Lecture 1:

Introduction

Computer Graphics and Imaging
UC Berkeley CS184/284A

Welcome to CS184 / 284A!

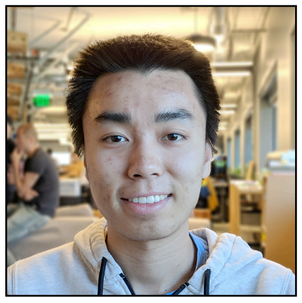
Prof. JRK

Prof. Ren Ng

Vivien Nguyen

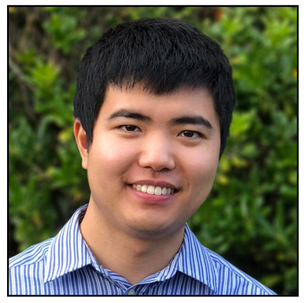
Dorian Chan

Jose Chavez



Richard Chen

Sudeep Dasari



James Fong

Jacob Holesinger

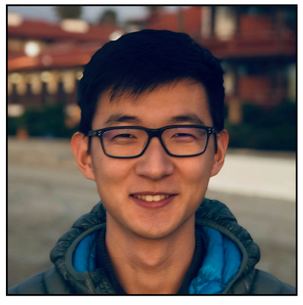
Seth Lu

Peter Manohar

Pratul Srinivasan

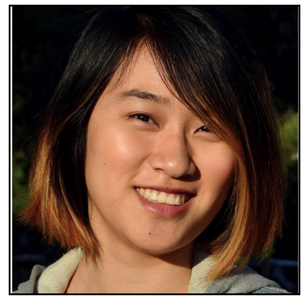
Henry Sun

Varsha Ramakrishnan



Xiling Xia

John Xiang



Jessie Yang

Welcome to CS184 / 284A!

Prof. Jonathan Ragan-Kelley

- Ph.D. 2014 on the Halide language (used in Google Pixel cameras, Adobe Photoshop, …)
- First research project: preview renderer for ILM
- Research interests: systems, compilers, languages for visual computing & graphics
- Fun fact: born (and did undergrad) at our rival across the Bay, but I've never been to Big Game

Welcome to CS184 / 284A!

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
- Research interests: computational imaging systems, computer graphics and computer vision
- Fun fact: born Malaysian, became Australian, lived in California for most of my life

Welcome to CS184 / 284A!

Prof. JRK

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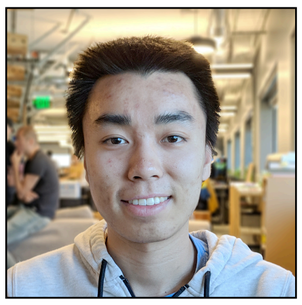

Richard Chen

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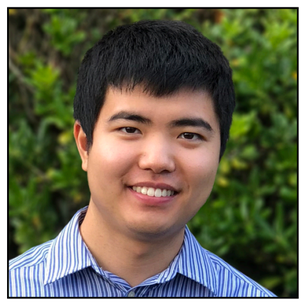

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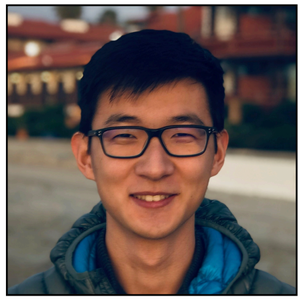


Xiling Xia

John Xiang

Jessie Yang

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

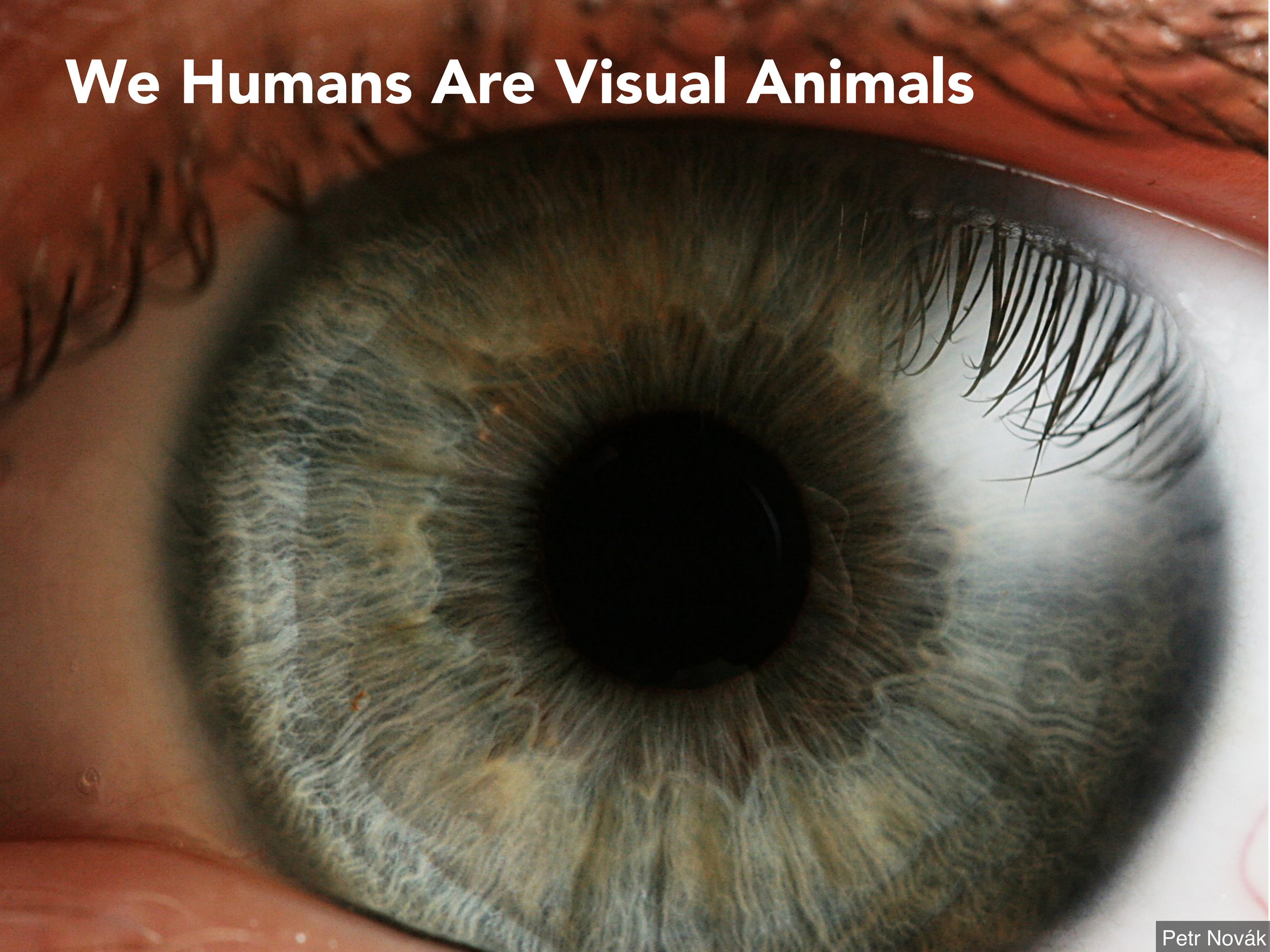
Jonathan Ragan-Kelley & Ren Ng

What is Computer Graphics?

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

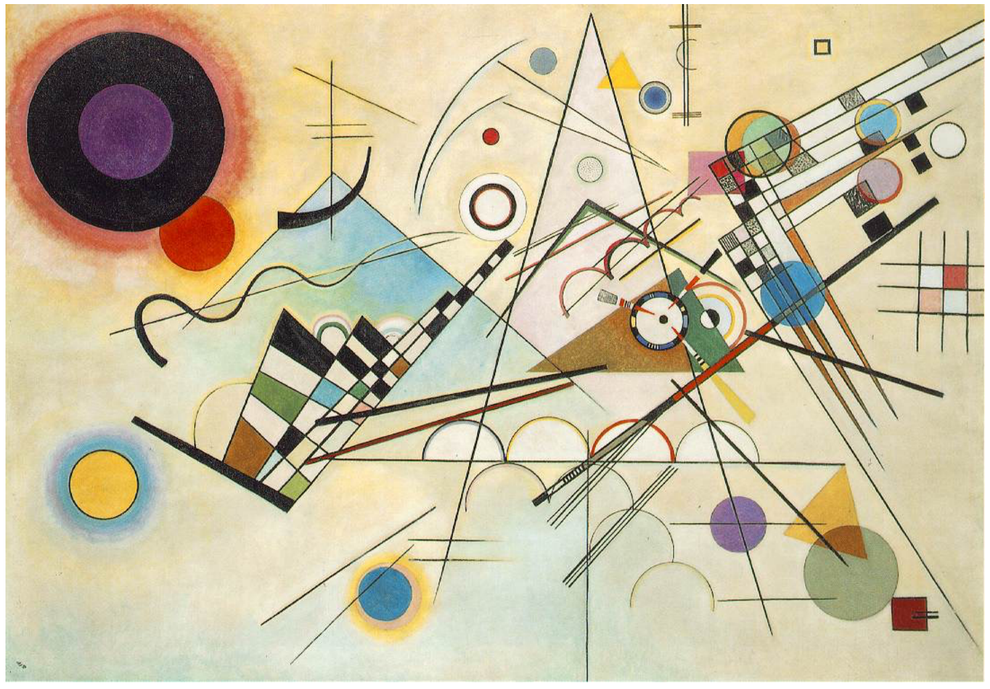
Why Visual Information?

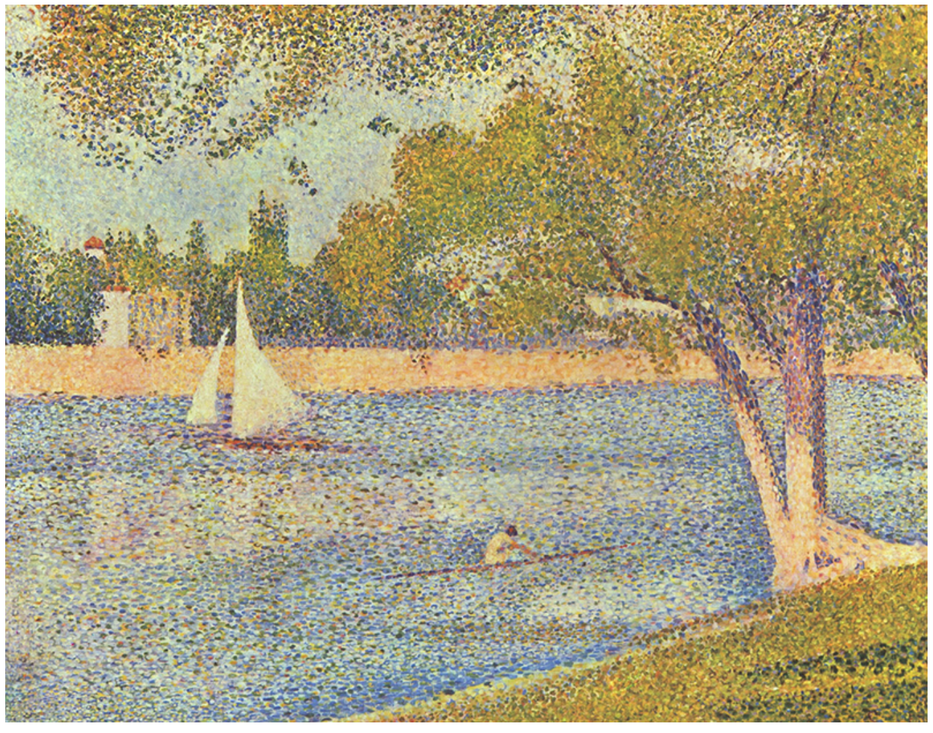
We Humans Are Visual Animals



Petr Novák

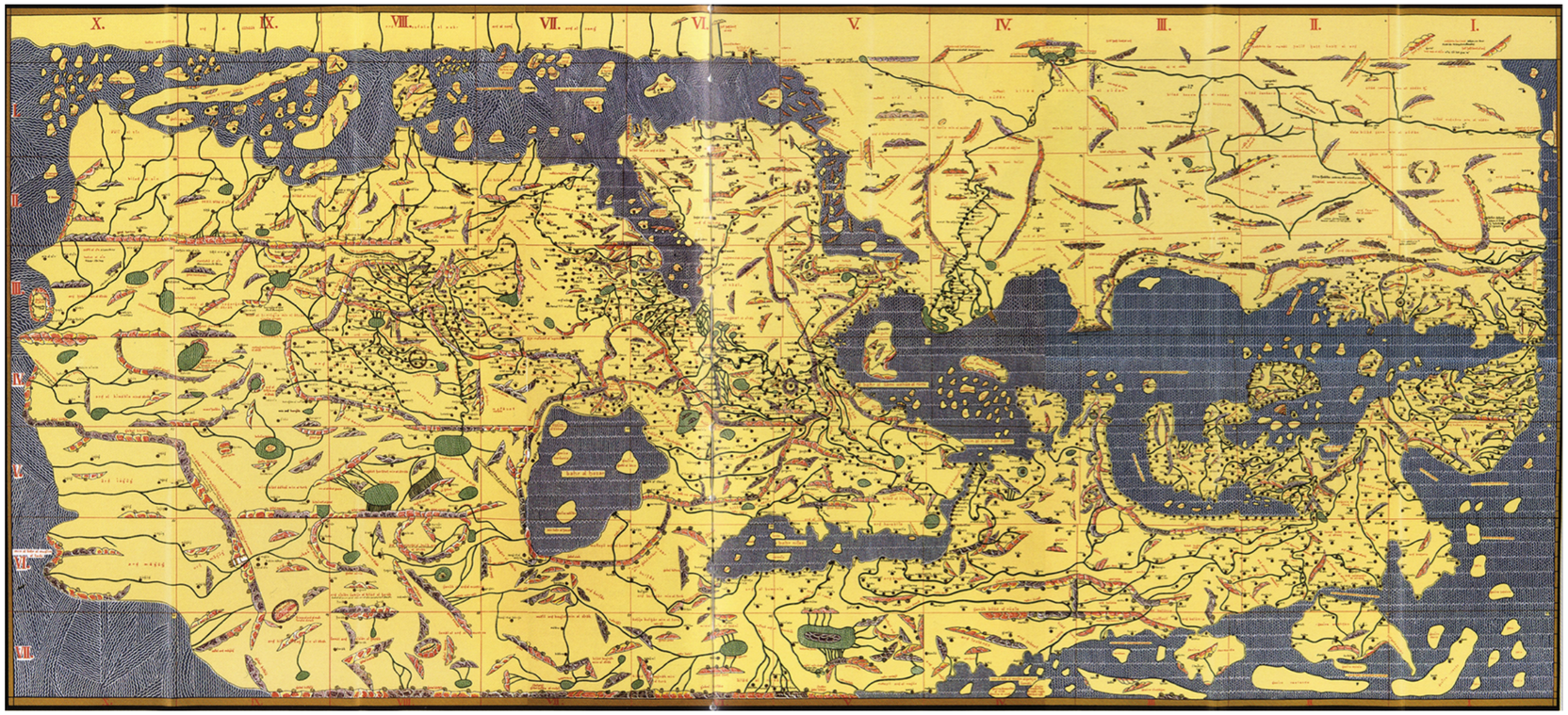
Visual Technology: Painting

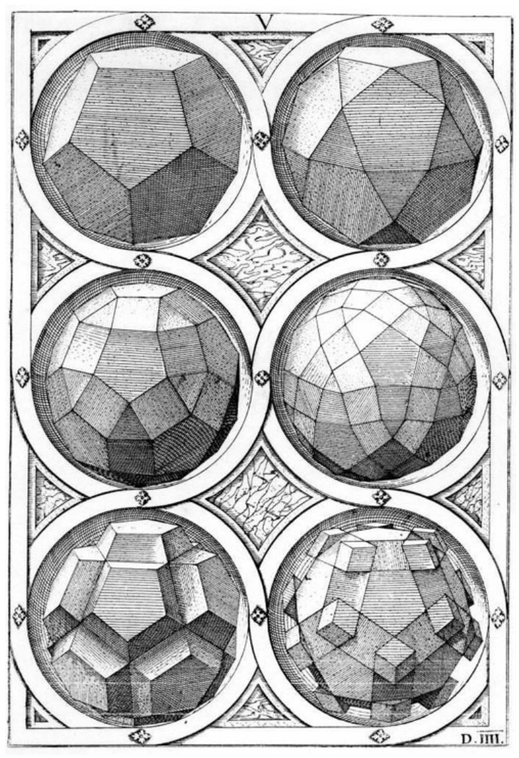




Pursuit of realism; also impressions, ideas, abstractions…

Visual Technology: Illustration





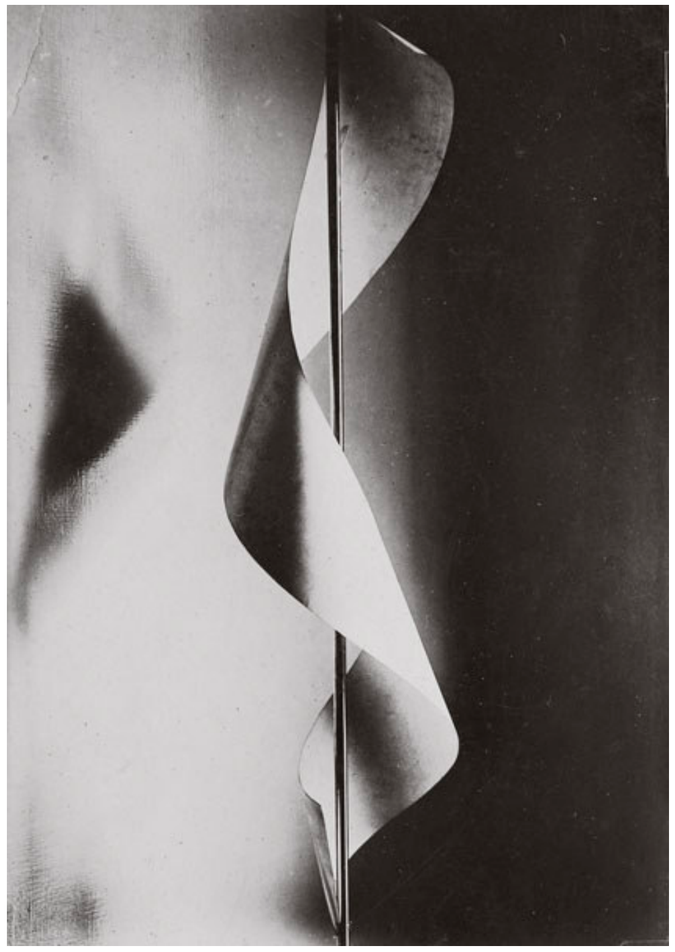
Not just art, also data, ideas, …

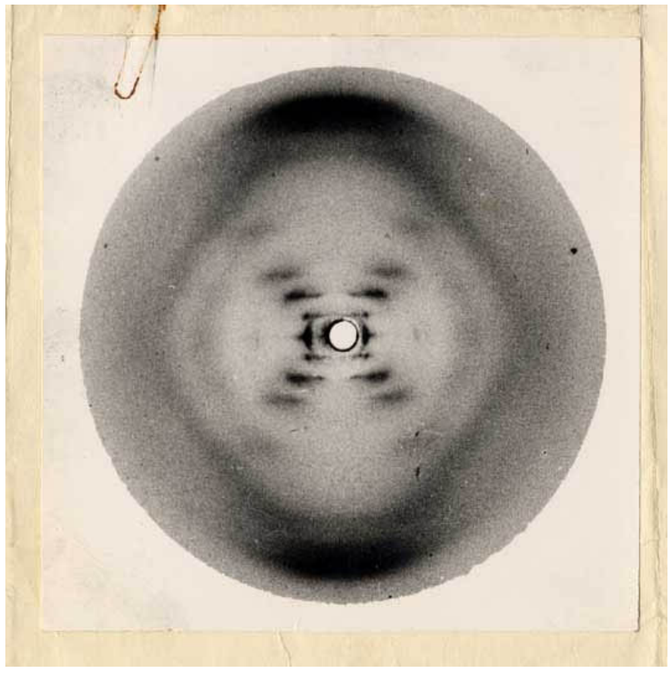
Visual Technology: Sculpture

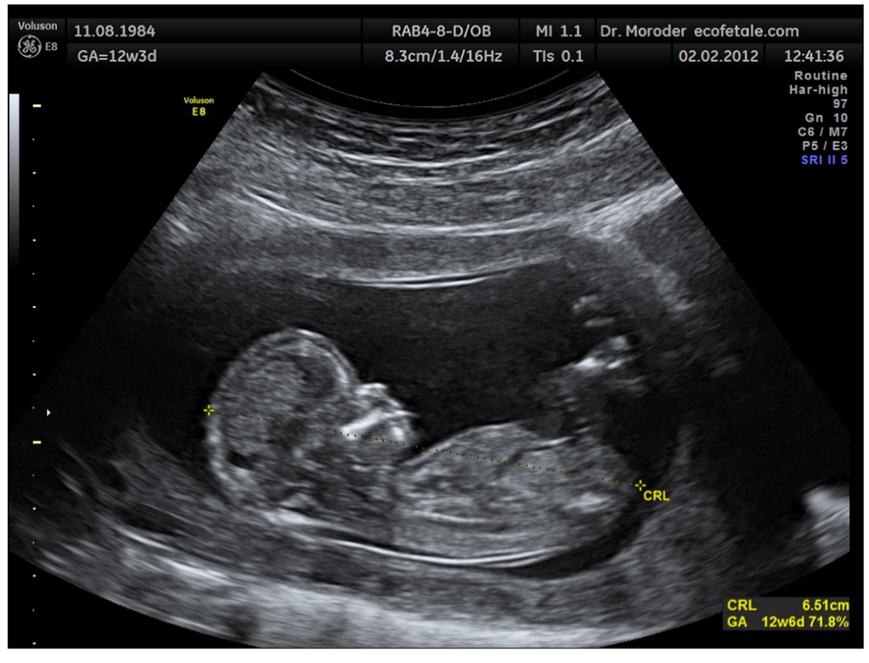
Visual Technology: Photography

Joseph Niépce, “View from the Window at Le Gras” (1826)

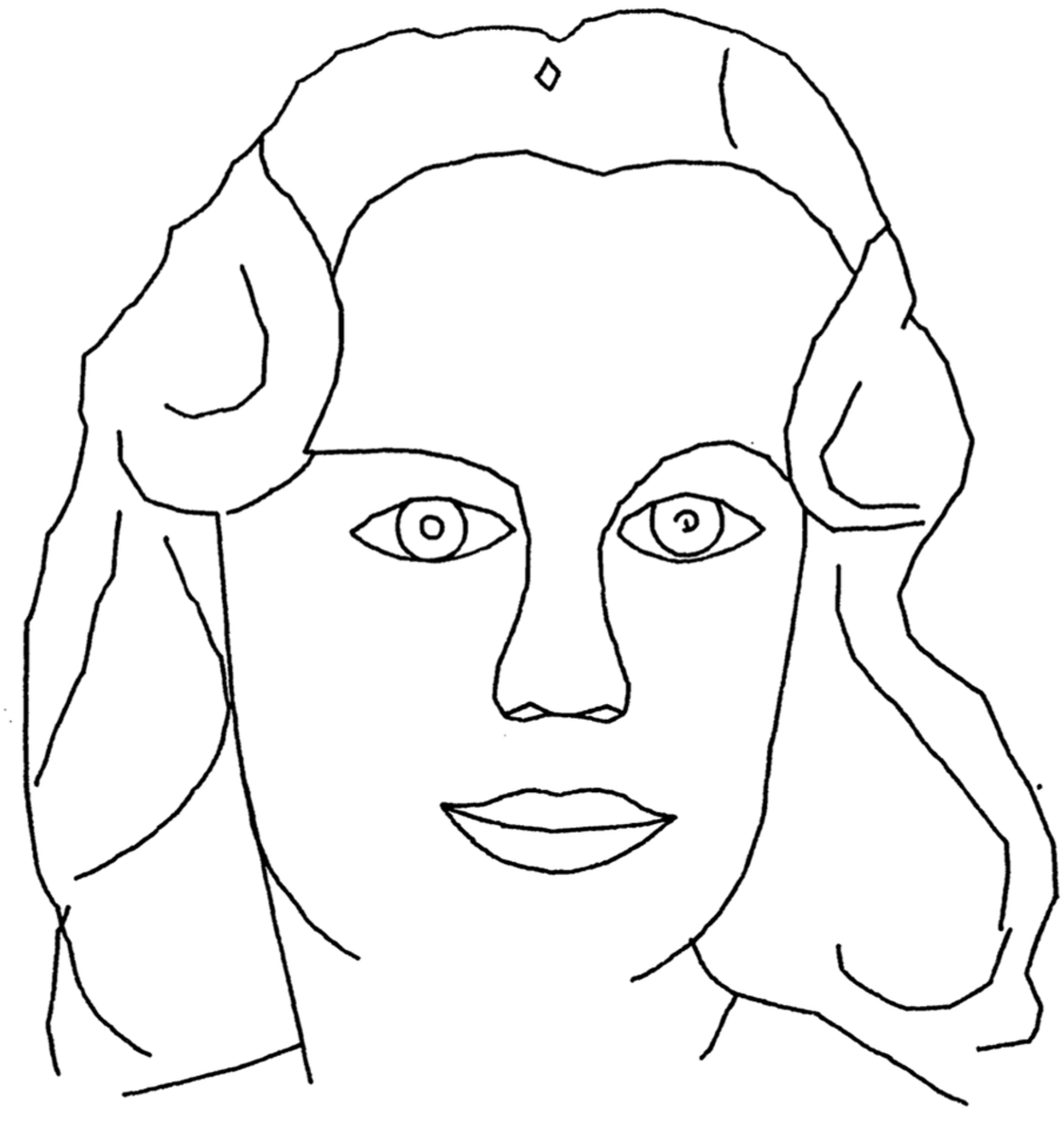
Visual Technology: Photography / Imaging

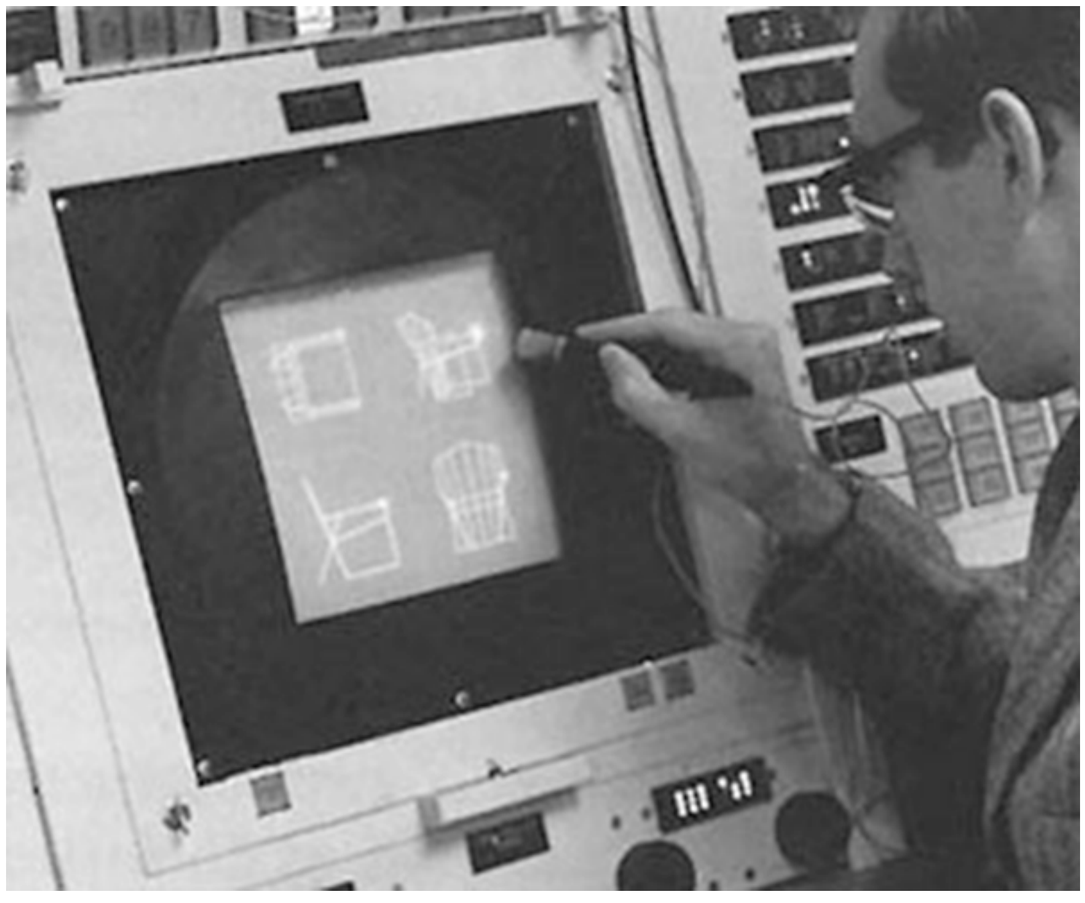






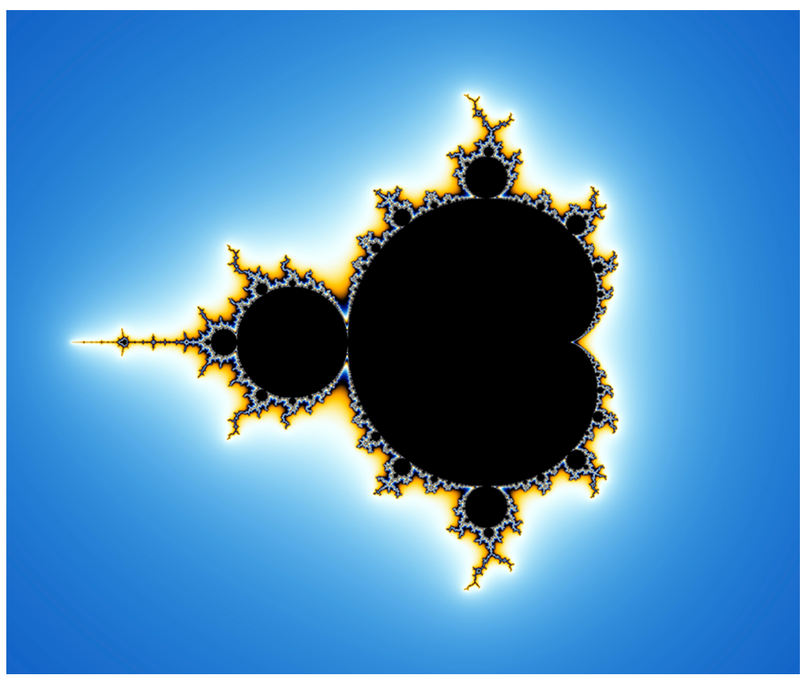
Visual Technology: Digital Imagery

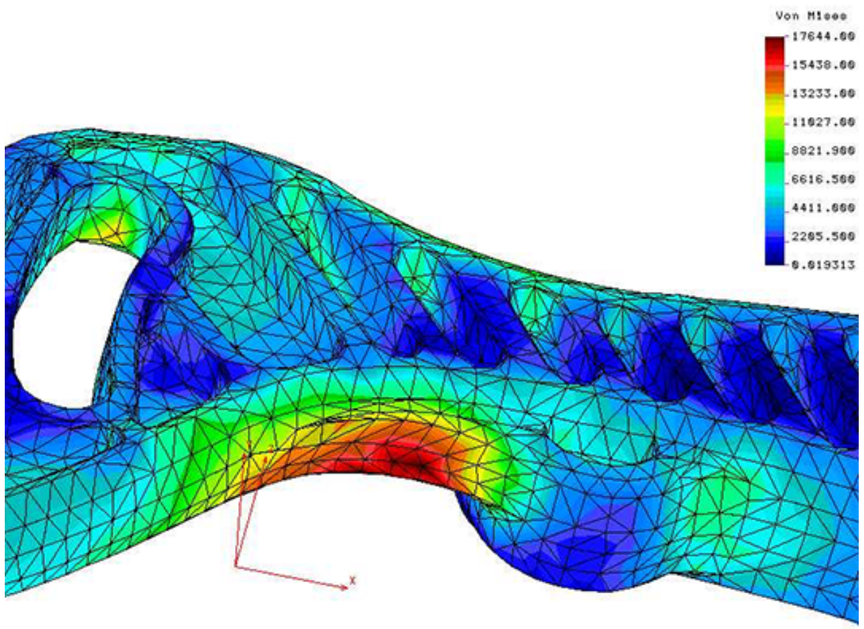


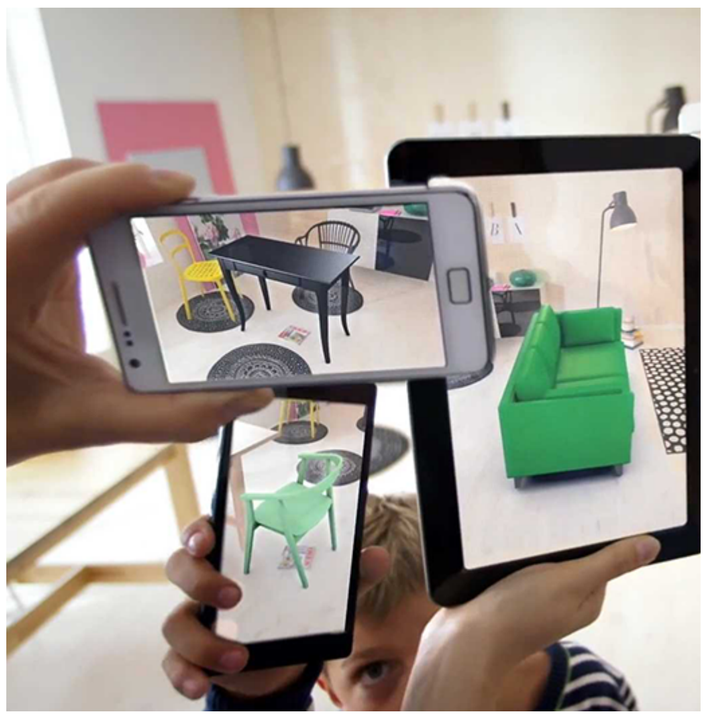


Ivan Sutherland, “Sketchpad” (1963)

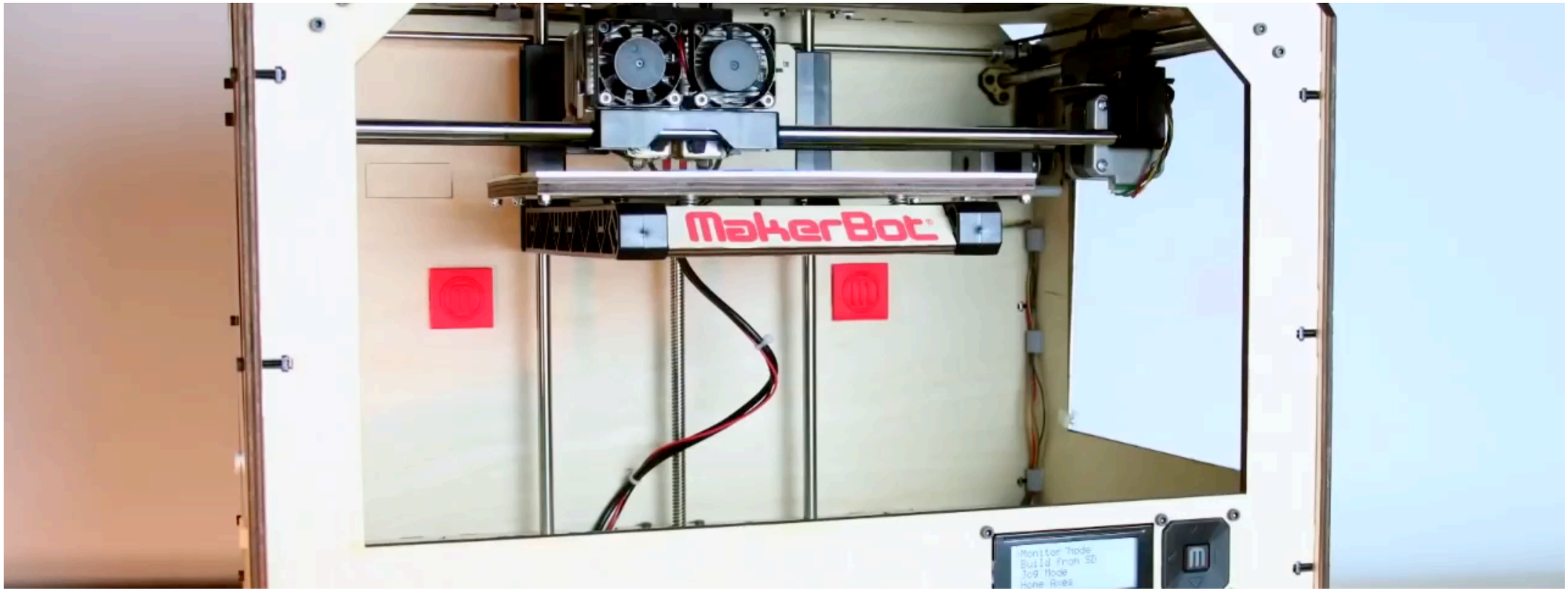
Visual Technology: Digital Imagery

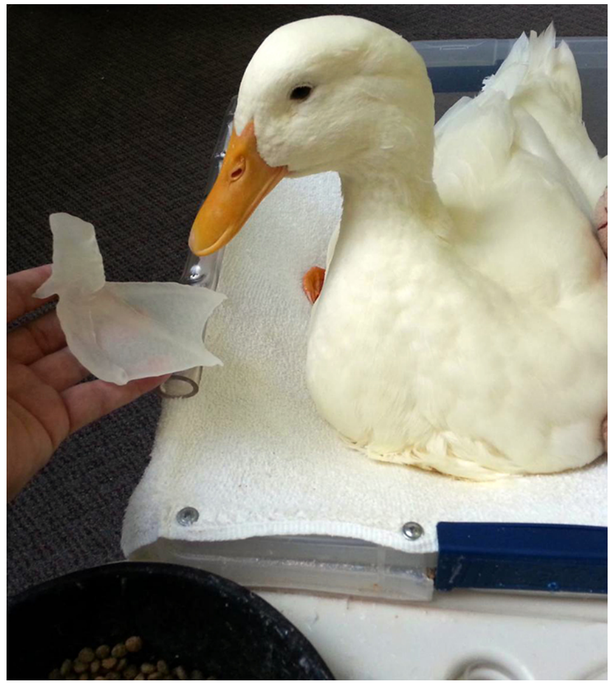






Visual Technology: 3D Fabrication





Discussion

Why are you interested in this course?

What do you want to learn about graphics & imaging?

- Amplifying artistic skills
- Real-time rendering
- GPU design
- Virtual reality
- Game development
- Education

Augmented reality

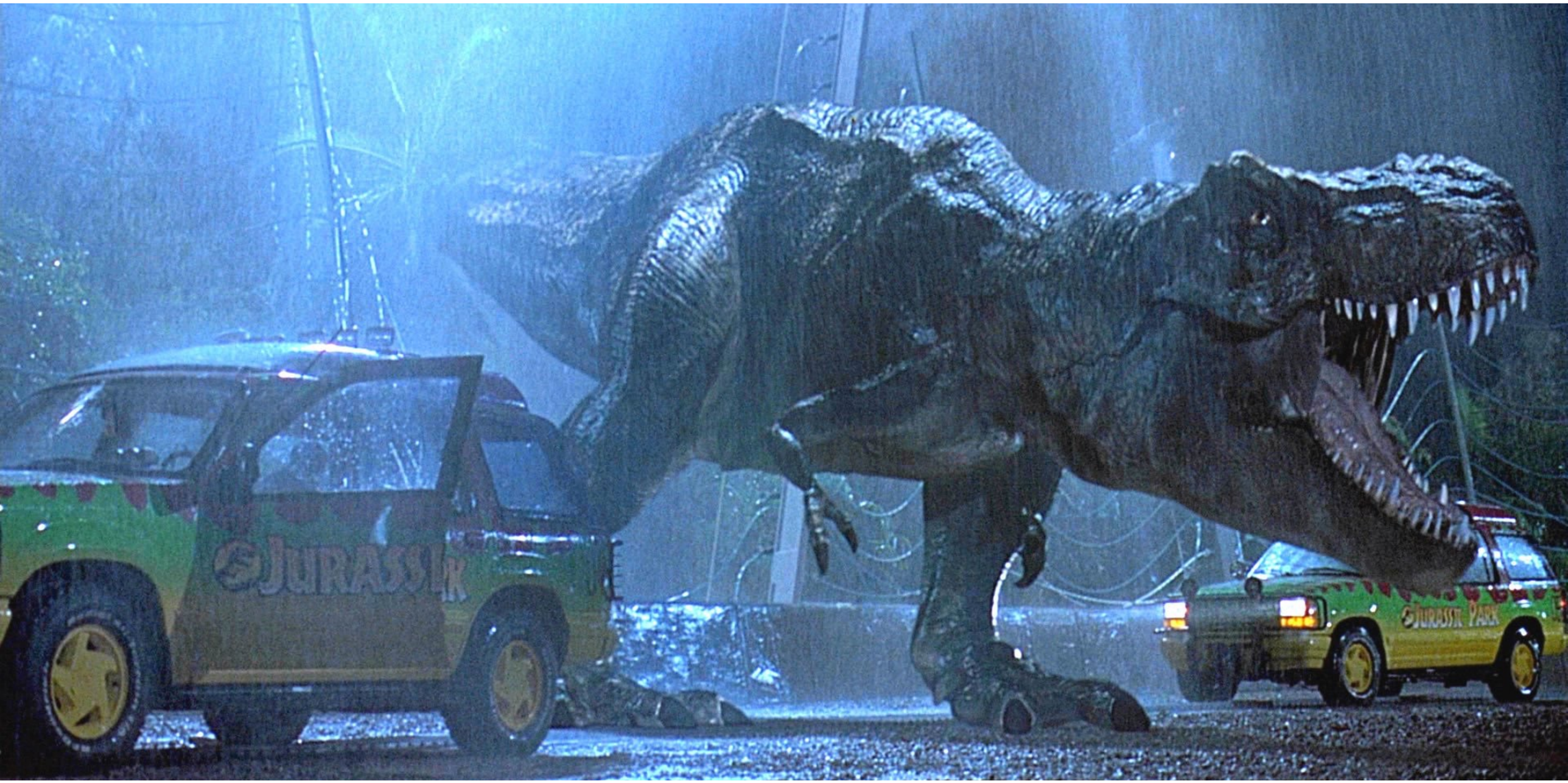
Shaders

Machine learning

Image processing

Why Study Computer Graphics and Imaging?

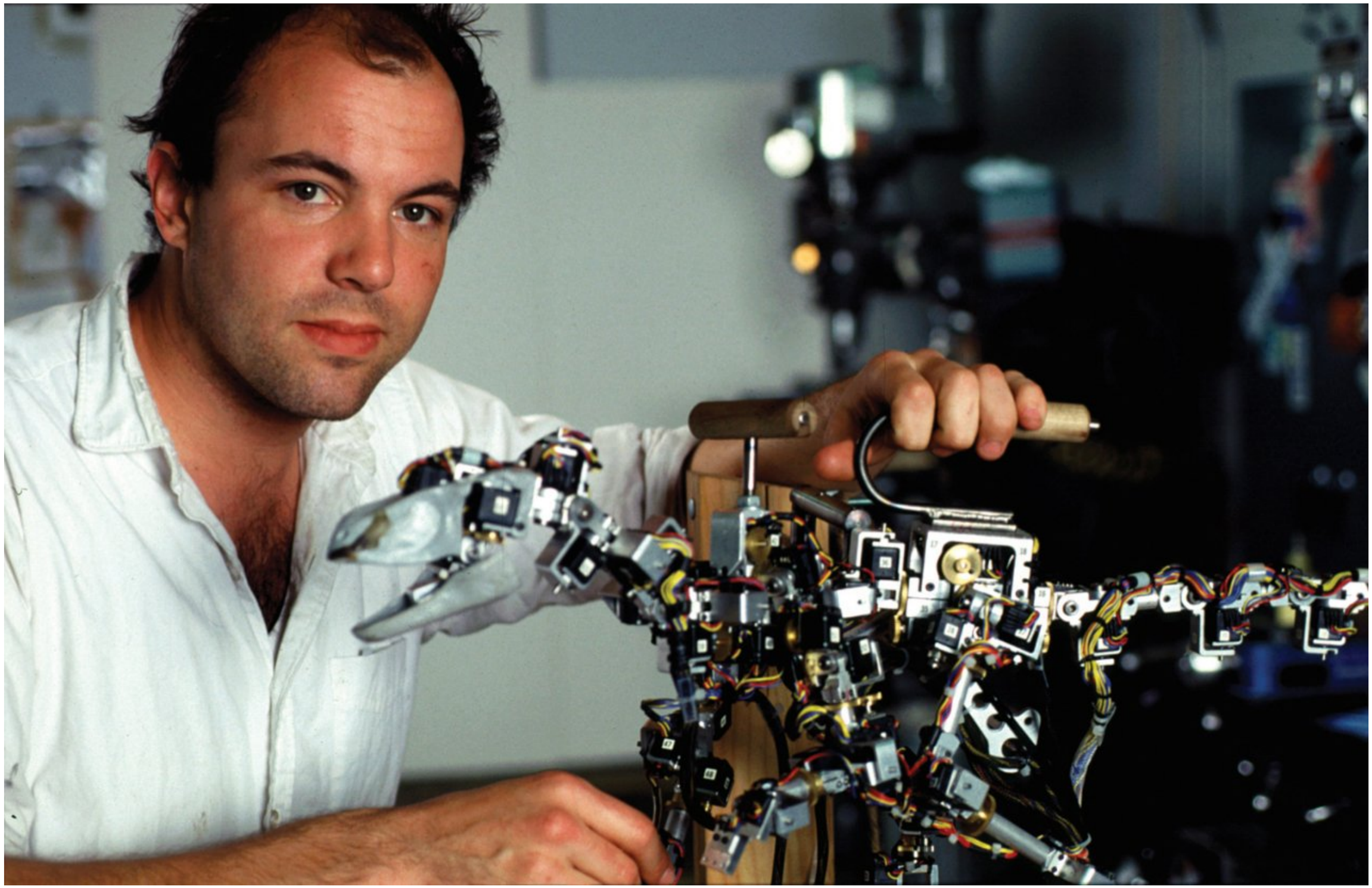
Movies



Jurassic Park (1993)

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

Movies



"Dinosaur Input Device"

Movies

The Matrix (1999)

Movies

The Matrix (1999)

Movies

Avatar (2009)

Movies

Avatar (2009)

Movies

Avatar (2009)

Games

Crysis 3 (2013)

Games

"Adam" Realtime Rendering Demo (Unity 2016)

Product Design and Visualization

Ikea - 75% of catalog is rendered imagery

Product Design and Visualization

Tesla Model X concept (2012)

Product Design and Visualization

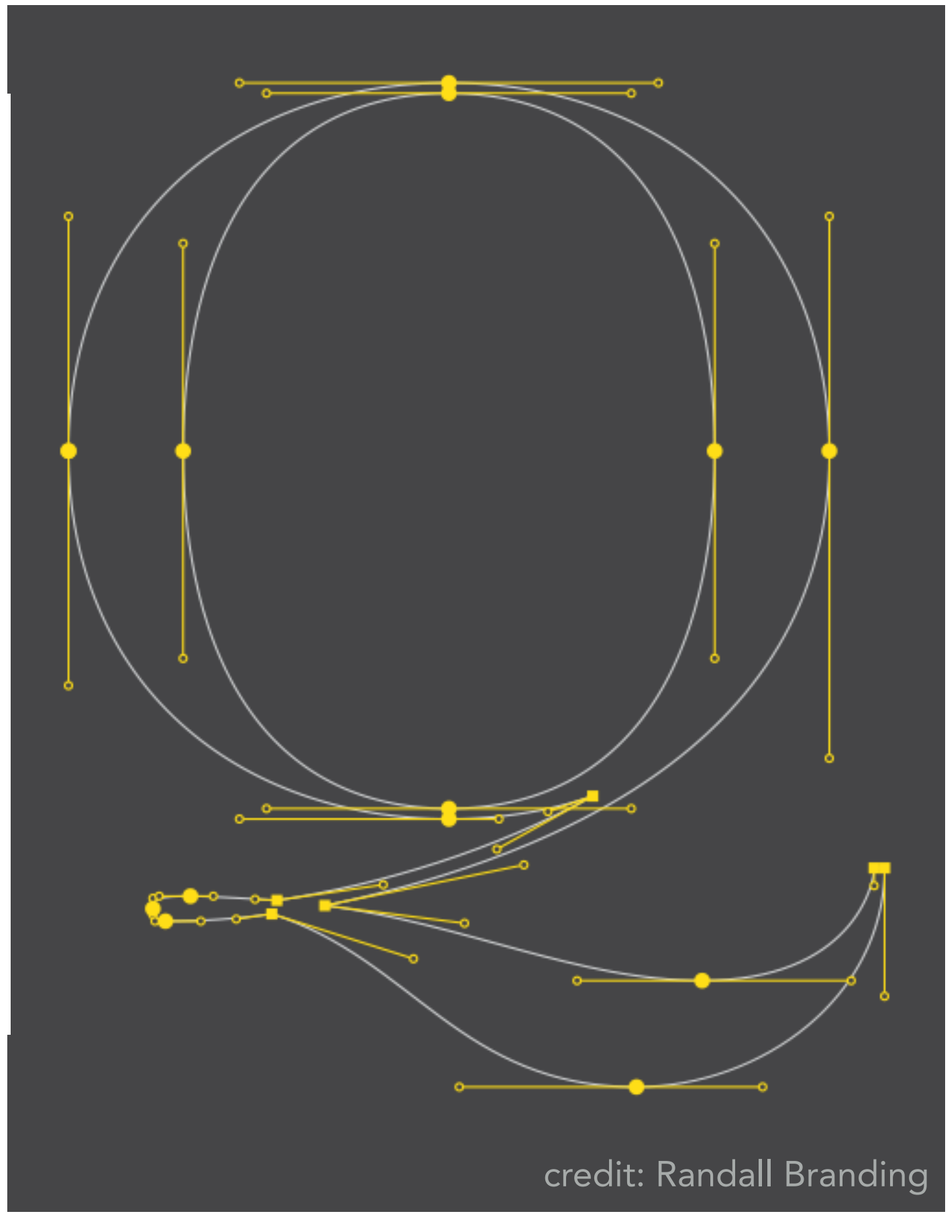
Credit: EV obsession.com, James Ayre

Tesla Model X review

Typography

The Quick Brown Fox Jumps Over The Lazy Dog

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 0123456789



credit: Randall Branding

Baskerville

Illustration

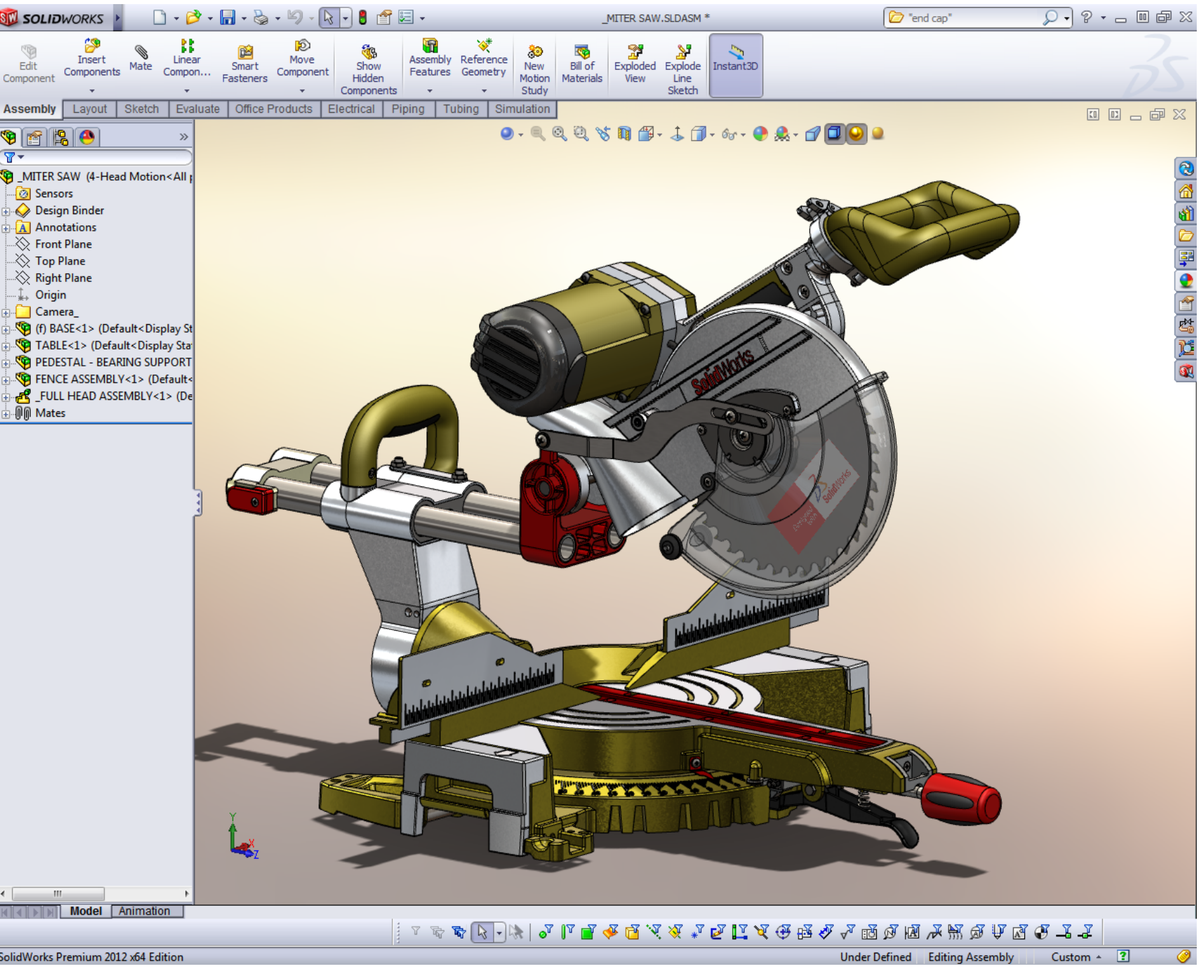
Cave painting c. 36,000 B.C.

Digital Illustration

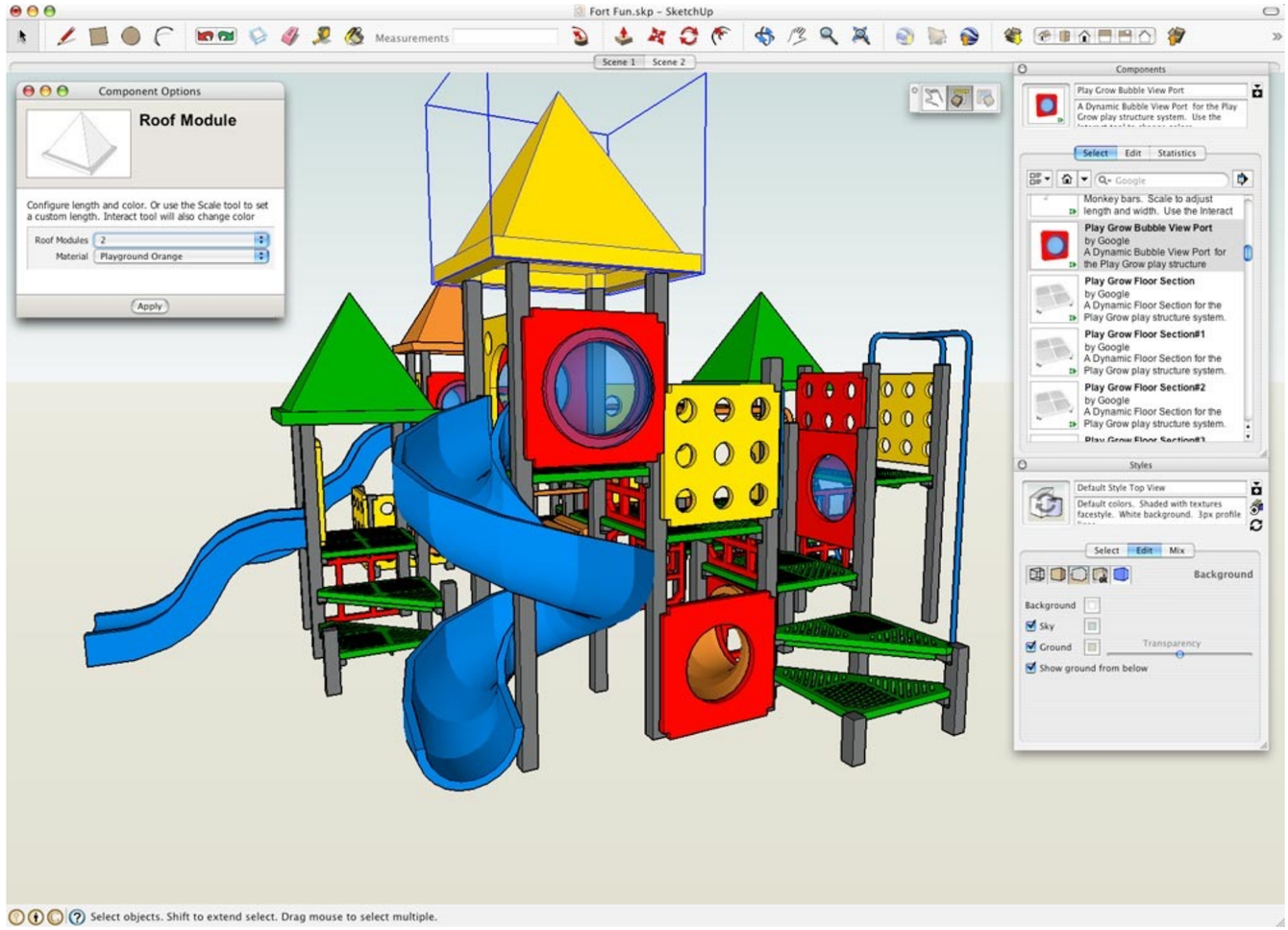
Meike Hakkart

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

Computer-Aided Design



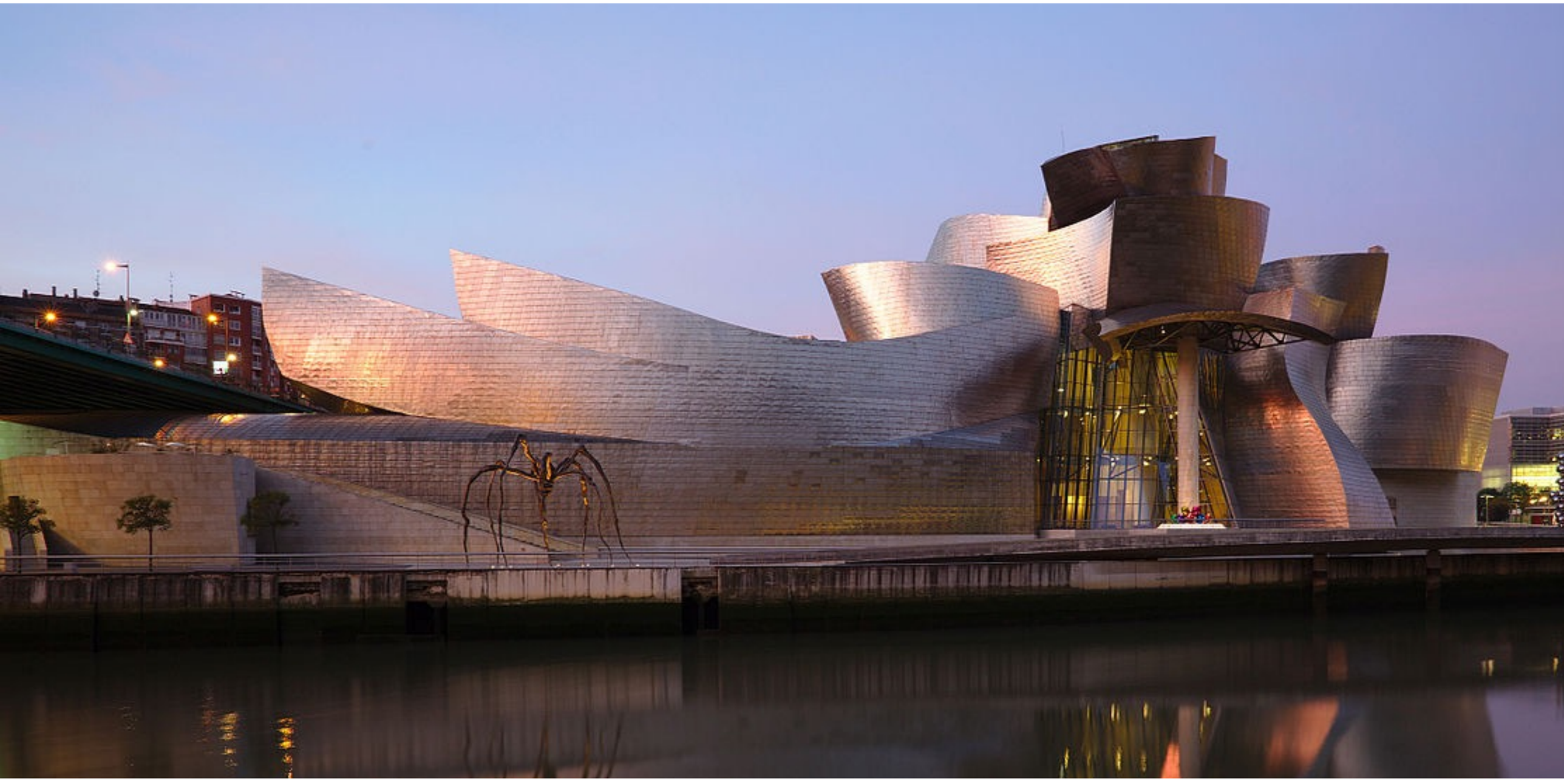
SolidWorks



SketchUp

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

Architectural Design

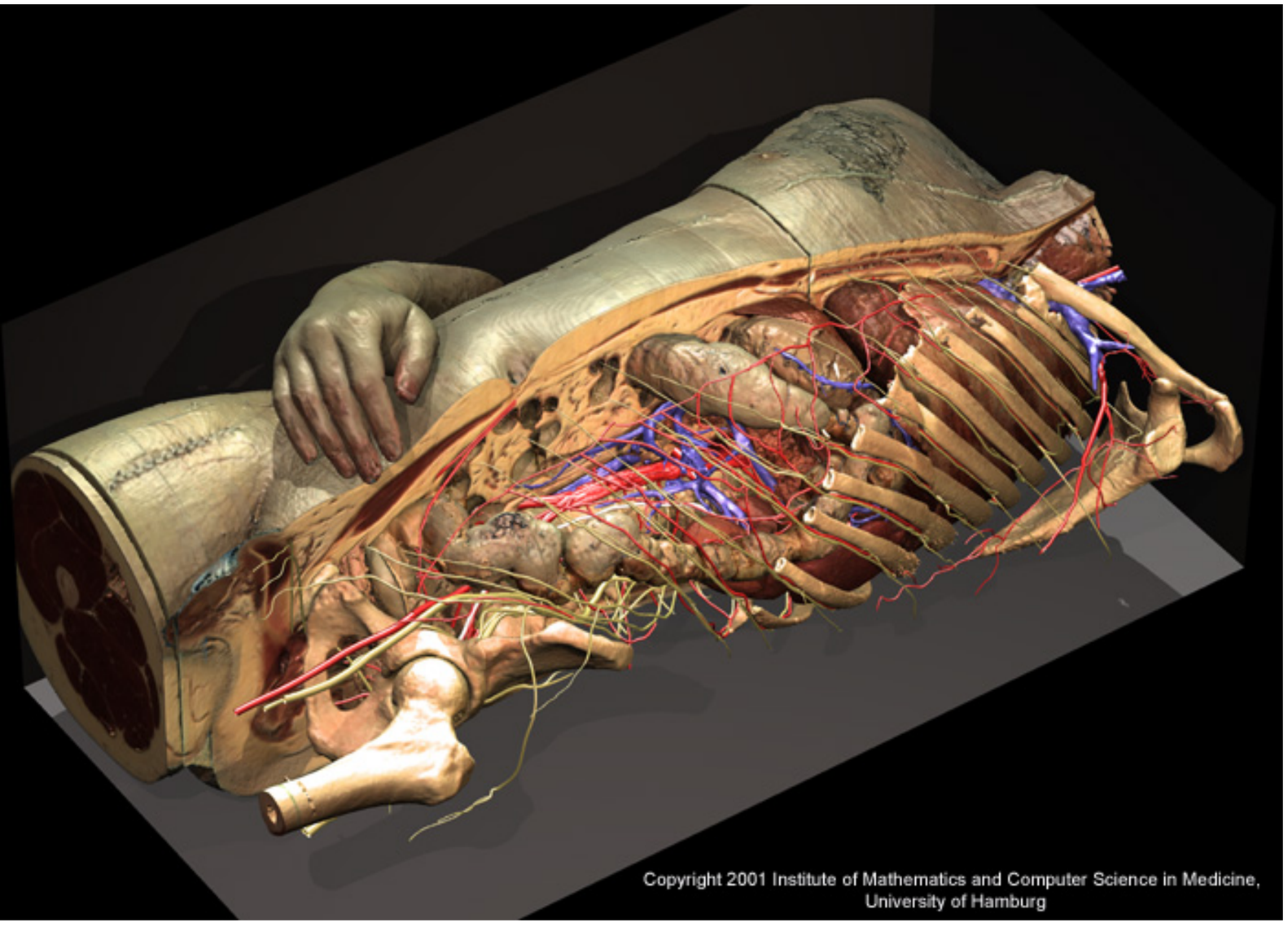


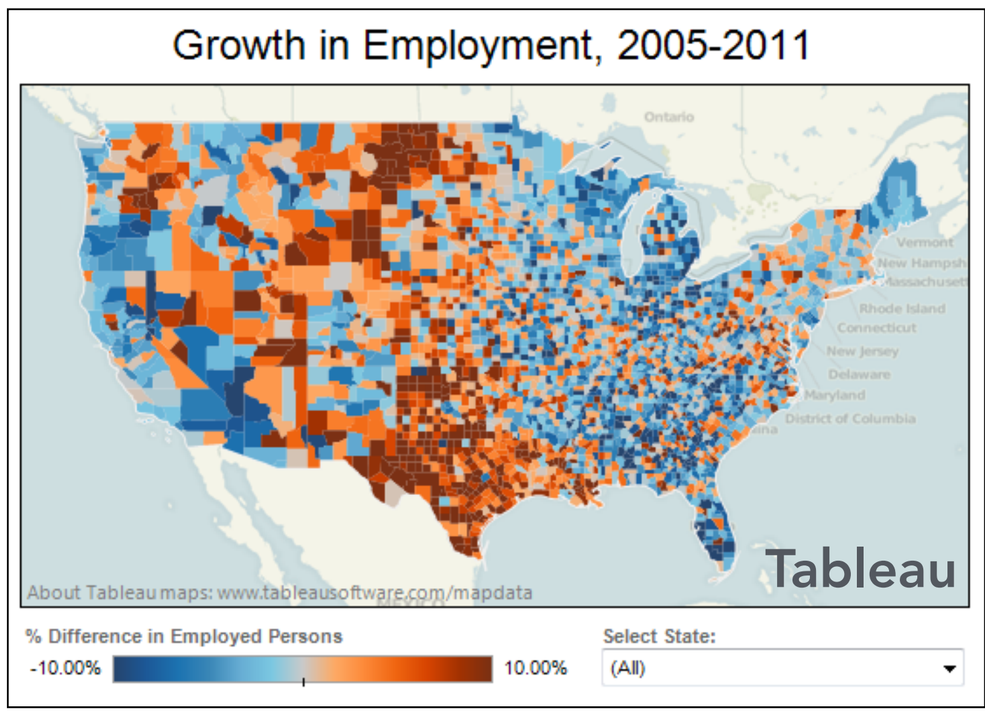
Bilbao Guggenheim, Frank Gehry

Architectural Design

Heydar Aliyev Center, Zaha Hadid Architects

Visualization





Science, engineering, medicine, journalism, …

Visual Simulation

Driving simulator
Toyota Higashifuji Technical Center

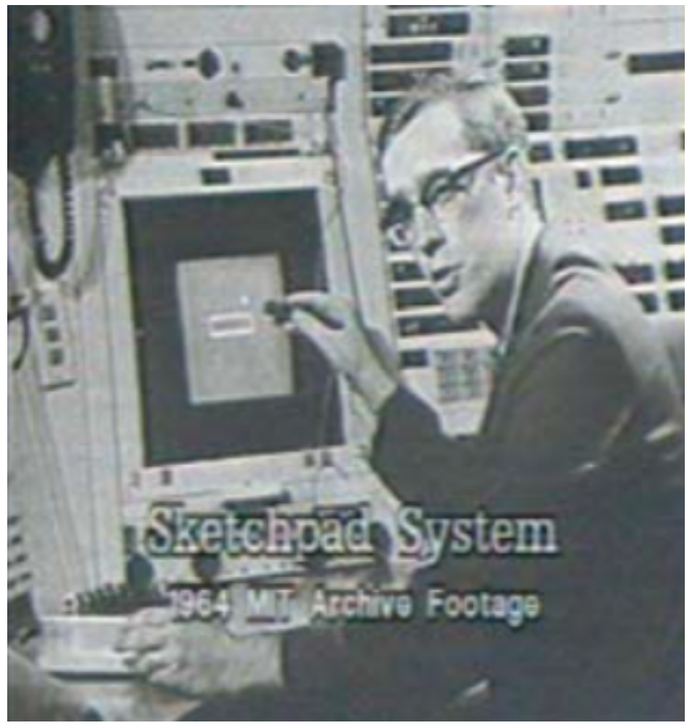
da Vinci surgical robot
Intuitive Surgical

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

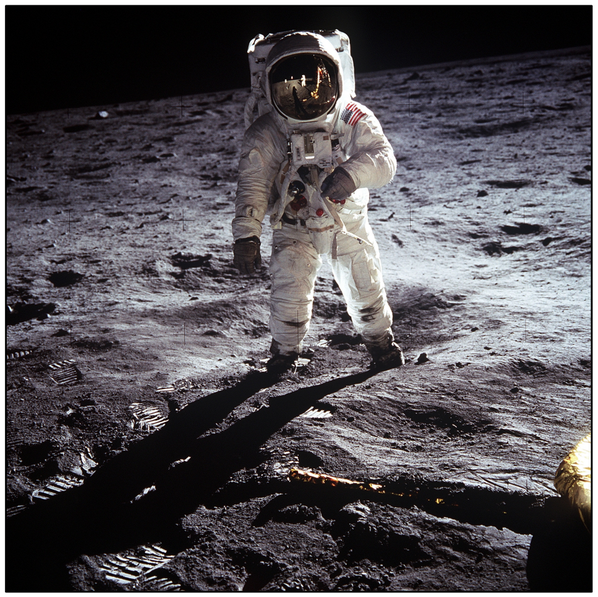
2D drawing and animation are ubiquitous in computing.

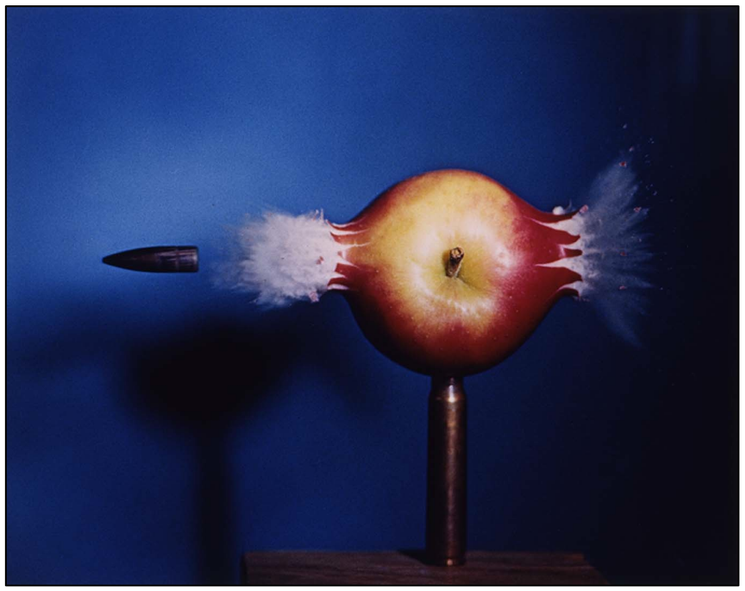
Typography, icons, images, transitions, transparency, ...

Graphical User Interfaces

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

Photography



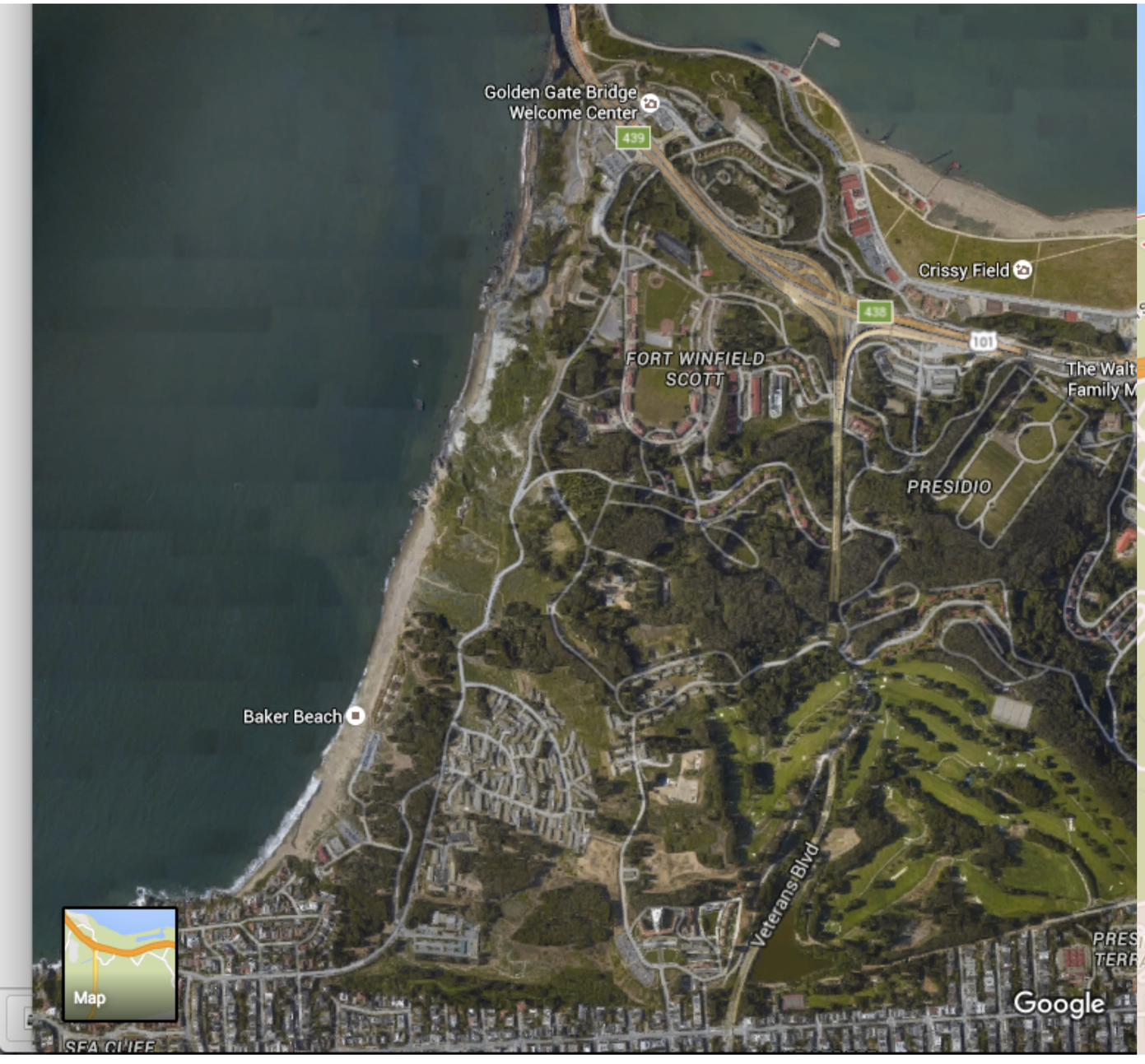


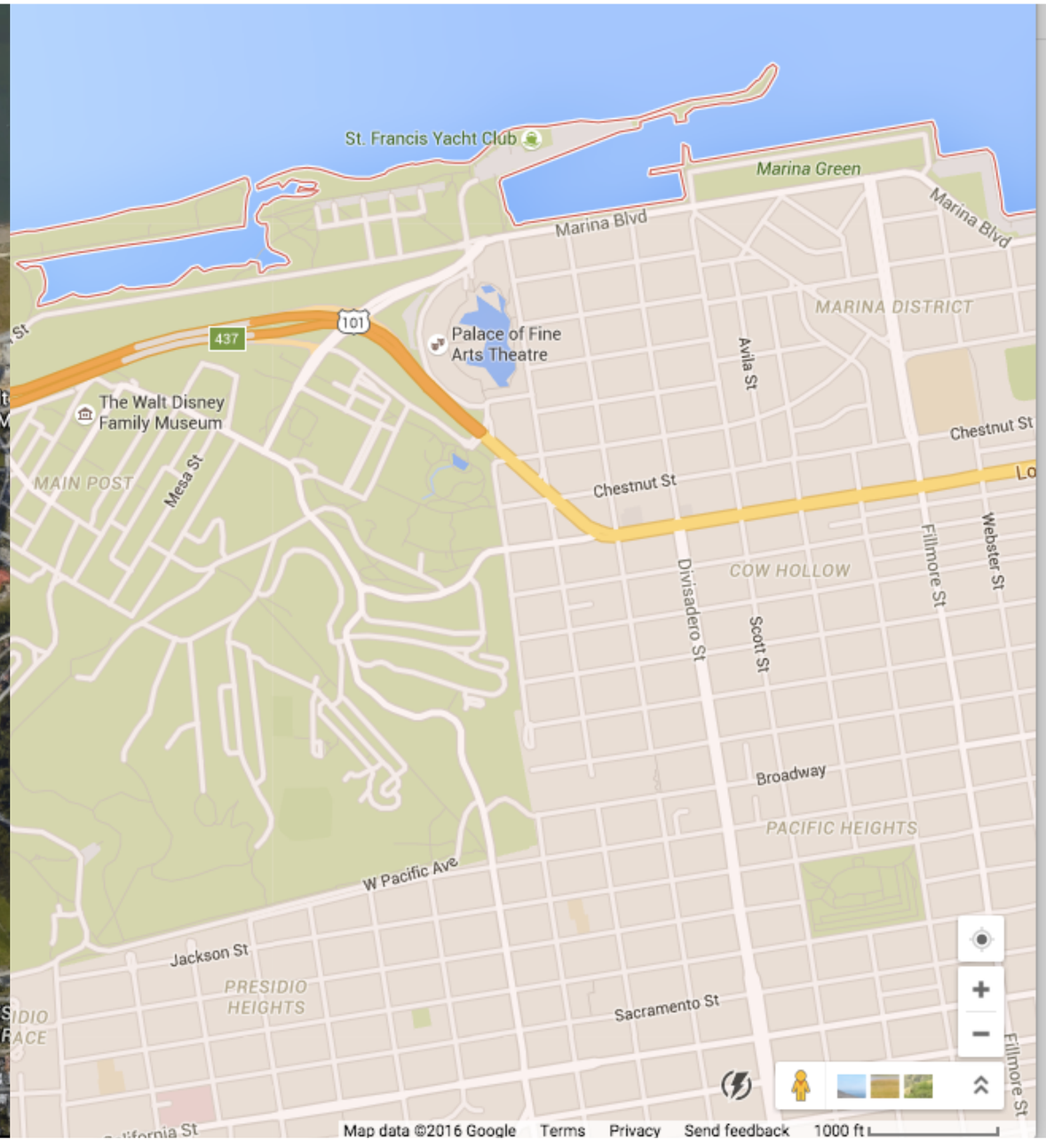
NASA | Walter Iooss | Steve McCurry
Harold Edgerton | NASA | National Geographic

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"

How Do Camera's Work?

Glenn Derene, Popular Mechanics

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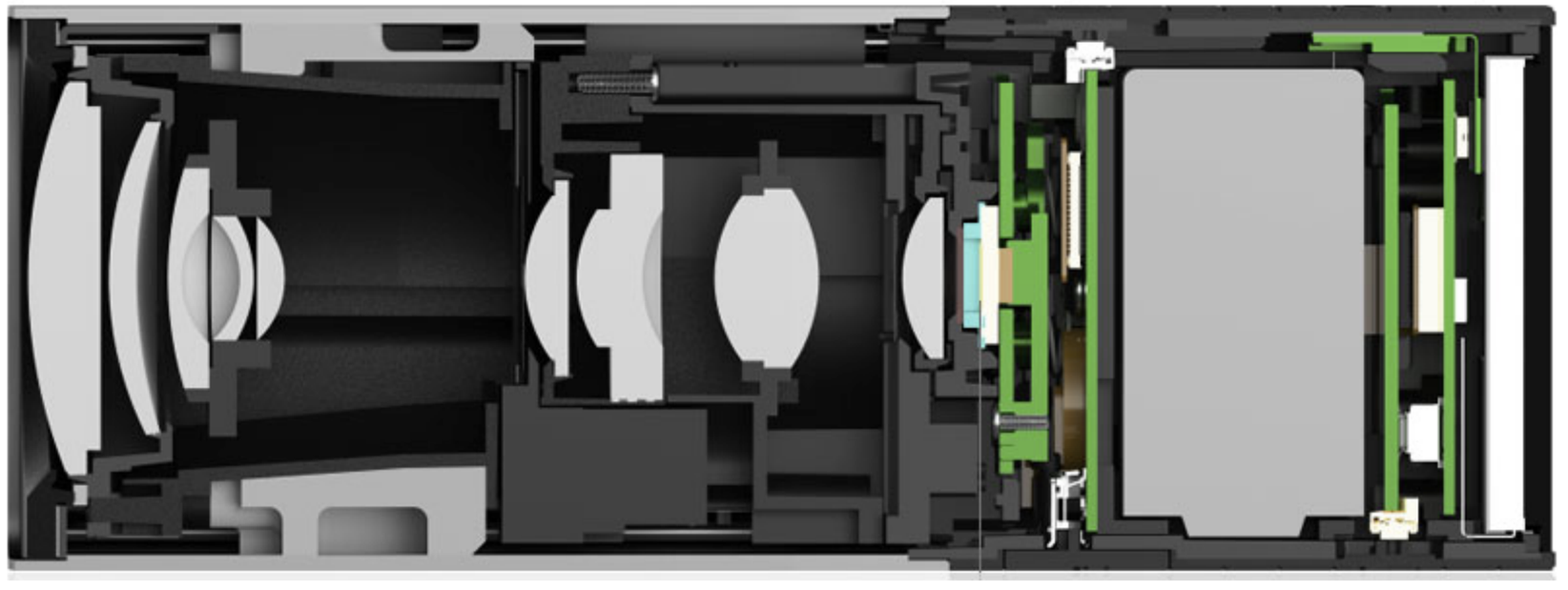
Digital and Computational Cameras



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

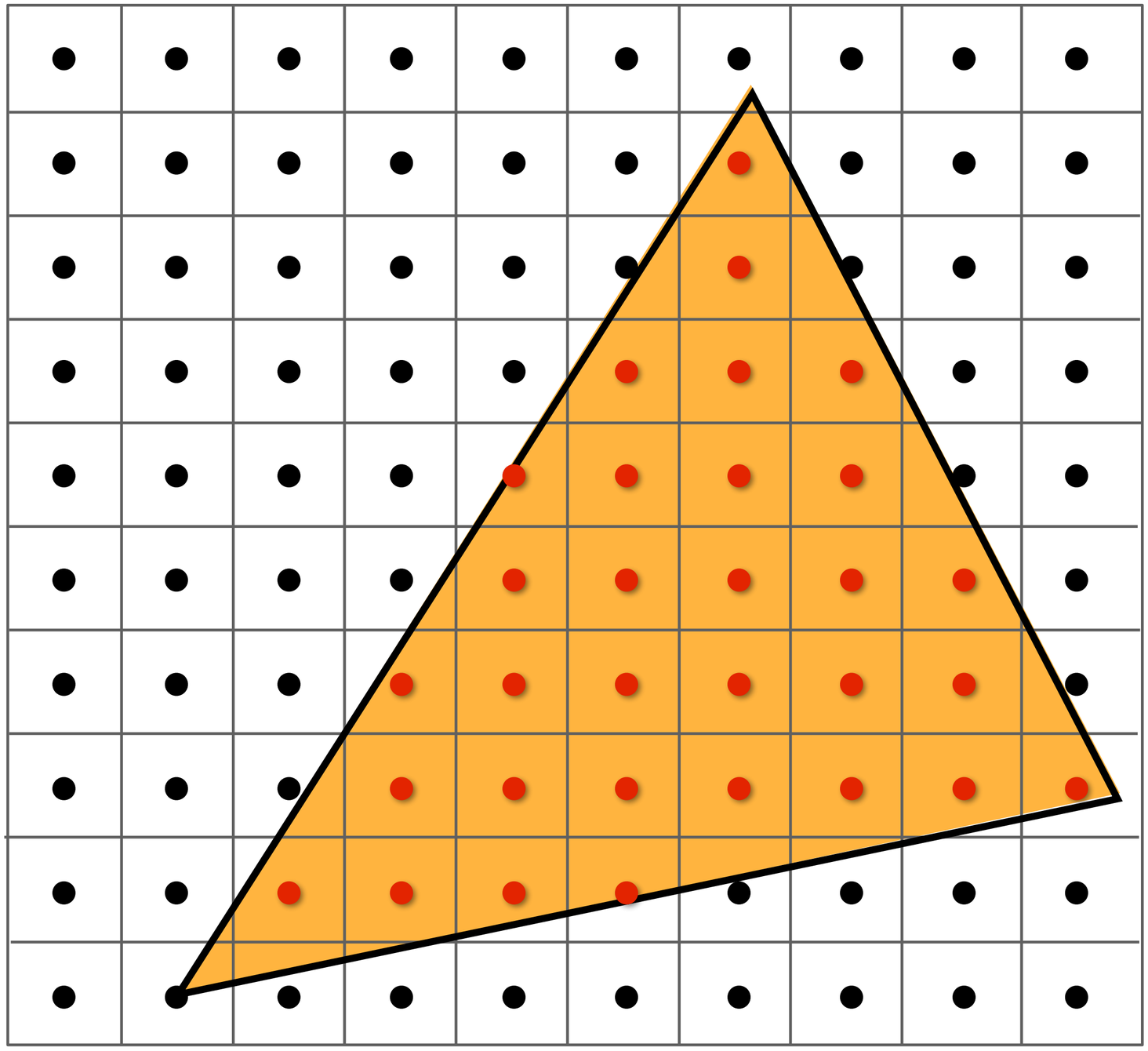
- Modeling the world, image synthesis
- 3D graphics: geometry, rendering, animation
- Image capture, manipulation, and display

Acquire core concepts and skills

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

Course Topics

Drawing Digital Images (Rasterization)

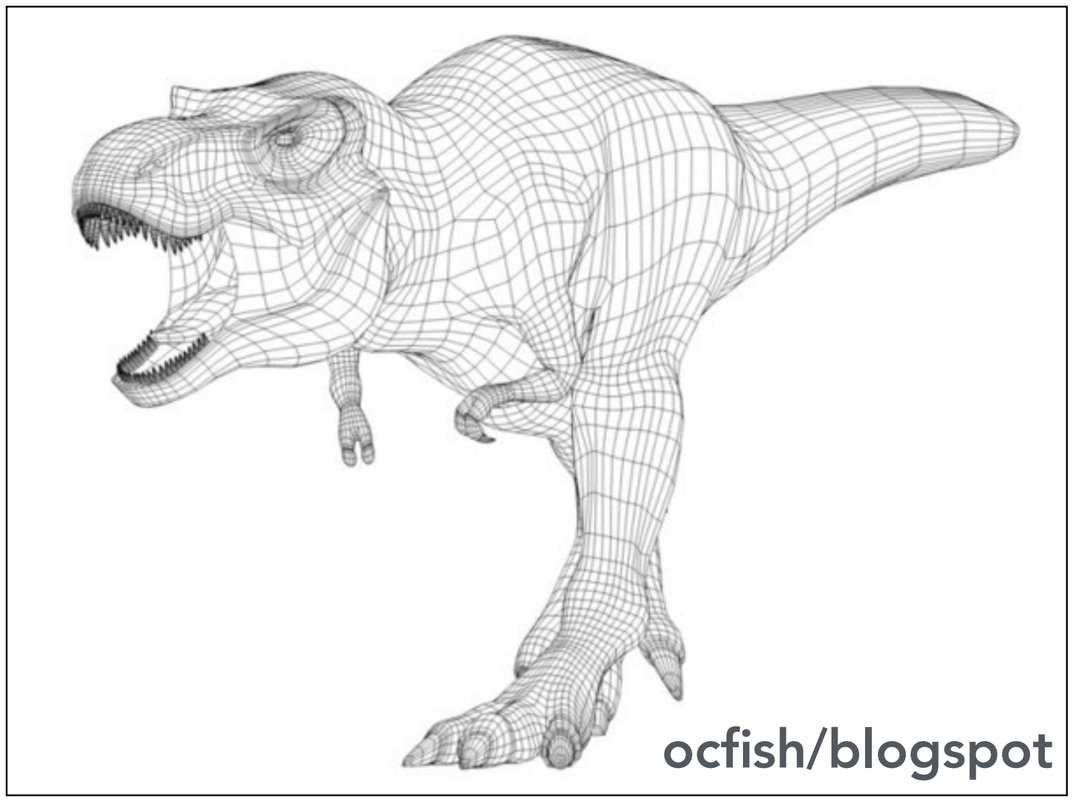


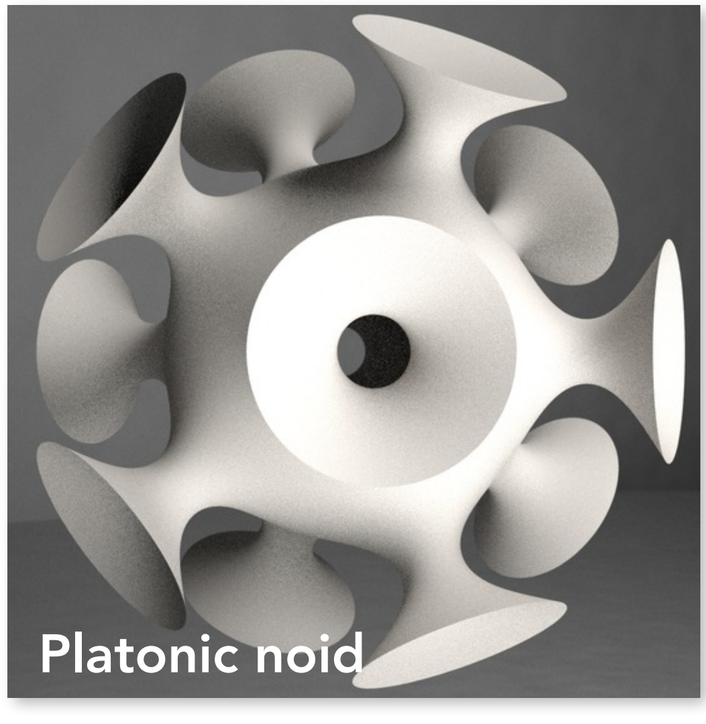
Jonathan Ragan-Kelley & Ren Ng

Filtering and Sampling

No Jaggies

Modeling Geometry





Modeling Material Properties

Modeling Lighting

Light Transport and Image Synthesis

Photograph (CCD) vs. computer rendering

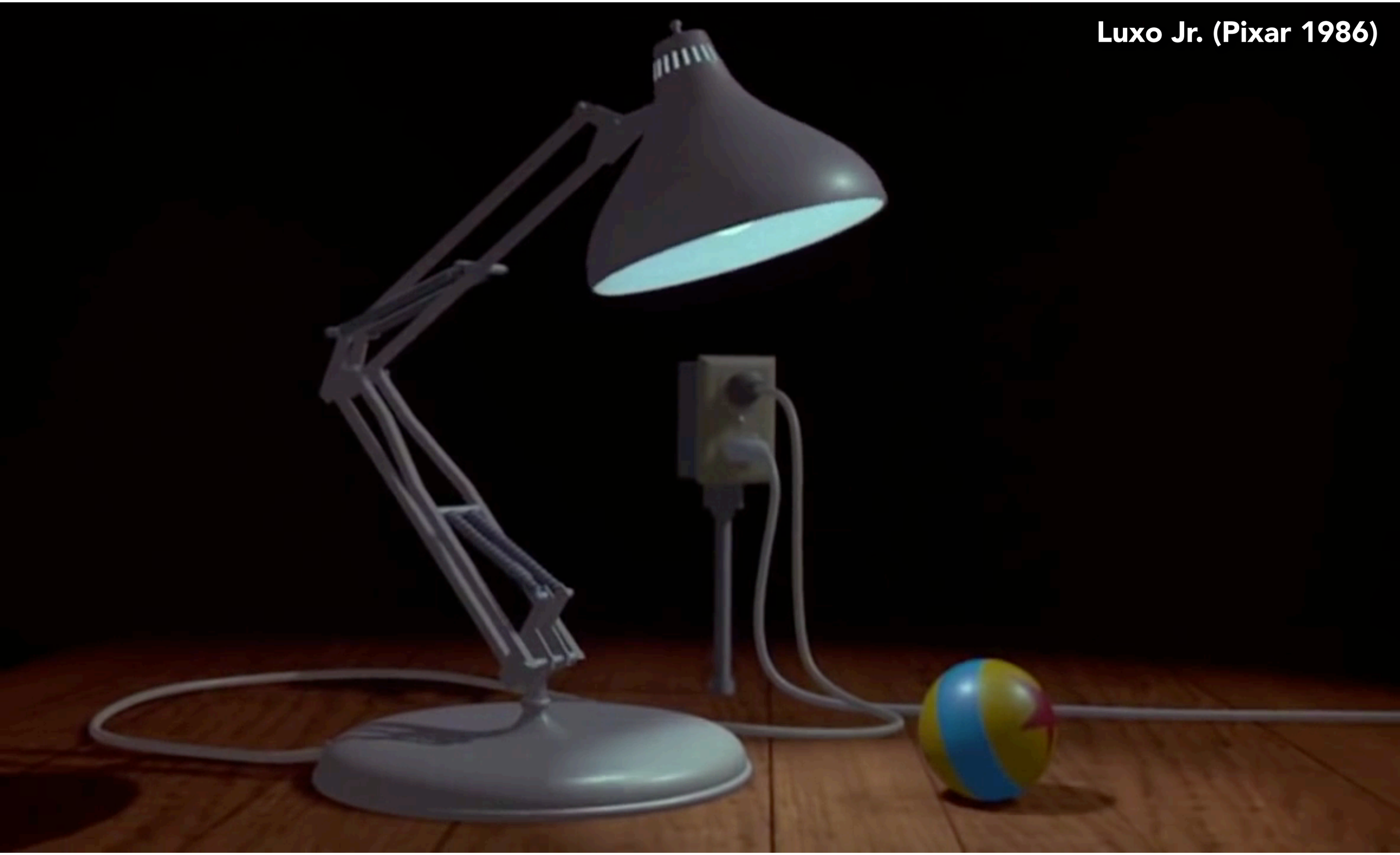
Digital and Computational Cameras

Glenn Derene, Popular Mechanics

CS184/284A

Jonathan Ragan-Kelley & Ren Ng

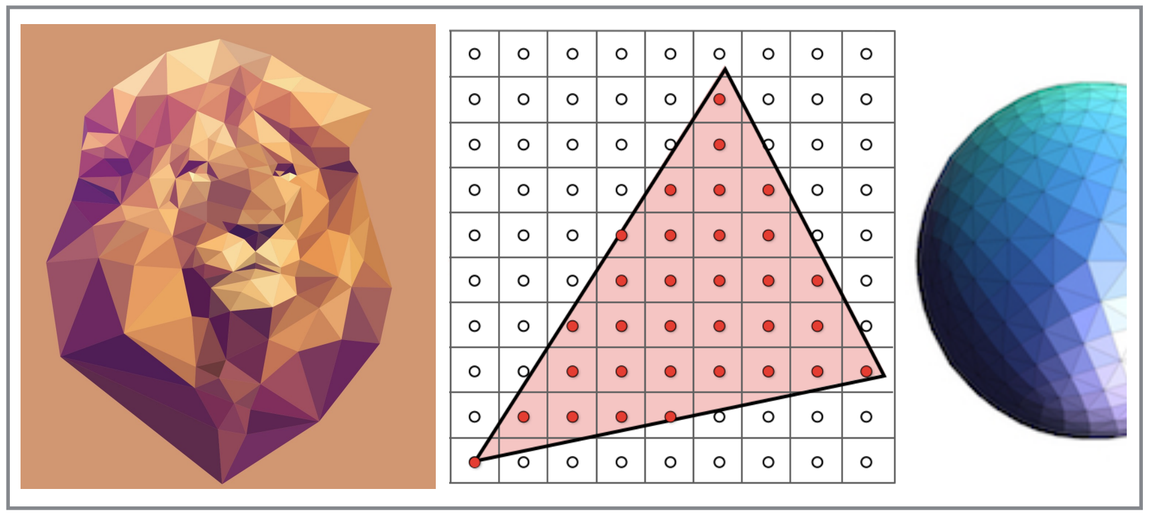
Animation and Physical Simulation



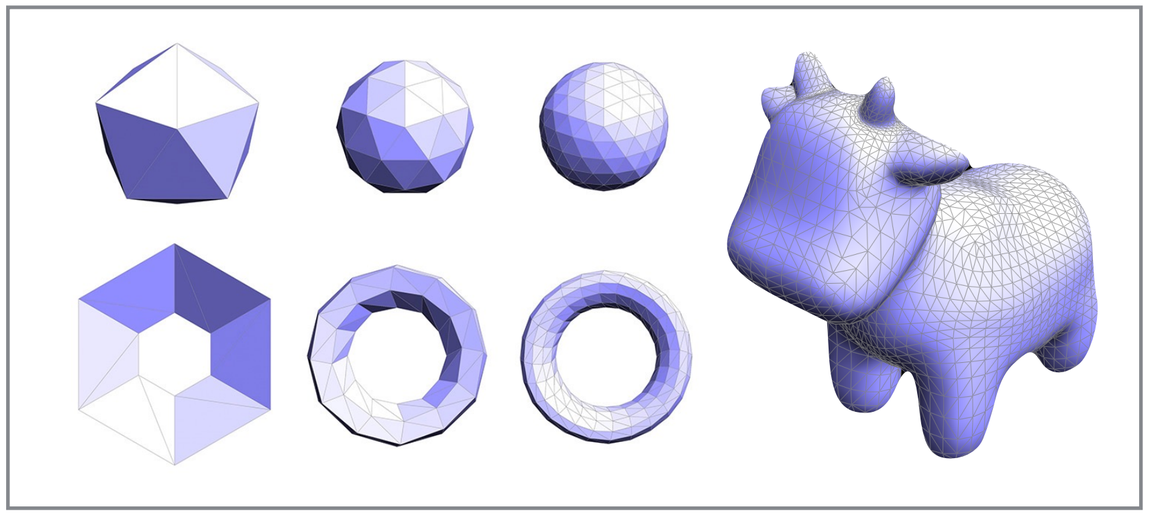
Virtual Reality

Hands-On Learning

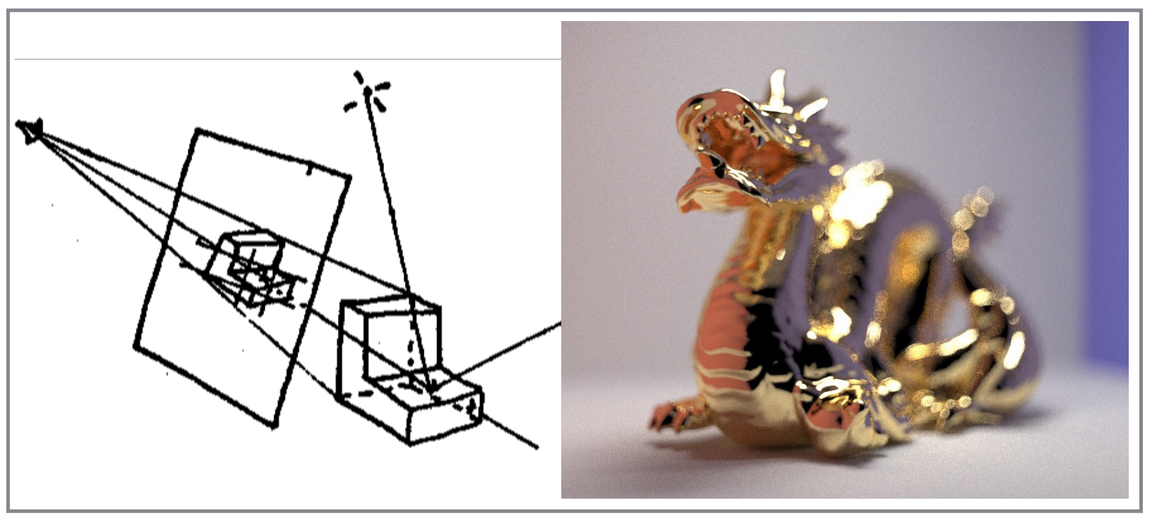
Course Assignments



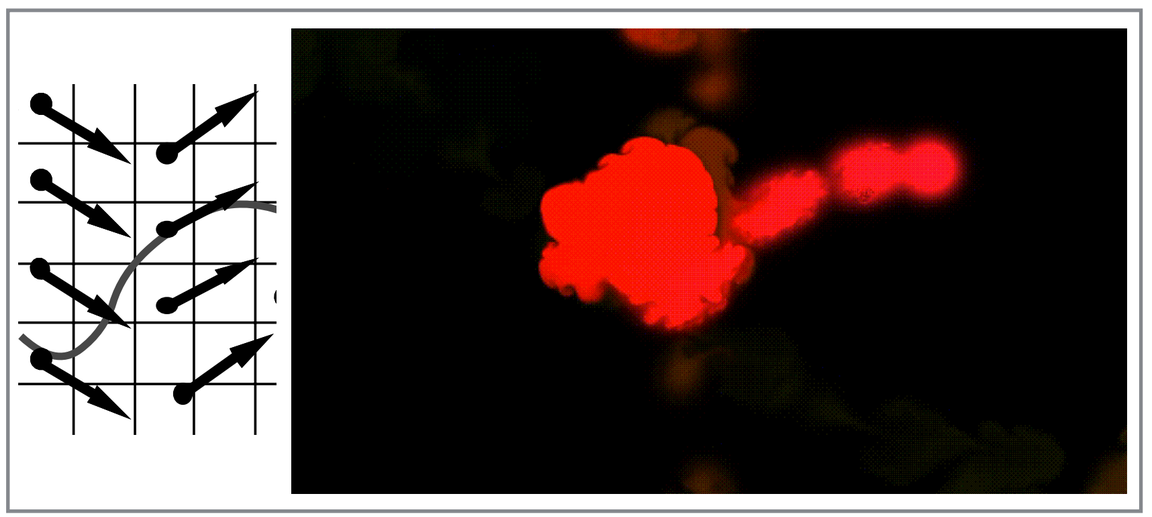
1. Digital Drawing (2 weeks)



2. Geometry (2 weeks)



3. Ray-Tracing (4 weeks)



4. Animation (2 weeks)

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Jonathan Ragan-Kelley & Ren Ng

Final Project

Project Competition

- Win a cool prize (TBA - past: visit Pixar)
- 4 weeks, let your creativity take flight!
  (we will have suggested projects)
- Proposal; checkpoint; presentation, video, report

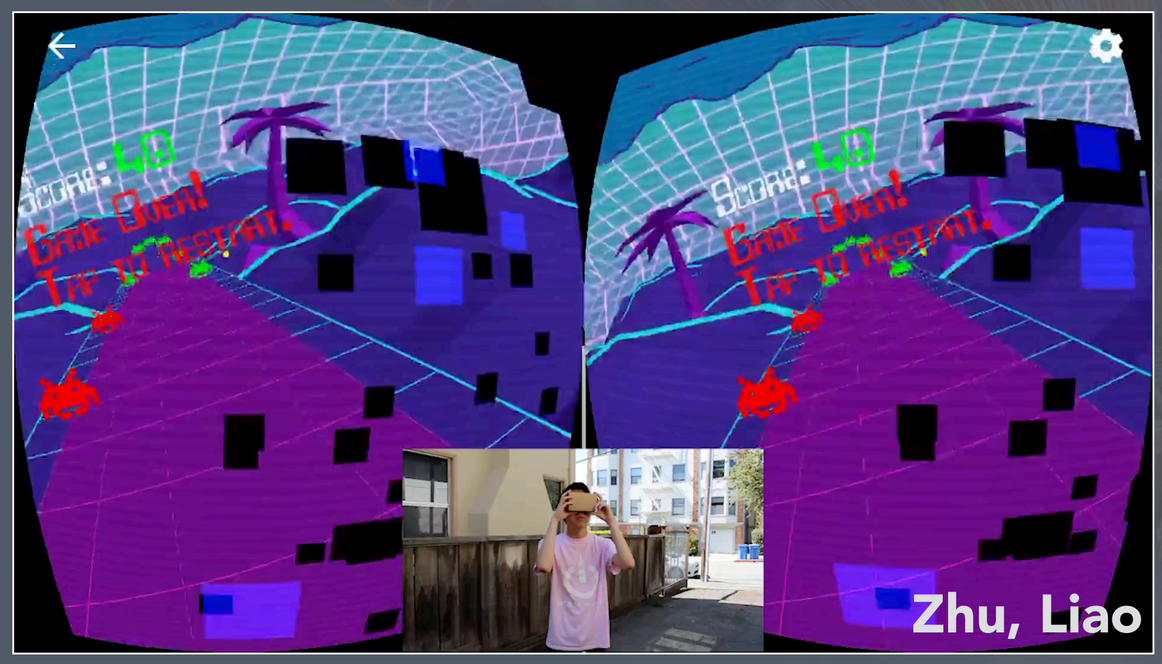
Credit: Pixar, Up

Final Project - Examples

Bhadra, Tsai, Ngan

Jiang, Dieppedalle, Singhal

Briggs, Shen, Xia



Zhu, Liao

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
- Class was basically full after dust settled
- This year, ~50% larger enrollment
- 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

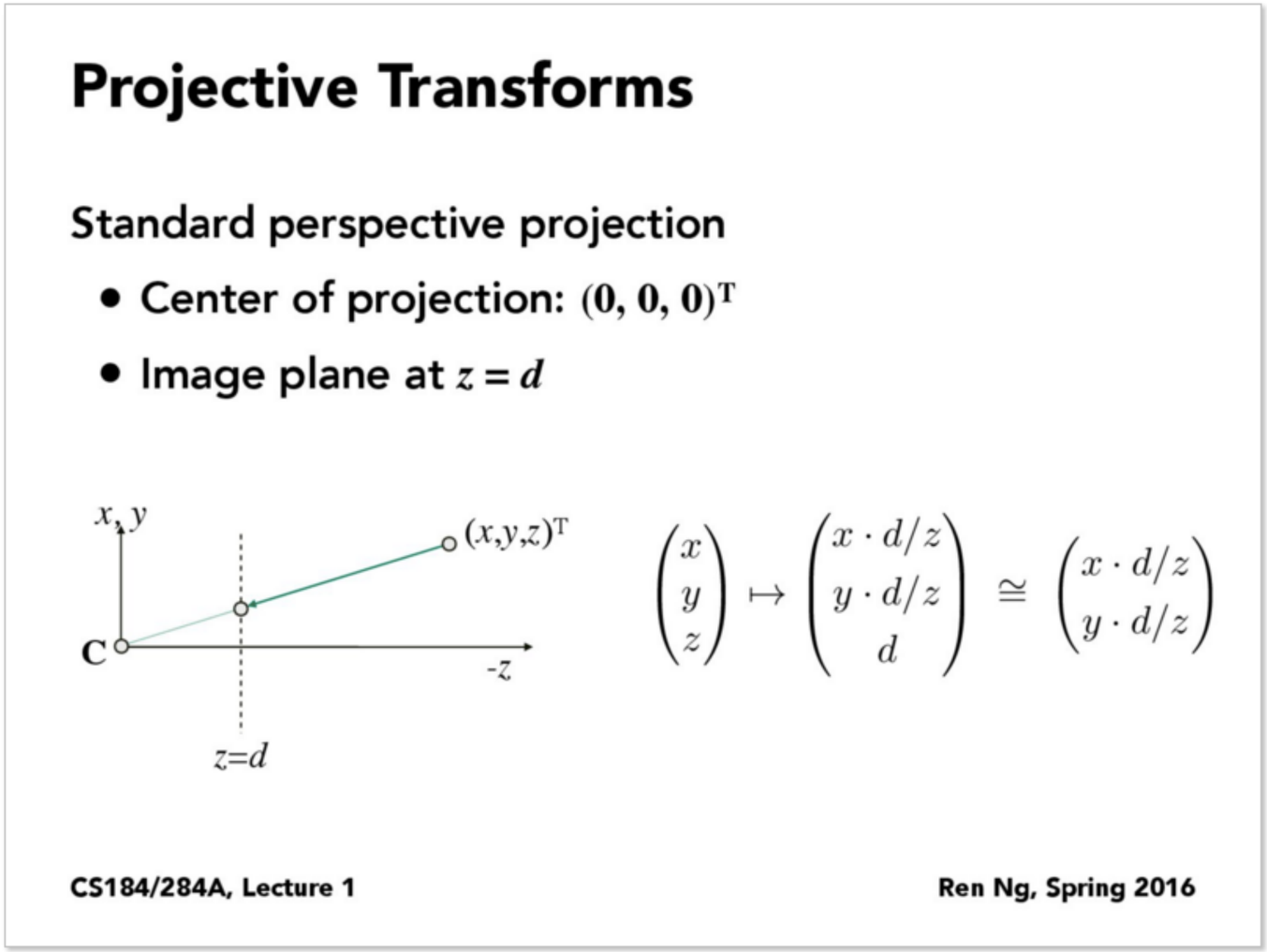
Course Website

cs184.org or
cs184.eecs.berkeley.edu

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

"Add private note" button:
You can add notes to yourself about this slide here.

Slide comments and discussion



CS184/284A

Jonathan Ragan-Kelley & Ren Ng

Piazza

piazza.com/berkeley/spring2019/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

There will be a "getting started" post about the website on Piazza

Webcasting

Lecture will be recorded this semester

- Screen capture and audio only.
- Videos available in CalCentral and bCourses

Section

Sections start next week (Jan. 29)
TAs will give a primer on C++, building class projects

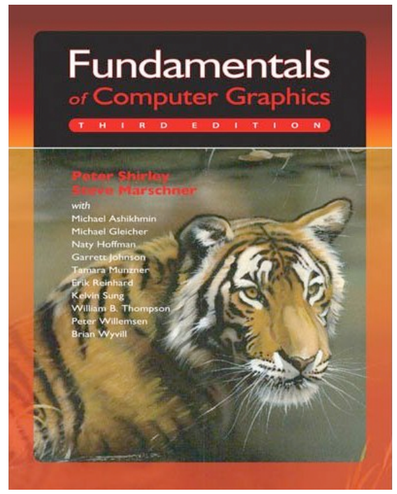
Details to appear on Piazza

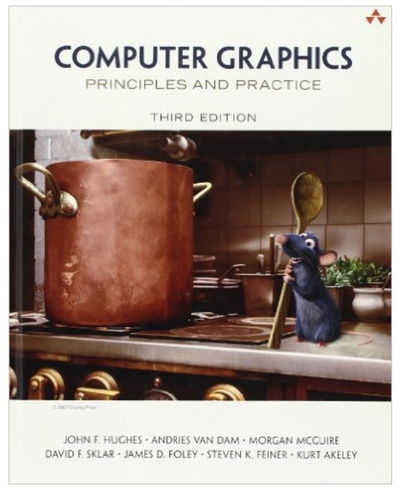
Resources

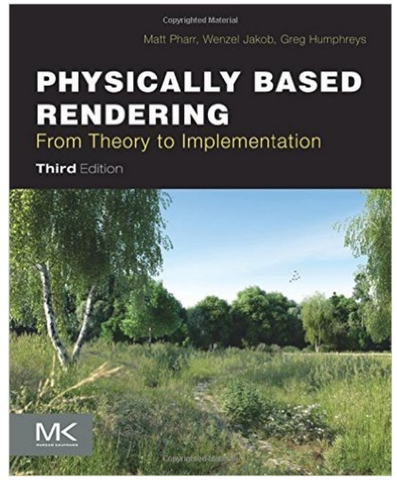
Lectures will be primary source

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

(40%) Assignments (5)

(20%) Final Project (in groups of three, presentations, report)

(35%) Exams

- Exam 1 on (tentative) Tuesday March 13, 7–9pm
- Exam 2 on (tentative) Tuesday April 24, 7–9pm
- No Final Exam

(5%) Participation

- Lecture attendance, website comments
- Piazza (give / get help), come to office hours and homework parties

284A 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 programming assignment deadline by 24 hours using one late day.
- 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!

Course Participation Grading Policy

Lecture attendance

- Attend *most** lectures for 10 weeks

*policy to be finalized & begin a bit later

- Will use "DeNero method" for tracking attendance

<u>Or</u> website participation

- Contribute at least 3 <u>well-thought-out</u> comments on lecture slides each week
- 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.

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…"

Class Philosophy

We want a very active class.

Come to class, participate in lecture.

Contribute on the website.

Questions?

Acknowledgments

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