CSCI 420: **Computer Graphics**

Fall 2015

Hao Li

http://cs420.hao-li.com

http://hao.li/

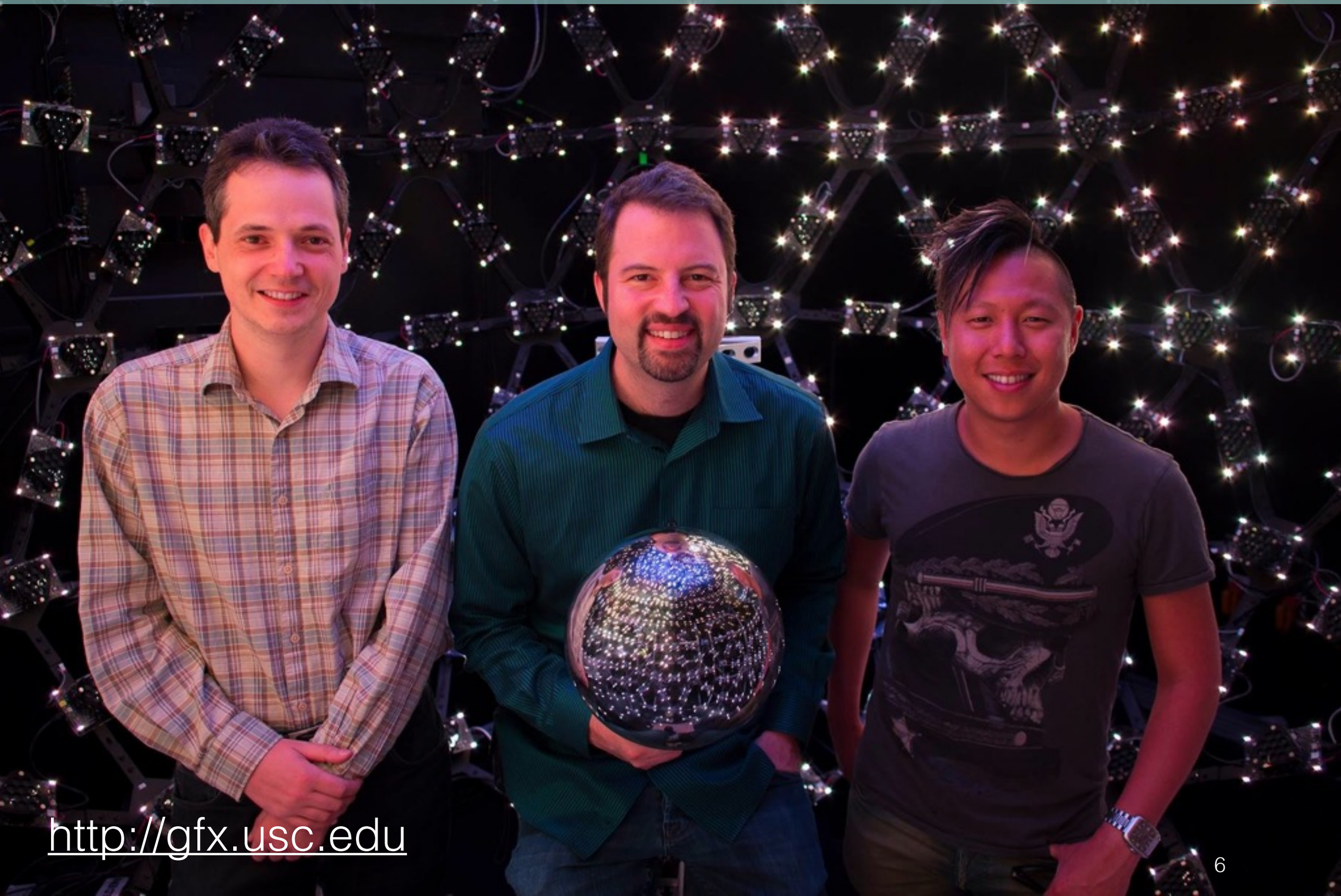
Geometric Capture [Lab]

About Me

Industrial Light & Magic

Weta Digital

USC Graphics



http://gfx.usc.edu

Science, Engineering, & Art

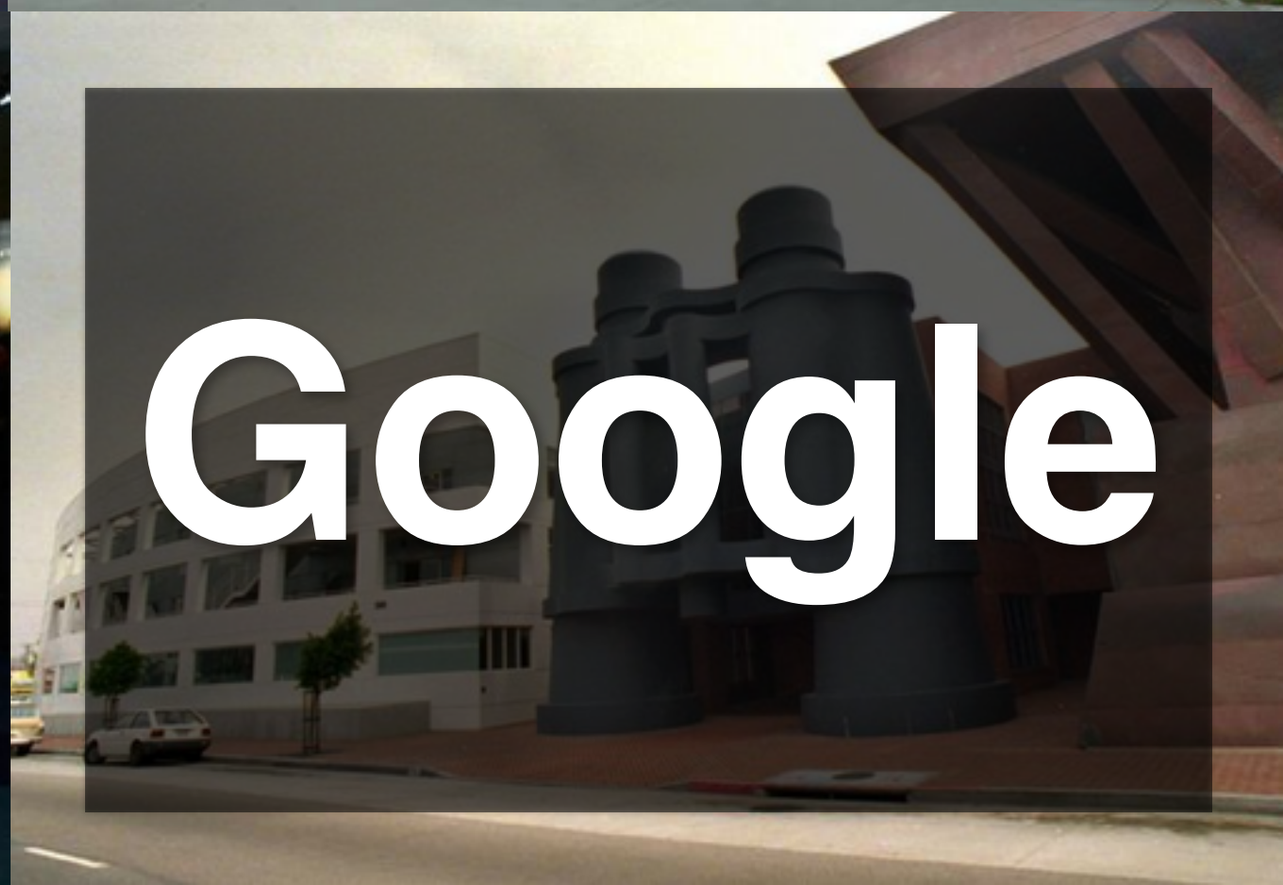
USC Viterbi
School of Engineering

USC School
of Cinematic Arts

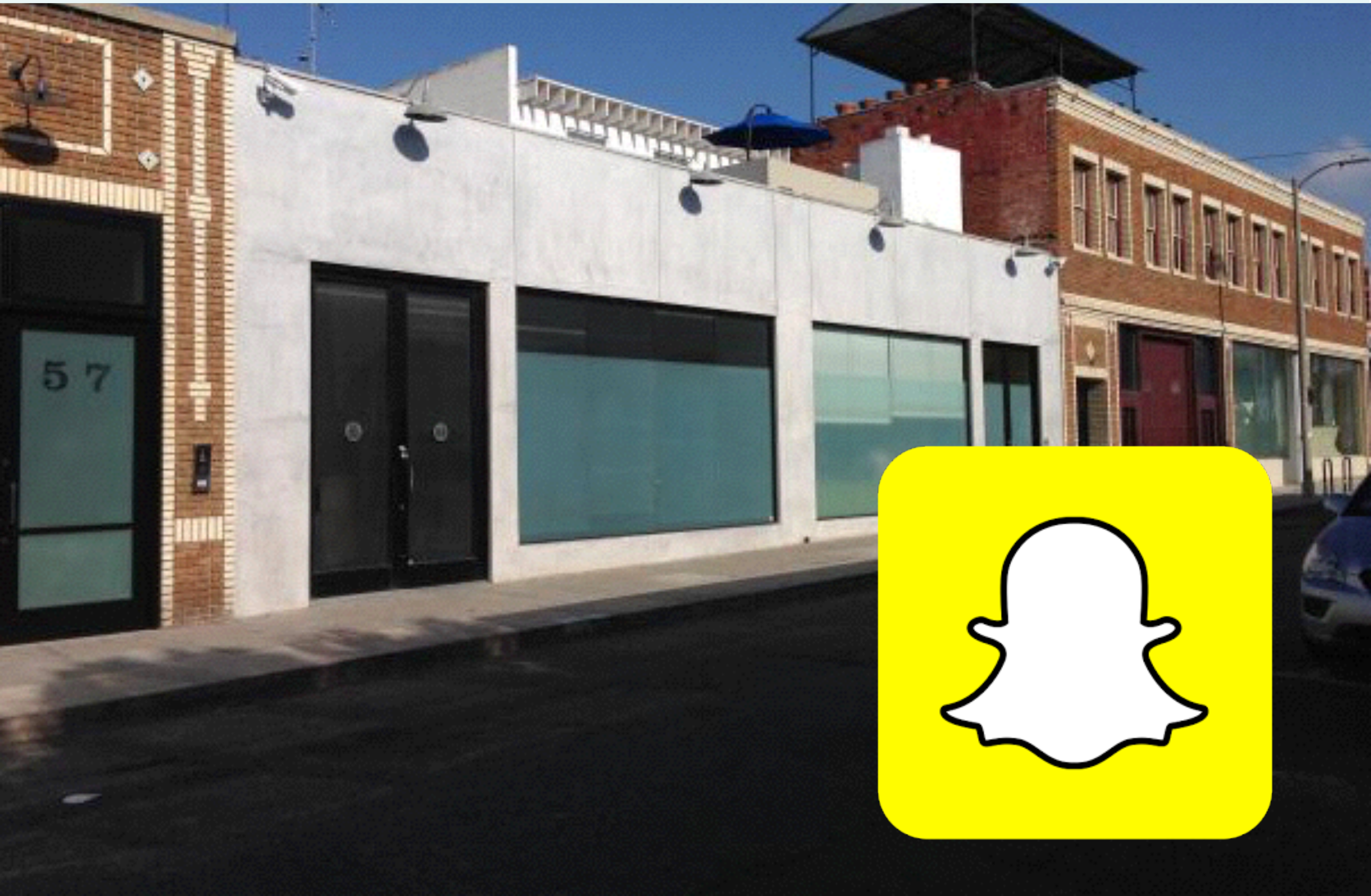
USC ICT
INSTITUTE FOR CREATIVE TECHNOLOGIES

USC Games

High Tech & Capital of Entertainment

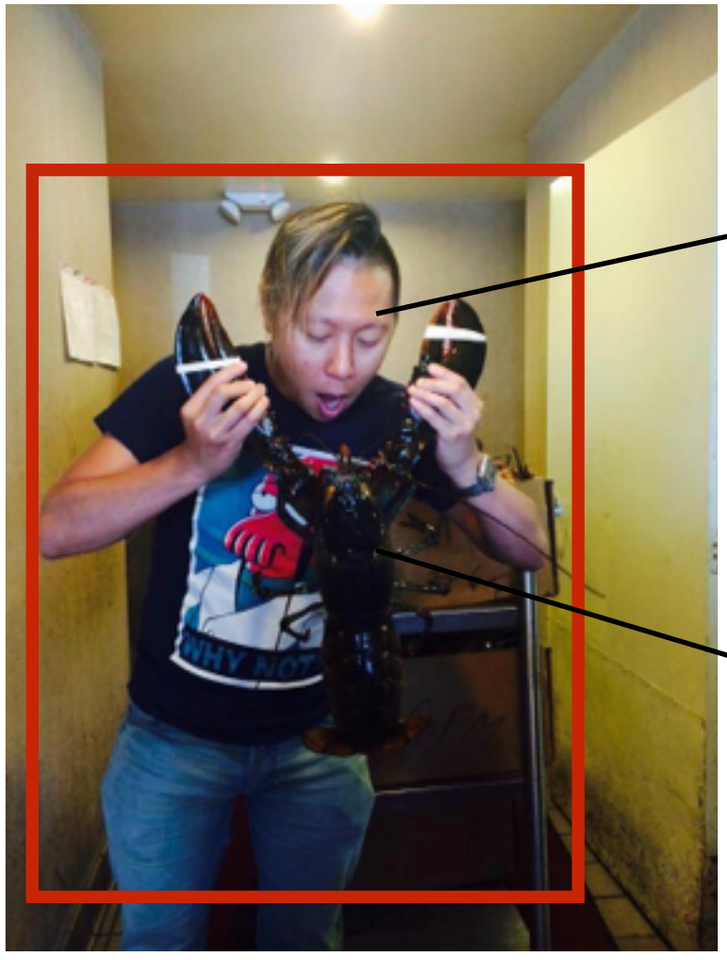


Silicon Beach



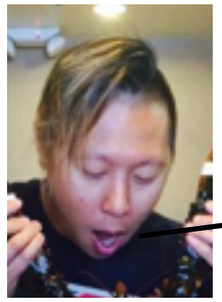
Computer Graphics vs. Vision

Computer Vision

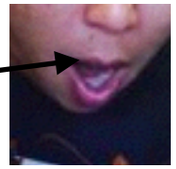


ROI

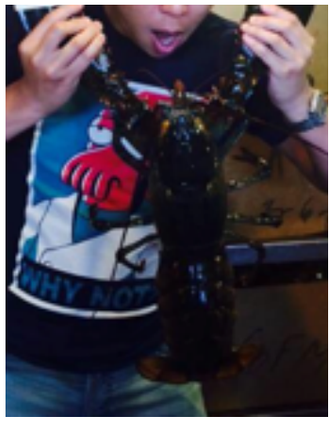
input
an image



face



mouth open 70%



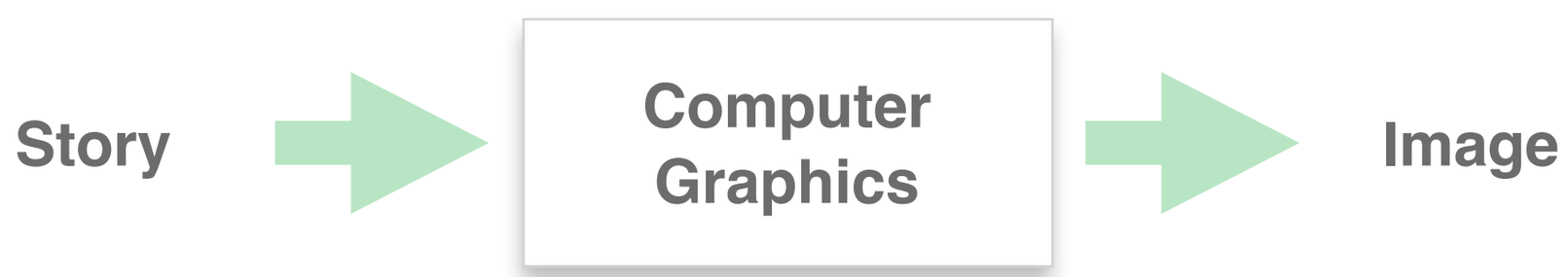
shrimp 20%
lobster 60%
crap 40%

output
Hao is eating a lobster

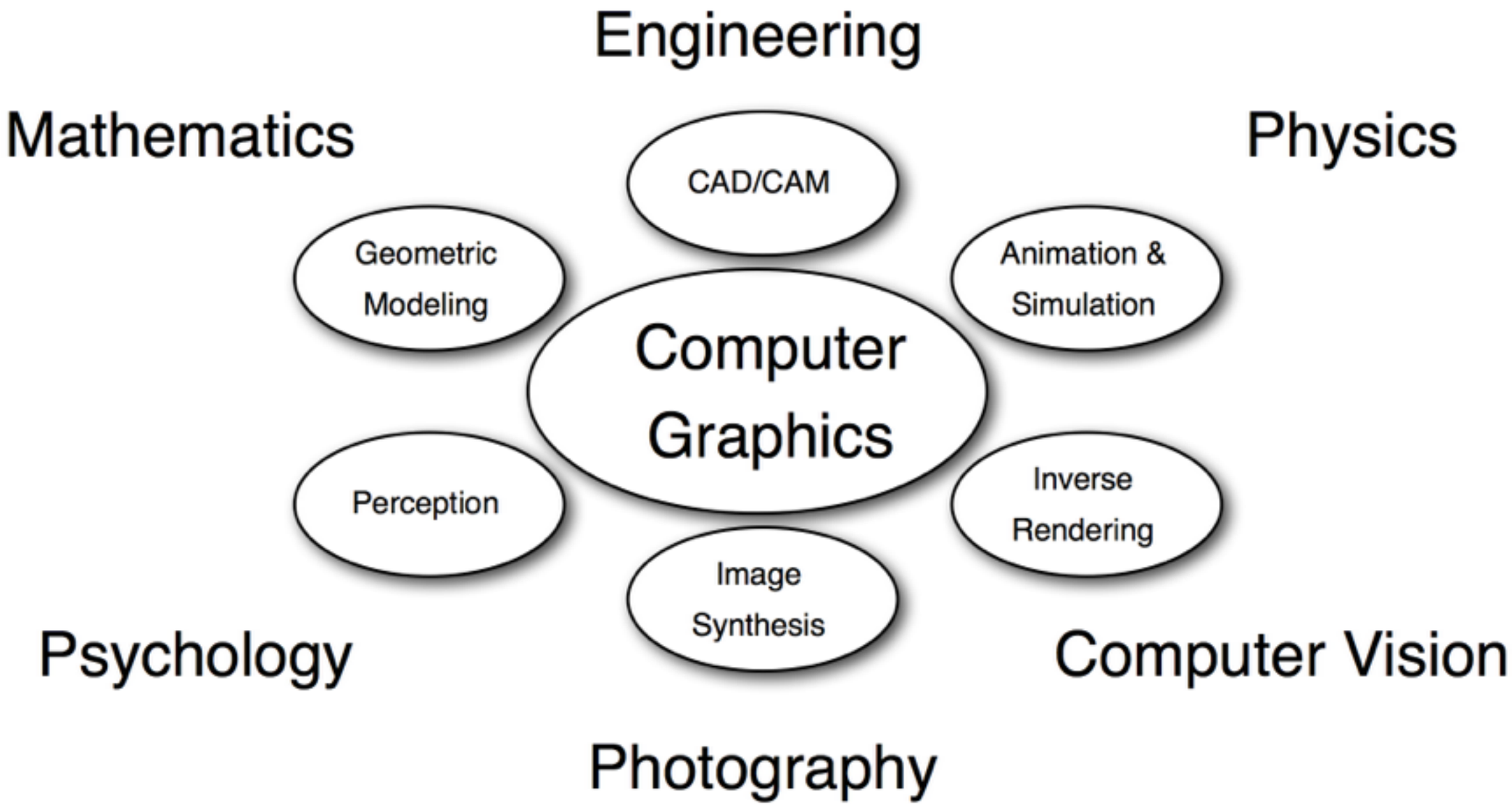
Image → **Computer Vision** → **Story**

Computer Graphics

and… Action!

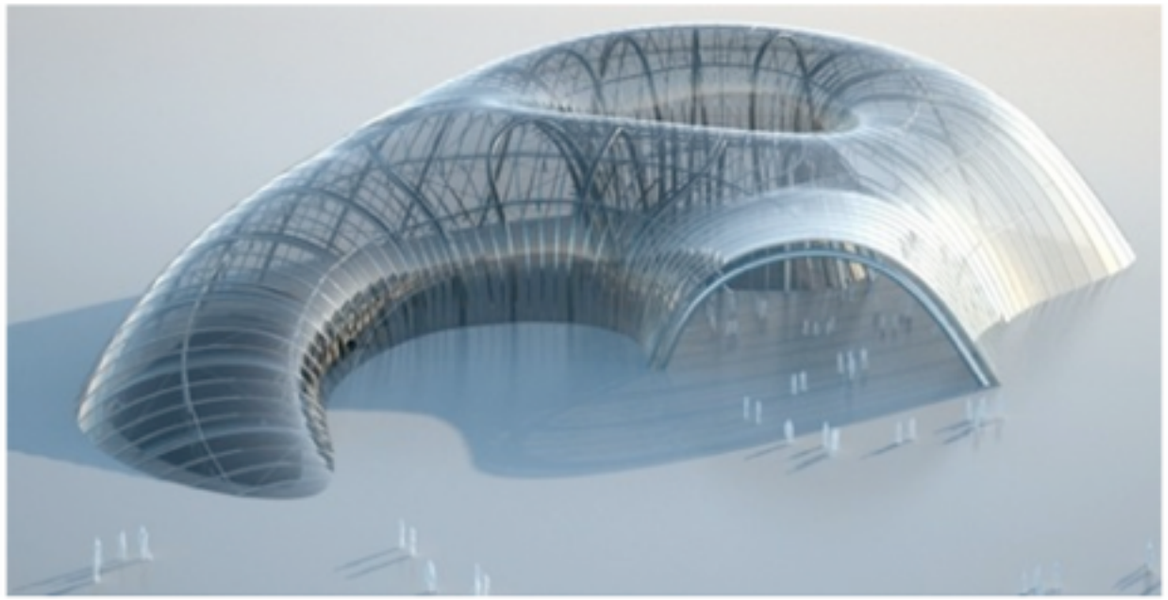


Related to many Disciplines



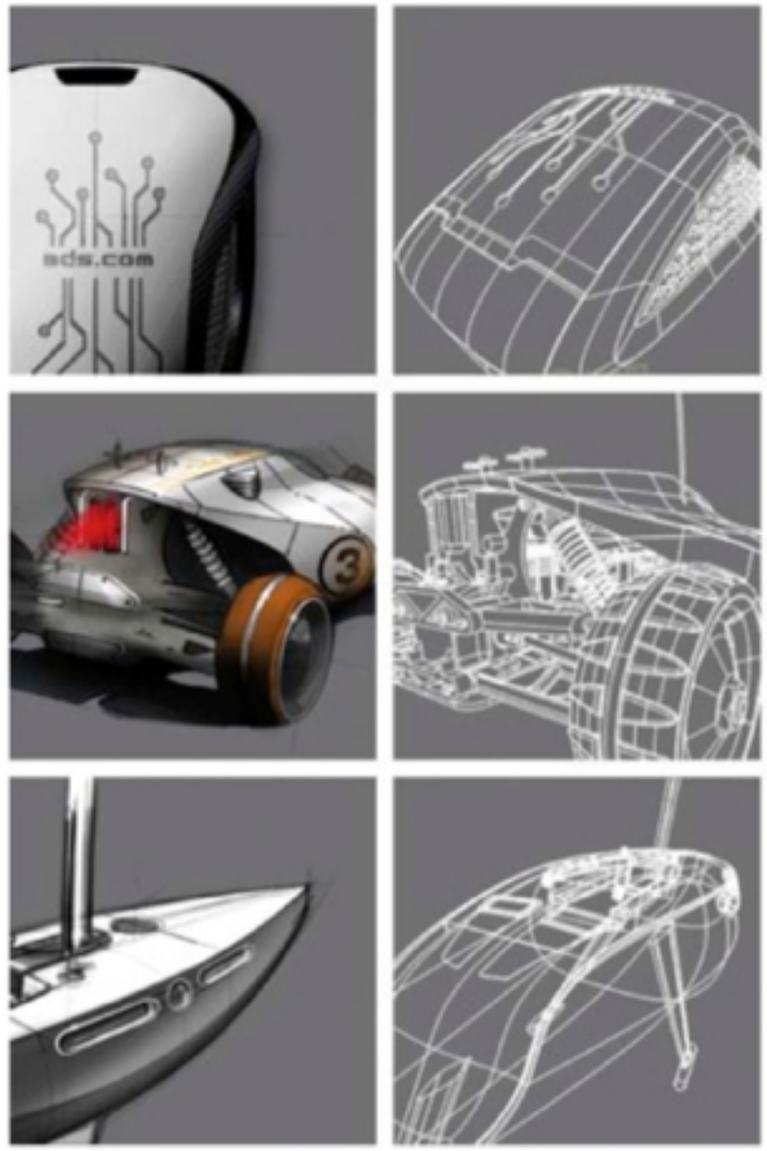
Applications

Computer Aided Design



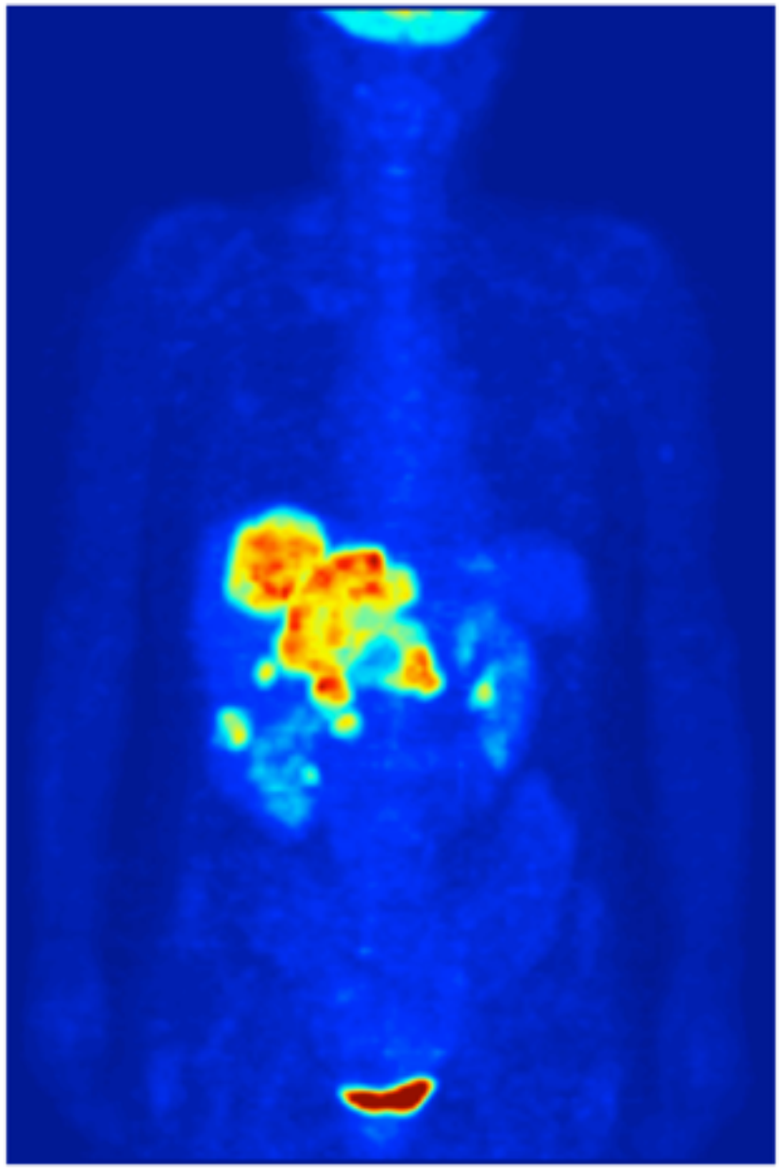
evolute - architectural design

cyberswift - mechanical design

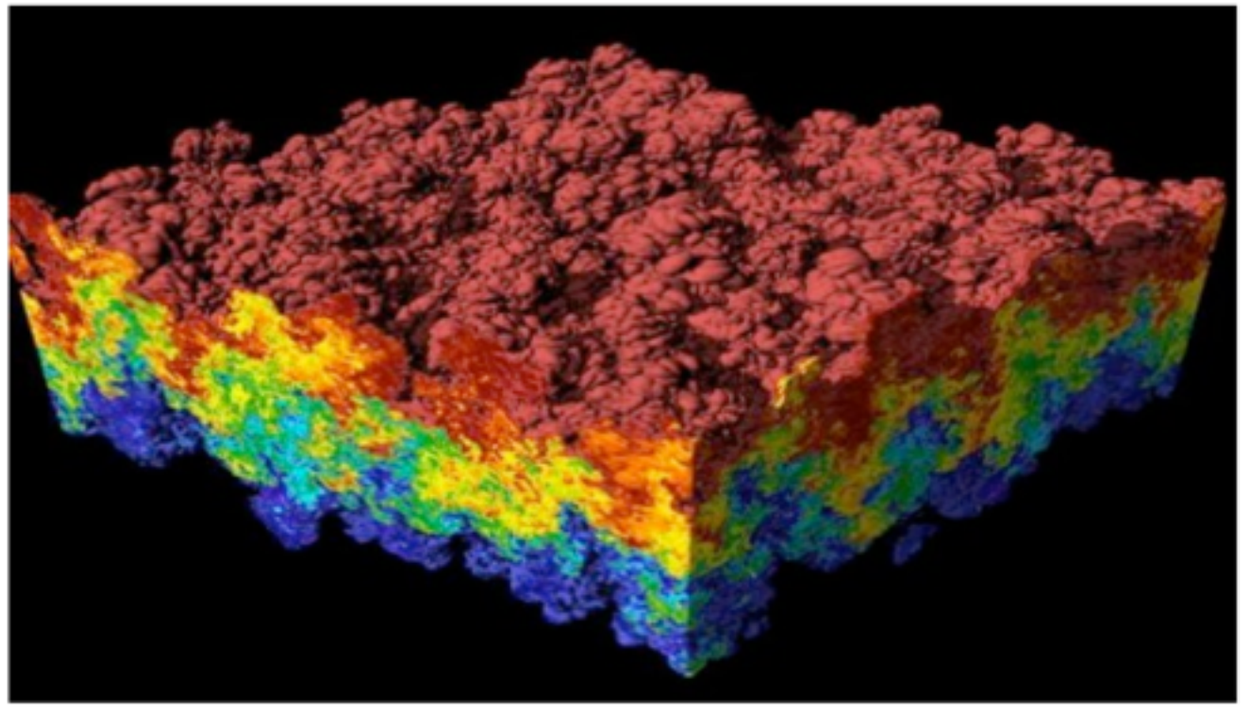


catia - product design

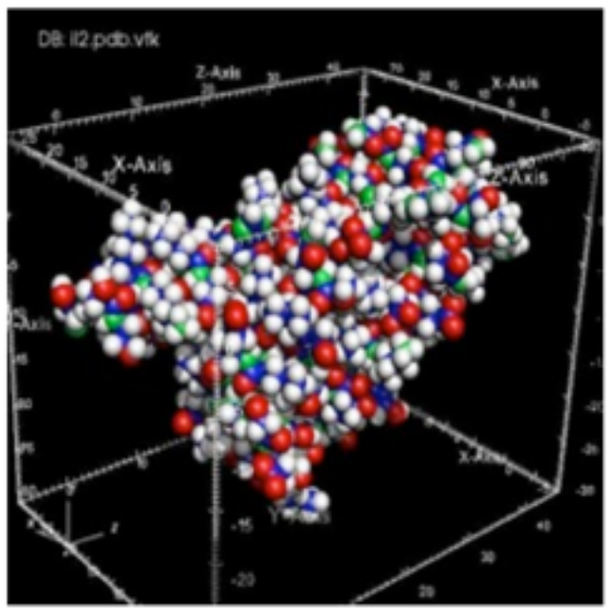
Scientific Visualization



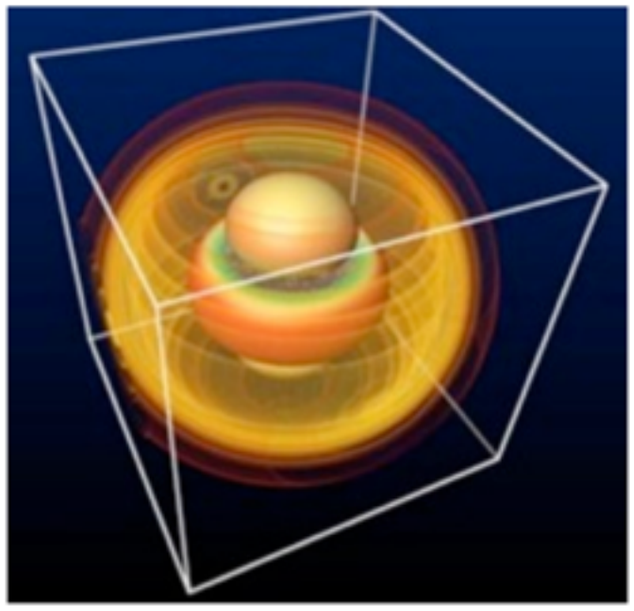
Wikipedia -PET scan



Wikipedia - mixing fluids



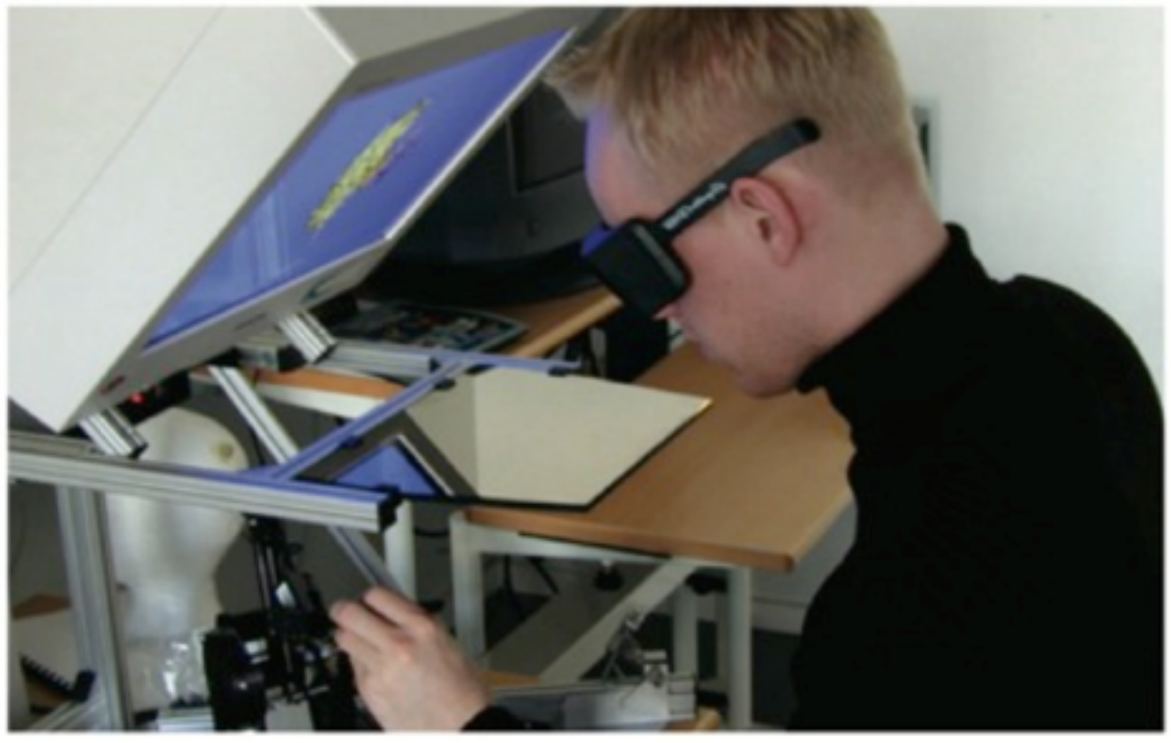
Wikipedia - protein rendering



Wikipedia - gravity waves

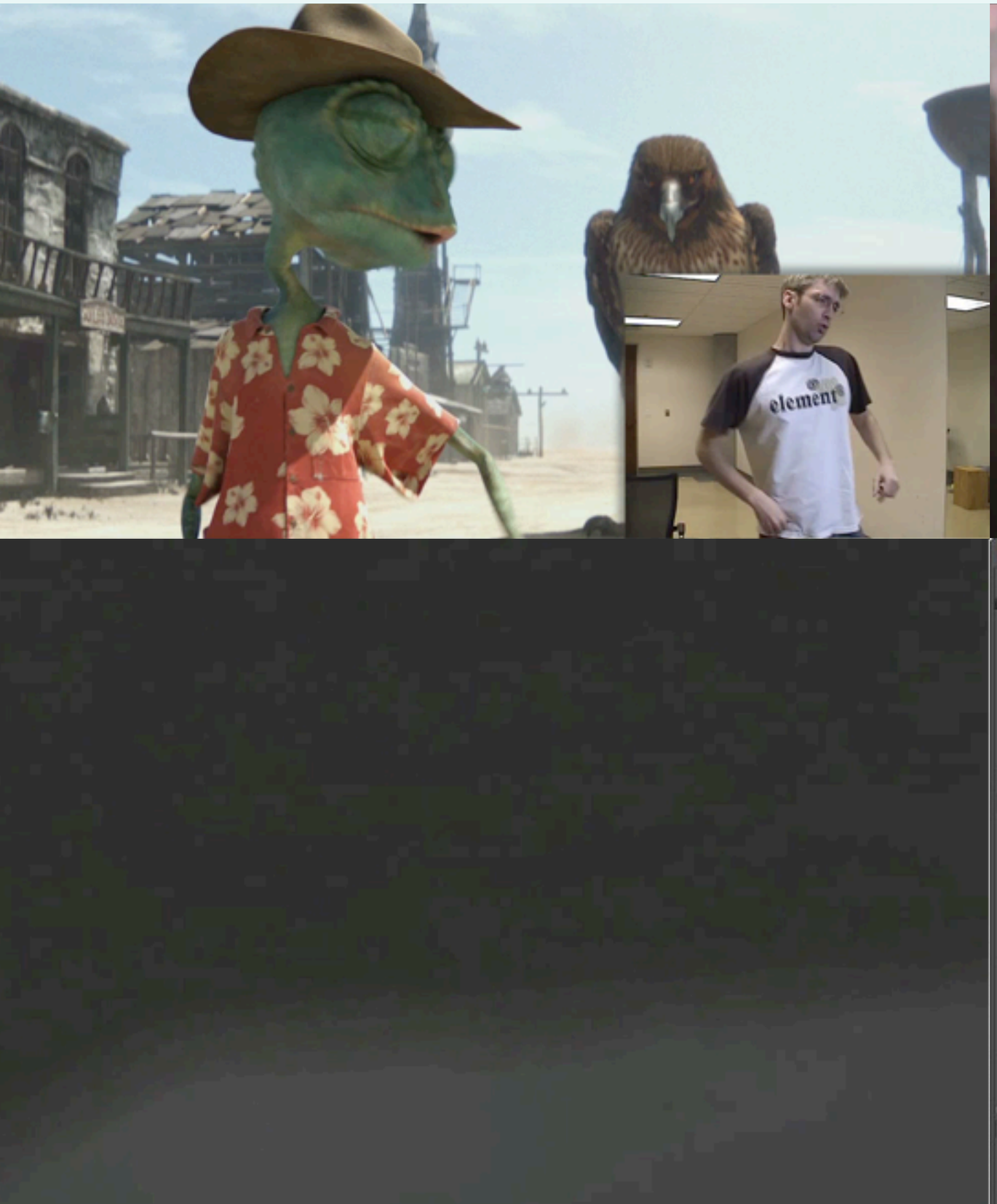
Training / Simulation

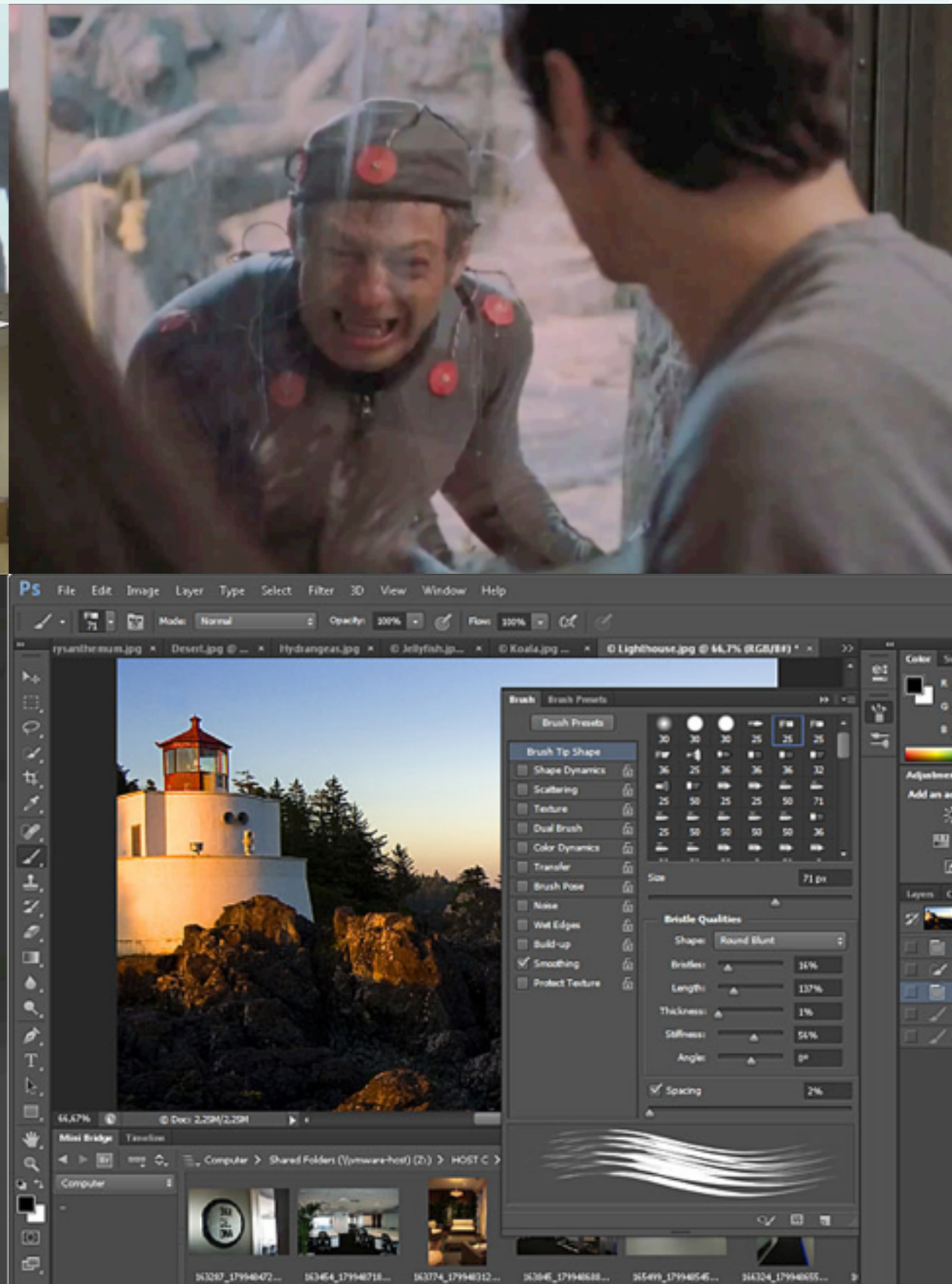
Microsoft - flight simulator



Aalborg University - surgery simulation

Entertainment

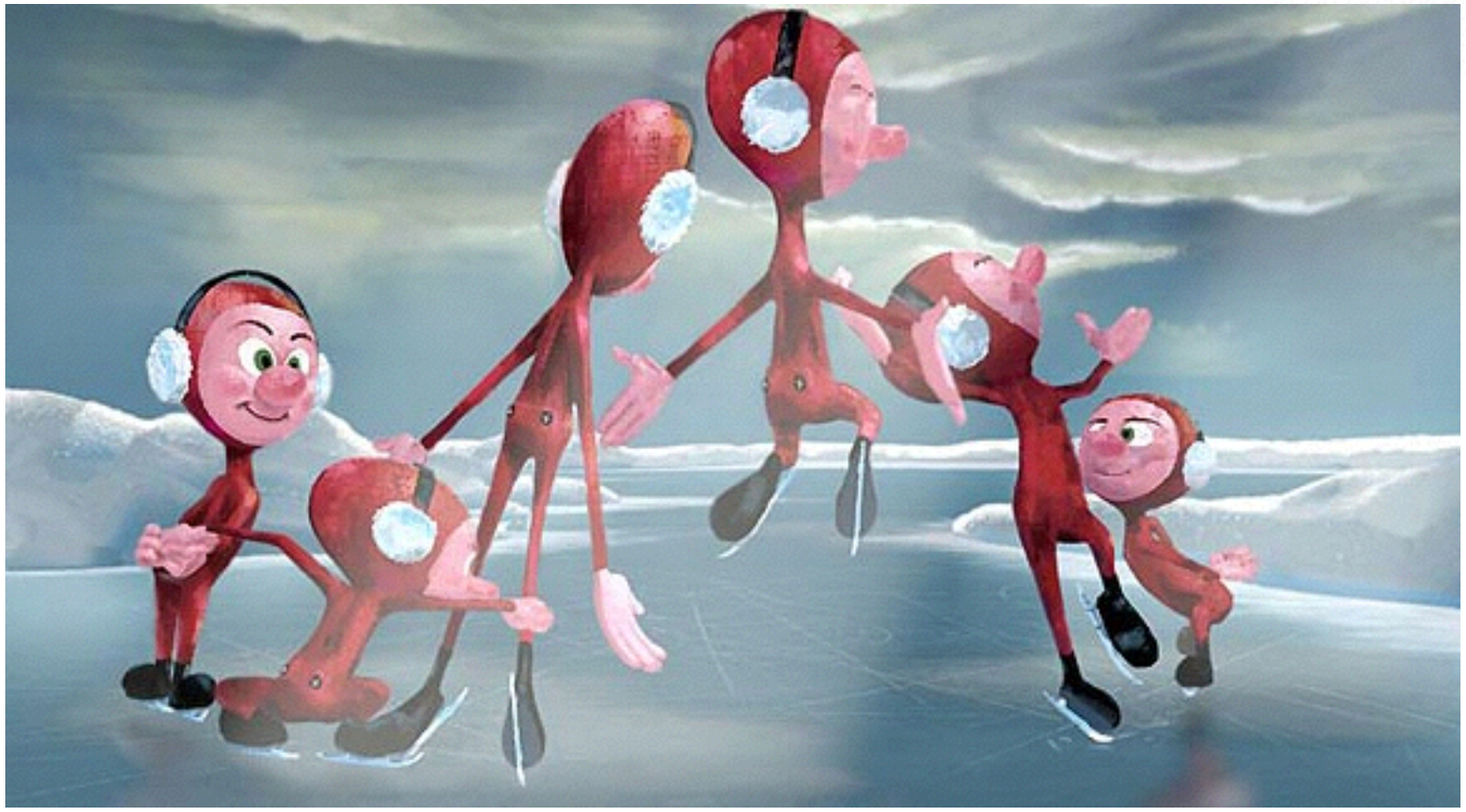




VFX

Computing Illustrations

A. Hertzmann, D. Zorin
SIGGRAPH 2000



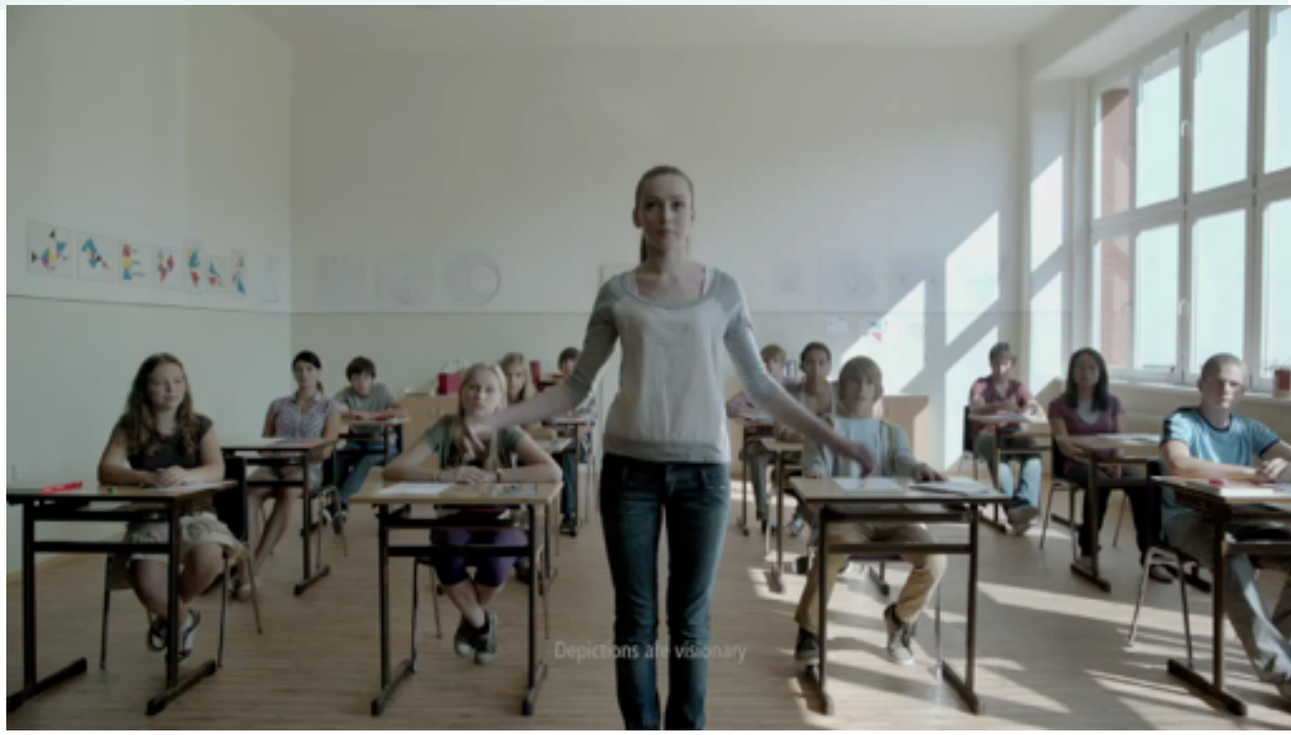
Pixar

Non-Photorealistic Rendering (NPR)

Into the Mainstream

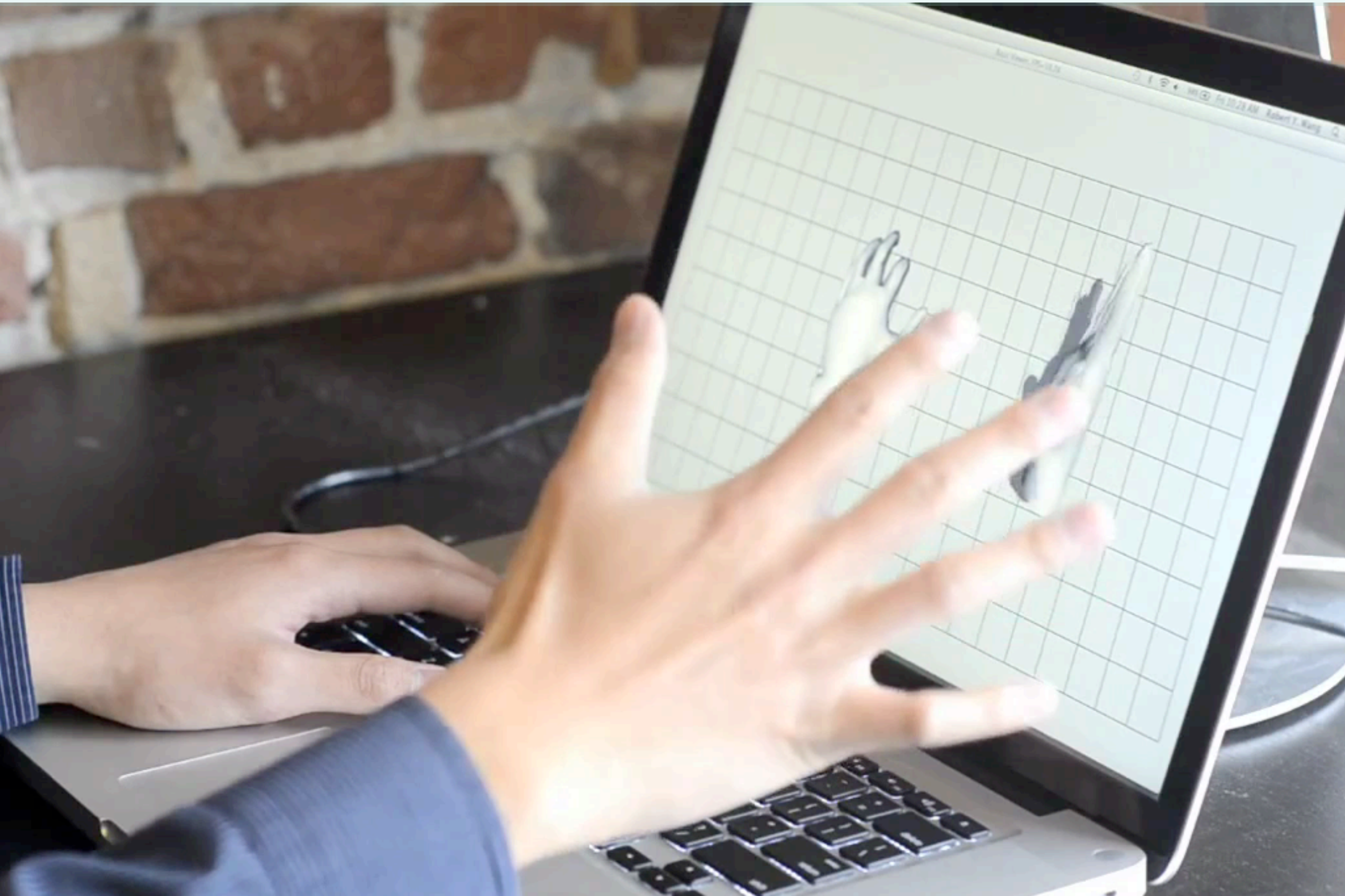
Home Entertainment

Human Computer Interfaces

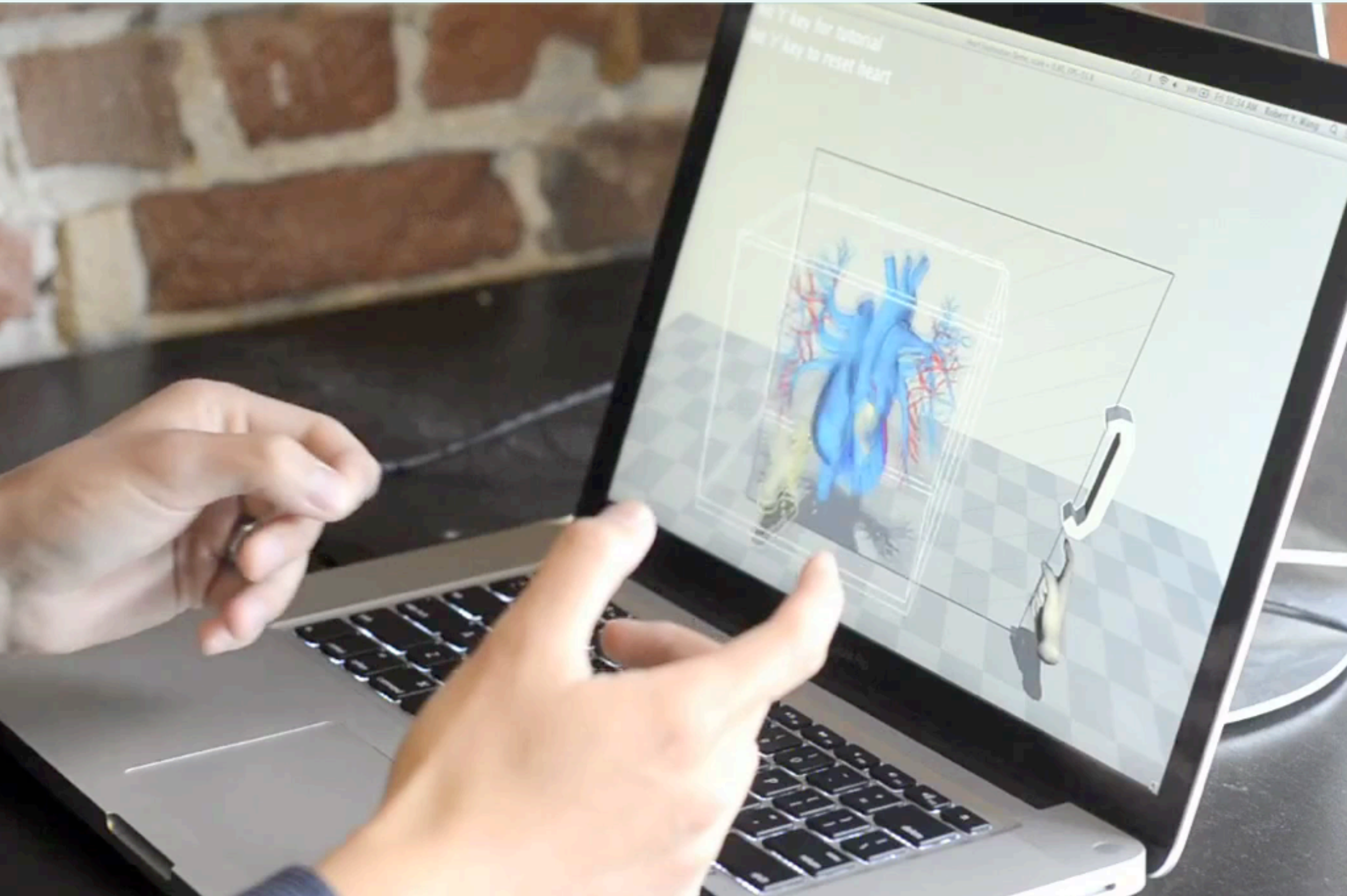


In Tablet

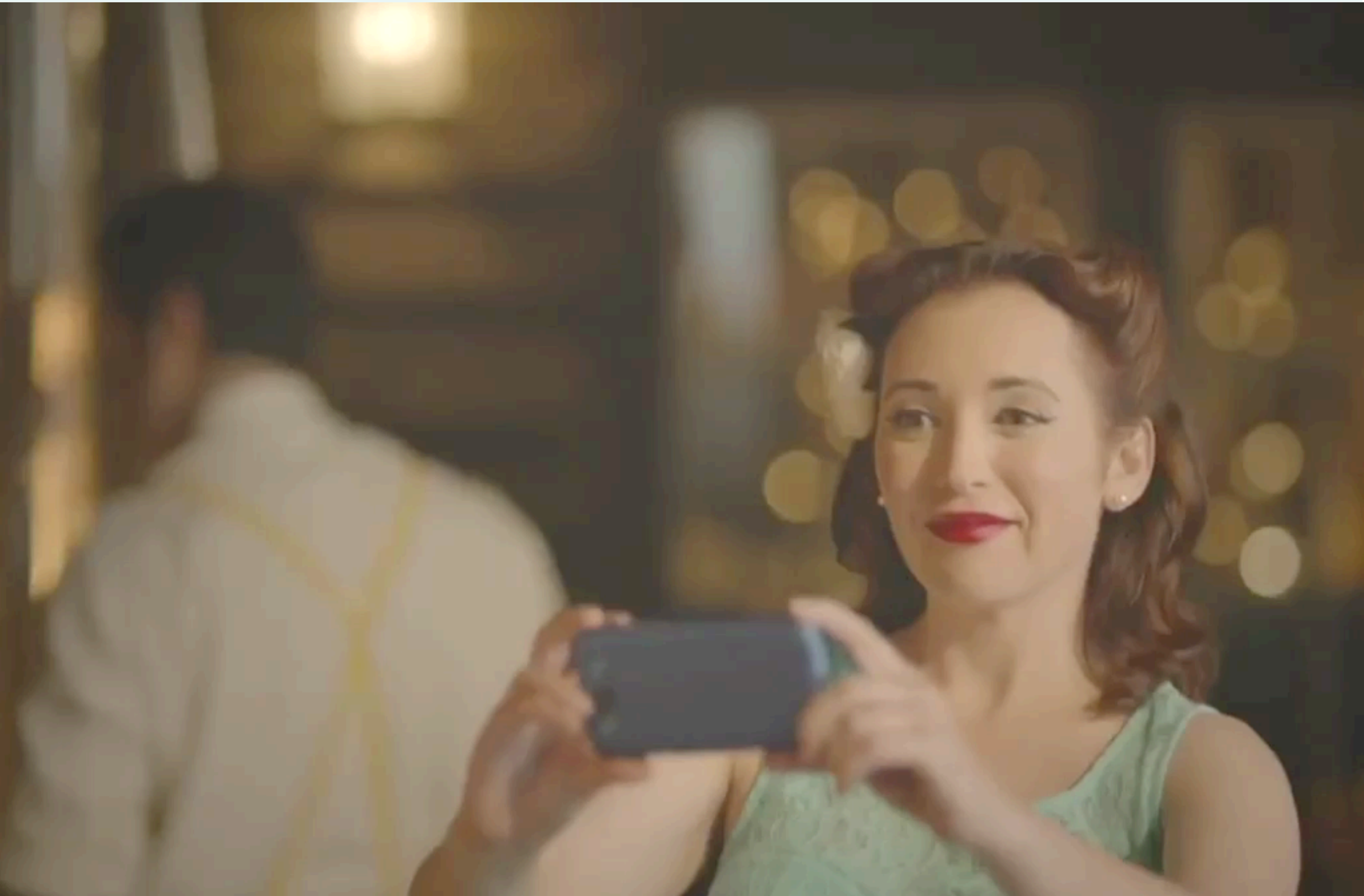
Laptops



Laptops



Smartphones



3D Printing

Fashion Industry

LE TOTE

phisix

3D Cities

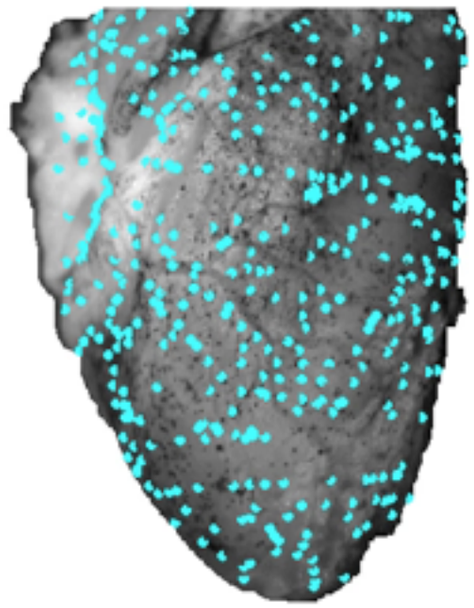
Google Earth

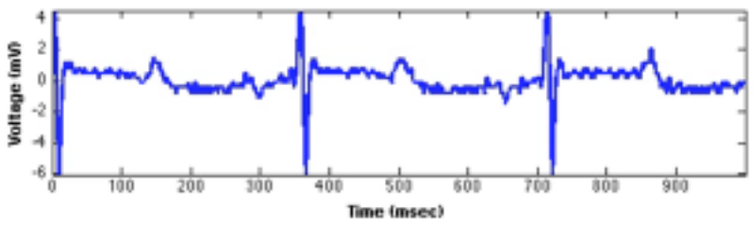
Oculus VR

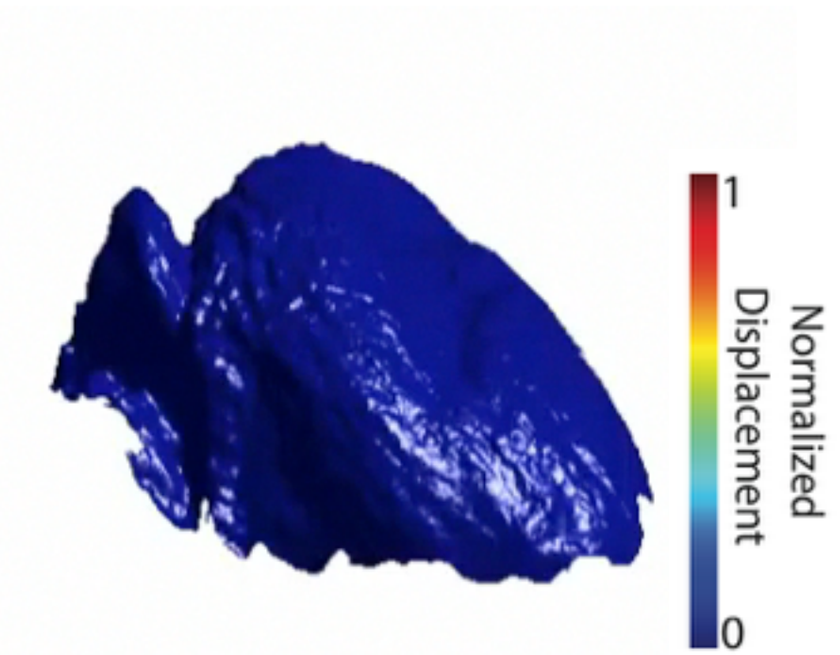
AR

Impacting Science

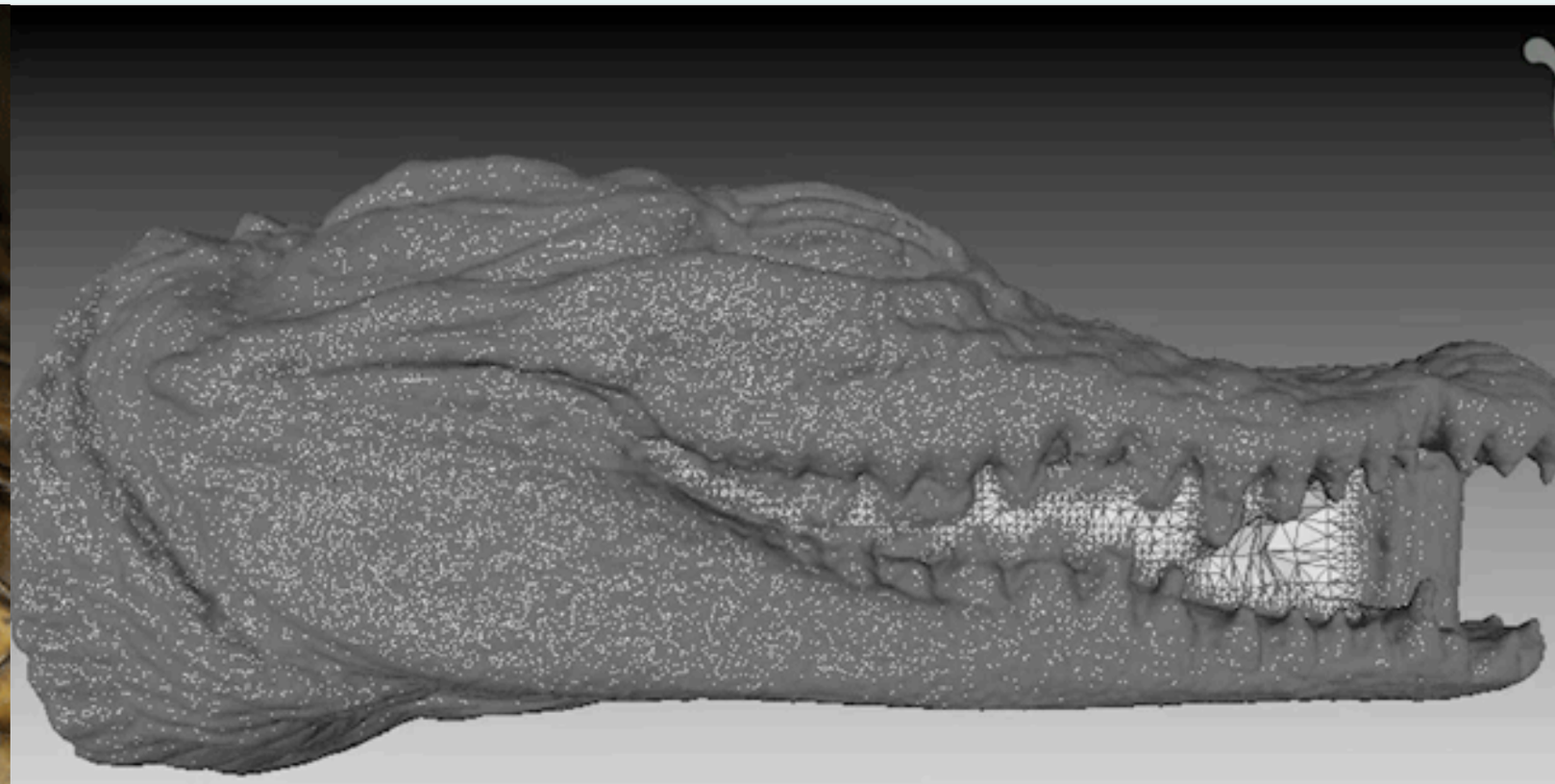
Cardiology




Voltage (mV)
4
2
0
-2
-4
-6
0
100
200
300
400
500
600
700
800
900
Time (msec)


1
0
Normalized
Displacement

Evolutionary Biology



Cancer Treatment

Target Audience

- **MSc** students, undergraduates, or interested **PhD** students
- **Computer Science**, Computer Engineering, Mathematics, Physics, Game Program, Biomedicine, Bioengineering, etc.
- Computer Graphics, Computer Vision, Robotics, Machine Learning, Signal and Image Processing, Medical Imaging

Administrative Stuff

Administrative

When and where?

- Tuesday, Thursday, 11:00 am - 12:20 pm
- Discussions on Thursday, 12:30 pm - 1:30 pm
- TTH 212 (Mark Taper Hall)

Credits

- 4 Units

This week

- No Discussion

The **Team**

Instructor

- Hao Li, hao.li@usc.edu
  - Office: SAL 244
  - Office hours: Tue, 2-4 PM

Assistants

- Kyle Olszewski, olszewsk@usc.edu
  - Office: TBD
  - Office hours: TBD
- Lingyu “Cosimo” Wei, lingyu.wei@usc.edu

Course Information On-Line

http://cs420.hao-li.com/

- Schedule (slides, readings)
- Assignments (details, due dates)
- Software (libraries, hints)
- Resources (books, tutorial, links)

http://blackboard.usc.edu/

- Submit assignments
- Forum, Q/A

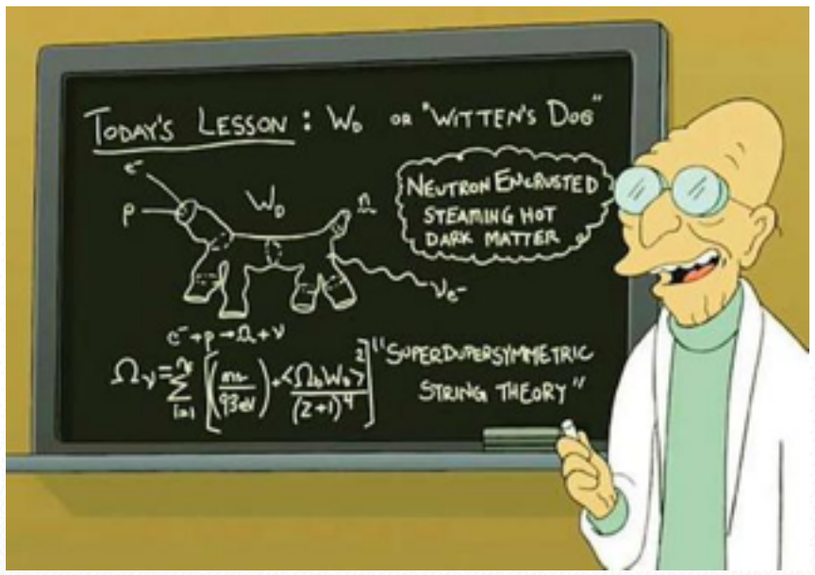
Prerequisites

Math

- Math 225 (Linear Algebra and Differential Equations)
- Familiarity with calculus and linear algebra

Coding

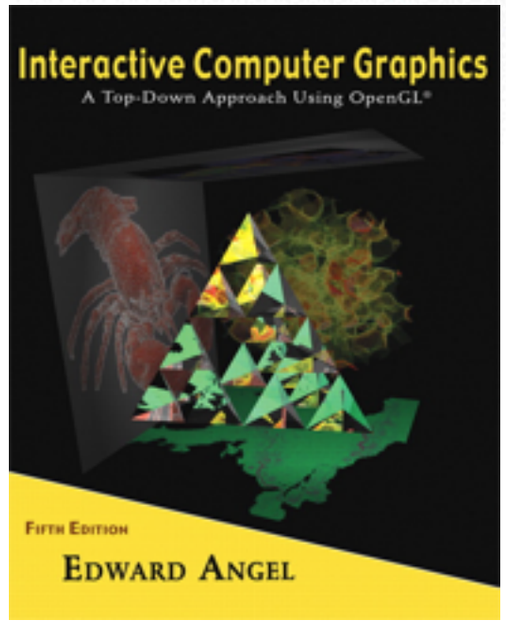
- CSCI 104 (Data Structures and Object-Oriented Design)
- C/C++ programming



Textbooks

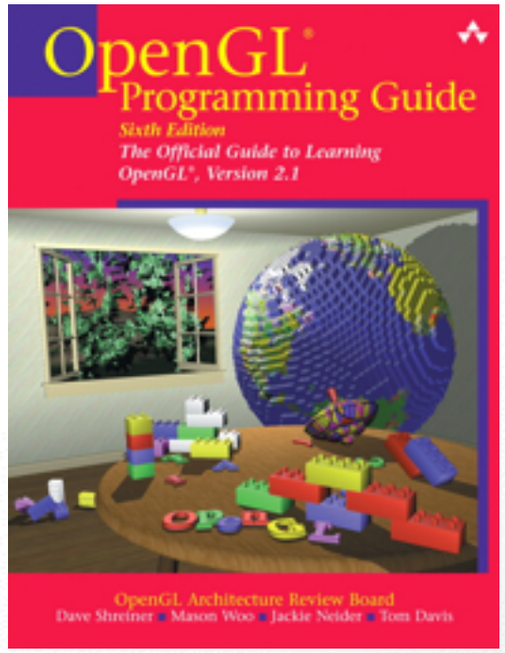
Interactive Computer Graphics

- A top-down approach with OpenGL, Fifth Edition, Edward Angel, Addison-Wesley



OpenGL Programming Guide ("Red Book")

- Basic version also available on-line (see Resources)



Grading

Exercises

- Ex 1: 16 %
- Ex 2: 17 %
- Ex 3: 17 %

Exams

- Midterm: 20% (one shee of notes only, in class)
- Final: 30% (one sheet of notes only)

Academic Integrity

- Do not copy any parts of the assignments from anyone
- Do not look at other student's code
- Collaboration only for the project
- USC Office of Student Judicial Affairs and Community Standards (Hell) will be notified
- Don't cheat, mkay?

Assignment Policies

Programming Assignments

- Hand in via Blackboard by end of due date
- Functionality and features
- Style and documentation
- Artistic impression

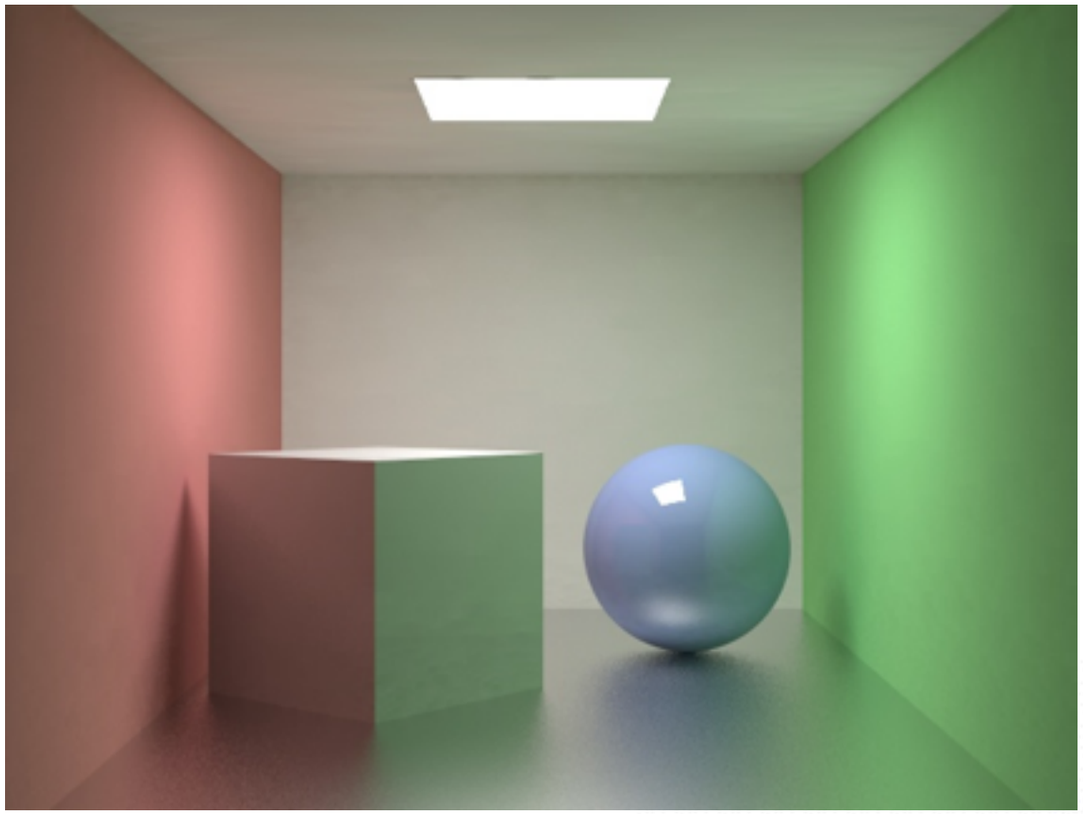
3 late days, usable any time during semester

Academic integrity policy applied rigorously

Computer Graphics

One of the “core” computer science disciplines:

- Algorithms and Theory
- Artificial Intelligence
- Computer Architecture
- **Computer Graphics**
- Computer Security
- Computer Systems
- Computer Vision
- Databases
- Machine Learning
- Networks
- Software Engineering



Course Overview

Theory / Computer Graphics Disciplines

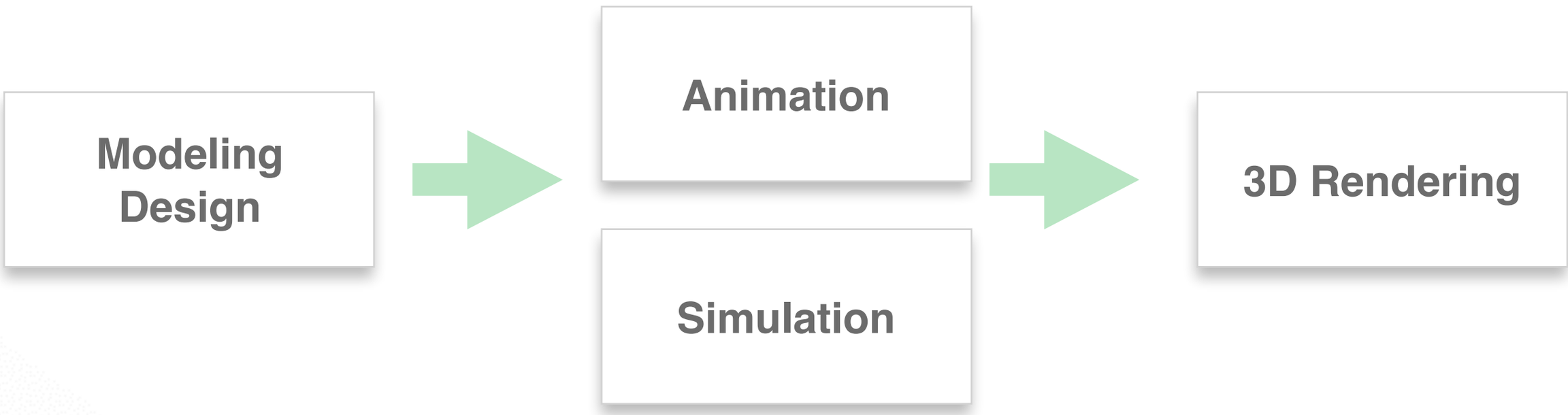
- Modeling: how to represent objects
- Animation: how to control and represent motion
- Rendering: how to create images of objects
- Image Processing: how to edit images

Practice: OpenGL graphics library

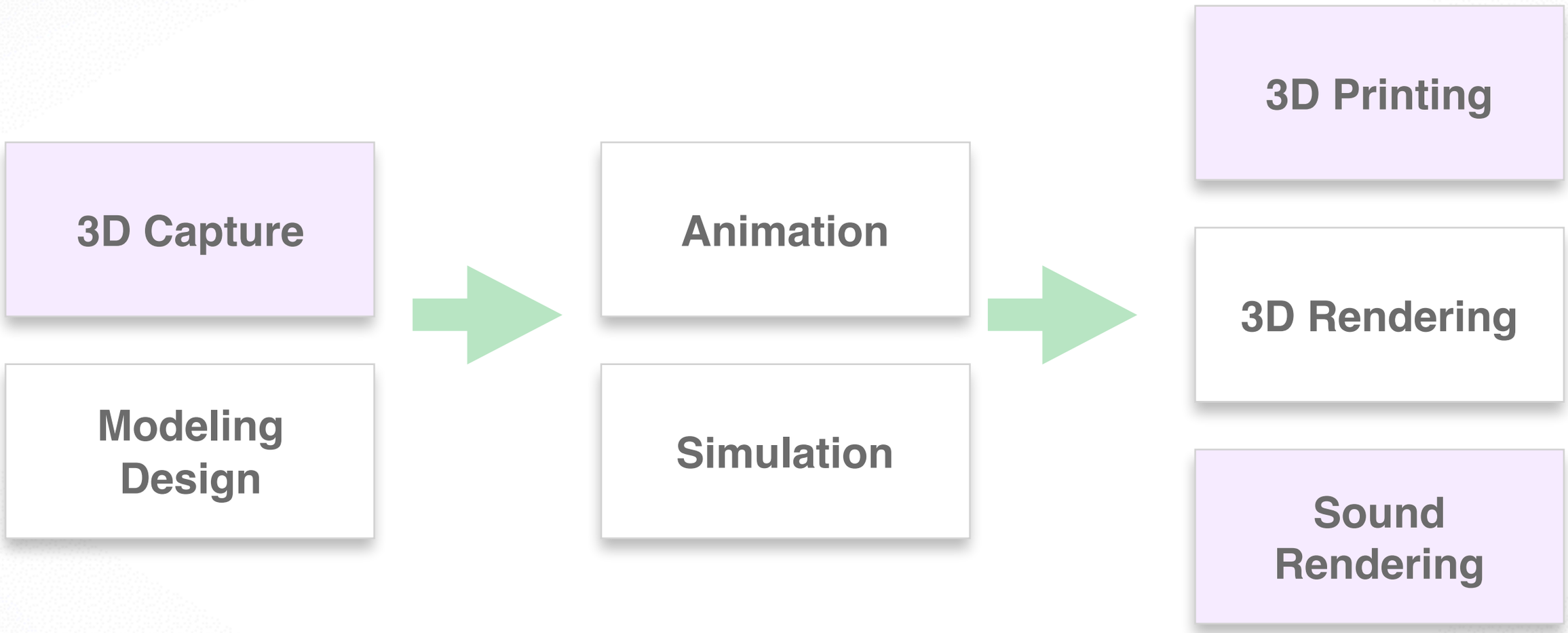
Not in this course:

- Human-Computer Interaction
- Graphic Design

3D Computer Graphics Pipeline



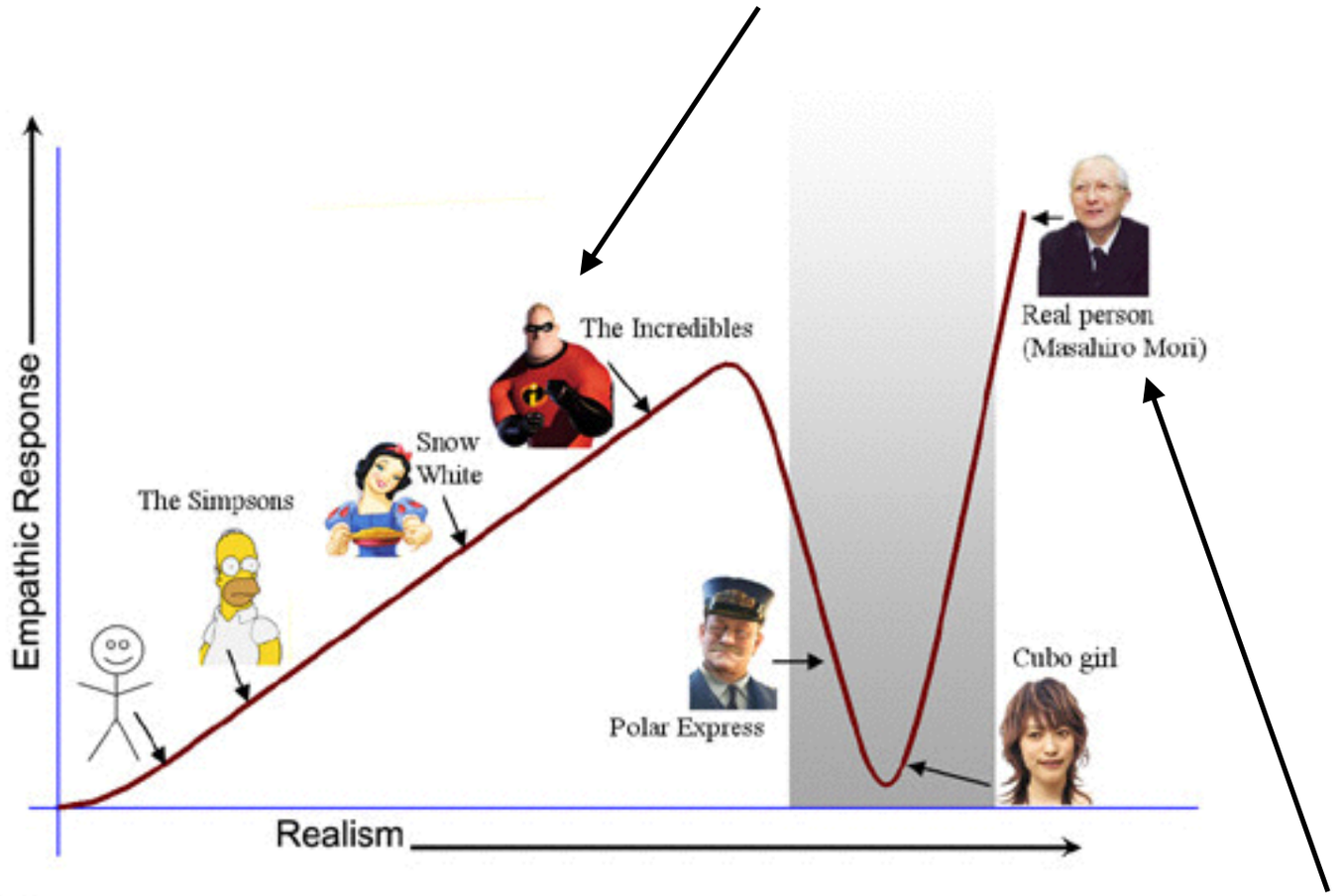
Emerging Fields



Goals in Computer Graphics

Creating a new reality (not necessarily scientific)

Practical, aesthetically pleasing, in real time



Synthetic images indistinguishable from reality

Practical, scientifically sounds, in real time

SIGGRAPH & SIGGRAPH Asia

- Main computer graphics event
- Twice a year
- up to 30K attendees
- Academia, industry, artists

ACMSIGGRAPH

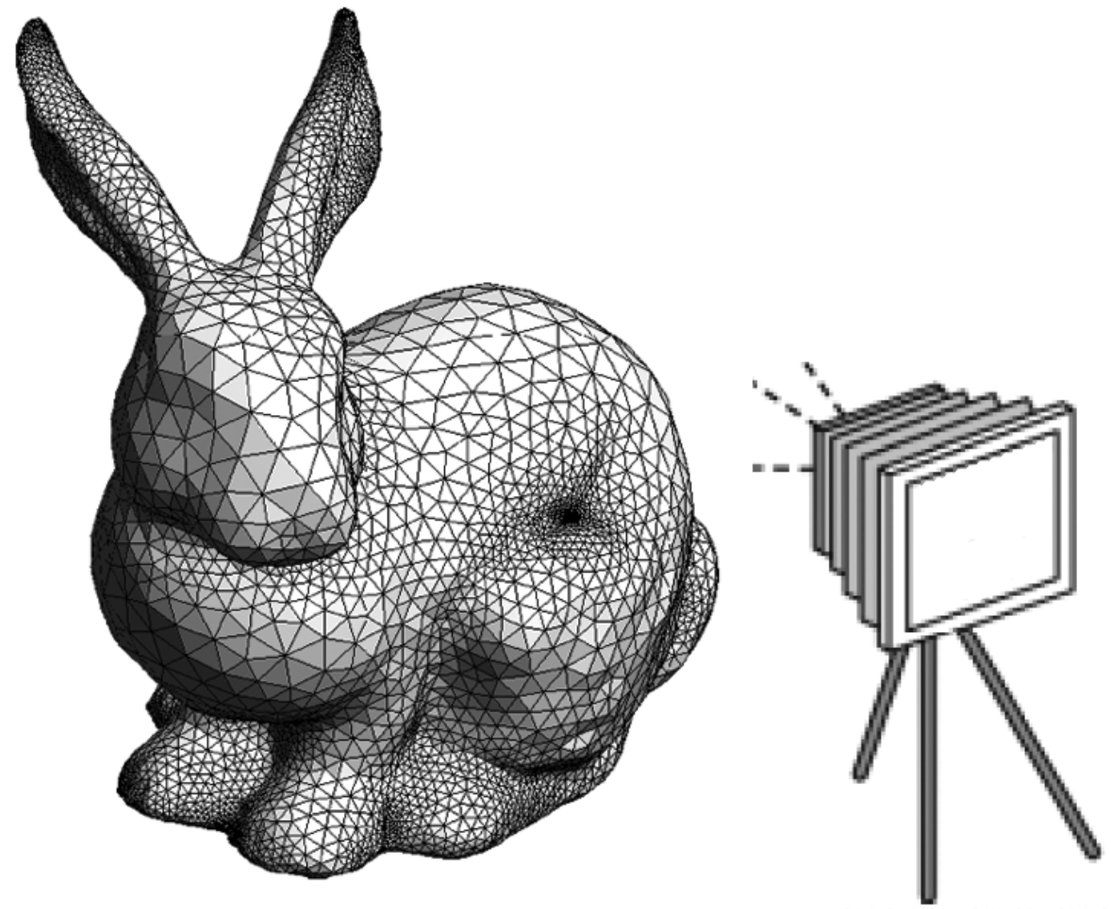
Course Overview

1.1 Introduction

- Graphics@USC
- What is Computer Graphics?
- Administrative Stuff
- Course Overview
- Research Trends

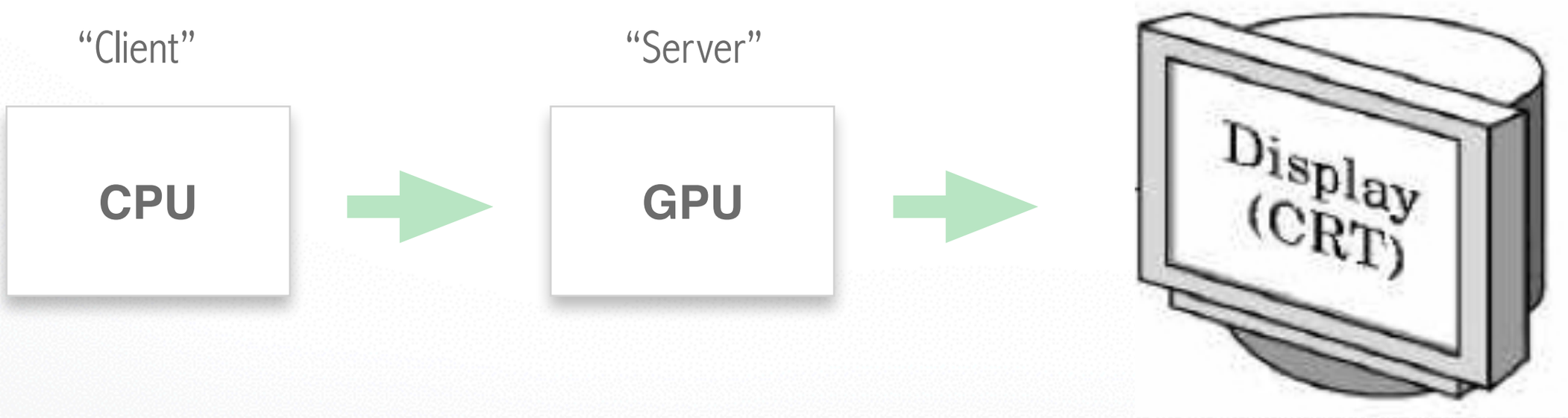
1.2 OpenGL Basics

- Primitives and attributes
- Color
- Viewing
- Control functions
- [Angel, Ch. 2]



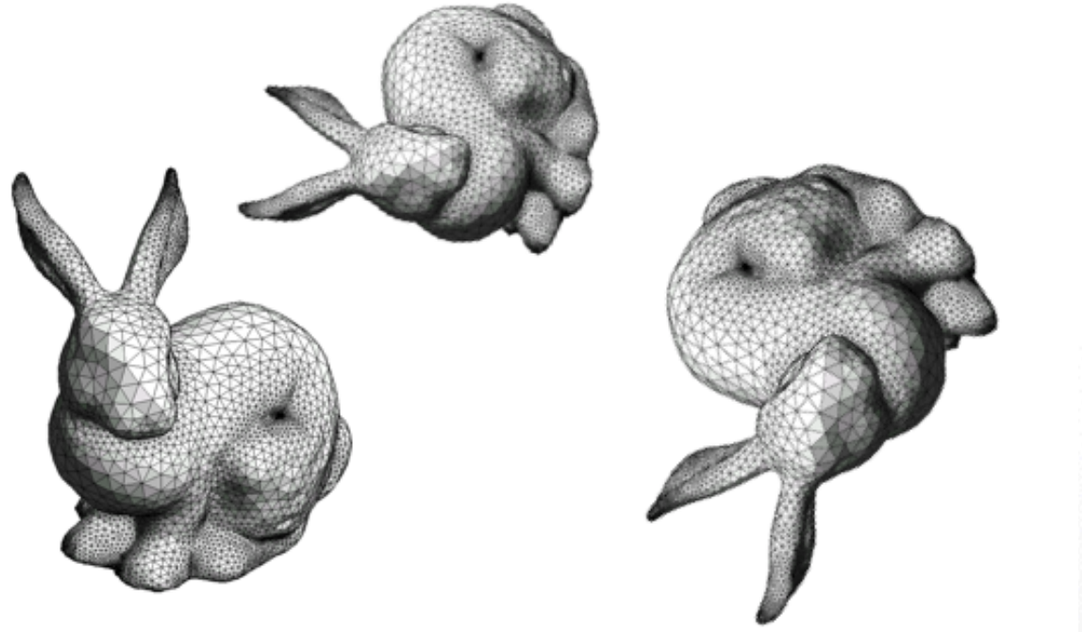
2.1 Input & Interaction

- Clients & servers
- Event driven programming
- Text & fonts
- [Angel, Ch. 3]



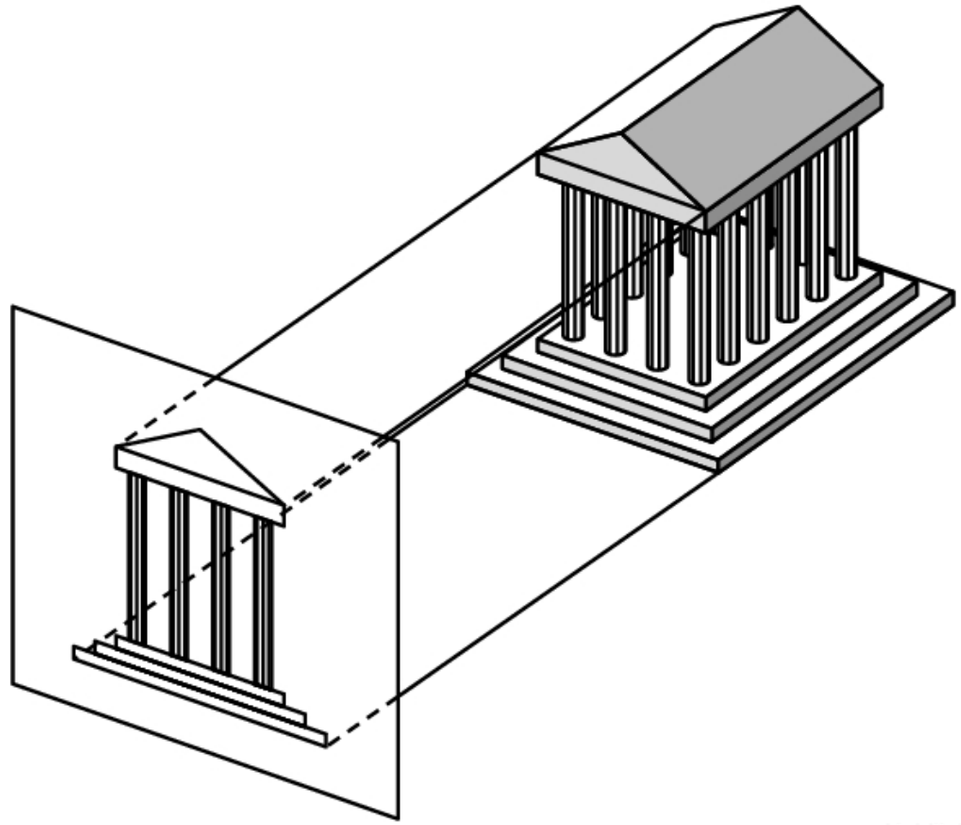
2.2 Objects & Transformations

- Linear algebra review
- Coordinate systems and frames
- Rotation, translation, scaling
- Homogenous coordinates
- OpenGL transformations
- [Angel, Ch. 4]



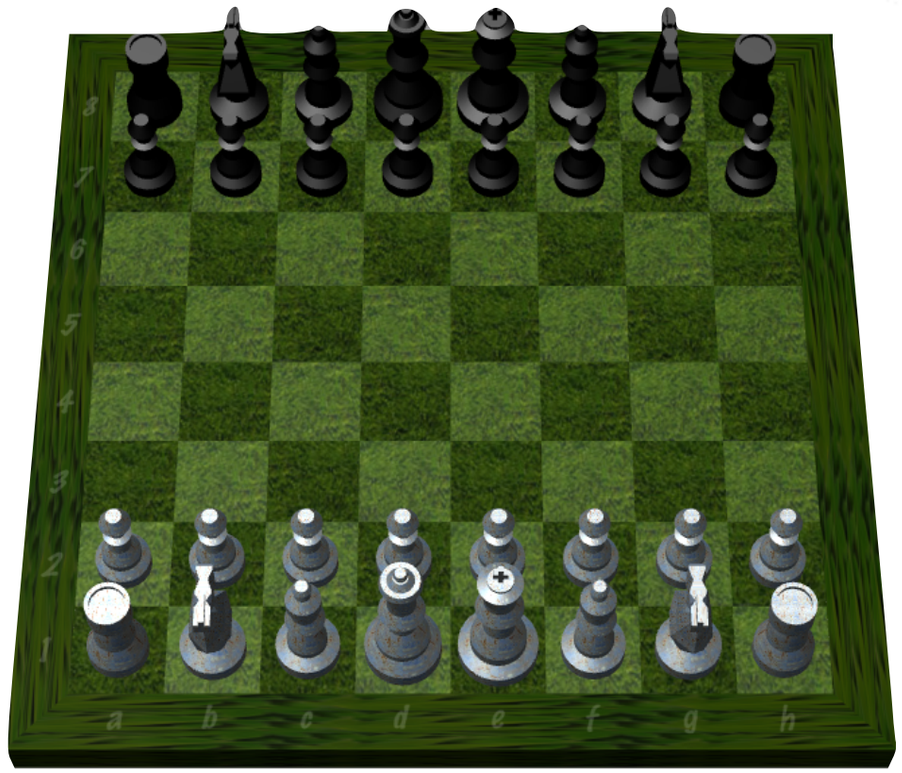
3.1 Viewing and Projection

- Orthographic projection
- Perspective projection
- Camera positioning
- Projection in OpenGL
- Hidden surface removal
- [Angel, Ch. 5]



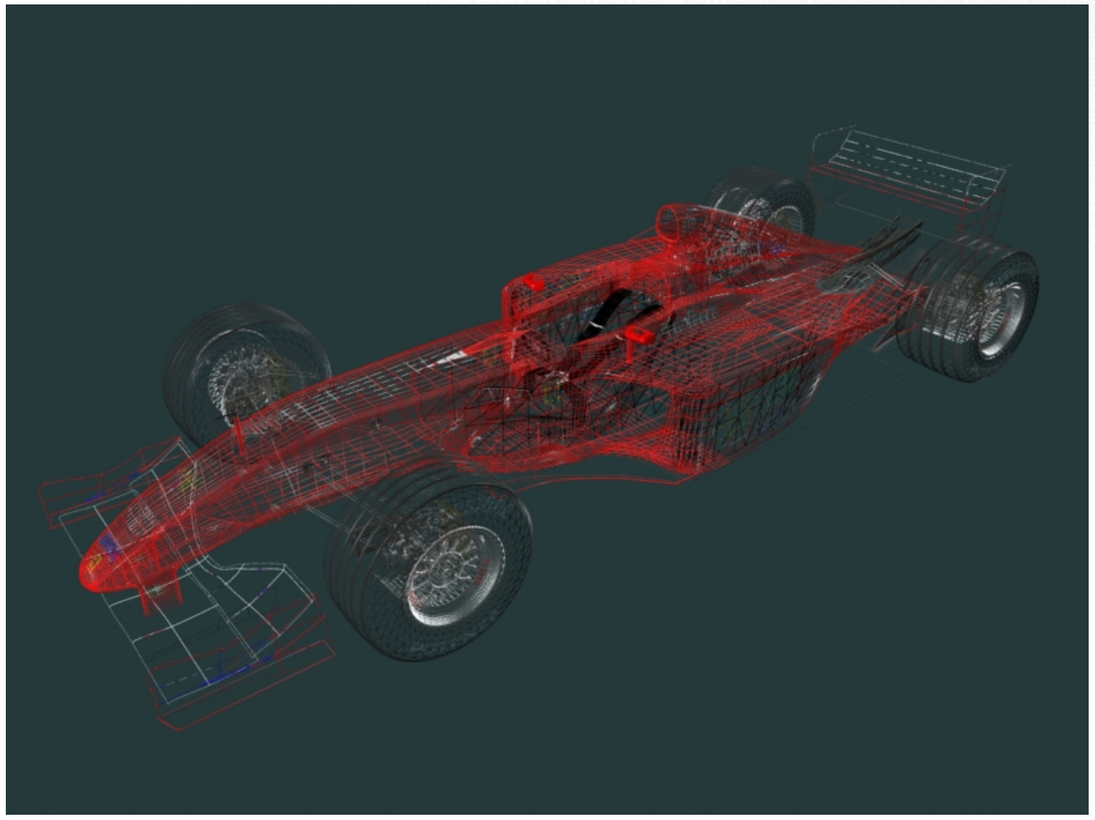
3.2 Hierarchical Models

- Re-using objects
- Animations
- OpenGL routines
- Parameters and transformations
- [Angel, Ch. 10]



4 Curves & Surfaces

- Recall 3D calculus
- Explicit representation
- Implicit representation
- Parametric curves & surfaces
- Hermite curves and surfaces
- Bézier curves and surfaces
- Splines
- Curves and surfaces in OpenGL
- [Angel, Ch. 12]



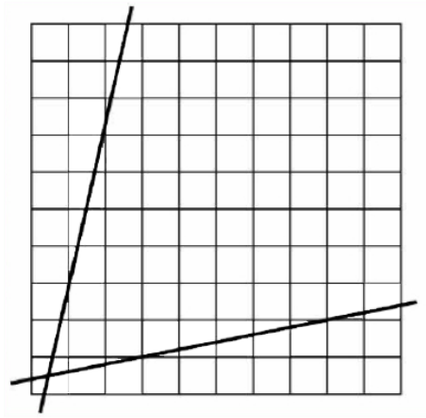
5.1 Light & Shading

- Light sources
- Ambient, diffuse, and specular reflection
- Normal vectors
- Material properties in OpenGL
- Radiosity
- [Angel, Ch. 6]

Tobian R. Metoc

5.2 Rendering

- Clipping
- Bounding boxes
- Hidden-surface removal
- Line drawing
- Scan conversion
- Anti-aliasing
- [Angel, Ch. 7,8]



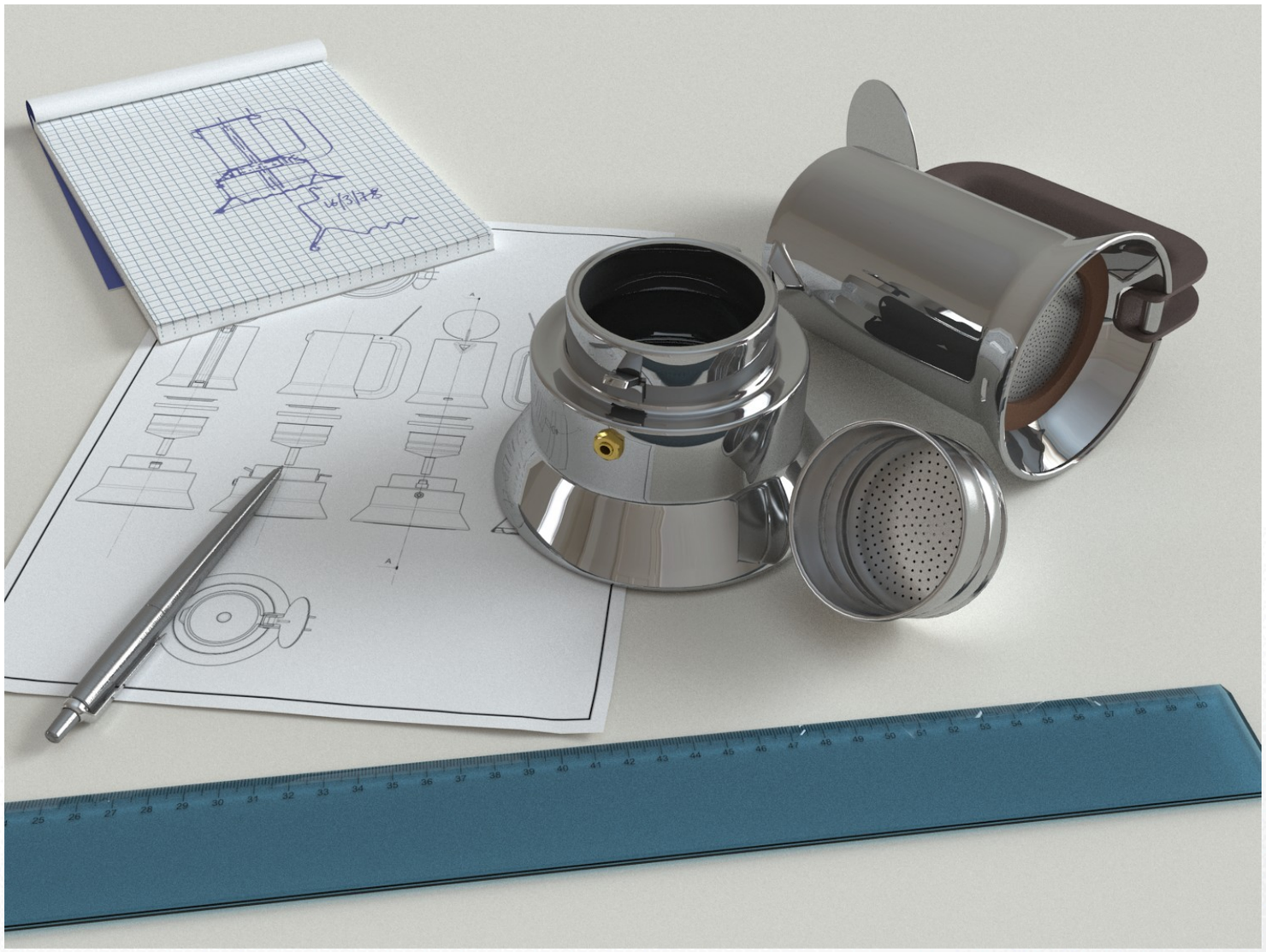
6-8 Textures and Pixels

- Texture mapping
- OpenGL texture primitives
- Bump maps
- Environment maps
- Opacity and blending
- Image filtering
- [Angel, Ch. 8]

texture mapping

9-10 Ray Tracing

- Basic ray tracing [Angel, Ch. 13]
- Spatial data structures [Angel, Ch. 10]
- Motion blur
- Soft shadows



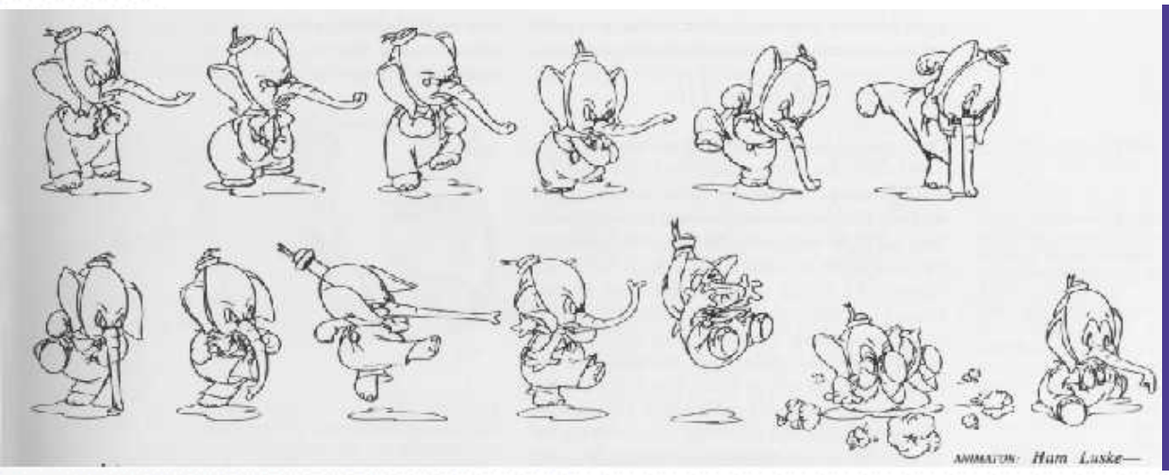
www.yafaray.org

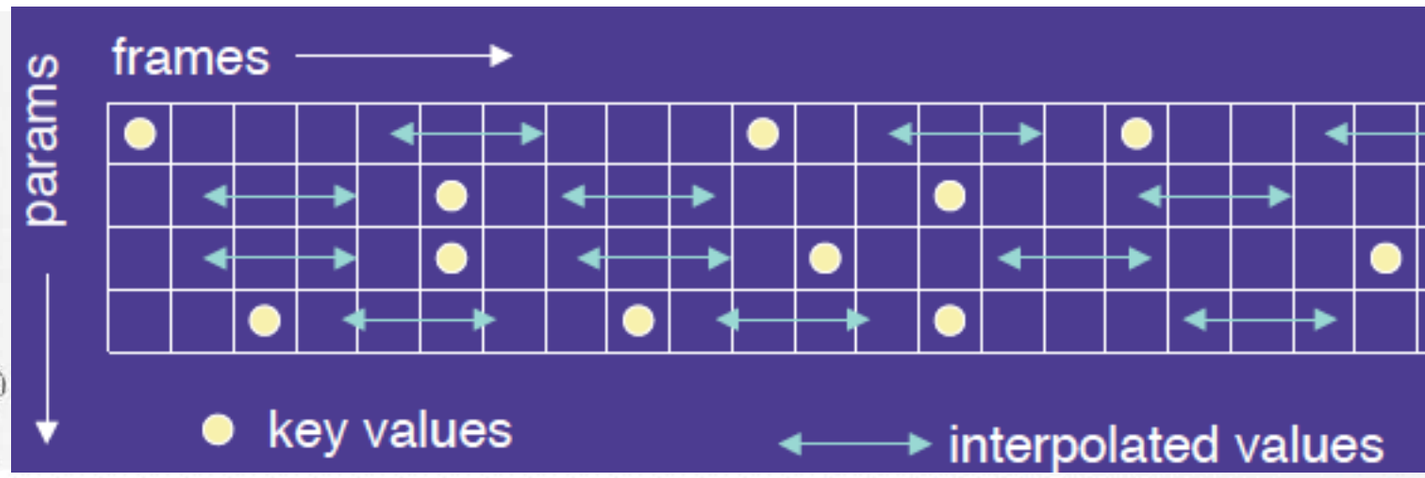
11.1 Radiosity

- Local vs global illumination
- Interreflections
- Radiosity equation
- Solution methods
- [Angel Ch. 13.4-5]

11.2 Animation

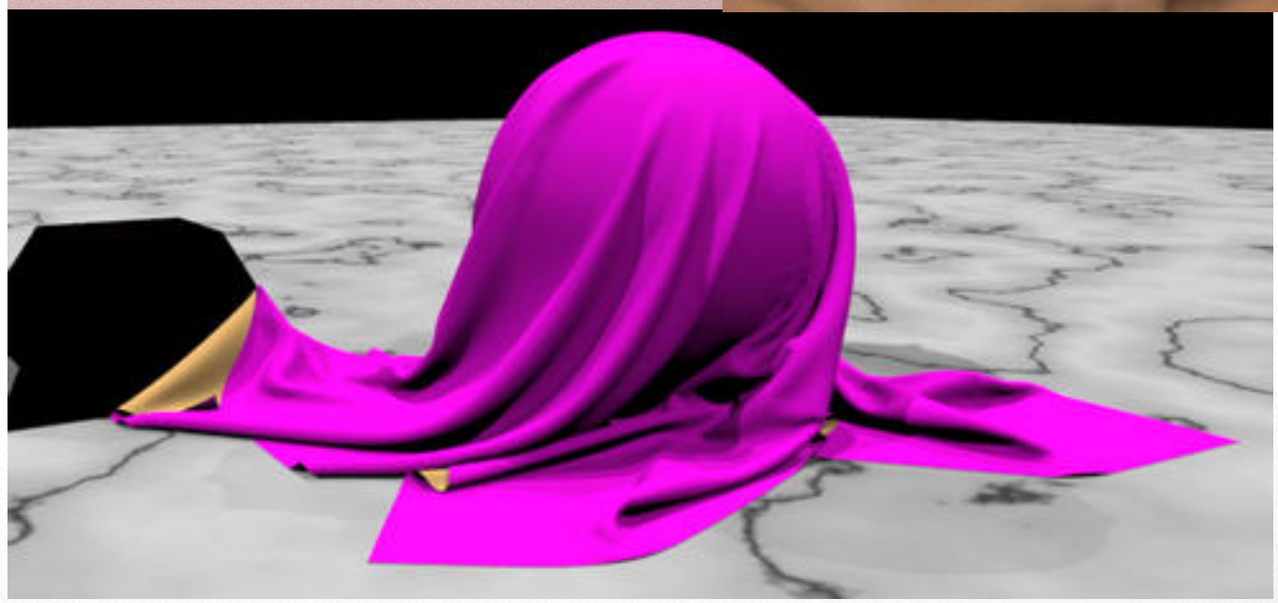
- Traditional Animation
- Keyframe Animation
- Computer Animation





12 Physically Based Models

- Particle systems
- Spring forces
- Cloth
- Collisions
- Constraints
- Fractals
- [Angel, Ch. 11]

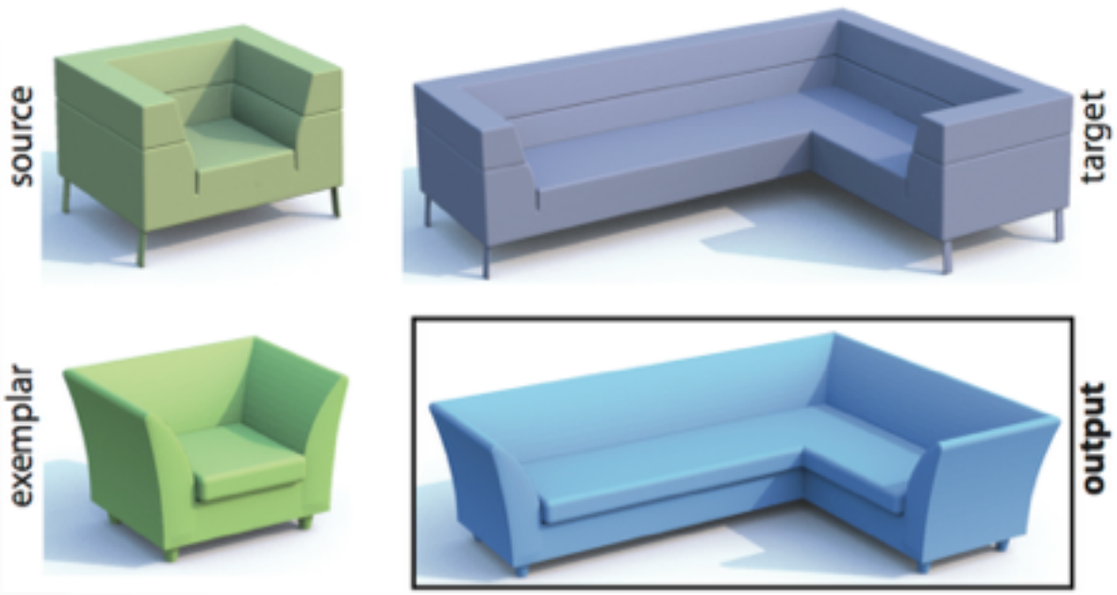


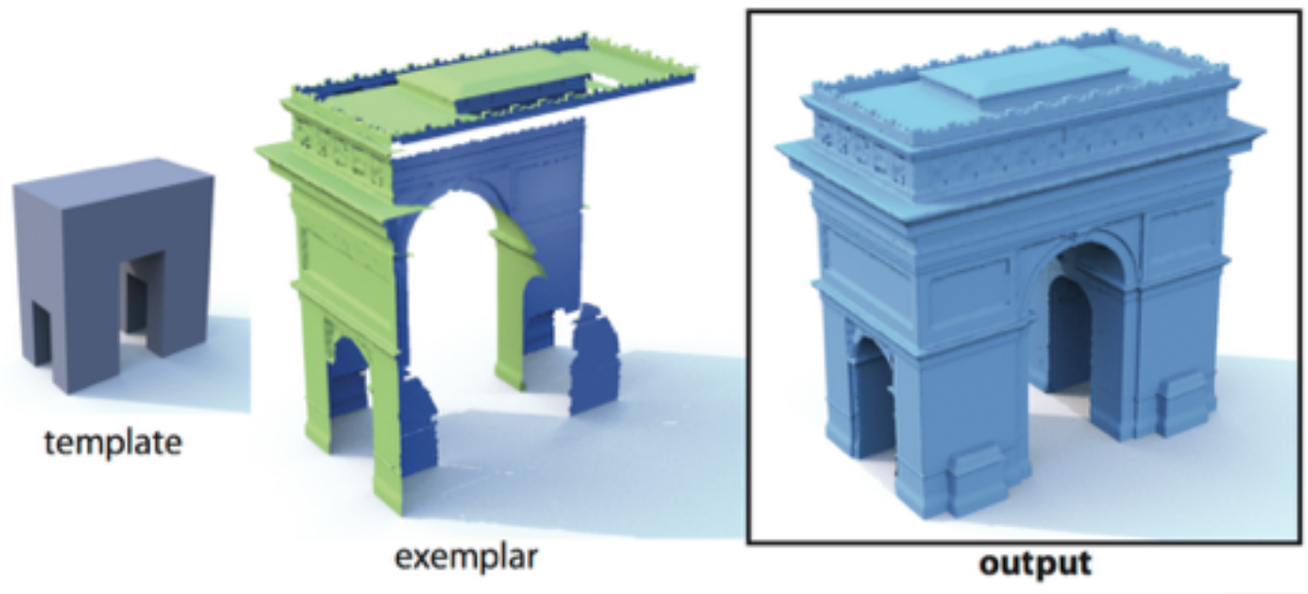
13 Image Processing

- Blending
- Display Color Models
- Filters
- Dithering
- [Angel, Ch 7-8]

14-15 Guest & “Wildcard” Lectures

- Realtime 3D Reconstruction
- Geometry Processing
- Graphics & Machine Learning
- Data-Driven Modeling
- …



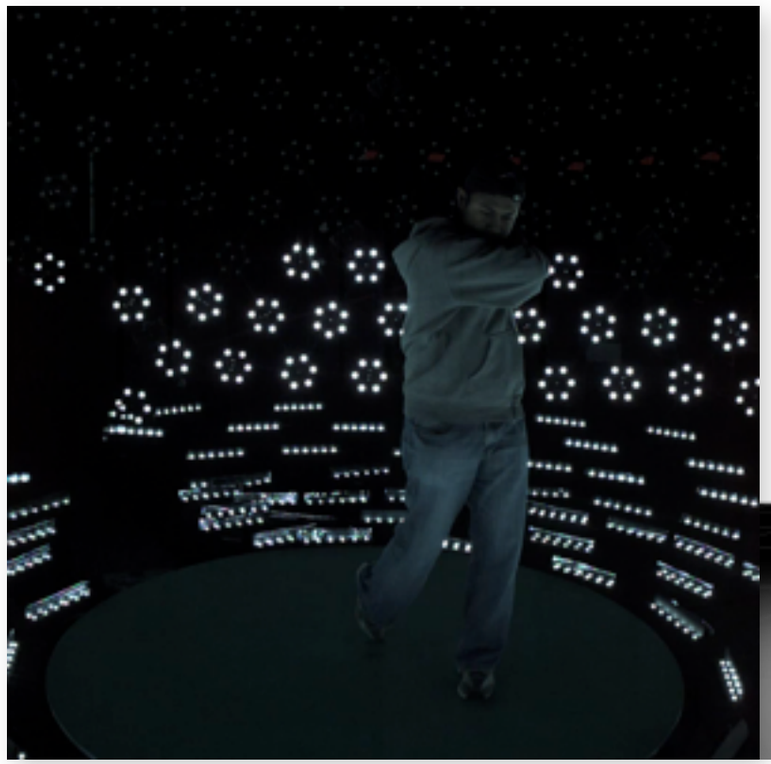


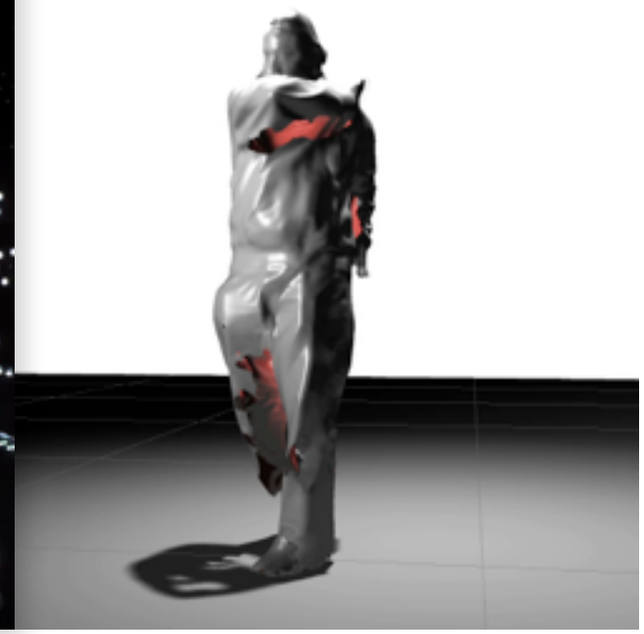
Research Trends

From Offline to Realtime

From Graphics to Vision

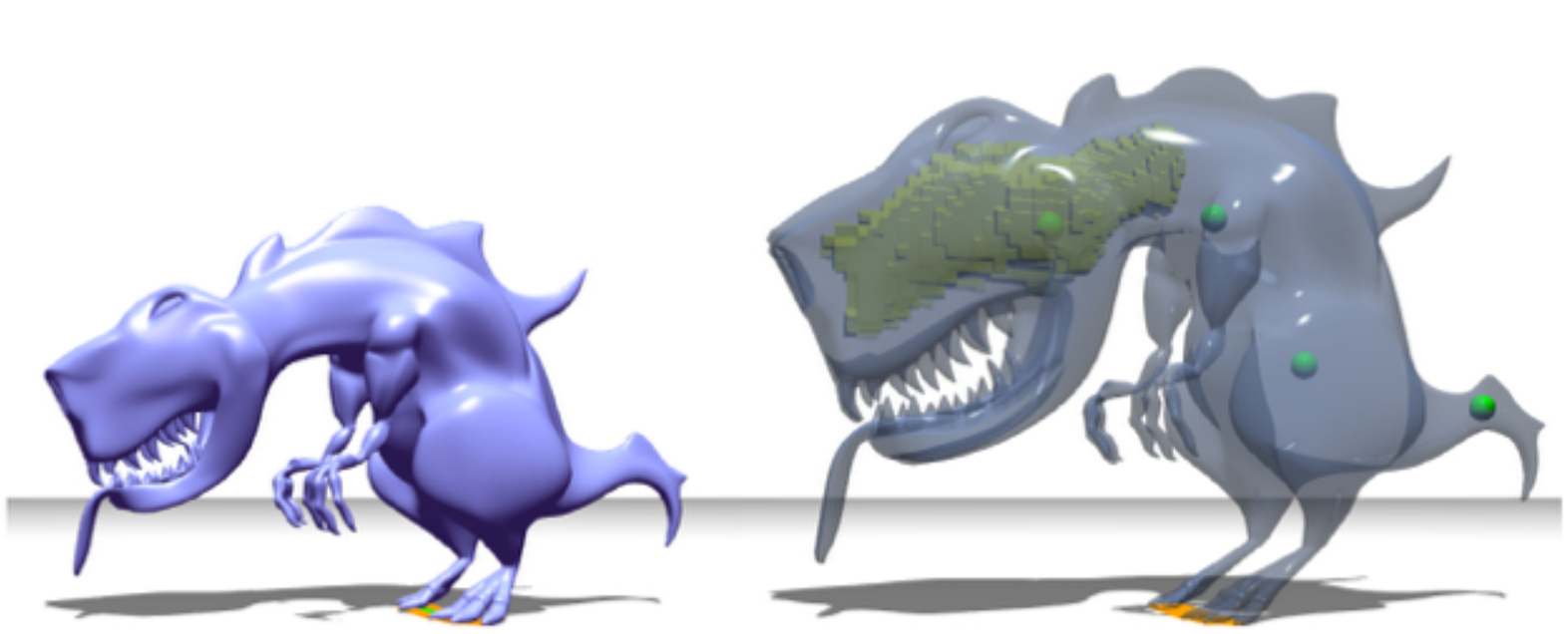
[Newcombe et al. ’11]
KinectFusion

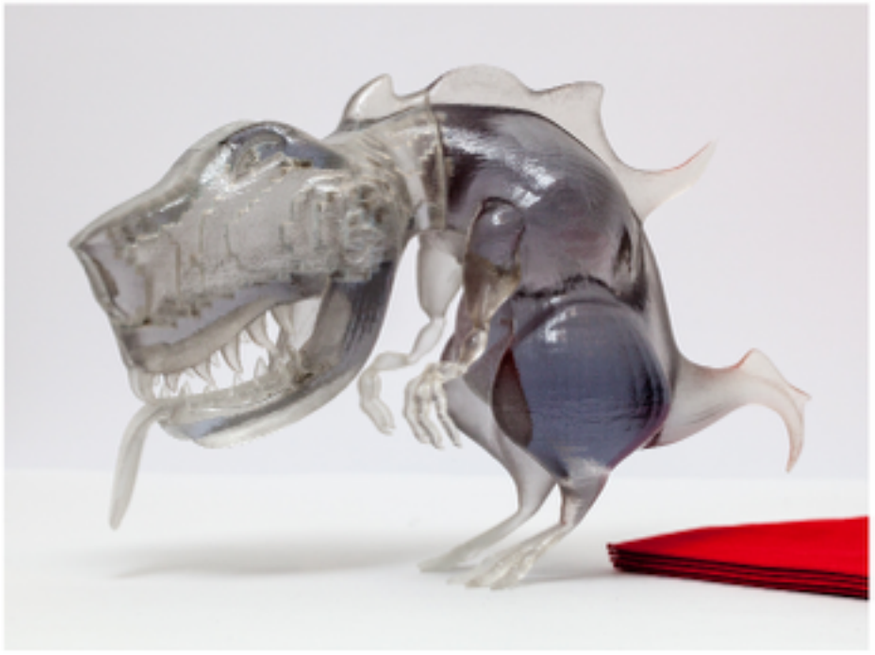


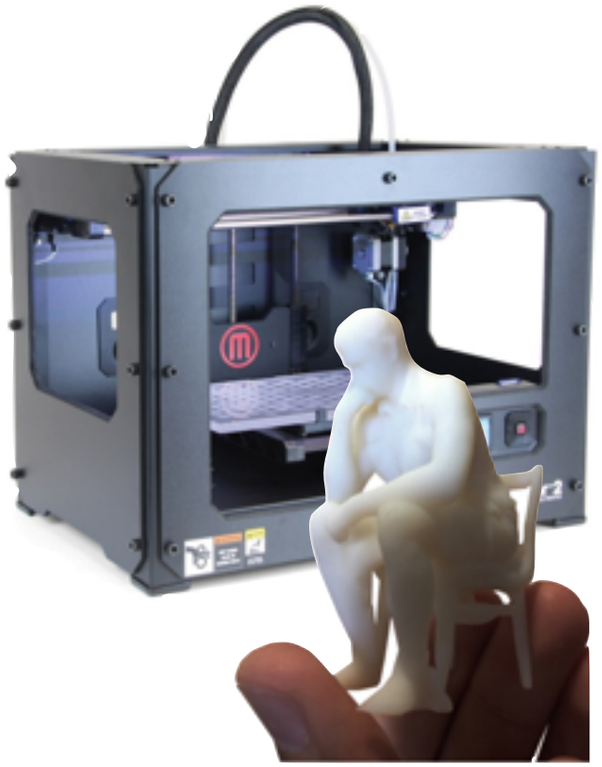


multi-view photometric stereo

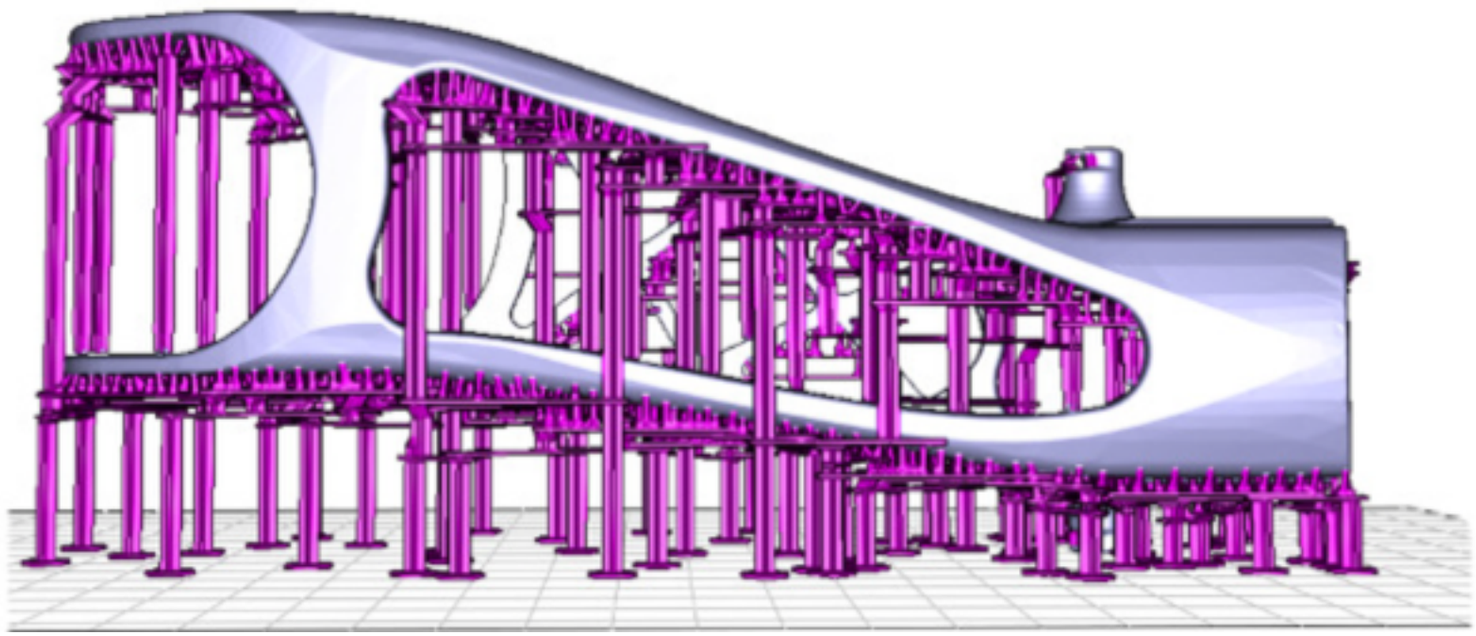
From Graphics to Fabrication







3D printing



From Production to Consumers

VFX

online shopping

Realtime Facial Animation

Live Demo

Acknowledgements

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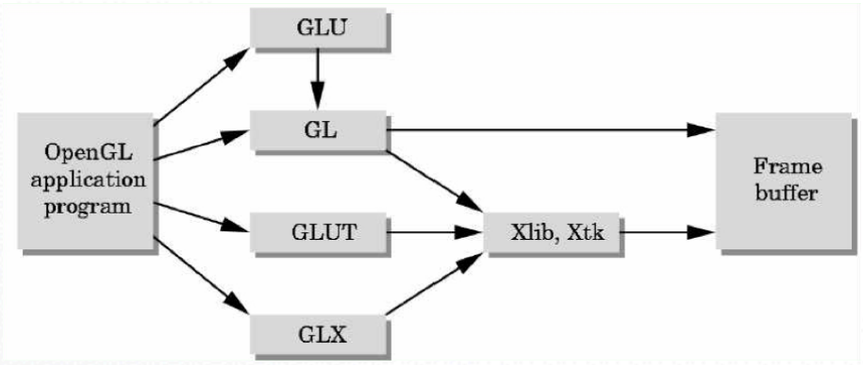
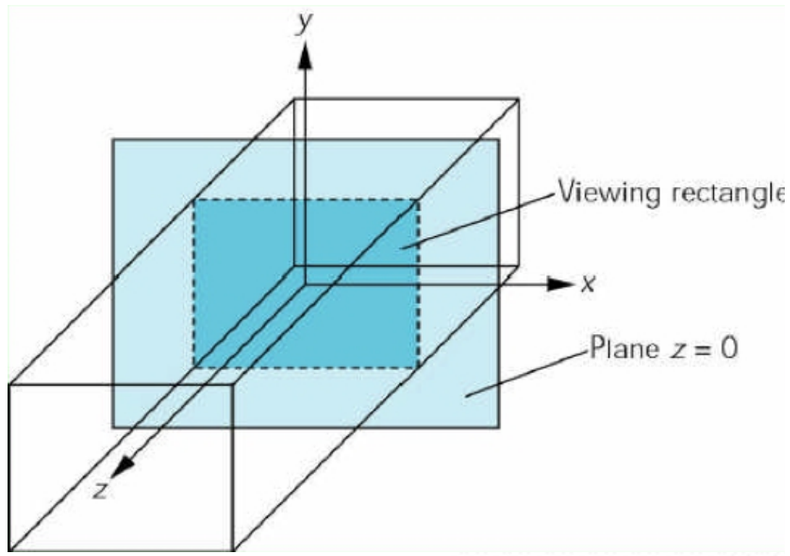
- Jessica Hodgins, CMU
- Mark Pauly, EPFL
- Justin Solomon, Stanford/Princeton/MIT
- Cornell, MIT, UC Berkeley, …

Next Time

- Basic Graphics Programming
- OpenGL Pipeline





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Thanks!