Lecture 1:

Introduction

Computer Graphics and Imaging
UC Berkeley CS184/284A

Welcome to CS184 / 284A!

Prof. Ren Ng

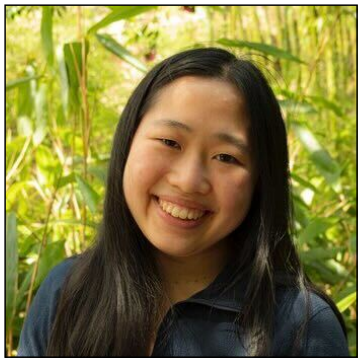
- Ph.D. 2006 on Digital Light Field Photography (evolving camera design using graphics technology)
- Founder of Lytro, a light field camera company
- Research interests: computational imaging systems, computer graphics, computer vision, human vision
- Fun fact: born Malaysian, became Australian, naturalized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

Welcome to CS184 / 284A!

Prof. James F. O'Brien

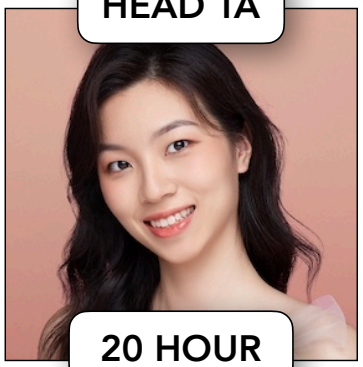
- Ph.D. GaTech 2000 on fracture propagation with application to destruction visual effects.
- Research: Computer graphics, computer animation, simulations of physical systems, human perception, rendering, image synthesis, machine learning, virtual reality, and media forensics.
- Industry: Klothed, Pixelux, Dreamworks, Avametric, Juice Technologies
- Enjoys: Photography, traveling, scuba, camping, beat saber, woodworking, and glassblowing.

Welcome to CS184 / 284A!

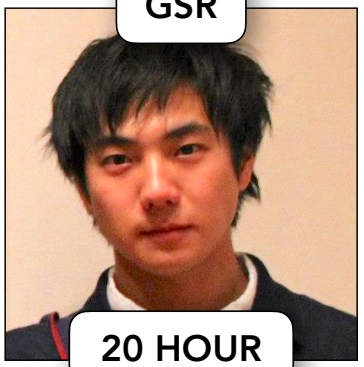


Ashley Chu

James Fong



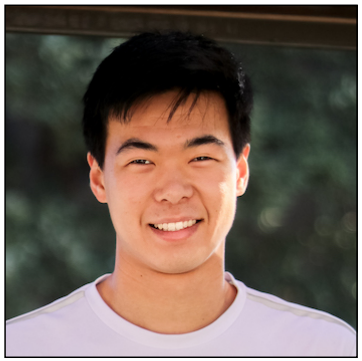
Catherine Gai



Astunobu Kotani

David McAllister

Michael Ren



Jeffrey Shen

Anjali Thakrar

Ethan Weber

Your Names: An Important Request

We want to get to know you

It starts with your names

We want to remember, but there are many of us

Please help us with this rule:

- Every time you participate in class, section, office hours, please remind us your name.

Example: “Hi, this is Susan. My question is about…”

Thank you very much!

CS184/284A: Computer Graphics & Imaging

Why Study Computer Graphics?

Course Overview

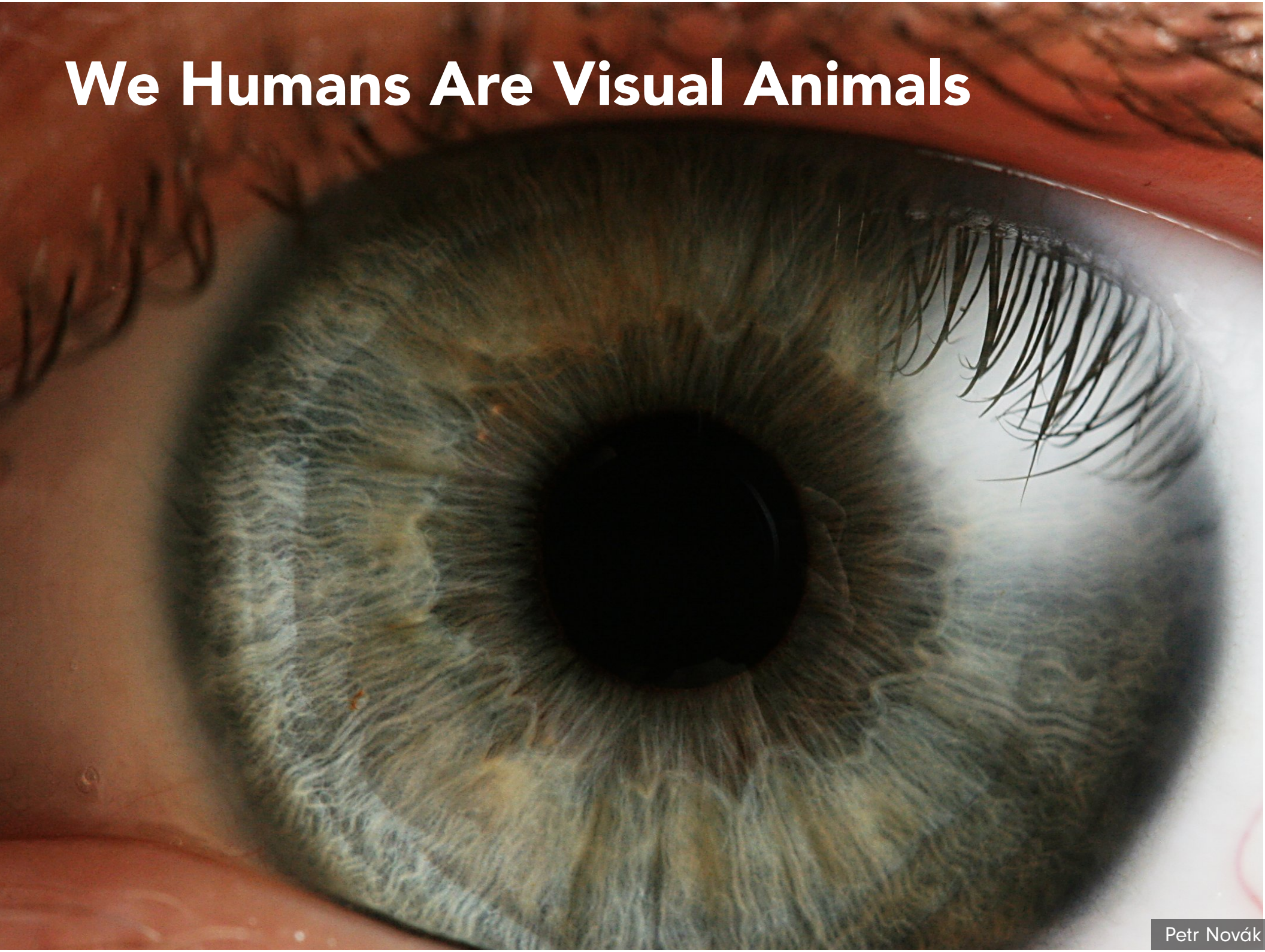
Logistics

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?

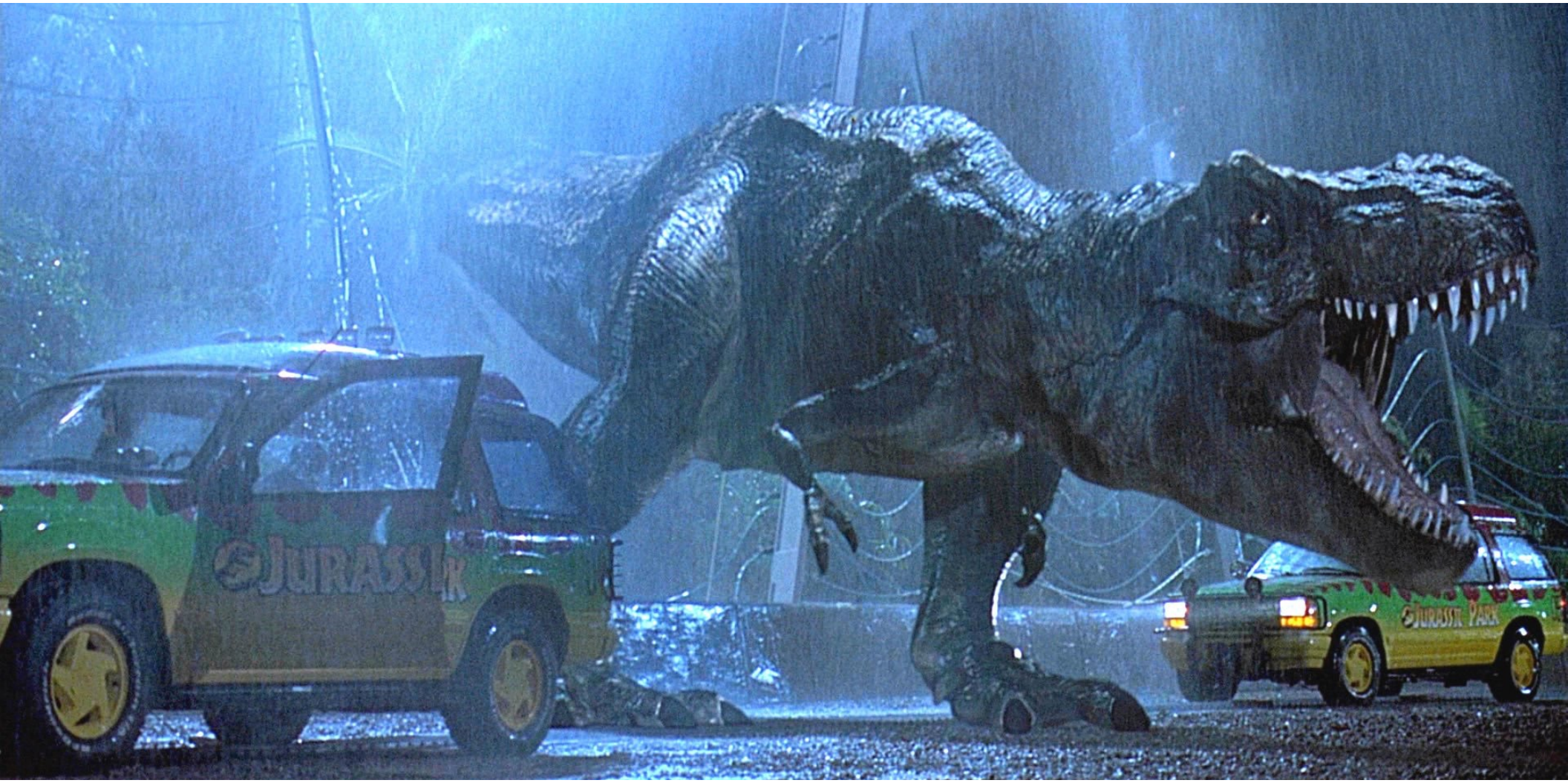
We Humans Are Visual Animals



Petr Novák

Why Study Computer Graphics and Imaging?

Movies



Jurassic Park (1993)

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

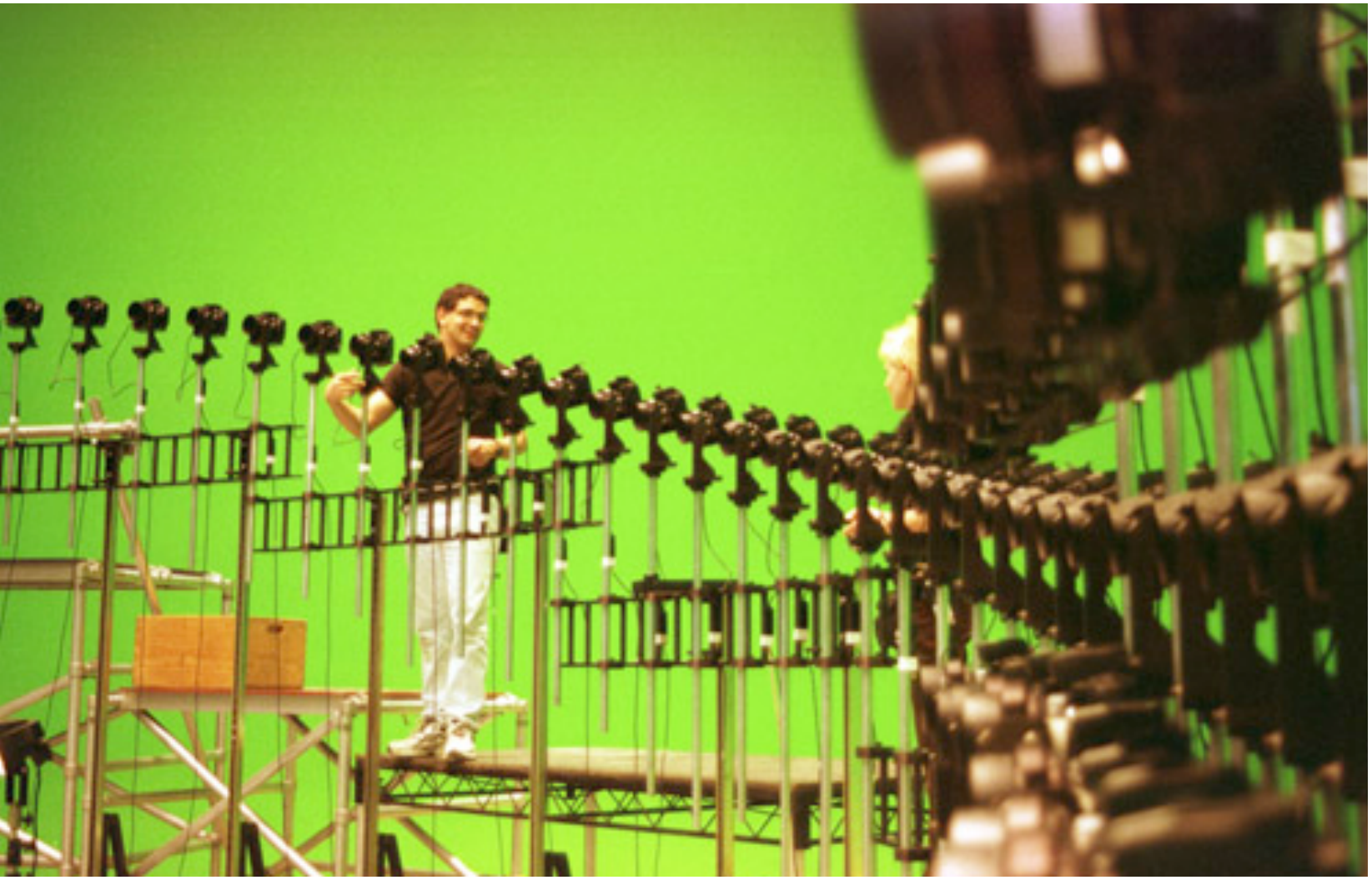
Movies

Toy Story (1995)

Movies

The Matrix (1999)

Movies



The Matrix (1999)

The Campanile

Debevec, Taylor and Malik SIGGRAPH 1996

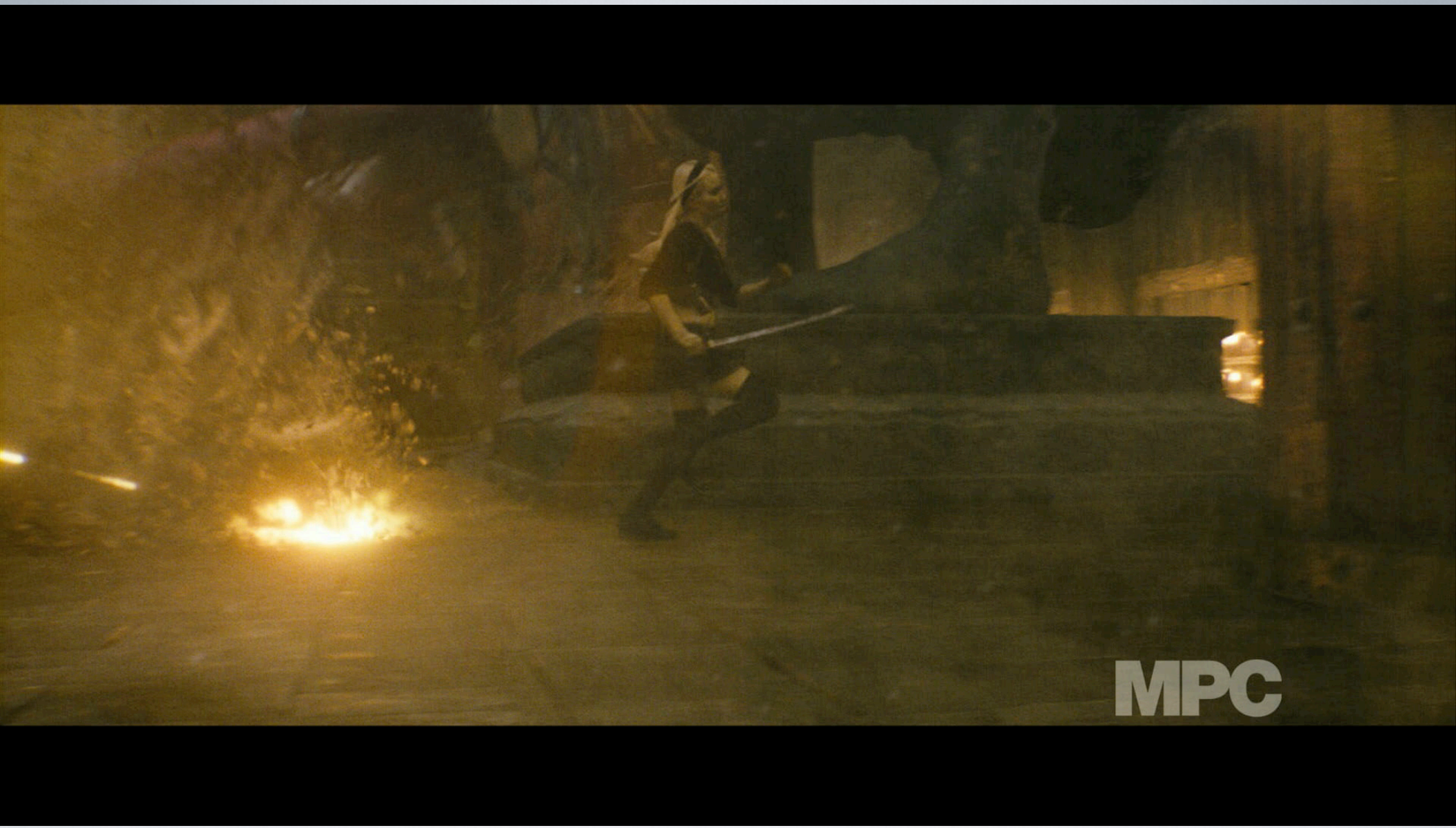
https://www.pauldebevec.com/Campanile/

Motion Capture

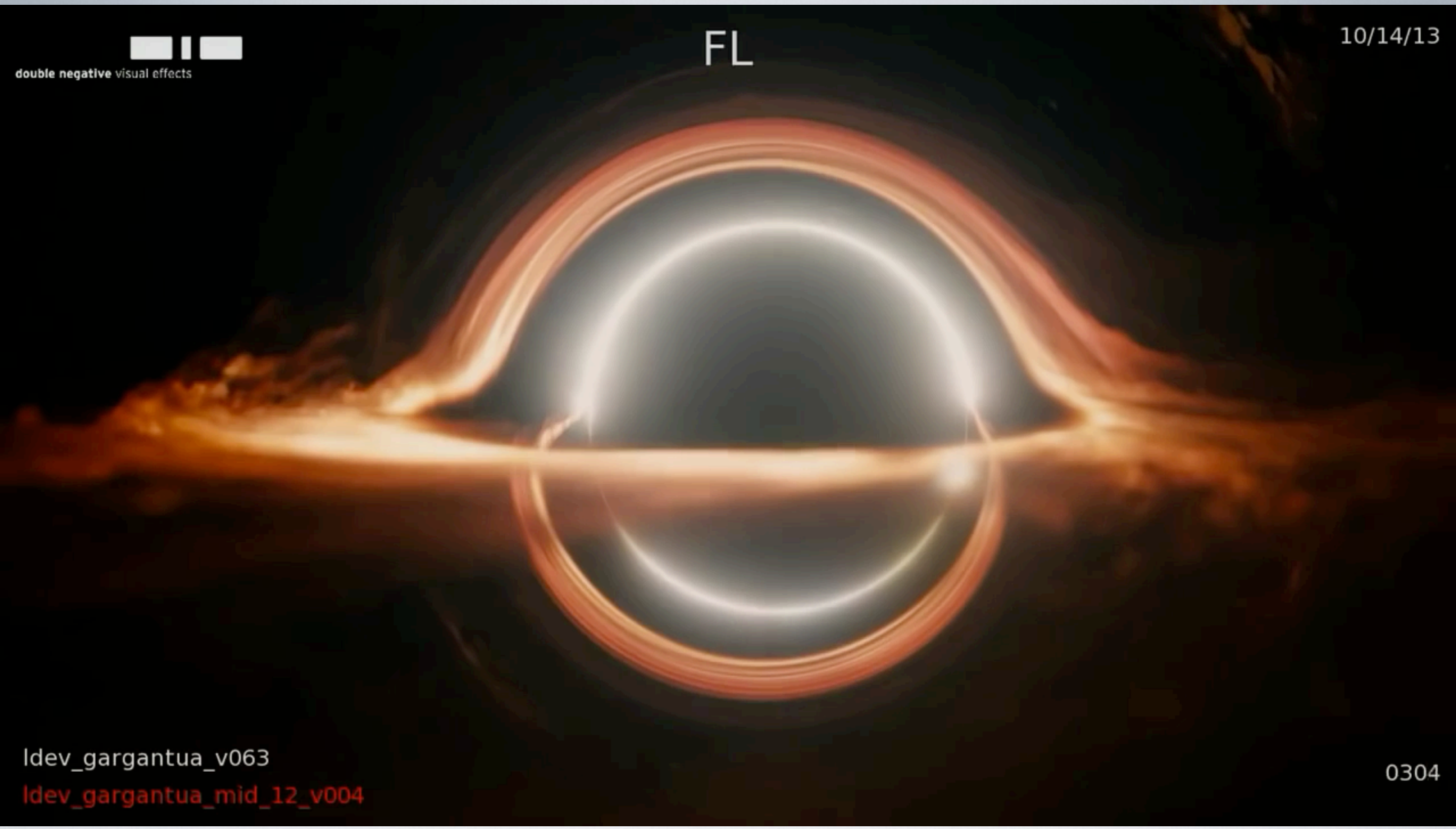
Andy Serkis in The Two Towers

Avatar (2009)

Titanic (1997)

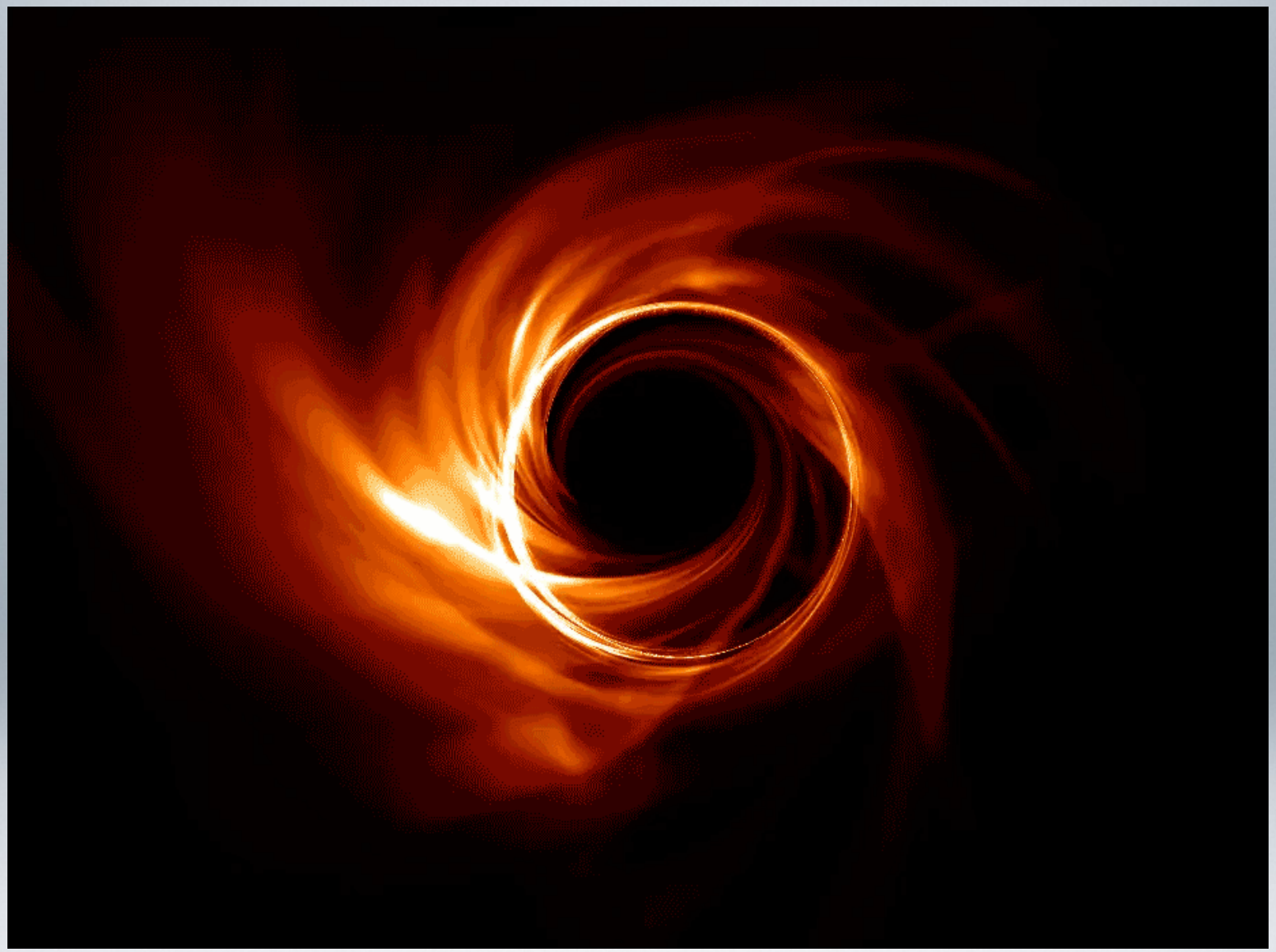


Sucker Punch (2009)



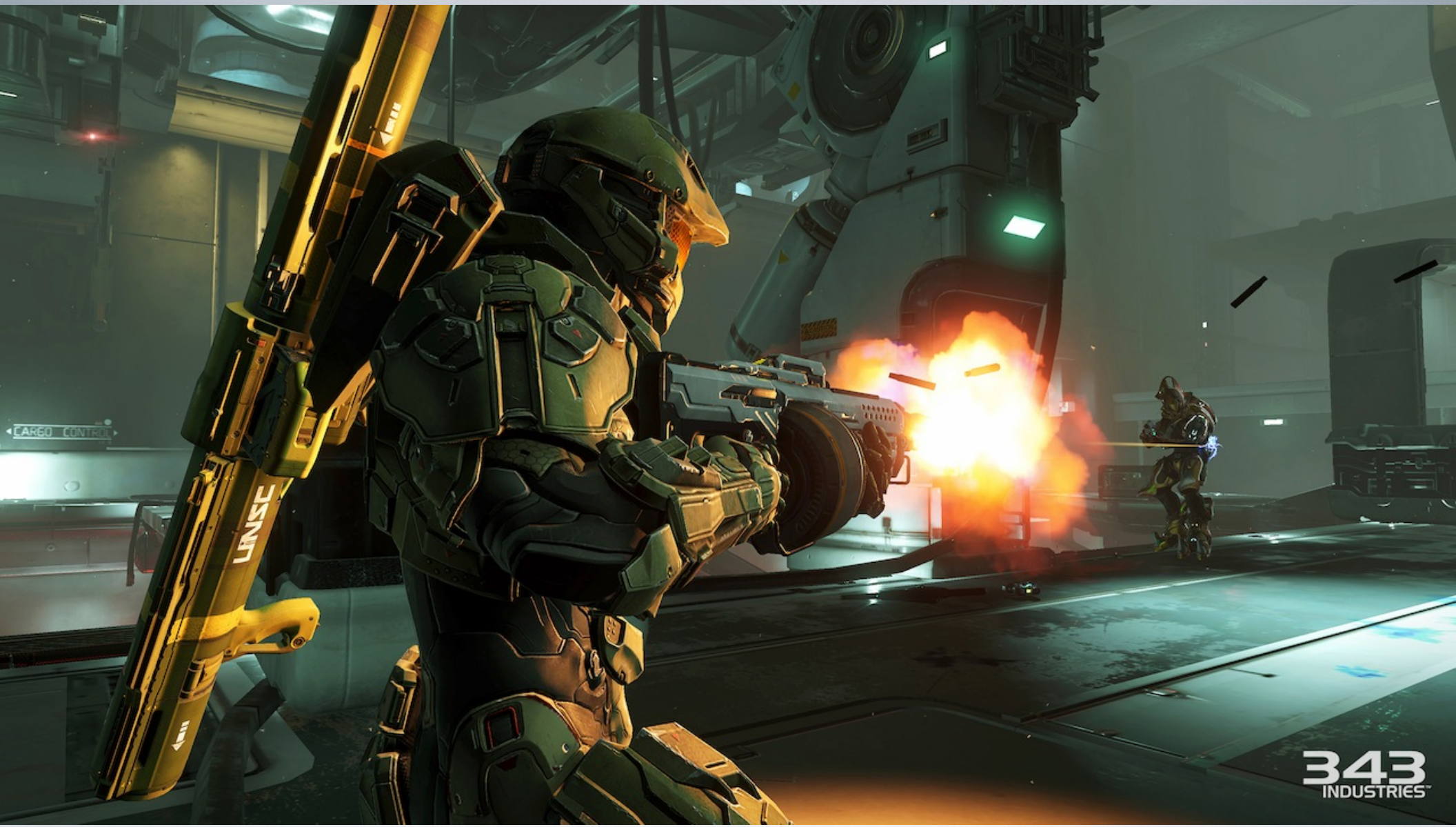
Interstellar (2014)

Event Horizon Telescope collaboration et al.



Event Horizon Telescope collaboration et al.

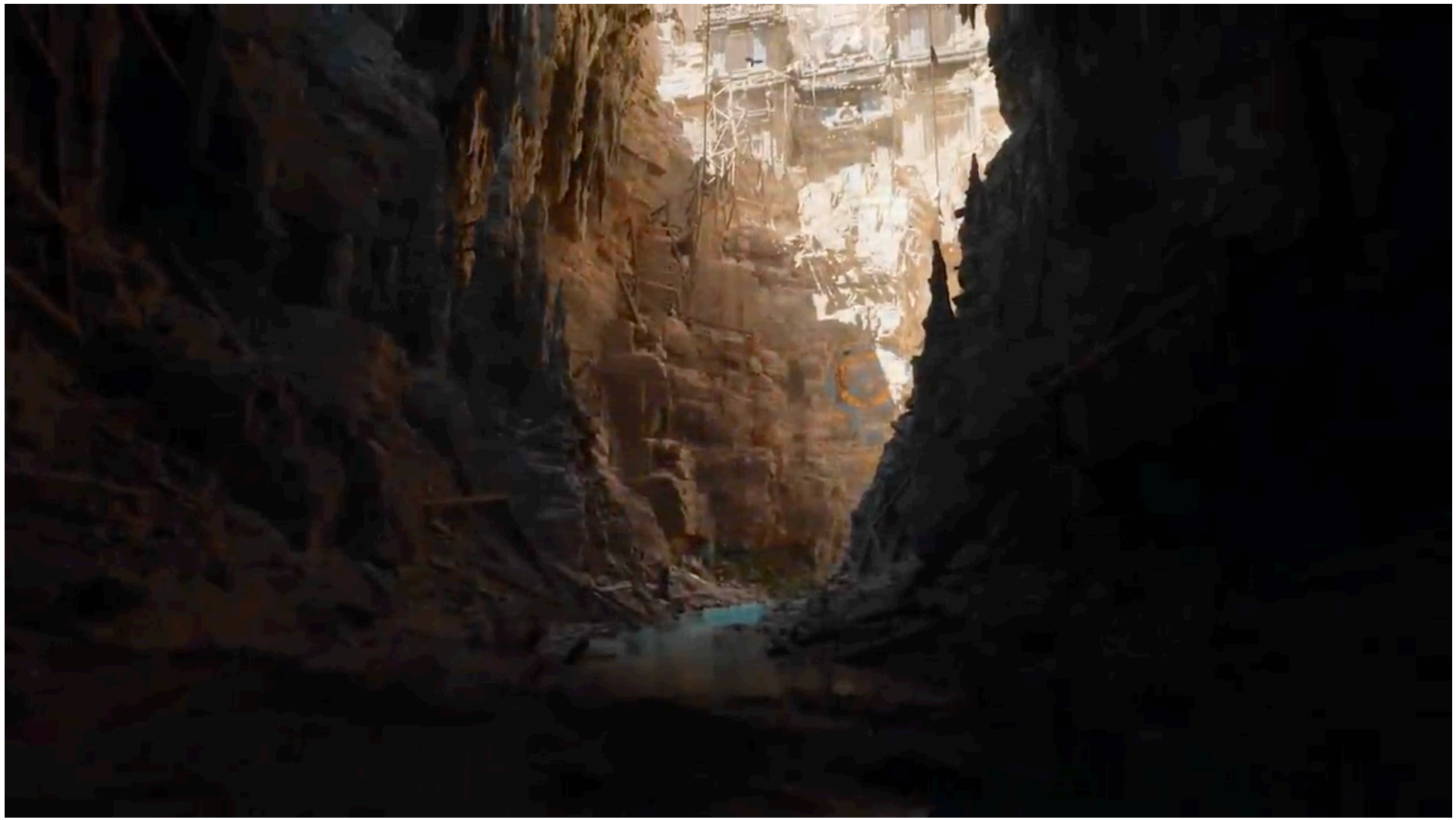
Games



Halo 5 (2015)

Red Dead Redemption 2, Rockstar, 2019

Games



Unreal Engine 5 Demo Realtime in PS5 (2020)

Battlefield 5 (2018)

Battlefield 5 (2018)

Games

Mirror's Edge (2008)

Child of Light (2014)

Ōkami (2006)

Assassin's Creed: Odyssey (2018)

Training Simulations

From America's Army

From CAE Inc.

Visual Simulation

Driving simulator
Toyota Higashifuji Technical Center

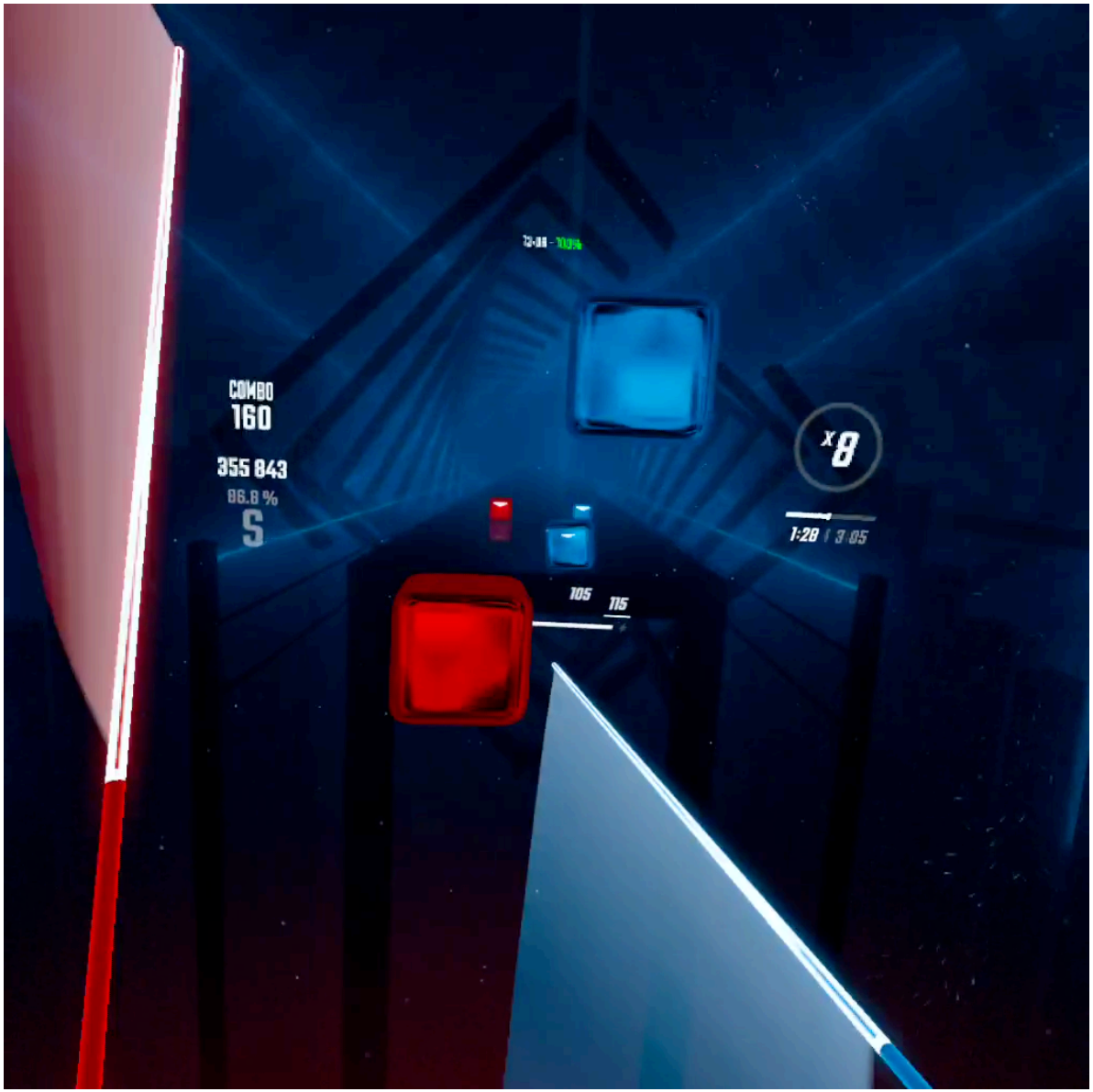
da Vinci surgical robot
Intuitive Surgical

Flight simulator, driving simulator, surgical simulator, …

Virtual Reality

HTC Vive headset and controllers

Virtual Reality

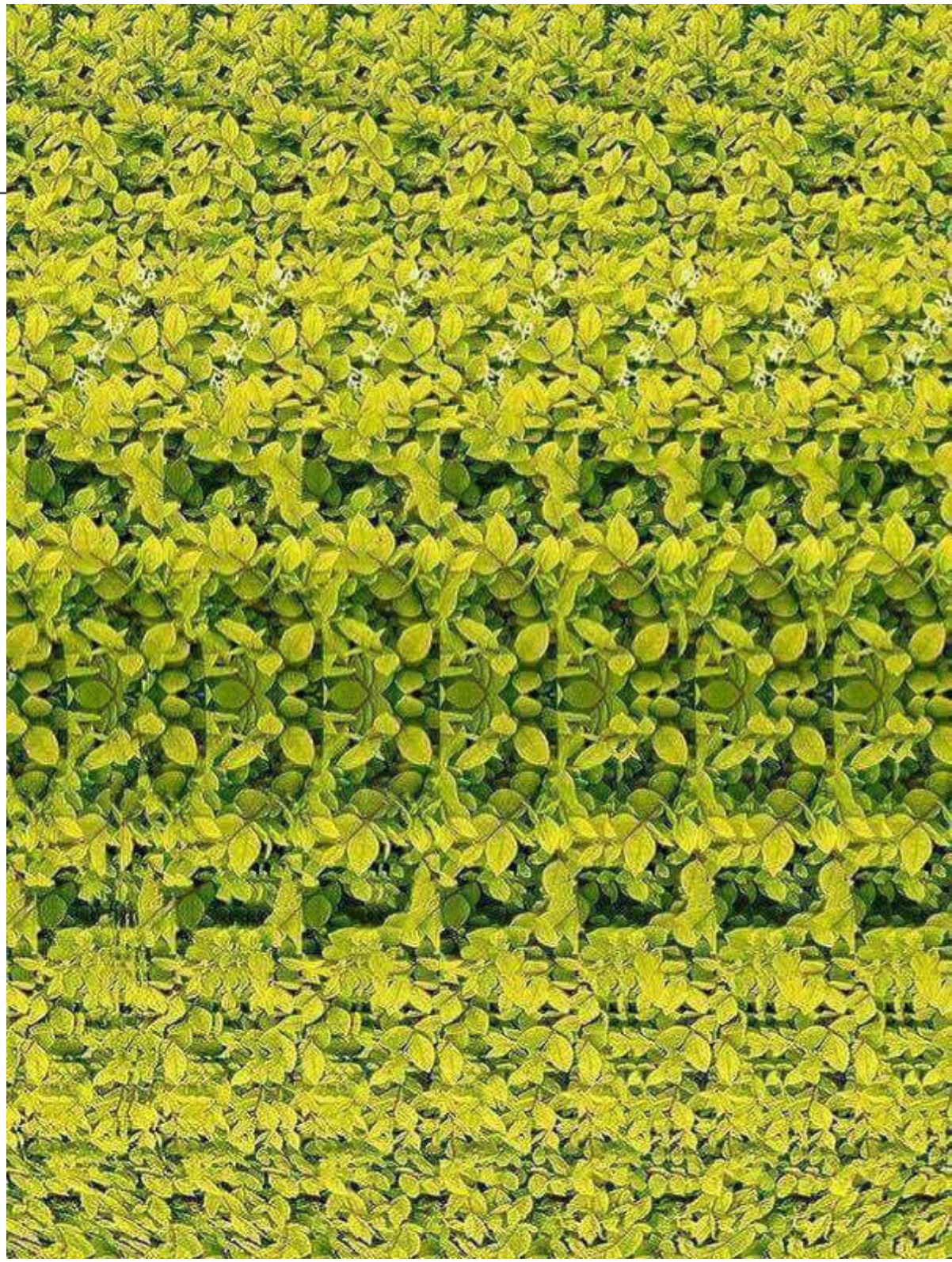


Augmented Reality

Microsoft Hololens augmented reality headset concept

Augmented Reality

Stereo Vison



Product Design and Visualization

Ikea - 75% of catalog is rendered imagery

Product Design and Visualization

Photograph

Simulation

Avametric 2016

Product Design and Visualization

Tesla Model X concept (2012)

Product Design and Visualization

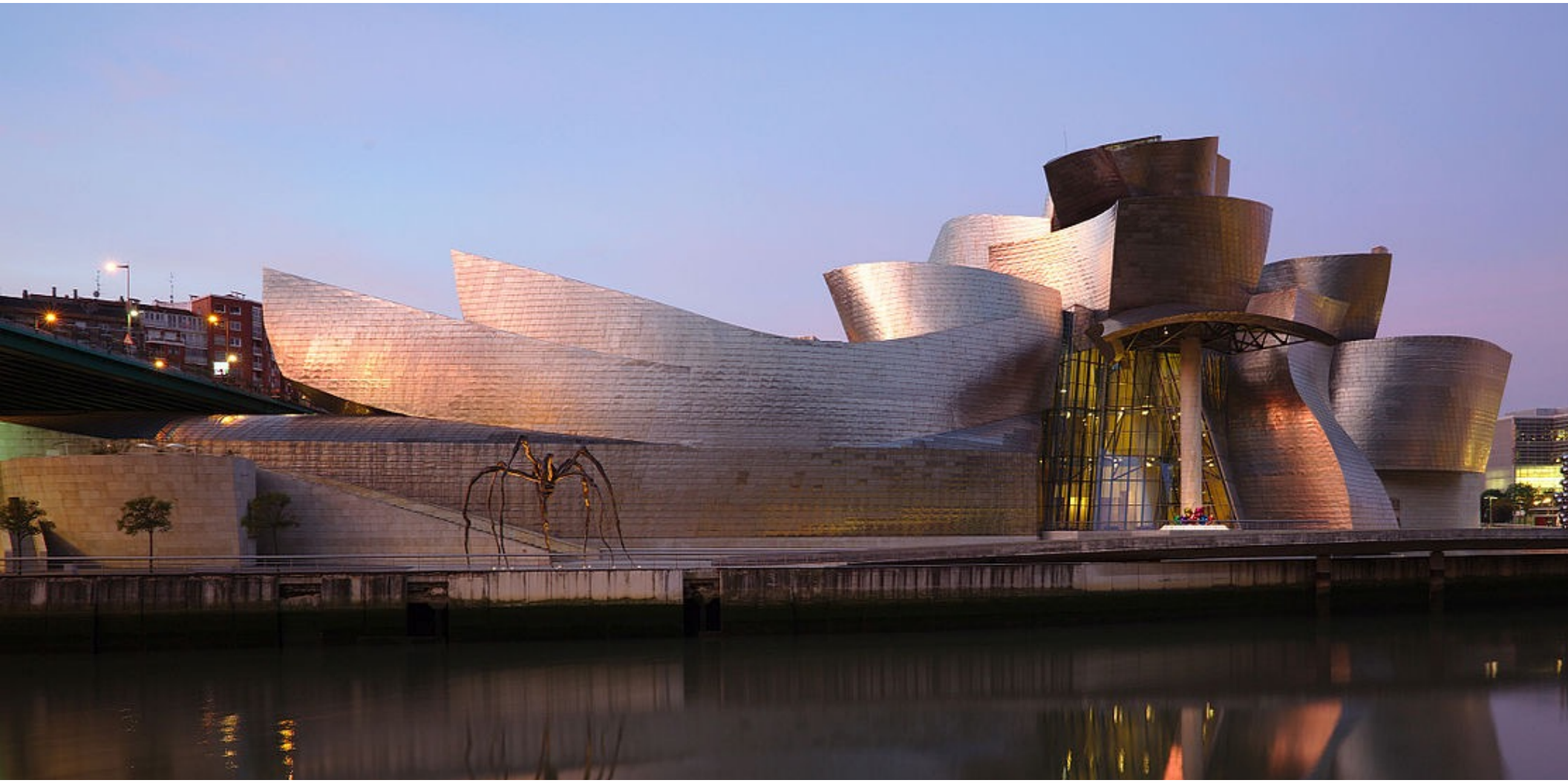
Credit: EV obsession.com, James Ayre

Tesla Model X production

Product Design and Visualization

Mill Blackbird

Architectural Design

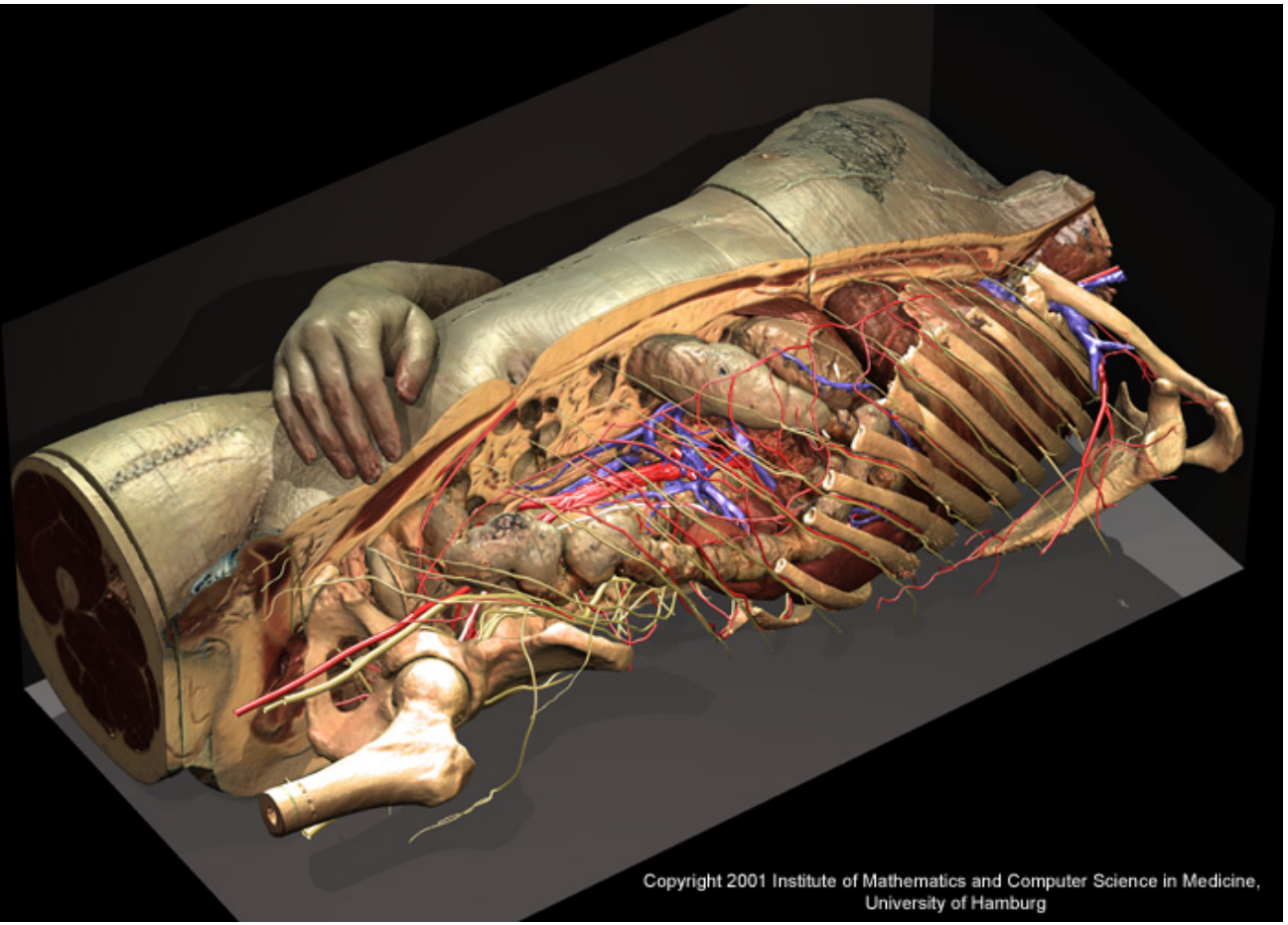


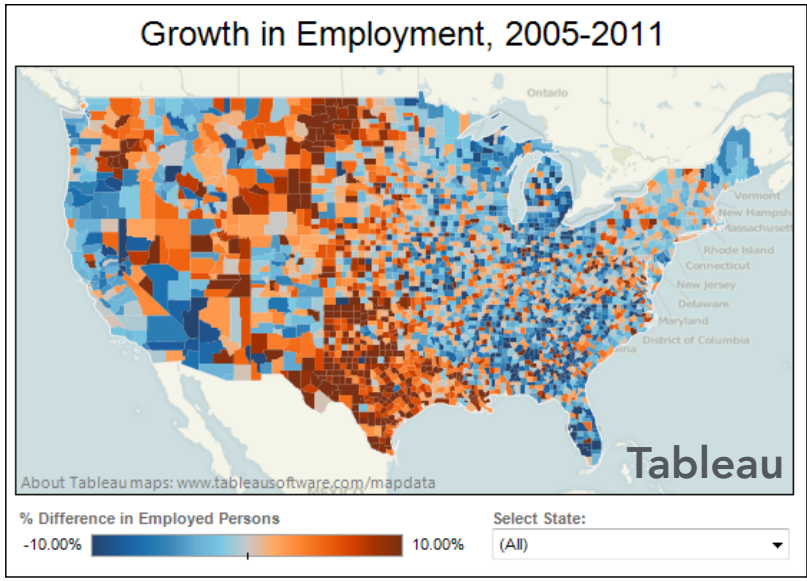
Bilbao Guggenheim, Frank Gehry

Architectural Design

Heydar Aliyev Center, Zaha Hadid Architects

Visualization



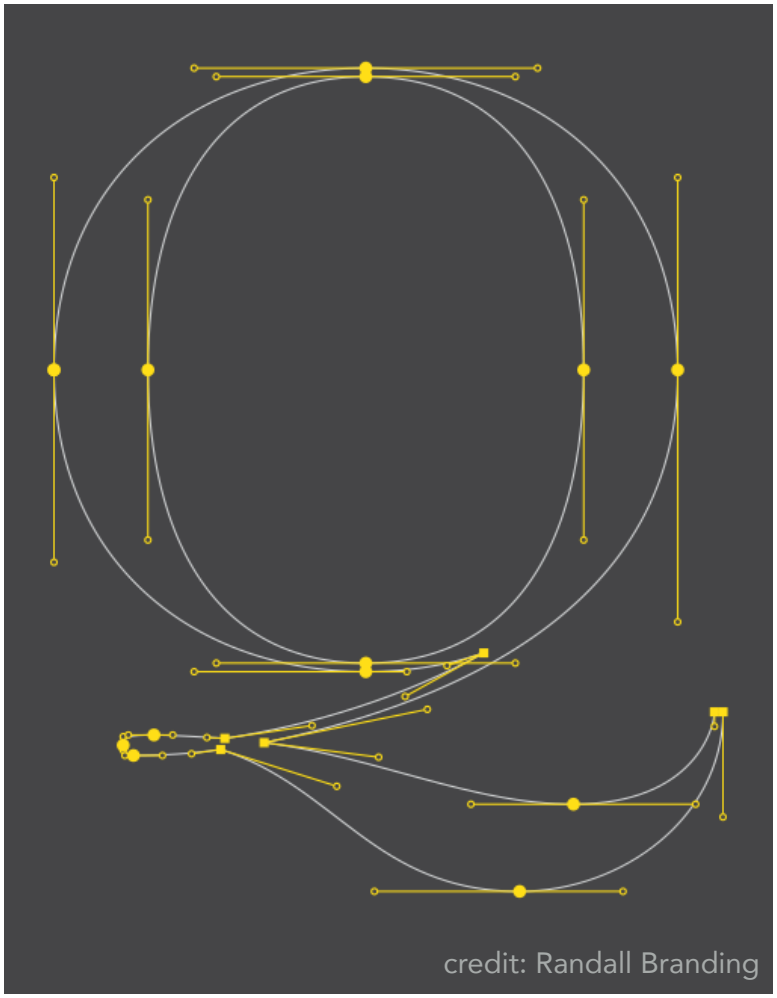


Science, engineering, medicine, journalism, ...

Typography

The Quick Brown Fox Jumps Over The Lazy Dog

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 0123456789

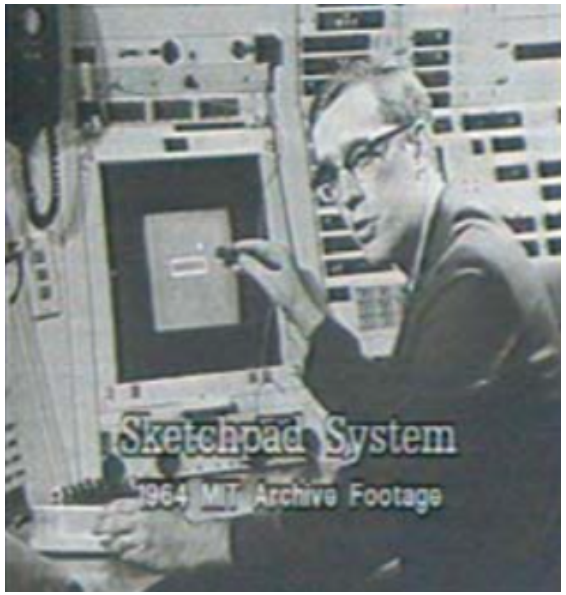


Baskerville

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

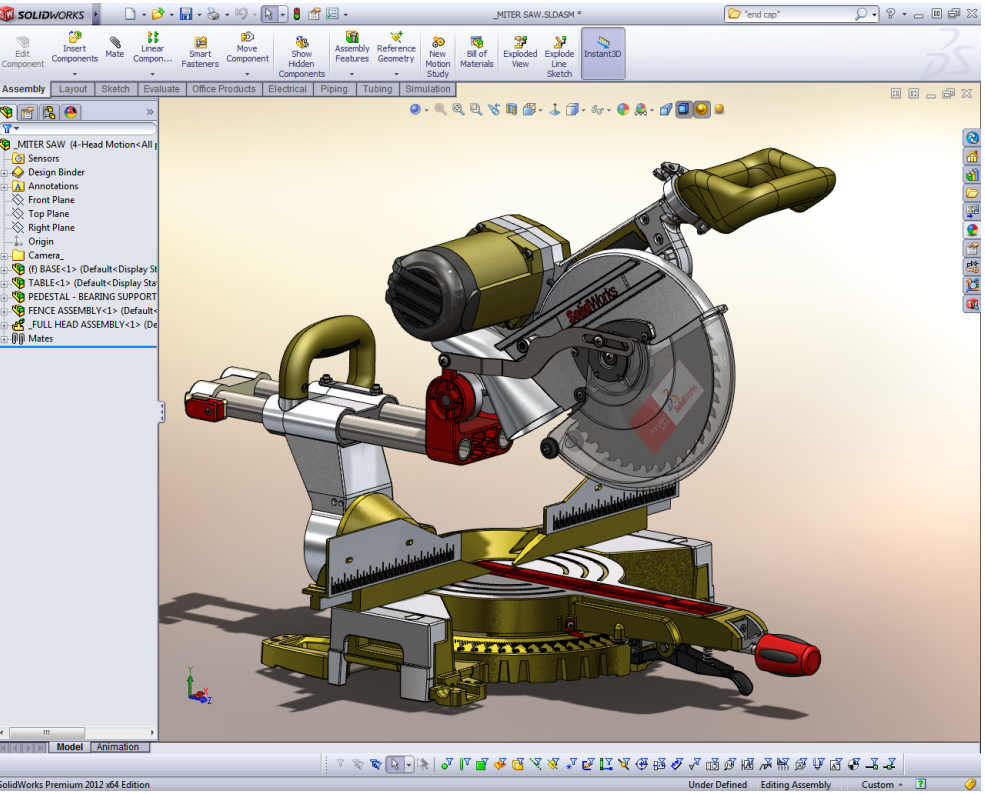
https://www.youtube.com/watch?v=YndL315tQq8

Digital Illustration

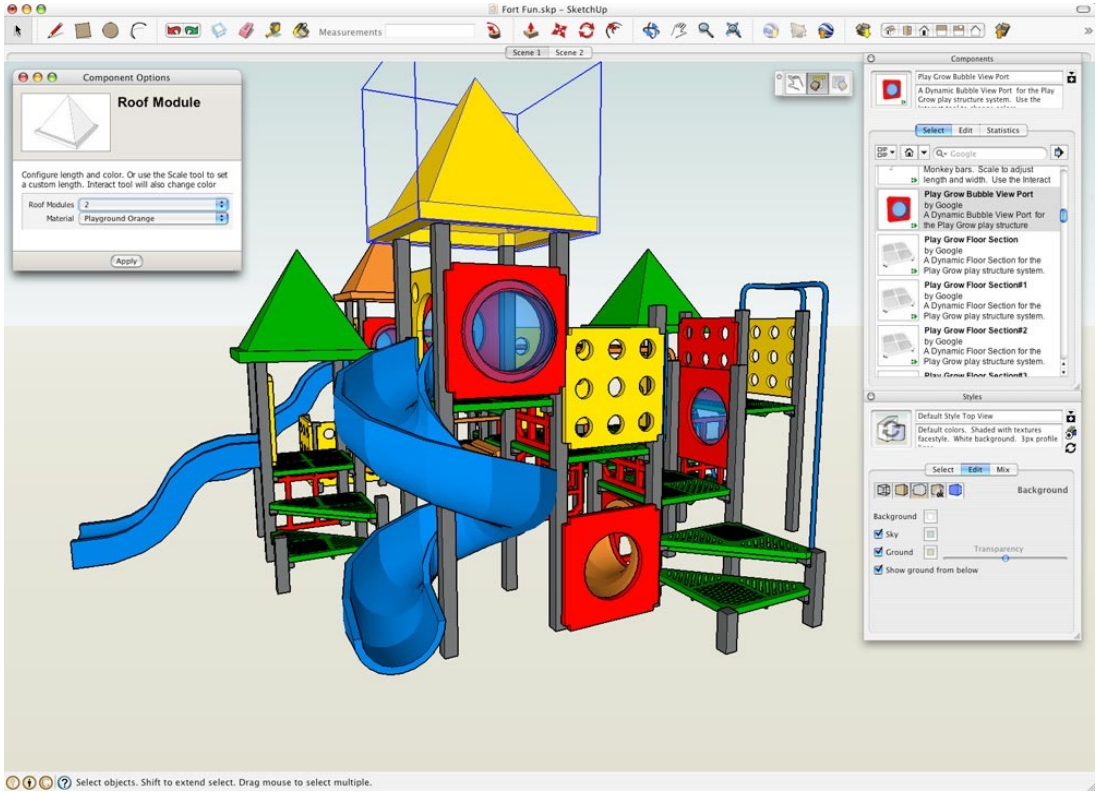
Meike Hakkart

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

Computer-Aided Design



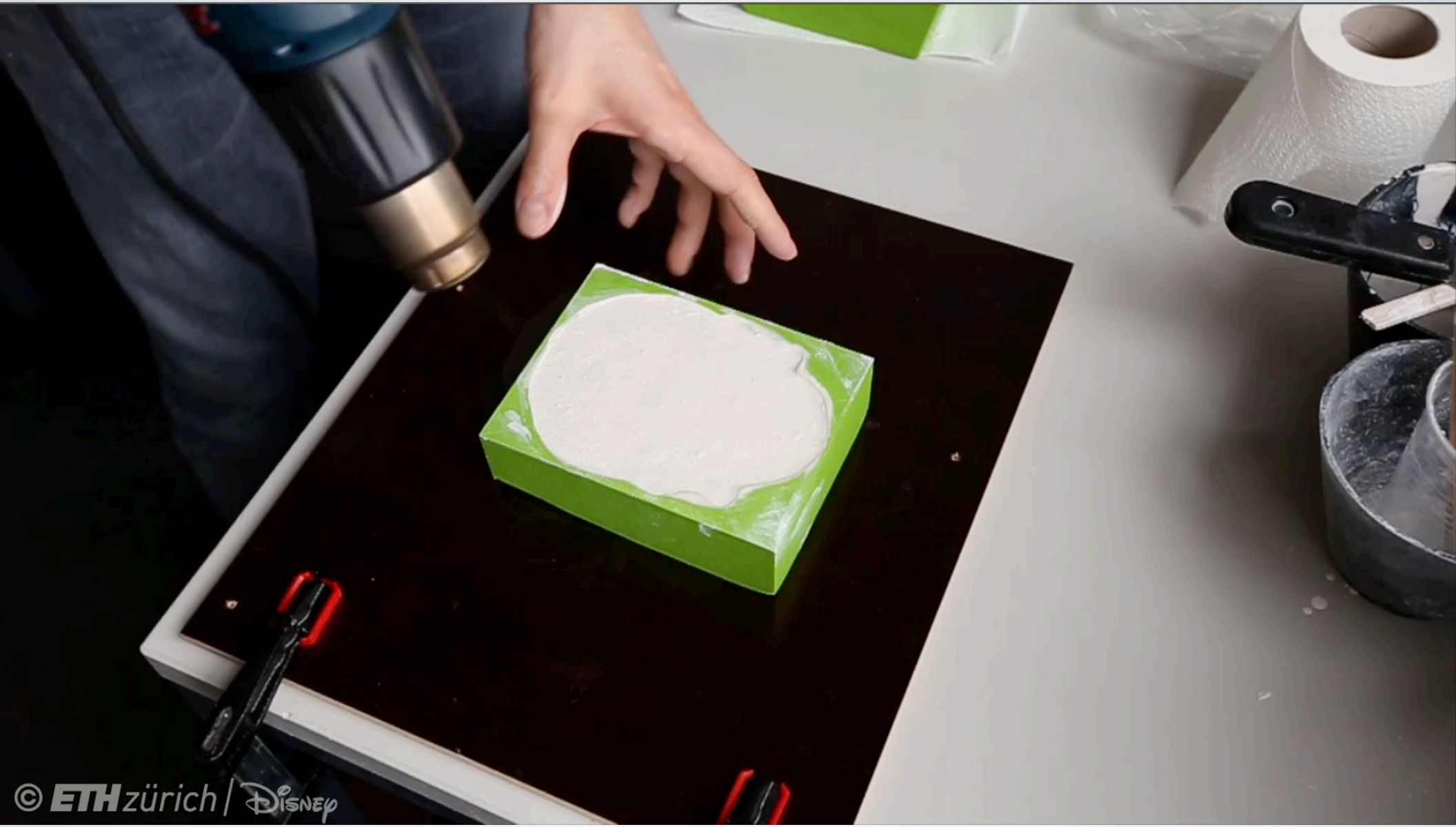
SolidWorks



SketchUp

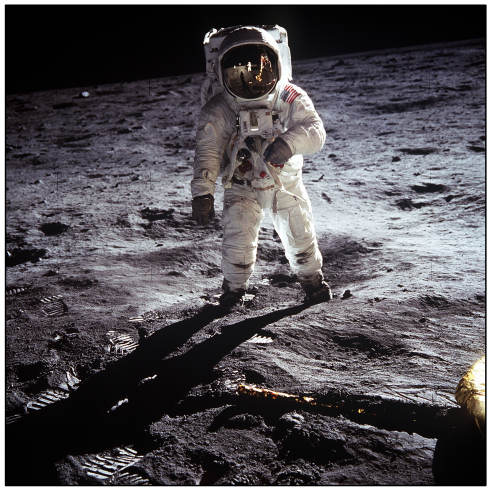
For mechanical, architectural, electronic, optical, …

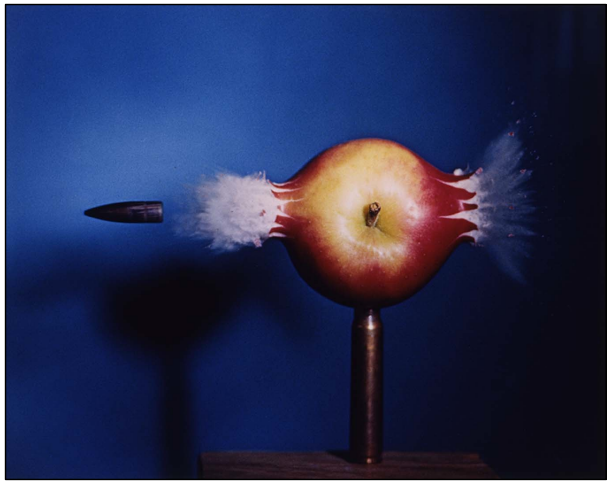
Fabrication



Computational Thermoforming
Christian Schuller, Daniele Panozzo, Anselm Grundhofer, Henning Zimmer, Evgeni Sorkine, Olga Sorkine-Hornung

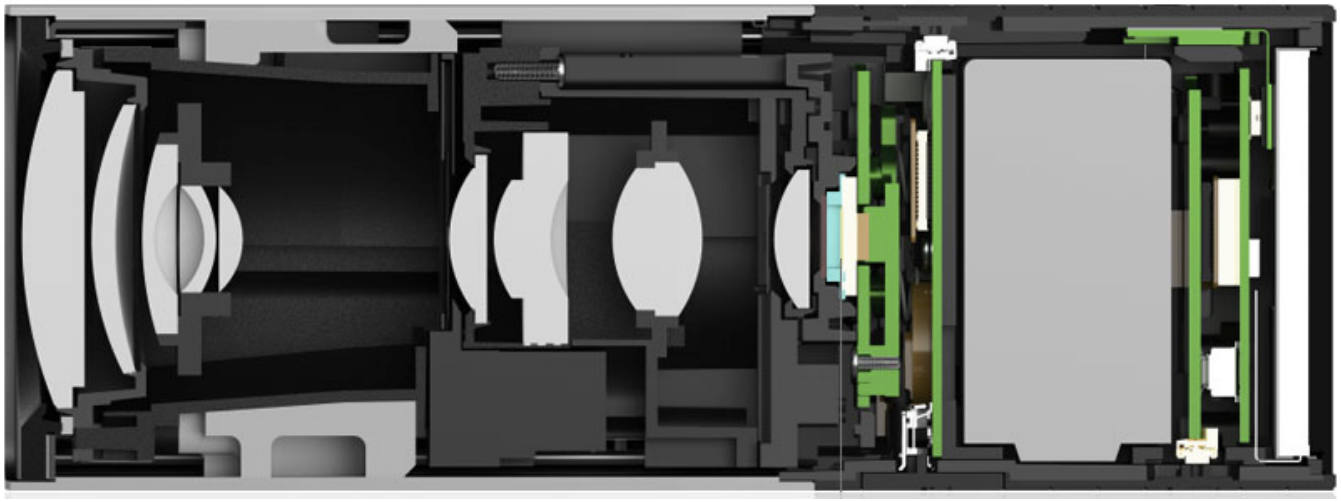
Photography





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

Digital and Computational Cameras

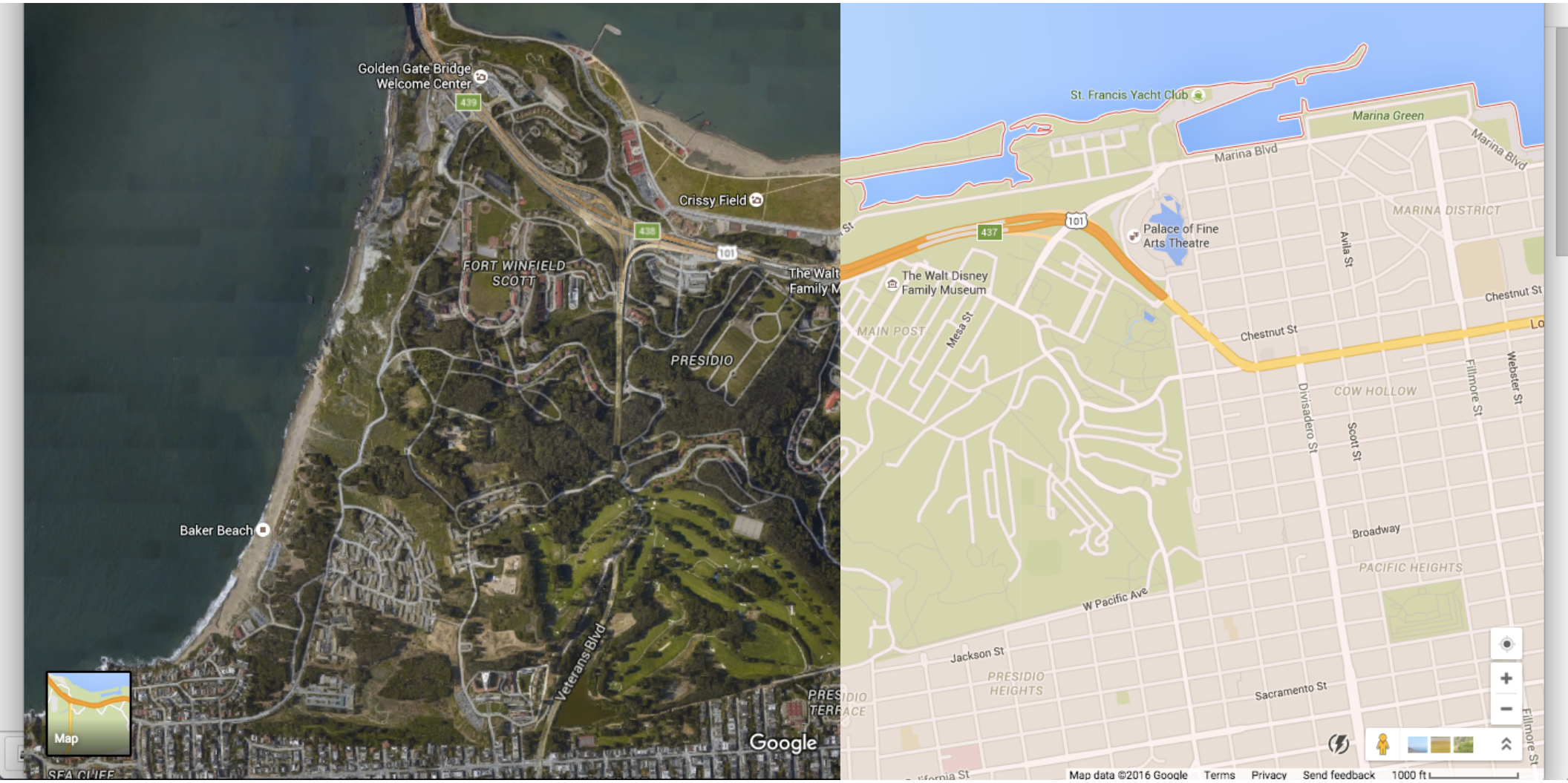


Panaromic stitching, HDR photos, light field cameras, …

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

Imaging for Robotics

Google's "Arm Farm"

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

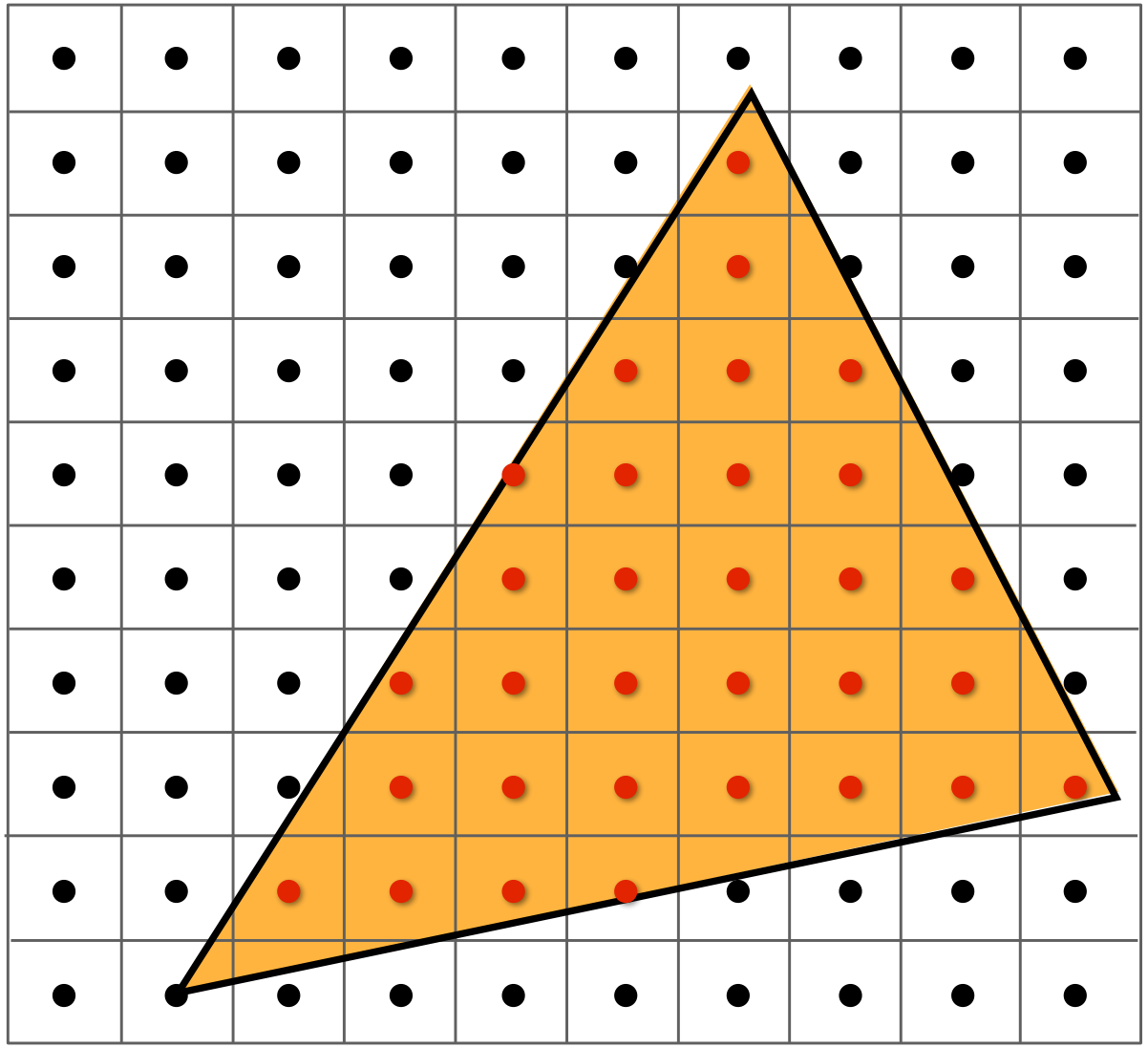
- Modeling the world, image synthesis
- 3D graphics: geometry, rendering, animation
- Image capture, manipulation and display

Acquire core concepts and skills

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

Course Topics

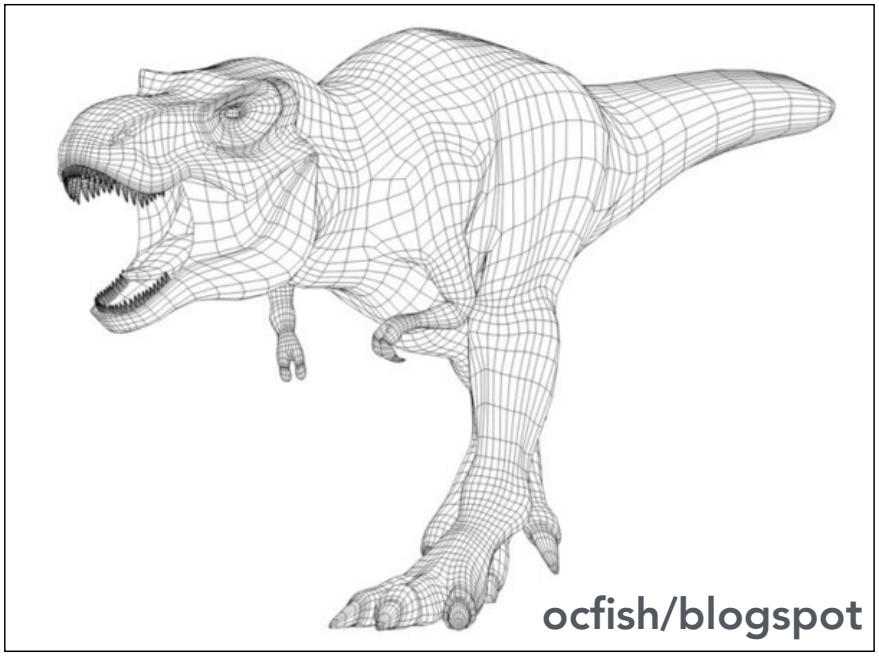
Drawing Digital Images (Rasterization)

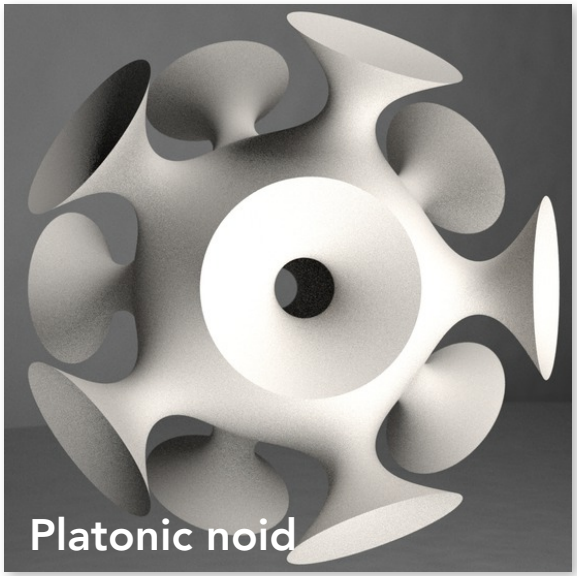


Filtering and Sampling

No Jaggies

Modeling Geometry





Modeling Material Properties

Modeling Lighting

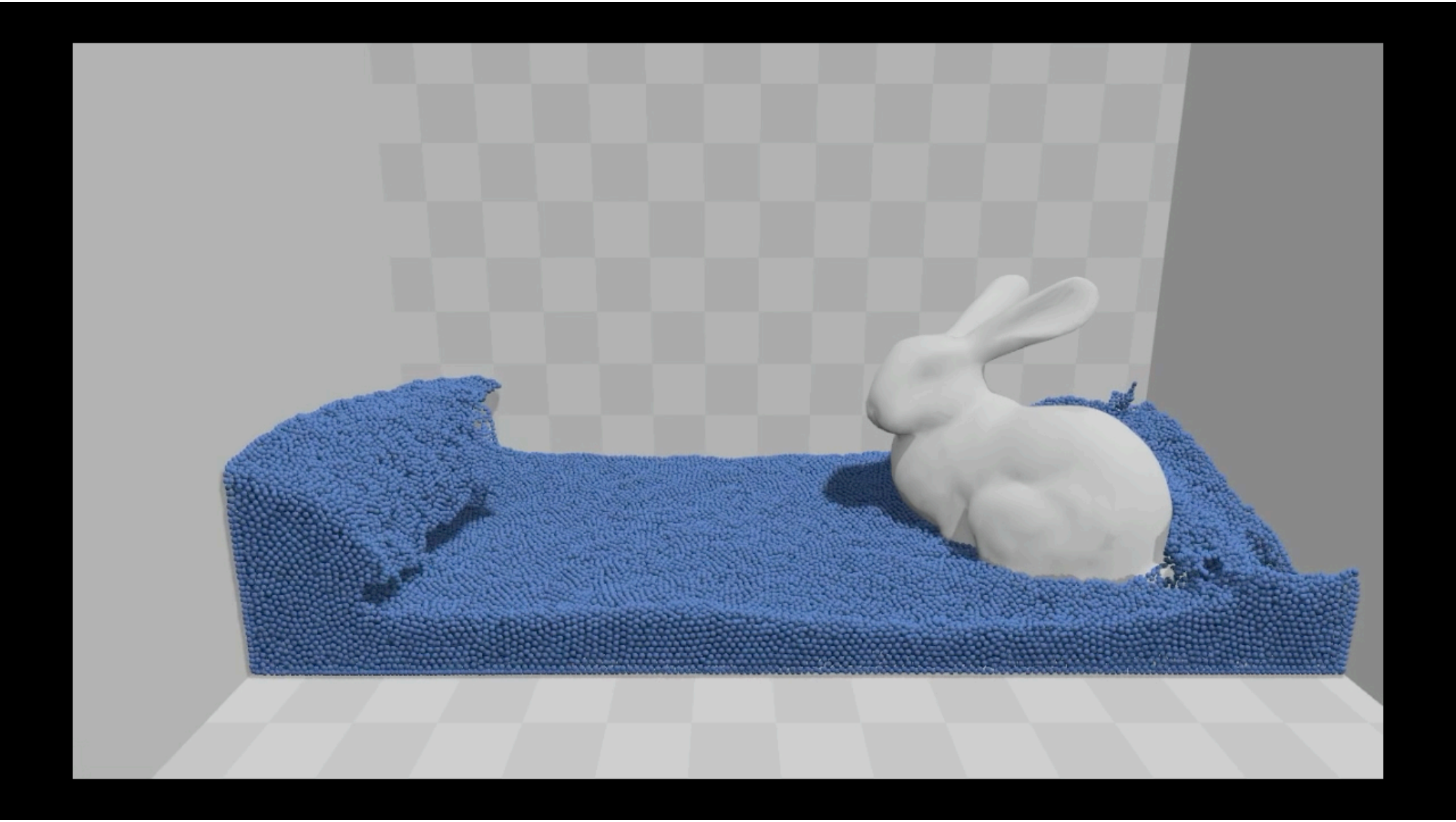
Light Transport and Image Synthesis

Photograph (CCD) vs. computer rendering

How Do Cameras Work?

Glenn Derene, Popular Mechanics

Animation and Physical Simulation

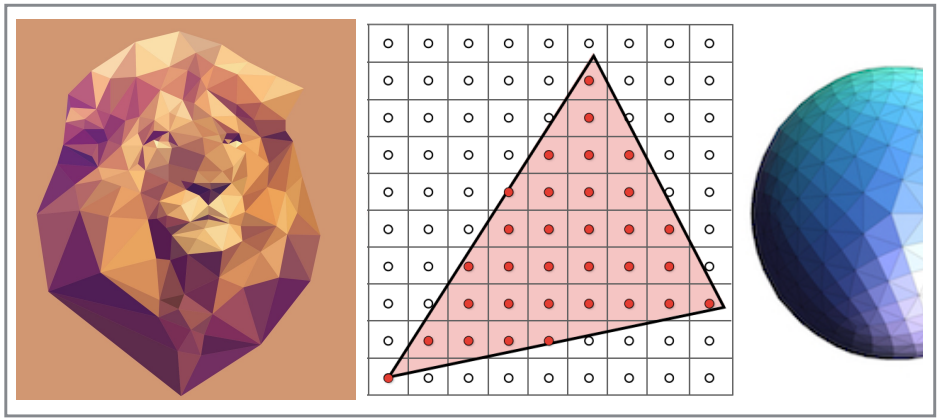


Position Based Fluids, Macklin and Müller

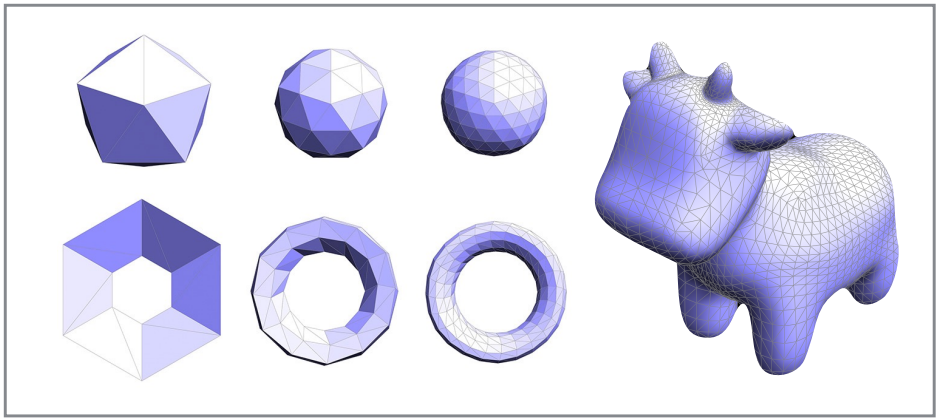
Virtual Reality

Hands-On Learning

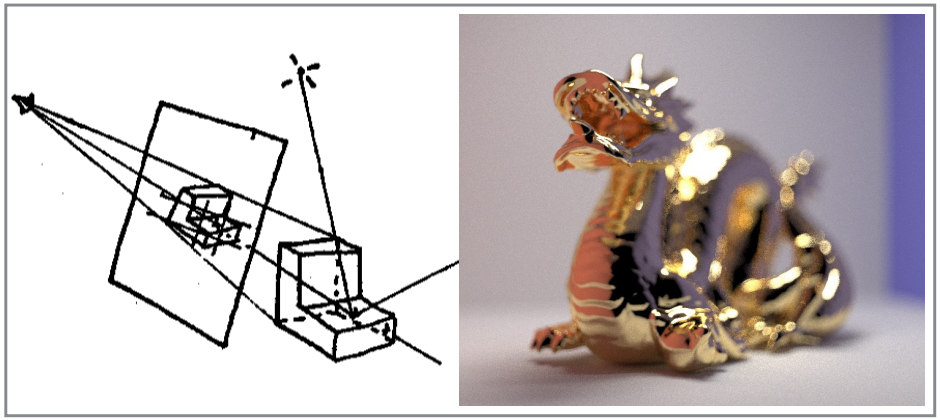
Course Assignments



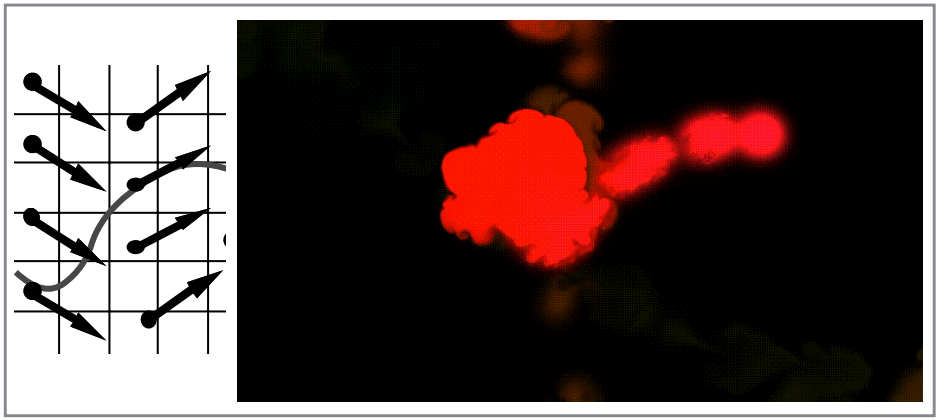
1. Digital Drawing (2 weeks)



2. Geometry (2 weeks)



3. Ray-Tracing (4 weeks)



4. Animation (2 weeks)

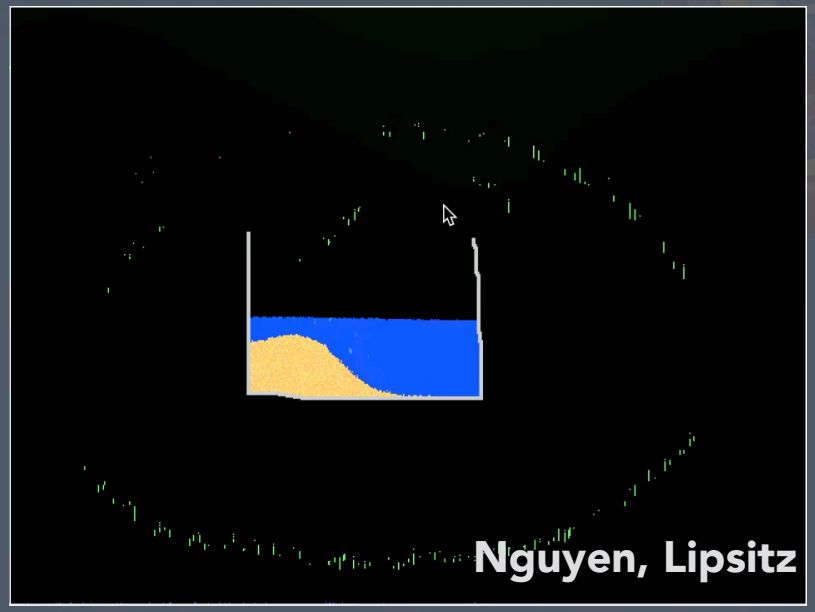
Final Project

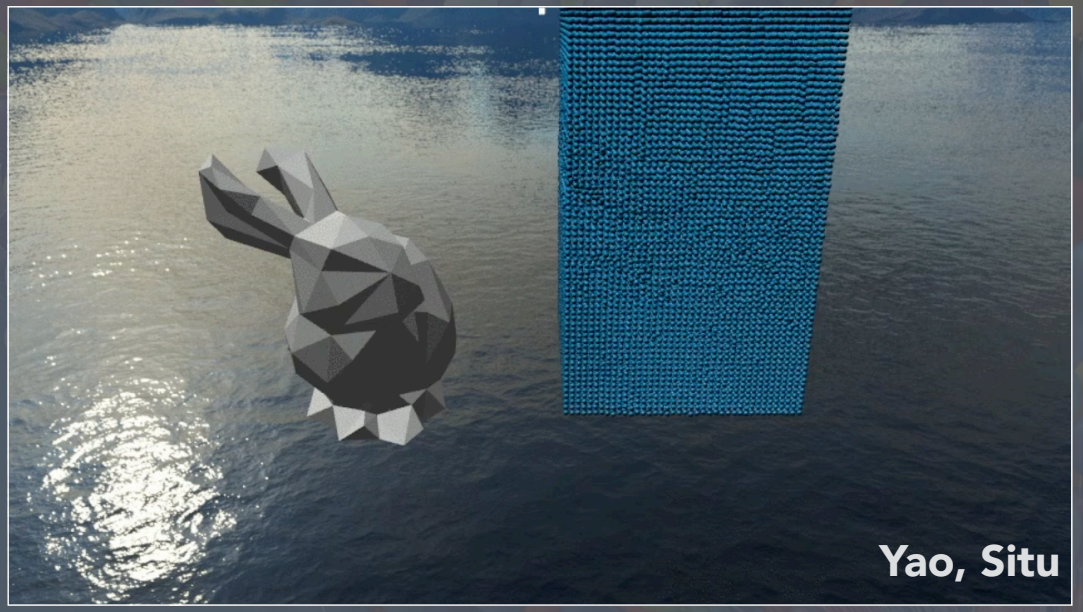
Project Competition

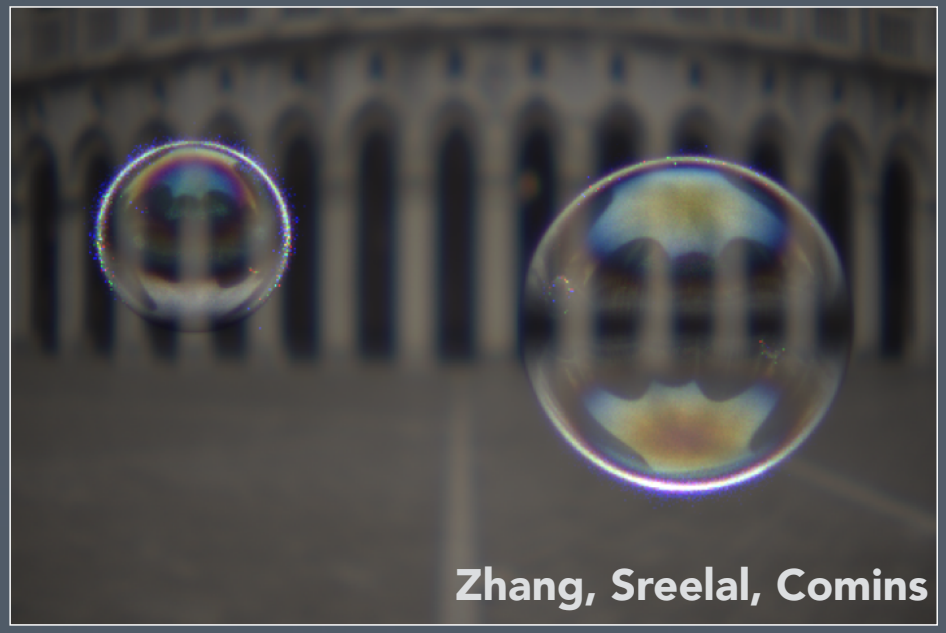
- 4 weeks, let your creativity take flight!
  (we will have suggested projects)
- Proposal; checkpoint; presentation, video, report

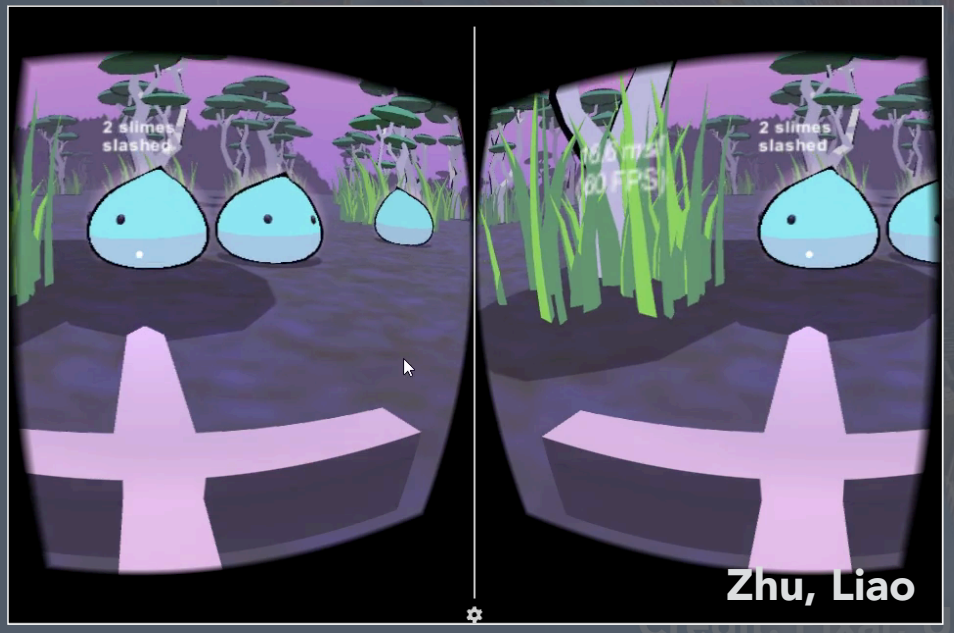
Credit: Pixar, Up

Final Project - Examples

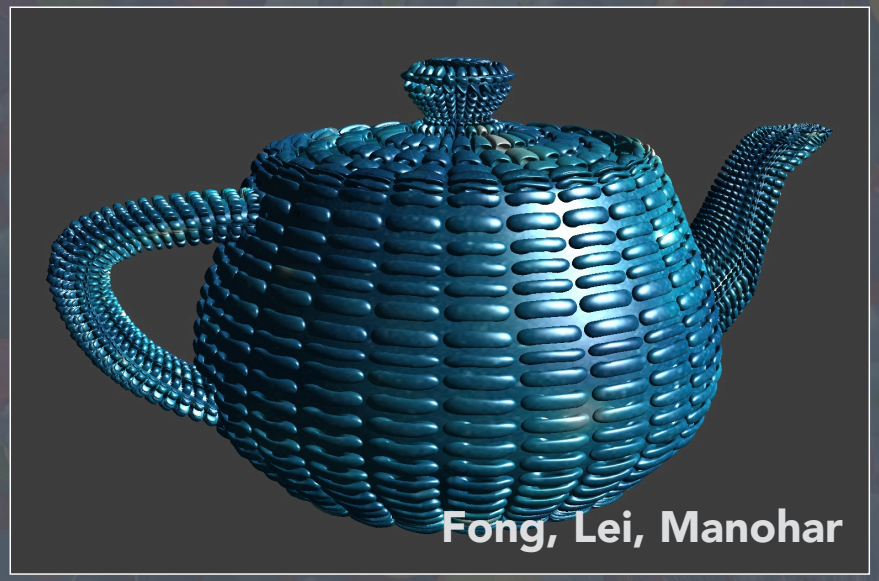


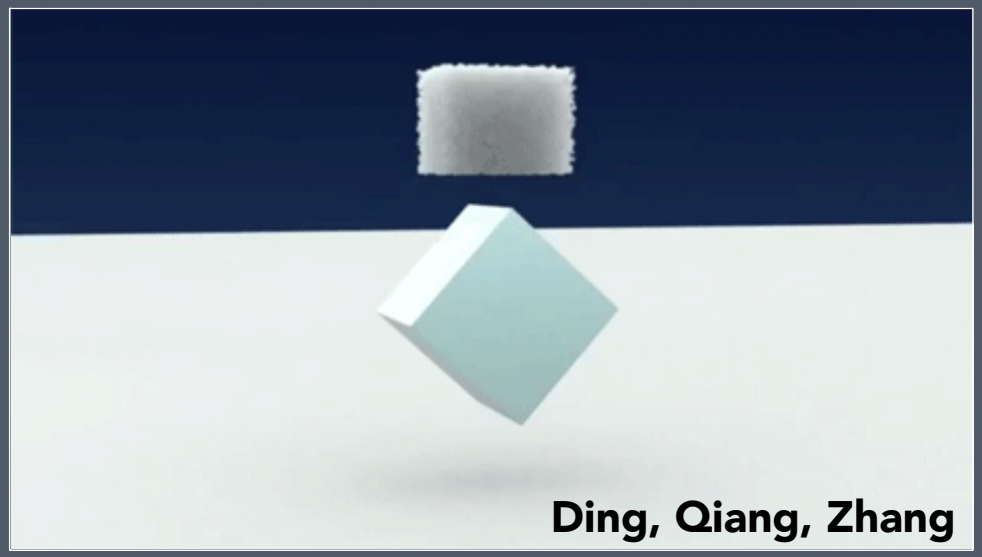


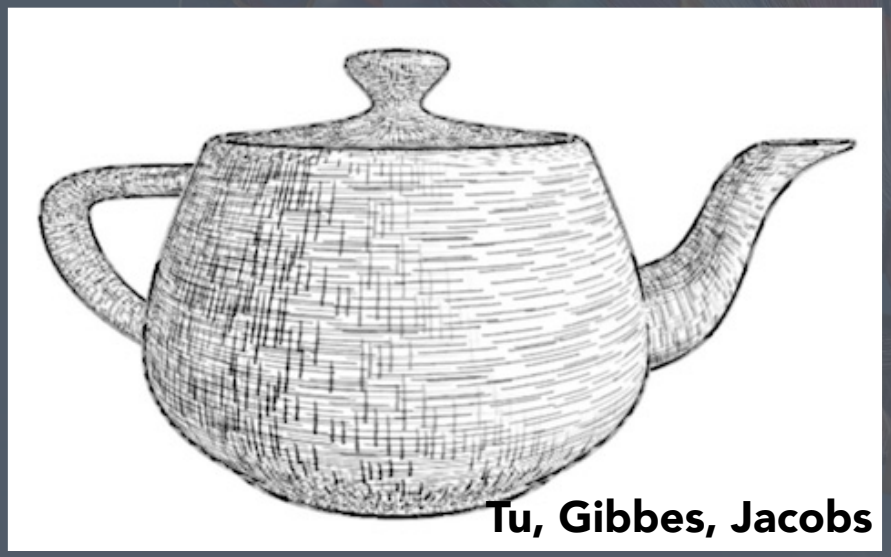




Final Project - Examples

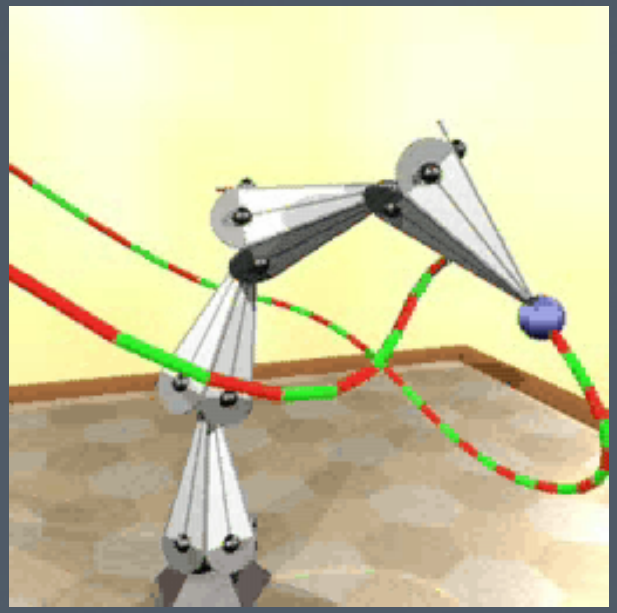


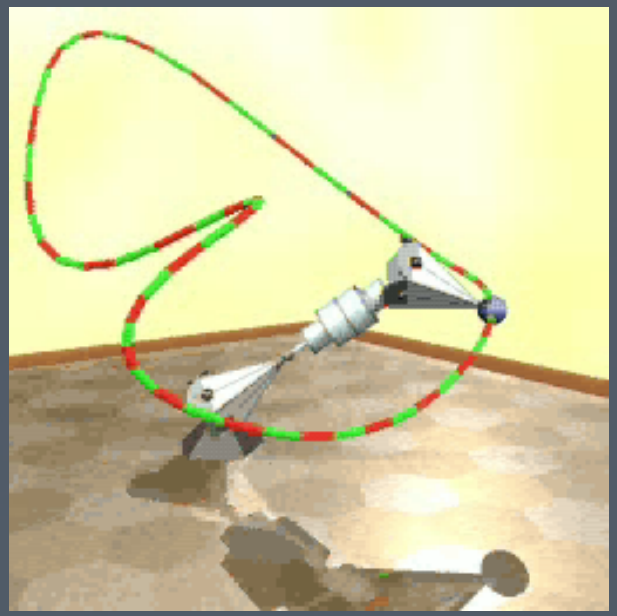




Credit: Pixar, Up

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

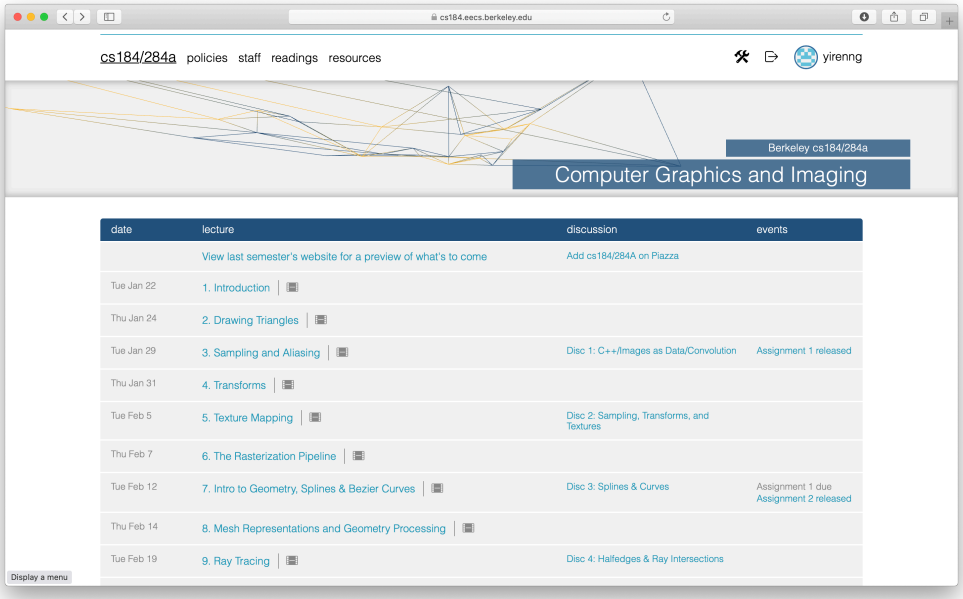
- Past years, high turnover from wait list
- Questions about enrollment:
  - CS184: ask scheduler (Cindy Conners) cs-scheduling@berkeley.edu
  - CS284A: contact instructors on Ed

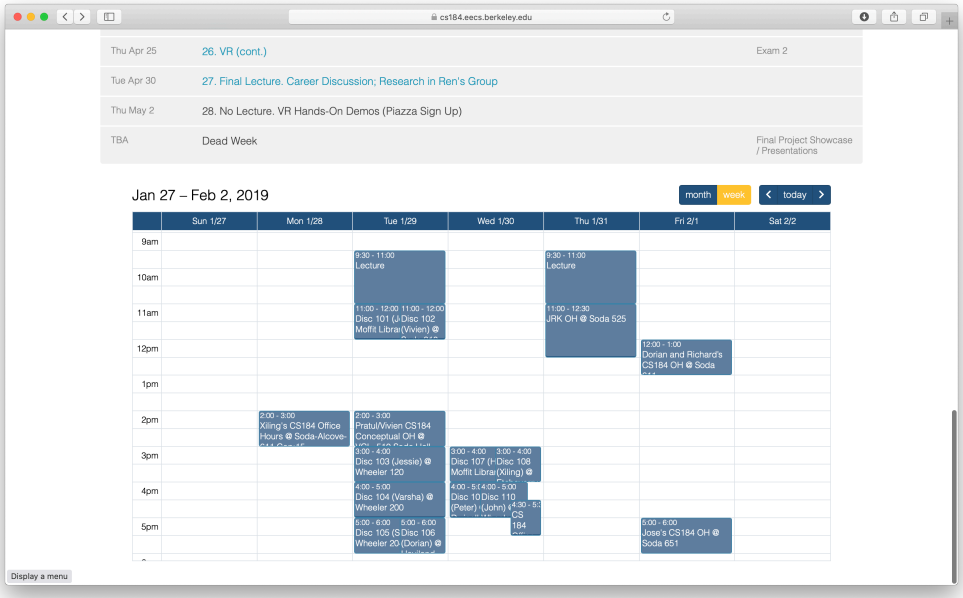
Course Schedule

cs184.eecs.berkeley.edu

Full schedule for class will be on website soon

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

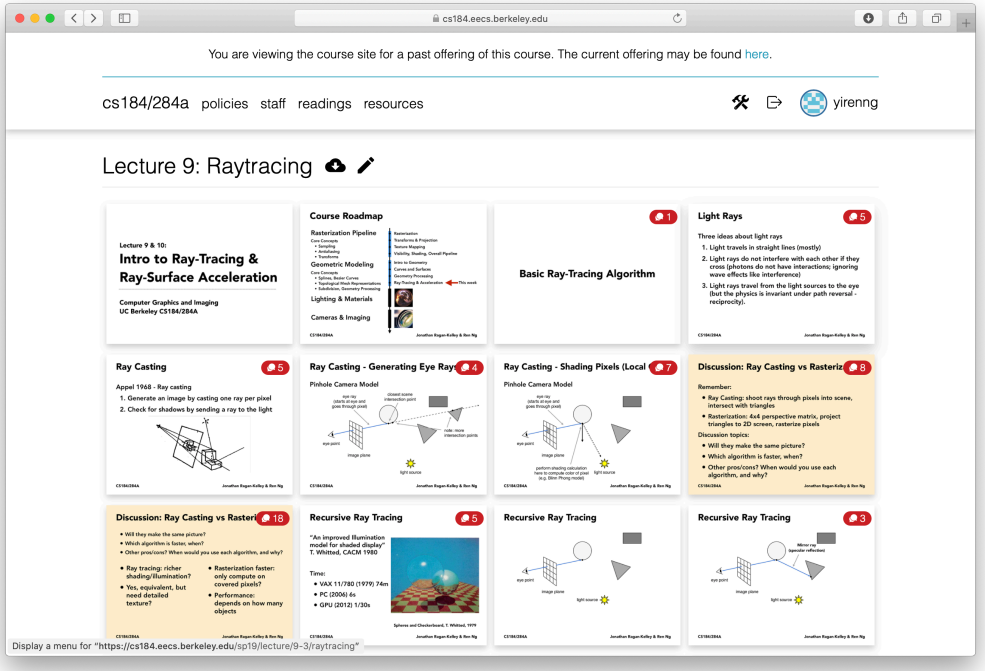


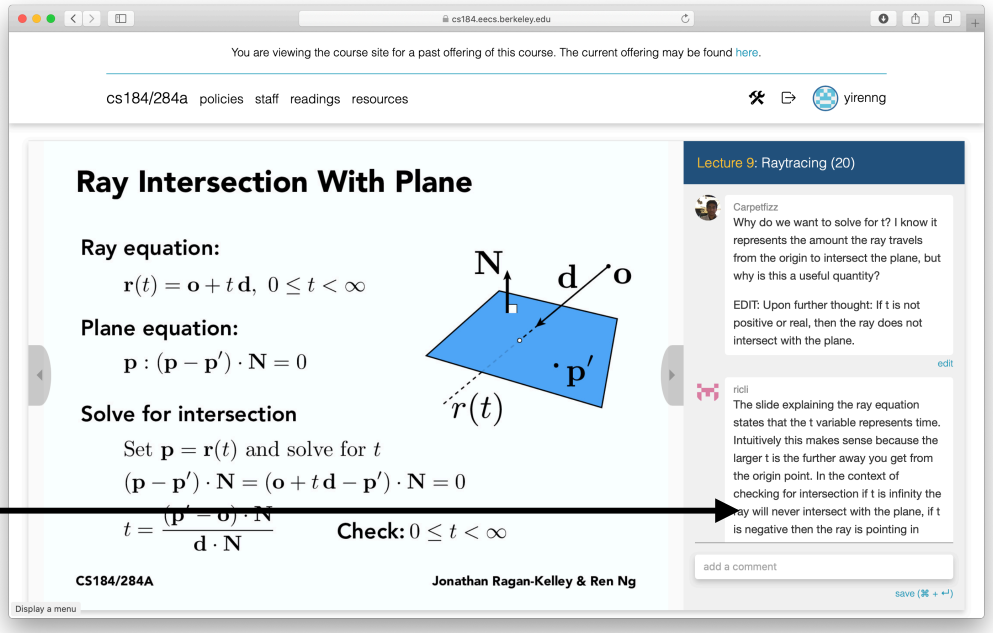


Lecture Slides

cs184.eecs.berkeley.edu

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





Slide comments and discussion

Ed

edstem.org

You should be added already (if not, please sign up)!

For logistics and general communication / discussion

- Please use Ed instead of email
- But intellectual discussions about content should primarily go on website as slide comments

Webcasting

Lecture will be recorded this semester

- Screen capture and audio only
- Videos will be linked from the course website

Section

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

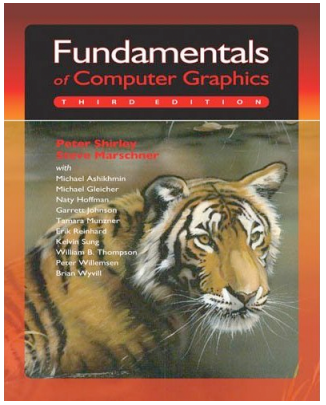
Resources

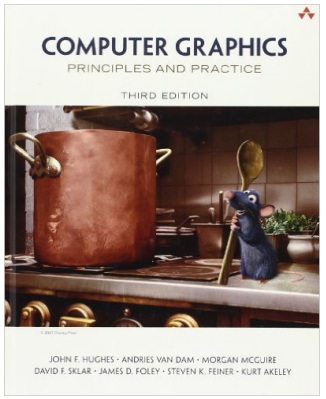
Lectures will be primary source

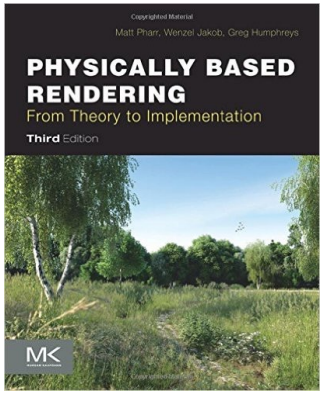
Textbook reference material (optional):

- 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 optional reading 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):

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

Details

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

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/discussion, and/or write website comments 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

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