

Introduction to Computer Graphics

GAMES101, Lingqi Yan, UC Santa Barbara

Lecture 1: Overview of Computer Graphics



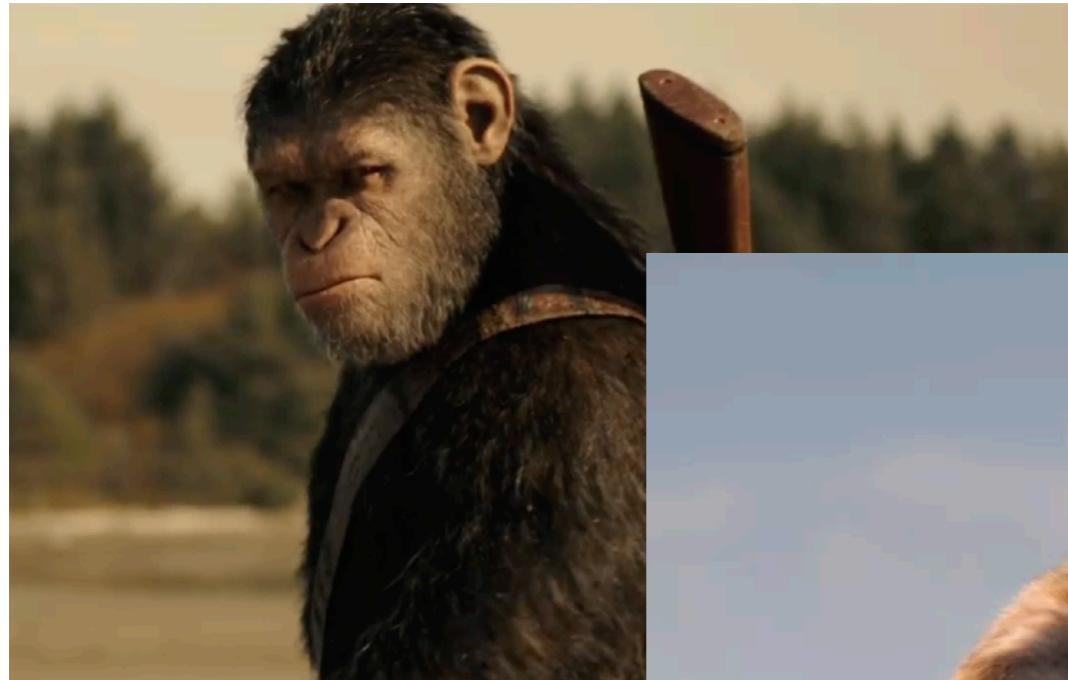
Welcome!

Instructor

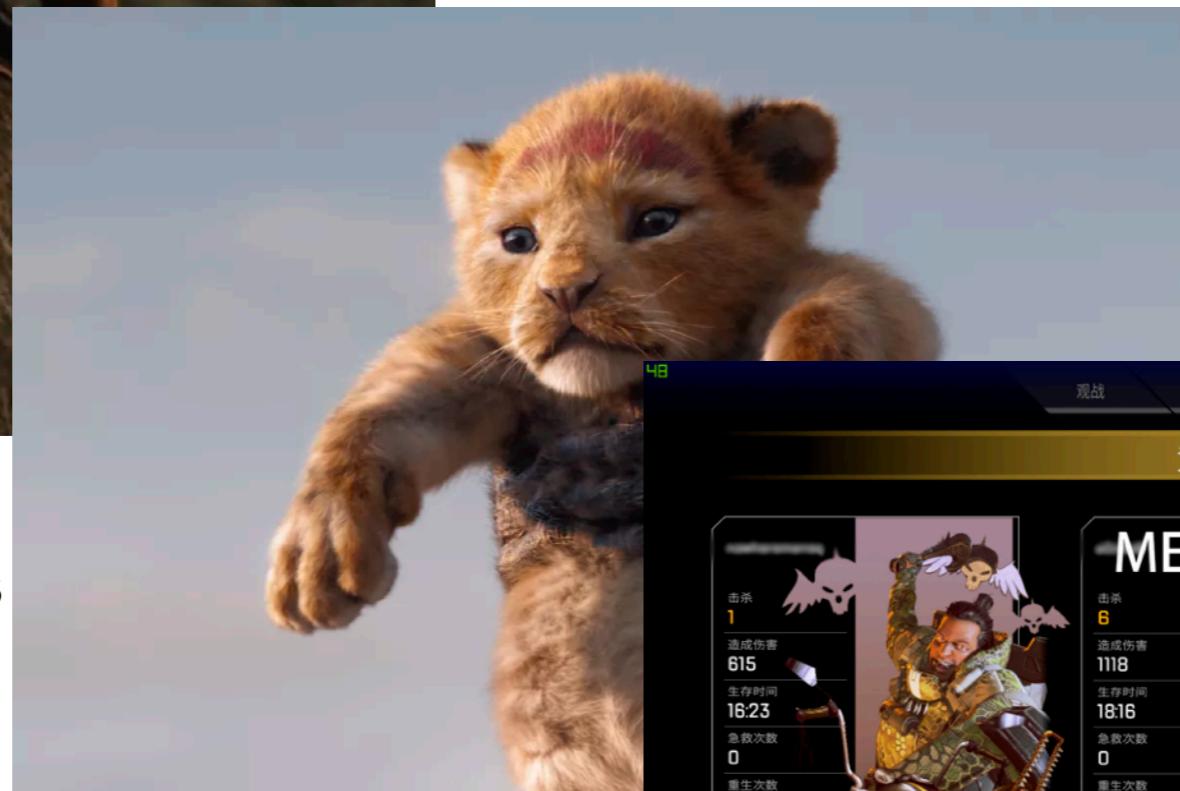
- Lingqi Yan (闫令琪)
 - 2018 - now: Assistant Professor @ UCSB
 - 2013 - 2018: Ph.D @ UC Berkeley
 - 2009 - 2013: B.E. @ Tsinghua University
 - Website: www.cs.ucsb.edu/~lingqi/
 - Research: Rendering in Computer Graphics
 - Hobbies: research, video games, piano, traveling, NBA, etc.



Instructor's Achievements



2018: Oscar Nominee
for Best Visual Effects



2019: research 2017
widely adopted in
Lion King HD



**2019: six APEX Champions in one evening
(collaborated with Adobe)**

Course Staff

- Teaching Assistants
 - 刘光哲 (清华, lgz17@mails.tsinghua.edu.cn)
 - 史雨宸 (中科大, syc0412@mail.ustc.edu.cn)
 - 邓俊辰 (哈工大, 1050106988@qq.com)
- More will be recruited soon after this lecture
(based on need)

Today's Topics

- What is Computer Graphics?
- Why study Computer Graphics?
- Course Topics
- Course Logistics
- Linear Algebra Review

What is Computer Graphics?

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

The use of computers to synthesize and manipulate visual information.

Today's Topics

- What is Computer Graphics?
- Why study Computer Graphics?
 - Applications
 - Fundamental Intellectual Challenges
 - Technical Challenges
- Course Topics
- Course Logistics

Video Games



Sekiro: Shadows Die twice (2019 Game of the Year)

Video Games



Borderlands 3 (2019)

Movies



The Matrix (1999)

Movies



Avatar (2009)

Animations



Zootopia (2016)

Animations



Frozen 2 (2019)

Design



CG



Photo

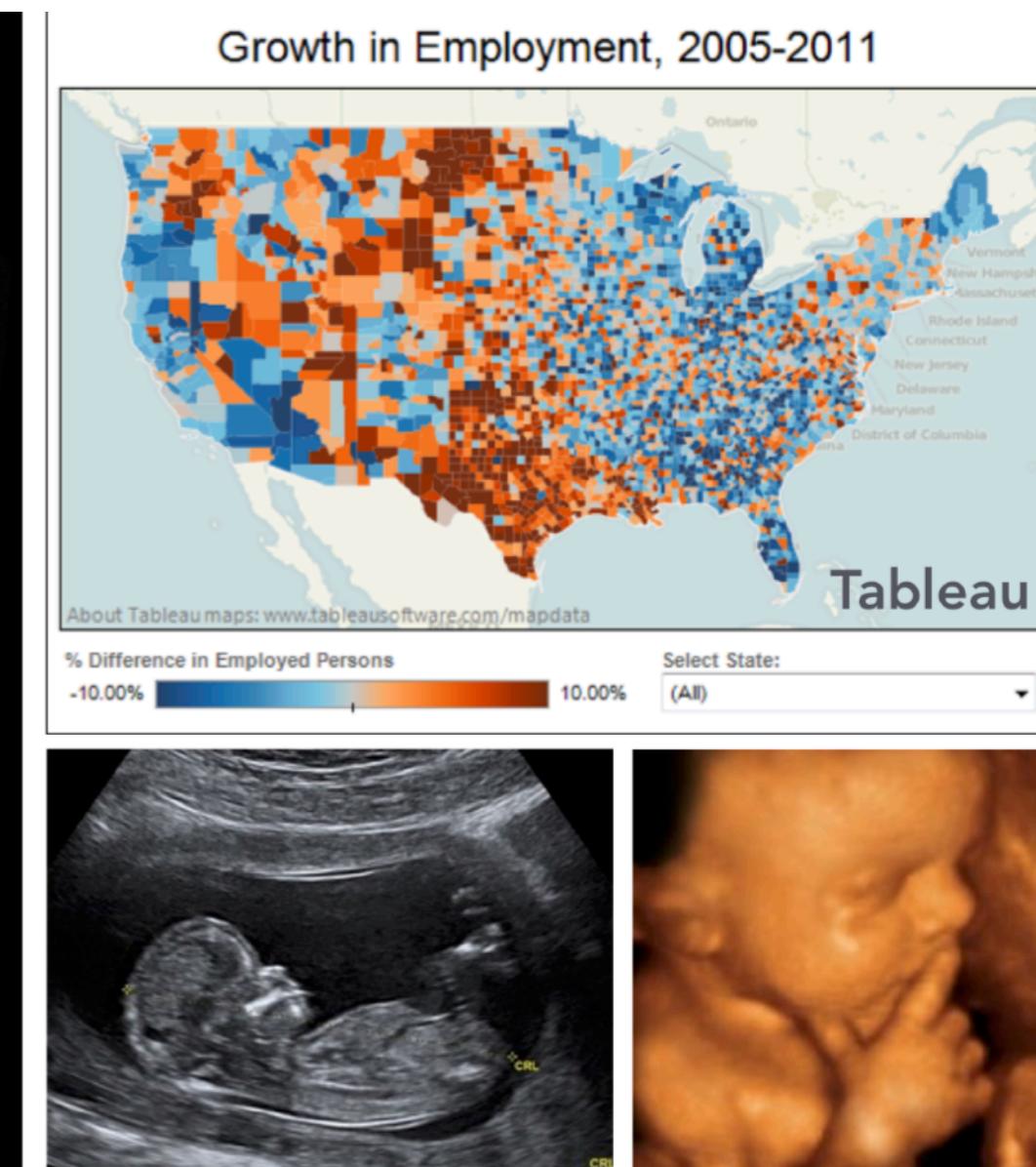
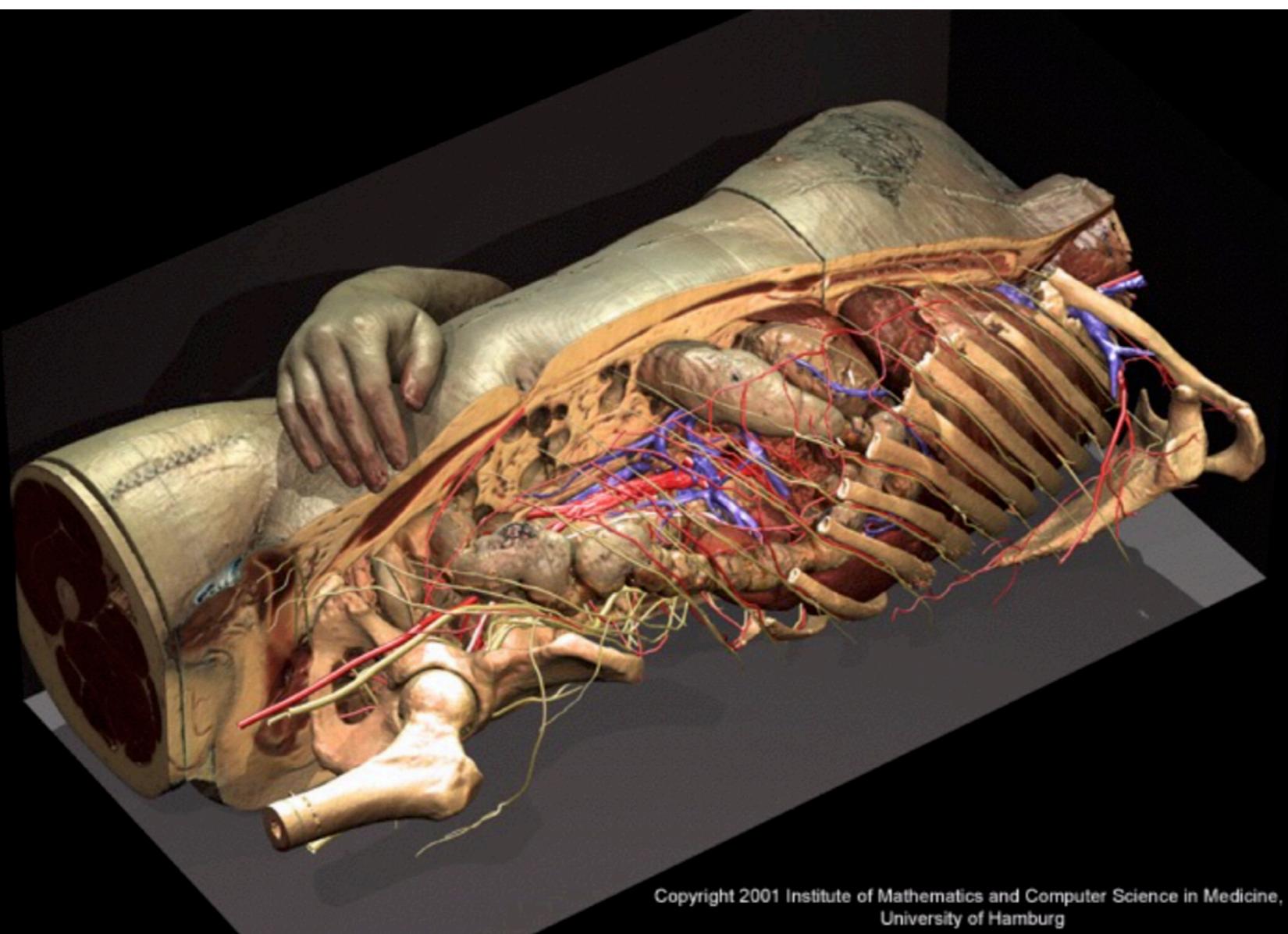
Autodesk Gallary

Design



Ikea - 75% of catalog is **rendered** imagery

Visualization



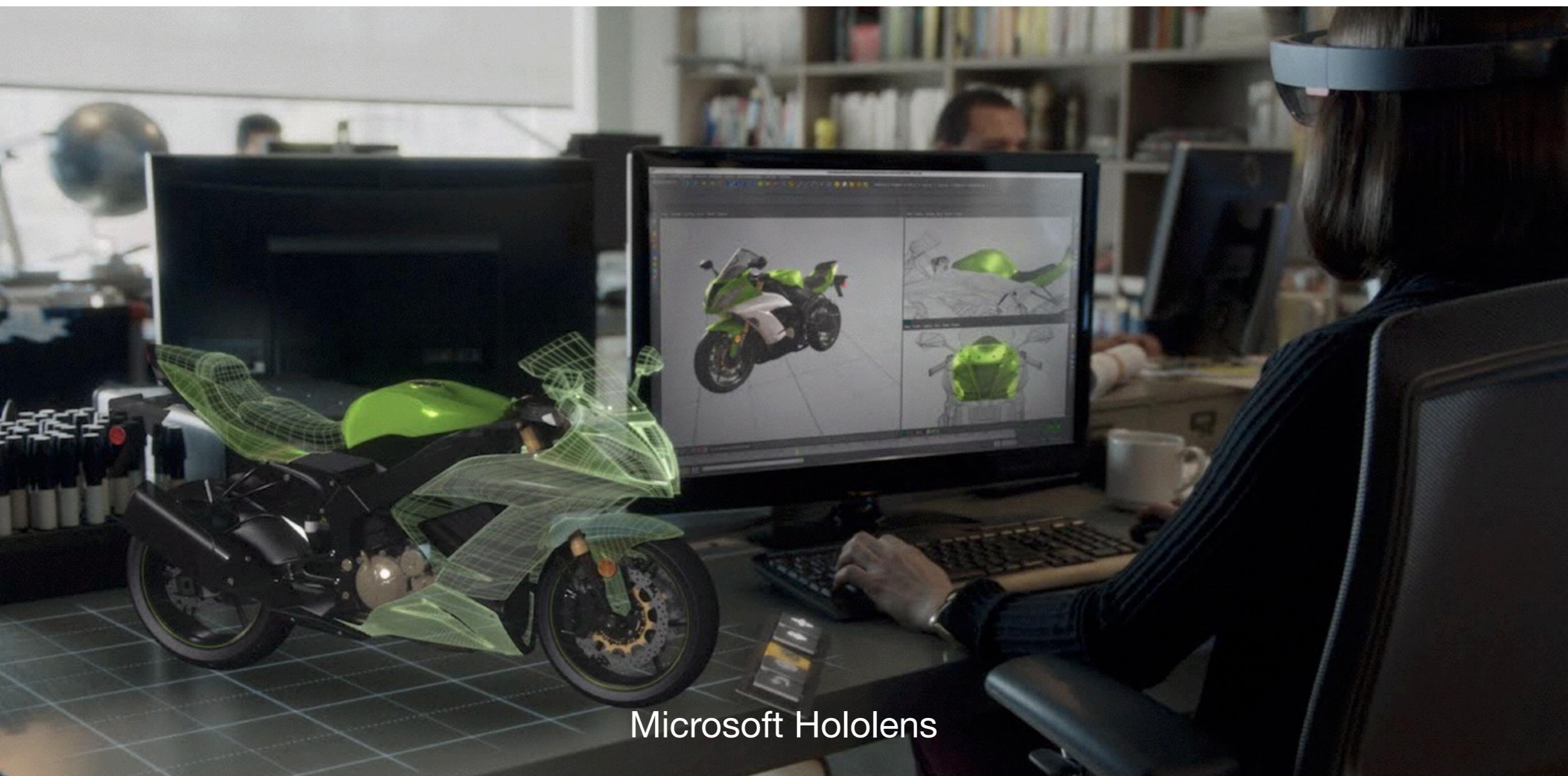
Science, engineering, medicine, journalism, etc.

Virtual Reality



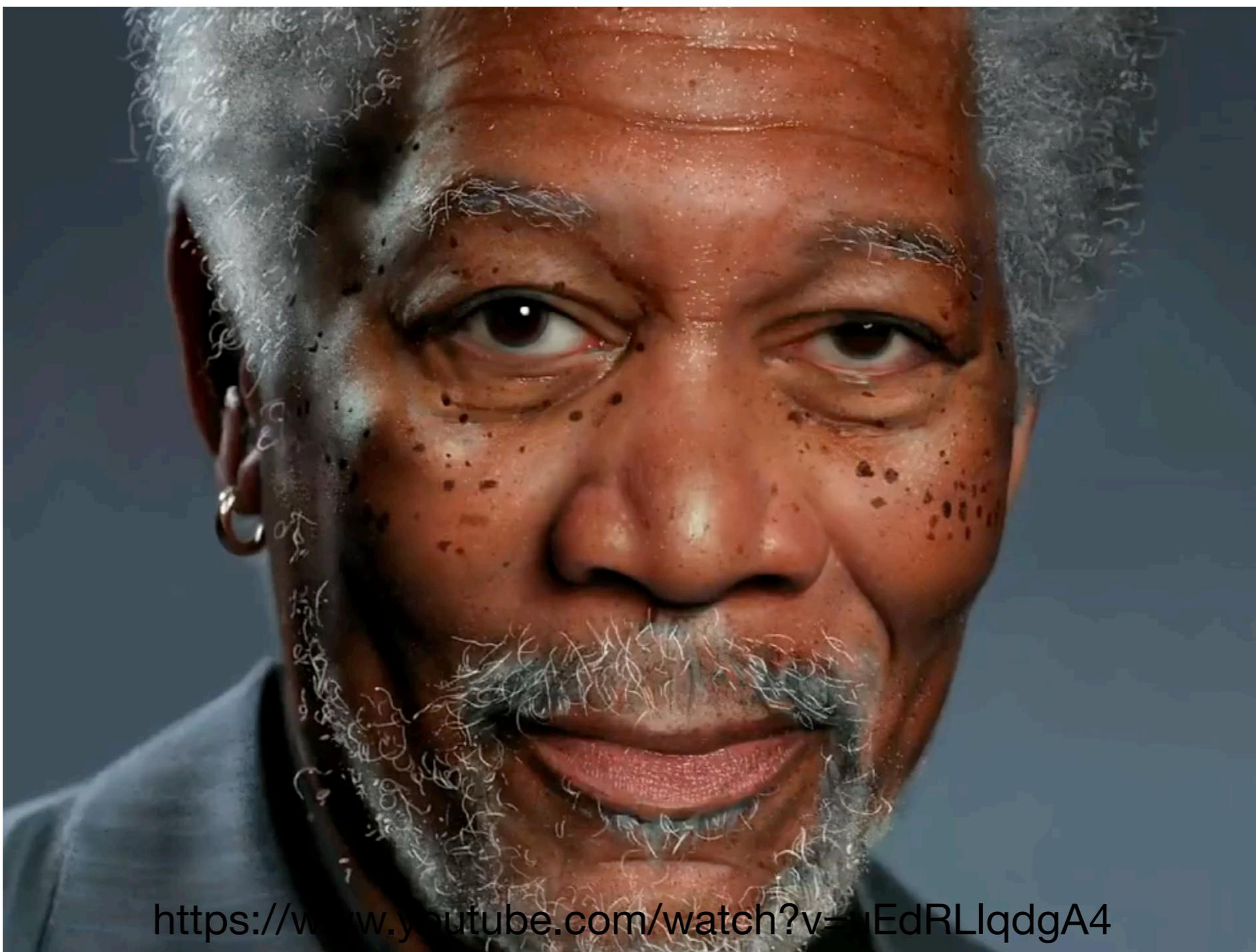
Oculus VR

Augmented Reality



Microsoft Hololens

Digital Illustration



<https://www.youtube.com/watch?v=jEdRLIqdgA4>

Simulation



The Dust Bowl phenomena



Black hole from Interstellar

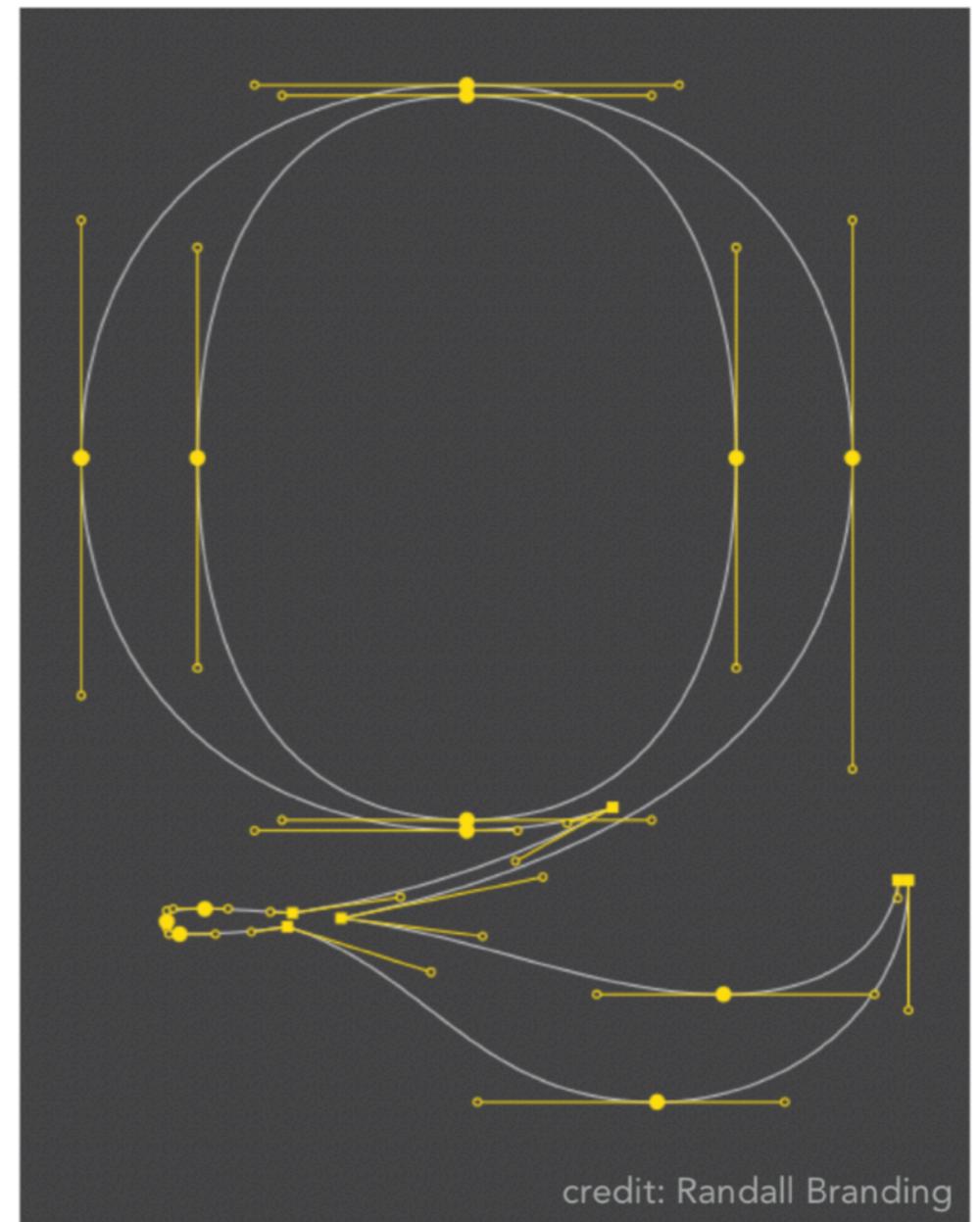
Graphical User Interfaces



Typography

The Quick Brown
Fox Jumps Over
The Lazy Dog

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz 01234567890



credit: Randall Branding

The font Baskerville

Why Study Computer Graphics?

- **Fundamental Intellectual Challenges**
 - Creates and interacts with realistic virtual world
 - Requires understanding of all aspects of physical world
 - New computing methods, displays, technologies

Why Study Computer Graphics?

- Technical Challenges
 - Math of (perspective) projections, curves, surfaces
 - Physics of lighting and shading
 - Representing / operating shapes in 3D
 - Animation / simulation
 - ~~3D graphics software programming and hardware~~

Why Study Computer Graphics?

- Forget about the previous reasons

**Computer Graphics
is
AWESOME!**

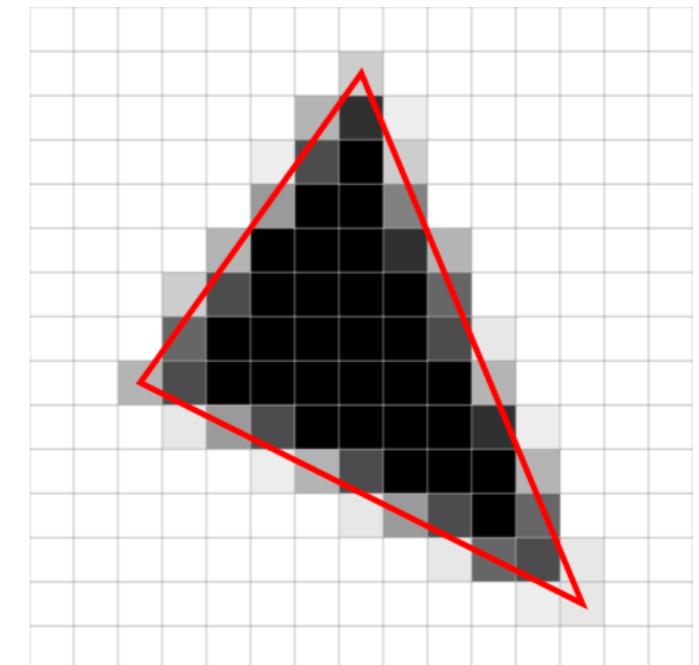
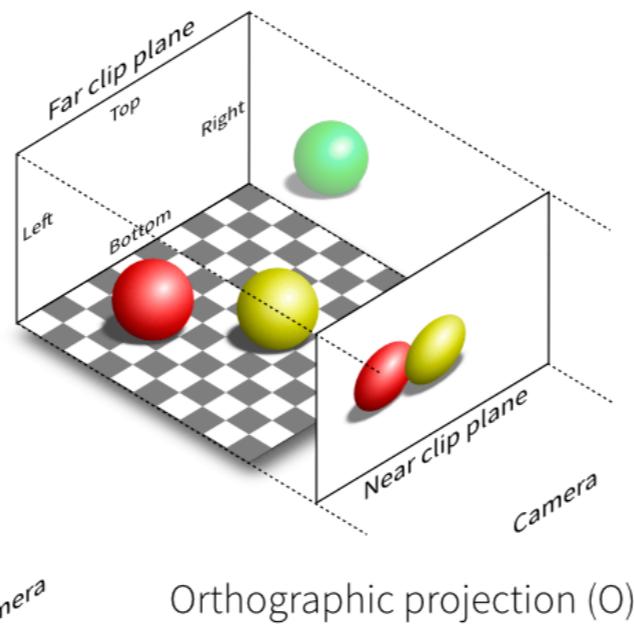
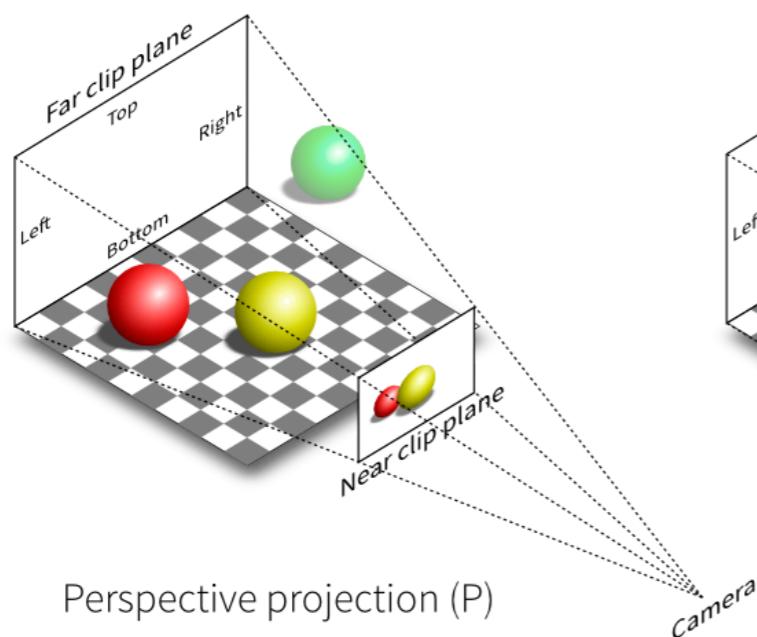
Questions?

Today's Topics

- What is Computer Graphics?
- Why study Computer Graphics?
- Course Topics (mainly 4 parts)
 - Rasterization
 - Curves and Meshes
 - Ray Tracing
 - Animation / Simulation
- Course Logistics

Rasterization

- Project **geometry primitives** (3D triangles / polygons) onto the screen
- Break projected primitives into **fragments** (pixels)
- Gold standard in Video Games (Real-time Applications)

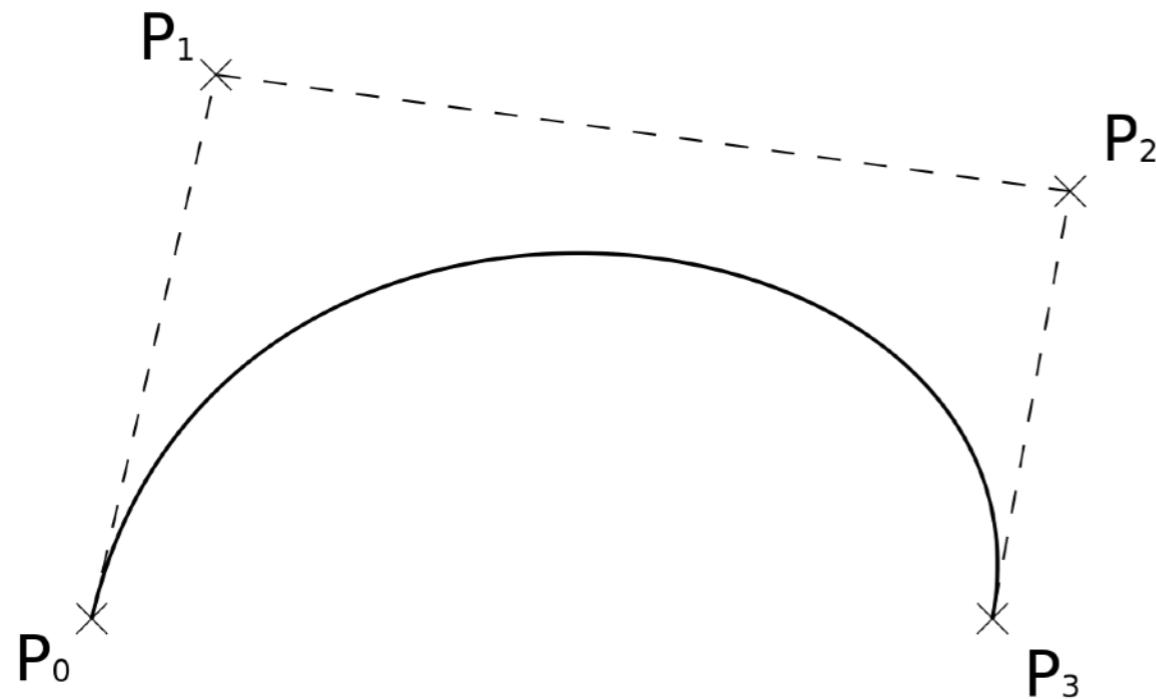


<http://vispy.org/modern-gl.html>

[https://commons.wikimedia.org/wiki/
File:Rasterisation-triangle_example.svg](https://commons.wikimedia.org/wiki/File:Rasterisation-triangle_example.svg)

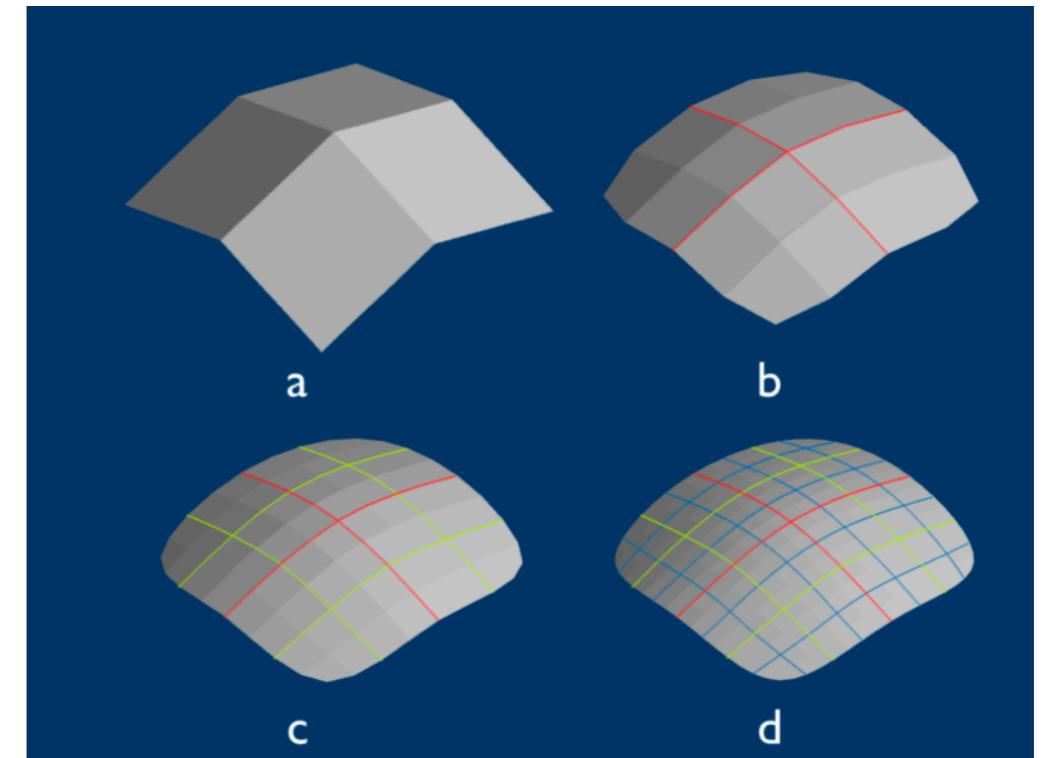
Curves and Meshes

- How to represent geometry in Computer Graphics



Bezier Curve

https://en.wikipedia.org/wiki/B%C3%A9zier_curve

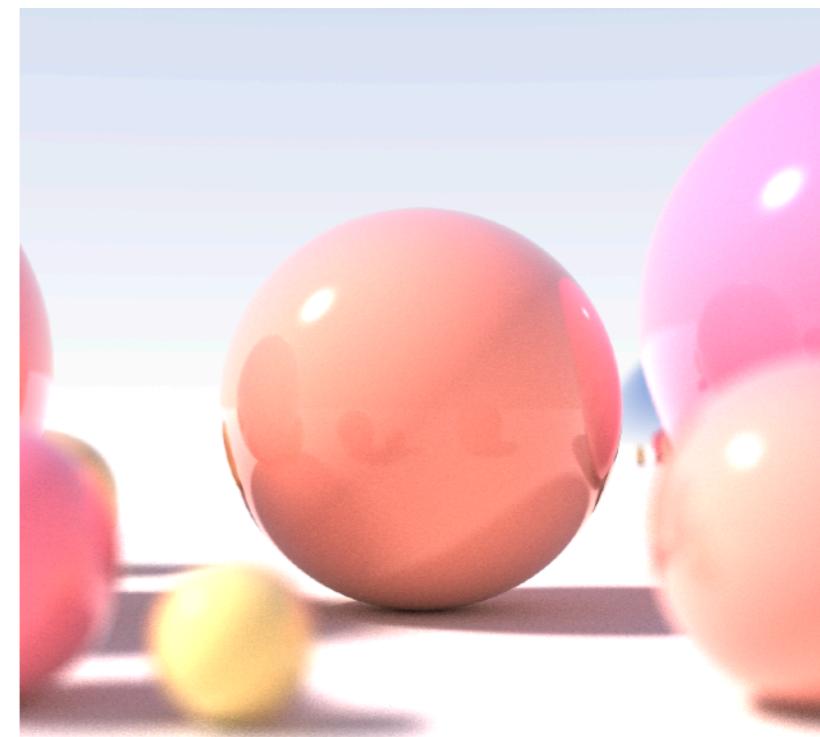
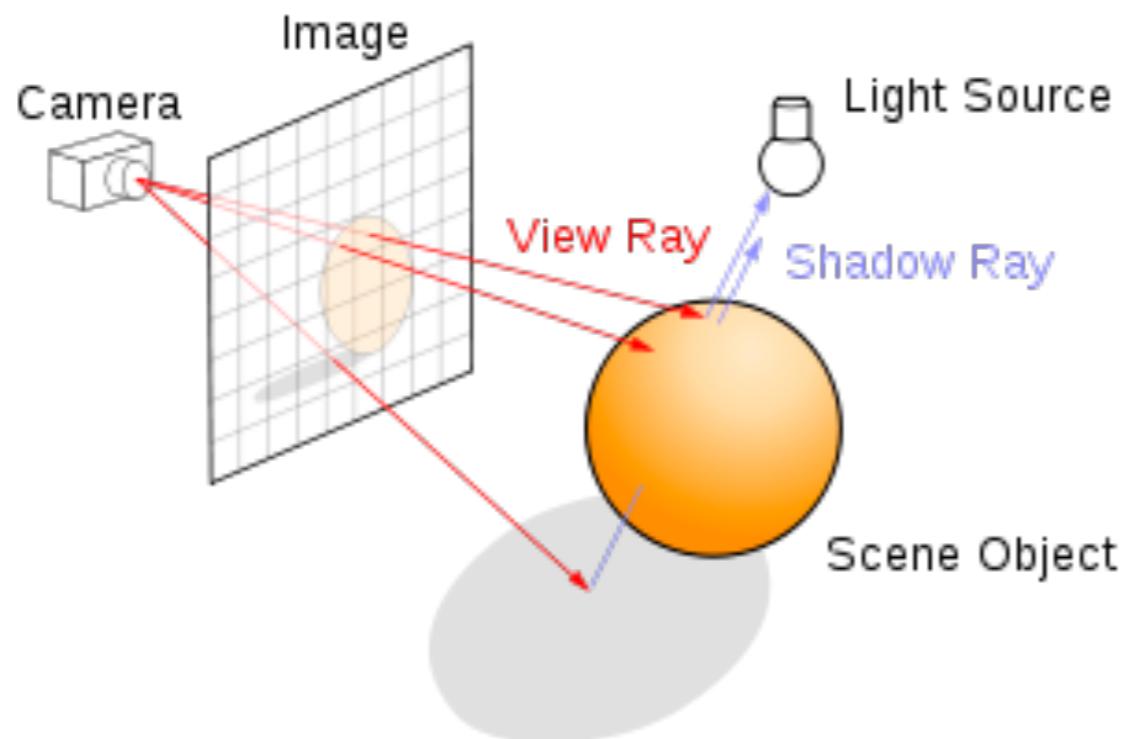


Catmull-Clark subdivision

https://commons.wikimedia.org/wiki/File:Catmull-Clark_subdivision_of_4_planes.png

Ray Tracing

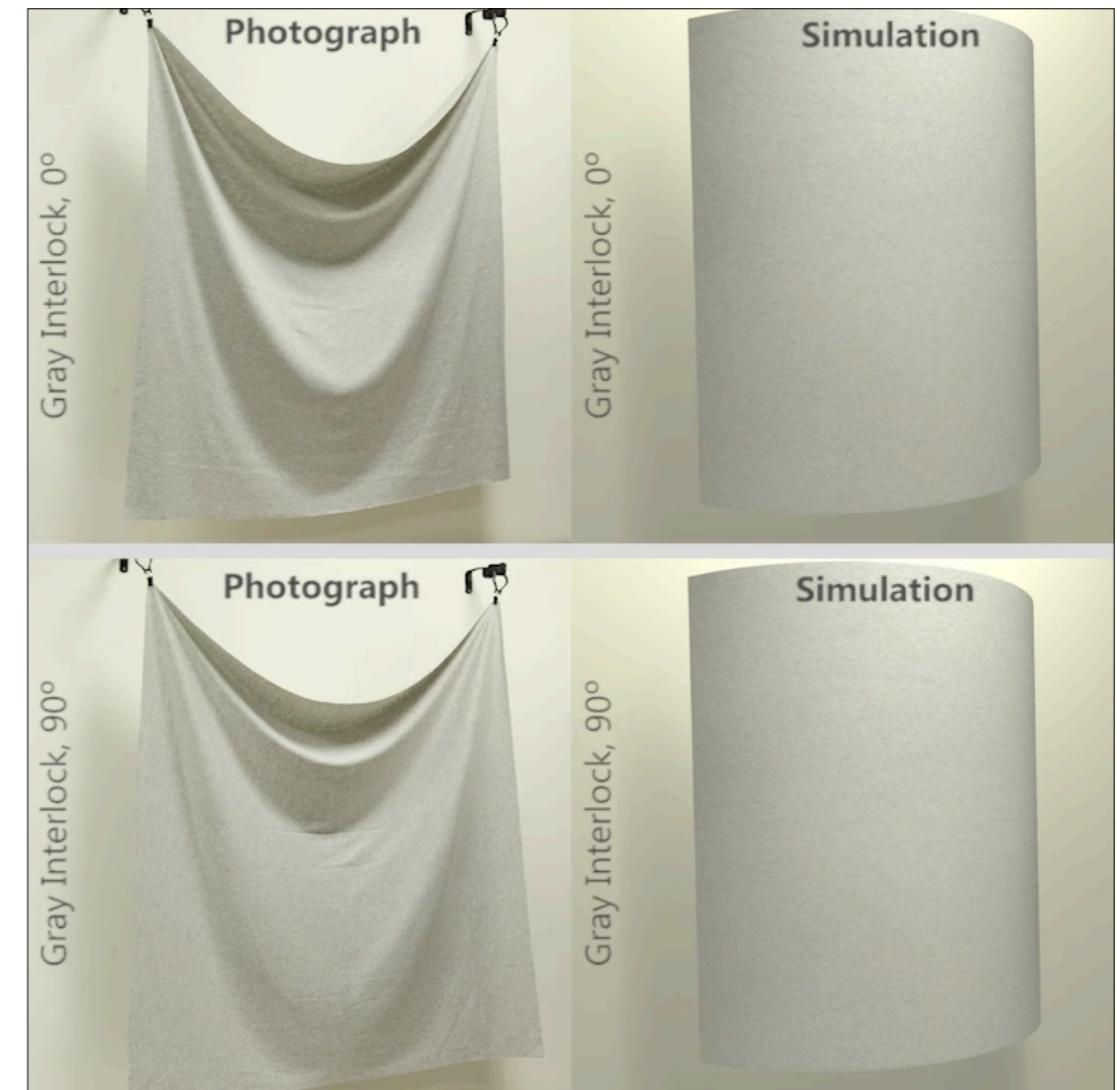
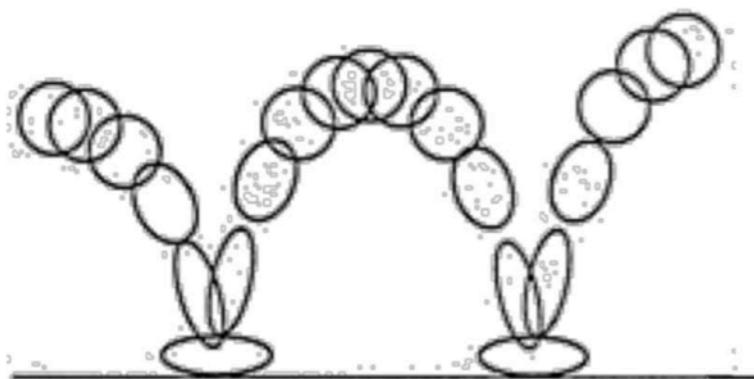
- Shoot rays from the camera through each pixel
 - Calculate **intersection** and **shading**
 - Continue to bounce the rays till they hit light sources
- Gold standard in Animations / Movies (Offline Applications)



[https://en.wikipedia.org/wiki/Ray_tracing_\(graphics\)](https://en.wikipedia.org/wiki/Ray_tracing_(graphics))

Animation / Simulation

- Key frame Animation
- Mass-spring System



https://cs184.eecs.berkeley.edu/sp18/lecture/simulation/slide_010

GAMES101 is NOT about

- Using OpenGL / DirectX / Vulkan
- The syntax of Shaders
- We learn Graphics,
not Graphics APIs!
- After this course,
you'll be able to learn these
by yourself (I promise)

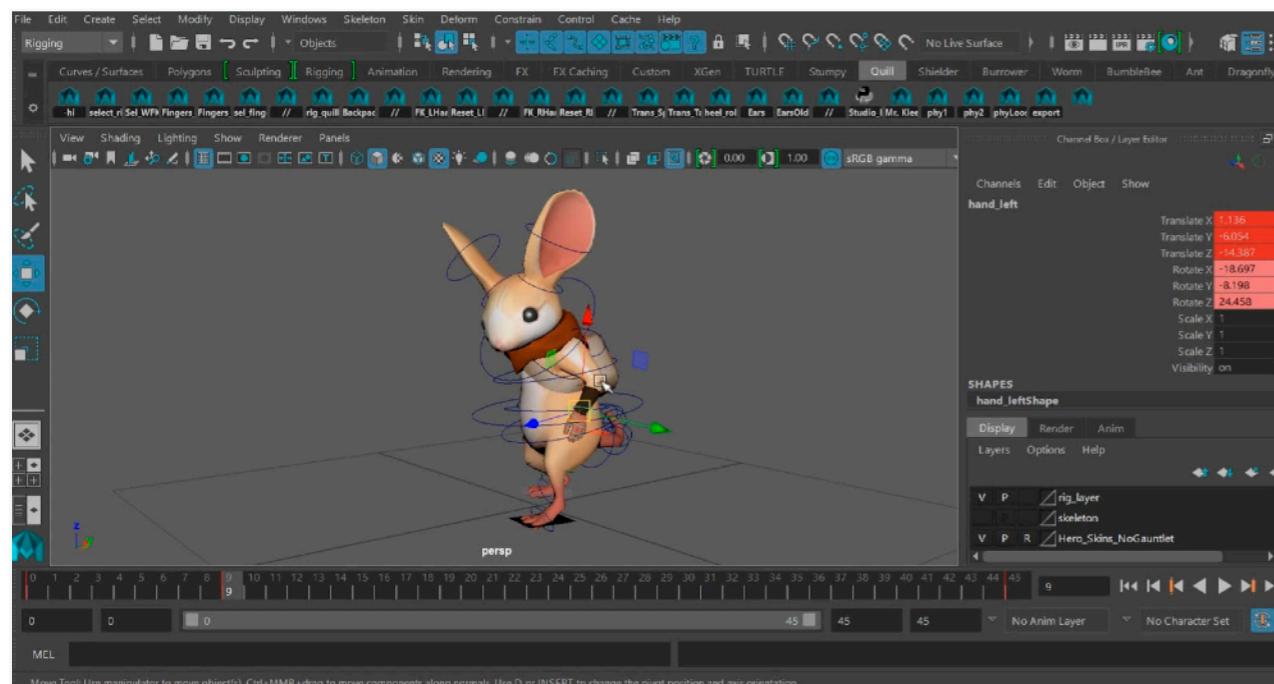
~~Name~~
gluPerspective — set up a perspective projection matrix

~~C Specification~~

```
void gluPerspective(GLdouble fovy,  
                    GLdouble aspect,  
                    GLdouble zNear,  
                    GLdouble zFar);
```

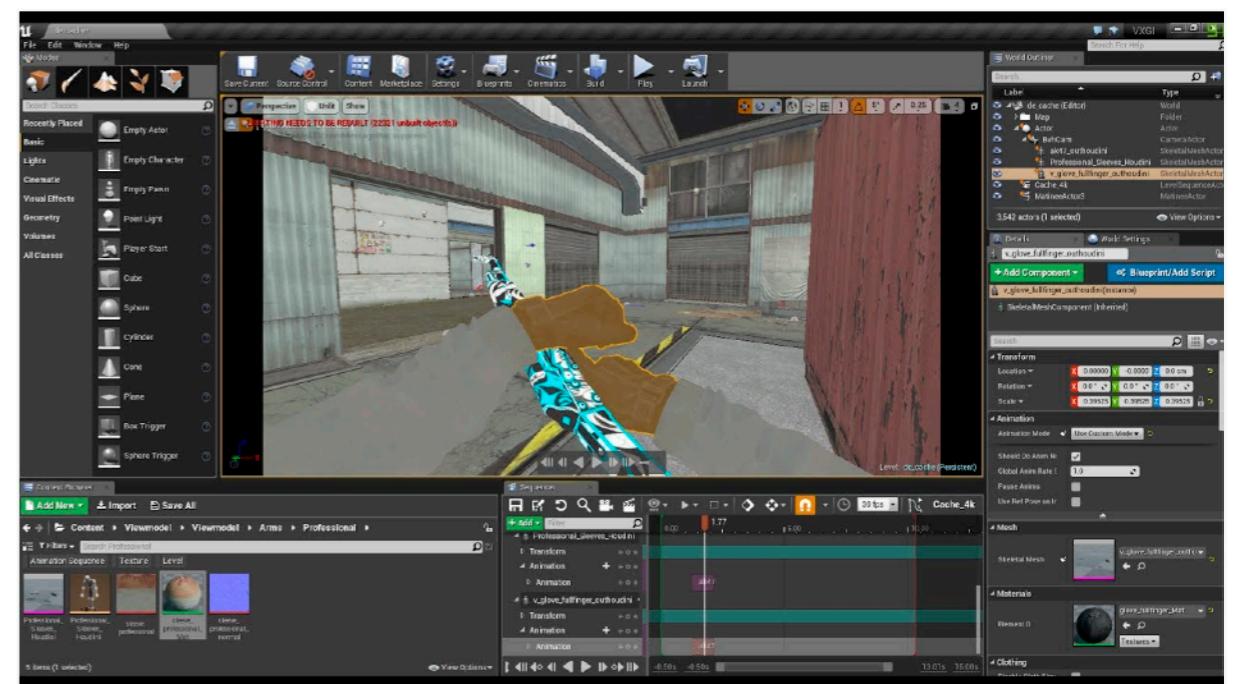
GAMES101 is NOT about

- 3D modeling using Maya / 3DS MAX / Blender, or
VR / game development using Unity / Unreal Engine
(where can I learn them?)



Modeling character animation in Maya

[<http://tutorials.cgrecord.net/2017/08/17-minute-animation-process-in-autodesk.html>]



CSGO PoV Cam set up in Unreal Engine

[<https://www.youtube.com/watch?v=3TQ18SmQSw0>]

GAMES101 is NOT about

- Computer Vision / Deep Learning topics, e.g. XYZ-GAN
(where can I learn them?)



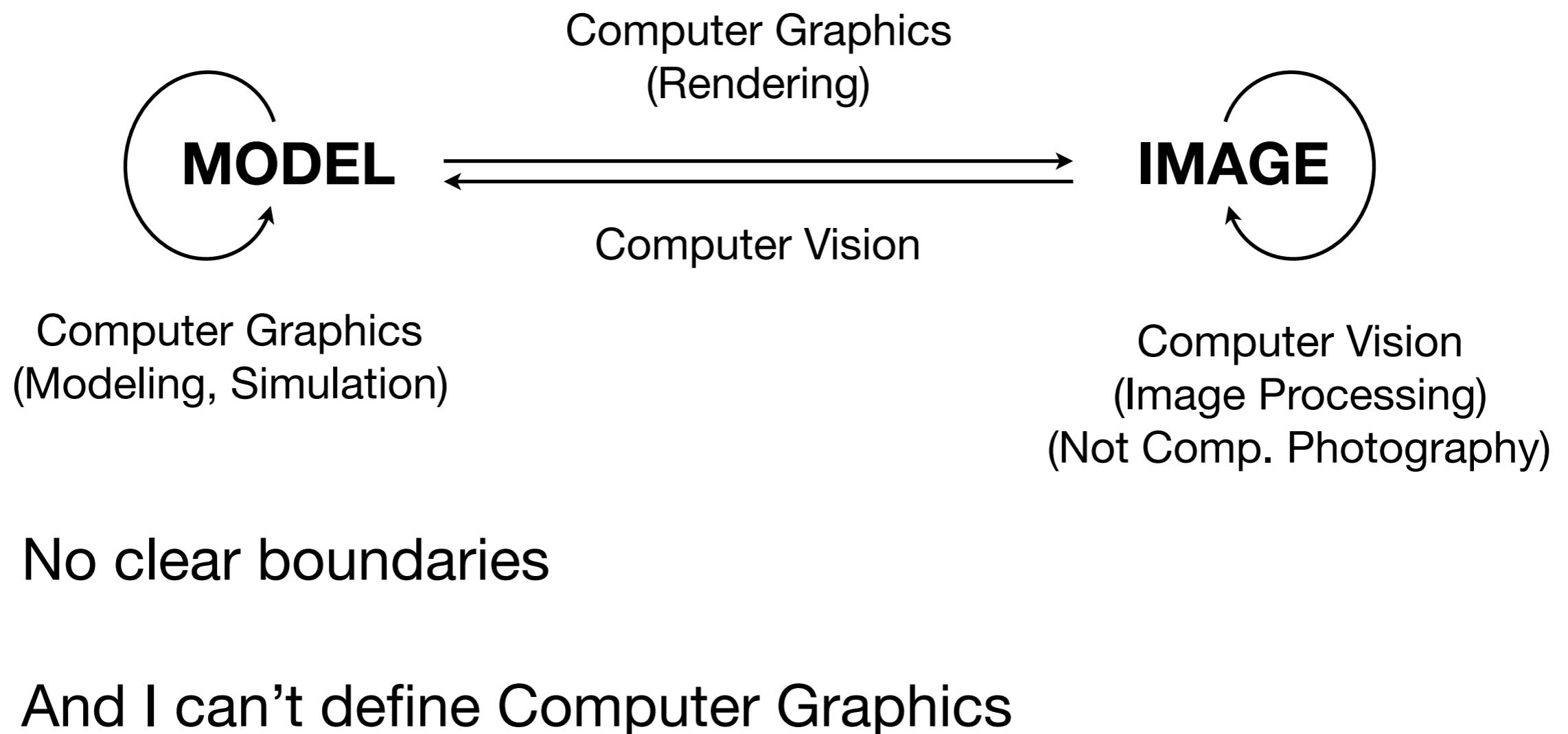
Semantic Segmentation

<https://modeldepot.io/oandrienko/icnet-for-fast-segmentation>

GAN 2.0: NVIDIA's
face generator (both are fake)

Differences?

- Personal Understanding



Questions?

Today's Topics

- What is Computer Graphics?
- Why study Computer Graphics?
- Course Topics
- Course Logistics

General Information

- Modern Course
 - Comprehensive but **without hardware programming!**
 - Pace / contents subject to change
- Course Website
 - <http://www.cs.ucsb.edu/~lingqi/teaching/games101.html>
 - Has all the needed information
 - Syllabus, slides, reading materials, etc.



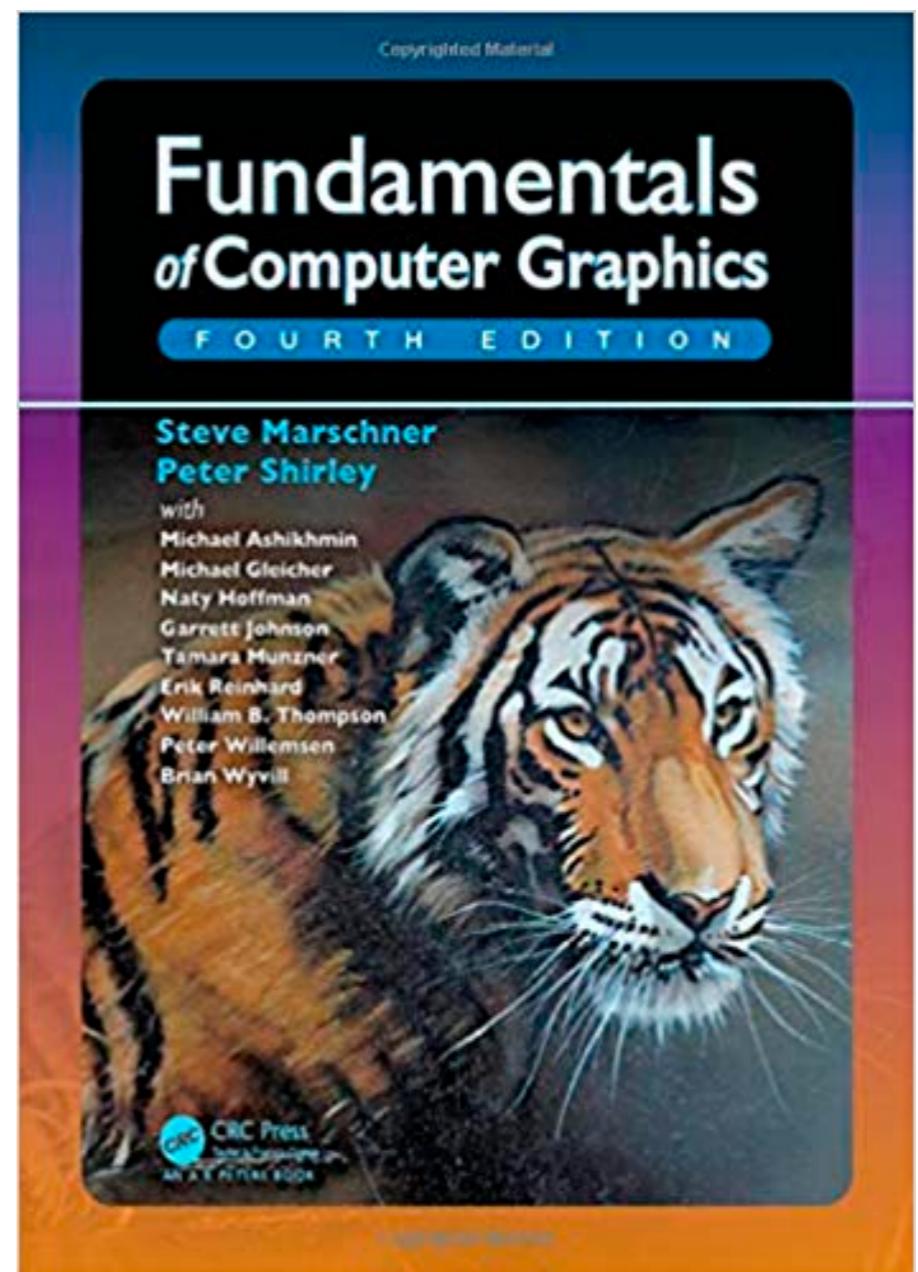
Course Website

- Course slides and (pre)-reading materials

Week	Date	Topics
1	Jan 7	Overview of Computer Graphics [PDF]
	Jan 9	Vectors and Linear Algebra Reading: Chapter 2 (Miscellaneous Math) and Chapter 5 (Linear Algebra)

References

- No Required Textbooks
 - Reading materials (if any) will available online before lectures
 - Lecture slides will be available after class
- Most recommended reference
 - Steve Marschner and Peter Shirley, "Fundamentals of Computer Graphics", 3rd or later edition.



Q & A

- Sign up on our BBS for discussion
(<http://games-cn.org/forums/forum/games-online-course-forum/>)

The screenshot shows a forum interface for the 'GAMES: Graphics And Mixed Environment Seminar'. The top navigation bar includes links for Home, Activity Notices, Previous Reports/PPT&Video, Online Courses, GAMES Offline Conference, Recruitment Information, Discussion Area, and Other Information. The main content area displays a discussion board for the 'Modern Computer Graphics' course. It shows three topics:

Topic	Voices	Posts	Last Post
现代计算机图形学入门讨论区主楼(置顶) Started by: Chen, Linghao	2	2	3 days, 20 hours ago 风儿
现代计算机图形学入门作业提交方式 Started by: Chen, Linghao	1	1	1 day, 12 hours ago Chen, Linghao
Frequently Asked Questions(Keep Updating) Started by: Chen, Linghao	1	1	3 days, 11 hours ago Chen, Linghao

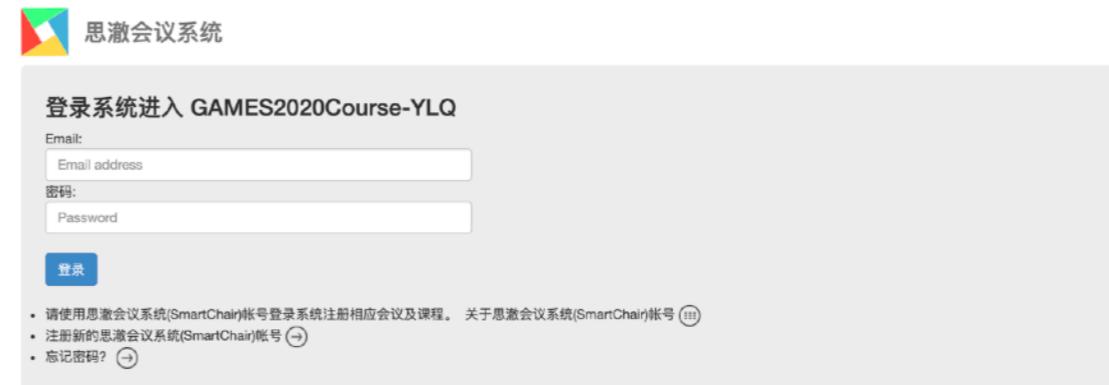
The sidebar on the right includes a 'FOLLOW:' section with a message bubble icon, a 'NEXT STORY' section with a link to 'GAMES在线课程 (现代计算机图形学入门) 讨论区', and a '活动通知' (Activity Notice) section featuring a thumbnail for 'GAMES Webinar 2020 - 127期 | Tuanfeng Y. Wang(miHoYo Research)'.

Assignments

- Assignments
 - Mostly programming tasks with provided code skeletons and virtual machine image
 - Weekly (usually no more than 20 lines of code per week)
 - Language: C++
- Submission
 - Submit your project by 11:59PM on/before the due dates (strictly enforced)
 - Feedback will be provided in a week

Assignments

- Assignment Submission Website
(<http://www.smartchair.org/GAMES2020Course-YLQ/>)



- No Exams

- Course Project / Final Project
 - Starting midway of this course
 - References will be provided, but you decide the topic
 - Best work will be posted online for showing off

GAMES2020在线课程：计算机图形学（闫令琪）

<http://games-cn.org/intro-graphics> 在线 2020年 2月9日 ~ 5月30日

本课程将全面而系统地介绍现代计算机图形学的四大组成部分：（1）光栅化成像，（2）几何表示，（3）光的传播理论，以及（4）动画与模拟。各个方面都会从基础原理出发讲解到实际应用，并介绍前沿的理论研究。通过本课程，你可以学习到计算机图形学背后的数学和物理知识，并锻炼实际的编程能力。

顾名思义，作为入门，本课程会尽可能的覆盖图形学的方方面面，把每一部分的基本概念都尽可能说清楚，让大家对计算机图形学有一个完整的、自上而下的全局把握。全局的理解很重要，学完本课程后，你会了解到图形学不等于 OpenGL，不等于光线追踪，而是一套生成整个虚拟世界的方法。从本课程的标题，大家还可以看到“现代”二字，也就是说，这门课所要给大家介绍的都是现代化的知识，也都是现代图形学工业界需要的图形学基础。

本课程与其它图形学教程还有一个重要的区别，那就是本课程不会讲授 OpenGL，甚至不会提及这个概念。本课程所讲授的内容是图形学背后的原理，而不是如何使用一个特定的图形学API。在学习完这门课的时候，你一定有能力自己使用OpenGL写实时渲染的程序。另外，本课程并不涉及计算机视觉、图像视频处理、深度学习，也不会介绍游戏引擎与三维建模软件的使用。

Use An IDE!

- IDE: Integrated Development Environment
- Helps you parse a entire project
 - And gives hints on syntax / usages of member functions, etc.
- Recommended IDEs
 - Visual Studio (Windows only) / Visual Studio Code (cross platform)
 - Qt Creator (personal)
- Not Recommended IDEs (for C++ programming)
 - CLion, Eclipse
 - Sublime Text, Vi / Vim, Emacs (not even IDEs)

Academic integrity

- Work alone for regular assignments
 - no copy-pasting from any other sources
- Do not publish your code (on Github, etc.) for assignments using our skeleton code
- Do not post your solution online
 - Discussion / explanation is welcomed

Questions?

Thank you!