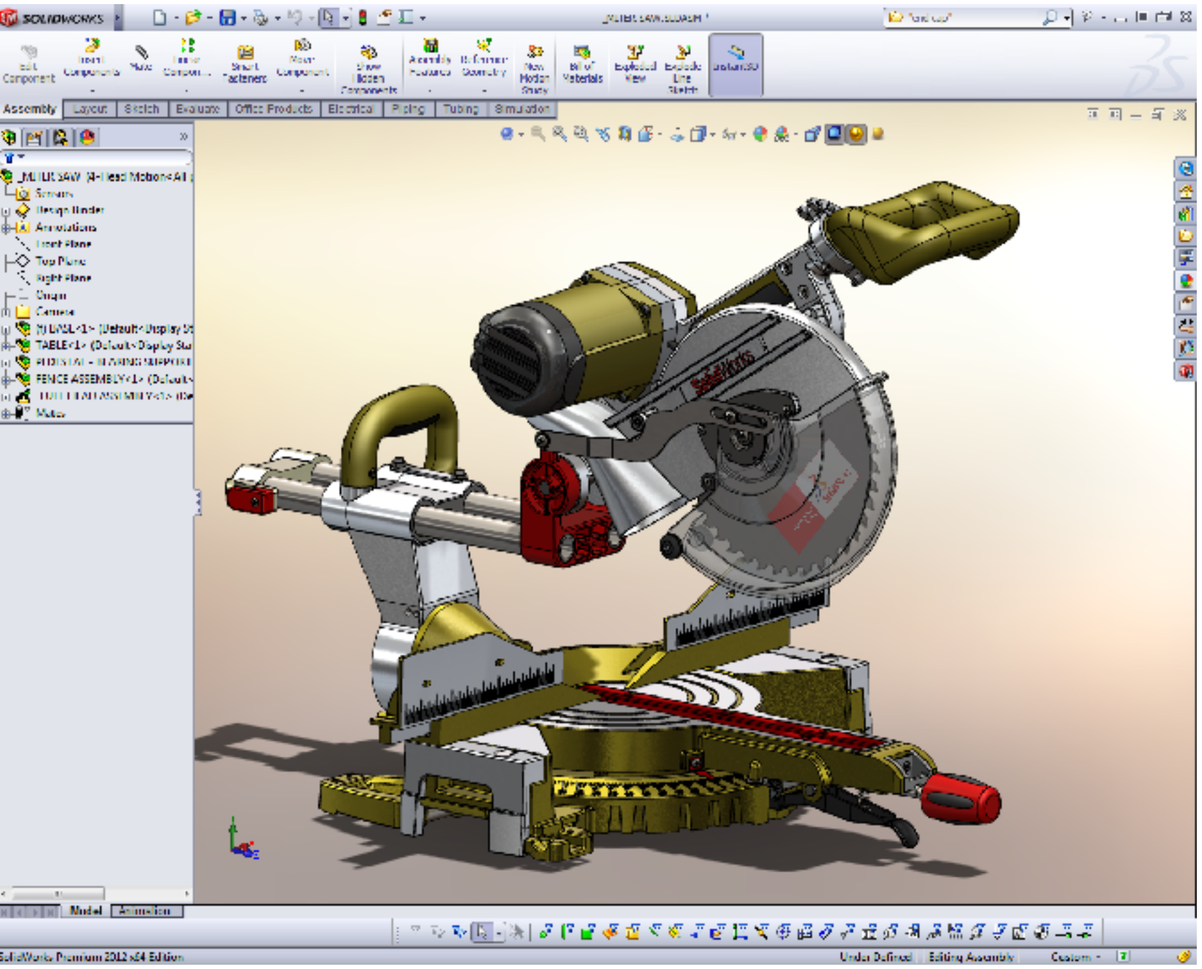
Cave painting c. 36,000 B.C.

Digital Illustration

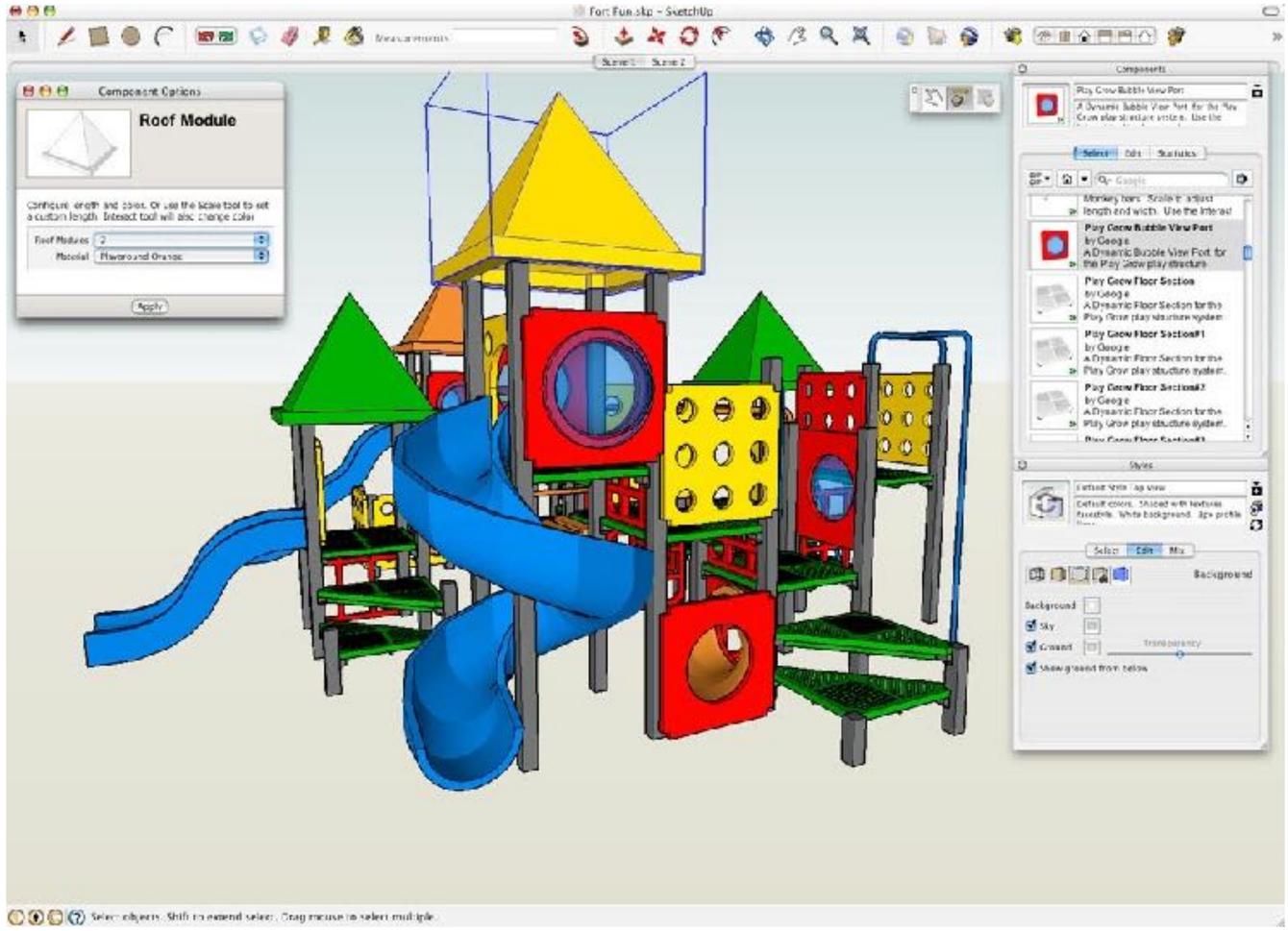
Meike Hakkart

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

Computer-Aided Design



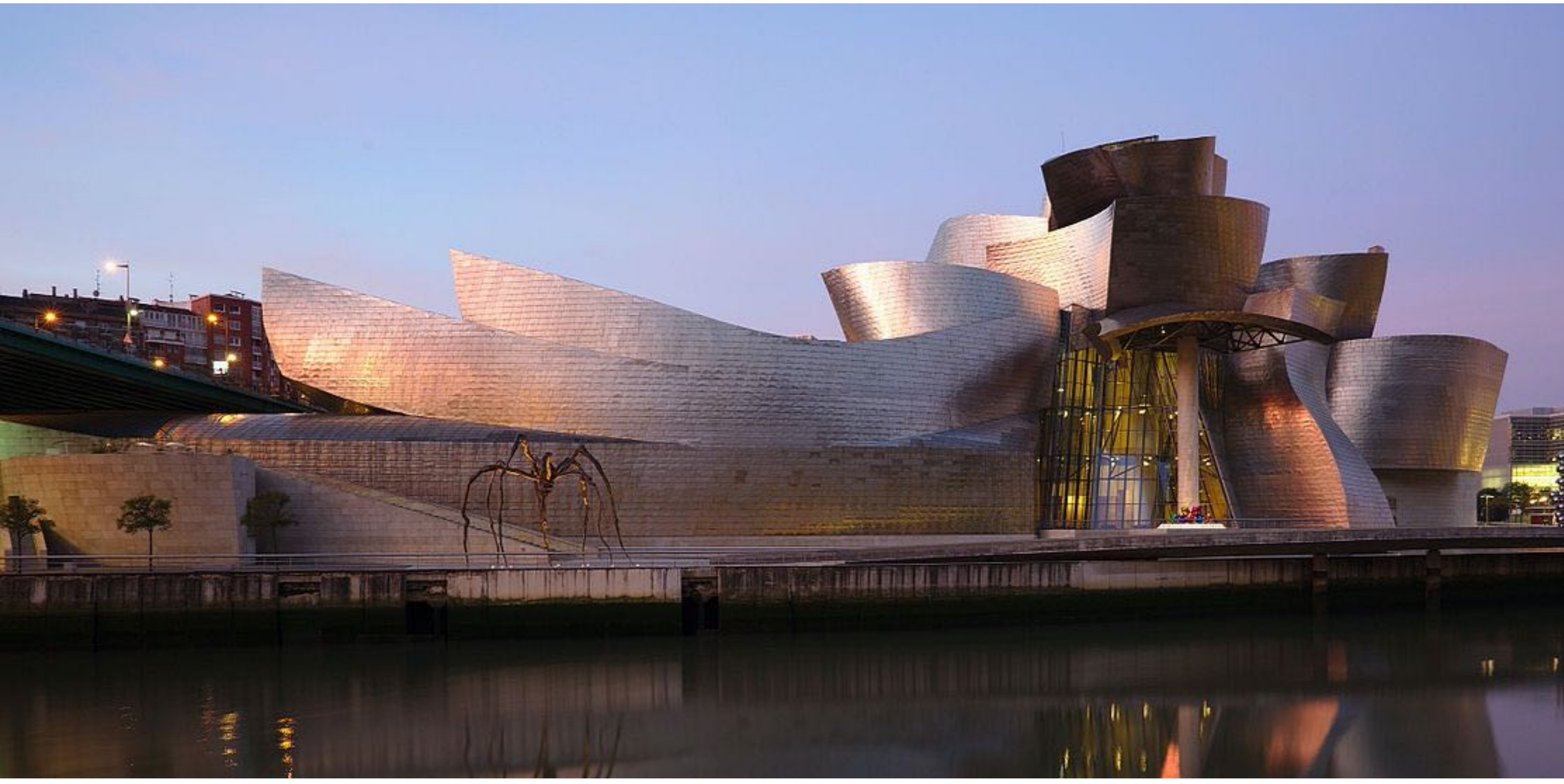
SolidWorks



SketchUp

For mechanical, architectural, electronic, optical, …

Architectural Design

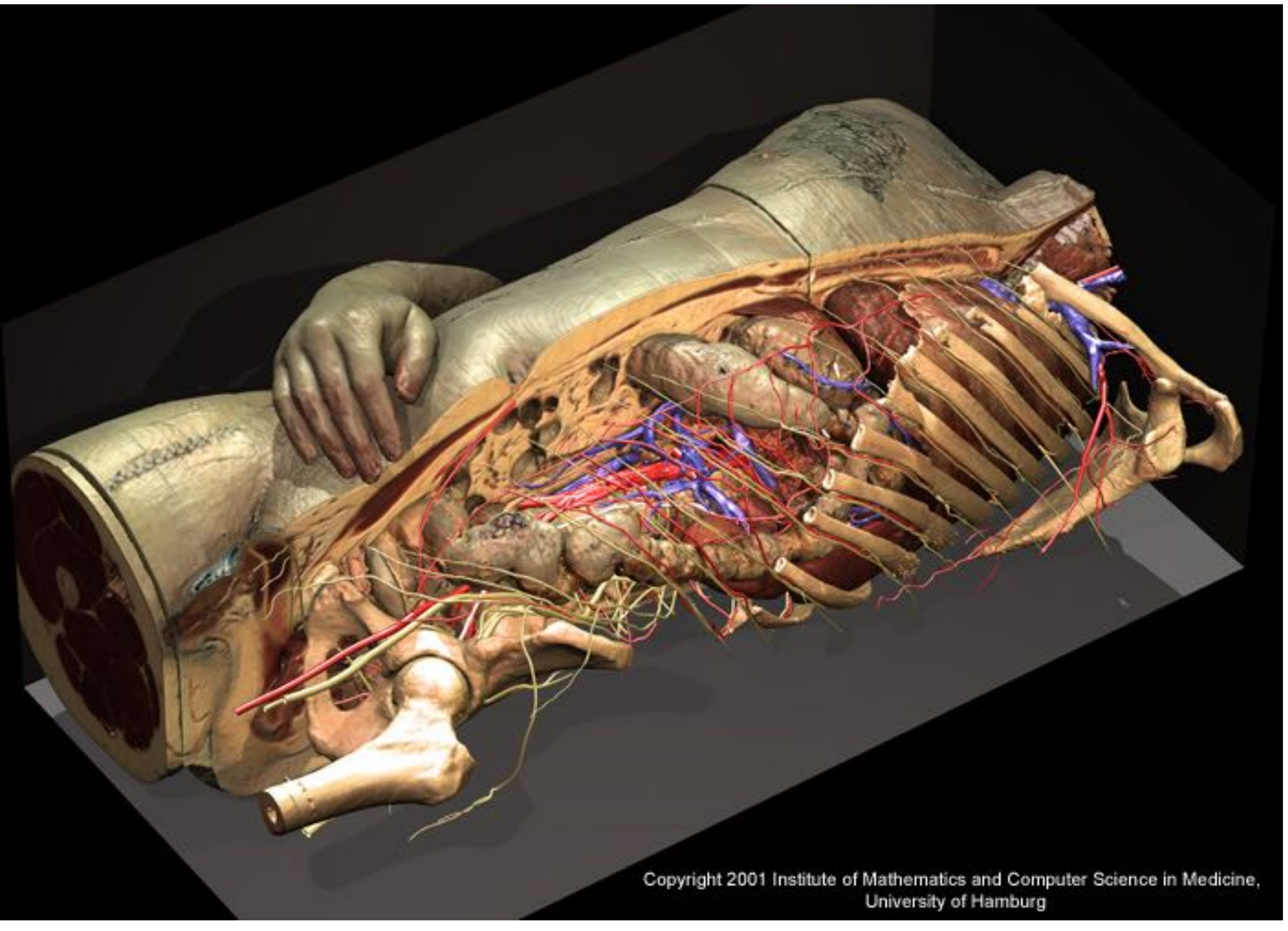


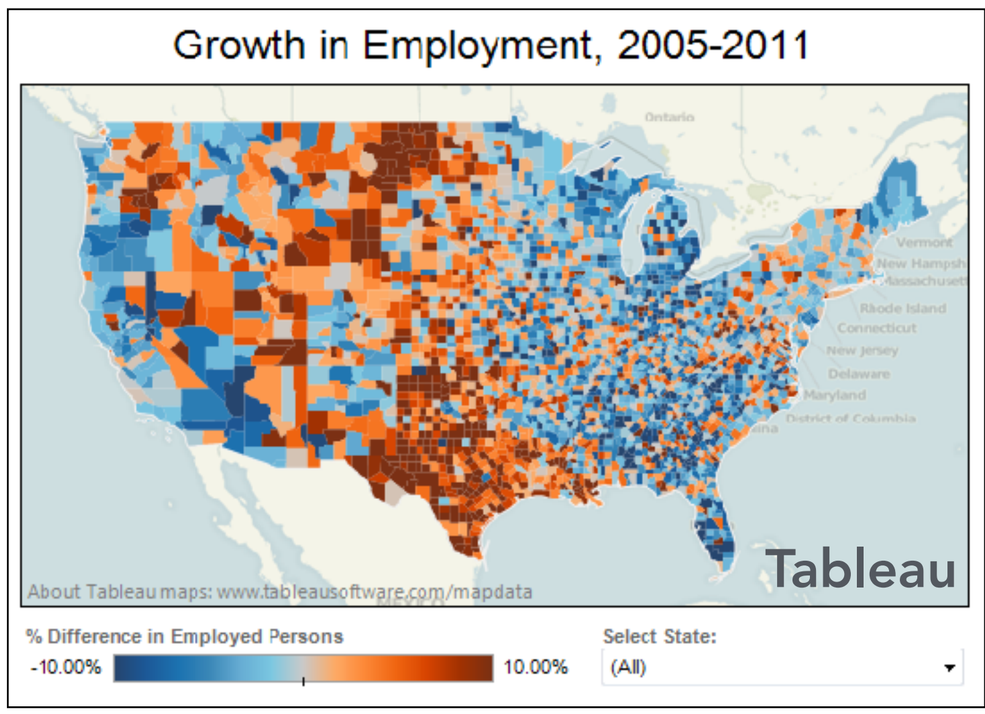
Bilbao Guggenheim, Frank Gehry

Architectural Design

Heydar Aliyev Center, Zaha Hadid Architects

Visualization





Science, engineering, medicine, journalism, ...

Visual Simulation

Driving simulator
Toyota Higashifuji Technical Center

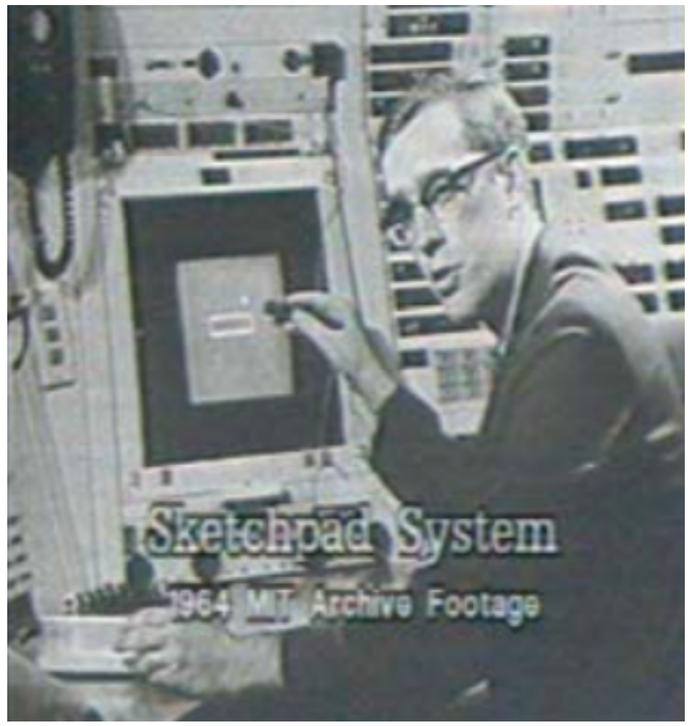
da Vinci surgical robot
Intuitive Surgical

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

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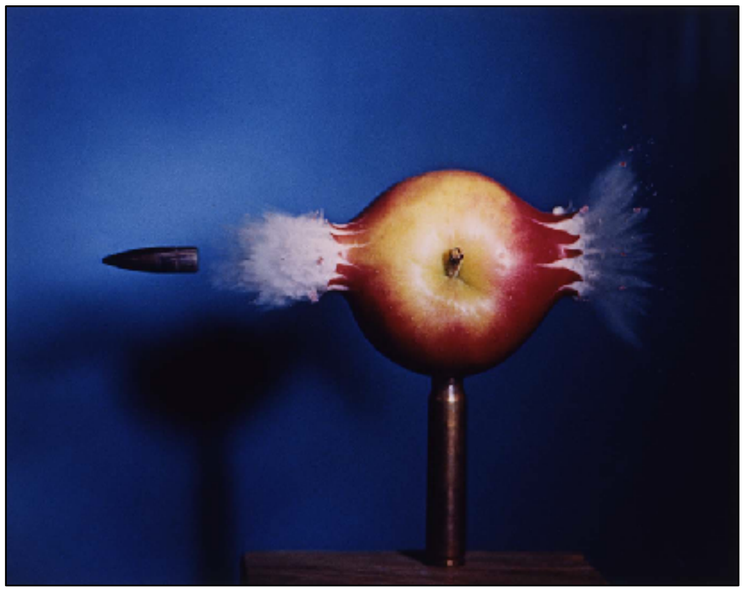
Graphical User Interfaces

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

Photography

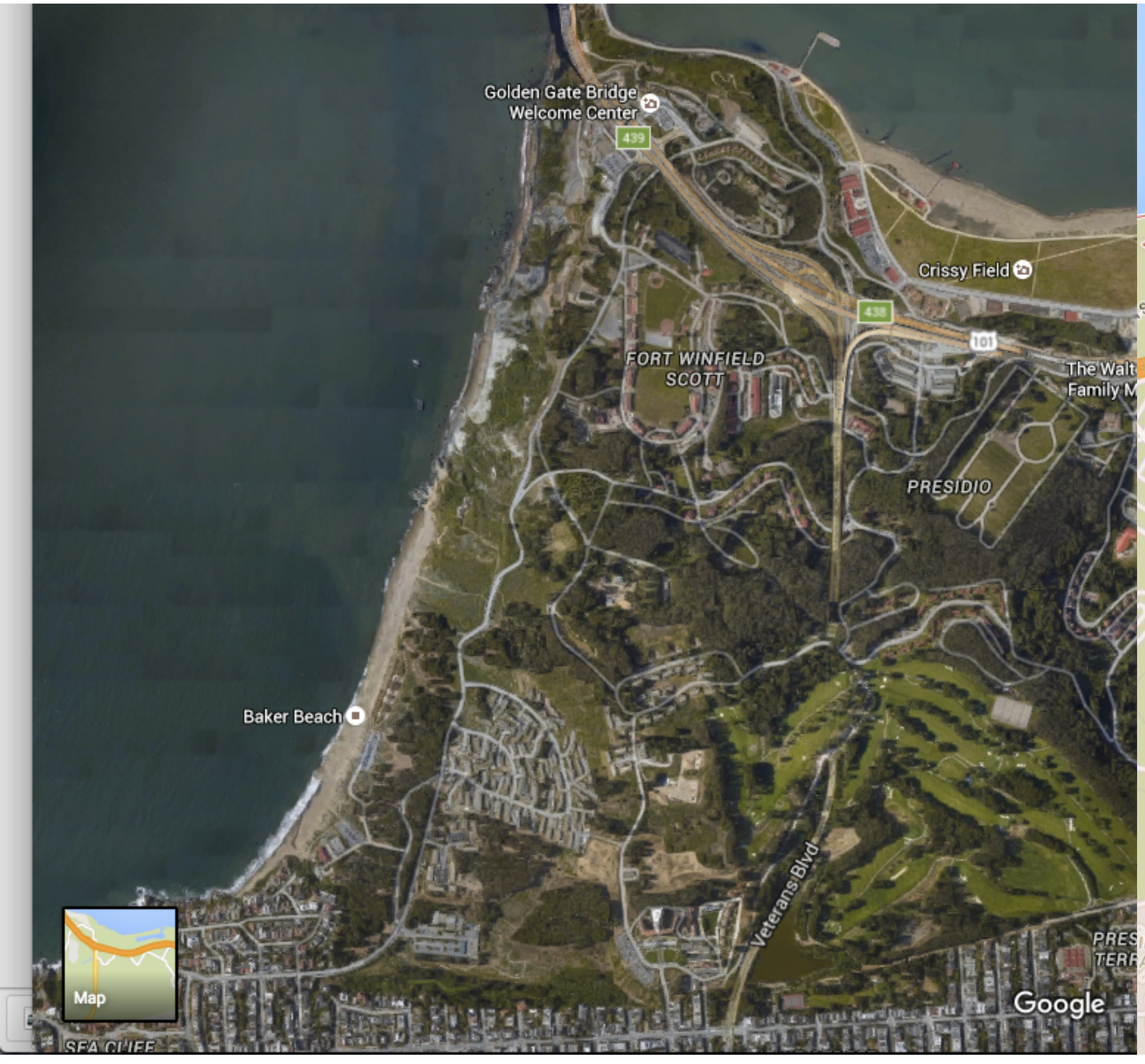


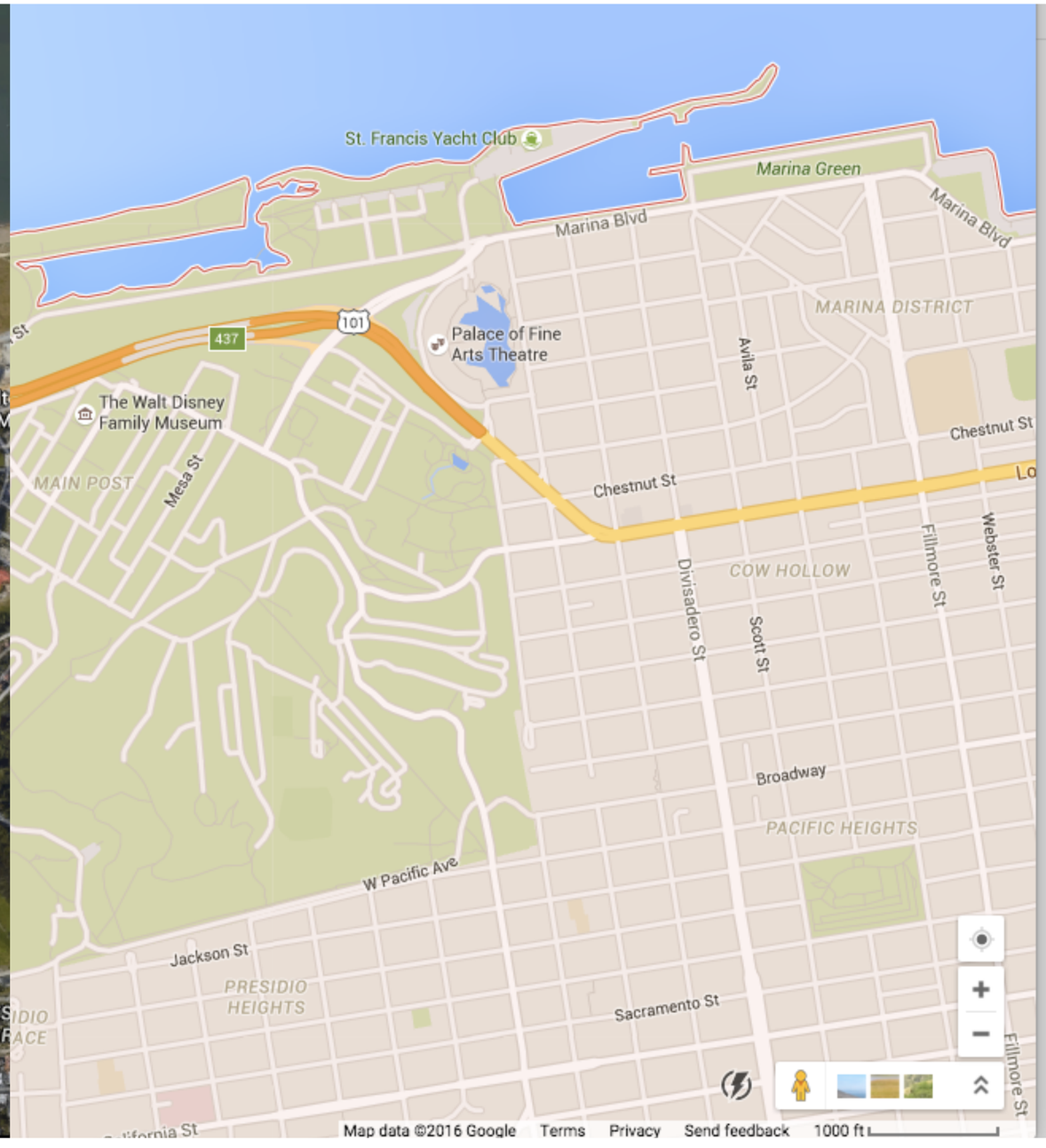
NASA | Walter Iooss | Steve McCurry
Harold Edgerton | NASA | National Geographic

Ubiquitous Imaging

Cameras everywhere

Imaging in Mapping



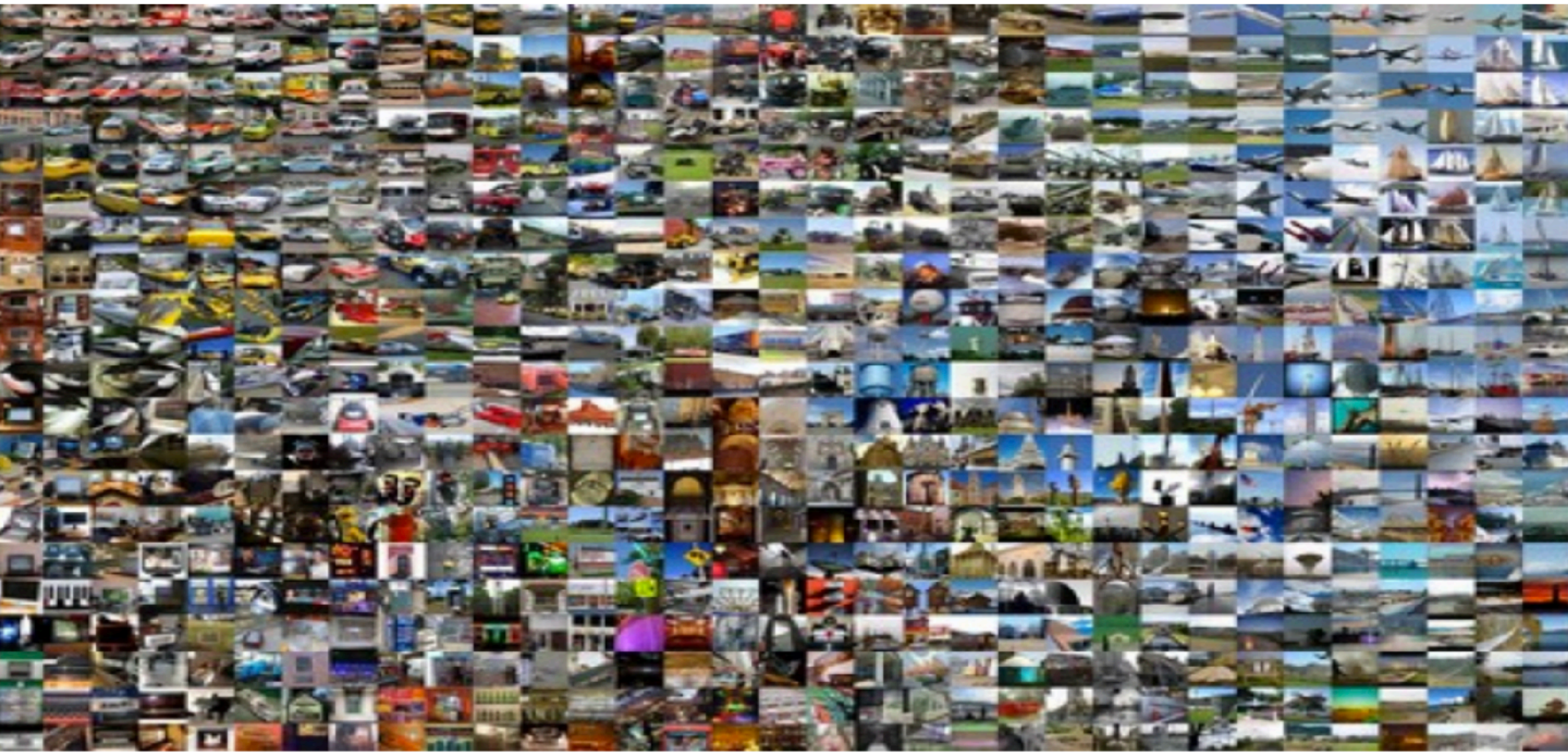


Maps, satellite imagery, street-level imaging,...

Imaging in Mapping

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

Imaging for Computer Vision



ImageNet: 15M images, 22K categories

http://image-net.org

Imaging for Machine Learning

Imaging for Robotics

Google's "Arm Farm"

How Do Camera's Work?

Glenn Derene, Popular Mechanics

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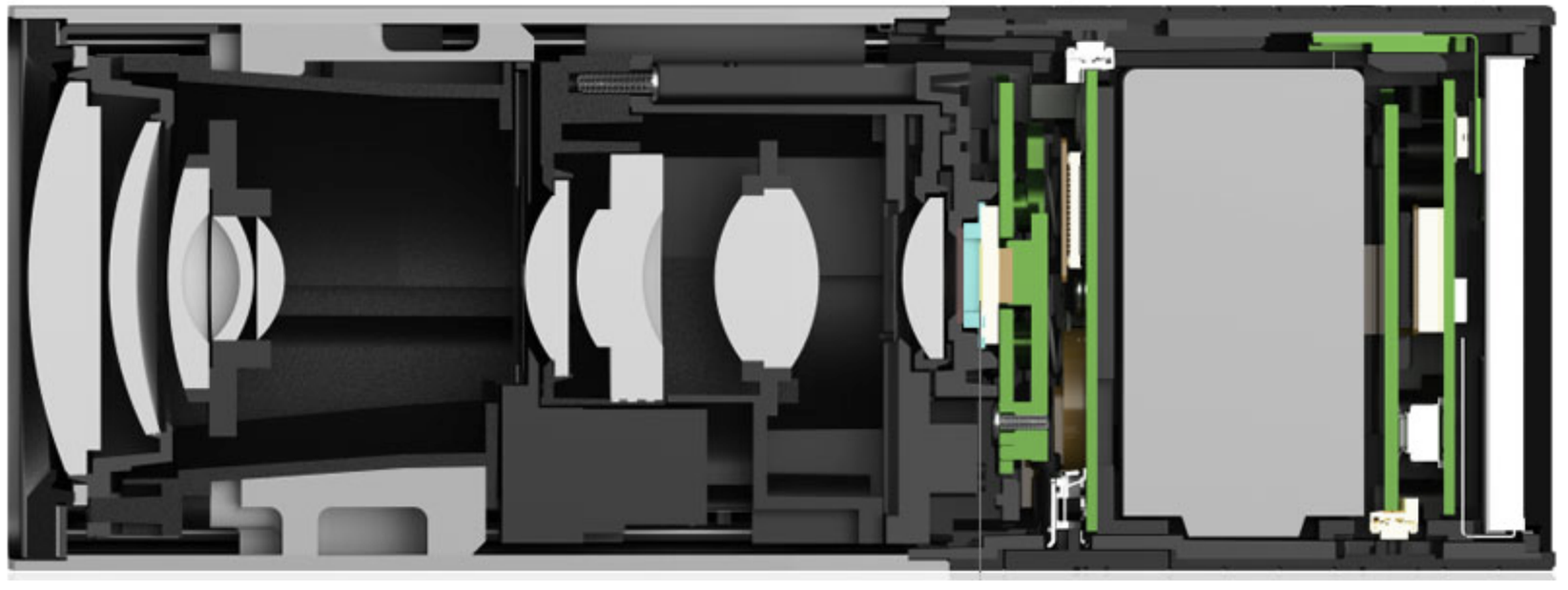
Digital and Computational Cameras

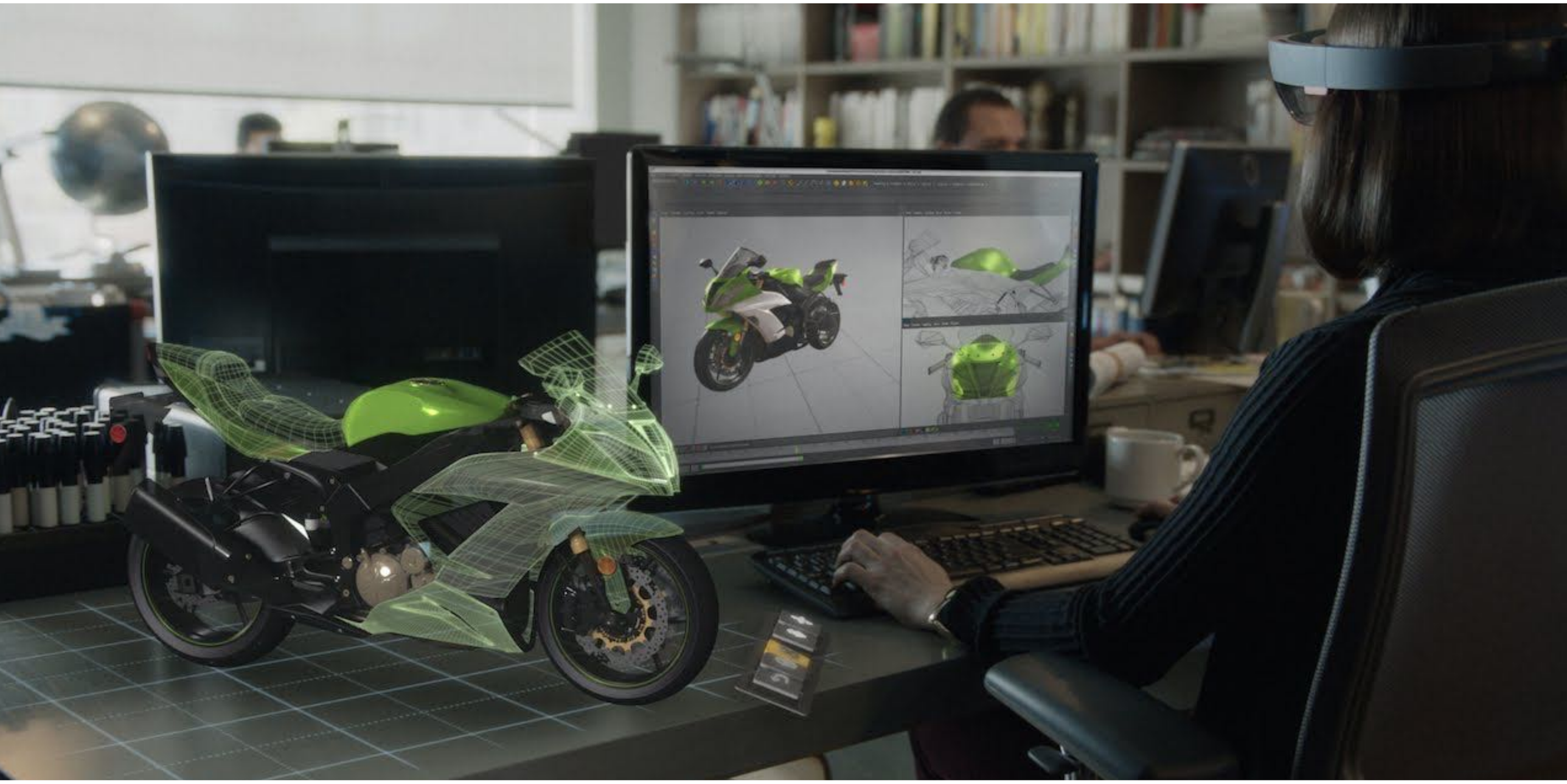


Panaromic stitching, HDR photos, light field cameras, …

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

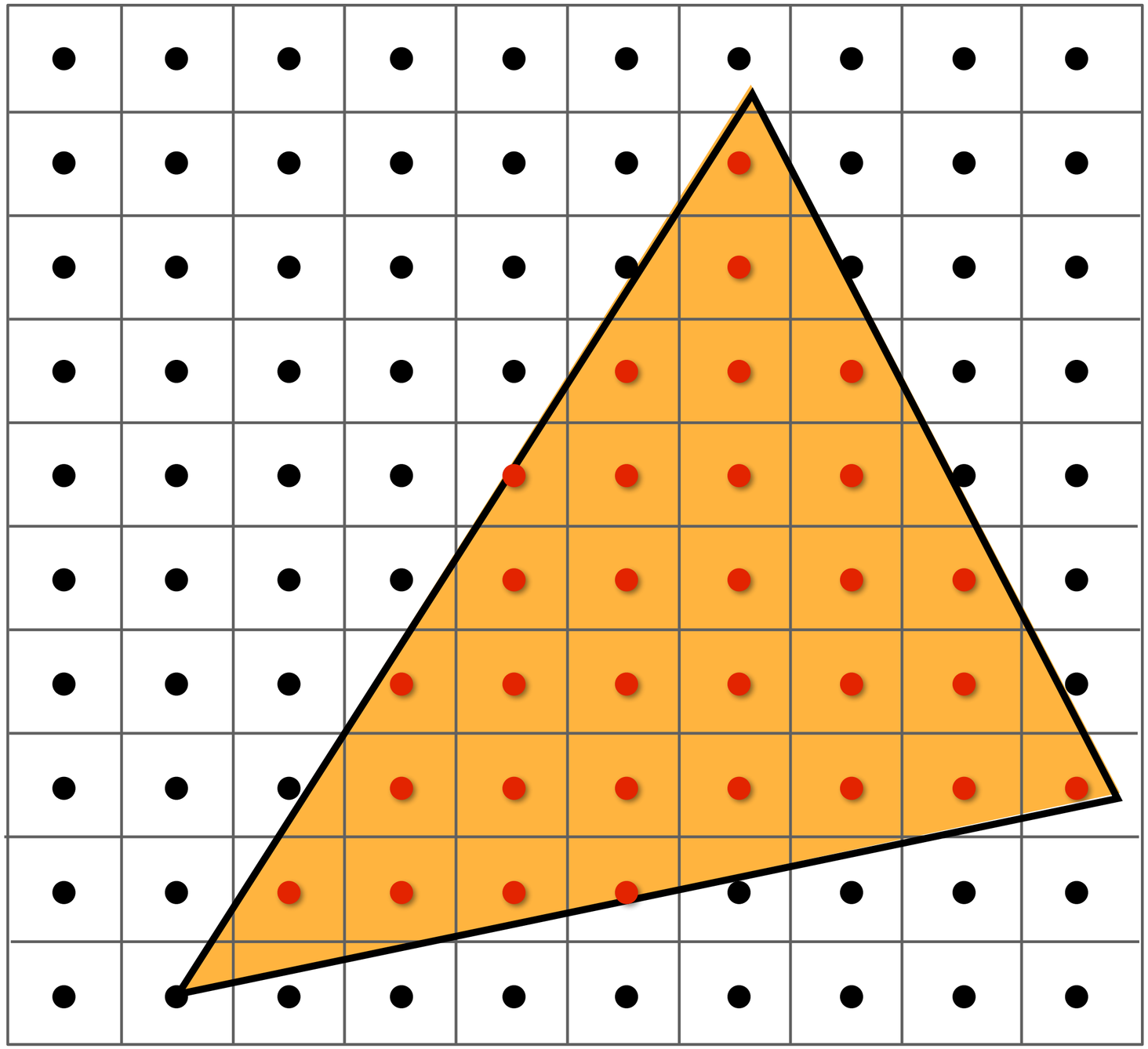
- Modeling the world, image synthesis
- 3D graphics: geometry, rendering, animation
- Image capture, manipulation and display

Acquire core concepts and skills

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

Course Topics

Drawing Digital Images (Rasterization)



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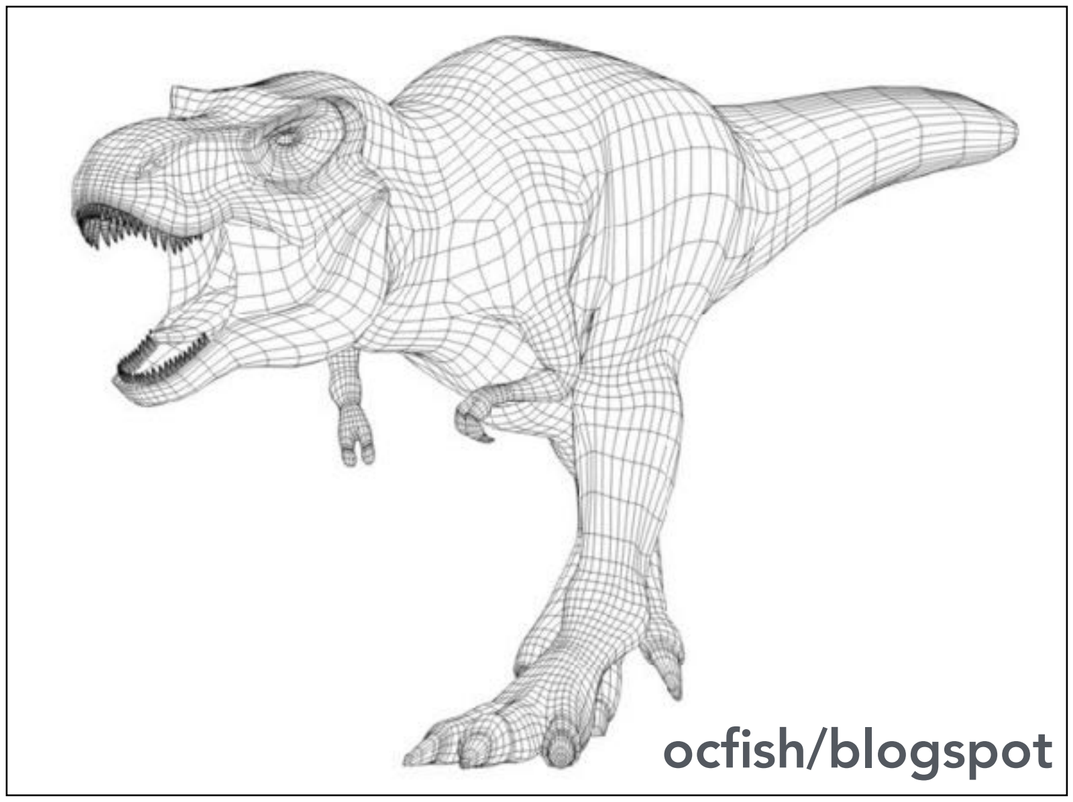
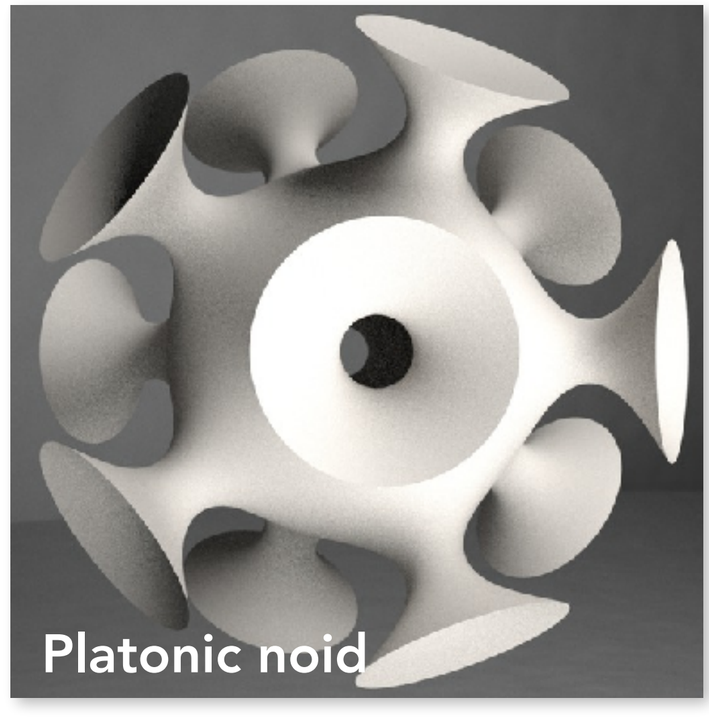
Filtering and Sampling

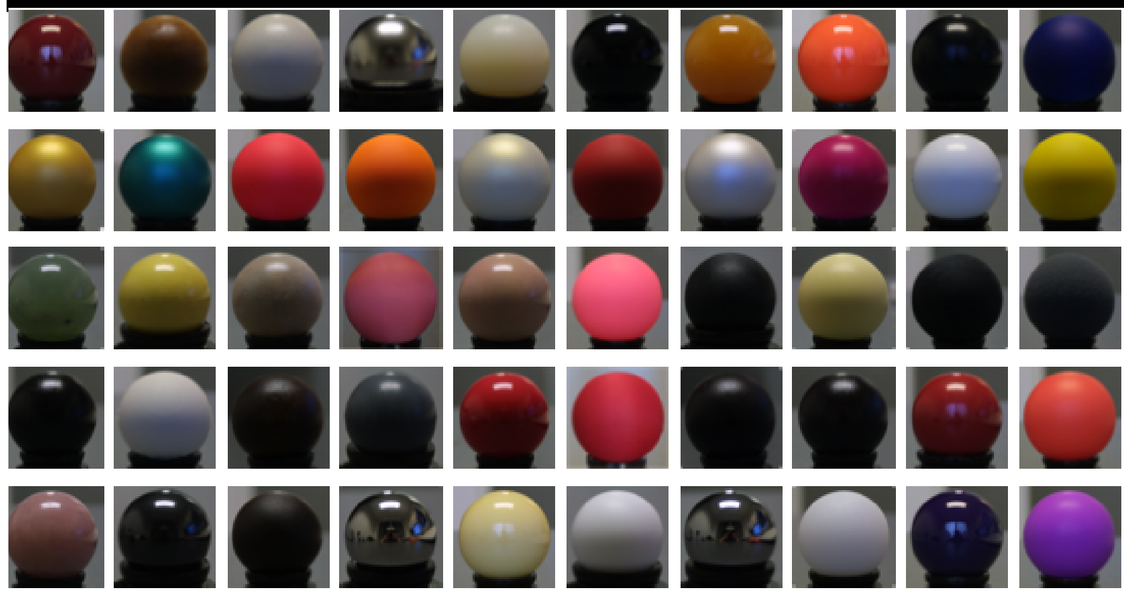
No Jaggies

Modeling Geometry





Modeling Material Properties



Modeling Lighting

Light Transport and Image Synthesis

Photograph (CCD) vs. computer rendering

Digital and Computational Cameras

Glenn Derene, Popular Mechanics

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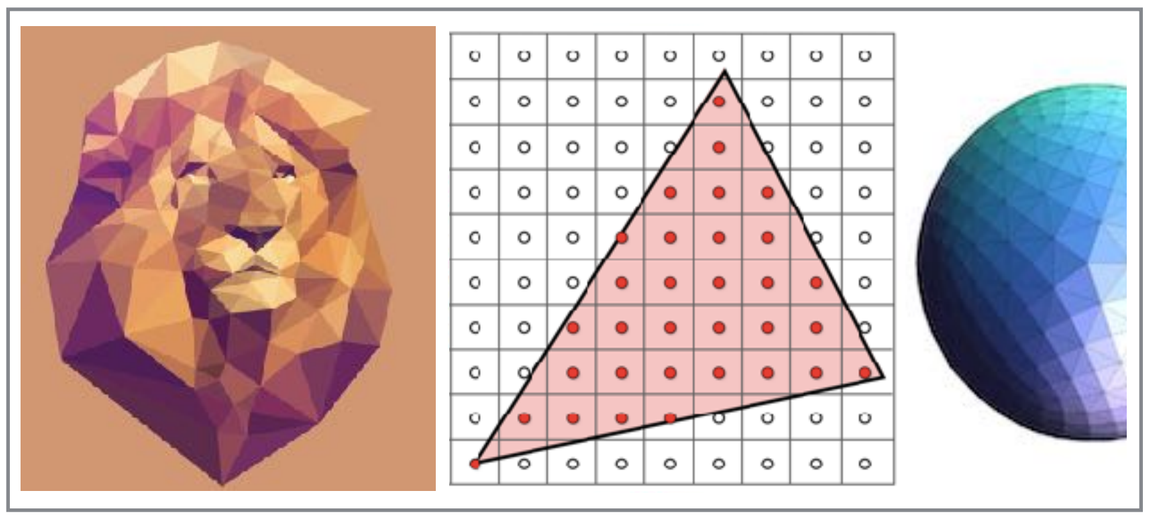
Animation and Physical Simulation

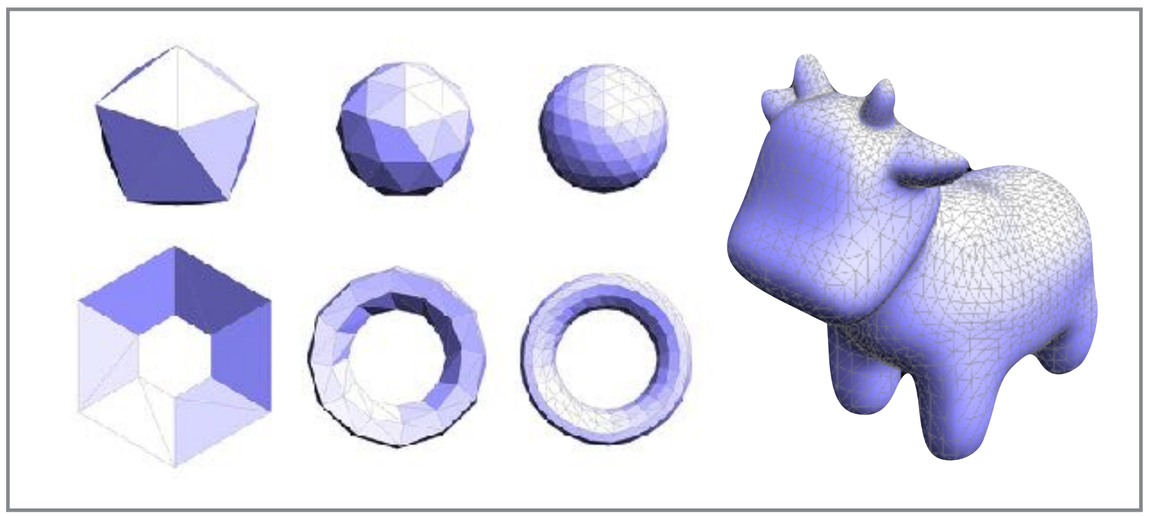
Virtual Reality

Hands-On Learning

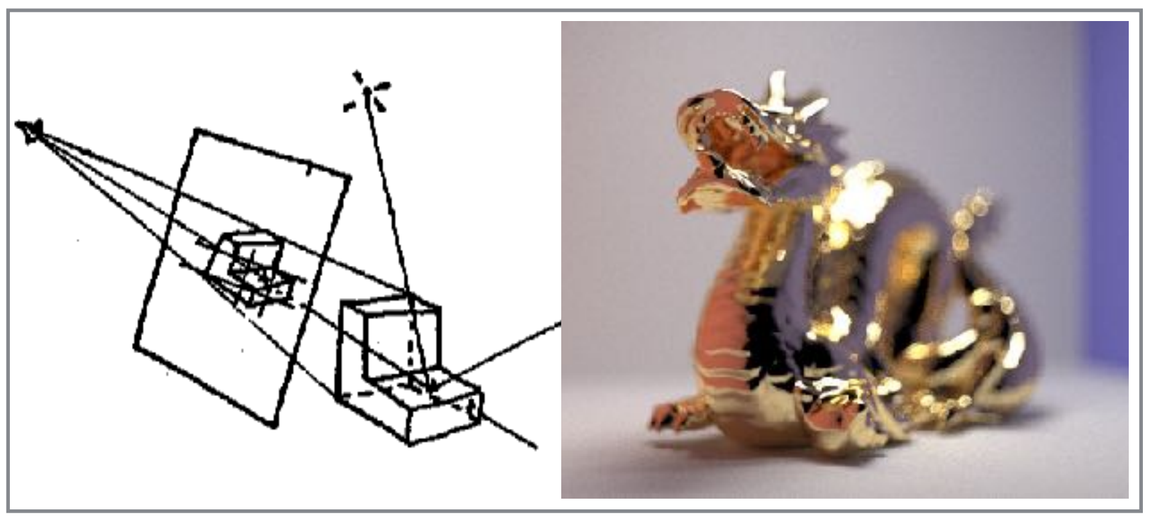
Course Assignments



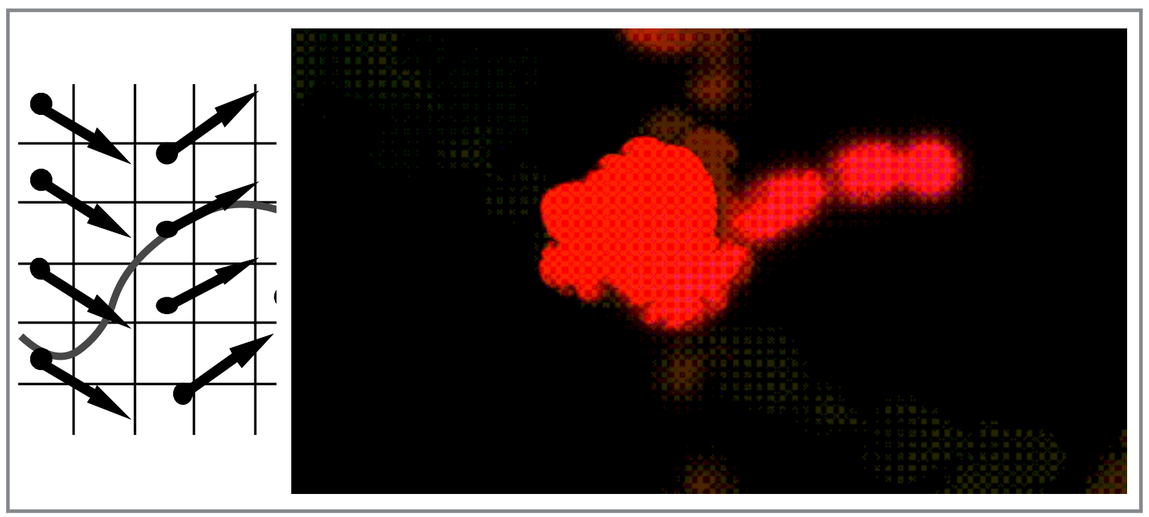
1. Digital Drawing (1 week)



2. Geometry (1 week)



3. Ray-Tracing (2 weeks)



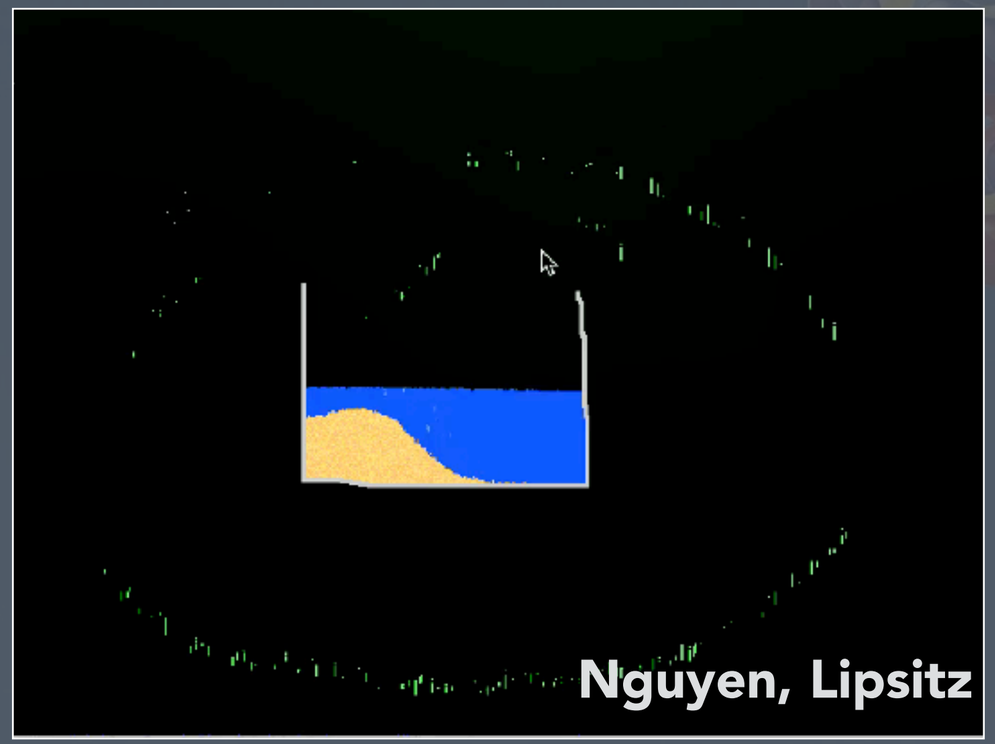
4. Animation (1 week)

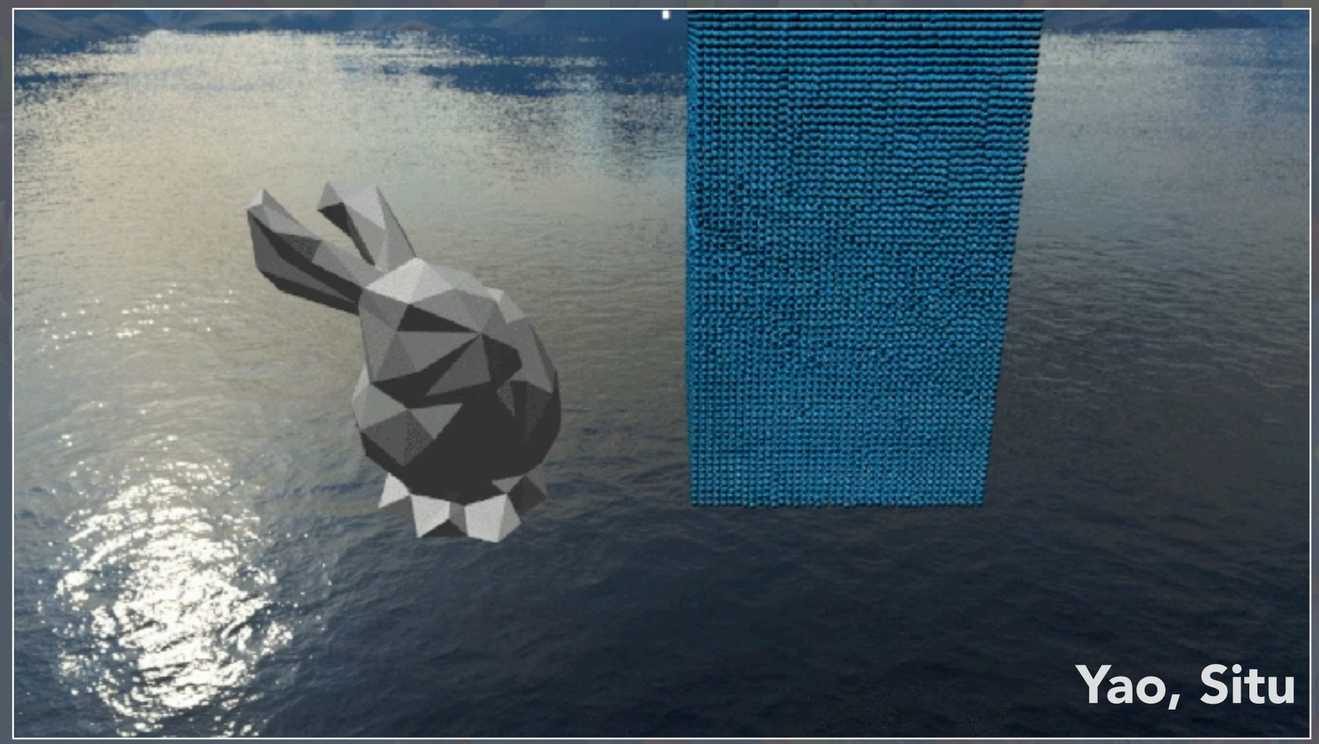
Final Project

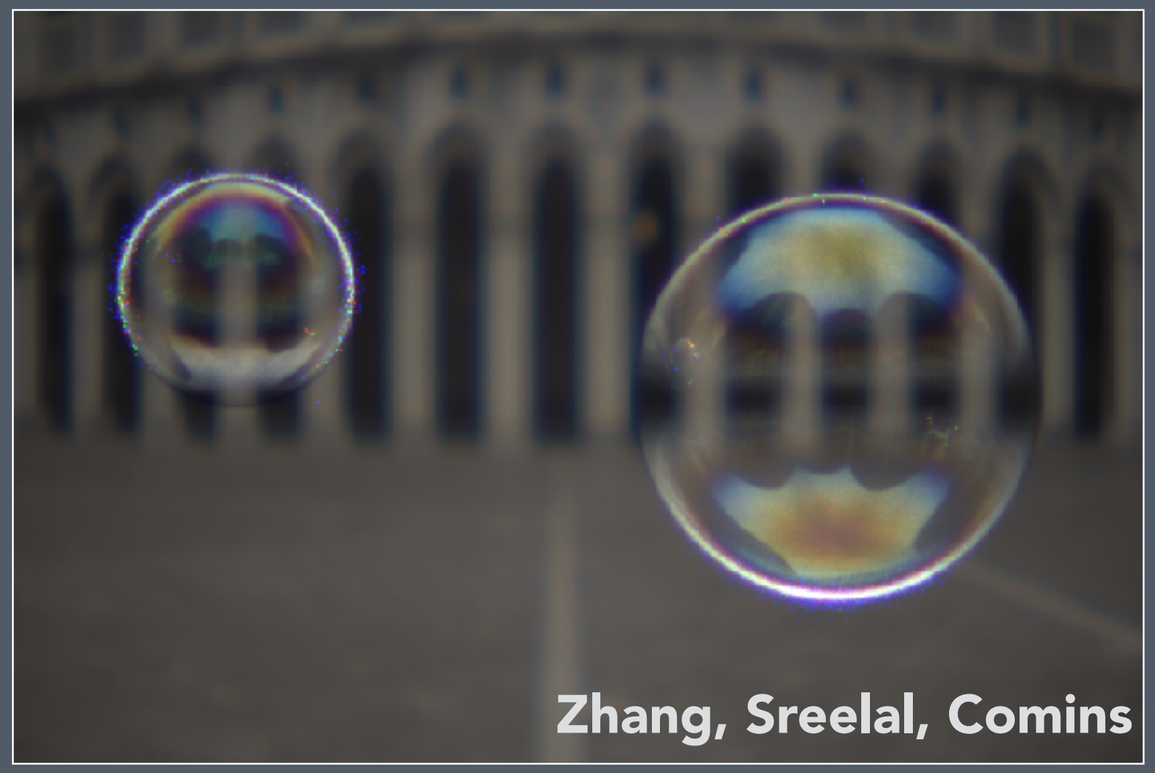
- 2 weeks, let your creativity take flight!
  (we will have suggested projects)
- Proposal; checkpoint; presentation, video, report

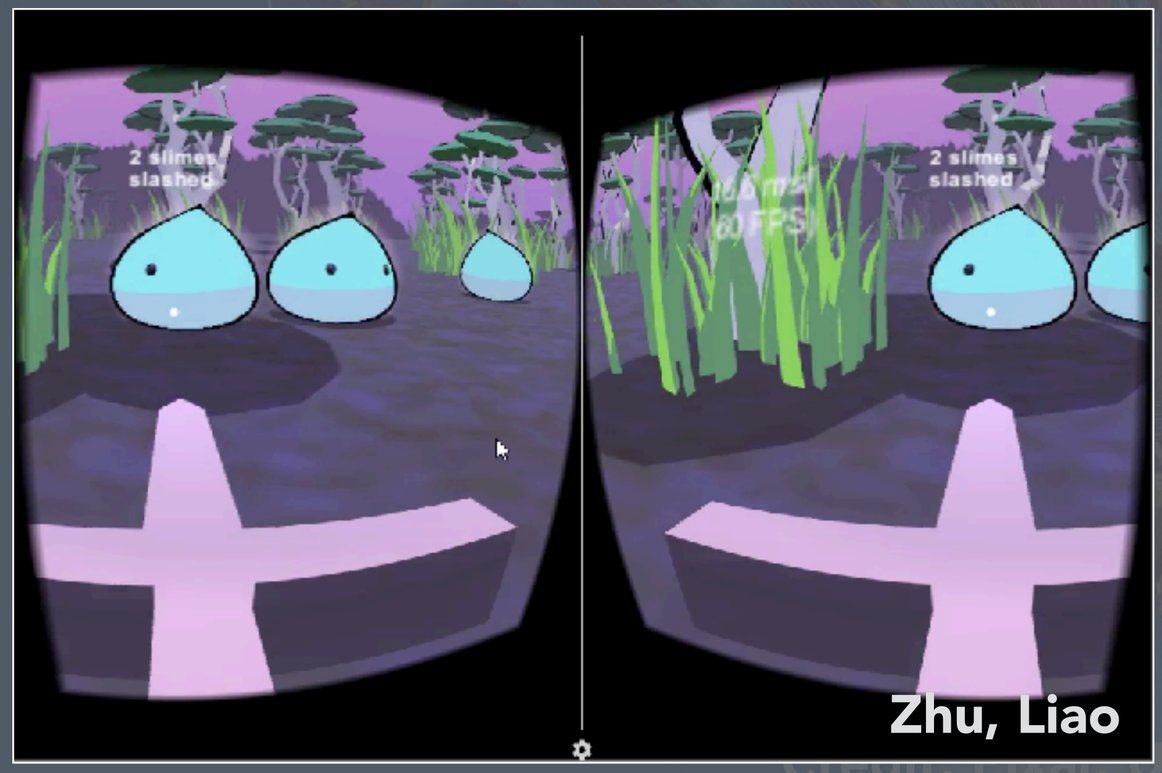
Credit: Pixar, Up

Final Project - Examples









Course Logistics

Prerequisites

Math

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

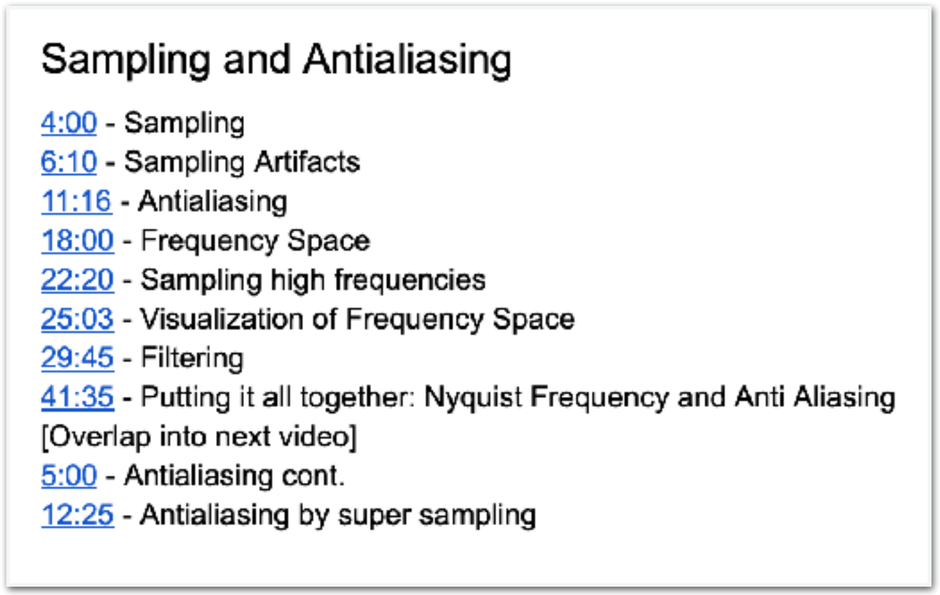
Programming

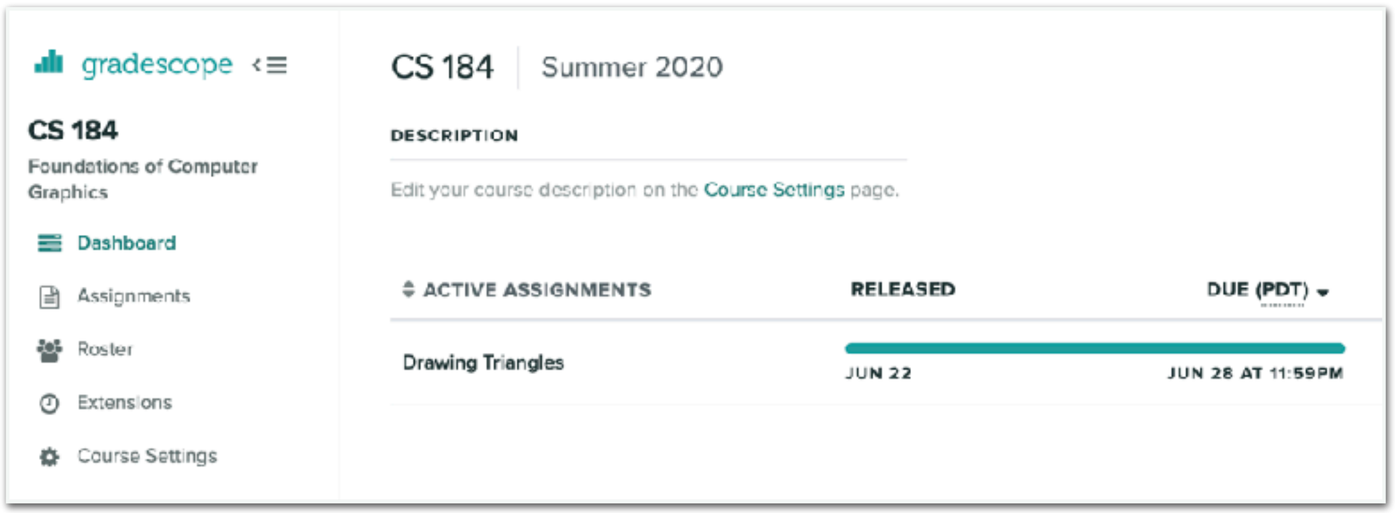
- Data structures (CS61B)
- Fluent with C and C++
- Fluent with development environment, debugging, etc.

Virtual Format Walkthrough

Pre-class

- Pre-recorded Lecture w/ Guide
  - Use Berkeley email to access
- Gradescope Checkpoints





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Virtual Format Walkthrough

In-class

- Demos
  - Typically on Mondays
  - Bridge between high-level mathematical concepts presented in lecture and programming projects
  - Jupyter notebooks released for you to play with!
- Reviews, Q&A
  - Probably most effective if you've already watched lecture videos
  - Come with questions, comments about the lectures!
  - We will highlight important points from lectures

Virtual Format Walkthrough

In-class

- Discussion
  - Recorded walk-through of discussion worksheet problems and solutions
  - Currently no plans to record during discussion times to encourage a more informal and conversational atmosphere
  - Both will be useful -- different approaches to the problems

Virtual Format Walkthrough

After-class

- Office Hours
  - Conceptual questions will be prioritized
  - Welcome to come for project help/debugging
  - Staffed by a single instructor or TA
- Project Party
  - Staffed by multiple TAs
  - Encourage collaborating with classmates
  - Held on Discord to more easily manage multiple voice channels

Course Website

cs184.org or cs184.eecs.berkeley.edu

- Lecture slides are the primary course reference materials
  - Lecture slides for pre-recorded lectures will be linked under Resources (or accessible via previous semester's website)
  - Slides from this summer will be linked on the front page
- Please review Policies page and Resources page carefully!

Piazza

https://piazza.com/class/kasxnp5kcbr6zs

Please sign up!

- Generally prefer Piazza logistics and general communication / discussion
- Community guidelines:
  - Use official project threads when they exist/folders for organization
  - Strive to be helpful and encouraging to other students! Participate actively on Piazza
  - Don't share code

Section

Sections start tomorrow -- C++ review and project environment set up.

Thursday's section is math review.

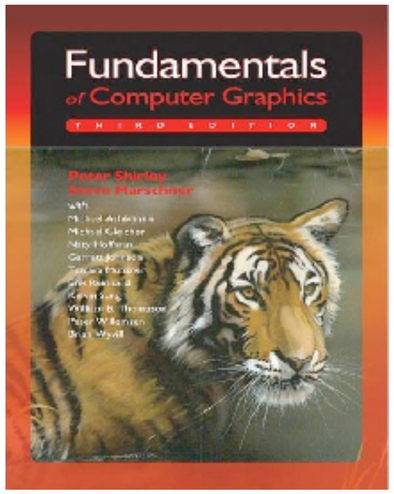
Moving forward, will be mostly worksheets related to lecture material.

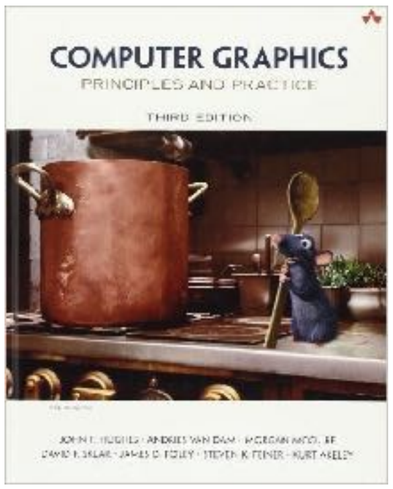
Resources

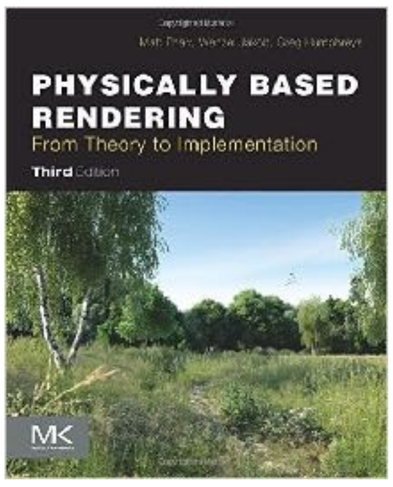
Lectures will be primary source

Textbooks

- 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

Assignments and Evaluation

(50%) Assignments (5)

(25%) Final Project (in groups of 1-3, presentations, report)

(20%) Midterm

- Exam on (tentative) Monday July 27

(5%) Participation

- Checkpoint quizzes - due on a weekly basis on Sundays at 11:59 PM
- Piazza (give / get help), come to office hours and homework parties

Late Days Policy

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

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

- Extend a programming assignment deadline by 24 hours using one late day.
- Because of summer course pace, *only 2 slip days* can be used for a single assignment.
- If you do not have remaining late days, 10% penalty per day.
- Use this flexibility to manage your own exceptional circumstances. No exceptions beyond this!

Class Philosophy

We want a very active class!

Come to class, participate in lecture.

Online classes are a new challenge we're all trying to figure out. Staying engaged can be hard, but is important to maximize learning and enjoyment!

This class moves quickly, especially in the summer. Stay on track, and ask for help as soon as you need it! We are here to support you however we can.

Questions?

Acknowledgments

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

Many thanks to Ren Ng for lecture slides and pre-recorded lectures!