

Lecture 1:

Introduction

Computer Graphics 2025
Fuzhou University - Computer Science

Welcome!

Ph.D. Yixin Zhuang (庄一新)



- Ph.D. on Computer Science (National University of Defense Technology, Washington University in St. Louis)
- Research interests: computer graphics, 3D vision, robotics
- Website: yixin26.github.io
- Email: yixin.zhuang@gmail.com

Today's Topics

What is Computer Graphics?

Why Study Computer Graphics?

Course Overview

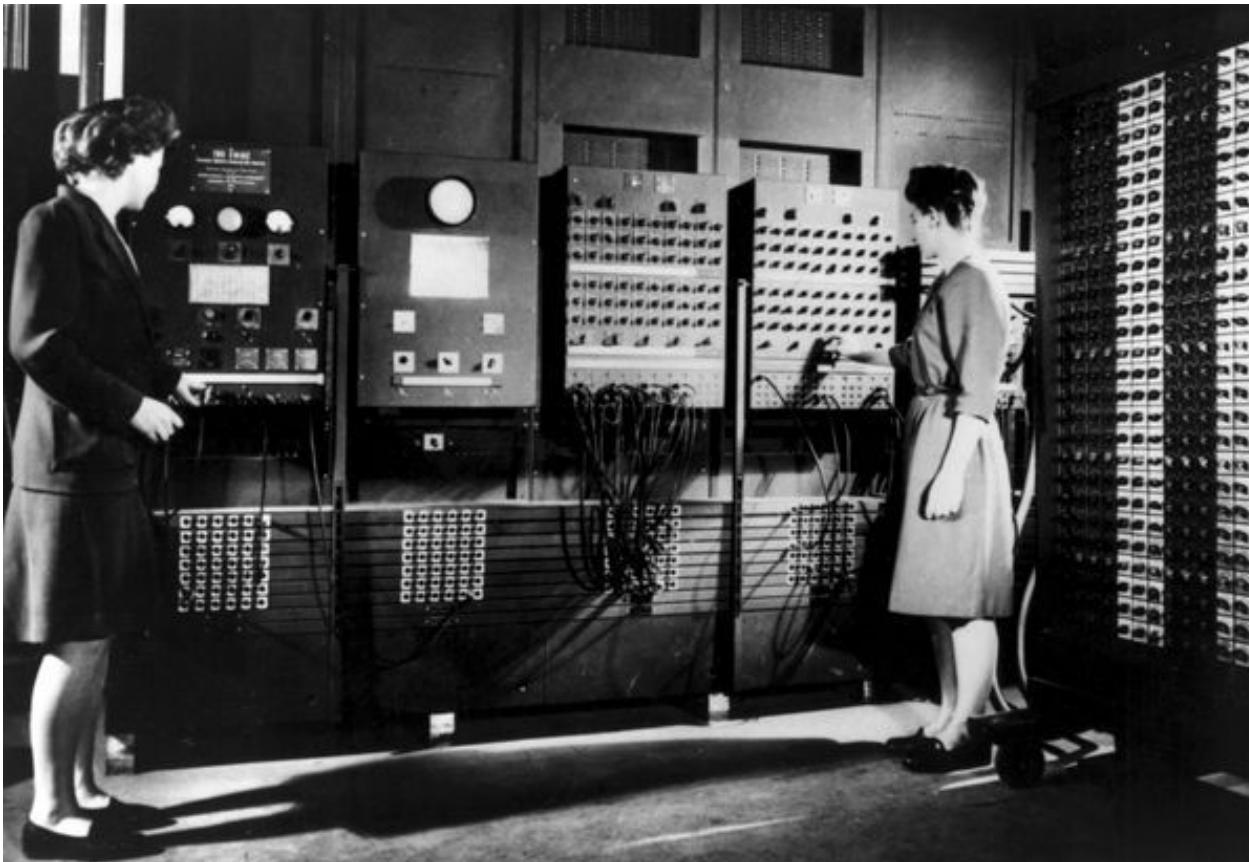
Logistics

What is Computer Graphics?

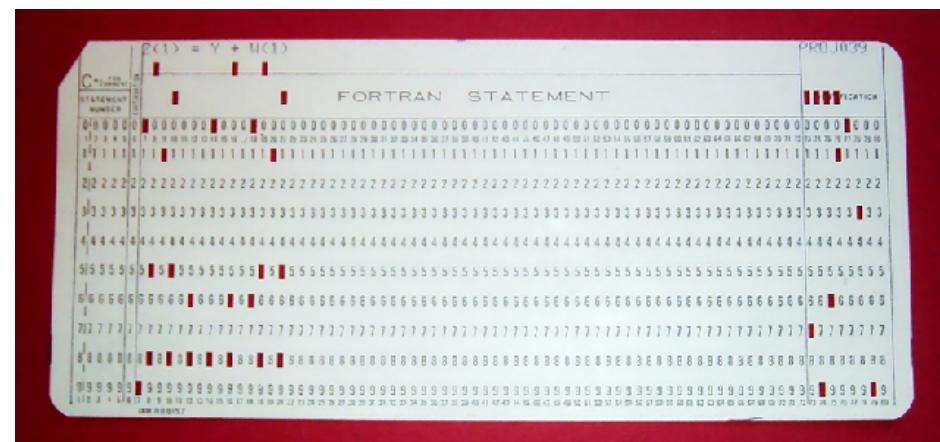


**More fundamentally:
What is Computer Graphics?**

Display the computational results

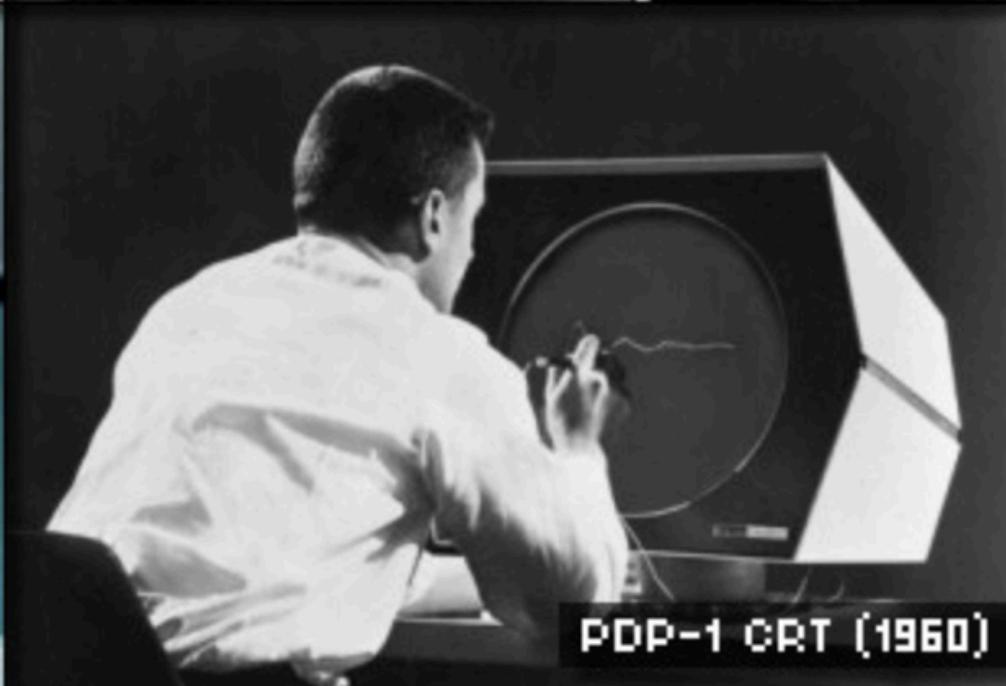


Early computer (ENIAC), 1945



punch card (~120 bytes)

Visual Display



Sketchpad (Ivan Sutherland, 1963)



MACINTOSH (1984)



Virtual and Augmented Reality



What is Computer Graphics?

com•put•er graph•ics /kəm'pyoodər 'grafiks/ *n.*

The use of computers to synthesize visual information.



digital information

computation



visual information

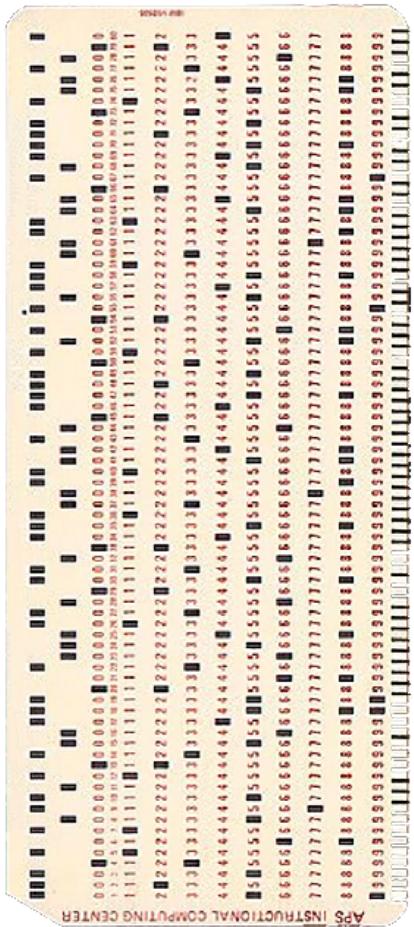


What is Computer Graphics?

com•put•er graph•ics /kəm'pyüər grāf'iks/

Why only visual?

The use of computers to synthesize visual information.



digital information

computation

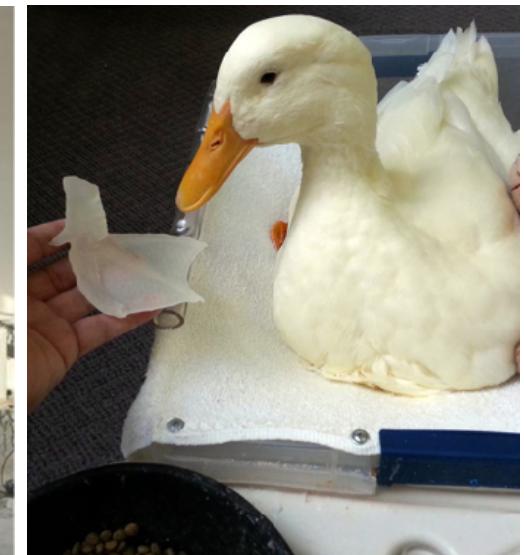
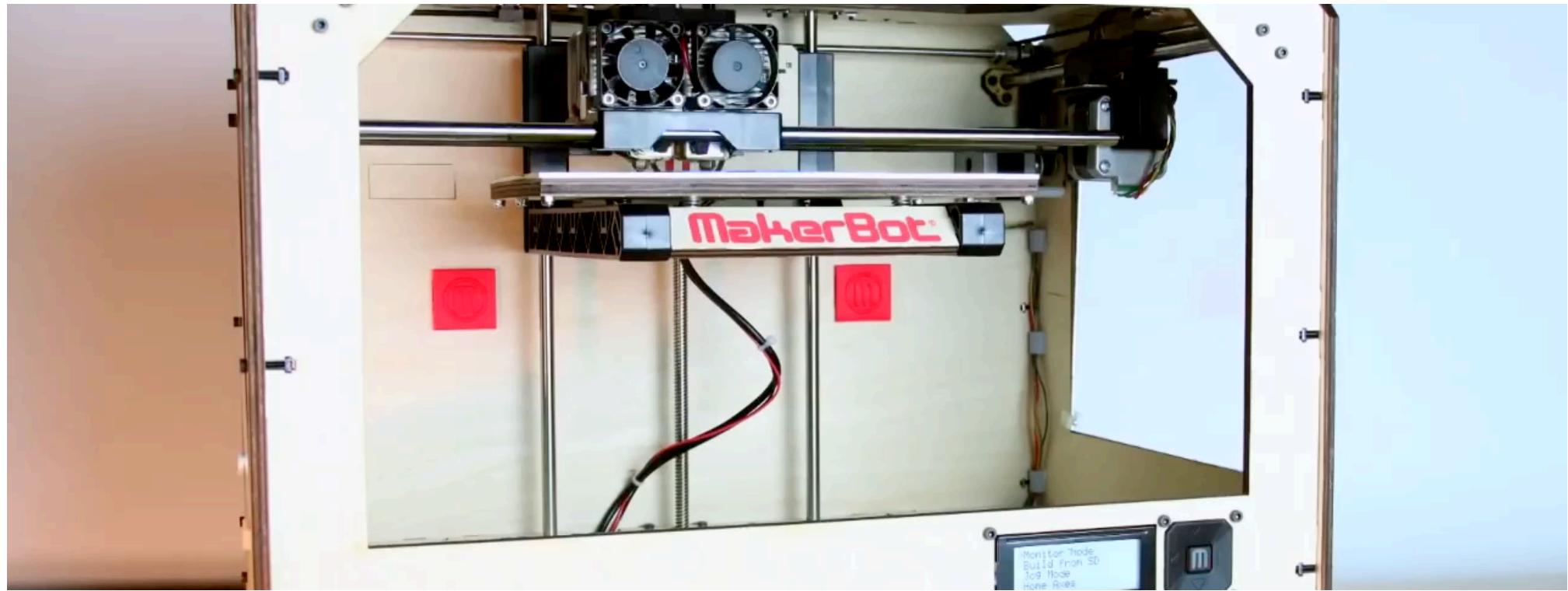


visual information



**Graphics has evolved a lot since
its early days...
no longer just about turning on
pixels!**

Turning digital information into physical matter



Computer Graphics is everywhere!

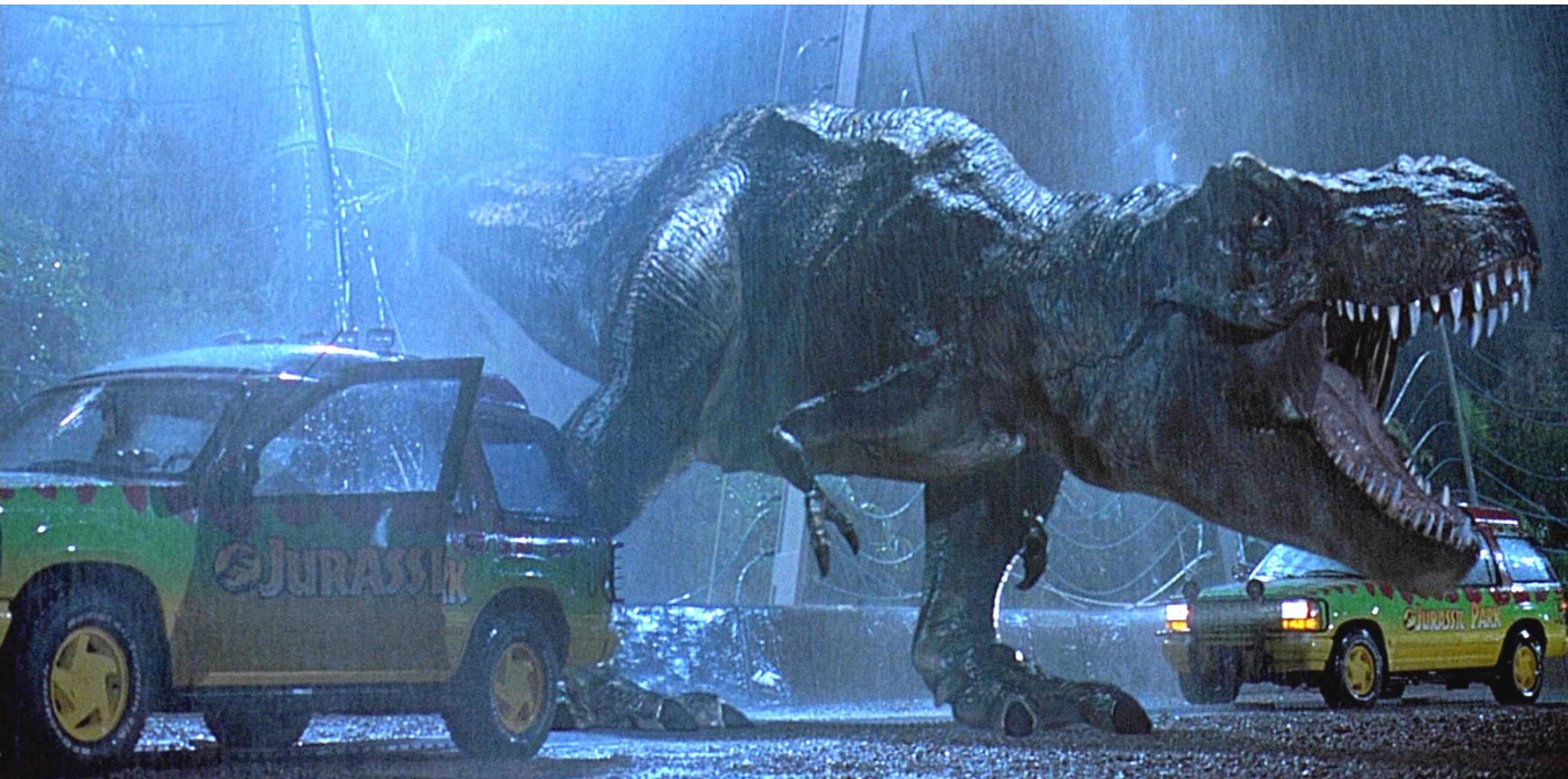
What is Computer Graphics?

com•put•er graph•ics /kəm'pyōodər 'grafiks/ n.

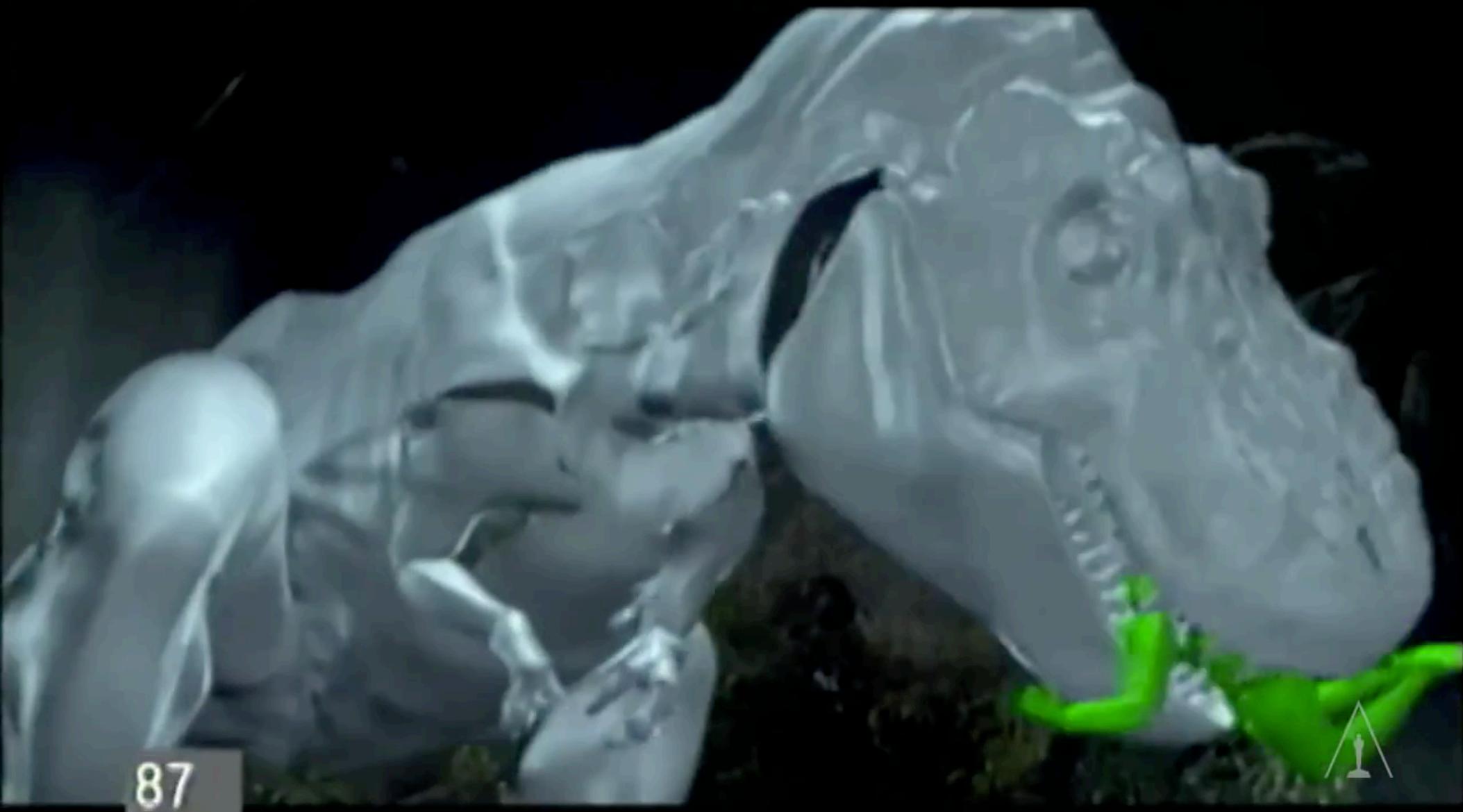
The use of computers to synthesize and manipulate visual information.

Why Study Computer Graphics?

Movies



Jurassic Park (1993)



87



Moments That Changed The Movies: Jurassic Park
<https://www.youtube.com/watch?v=KWsbcbVYqN8>

Movies

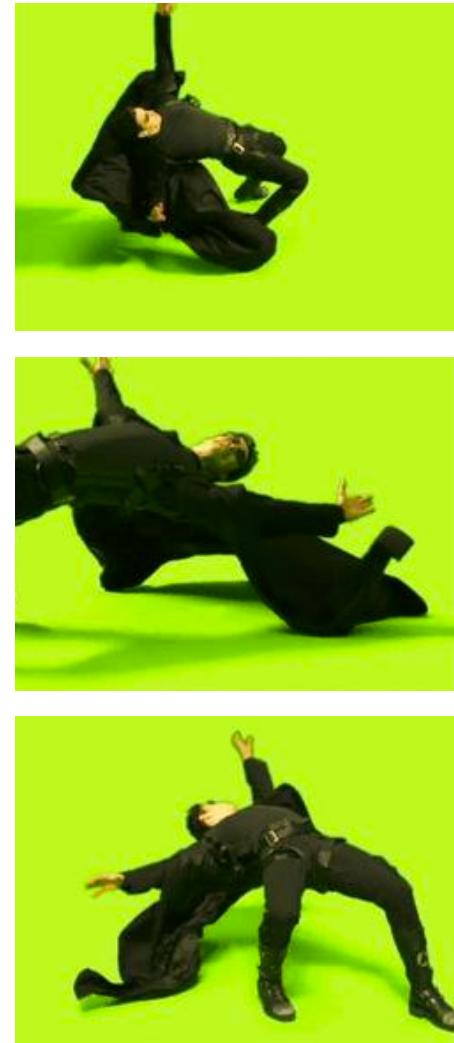
(特效：子弹头时间)



The Matrix (1999)

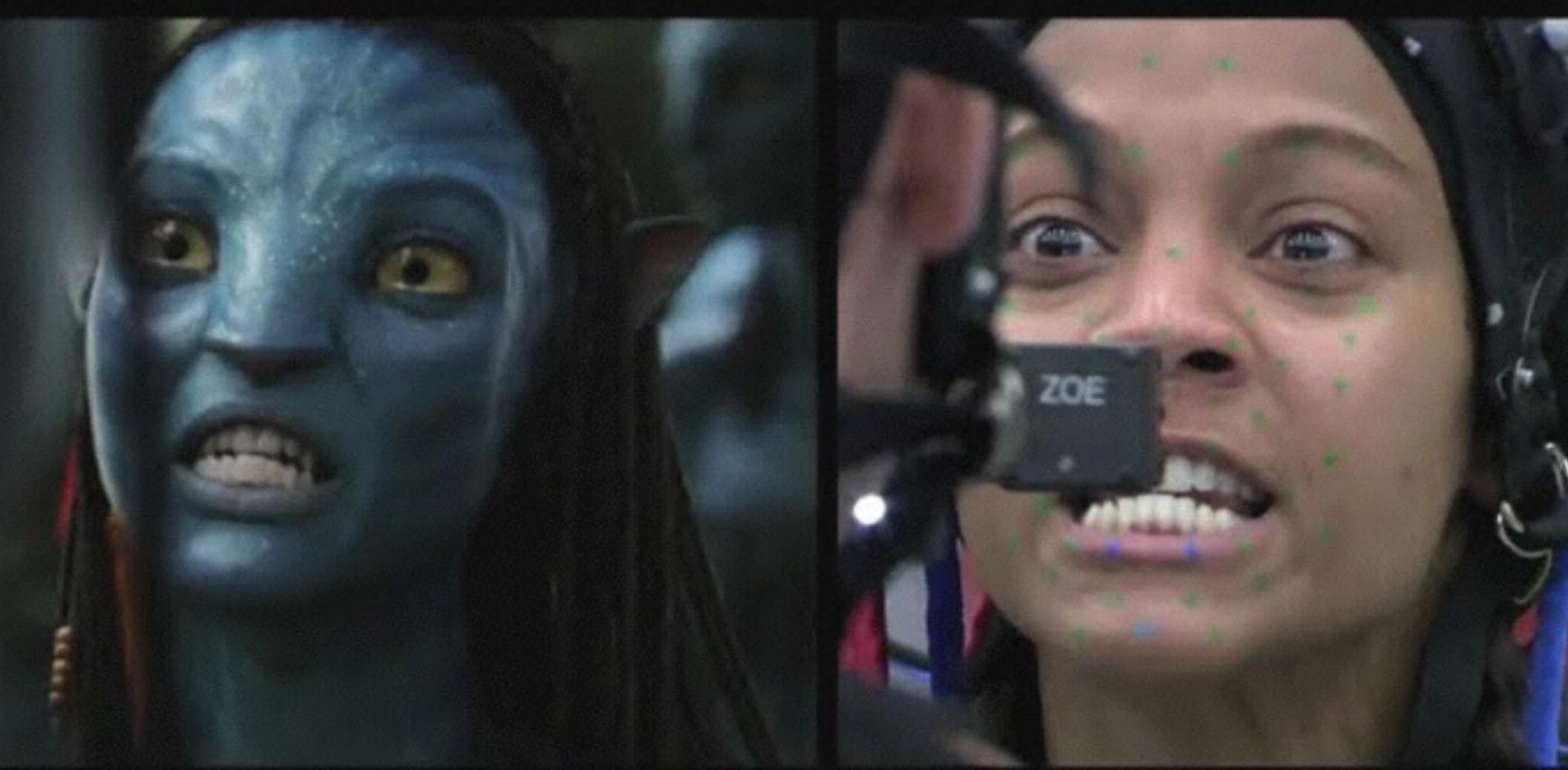
Movies

(子弹头时间拍摄方法)



The Matrix (1999)

(动画：人脸运动捕捉)



Avatar (2009)

Movies

(动画：肢体和人脸运动捕捉)



Andy Serkis in The Two Towers

Movies

(动画：毛发细节建模)



Zootopia (2016)

Movies

(仿真：气流物理模拟)



Frozen 2 (2019)

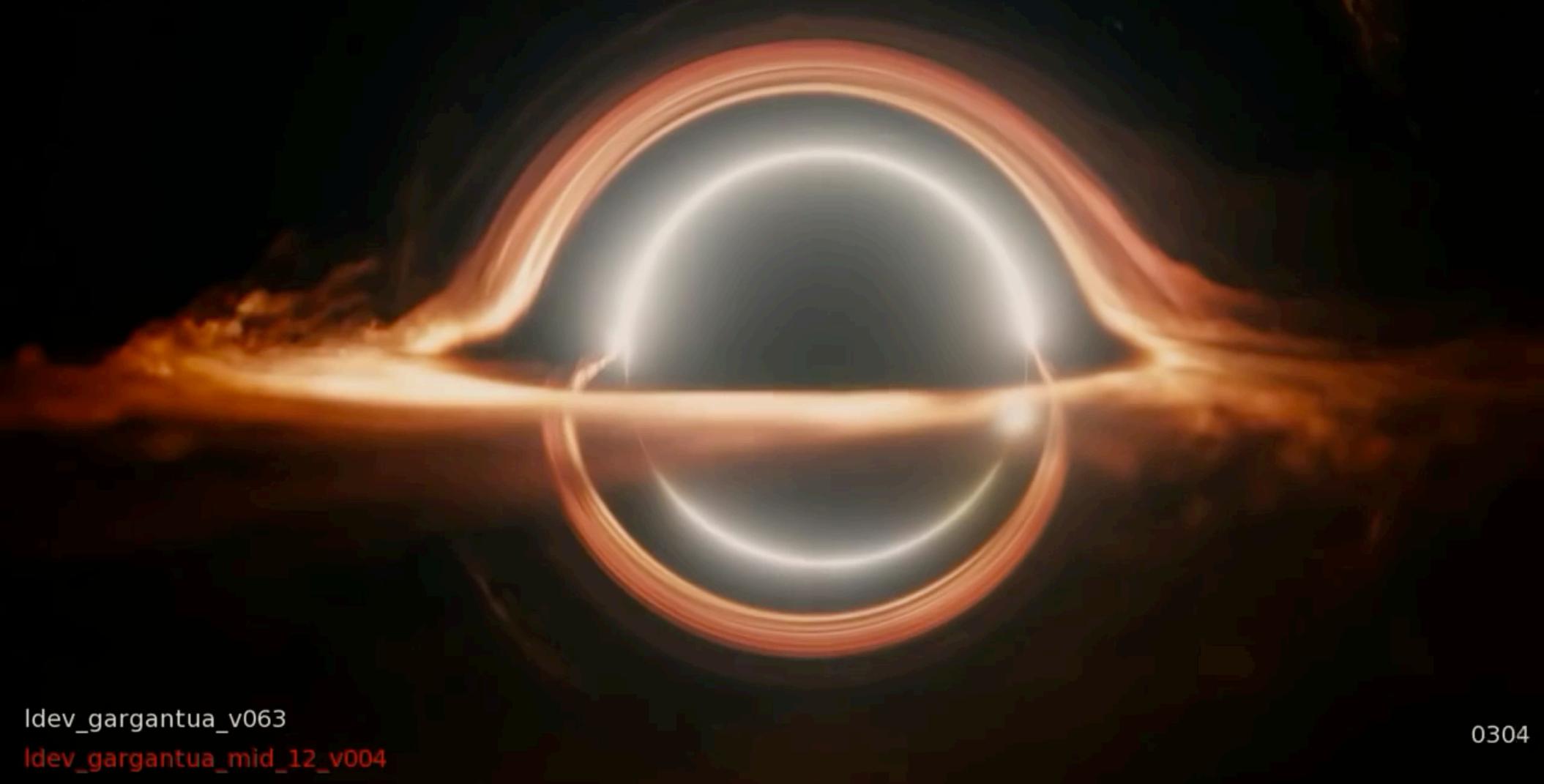
(可视化：黑洞形状)



10/14/13

FL

double negative visual effects



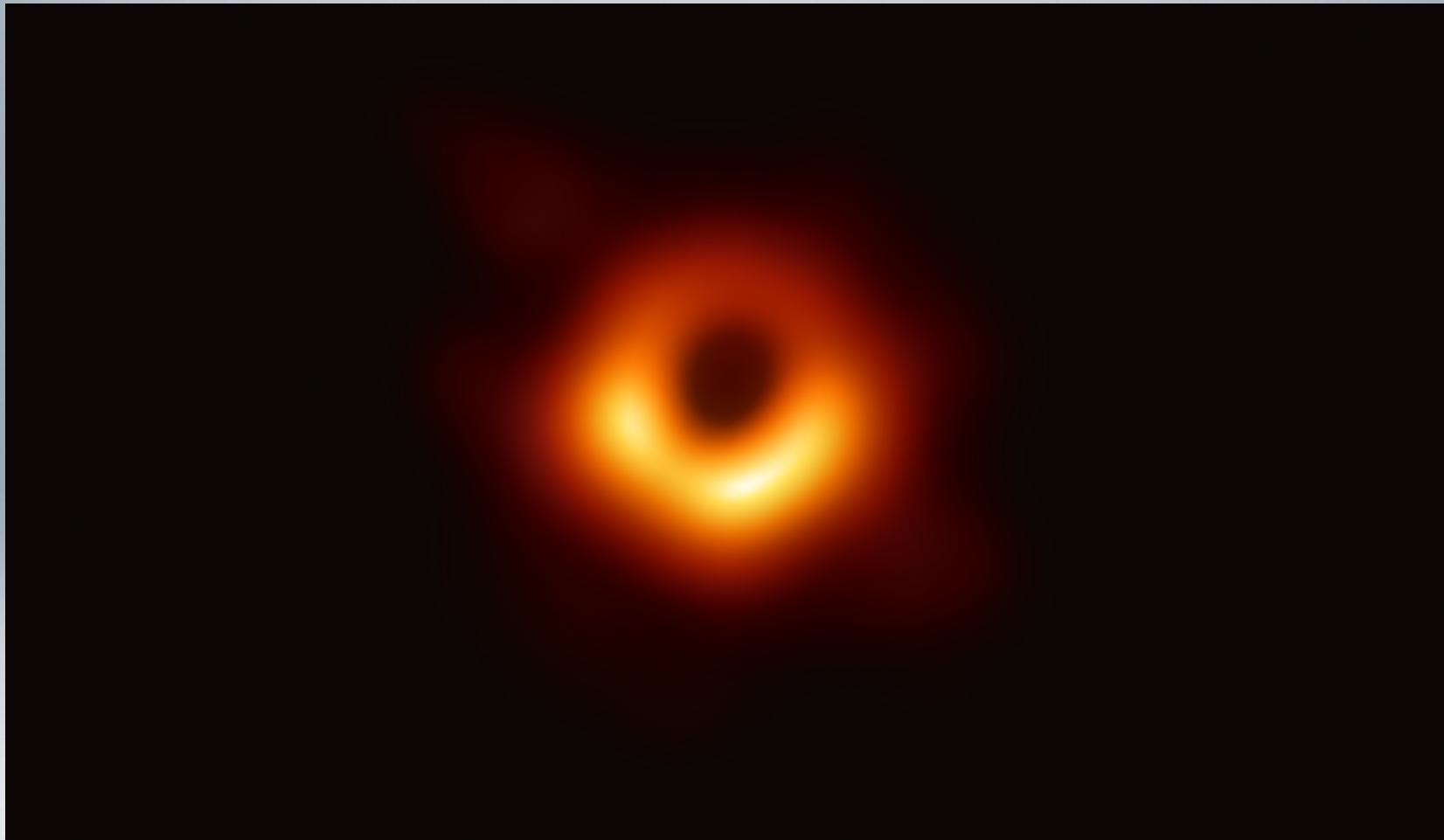
ldev_gargantua_v063

ldev_gargantua_mid_12_v004

0304

Interstellar (2014)

(可视化：真实黑洞形状)



Event Horizon Telescope collaboration et al.

Games

(游戏：建模)



Halo 5 (2015)

(游戏：渲染)



Battlefield 5 (2018)

(游戏：大尺度场景)

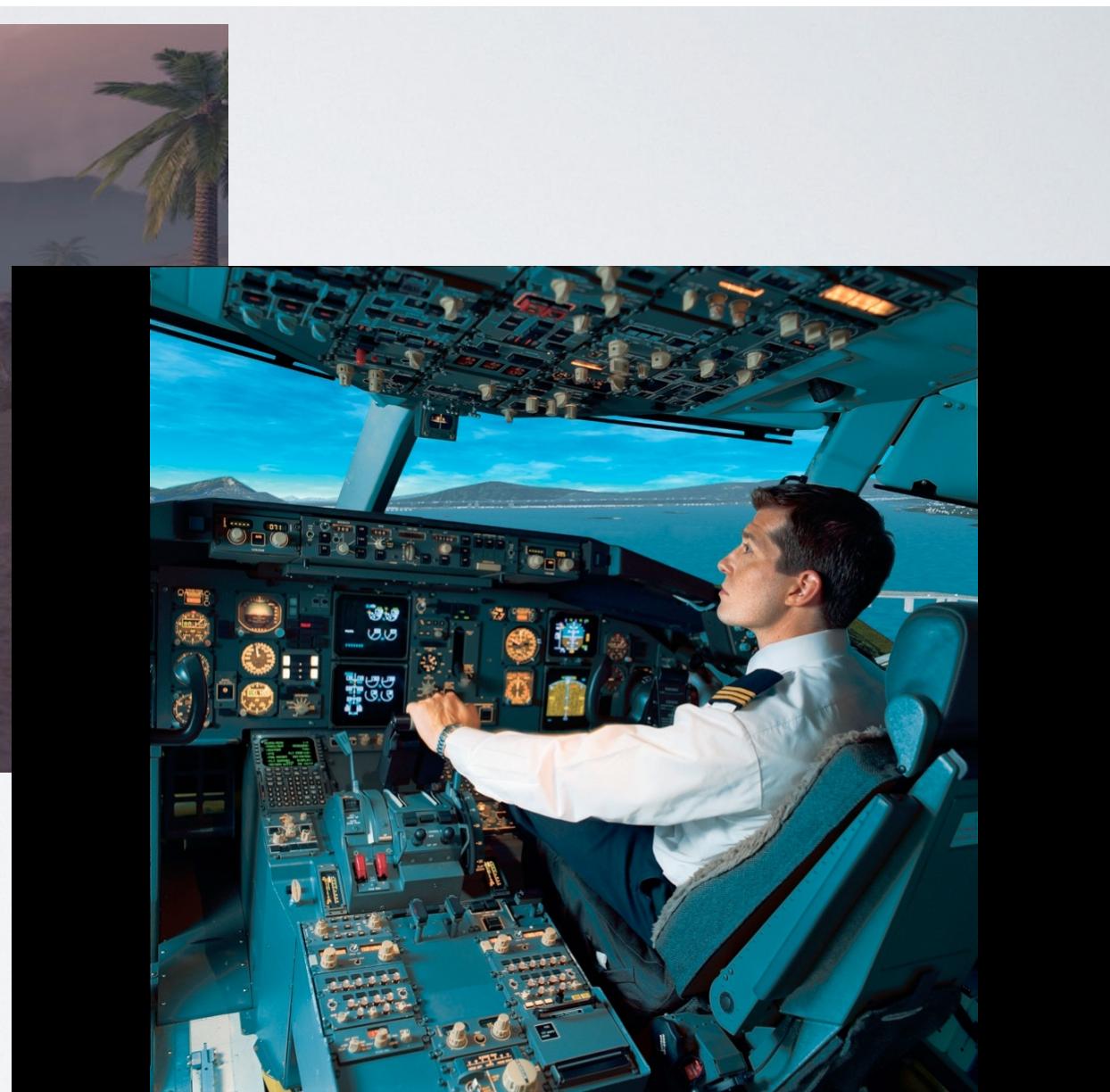


Red Dead Redemption 2, Rockstar, 2019

Training Simulations



From America's Army



From CAE Inc.

Visual Simulation



Driving simulator
Toyota Higashifuji Technical Center



da Vinci surgical robot
Intuitive Surgical

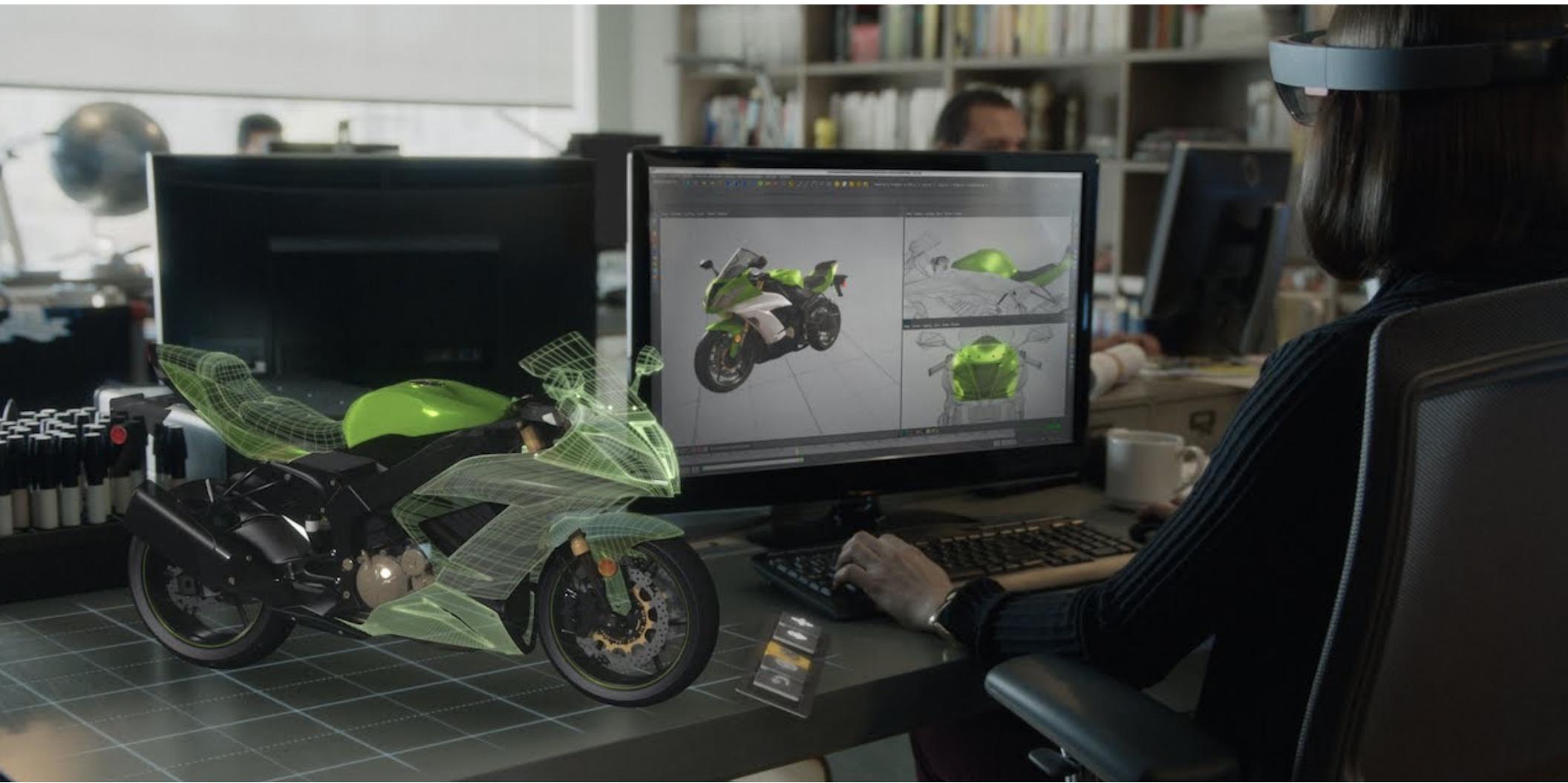
Flight simulator, driving simulator, surgical simulator, ...

Virtual Reality



HTC Vive headset and controllers

Augmented Reality



Microsoft Hololens augmented reality headset concept

Product Design and Visualization



Ikea - 75% of catalog is rendered imagery

Product Design and Visualization



Photograph



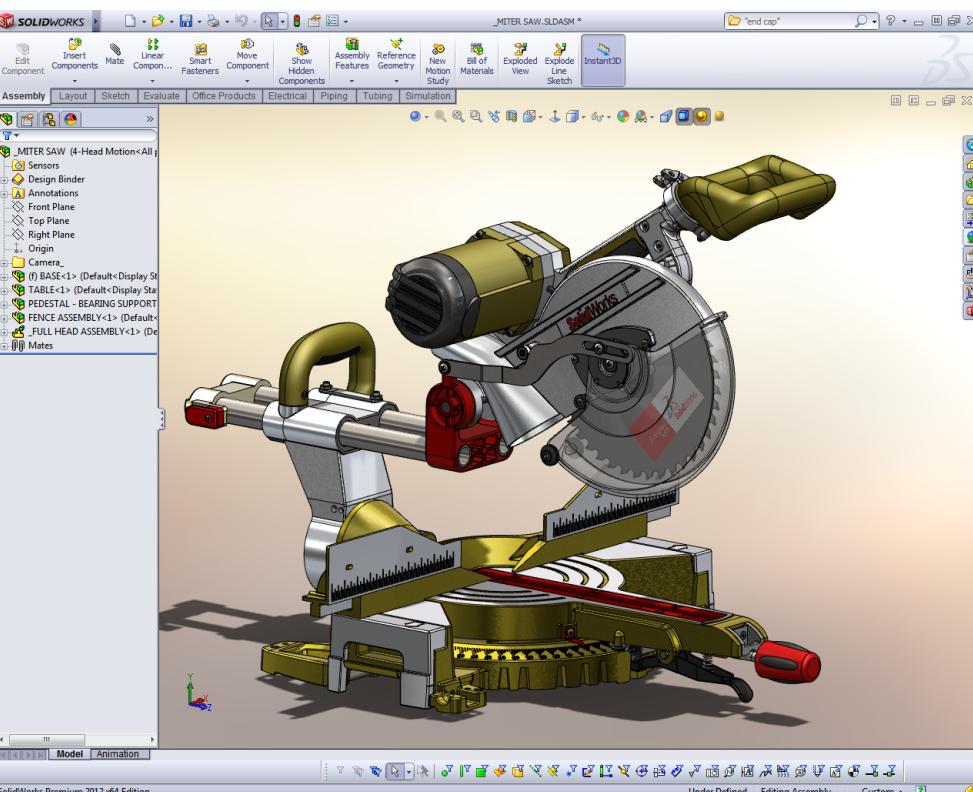
Simulation

Product Design and Visualization

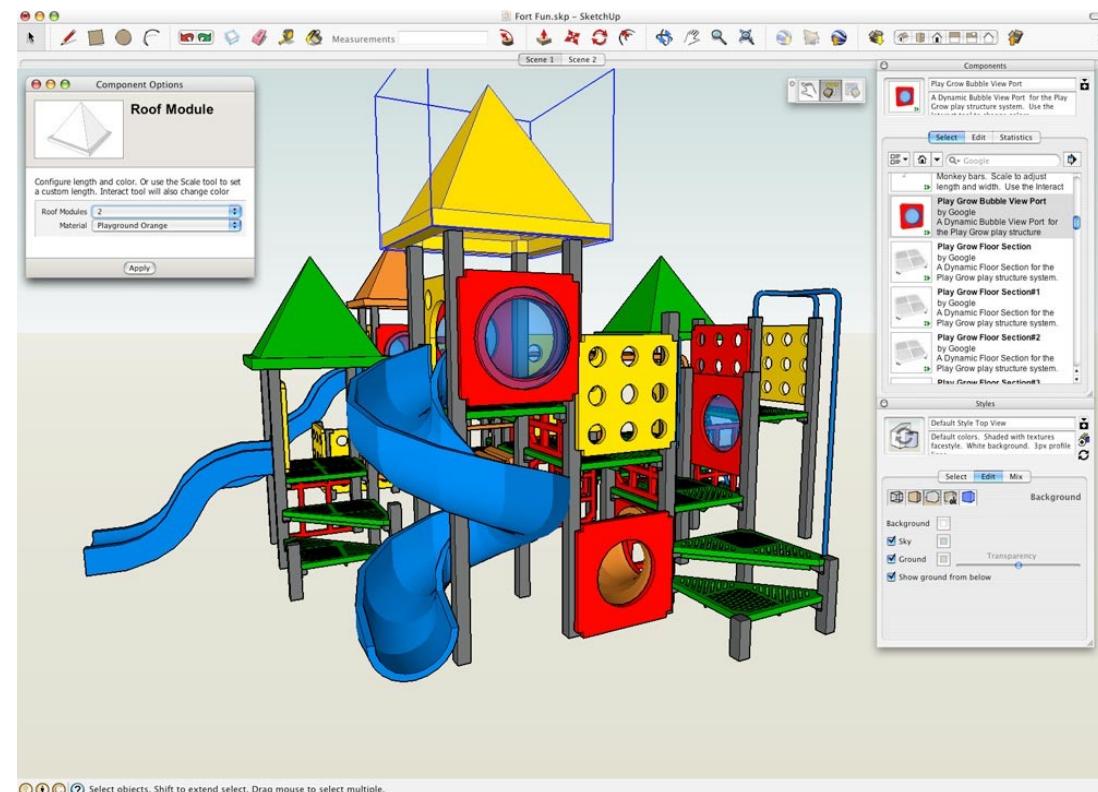


Tesla Model X concept (2012)

Computer-Aided Design



SolidWorks



SketchUp

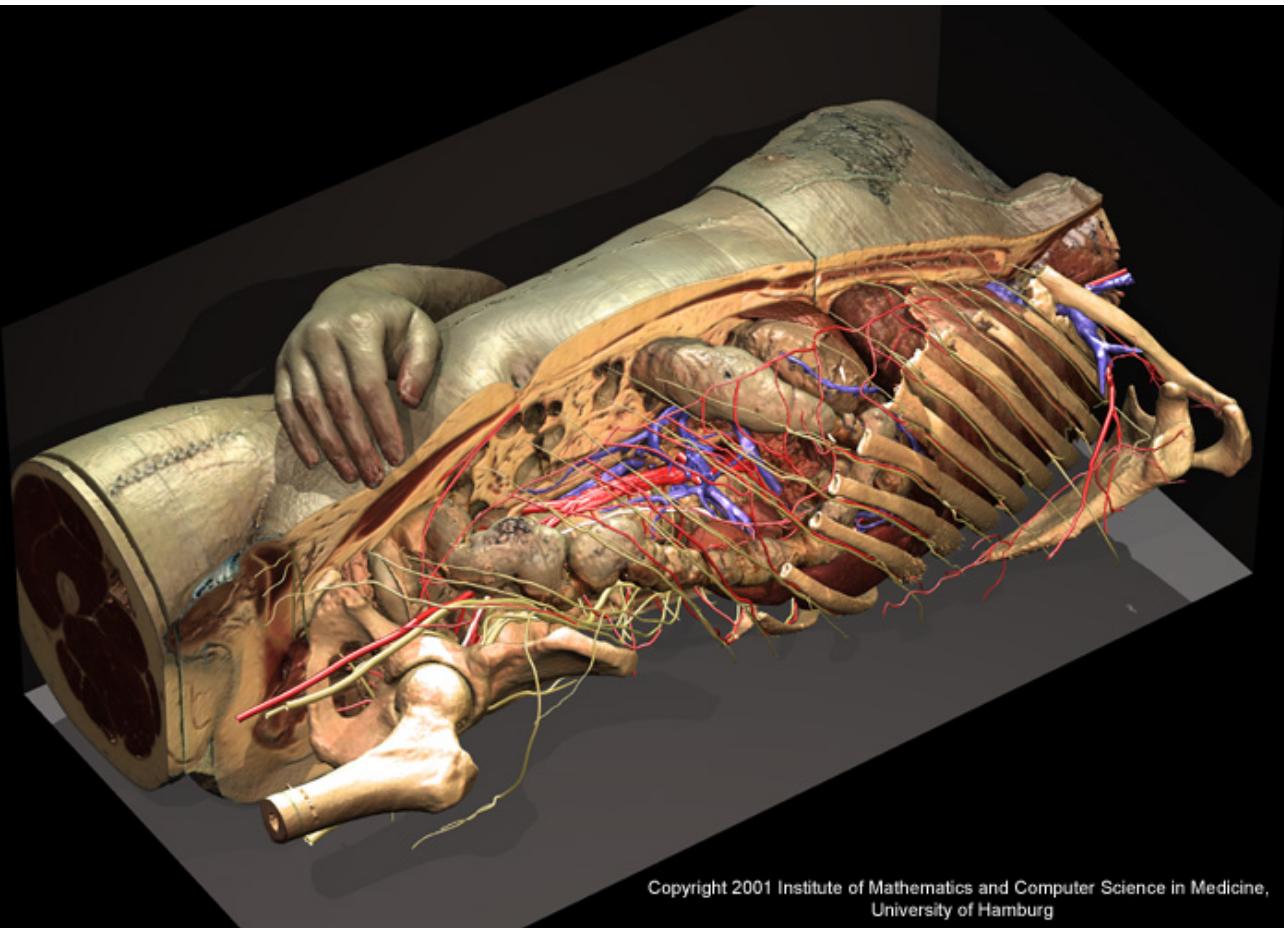
For mechanical, architectural, electronic, optical, ...

Architectural Design

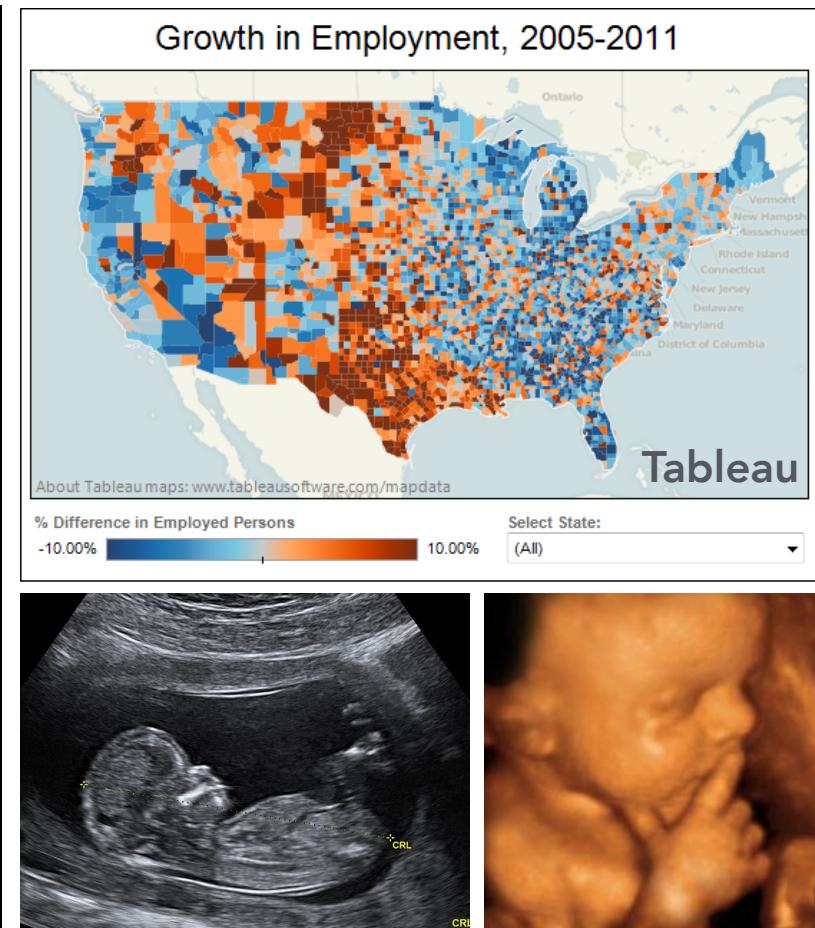


Heydar Aliyev Center, Zaha Hadid Architects

Visualization



Copyright 2001 Institute of Mathematics and Computer Science in Medicine,
University of Hamburg

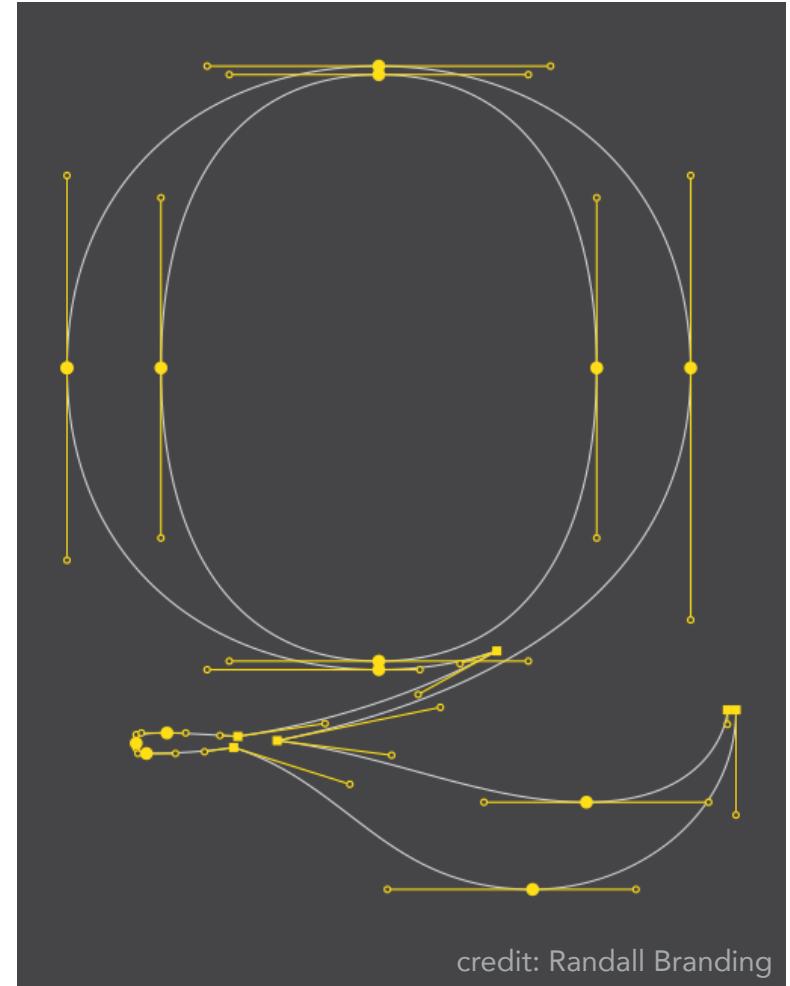


Science, engineering, medicine, journalism, ...

Typography

The Quick Brown
Fox Jumps Over
The Lazy Dog

ABCDEFGHIJKLMNPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 0123456789



Baskerville

Graphical User Interfaces



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

Foundations of Graphics

These applications require sophisticated theory and systems

- Theory
 - basic representations (how do you digitally encode shape, motion?)
 - sampling & aliasing (how do you acquire & reproduce a signal?)
 - numerical methods (how do you manipulate signals numerically?)
 - radiometry & light transport (how does light behave?)
 - perception (how does this all relate to humans?)
- System
 - parallel, heterogeneous processing
 - graphics-specific programming languages

Today's Topics

What is Computer Graphics?

Why Study Computer Graphics?

Course Overview

Logistics

Activity: modeling and drawing a cube

- Goal: generate a realistic drawing of a cube
- Key questions:
 - Modeling: how do we describe the cube?
 - Rendering: how do we then visualize this model?



Activity: modeling the cube

- Suppose our cube is...
 - centered at the origin $(0,0,0)$
 - has dimensions $2 \times 2 \times 2$
 - edges are aligned with x/y/z axes
- **QUESTION: What are the coordinates of the cube vertices?**

A: $(1, 1, 1)$

E: $(1, 1, -1)$

B: $(-1, 1, 1)$

F: $(-1, 1, -1)$

C: $(1, -1, 1)$

G: $(1, -1, -1)$

D: $(-1, -1, 1)$

H: $(-1, -1, -1)$

- **QUESTION: What about the edges?**

AB, CD, EF, GH,

AC, BD, EG, FH,

AE, CG, BF, DH

Activity: modeling the cube

- Now have a digital description of the cube:

VERTICES

A: (1, 1, 1) E: (1, 1, -1)

B: (-1, 1, 1) F: (-1, 1, -1)

C: (1, -1, 1) G: (1, -1, -1)

D: (-1, -1, 1) H: (-1, -1, -1)

EDGES

AB, CD, EF, GH,

AC, BD, EG, FH,

AE, CG, BF, DH

- How do we draw this 3D cube as a 2D (flat) image?

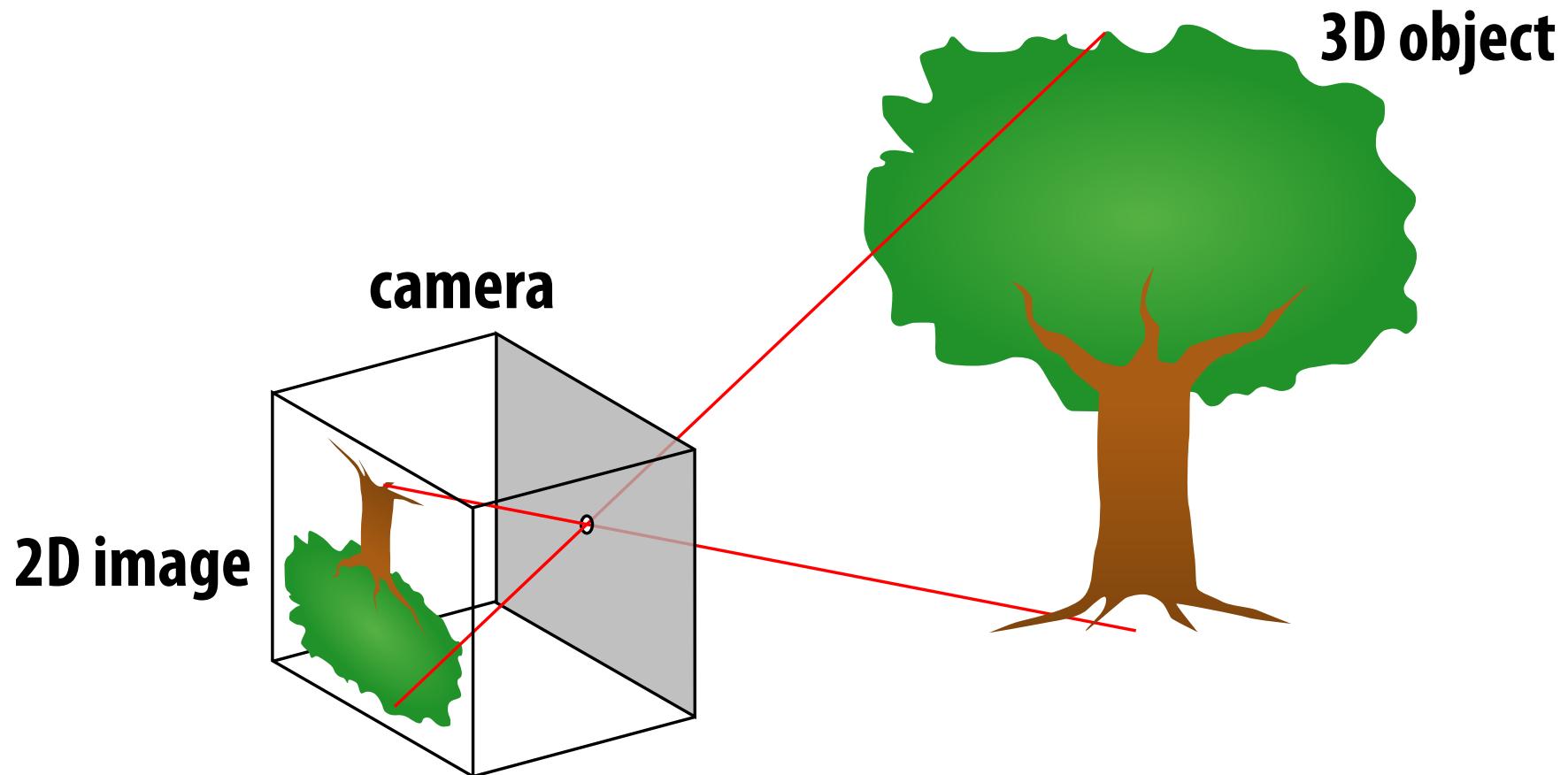
- Basic strategy:

1. map 3D vertices to 2D points in the image

2. connect 2D points with straight lines

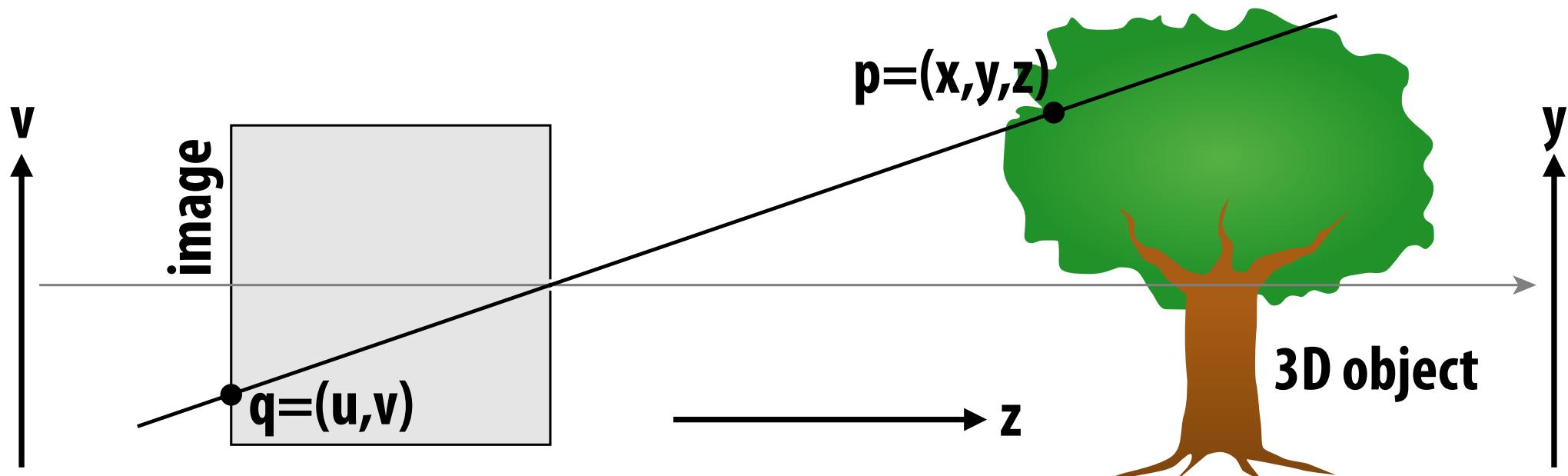
Perspective Projection

- Objects look smaller as they get further away ("perspective")
- Why does this happen?
- Consider simple ("pinhole") model of a camera:



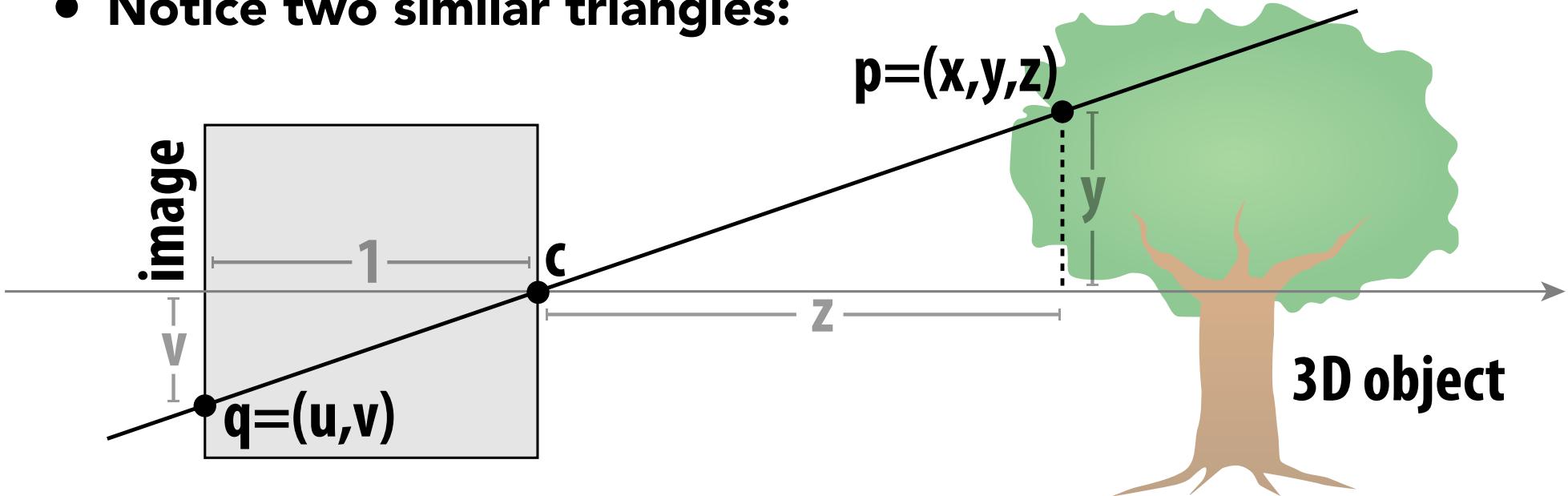
Perspective Projection: side view

- Where exactly does a point $p = (x, y, z)$ end up on the image?
- Let's call the image point $q = (u, v)$



Perspective Projection: side view

- Where exactly does a point $p = (x, y, z)$ end up on the image?
- Let's call the image point $q = (u, v)$
- Notice two similar triangles:



- Assume camera has unit size, origin is at pinhole c
- Then $v/1 = y/z$, i.e., vertical coordinate is just the slope y/z
- Likewise, horizontal coordinate is $u=x/z$

Activity: now draw it!

- Need 12 volunteers
 - each person will draw one cube edge
 - assume camera is at $c=(2,3,5)$
 - convert (X,Y,Z) of both endpoints to (u,v) :
 1. subtract camera c from vertex (X,Y,Z) to get (x,y,z)
 2. divide (x,y) by z to get (u,v) —write as a fraction
 - draw line between (u_1,v_1) and (u_2,v_2)

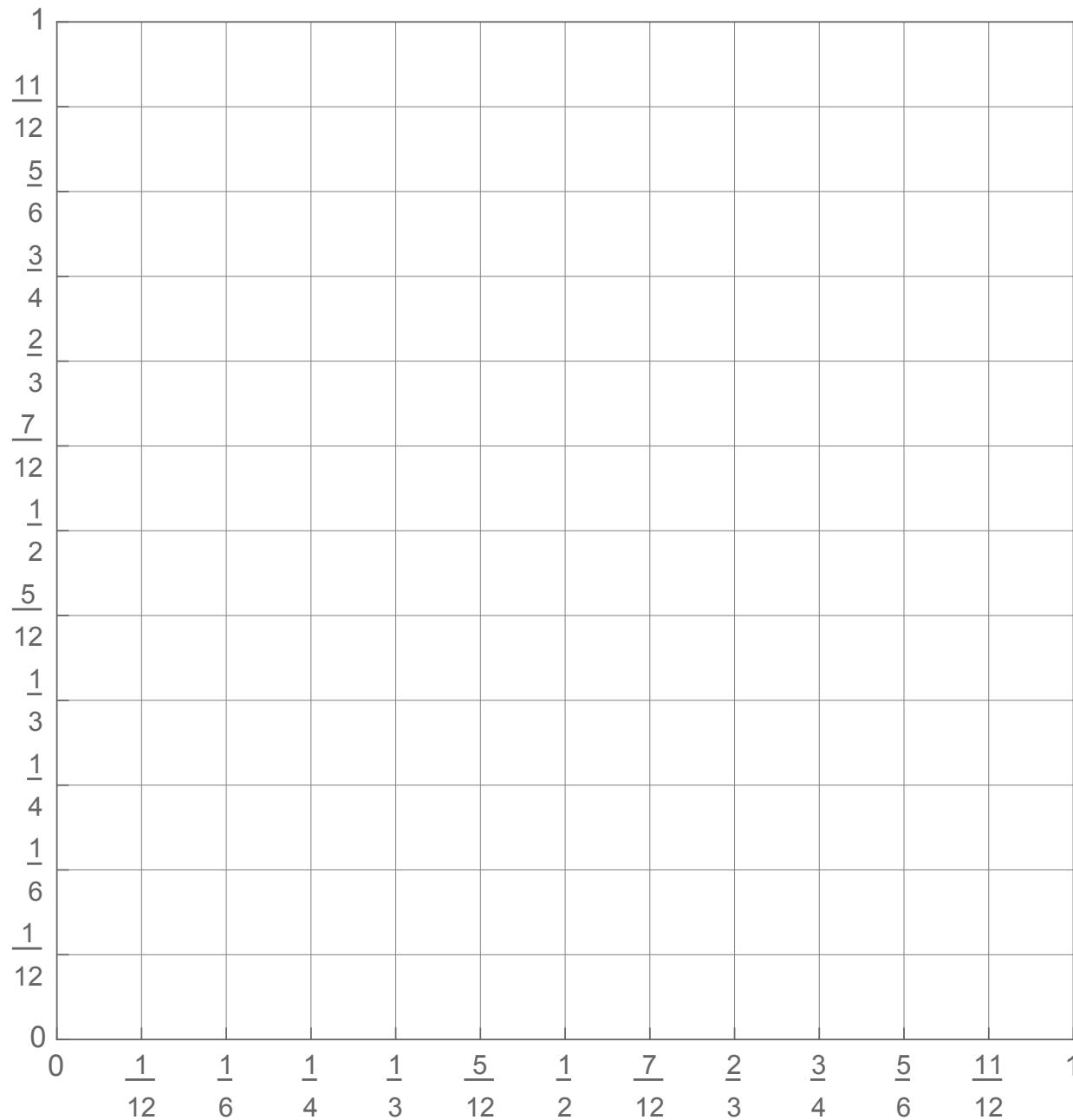
VERTICES

A: (1 , 1 , 1)	E: (1 , 1 , - 1)
B: (- 1 , 1 , 1)	F: (- 1 , 1 , - 1)
C: (1 , - 1 , 1)	G: (1 , - 1 , - 1)
D: (- 1 , - 1 , 1)	H: (- 1 , - 1 , - 1)

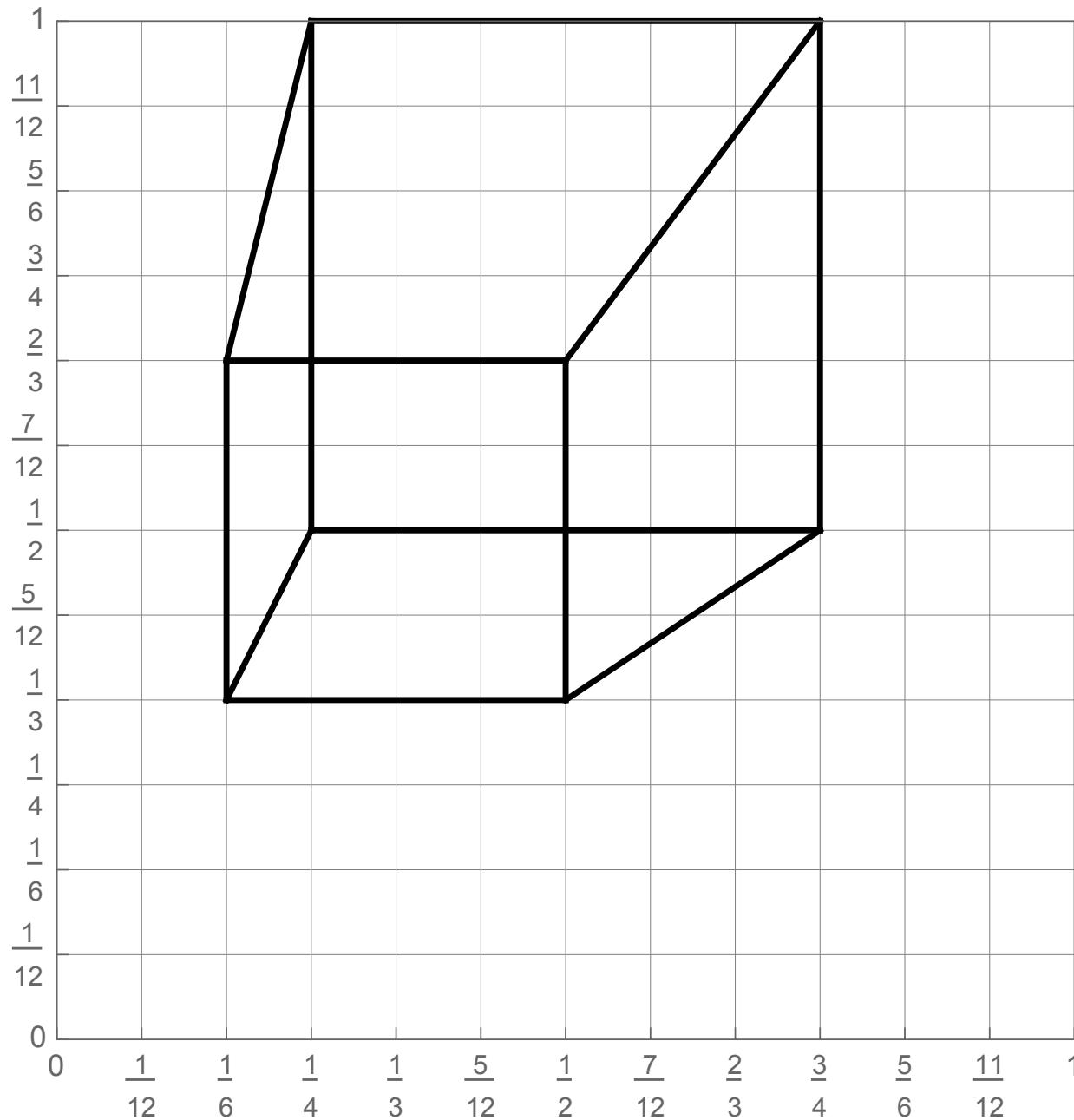
EDGES

AB , CD , EF , GH ,
AC , BD , EG , FH ,
AE , CG , BF , DH

Activity: output on a graph paper



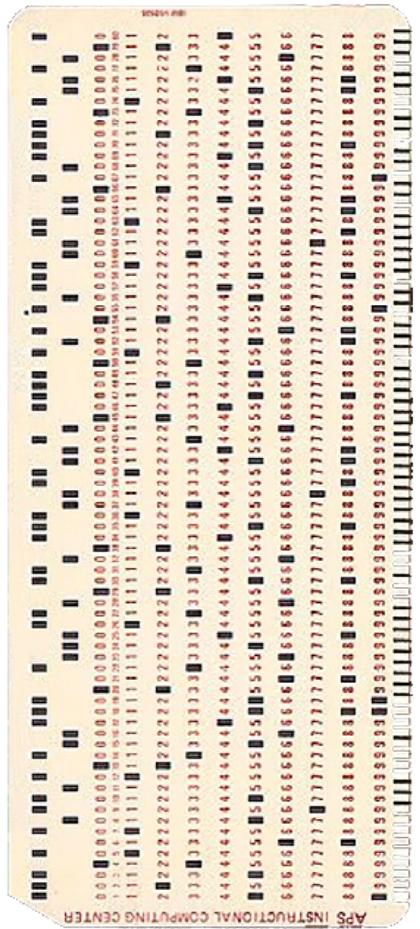
Activity: how did we do?



2D coordinates:

- A: $\frac{1}{4}, \frac{1}{2}$
- B: $\frac{3}{4}, \frac{1}{2}$
- C: $\frac{1}{4}, 1$
- D: $\frac{3}{4}, 1$
- E: $\frac{1}{6}, \frac{1}{3}$
- F: $\frac{1}{2}, \frac{1}{3}$
- G: $\frac{1}{6}, \frac{2}{3}$
- H: $\frac{1}{2}, \frac{2}{3}$

Success! We turned purely digital information into purely visual information, using a completely algorithmic procedure.



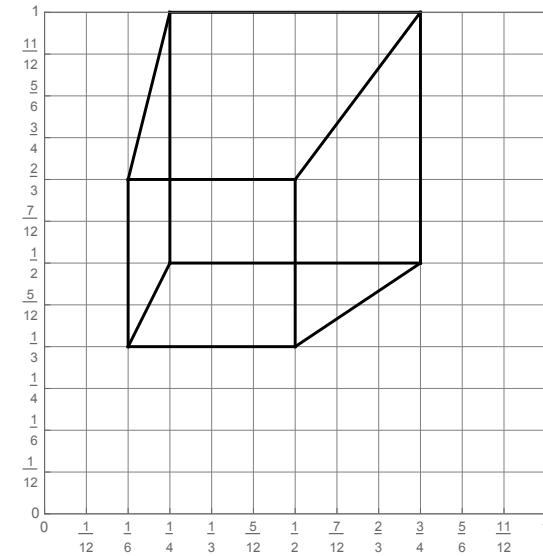
digital information

computation



visual information





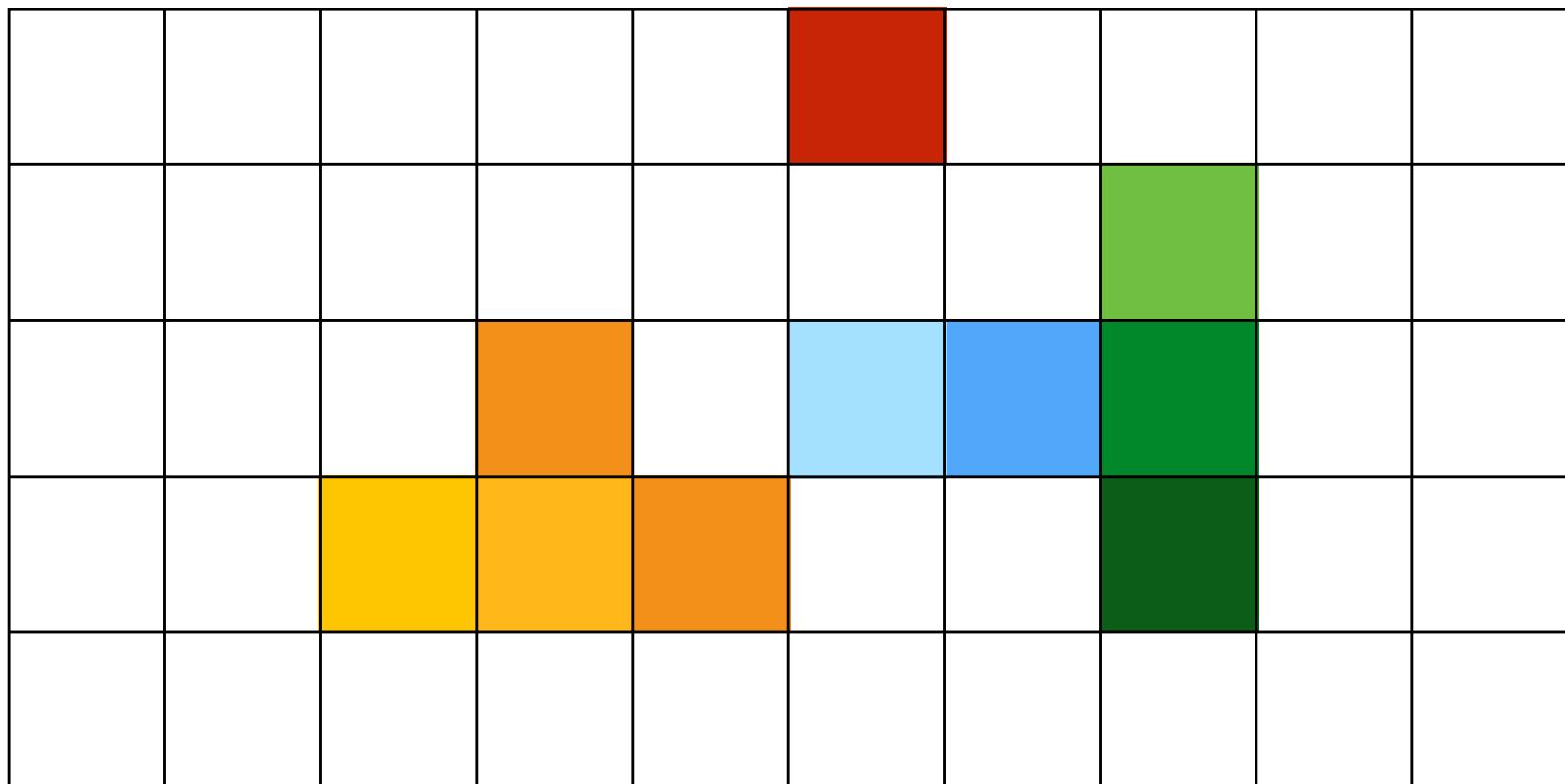
**Not finished yet!
how do we draw lines on a computer?**

Close up photo of pixels on a modern display



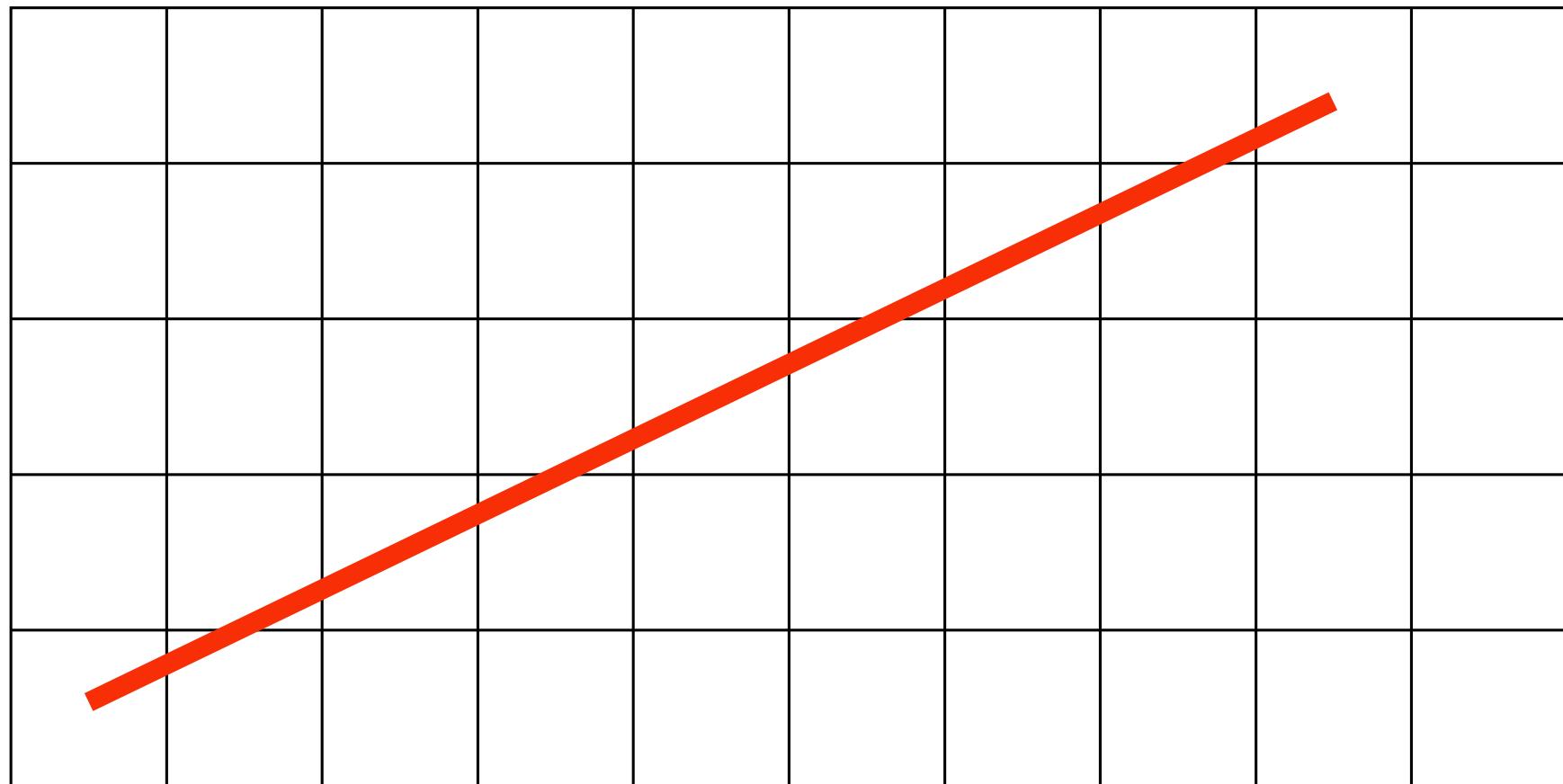
Output for a raster display

- Common abstraction of a raster display:
 - Image represented as a 2D grid of “pixels” (picture elements)
Each pixel can take on a unique color value



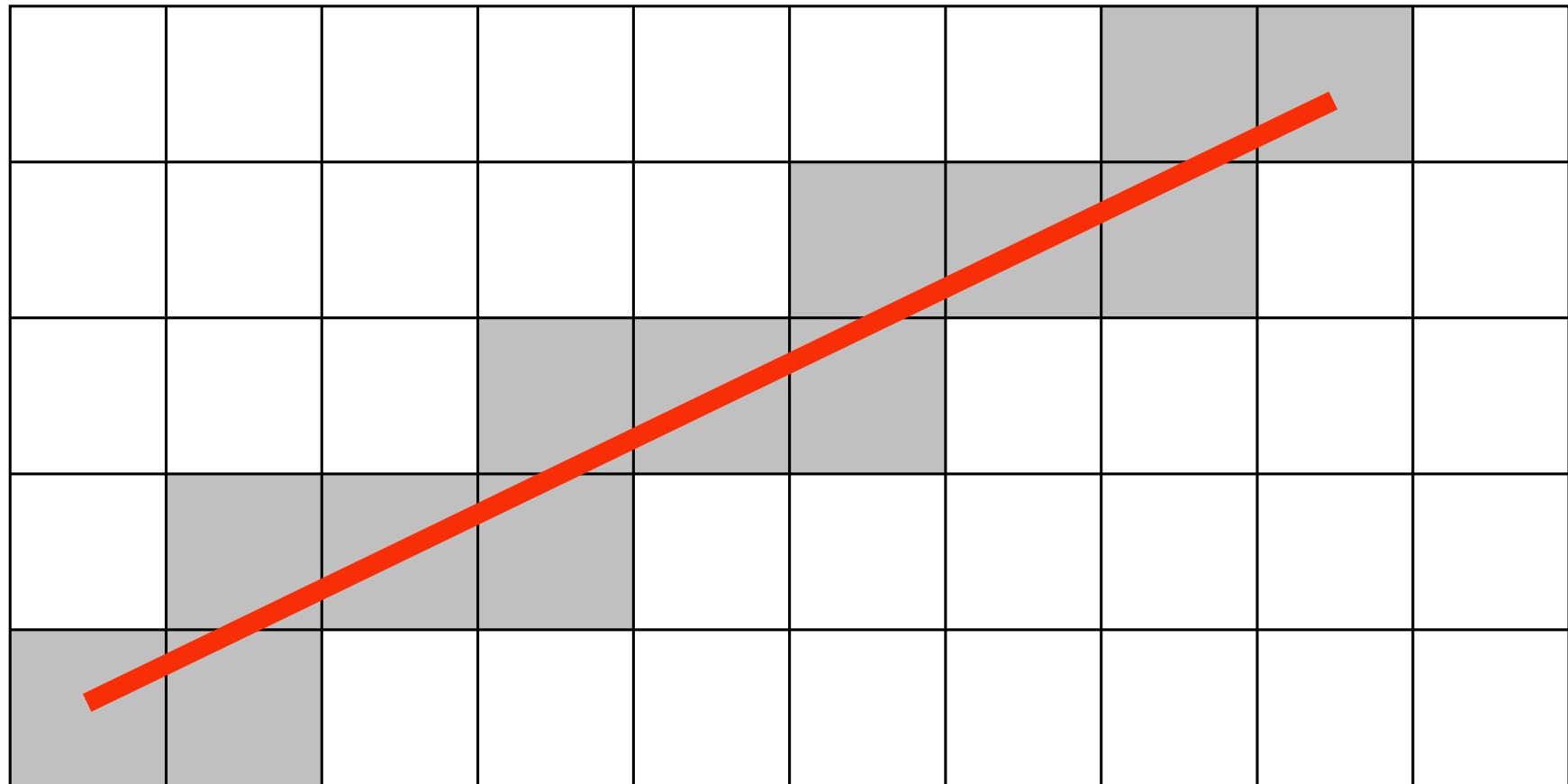
What pixels should we color in to depict a line?

"Rasterization": process of converting a continuous object to a discrete representation on a raster grid (pixel grid)

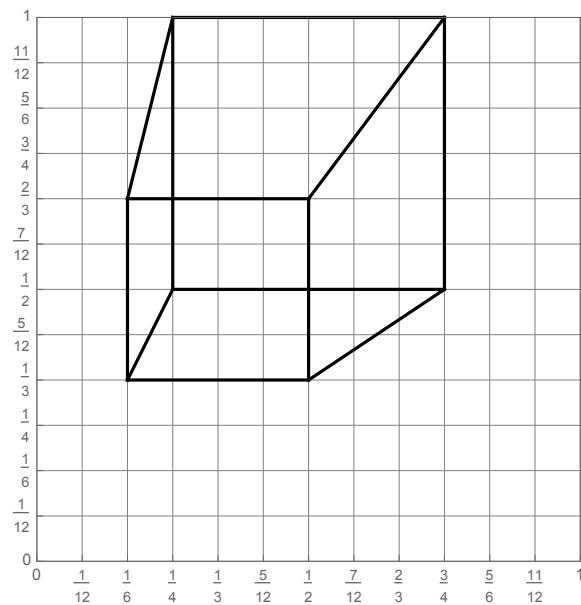


What pixels should we color in to depict a line?

Light up all pixels intersected by the line?

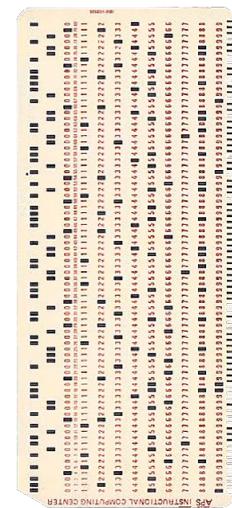


Activity: modeling and drawing a cube



2D coordinates:

- A: $1/4, 1/2$
- B: $3/4, 1/2$
- C: $1/4, 1$
- D: $3/4, 1$
- E: $1/6, 1/3$
- F: $1/2, 1/3$
- G: $1/6, 2/3$
- H: $1/2, 2/3$



digital information

computation



visual information



We just rendered a simple line drawing of a cube.

But for more realistic pictures, we need a much richer model of the world:

Geometry

Materials

Lights

Cameras

Motions

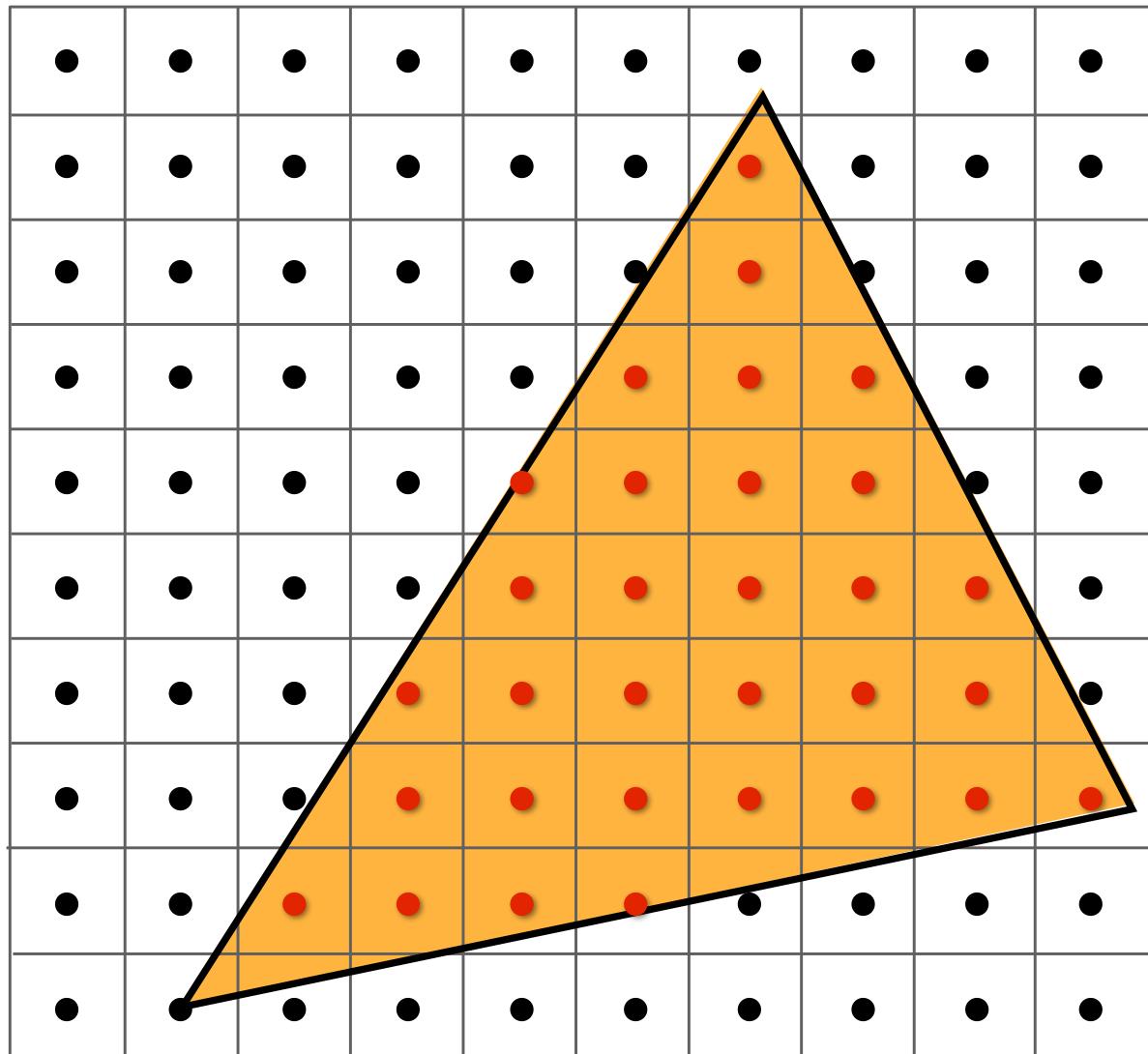
...

Will see all of this as our course progresses.

Course Topics

- 1. Drawing Digital Images (Rasterization)** (图形显示成图像)
- 2. Filtering and Sampling** (图形到图像转变的滤波和采样)
- 3. Modeling Geometry** (三维对象的图形建模)
- 4. Modeling Material Properties** (三维对象的材质属性)
- 5. Modeling Lighting** (光照建模)
- 6. How Do Cameras Work?** (相机模型和成像原理)
- 7. Animation and Physical Simulation** (动画和物理模拟)
- 8. Virtual Reality** (虚拟现实)

Drawing Digital Images (Rasterization)

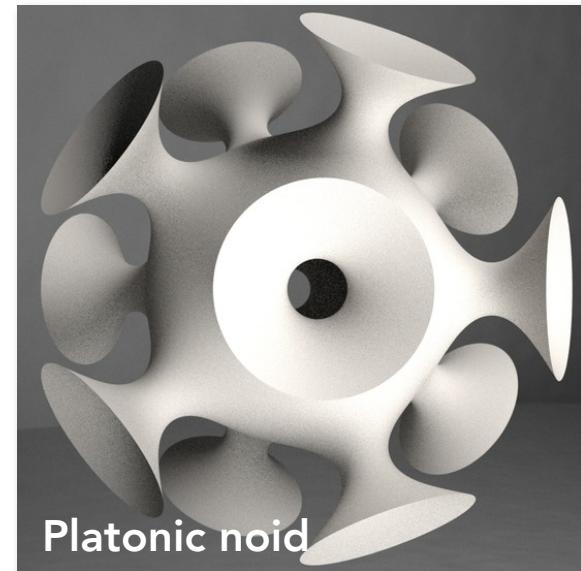
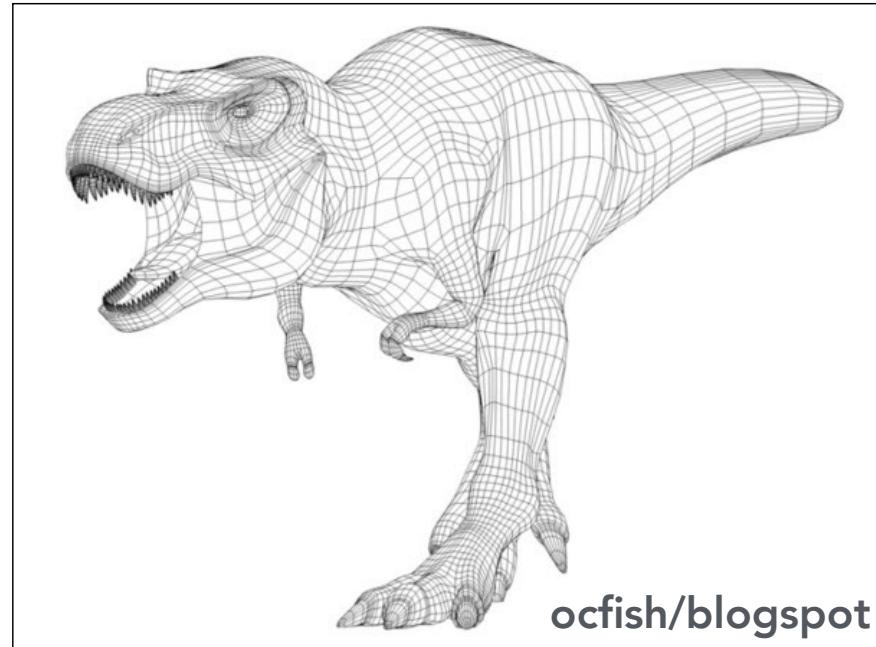


Filtering and Sampling

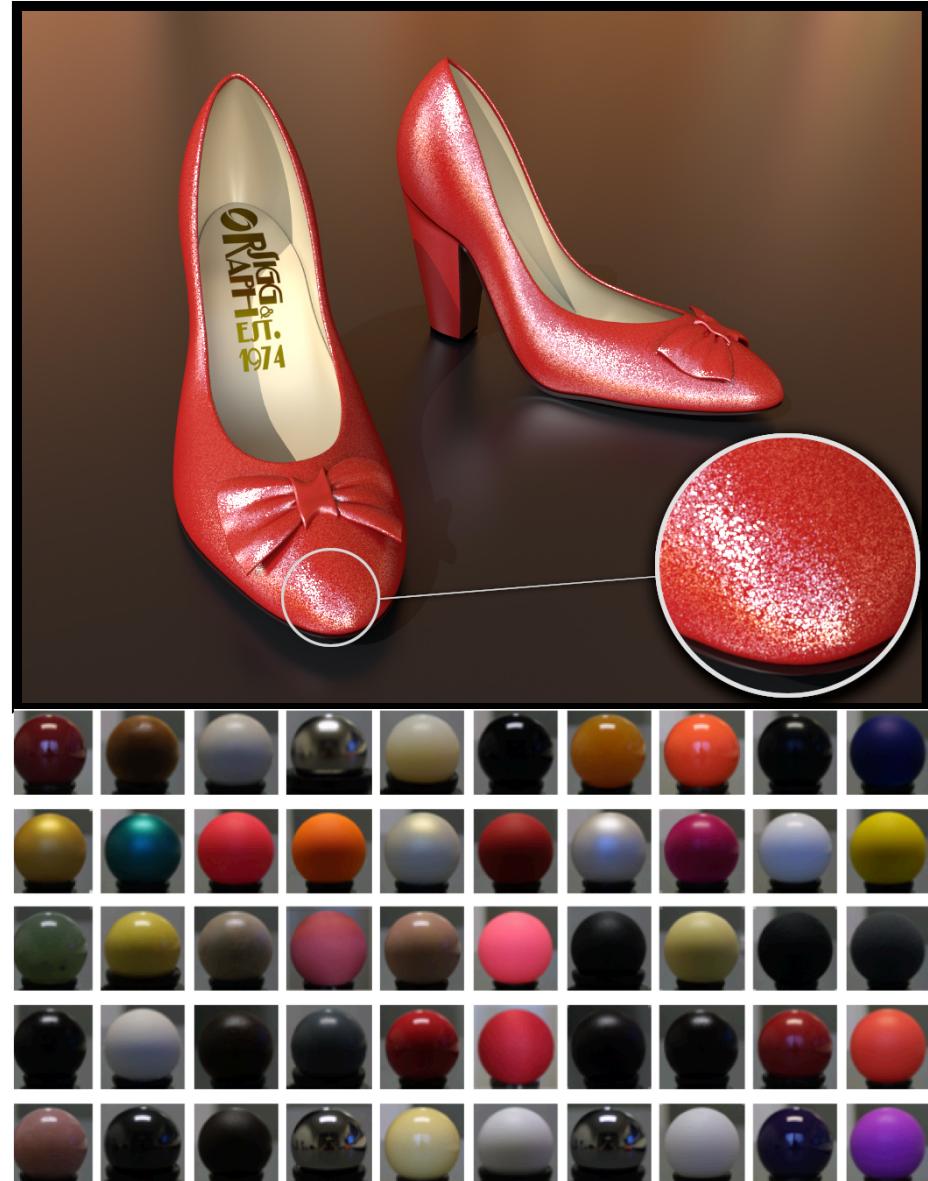


No Jaggies

Modeling Geometry



Modeling Material Properties

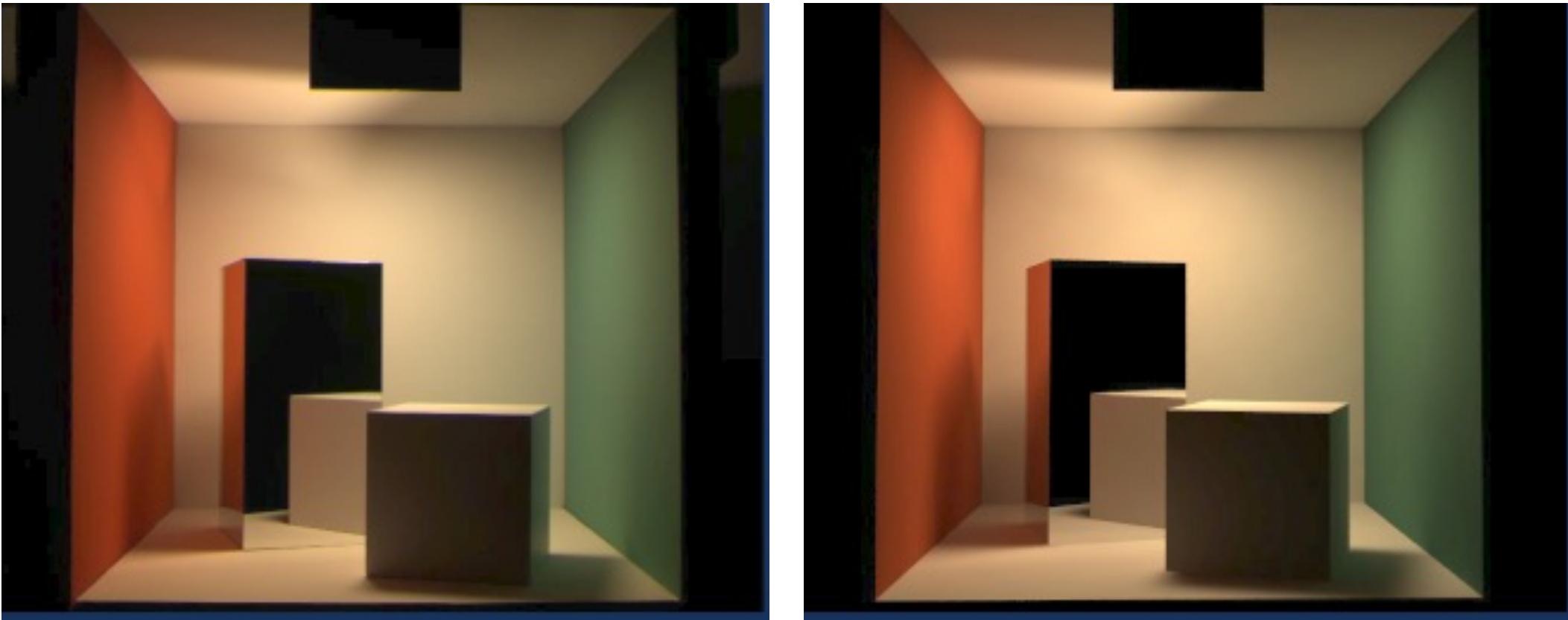


Modeling Lighting

WALL-E, (Pixar 2008)



Light Transport and Image Synthesis



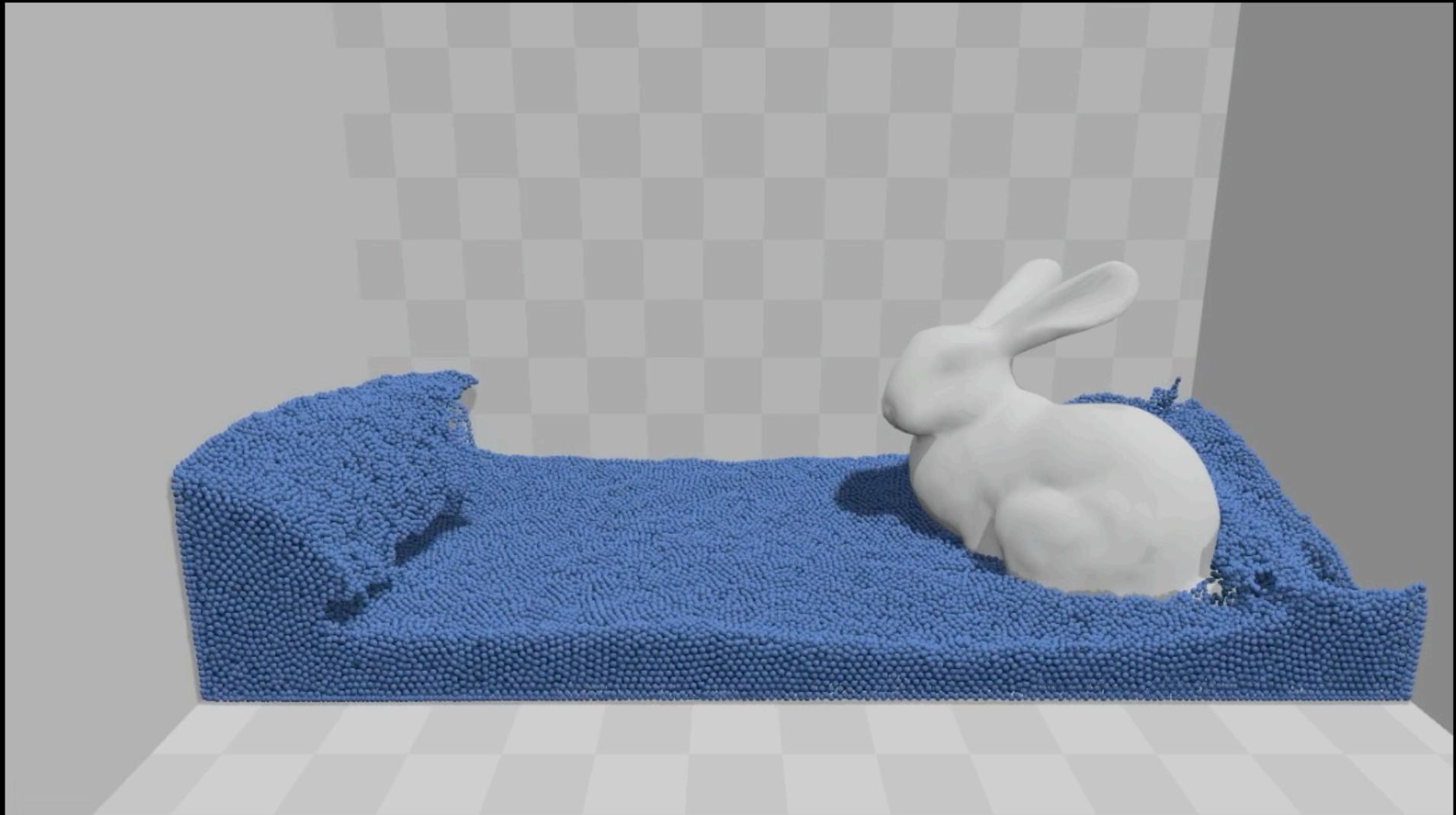
Photograph (CCD) vs. computer rendering

How Do Cameras Work?



Glenn Derene, Popular Mechanics

Animation and Physical Simulation



Position Based Fluids, Macklin and Müller

Virtual Reality



Course Goals

Overview of core ideas in graphics

- 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, ...)

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Prerequisites

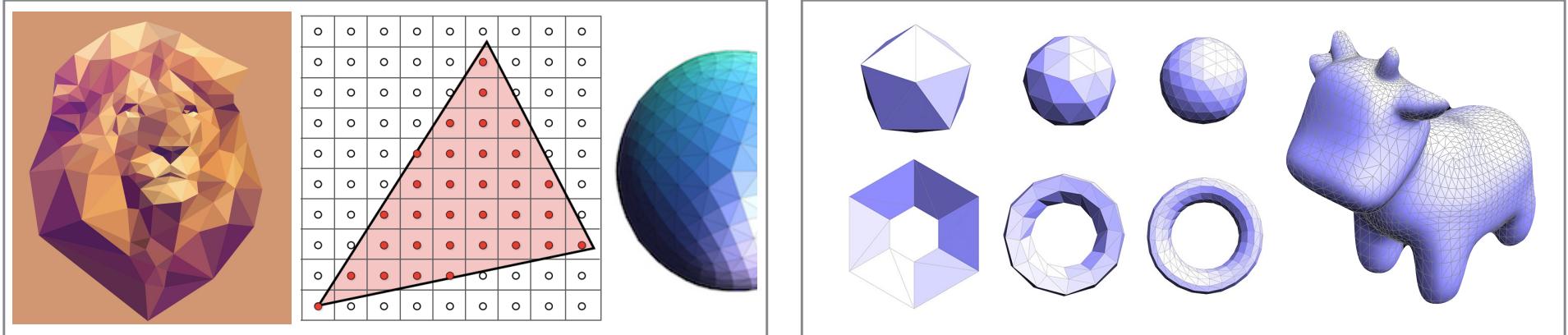
Math

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

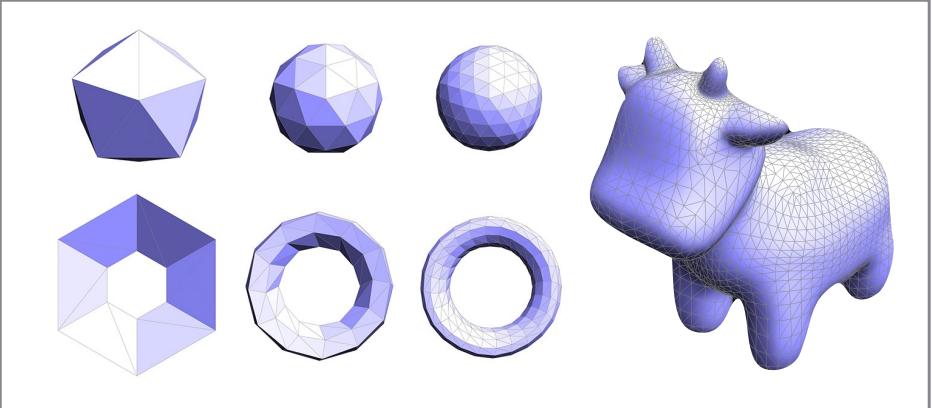
Programming

- **Data structures**
- **Fluent with C and C++**
- **Fluent with development environment, debugging, etc.**

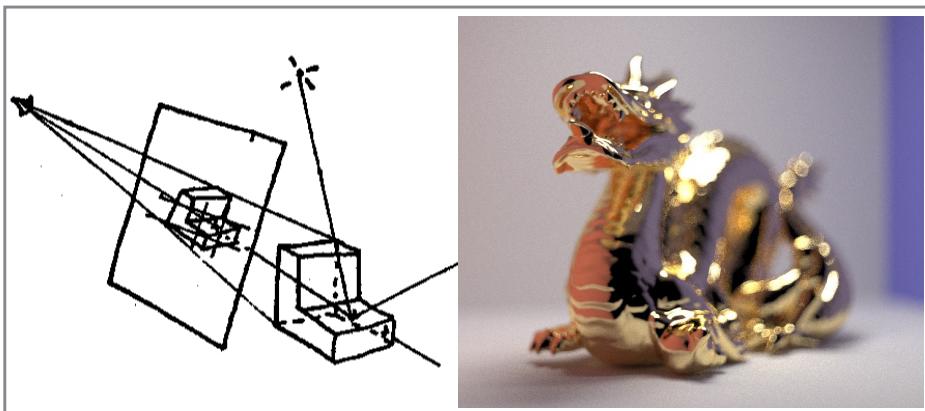
Course Assignments



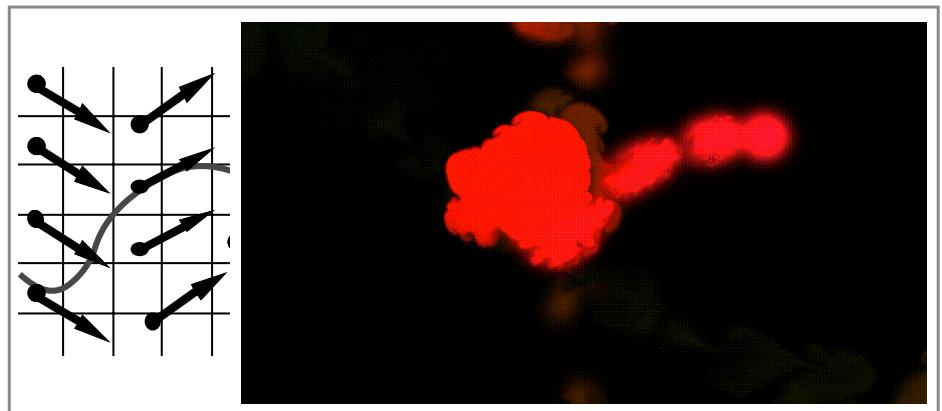
1. Digital Drawing (2 weeks)



2. Geometry (2 weeks)



3. Ray-Tracing (2 weeks)



4. Animation (2 weeks)

Course Deliverables and Assessment

Your course grade is out of 100 total points

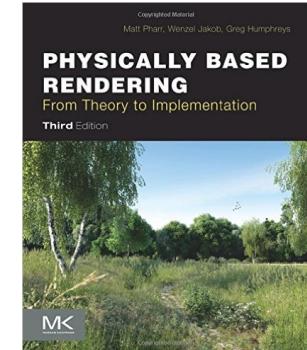
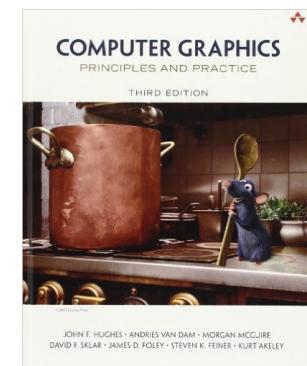
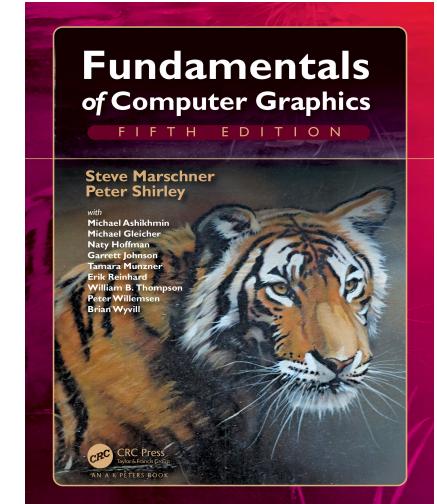
- Four homework assignments, 10 points each**
- Final exams, 50 points each**
- Participation, 10 points**

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



Acknowledgement

The screenshot shows the GAMES101: Modern Computer Graphics course page. It features a dark header with the text "计算机图形学与混合现实在线平台" and "GAMES: Graphics And Mixed Environment Symposium". Below the header is a navigation bar with links to "首页", "活动通知", "往期报告PPT&视频", "在线课程", "学术沙龙", "GAMES线下会议", and "更多资源". A "活动通知" section is visible. The main content area is titled "GAMES101:现代计算机图形学入门" and includes a photo of a cow with a small umbrella on its back, a butterfly, and a checkered floor. The text "现代计算机图形学入门" is overlaid on the image. Below this is a yellow banner with the text "Games101".

The screenshot shows the CMU Computer Graphics course page. The title "Computer Graphics" is at the top, followed by "(CMU 15-362/662)". Below the title are four 3D renderings: a cow with a cocktail, a white cow, a green horse, and a blue blob-like shape. A credit line "credits:@over_the_mooo" is shown. The "Basic Info" section includes the schedule "Tues/Thurs 12:30pm-1:50pm DH (Doherty Hall) 1212" and instructors "Oscar Dadfar & Minchen Li". A note says "See the [course info](#) page for more info on policies and logistics." The "Fall 2024 Schedule" lists the following events:

Date	Topic	Assignment
Aug 29	Introduction & The Graphics Pipeline	Assignment 0.0 OUT
Aug 31	Linear Algebra & Vector Calculus	Assignment 0.5 OUT
Sep 05	C++: A Programmer's Perspective	
Sep 07	Coordinate Spaces & Transformations	Assignment 0.0 DUE Assignment 1.0 OUT
Sep 12	Perspective Projection & Rasterization	

CMU 15-362/662

The screenshot shows the UC Berkeley CS184/284A course page. The title "CS184/284A: Home" is at the top. Below it is a navigation menu with links to "CS184/284A", "Policies", "Staff", "Readings", "Resources", and "Comments". A "login with" button is also present. The main content area features a complex 3D wireframe diagram of a geometric shape, likely a polyhedron or a complex surface. A blue banner at the bottom reads "Berkeley CS184/284A" and "Computer Graphics and Imaging".

UCB CS184



福大计算机图形学20...

群号：1059857176



扫一扫二维码，加入群聊