

CSCI 420: **Computer Graphics**

Fall 2014

Hao Li

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



<http://hao.li/>

Geometric Capture [Lab]



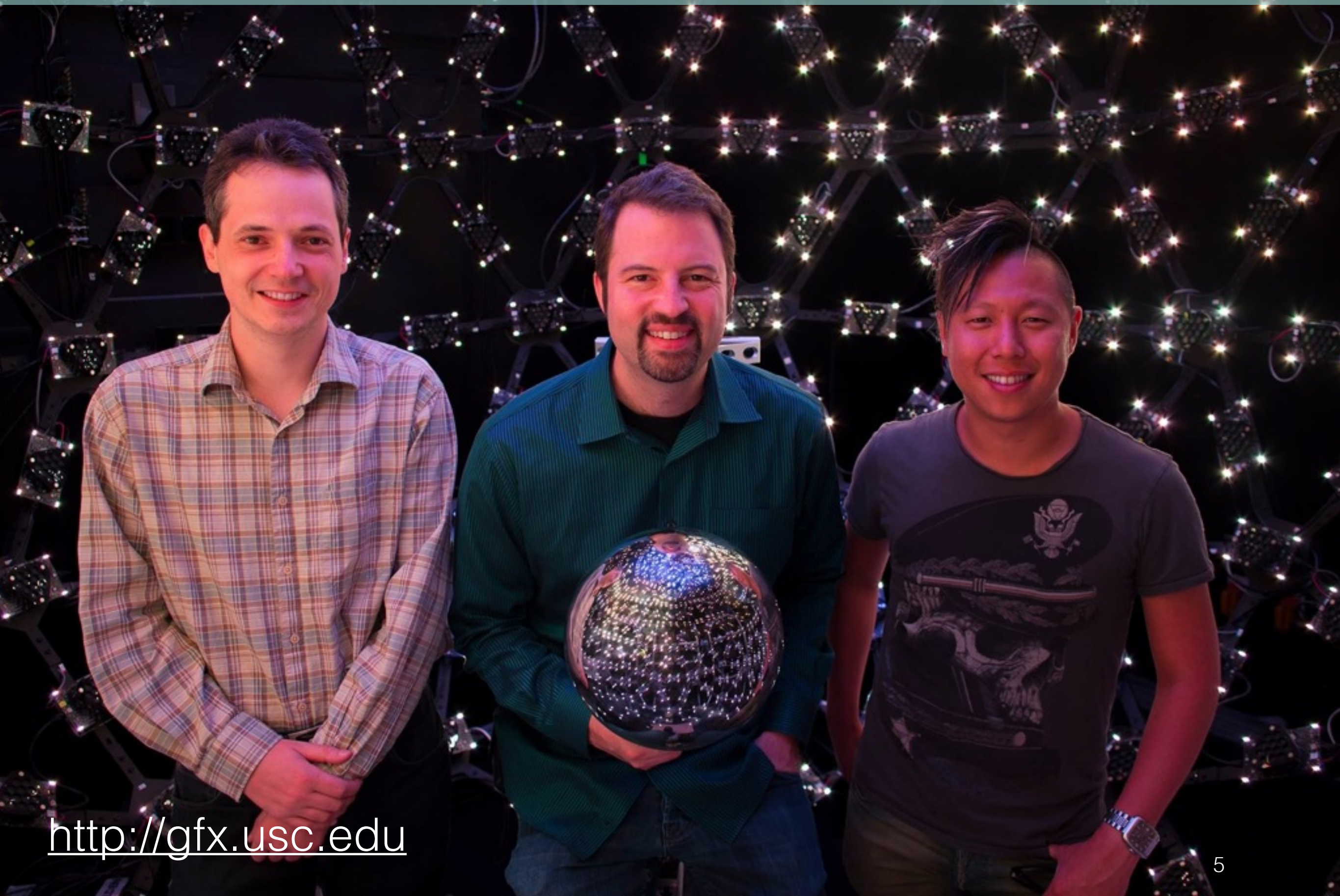
About Me



Industrial Light & Magic



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



Disney

A photograph of a Disney building with a large Mickey Mouse head silhouette on the roof. The building is a multi-story structure with a red and white striped awning. The word "Disney" is written in large, white, stylized letters across the front of the building.

DreamWorks

A photograph of the DreamWorks building, a large, modern structure with a prominent archway. The word "DREAMWORKS" is visible on the building's facade. The building is surrounded by greenery and trees.

Activision

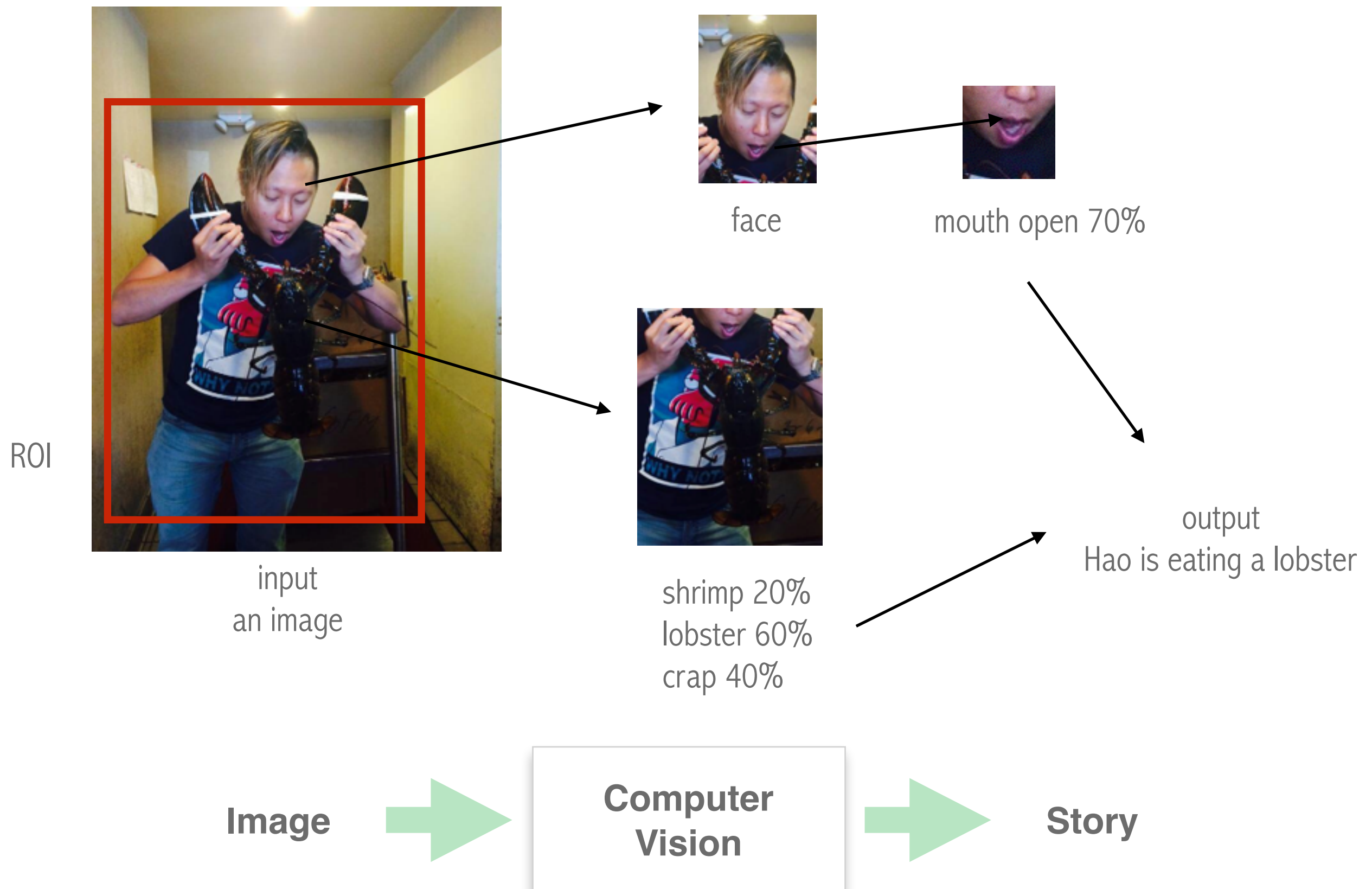
A photograph of an Activision game store display. The word "ACTIVISION" is prominently displayed in large, white, stylized letters. Below it, a sign for "CALL OF DUTY BLACK OPS II" is visible. The display is set up in a dark, industrial-looking environment with various game-related items and people in the background.

Google

A photograph of the Google building, a large, modern structure with a prominent archway. The word "Google" is written in large, white, stylized letters across the front of the building. The building is surrounded by greenery and trees.

Computer Graphics vs. Vision

Computer Vision

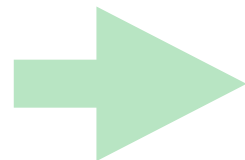


Computer Graphics

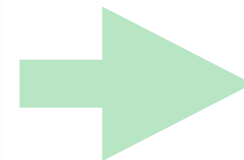


and... Action!

Story

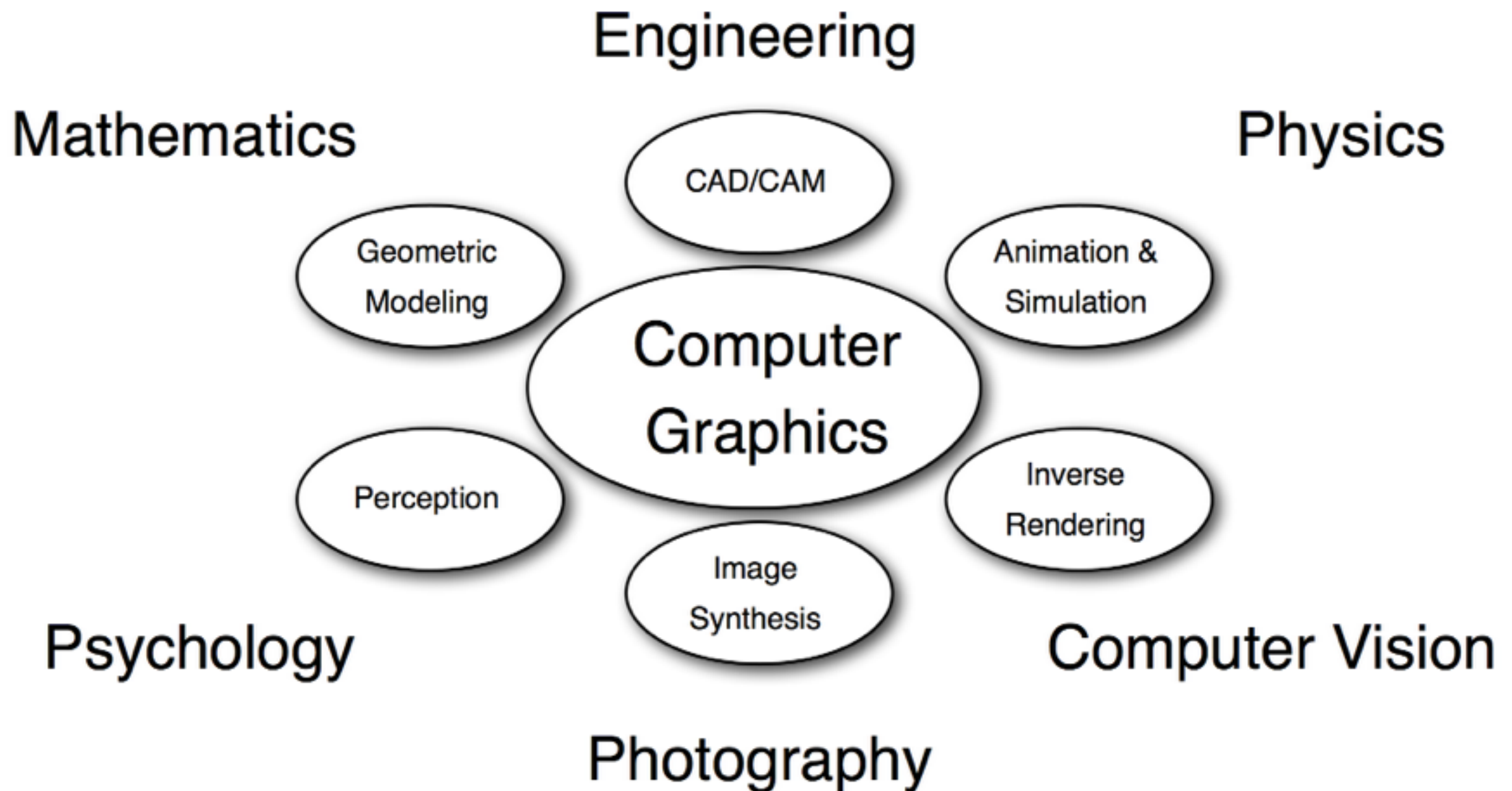


**Computer
Graphics**



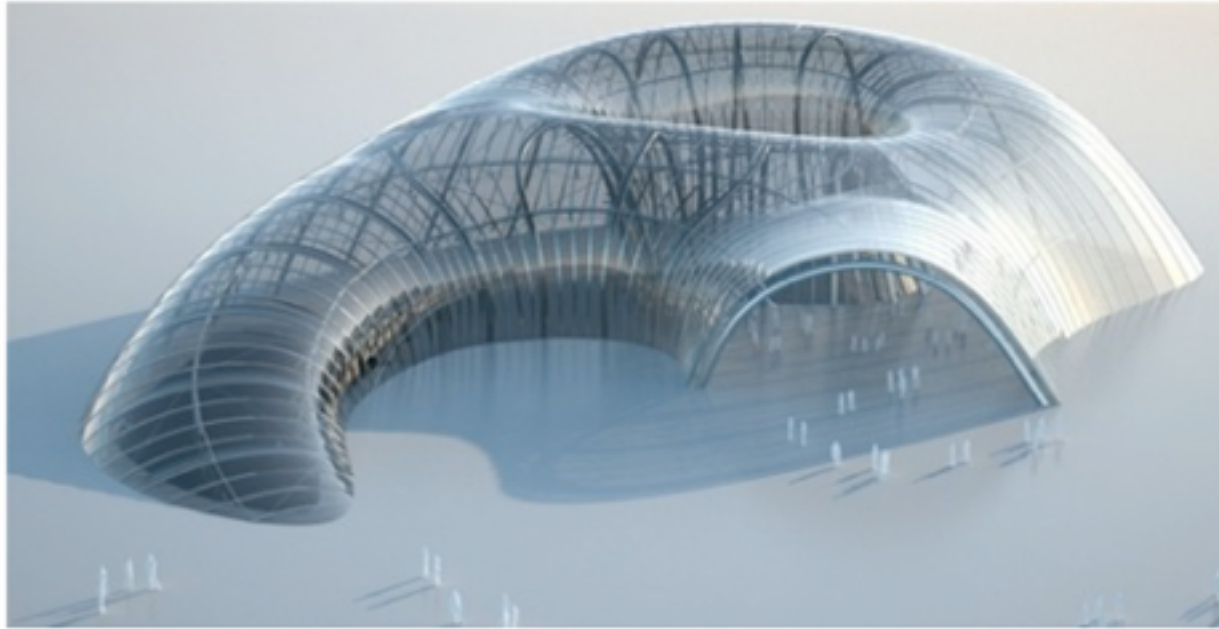
Image

Related to many Disciplines



Applications

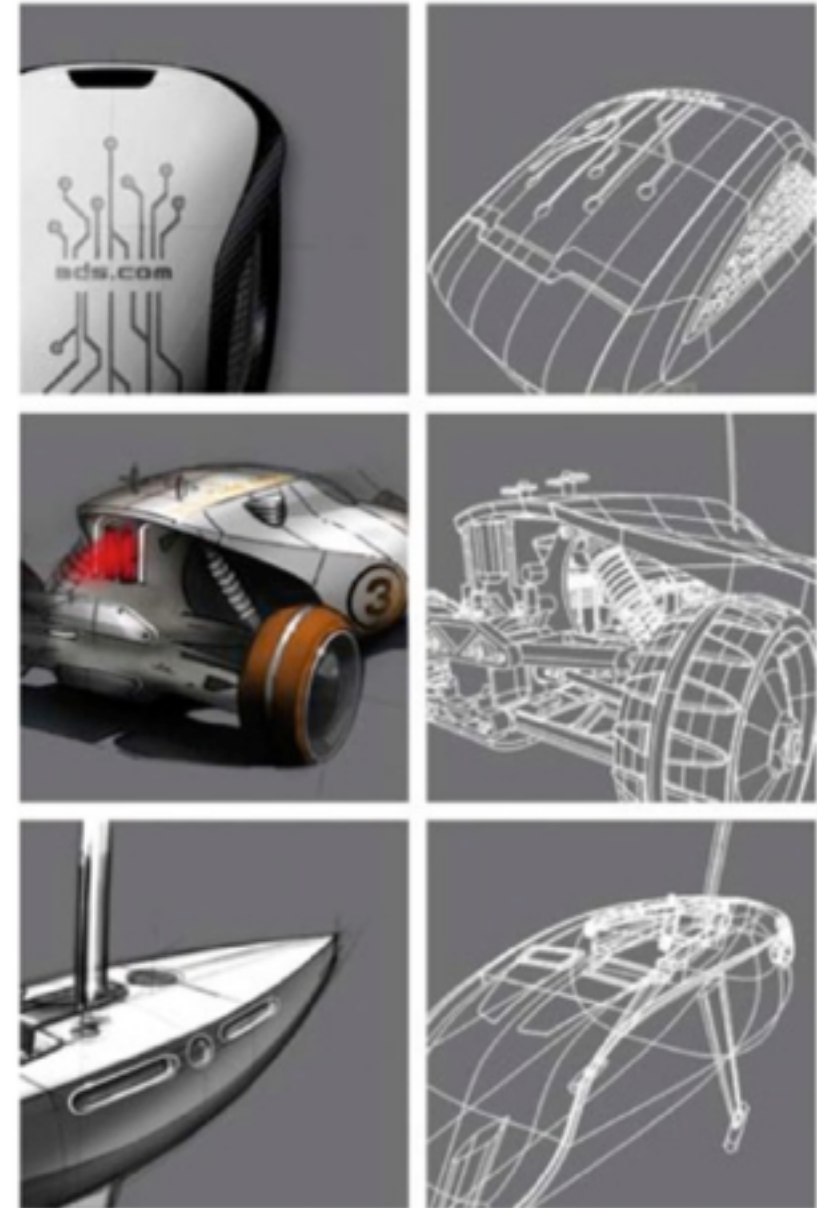
Computer Aided Design



evolute - architectural design

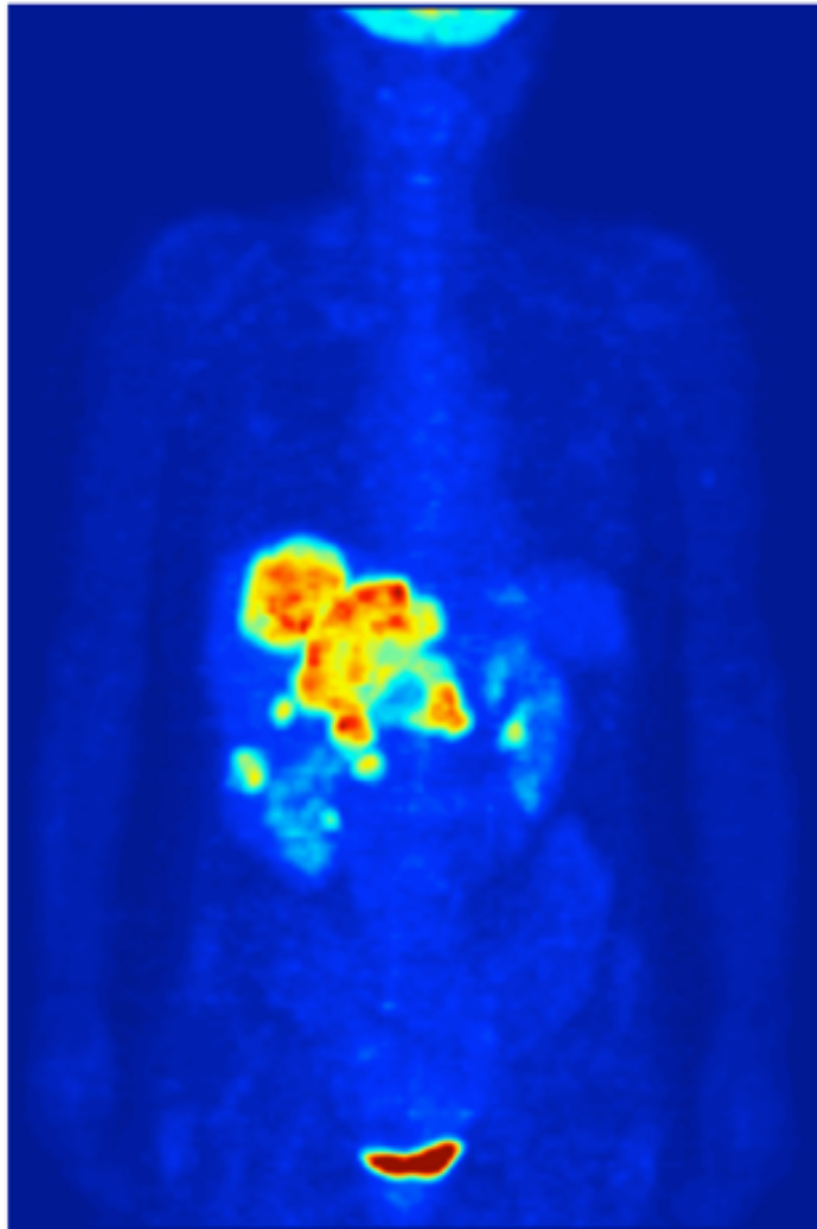


cyberswift - mechanical design

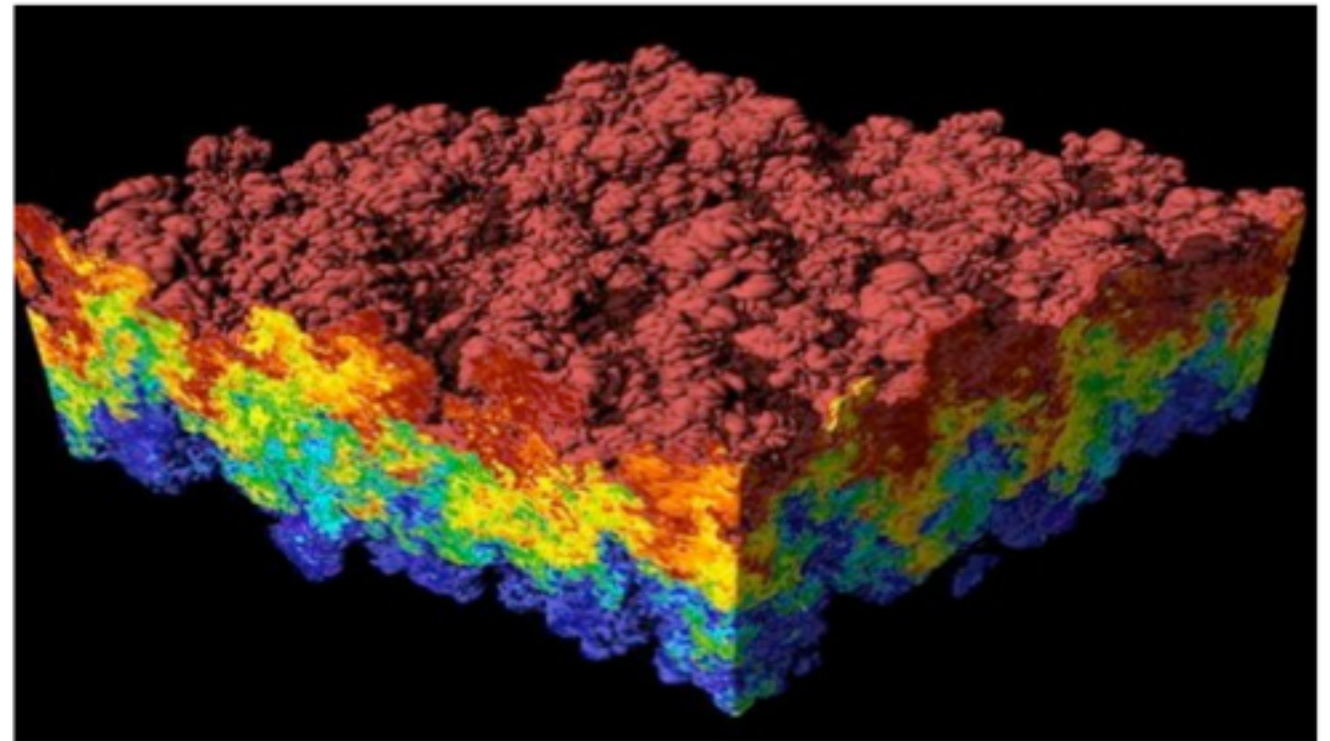


catia - product design

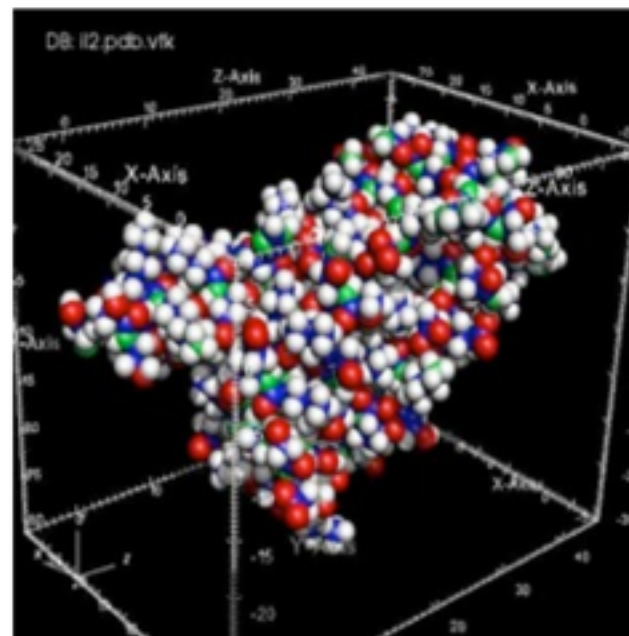
Scientific Visualization



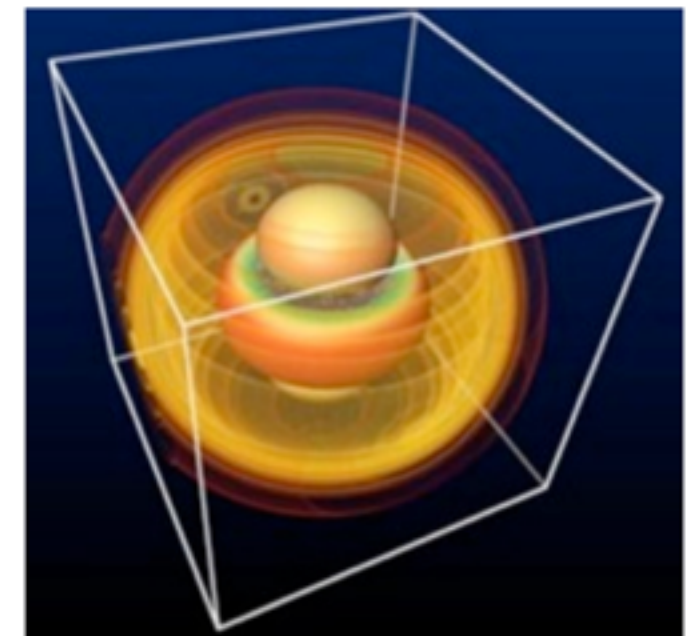
Wikipedia -PET scan



Wikipedia - mixing fluids



Wikipedia - protein rendering



Wikipedia - gravity waves

Training / Simulation

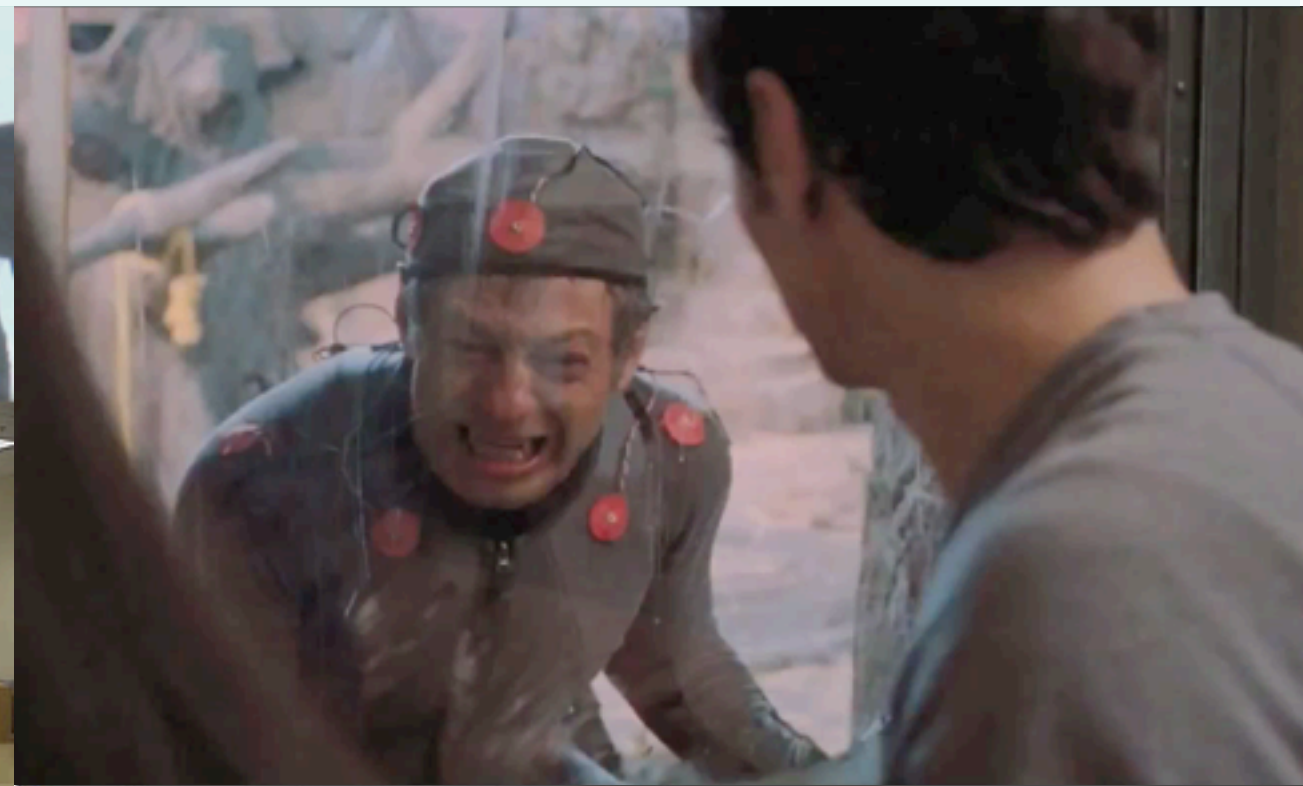


Microsoft - flight simulator



Aalborg University - surgery simulation

Entertainment

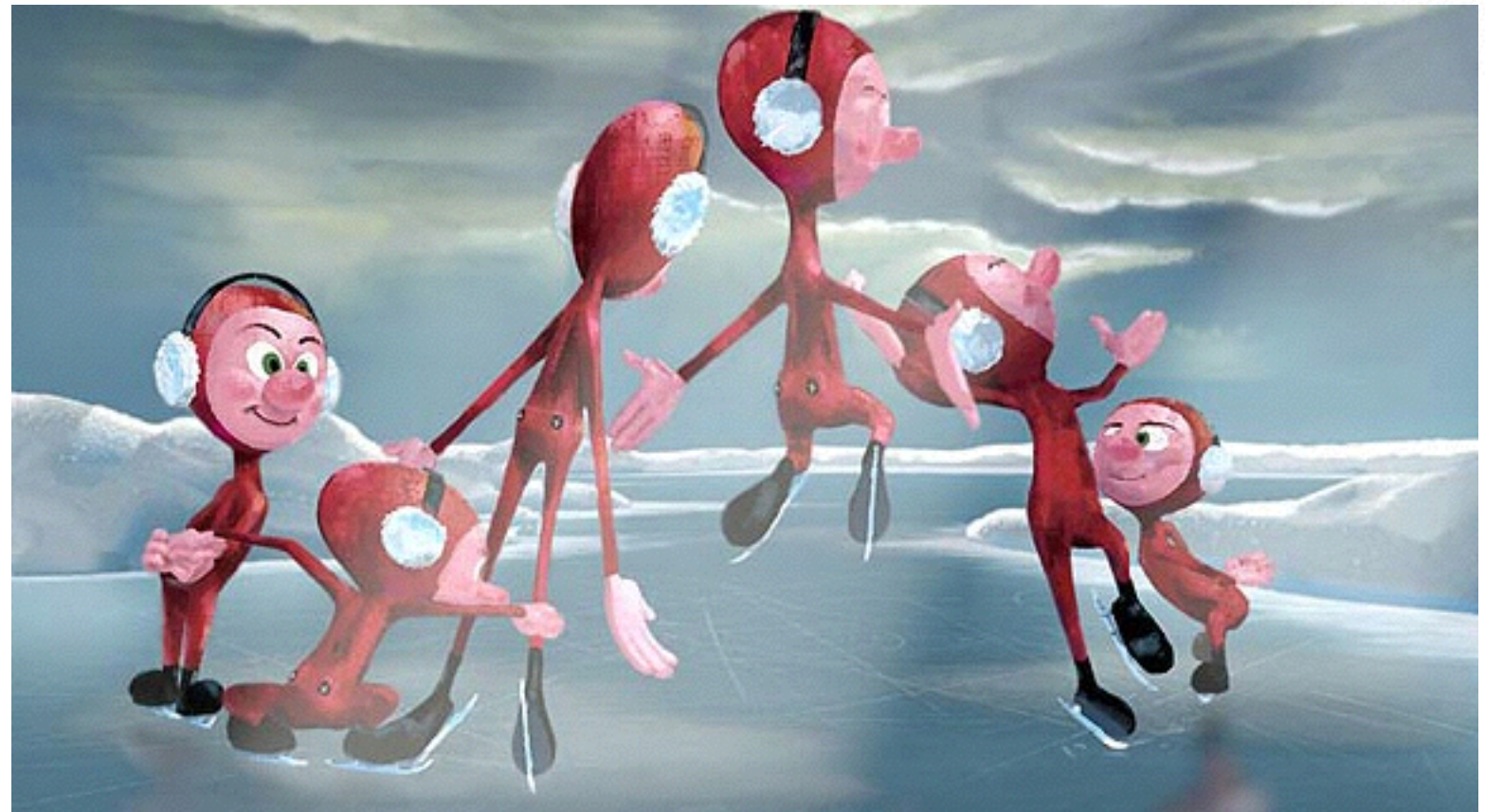


VFX

Computing Illustrations



A. Hertzmann, D. Zorin
SIGGRAPH 2000



Pixar

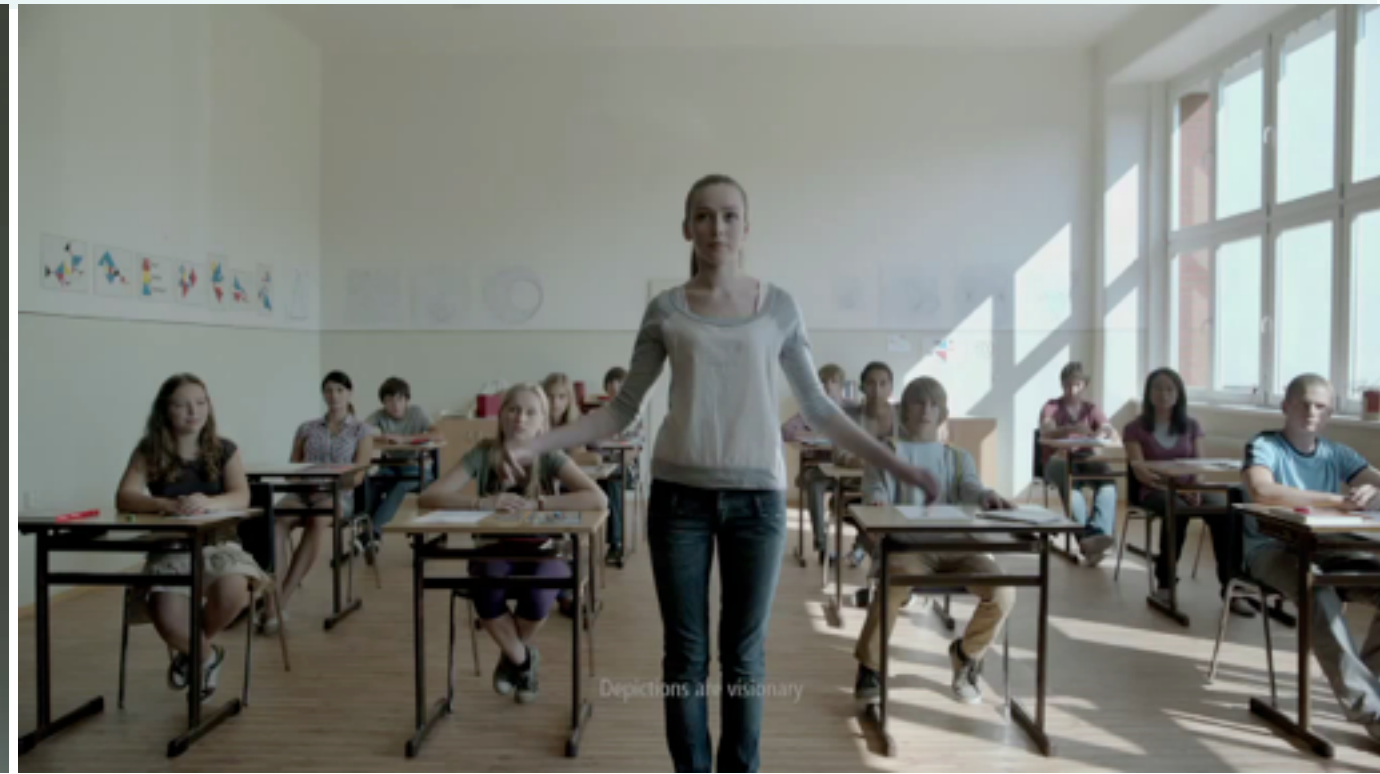
Non-Photorealistic Rendering (NPR)

Into the Mainstream

Home Entertainment



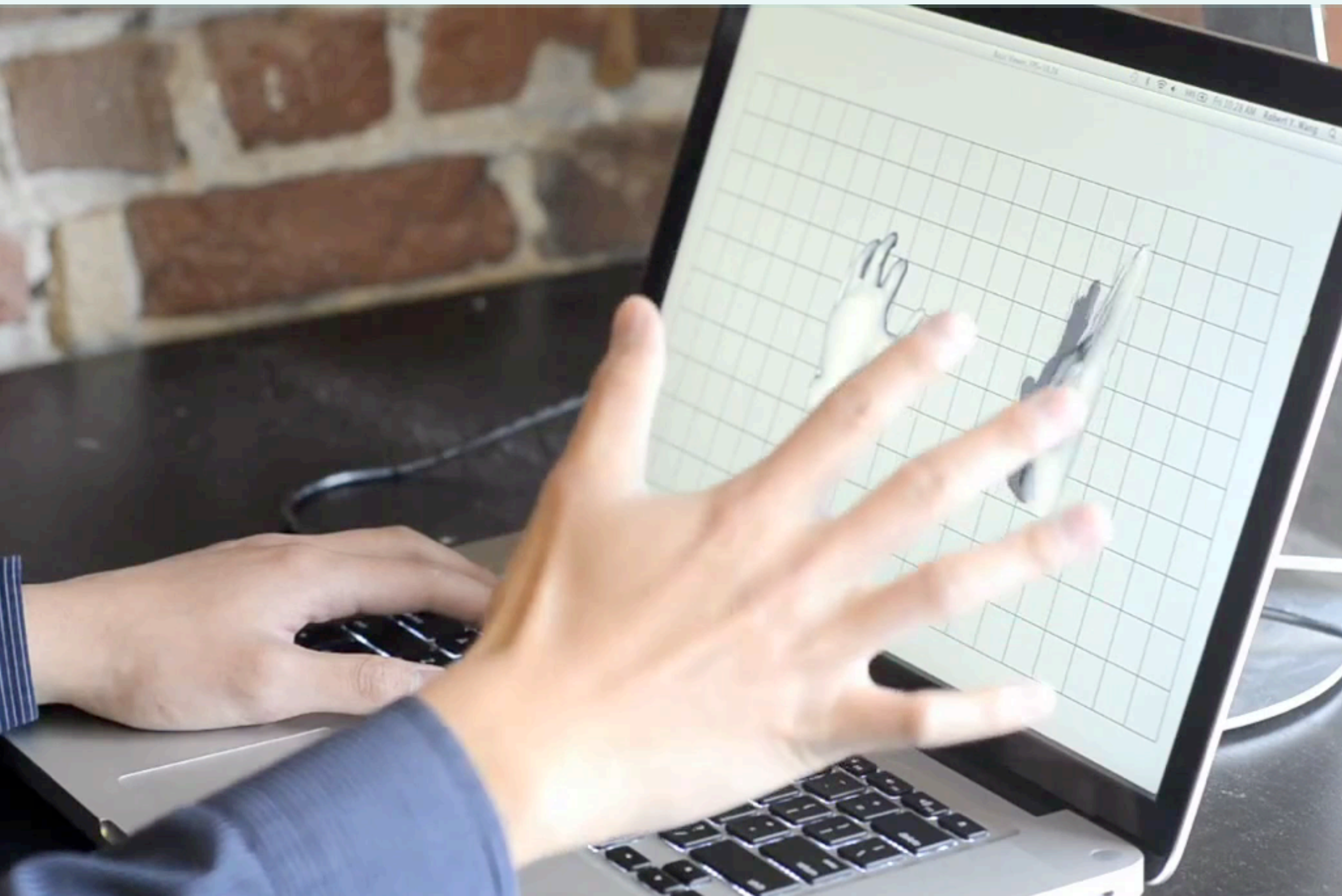
Human Computer Interfaces



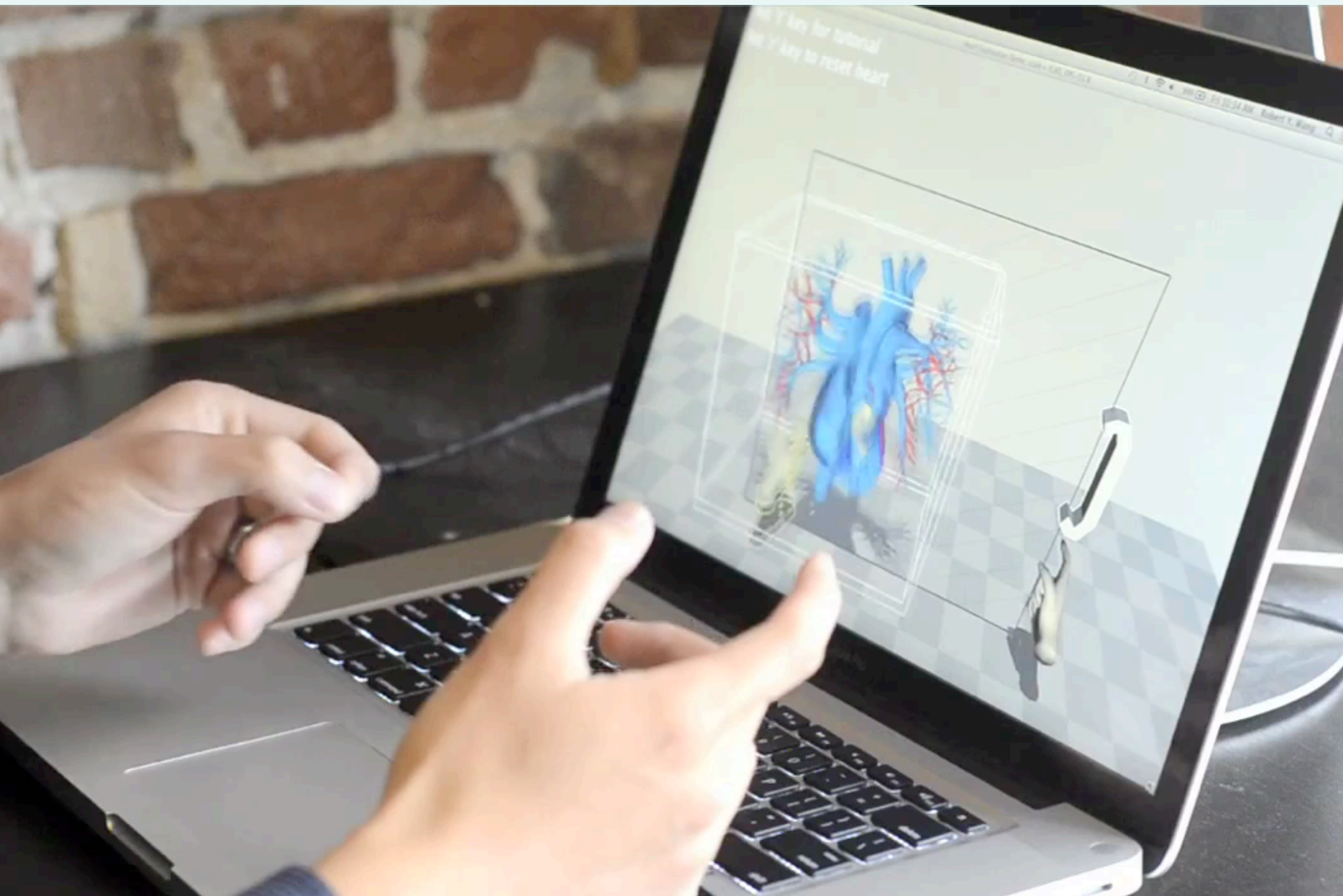
In Tablet



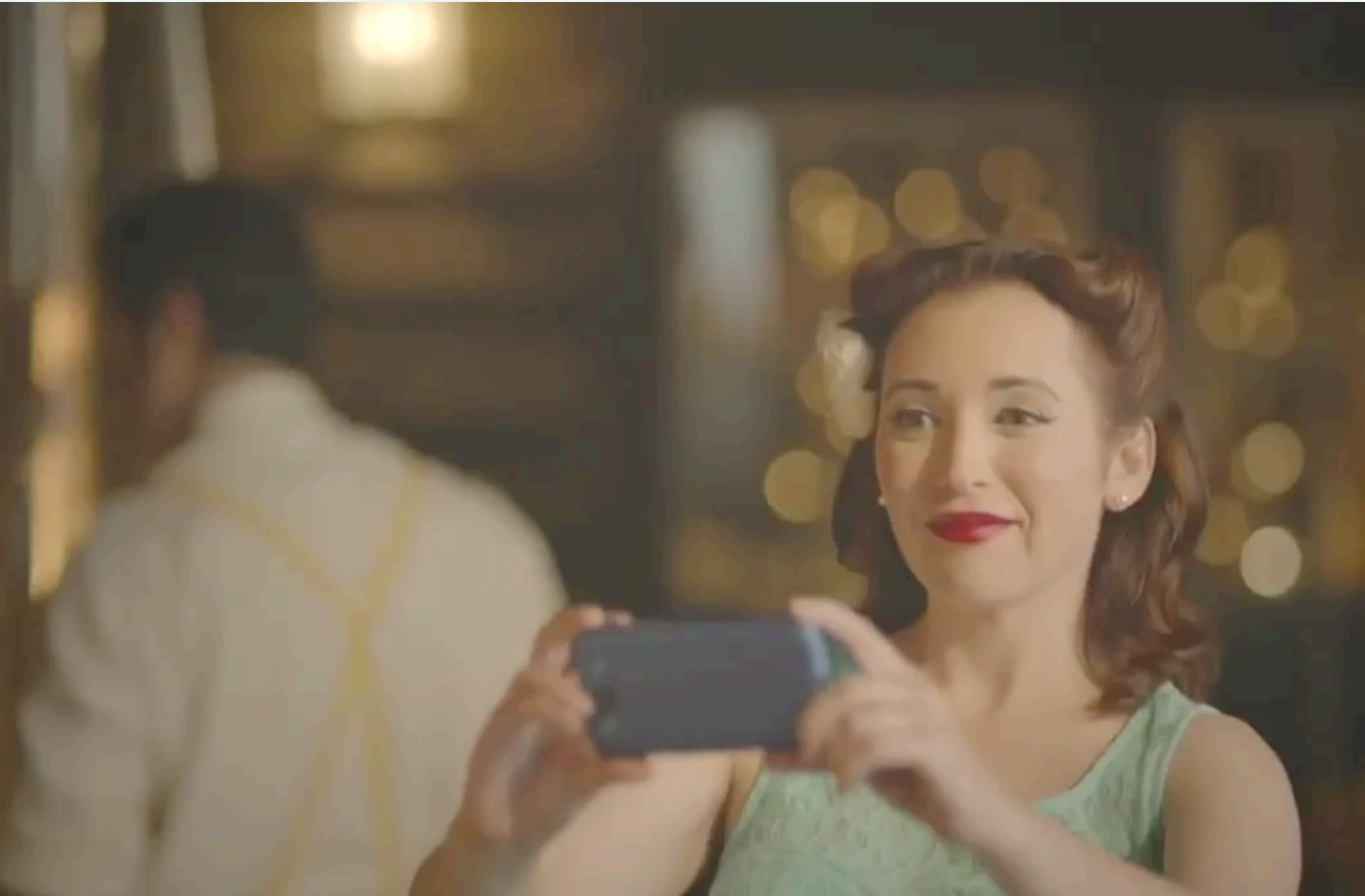
Laptops



Laptops



Smartphones



3D Printing



Fashion Industry

LE TOTE
Your closet. Expanded.

phisix

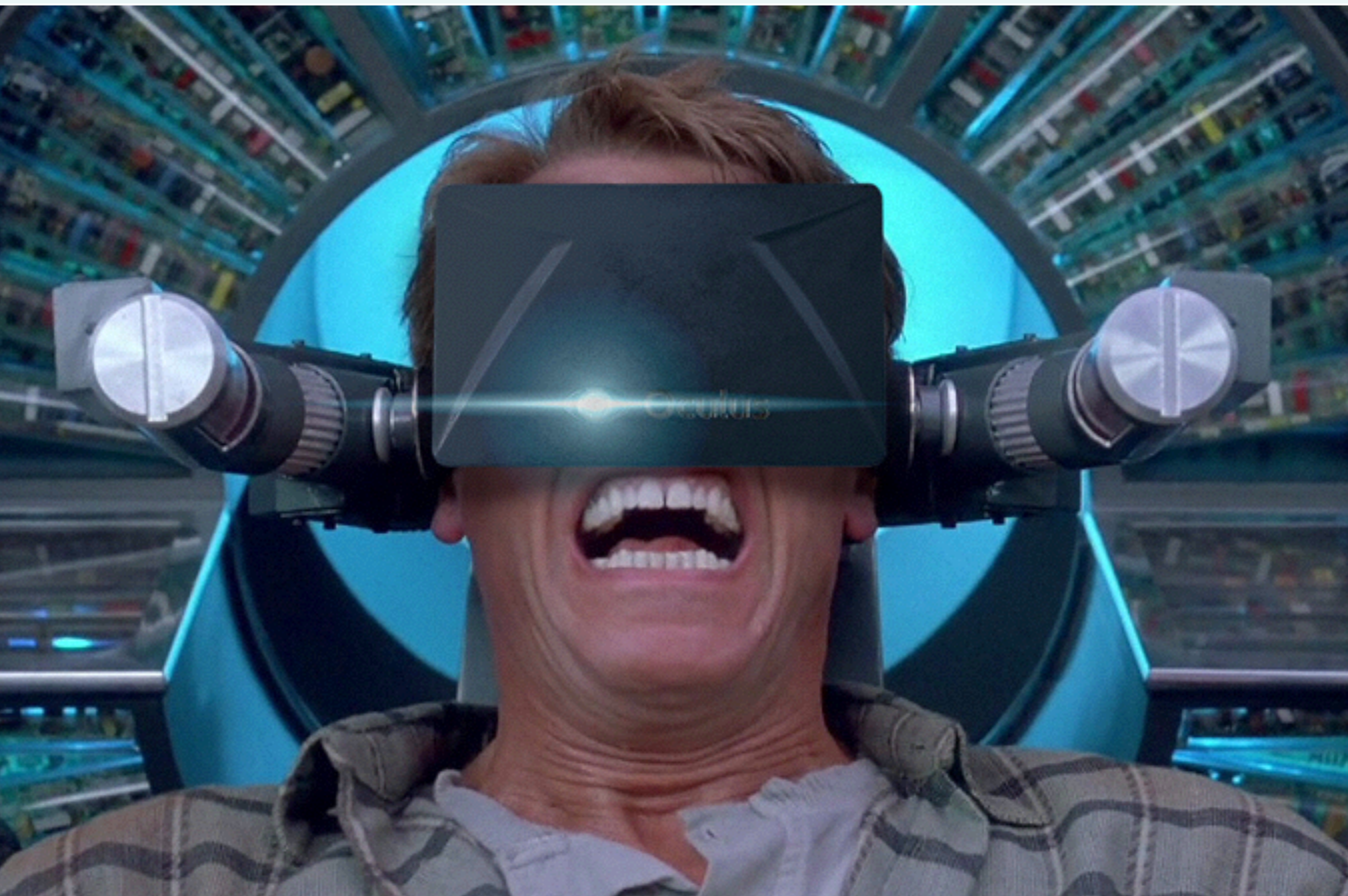
3D Cities



Google Earth



Oculus VR

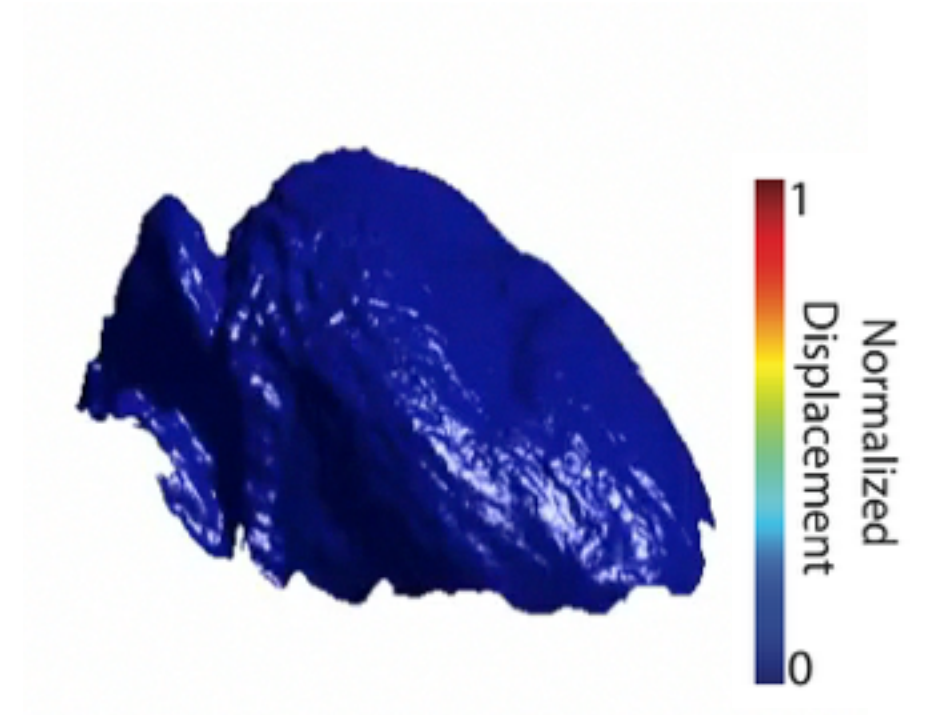
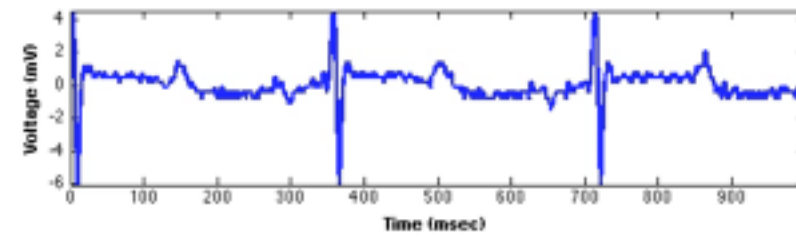
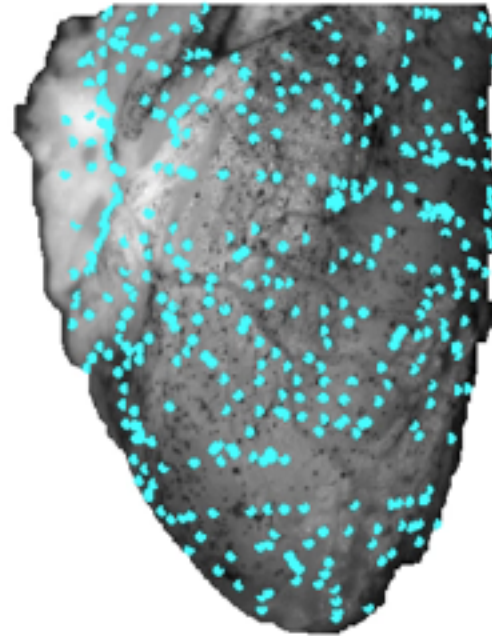


AR

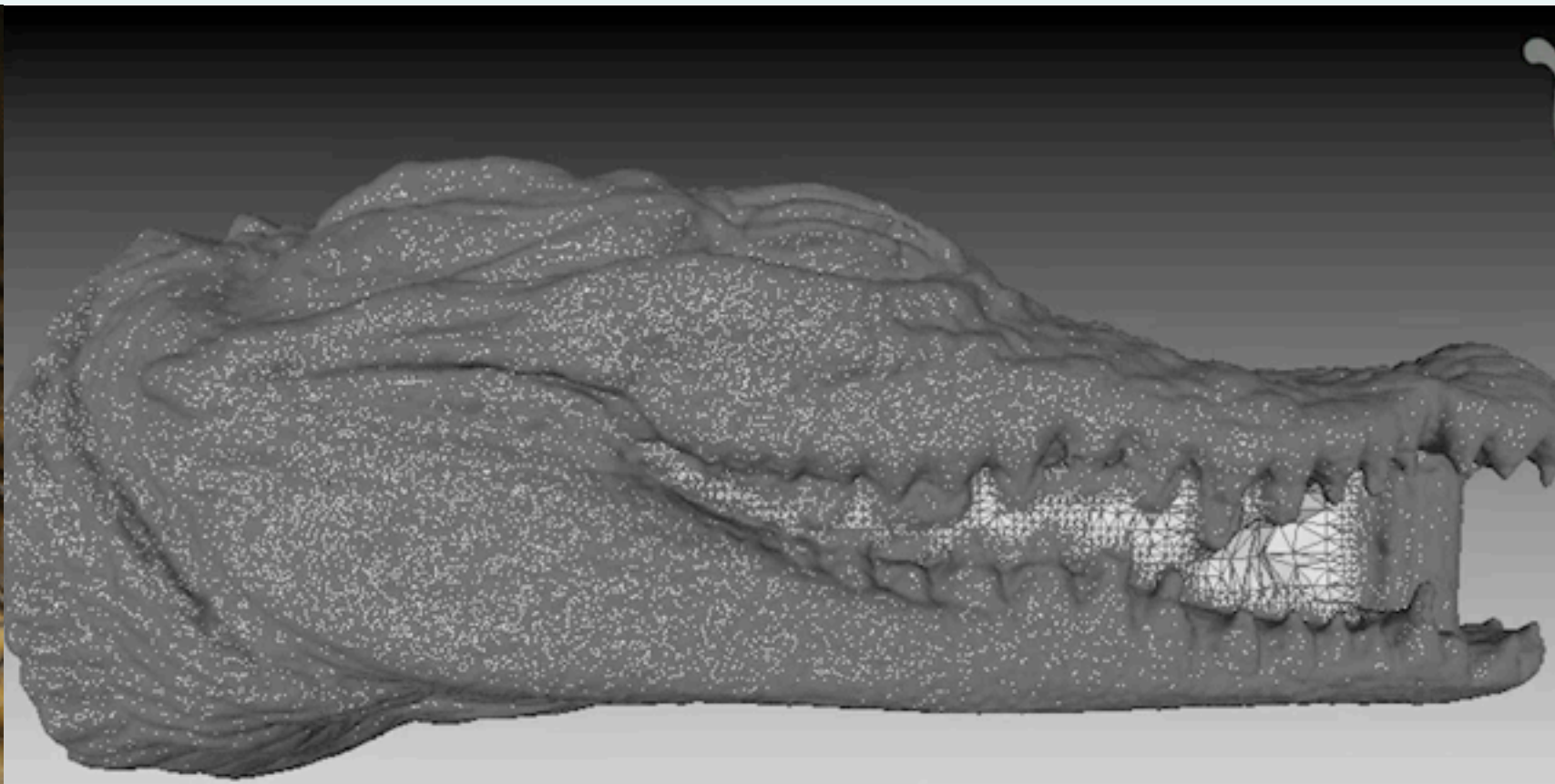


Into the Mainstream

Cardiology



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, 5:00 pm - 5:50 pm
- TTH 208 (Mark Taper Hall)

Credits

- 4 Units

This week

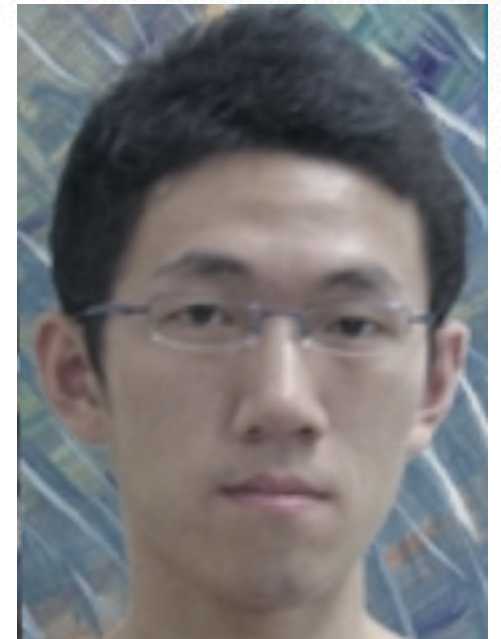
- No Discussion



The Team

Instructor

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



Assistants

- Kyle Olszewski, olszewsk@usc.edu
 - Office: TBD
 - Office hours: TBD
- Liwen Hu, liwenhu@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

The screenshot shows a web browser window with the title "Hao Li - teaching [CS...". The website header includes the name "Hao Li" and navigation links: "about me", "publications", "teaching", "artworks", "photos", "full cv", "software", and "press". The USC University of Southern California logo is also present. The main heading is "CSCI 420: Computer Graphics FS 2014".

Administrative

Lecture URL: <http://cs420.hao-li.com>
Exercises / Q&A: <http://blackboard.usc.edu>
Type: Lecture, 4 units

Map

Lecture

Class number: 001-30230R
Hours: 11:00 am - 12:20 pm
Days: Tuesday, Thursday
Room: TTH 208 (Mark Taper Hall)
3501 Trousdale Pkwy

Discussion

Class number: 001-30053R
Hours: 5:00 - 5:50 pm
Days: Thursday
Room: TTH 208 (Mark Taper Hall)
3501 Trousdale Pkwy

A row of five images is displayed: a person in a blue space suit, a gorilla, a teapot, a white swan in a blue pool, and the robot WALL-E.

Instructor

Prof. Dr. Hao Li
Office: SAL 244
Office hours: Tue 2:00 PM - 4:00 PM
Email: hao.li@usc.edu

TA

Kyle Olszewski
Office: TBD
Office hours: TBD
Email: olszewsk@usc.edu

Co-Instructor

Dr. Chongyang Ma
Email: chongyang.ma@usc.edu

Co-TA

Lwen Hu
Email: lwenhu@usc.edu

Grader

Kevin Macwan
Email: kmacwan@usc.edu

Grader

Yanqing Liu
Email: yanqing@usc.edu

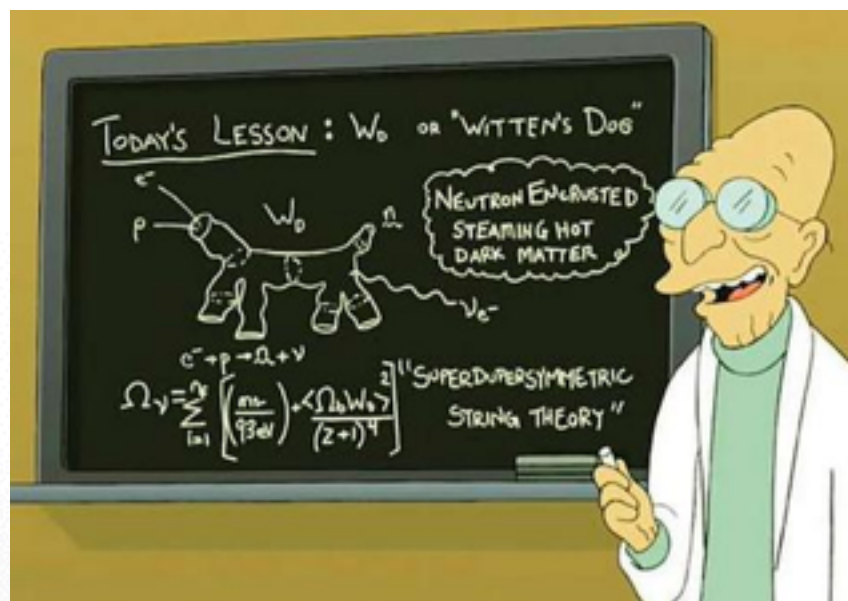
Prerequisites

Math

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

Coding

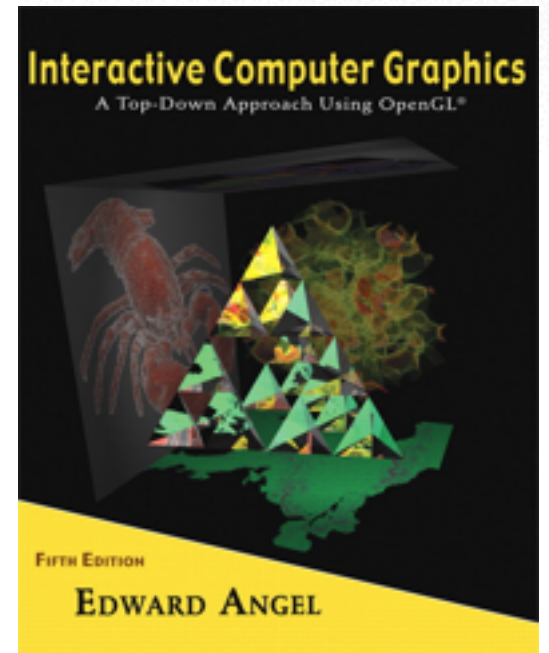
- CSCI 104 (Data Structures and Object-Oriented Design)
- C/C++ programming



Textbooks

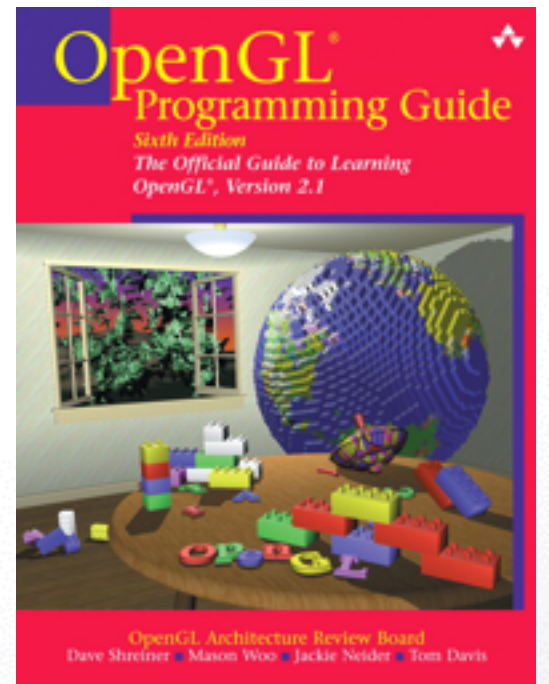
Interactive Computer Graphics

- 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 sheet 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

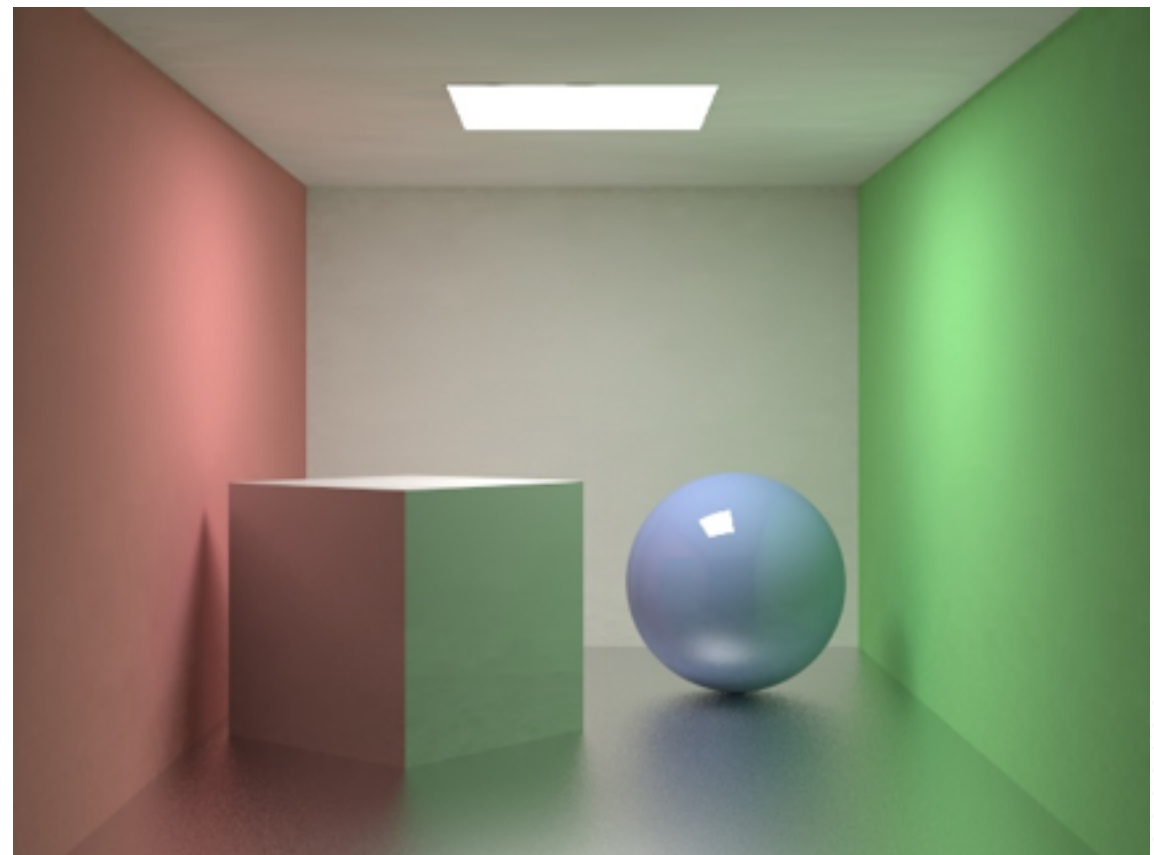
3 late days, usable any time during semester

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

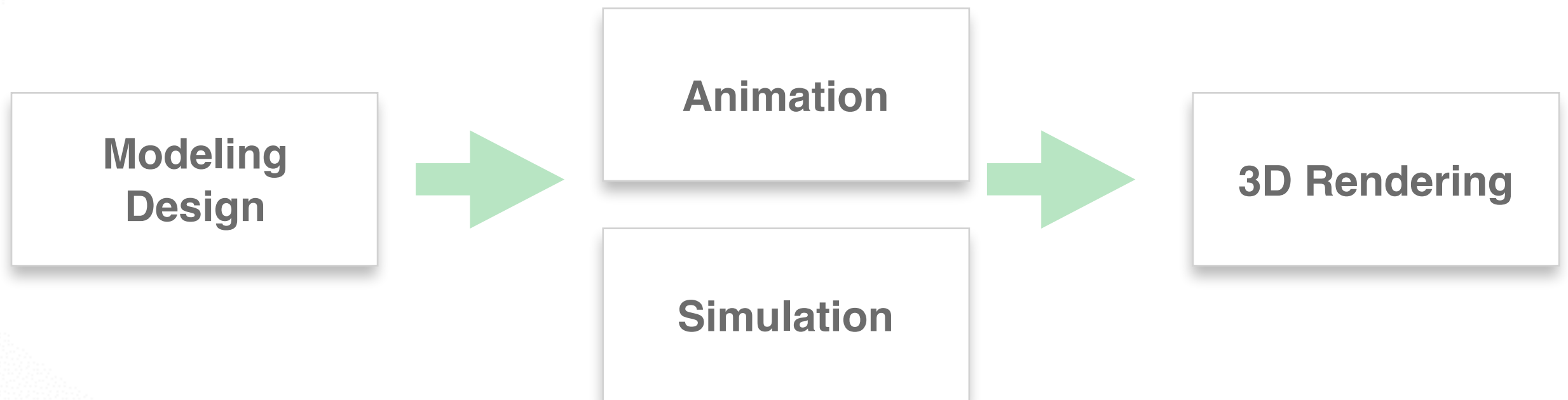
- Modeling: how to represent objects
- Animation: how to control and represent motion
- Rendering: how to create images of objects
- Image Processing: how to edit images

Practice: OpenGL graphics library

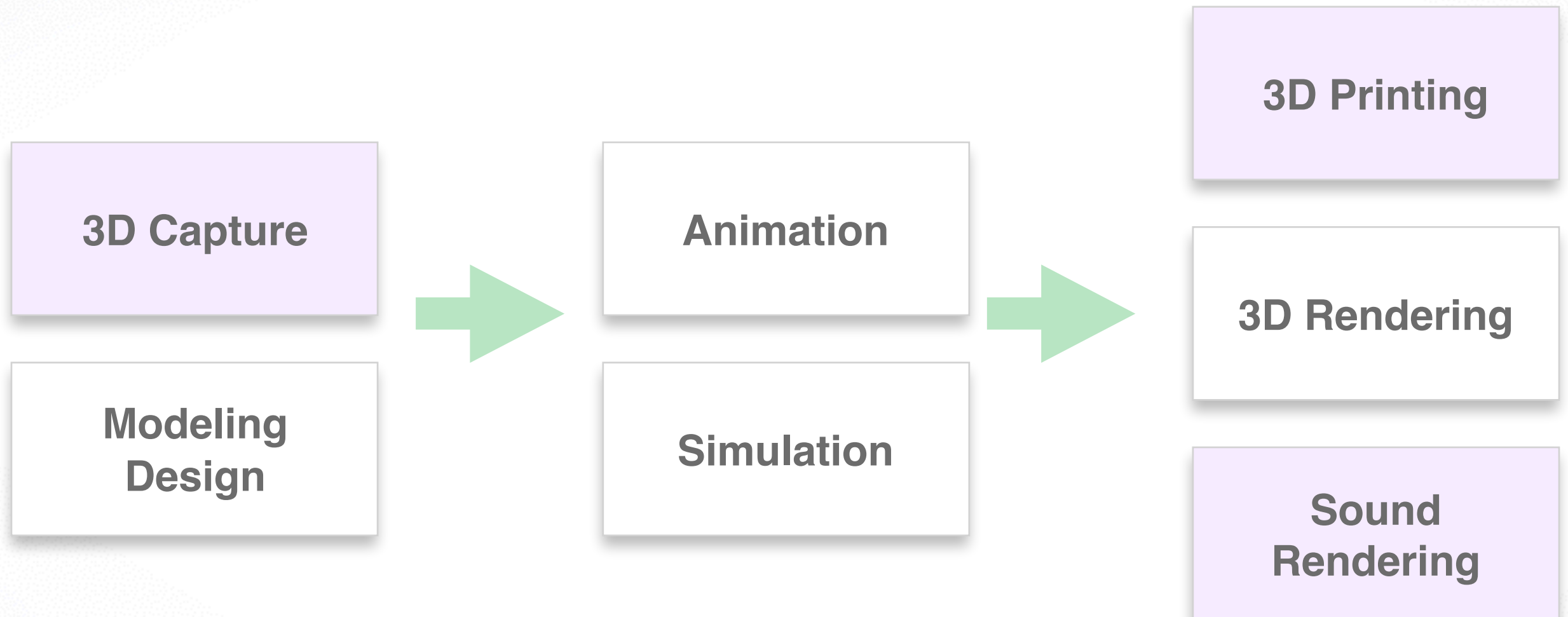
Not in this course:

- Human-Computer Interaction
- Graphic Design

3D Computer Graphics Pipeline



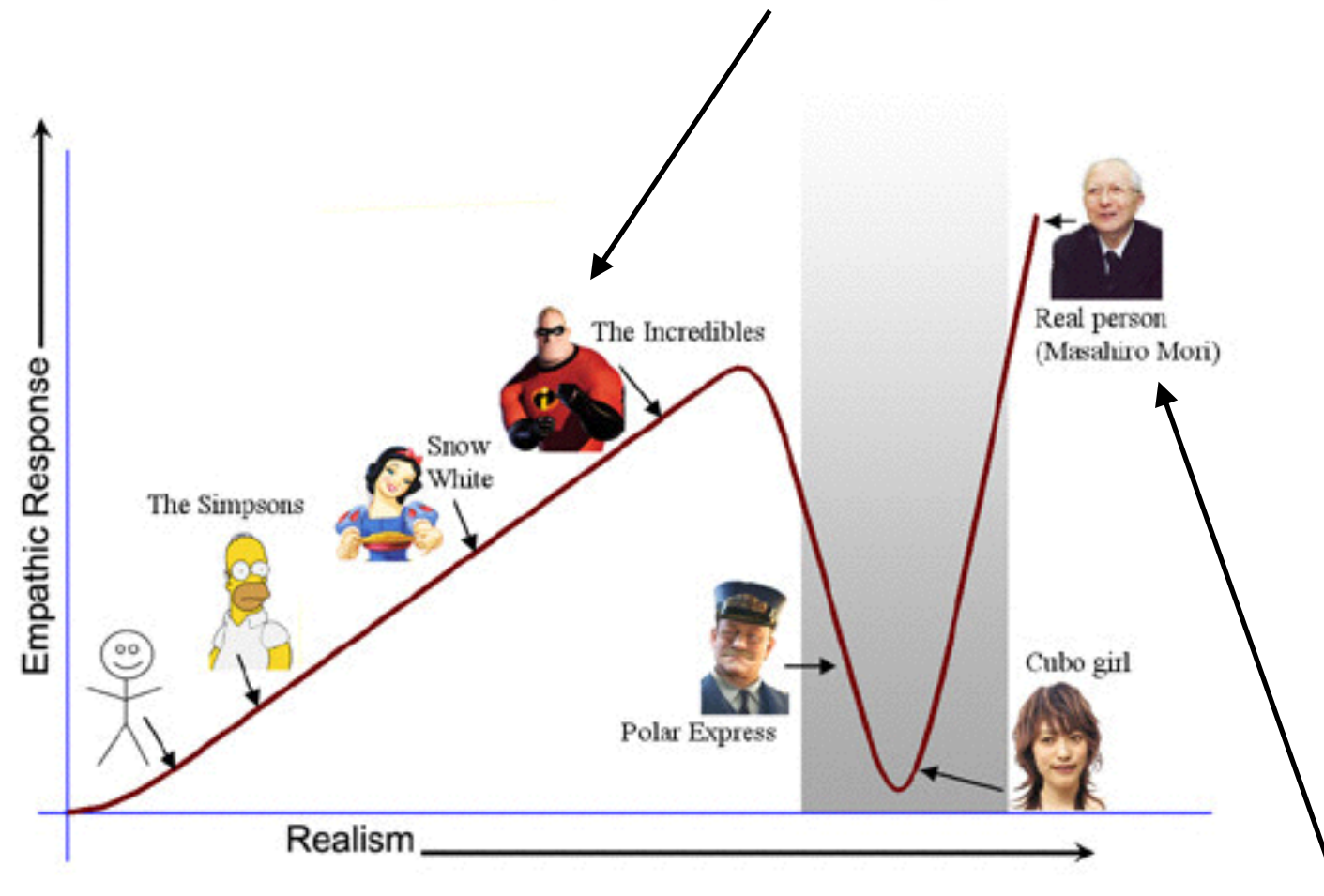
Emerging Fields



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



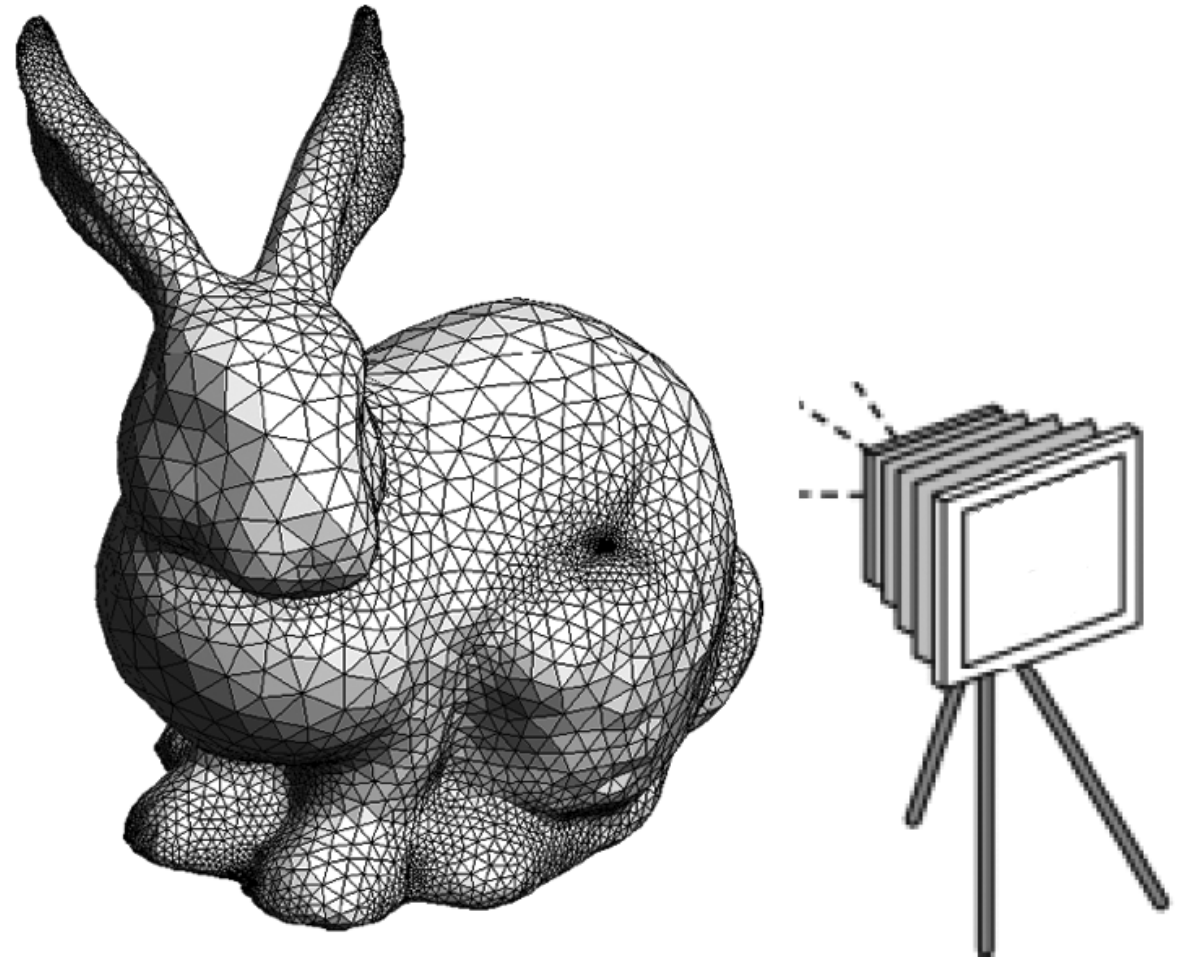
Course Overview

1.1 Introduction

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

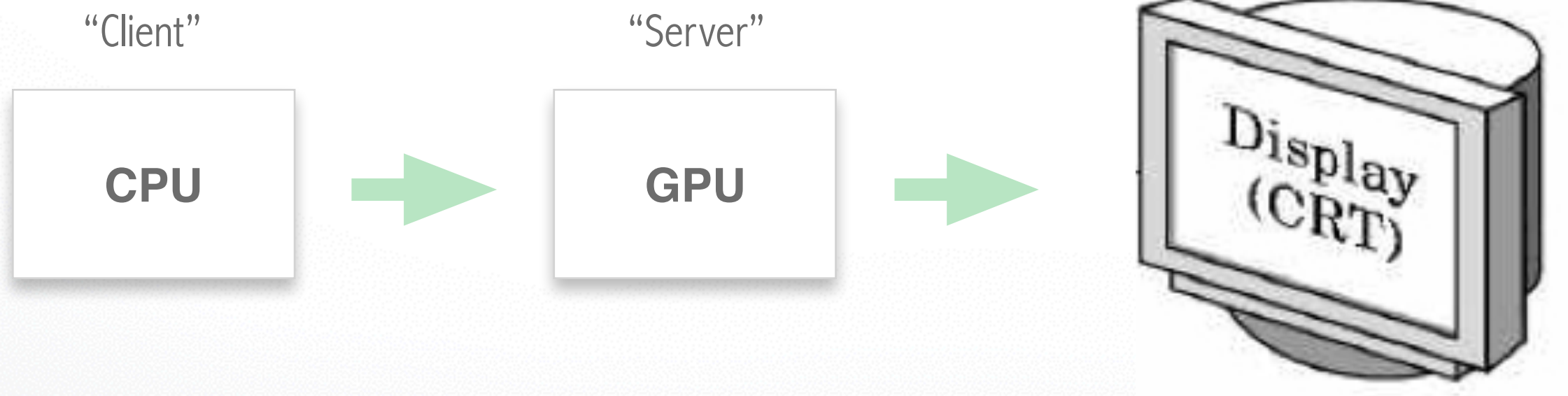
1.2 OpenGL Basics

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



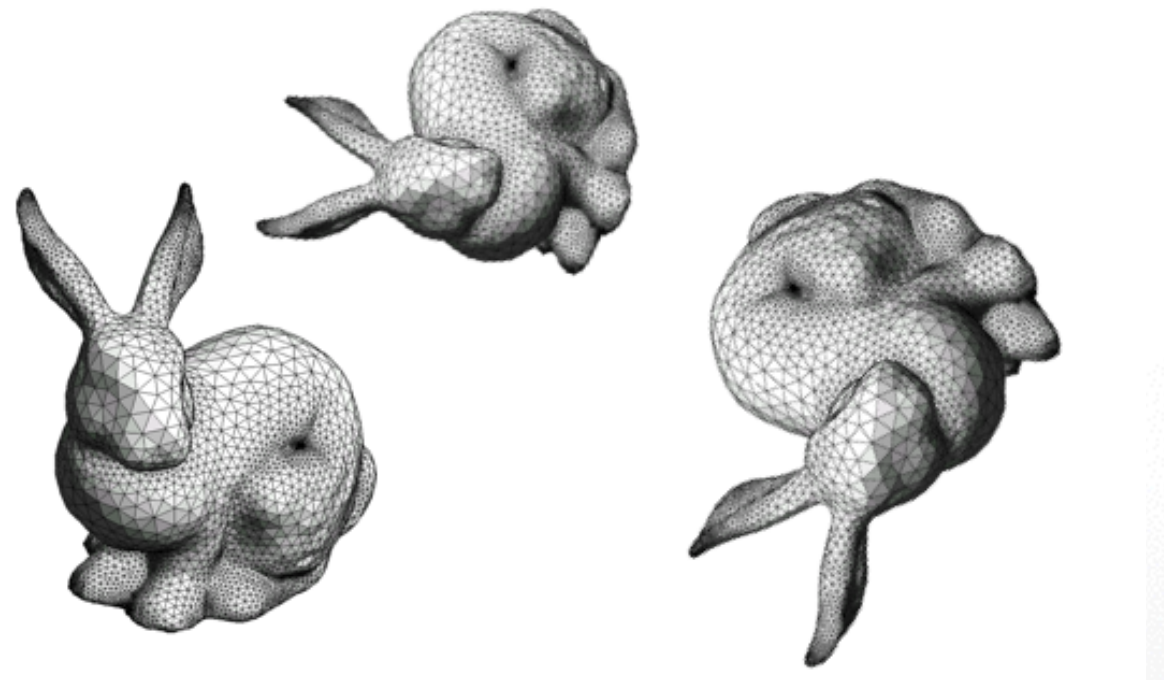
2.1 Input & Interaction

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



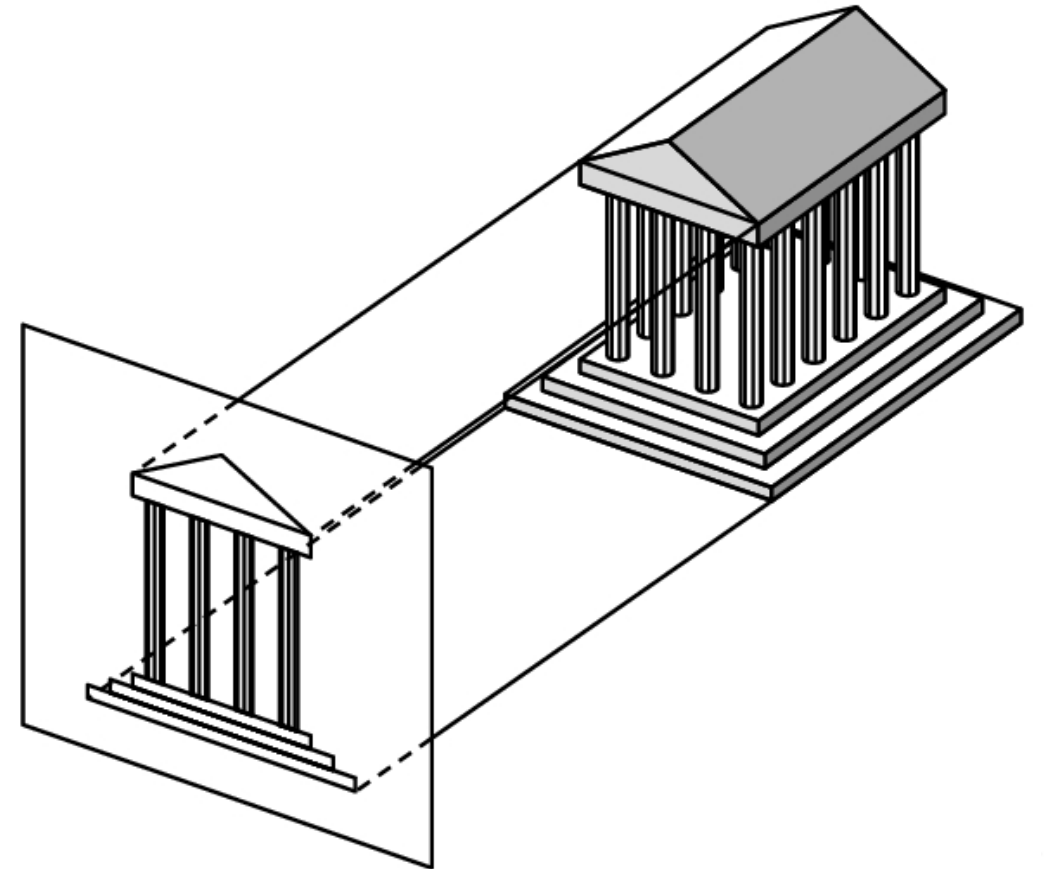
2.2 Objects & Transformations

- 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]



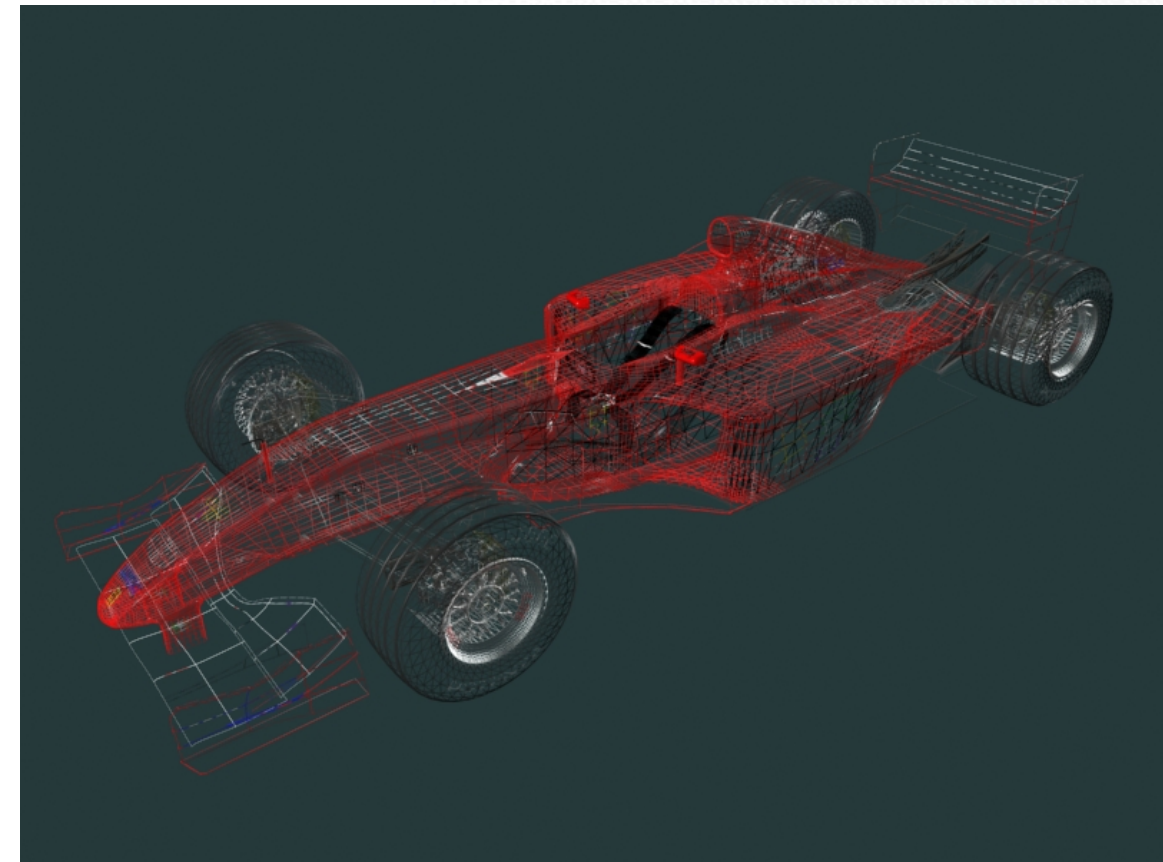
3.2 Hierarchical Models

- 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

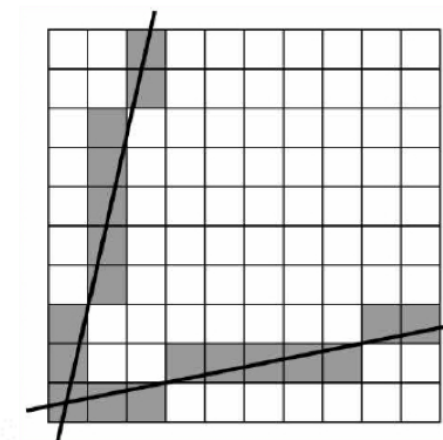
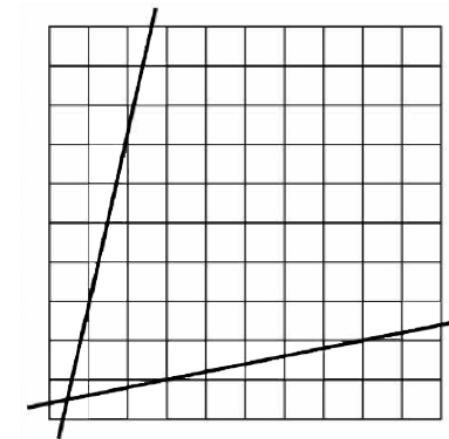
- Light sources
- Ambient, diffuse, and specular reflection
- Normal vectors
- Material properties in OpenGL
- Radiosity
- [Angel, Ch. 6]



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]

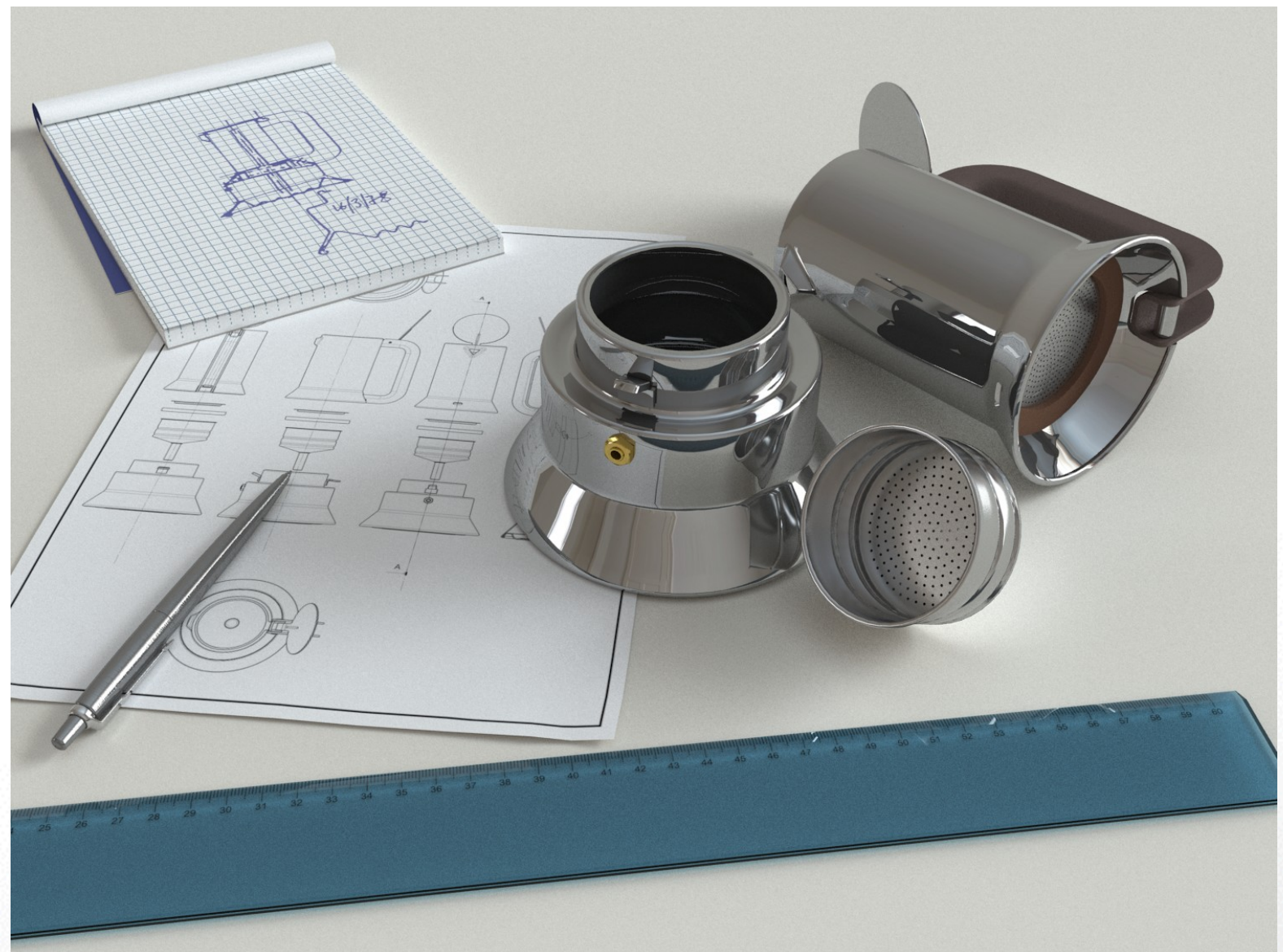


texture mapping



9-10 Ray Tracing

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



www.yafaray.org

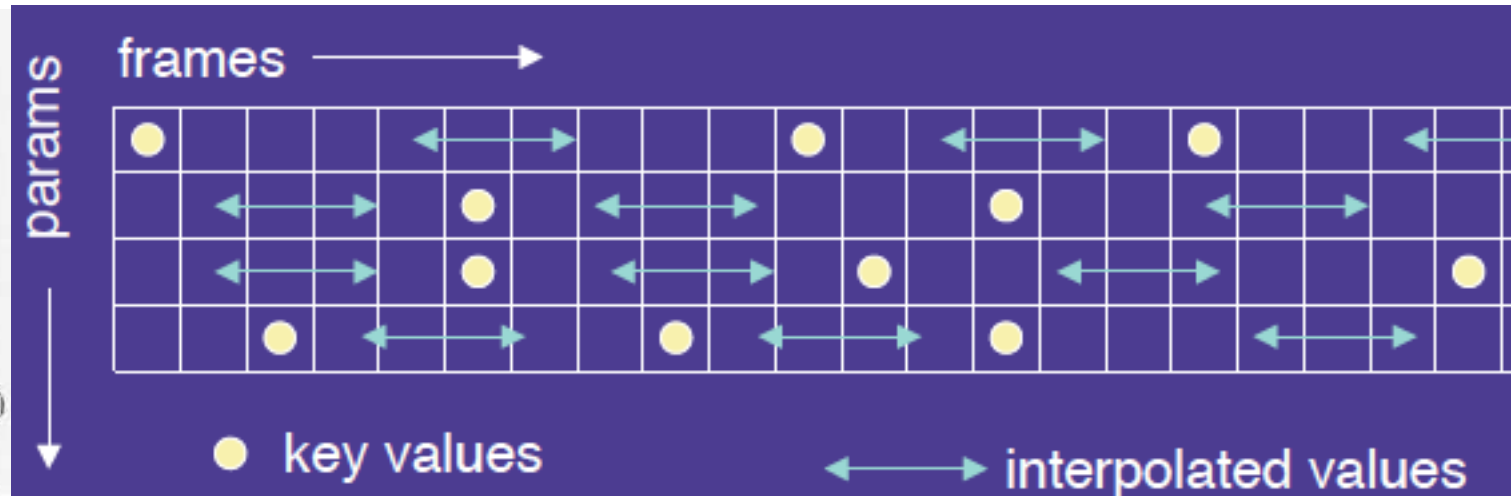
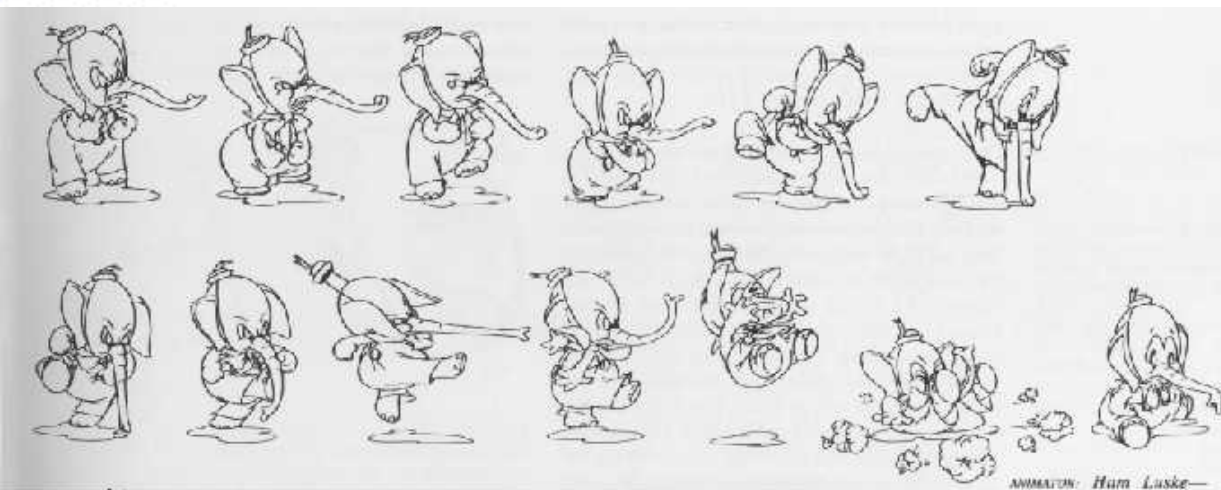
11.1 Radiosity

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



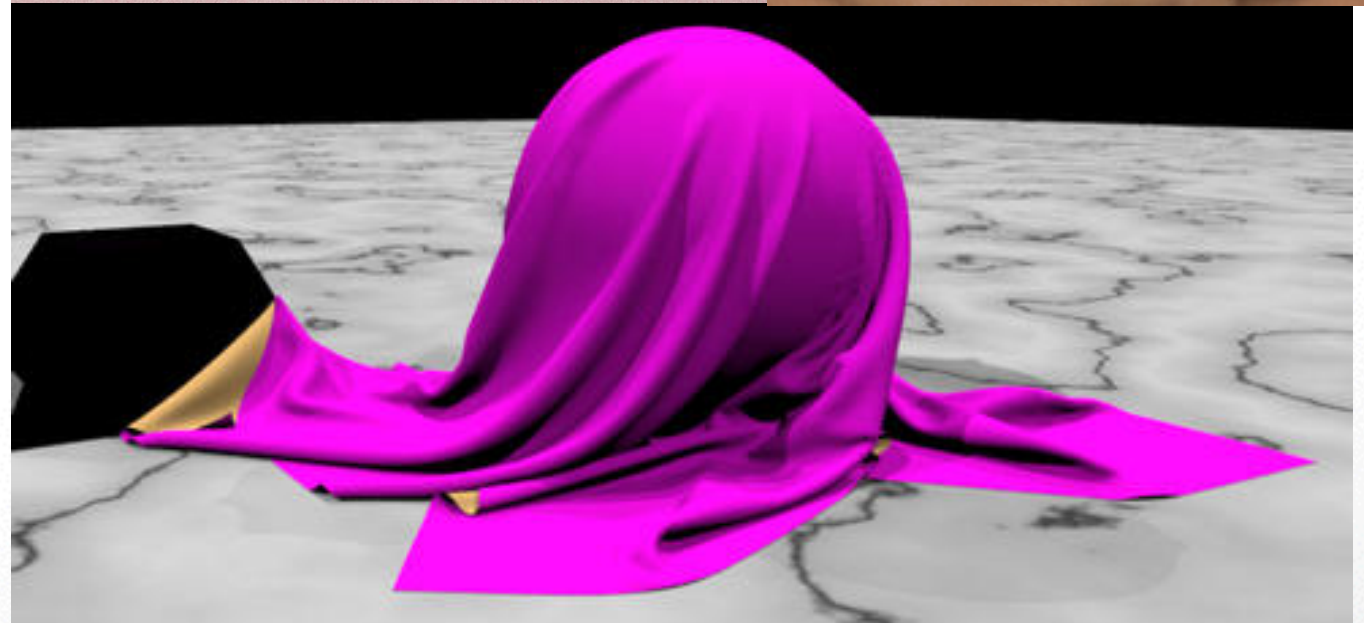
11.2 Animation

- Traditional Animation
- Keyframe Animation
- Computer Animation



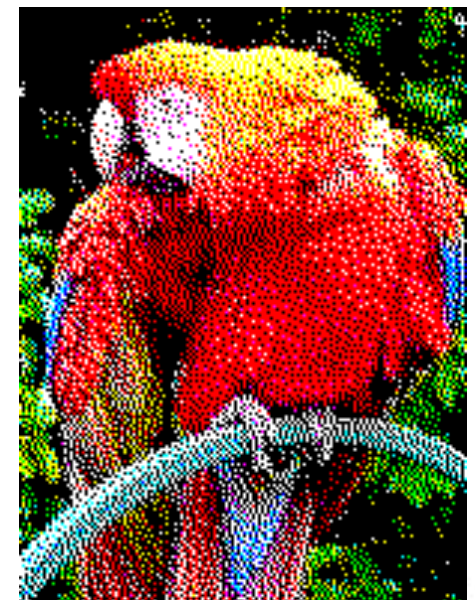
12 Physically Based Models

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



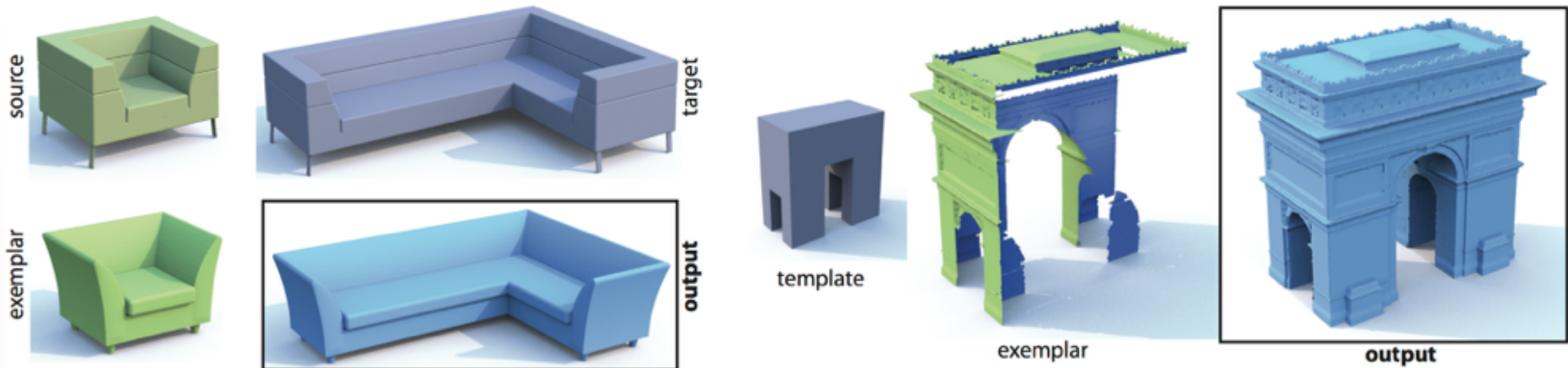
13 Image Processing

- 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

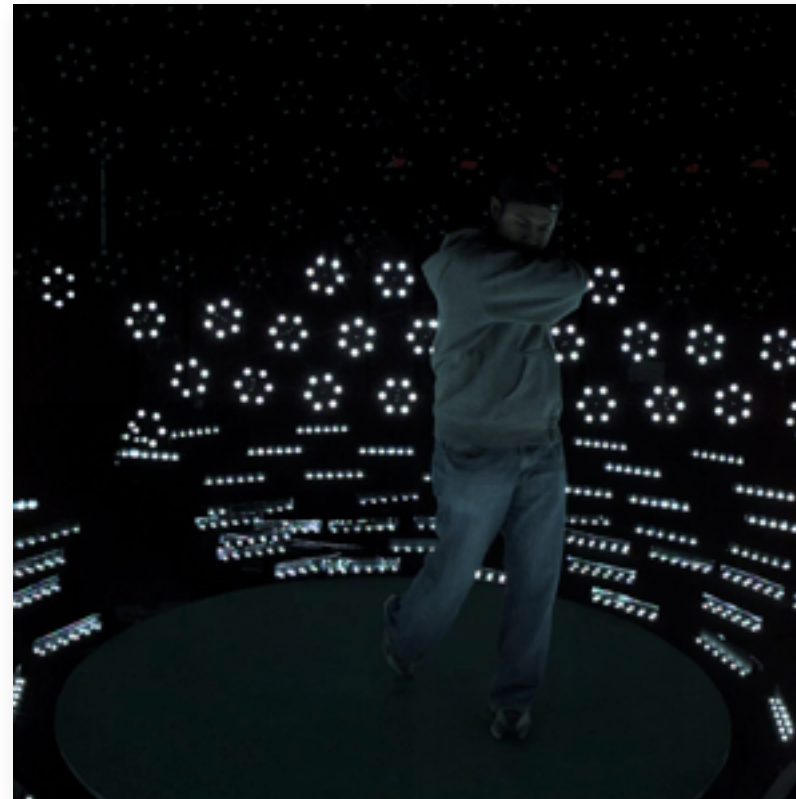
From Offline to Realtime



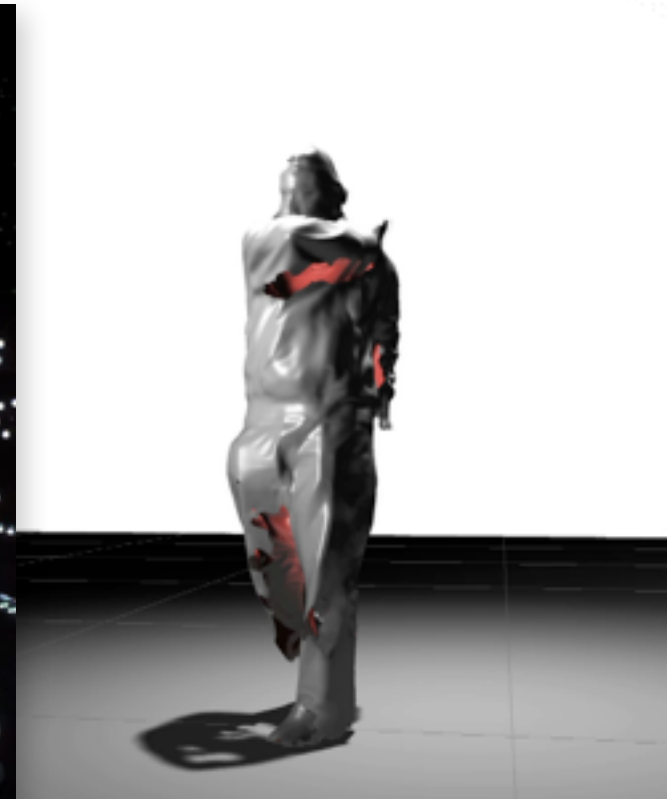
From Graphics to Vision



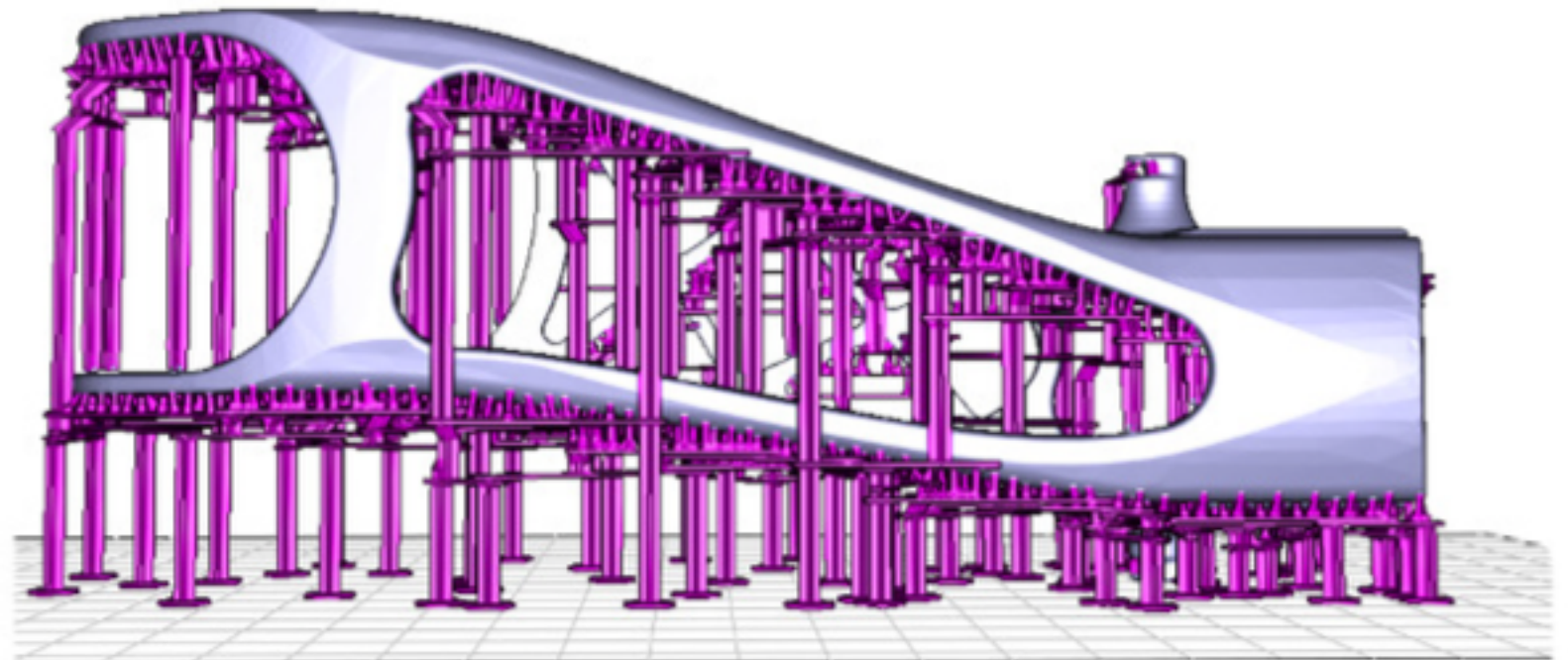
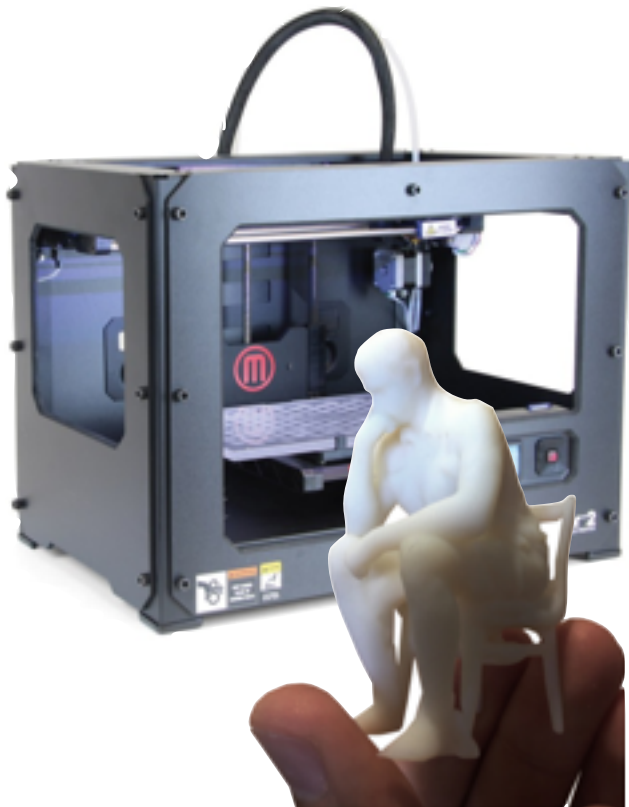
[Newcombe et al. '11]
KinectFusion



multi-view photometric stereo



From Graphics to Fabrication

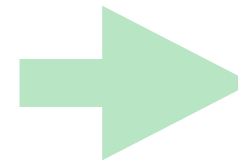


3D printing

From Production to Consumers



VFX



online shopping

Realtime Facial Animation

Live Demo



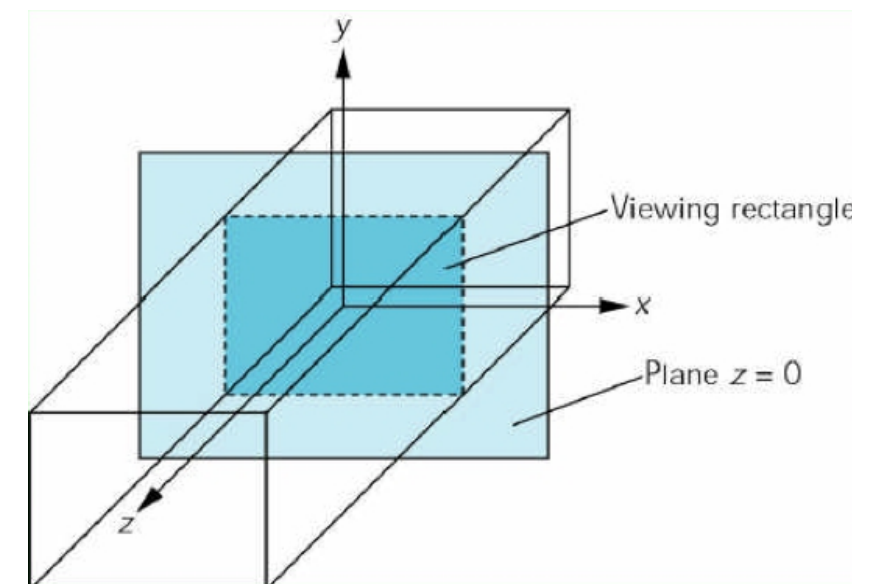
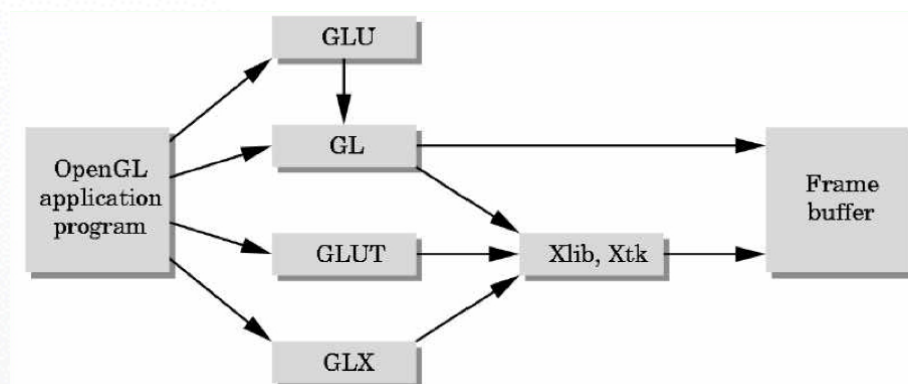
Acknowledgements

Lecture based on material from:

- Jernej Barbic, USC
- Saty Raghavachary, USC
- Frank Pfenning, CMU
- Jessica Hodgins, CMU
- Mark Pauly, EPFL
- Cornell, MIT, UC Berkeley, ...

Next Time

- Basic Graphics Programming
- OpenGL Pipeline



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

Thanks!

