Introduction to Computer Graphics
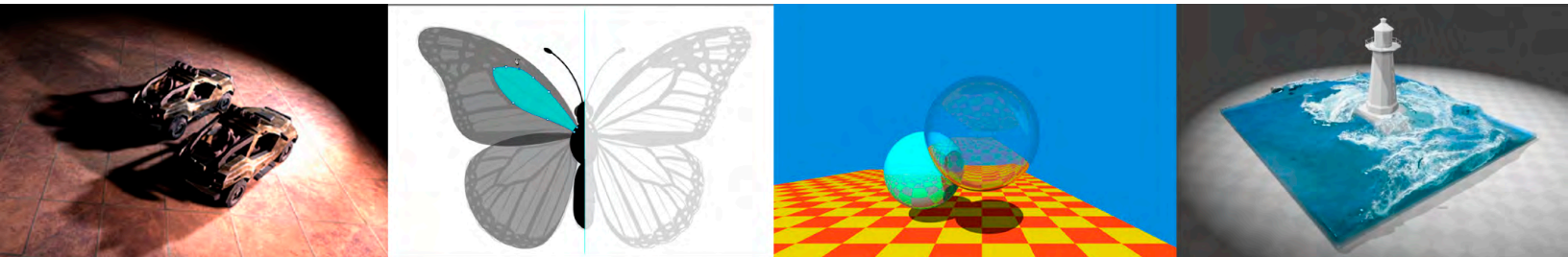
GAMES101, Lingqi Yan, UC Santa Barbara

Lecture 1:
Overview of Computer Graphics

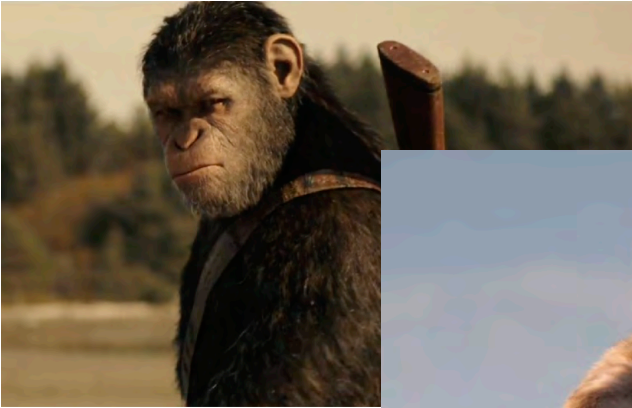http://www.cs.ucsb.edu/~lingqi/teaching/games101.html

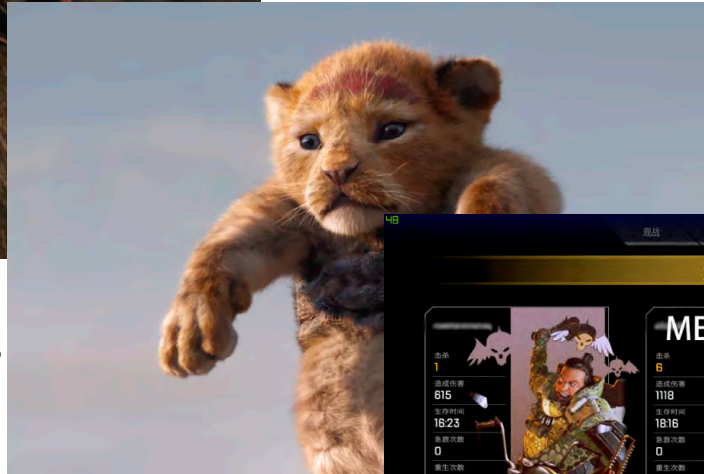# Welcome!

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 /kəmˈpyo͞odər ˈɡrafiks/ 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

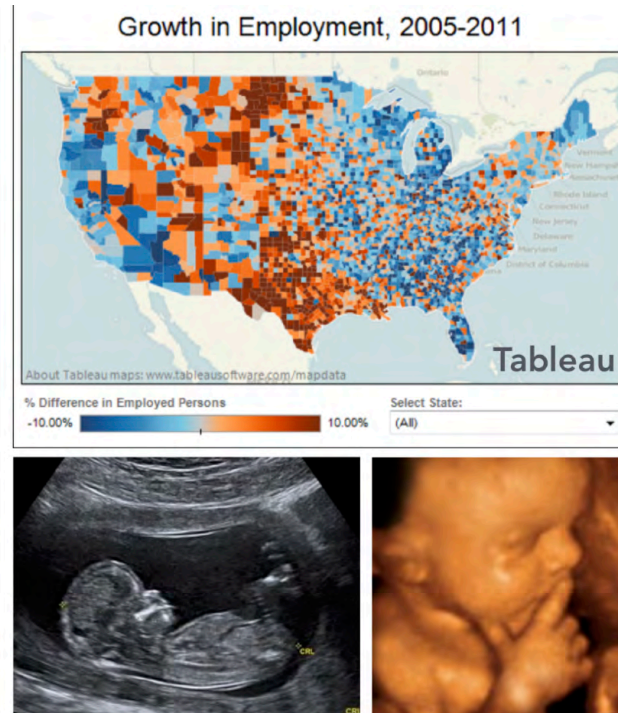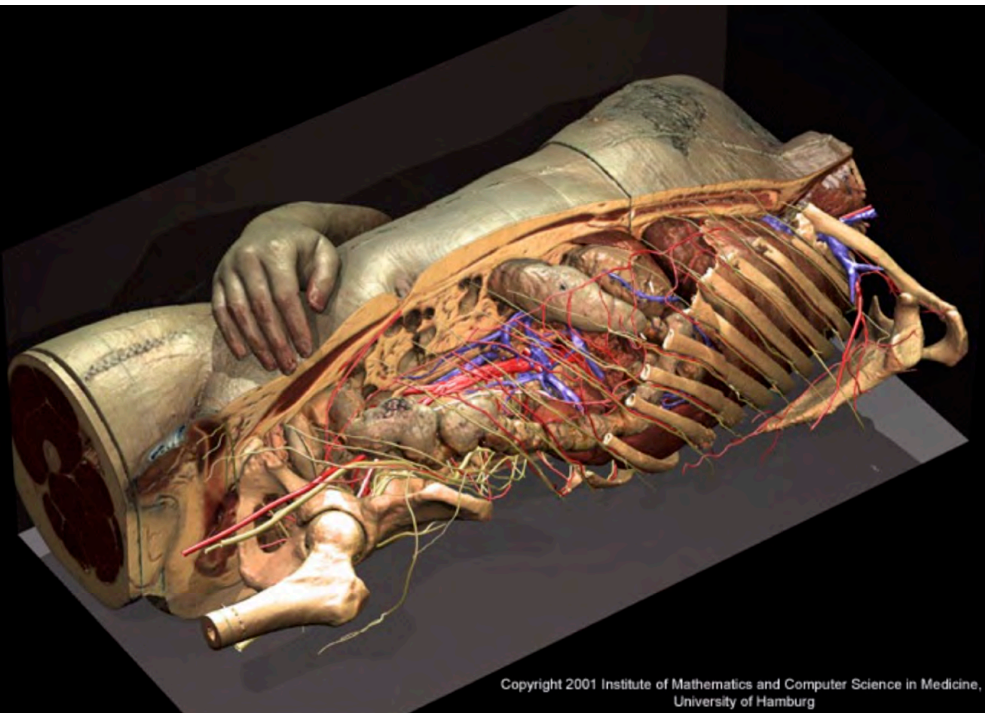CG   Photo

Autodesk Gallary
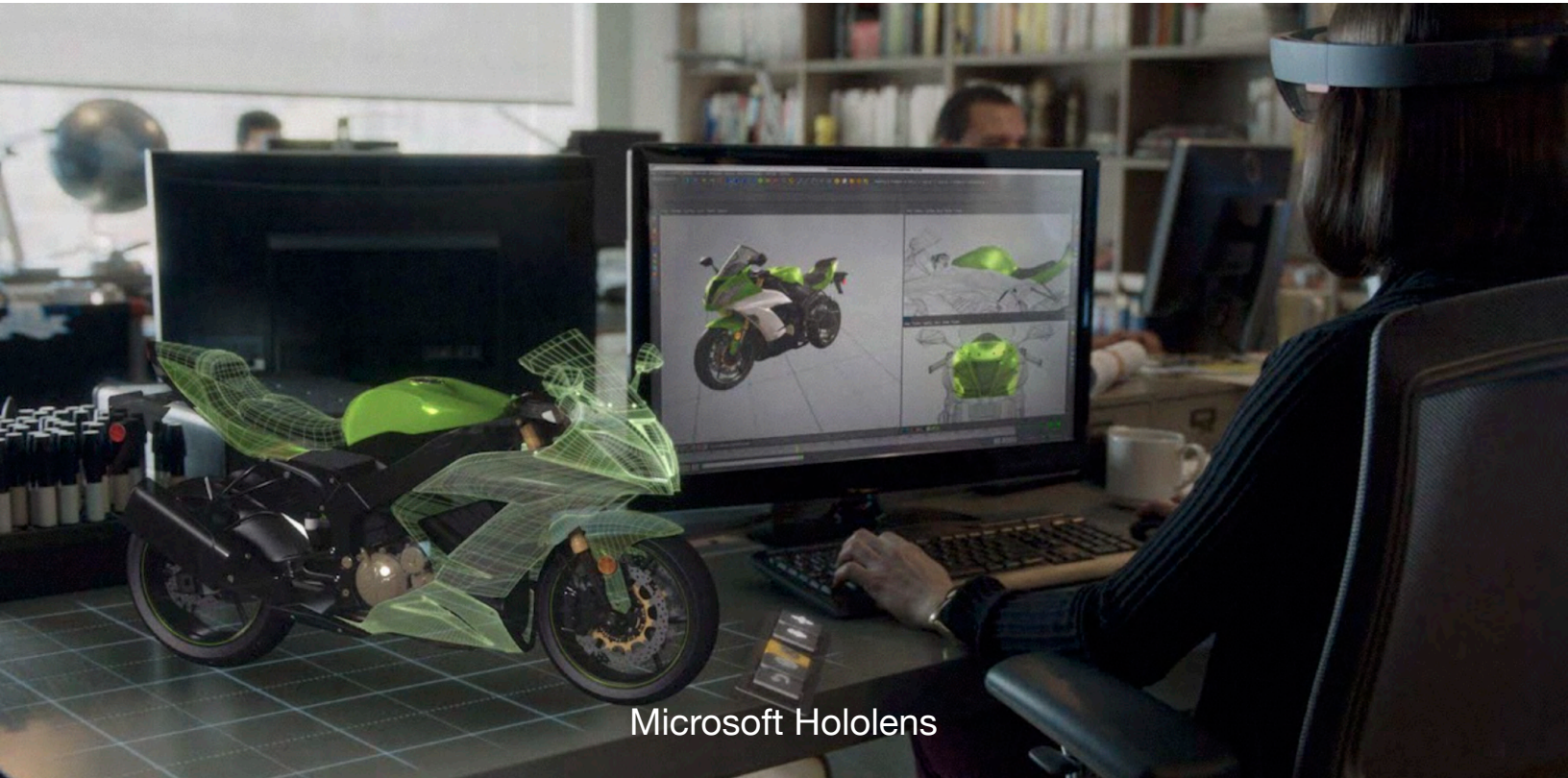
Design

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

Visualization

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

Growth in Employment, 2005-2011

Tableau

Science, engineering, medicine, journalism, etc.

Virtual Reality

Oculus VR

Augmented Reality

Microsoft Hololens

Digital Illustration

https://www.youtube.com/watch?v=uEdRLlqdgA4

Simulation

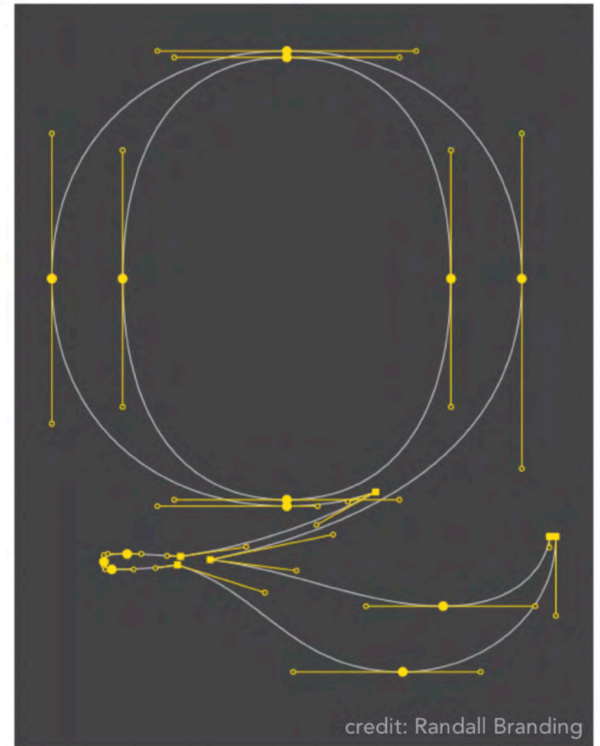The Dust Bowl phenomena

Black hole from Interstellar

Graphical User Interfaces

Typography

The Quick Brown Fox Jumps Over The Lazy Dog

ABCDEFGHIJKLMNOPQRSDTUVWXYZ
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

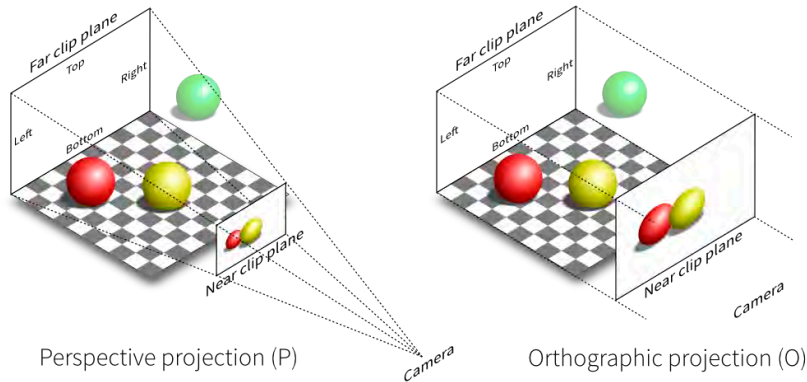# Computer Graphics
is
AWESOME!

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)
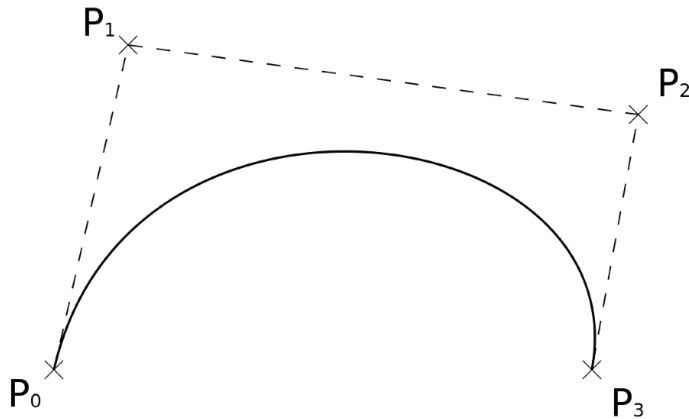
- Gold standard in Video Games (Real-time Applications)

Perspective projection (P)   Orthographic projection (O)

http://vispy.org/modern-gl.html
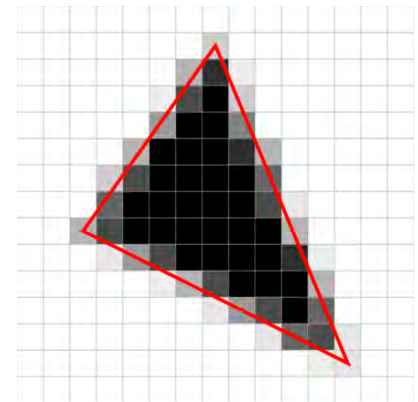
https://commons.wikimedia.org/wiki/
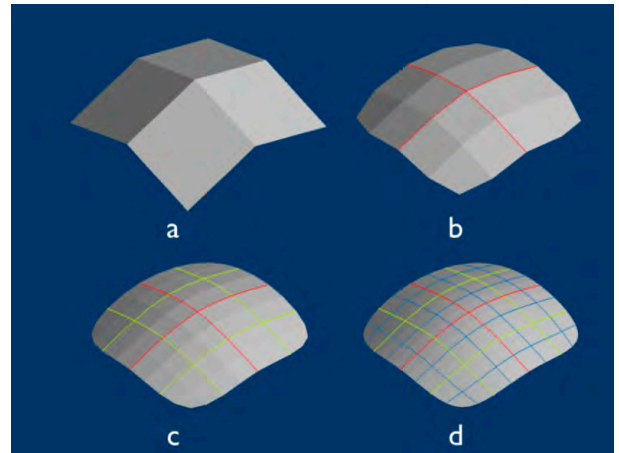File:Rasterisation-triangle_example.svg

Curves and Meshes

- How to represent geometry in Computer Graphics

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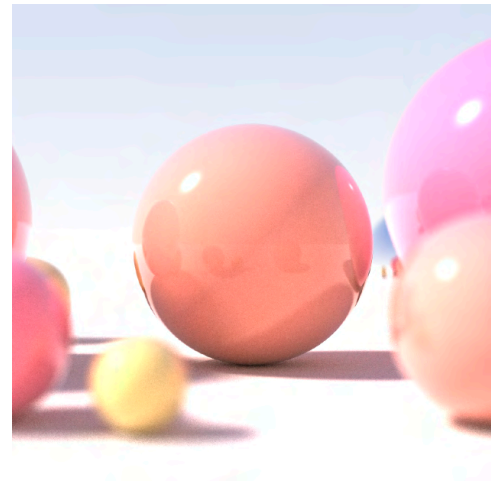
https://en.wikipedia.org/wiki/B%C3%A9zier_curve
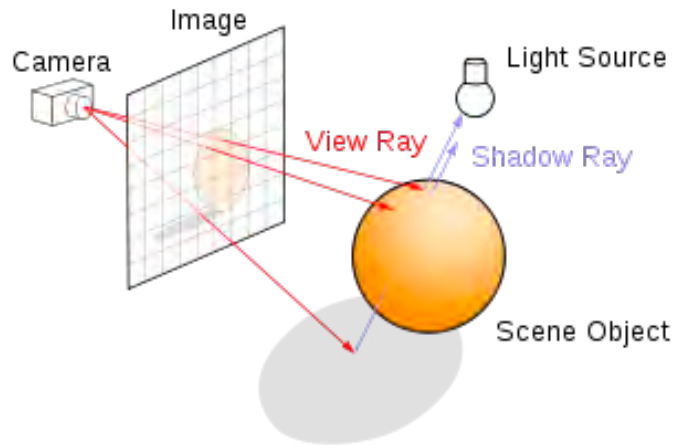

Catmull-Clark subdivision

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

Ray Tracing

- Shoot rays from the camera though 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)

Animation / Simulation

- Key frame Animation

- Mass-spring System

https://cs184.eecs.berkeley.edu/sp18/lecture/simulation/slide_010
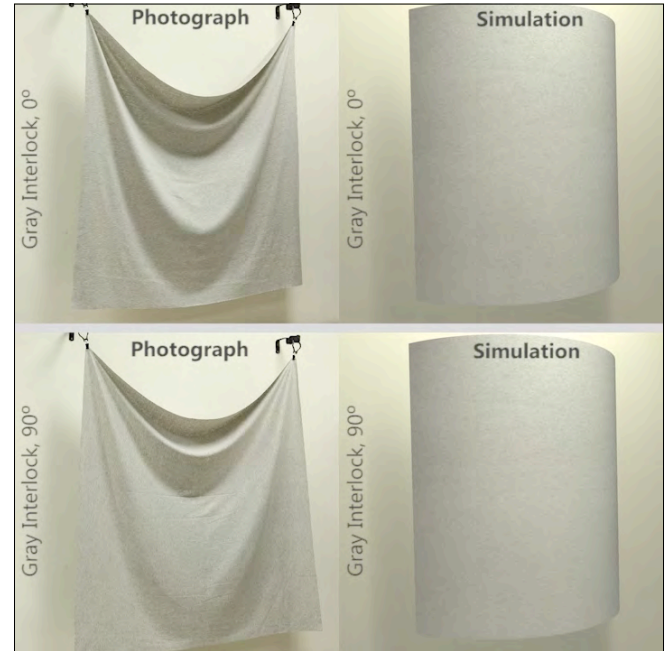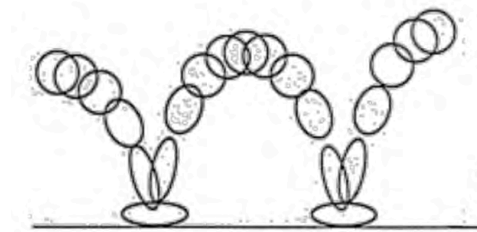
GAMES101 is NOT about

- Using OpenGL / DirectX / Vulkan

- The syntax of Shaders

- We learn Graphics,
  not Graphics APIs!

- After this course,
  you'll be able to learn these
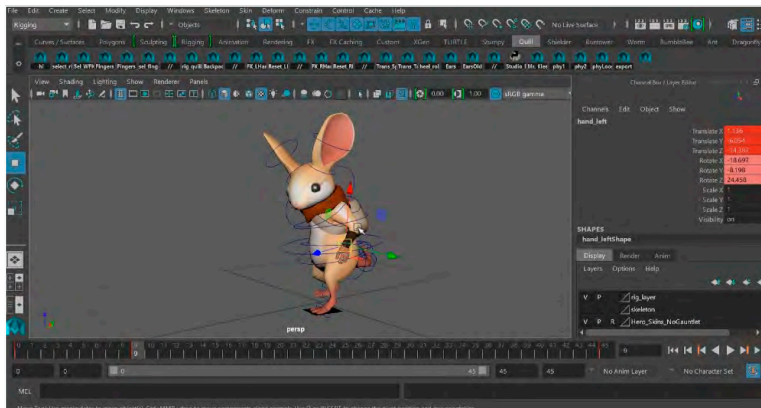 by yourself (**I promise**)

Name

gluPerspective — setup a perspective projection matrix

C Specification

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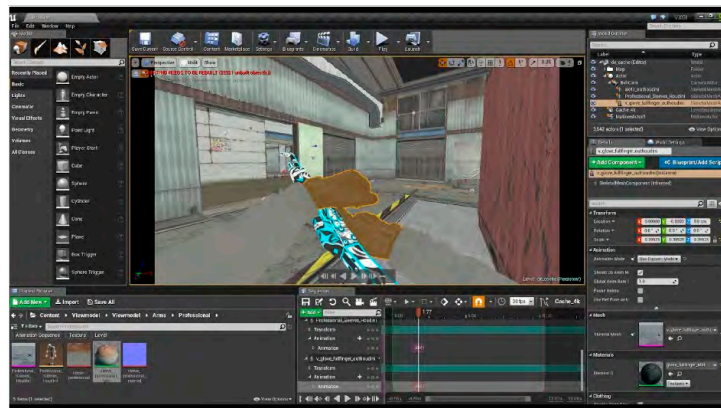   GLdouble *zFar*);

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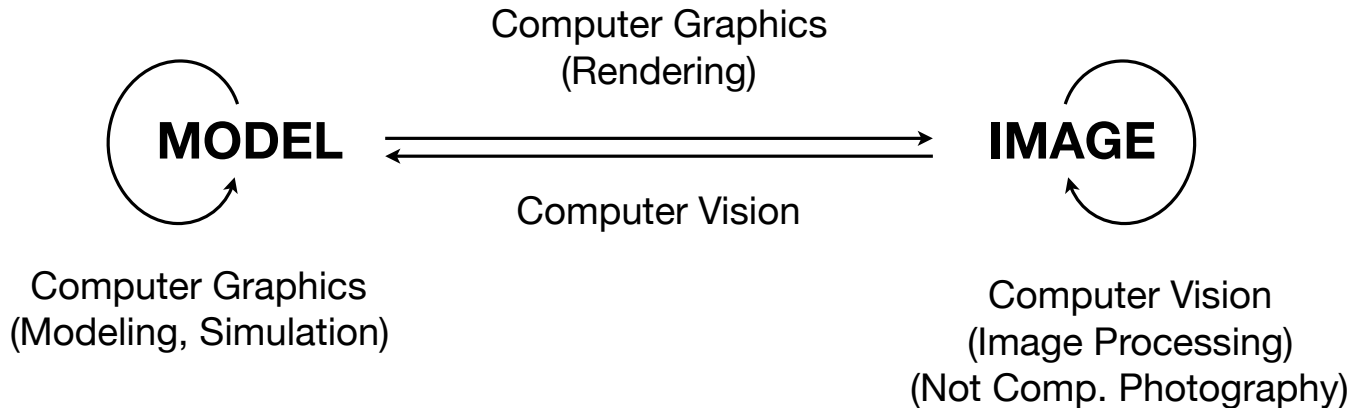https://modeldepot.io/oandrienko/icnet-for-fast-segmentation

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

Differences?

- Personal Understanding

Computer Graphics
(Rendering)

MODEL $\longleftarrow$ $\longrightarrow$ **IMAGE**

Computer Vision

Computer Graphics
(Modeling, Simulation)

Computer Vision
(Image Processing)
(Not Comp. Photography)

- No clear boundaries

- And I can't define Computer Graphics

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.
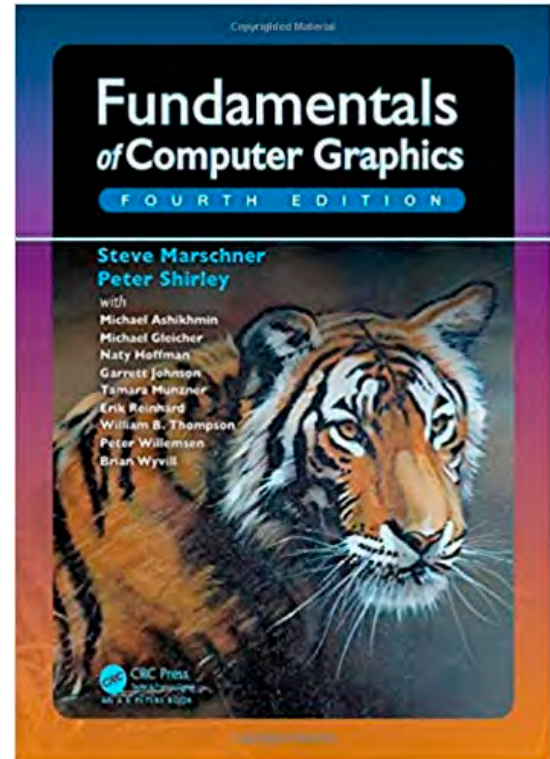
Q & A

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

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

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!