Computer Graphics -Introduction

Junjie Cao @ DLUT

Spring 2017

http://jjcao.github.io/ComputerGraphics/

About Me

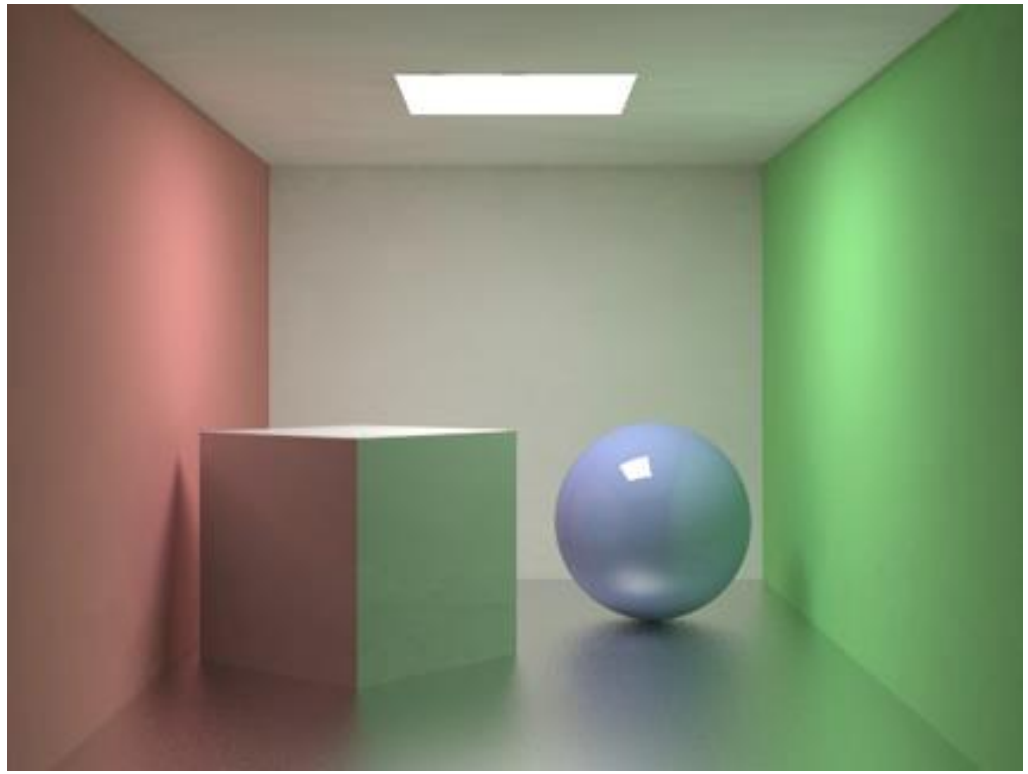
- jjcao.github.io
- CGGI: cggi.dlut.edu.cn

Context

- History
- Applications
- What is CG
- Stuff
- Topics
- What would you achieve
- Trends

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



Computer Graphics vs. Vision

What is computer graphics?

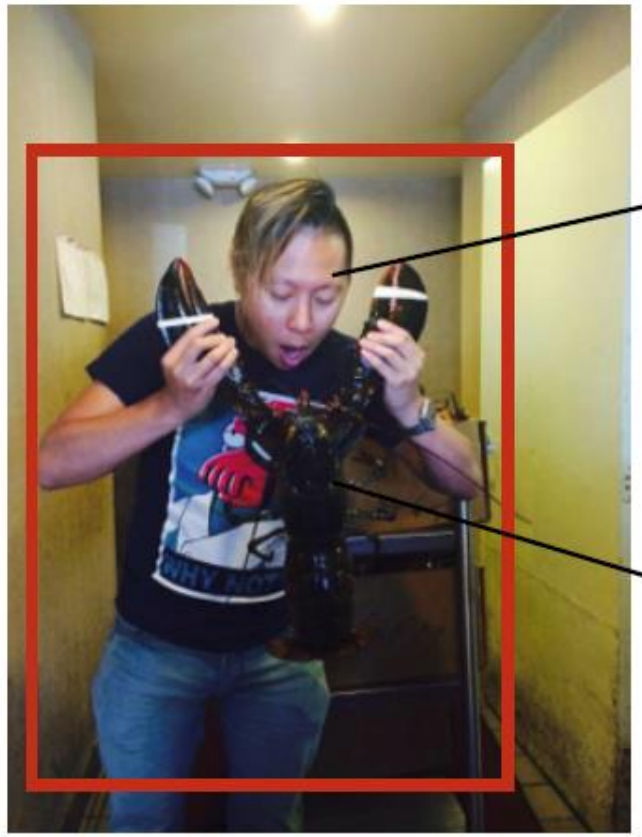
- The use of computers to synthesize and manipulate **visual information**.

- The use of computers to synthesize and manipulate **sensory information**.

(sound)

(touch)

Computer Vision



ROI

input
an image

face

mouth open 70%

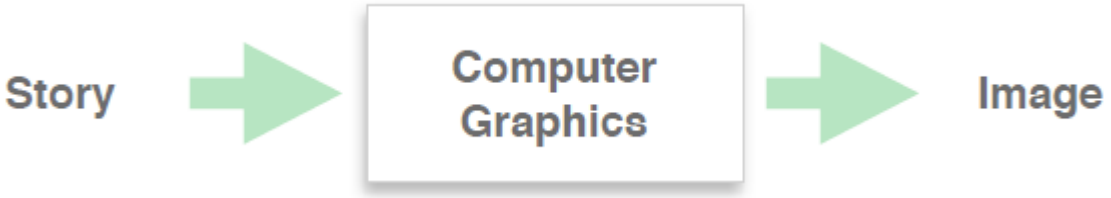
shrimp 20%
lobster 60%
crap 40%

output
Hao is eating a lobster

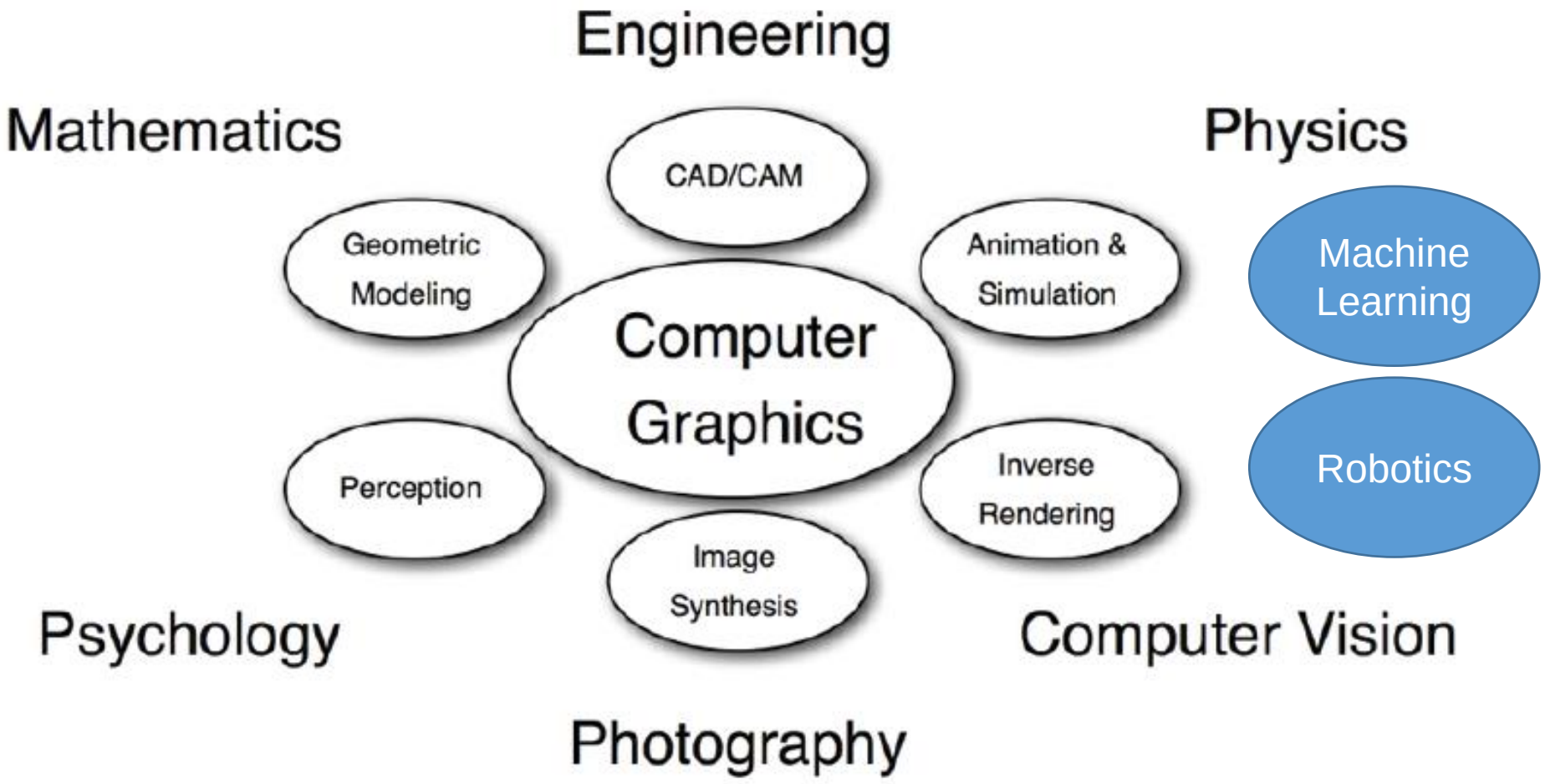
Image → Computer Vision → Story

Computer Graphics

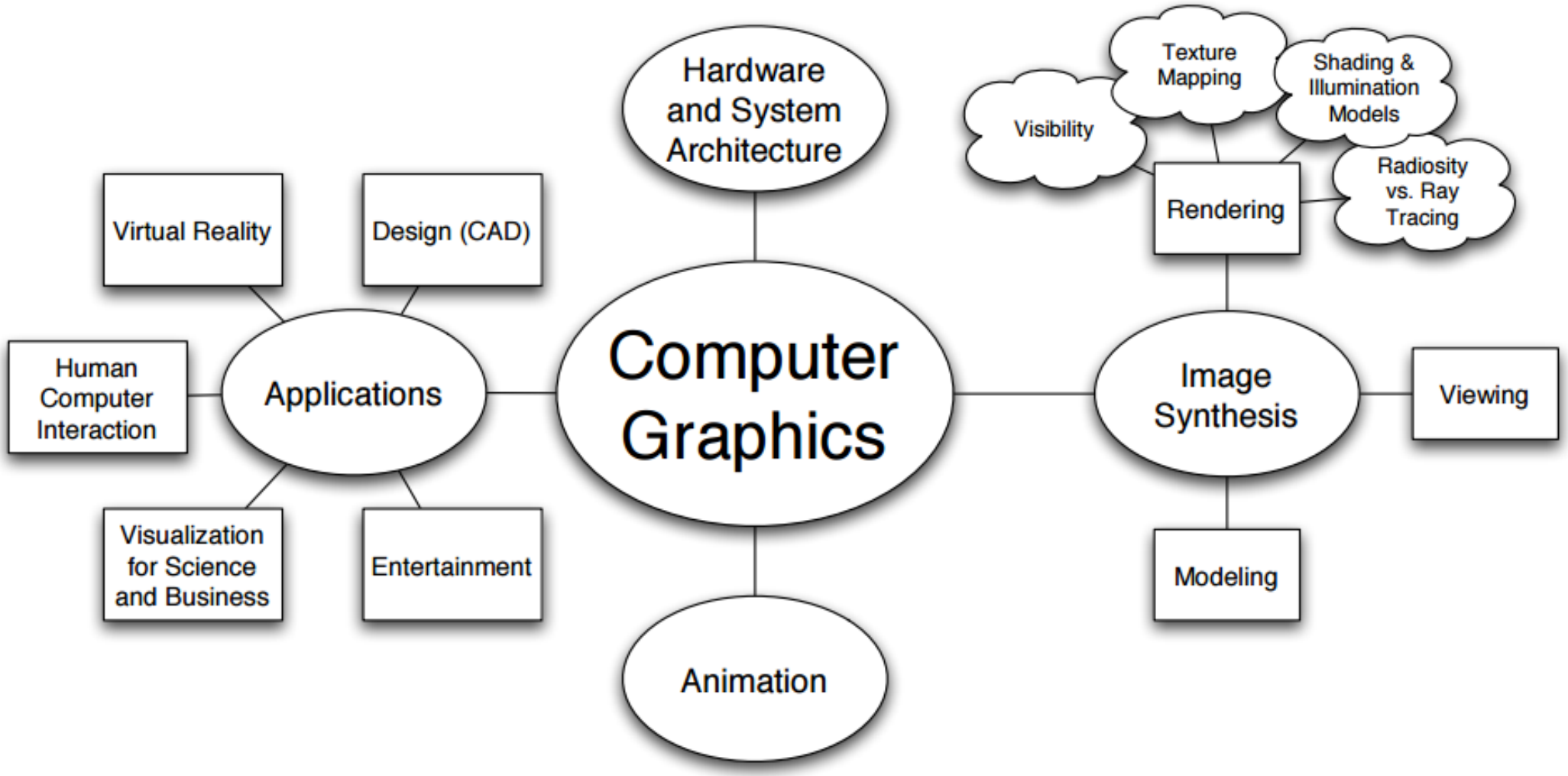
Action!



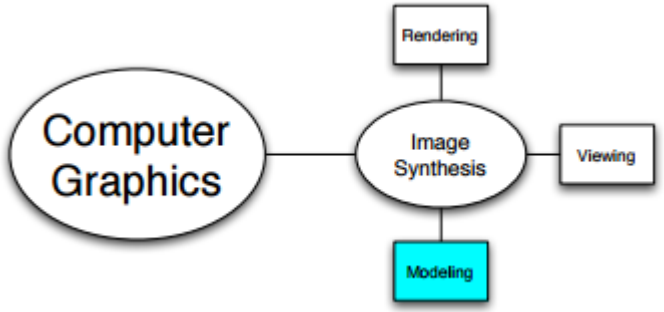
Related to many Disciplines



What Is Computer Graphics?

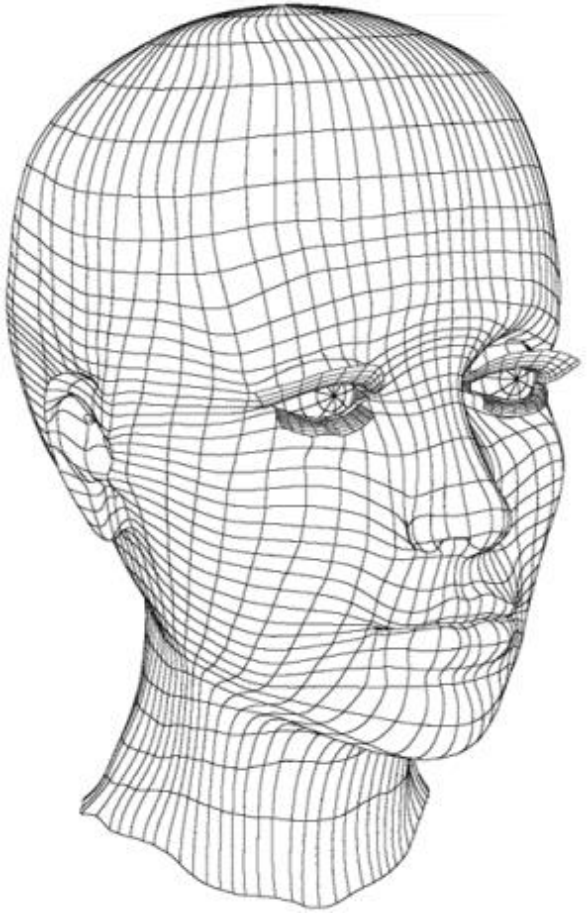


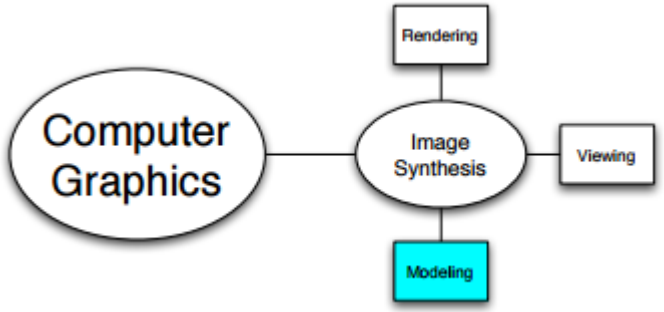
Modeling



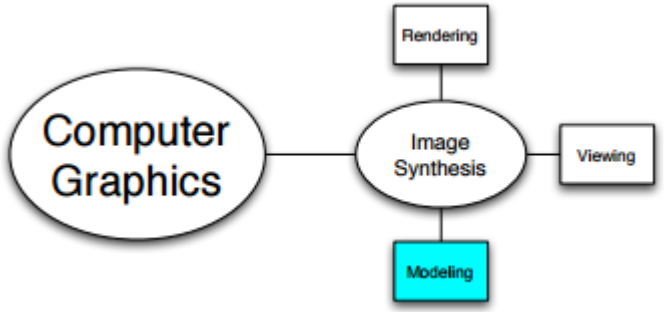
- How to represent real environments
  - Geometry: curves, surfaces, volumes
  - Photometry: light, color, reflectance
- How to build these representations
  - Interactive: sculpt it
  - Algorithmic: let it grow (fractals, extraction)
  - Scanning: via 3D sensing

Modeling: Interactive

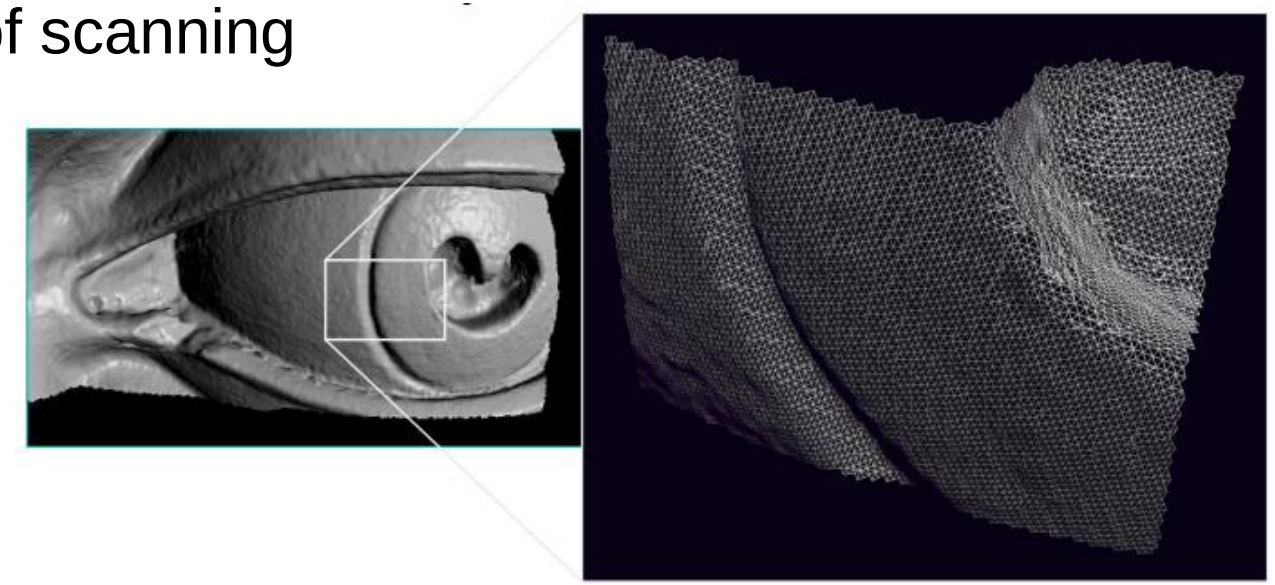




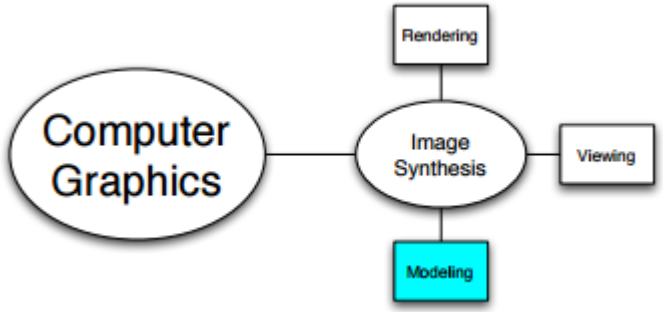
Modeling: Scanning

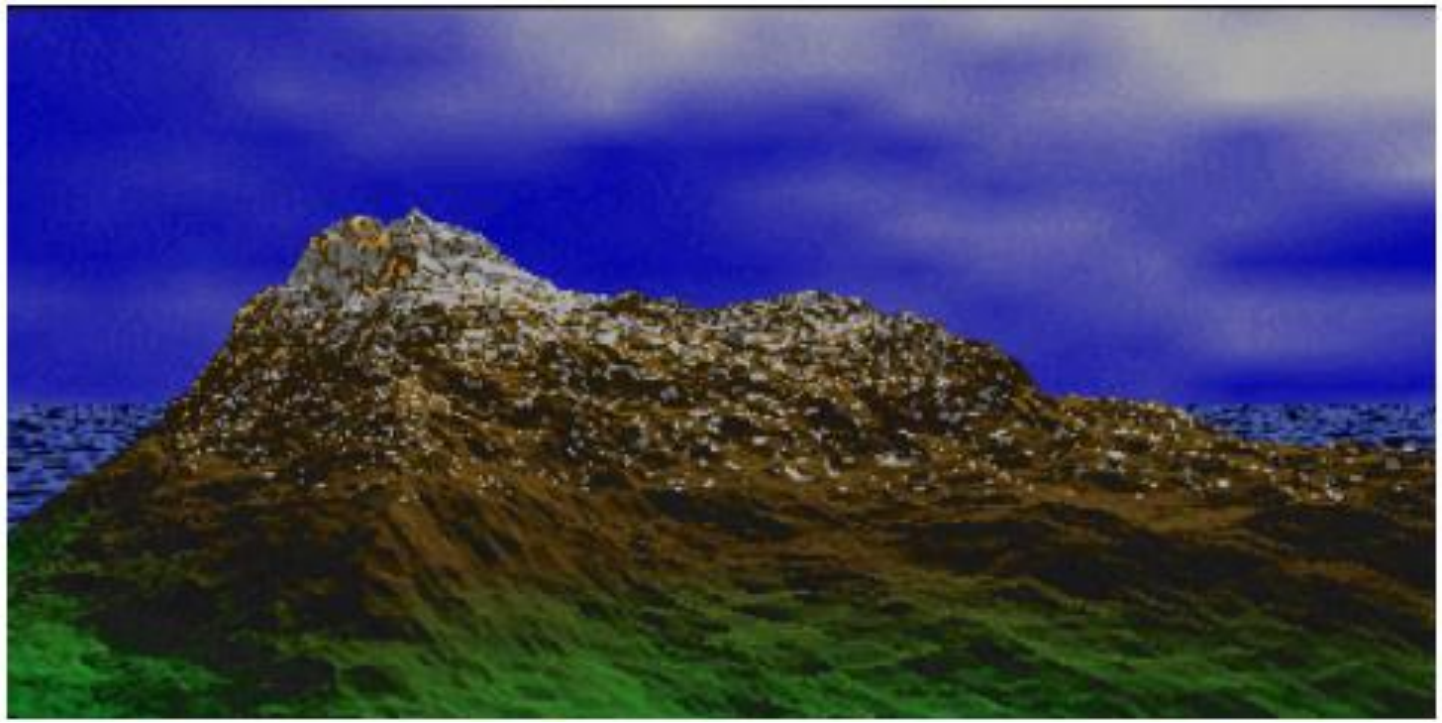


- David
  - 480 individually aimed scans
  - 2 billion polygons
  - 7,000 color images
  - 32 gigabytes
  - 30 nights of scanning
  - 22 people



Modeling: Algorithmic and Procedural

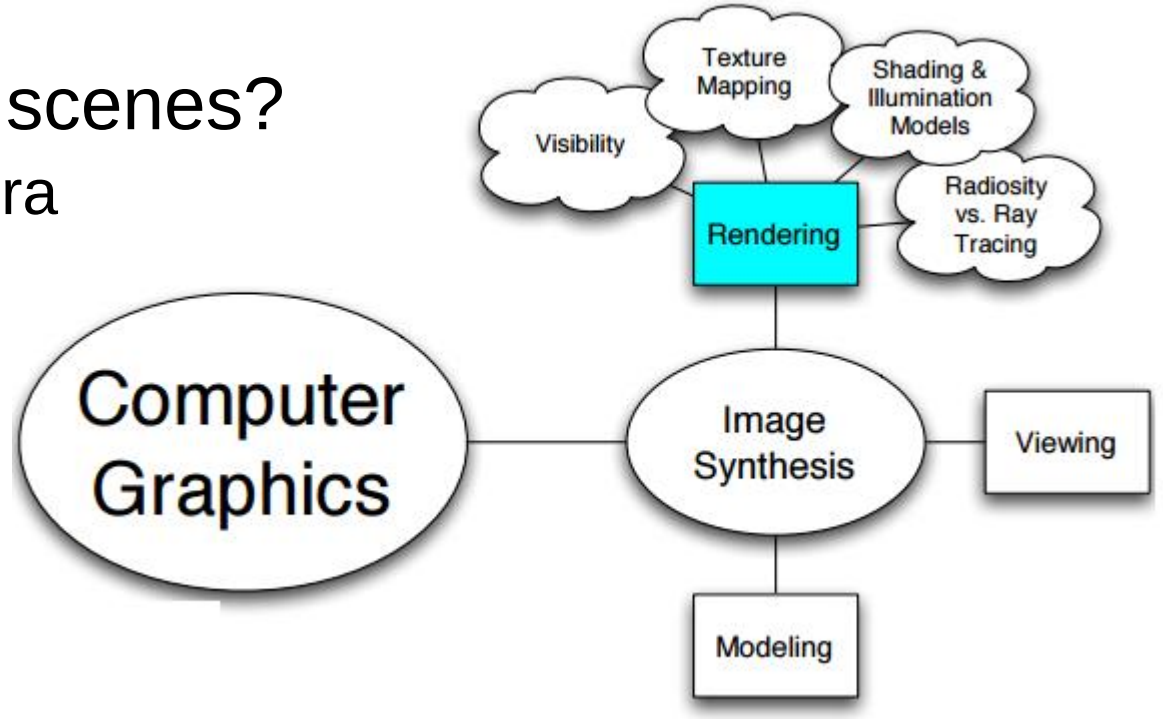




fractals

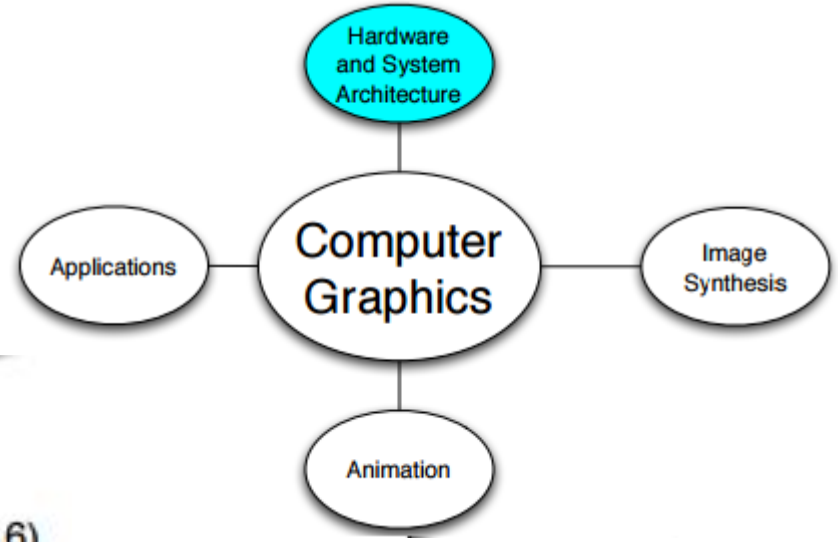
Rendering

- What is an image?
  - Distribution of light energy on 2D “film”
- How do we represent and store images?
  - Sampled array of “pixels”: p[x,y]
- How do we generate images from scenes?
  - Input: 3D description of scene, camera
  - Project to camera’s viewpoint
  - Illumination

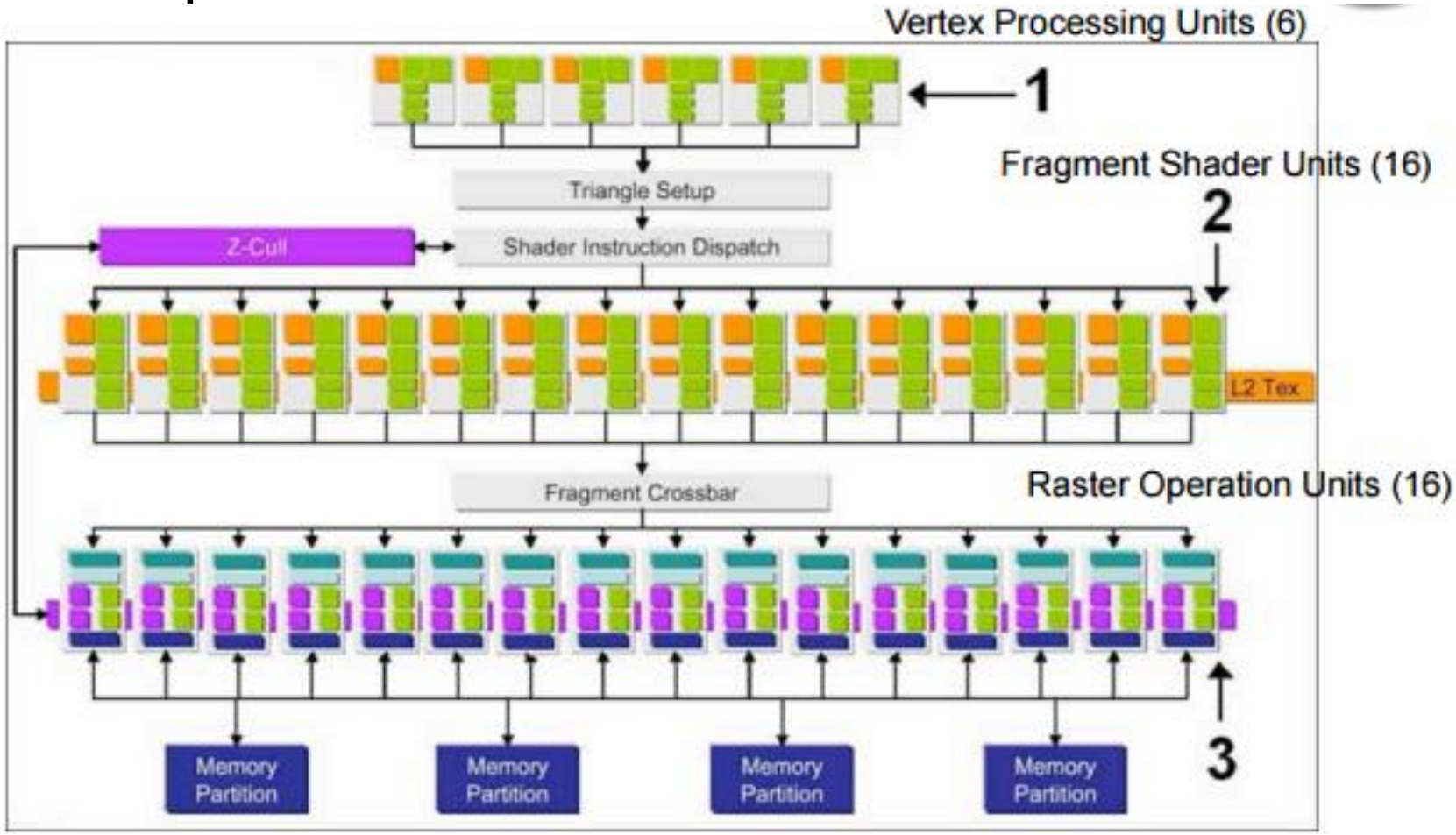


Realistic lighting environments

Hardware

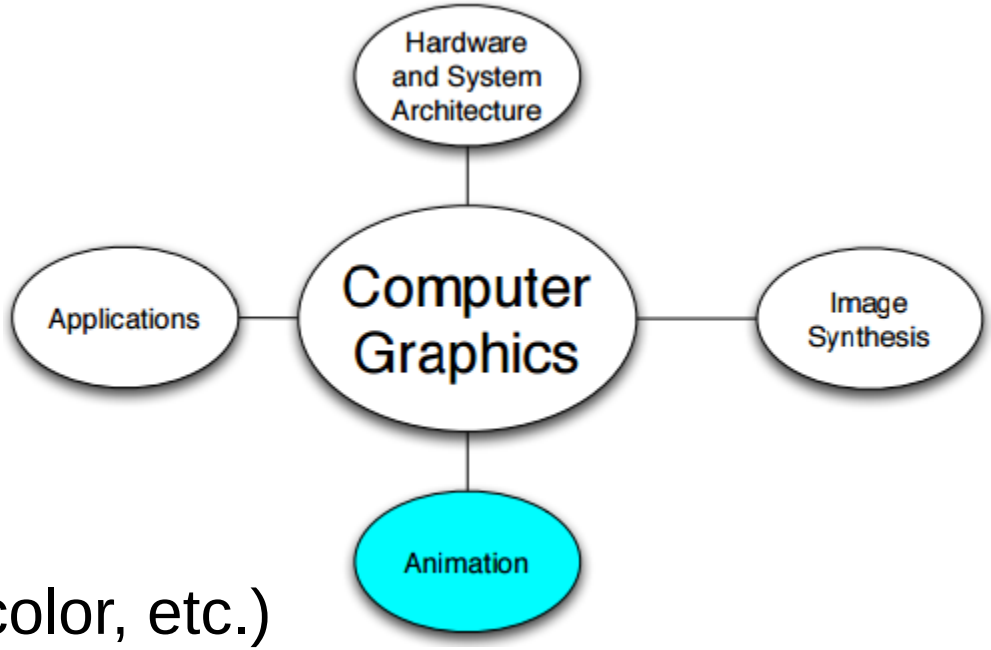


- Example: NVIDIA GeForce 6800



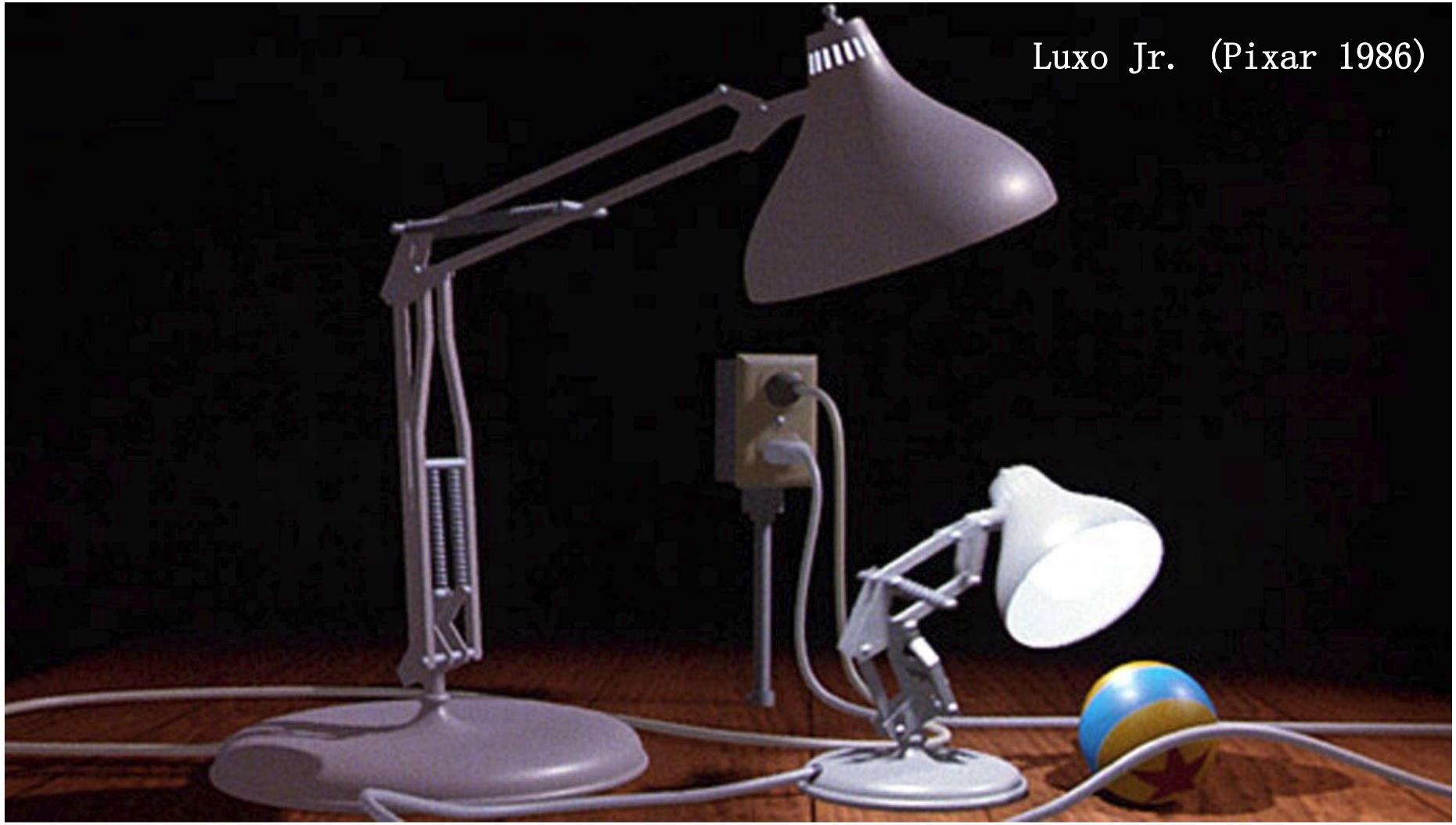
Game => High performance computing => Deep learning

Animation



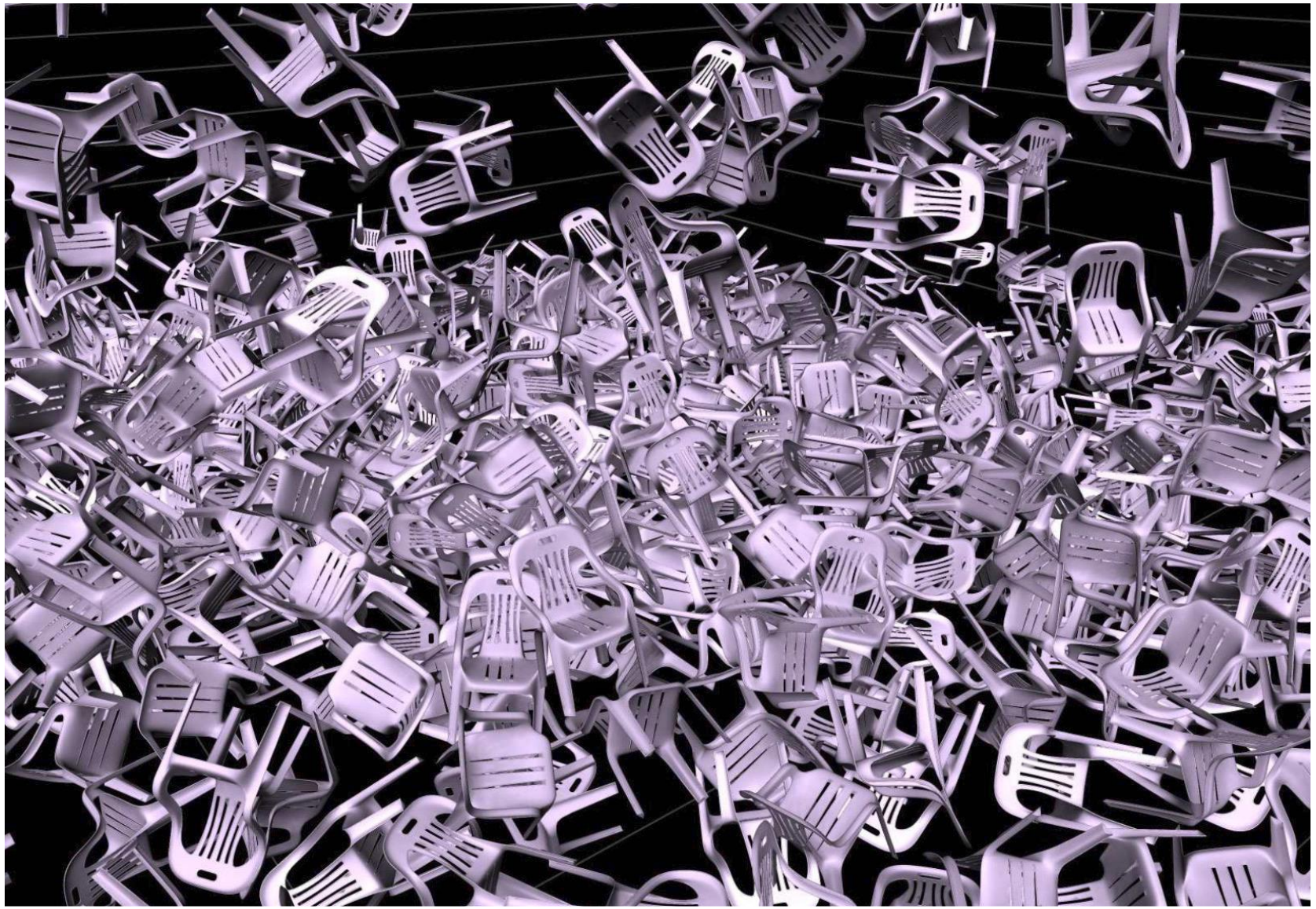
- Model how things move
- Temporal change of
  - Objects (position, orientation, size, shape, color, etc.)
  - Camera (position, direction, angle, focus, etc.)
  - Illumination (position, direction, color, brightness)
- Represent motion
  - Sequence of stills
  - Parameter curves

Animation: modeling motion



https://www.youtube.com/watch?v=wYfYtV_2ezs

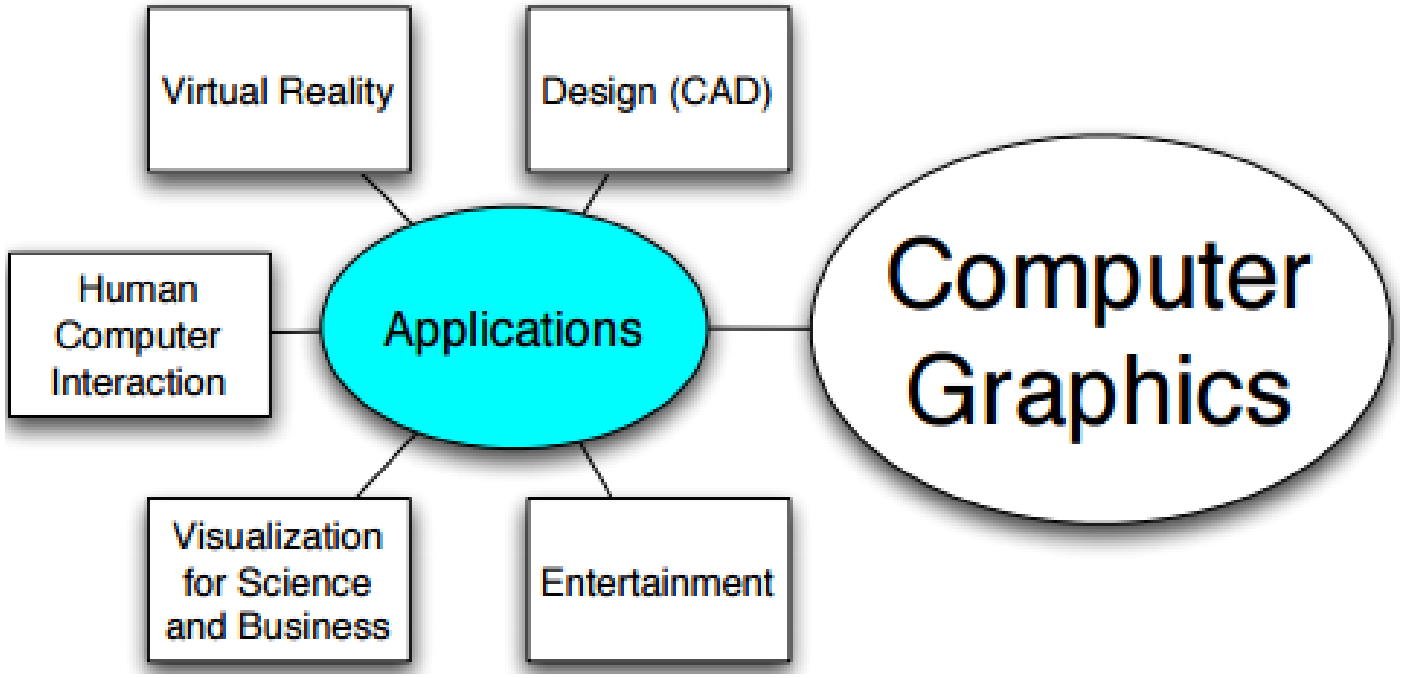
Physically-based simulation of motion



https://www.youtube.com/watch?v=tT81VPk_ukU

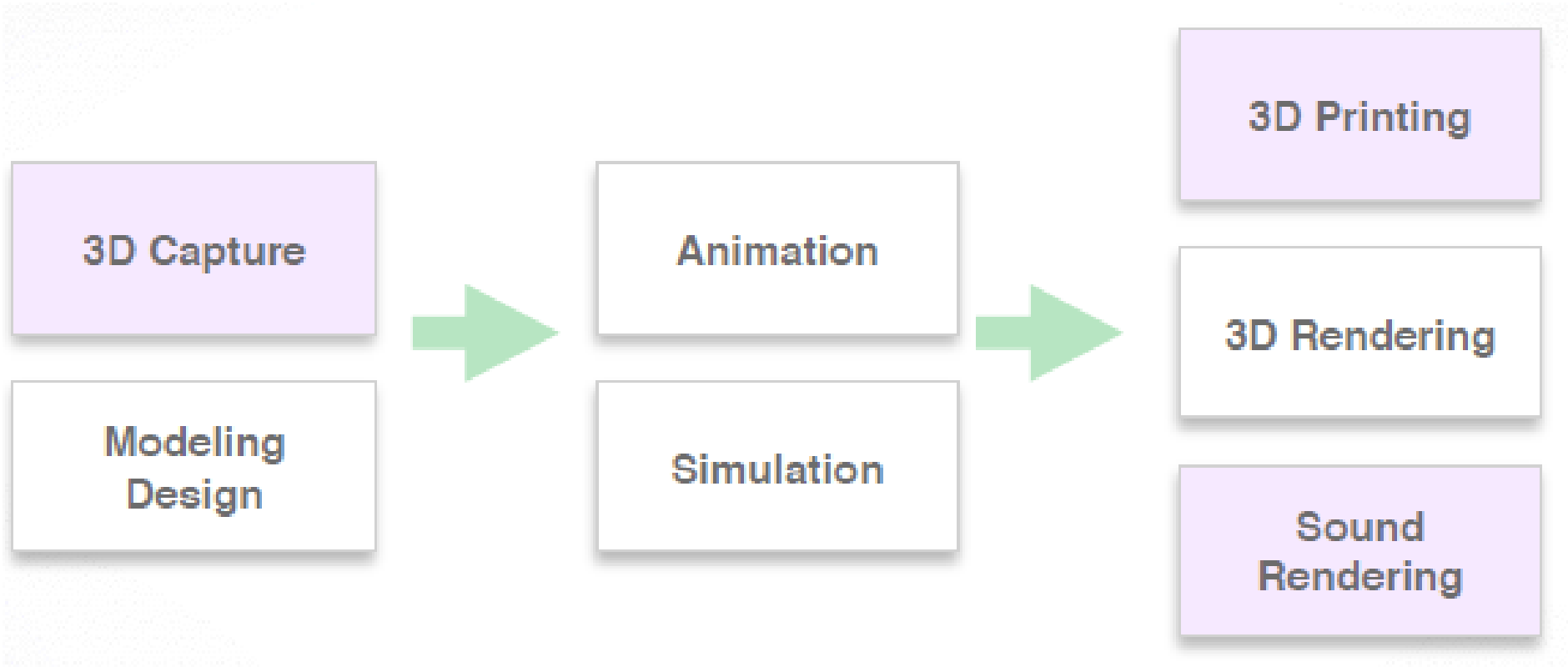
[James 2004]

Uses Of Graphics



- Special effects
- Feature animation
- Computer Games
- Virtual environments
- Visualization (science, business, cartography, ...)
- Design
- Interaction

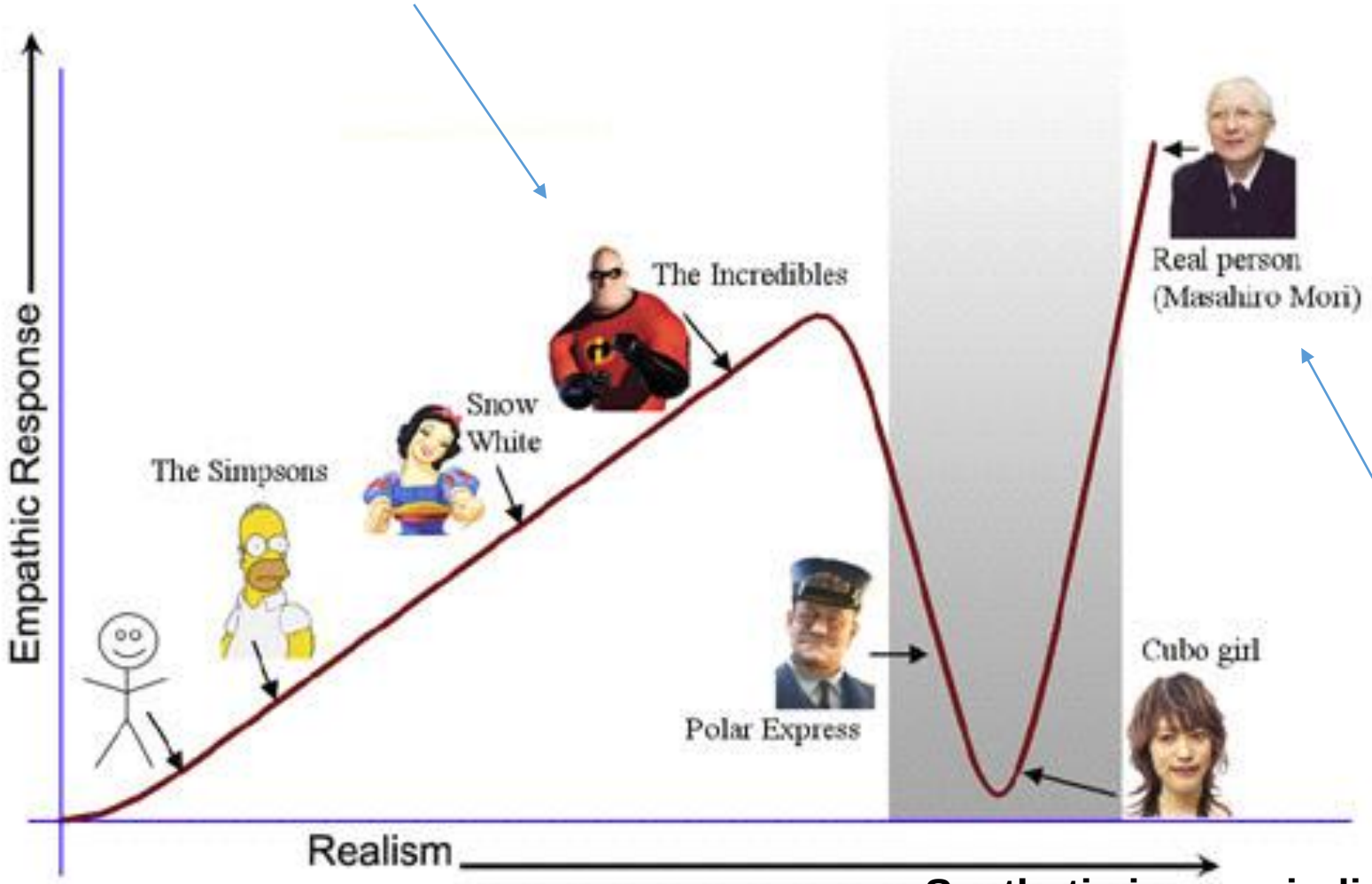
3D Computer Graphics Pipeline



Emerging Fields

Goals in Computer Graphics

Creating a new reality (not necessarily scientific) Practical, aesthetically pleasing, in real time



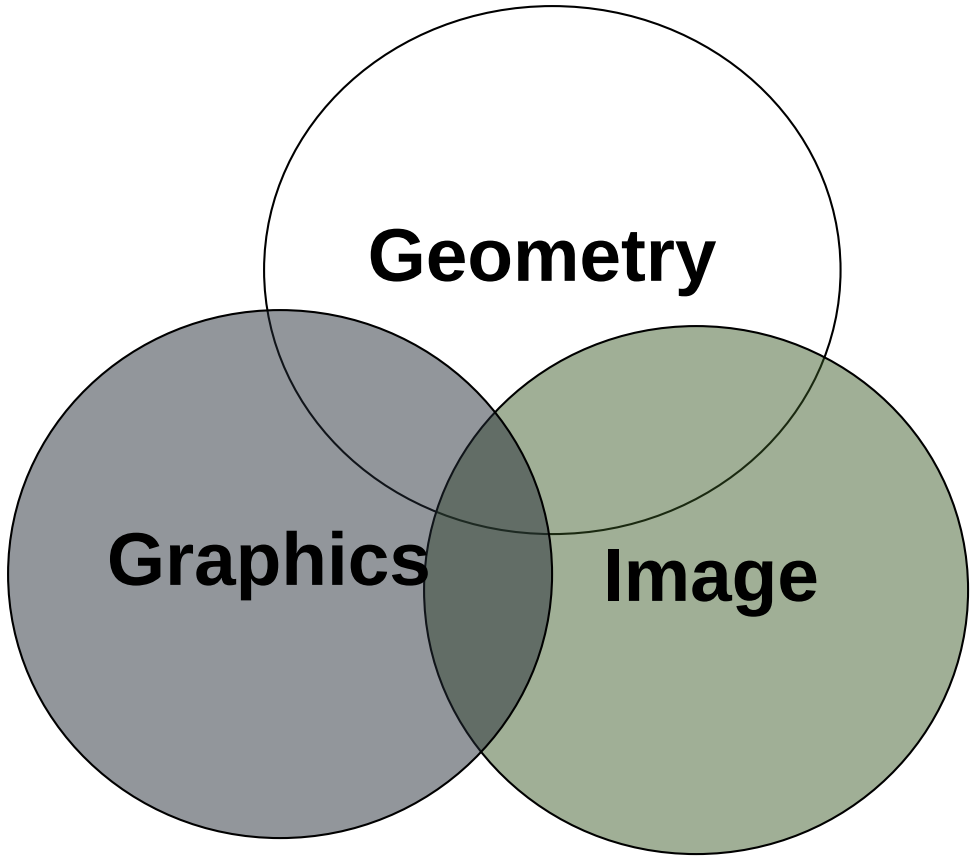
Synthetic images indistinguishable from reality
Practical, scientifically sounds, in real time

SIGGRAPH & SIGGRAPH Asia

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

SIGGRAPH & SIGGRAPH Asia

- SIGGRAPH 2015 Technical Papers Preview Trailer
- SIGGRAPH 2016 Technical Papers Preview Trailer


Geometry
Graphics
Image

几何、图形、图像密不可分

- PDE method for Image processing
- Image interpolation
- Geometry Image
- Mesh filtering
- Segmentations
- Compression
- ……

Administrative Stuff

Course Information On-Line

- http://jjcao.github.io/ComputerGraphics/
  - Schedule (slides, readings)
  - Assignments (details, due dates)
  - Software (libraries, tutorial, links)

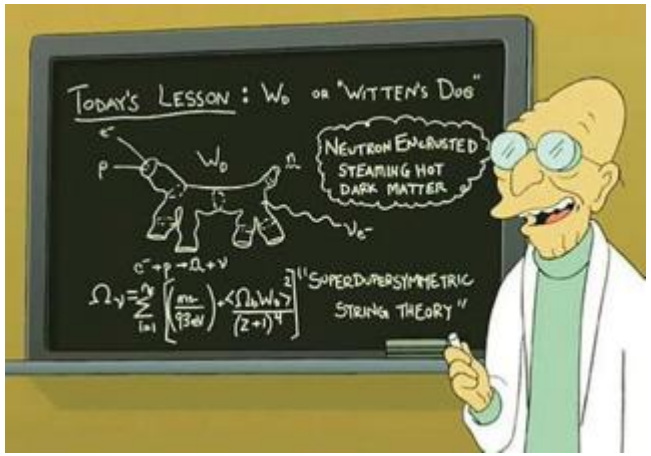
- https://piazza.com/
  - Submit assignments
  - Forum, Q/A

The team

- **Instructor**
  - **Junjie Cao, jjcao@dlut.edu.cn, http://jjcao.github.io**
- **Assistants**
  - **?**

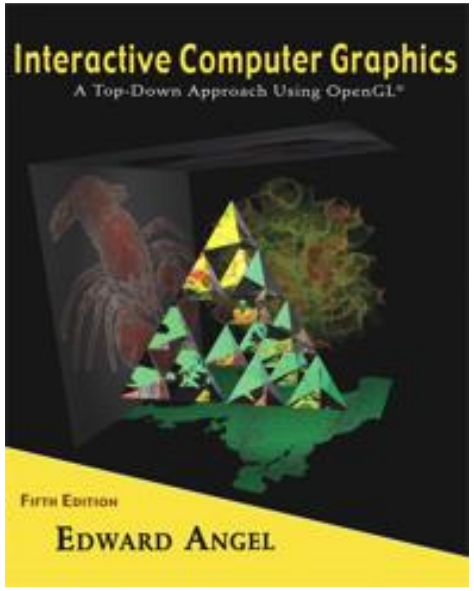
Prerequisites/What Is It I Expect?

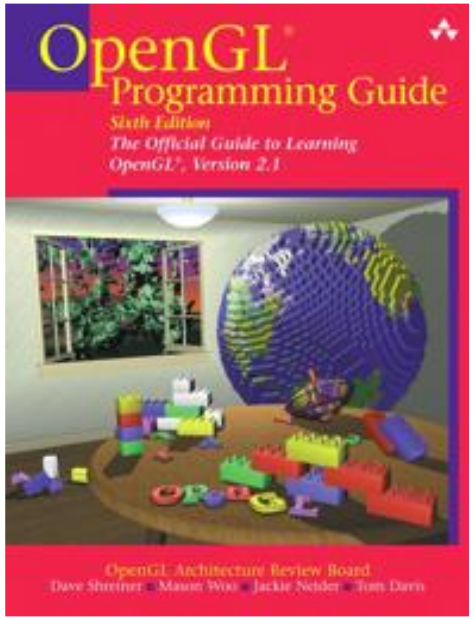
- Coding
  - C/C++
  - Preferably some previous OpenGL exposure
  - Data structures, algorithms
- Math
  - Linear Algebra
  - Differential Equations
- Keeping up with the text(s) is very important



Textbooks

- **Interactive Computer Graphics (“Angel”)**
  - A top-down approach with OpenGL, 6th Edition, Edward Angel, Addison-Wesley
- **OpenGL Programming Guide (“Red Book”)**





Grading

- Classroom Test + Exercises 30%

- Assignments 70%: Document + Compilable code + Executable files
  - Assignment 1: 20 %
  - Assignment 2: 40 %
  - Assignment 3: 40 %

- Two students a team

Document in A4 & electronic:
functions (required + optional)

RF1
Text description;
Code segment for the function
Image illustration;

RF2
Text description;
Code segment for the function
Image illustration;

OF1
Text description;
Code segment for the function
Image illustration;

Code in electronic:

- I can open *.sln and build it successfully and without modify setting and anything outside the folder.

- Compress whole folder into a zip
- Run packing.bat before compression

- Good function name and proper comments

Exe in electronic:

- A folder with exe, dll, and input data.

- Compress whole folder into a zip.

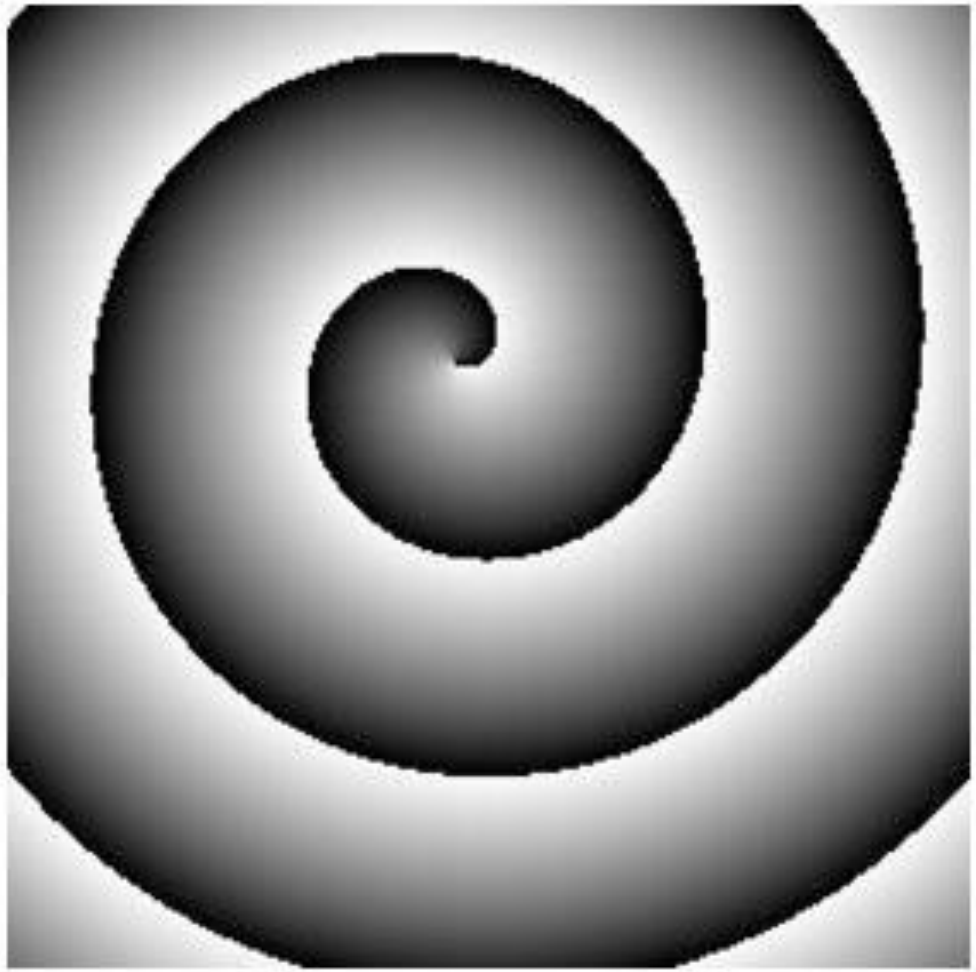
Academic Integrity

- Do not copy any parts of the assignments from anyone
- Do not look at other student’s code
- Collaboration only for the project
- Don’t cheat, okay?

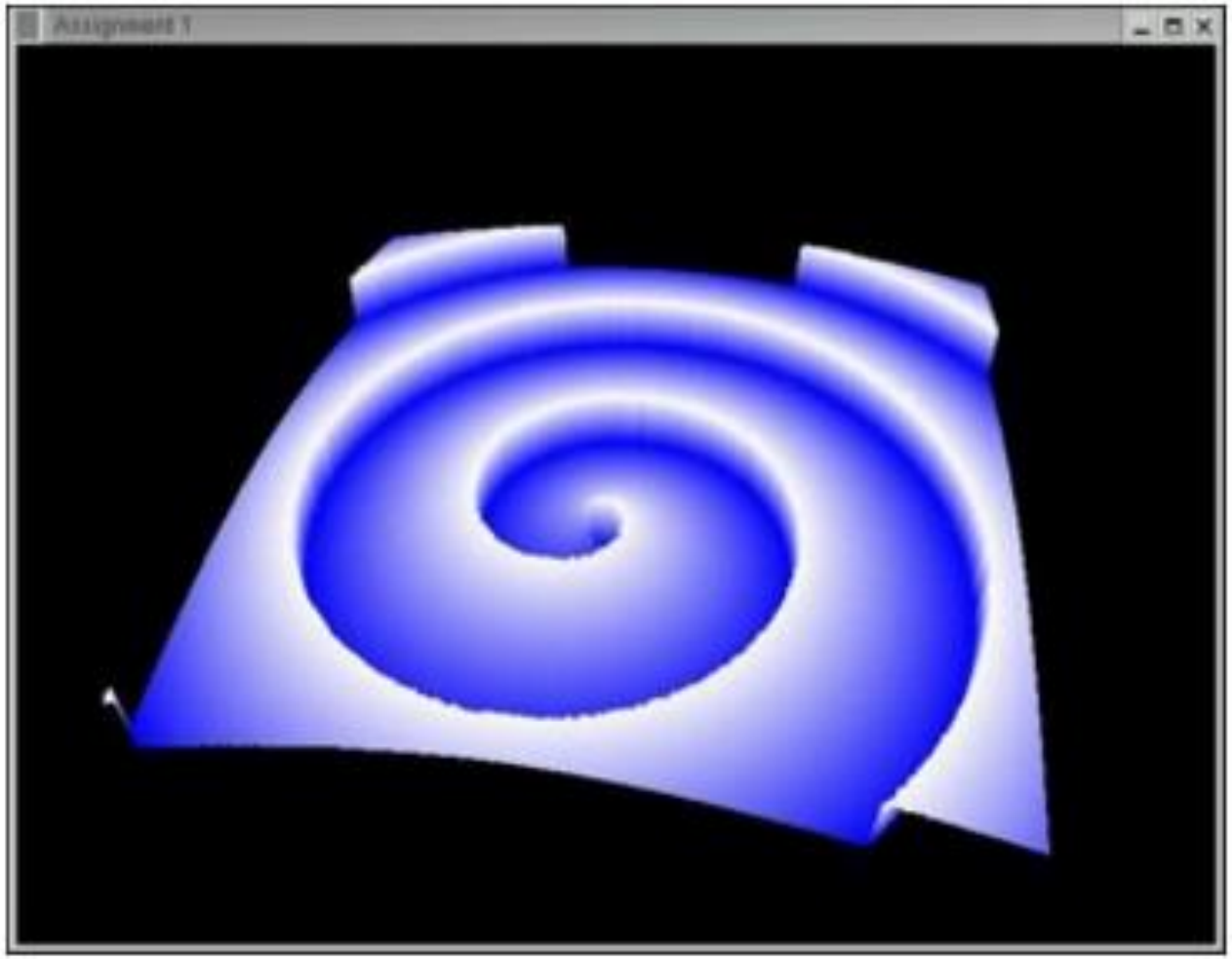
Assignment Policies

- Programming Assignments
  - Hand in via Piazza
  - Functionality and features
  - Style and documentation
  - Artistic impression
- Academic integrity policy applied rigorously

Assignment 1 – Height field

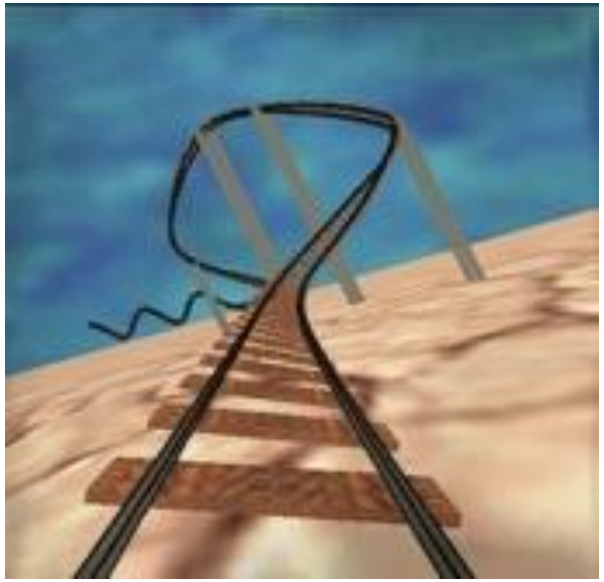


input (source image)

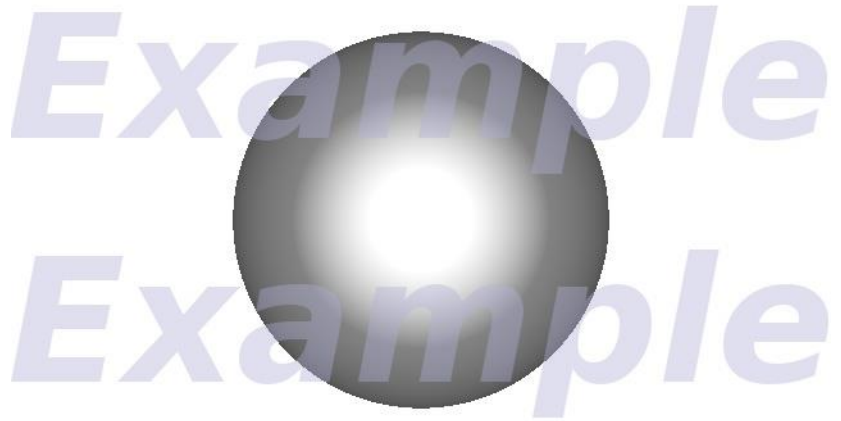


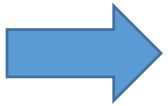
output (height field)

Assignment 2 – **Simulating a Roller Coaster**



Assignment 3 – Height field

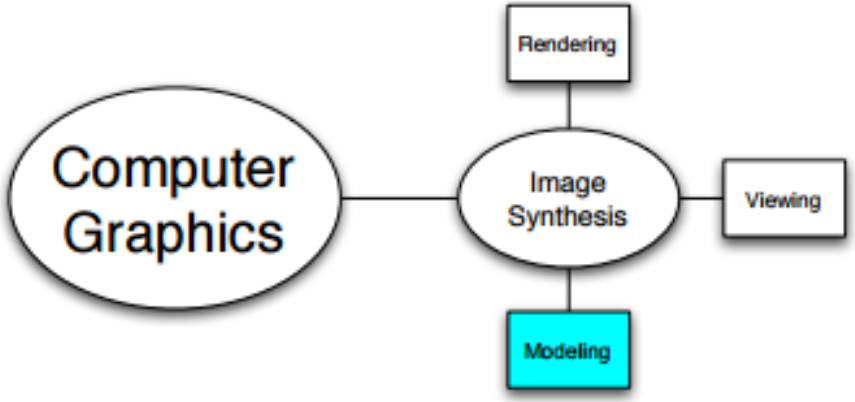




Introduction

- What is Computer Graphics?
  - Applications
  - History
  - Relations with other Disciplines
- Administrative Stuff
- **Course Overview**
- Research Trends

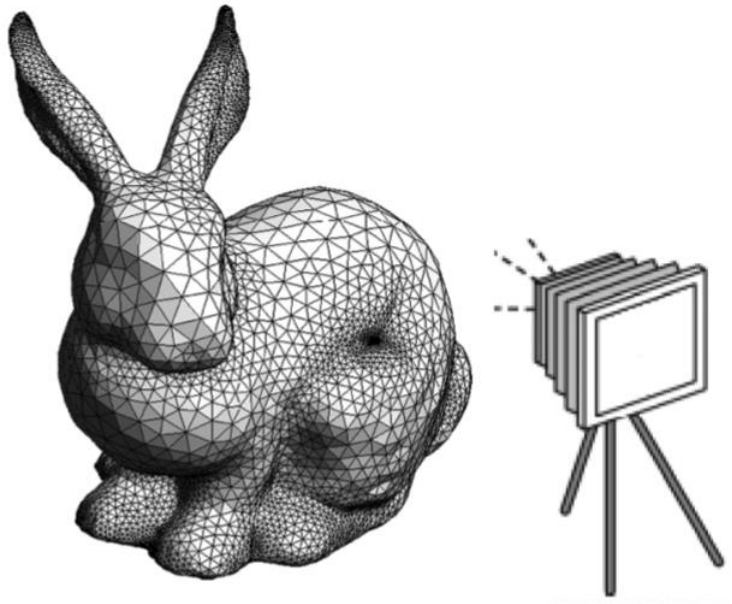
Topics / Course Overview

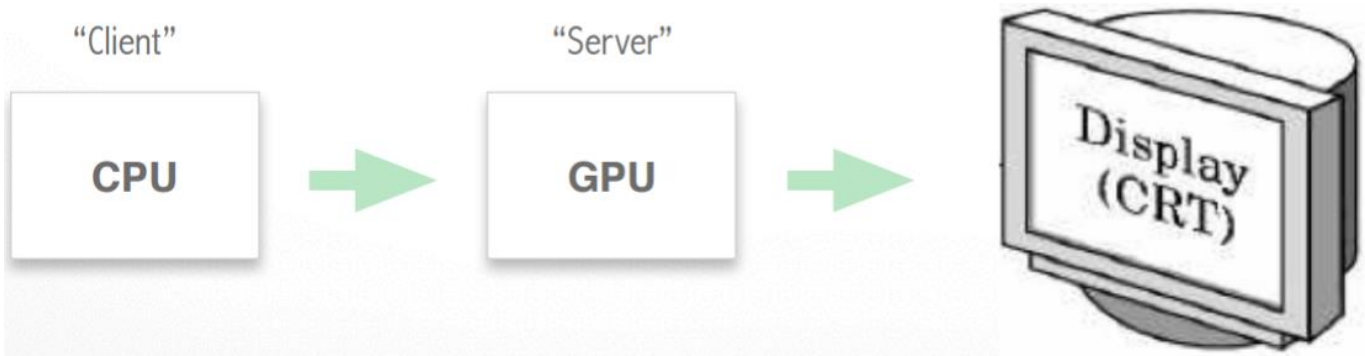


- **Theory / Computer Graphics Disciplines**
  - Image Processing: how to edit images
  - Modeling: how to represent objects
  - Rendering: how to create images of objects
  - Animation: how to control and represent motion
- **Practice: OpenGL graphics library**

OpenGL Basics

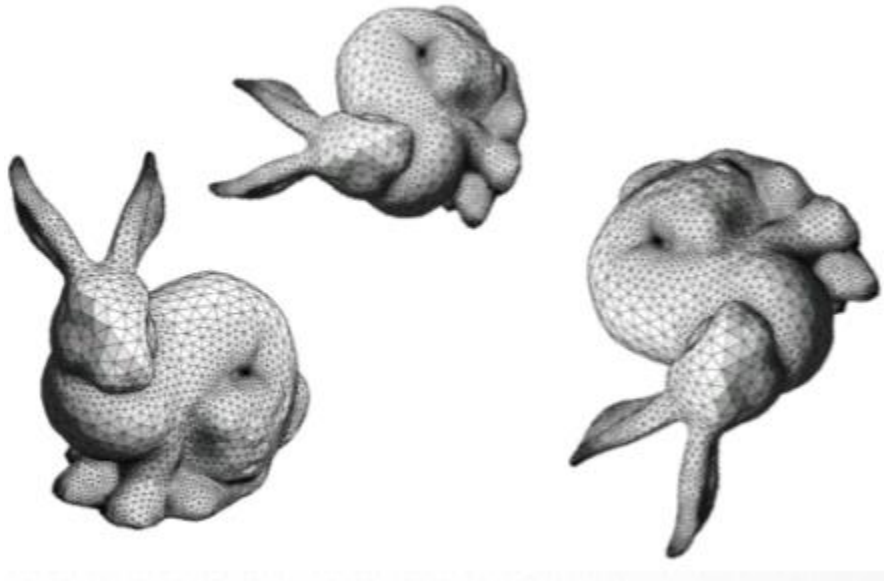
- Primitives and attributes
  - Text & fonts
- Color
- Viewing
- Control functions
  - Clients & servers
  - Event driven programming
- [Angel, Ch. 2]





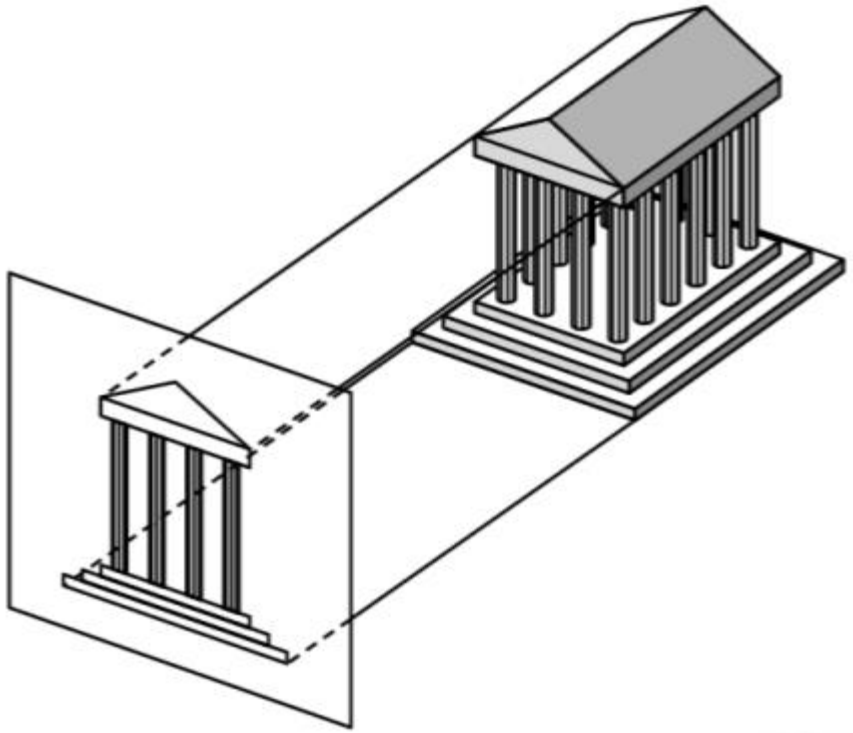
Objects & Transformations

- Linear algebra review
- Coordinate systems and frames
- Rotation, translation, scaling
- Homogenous coordinates
- OpenGL transformations
- [Angel, Ch. 3]



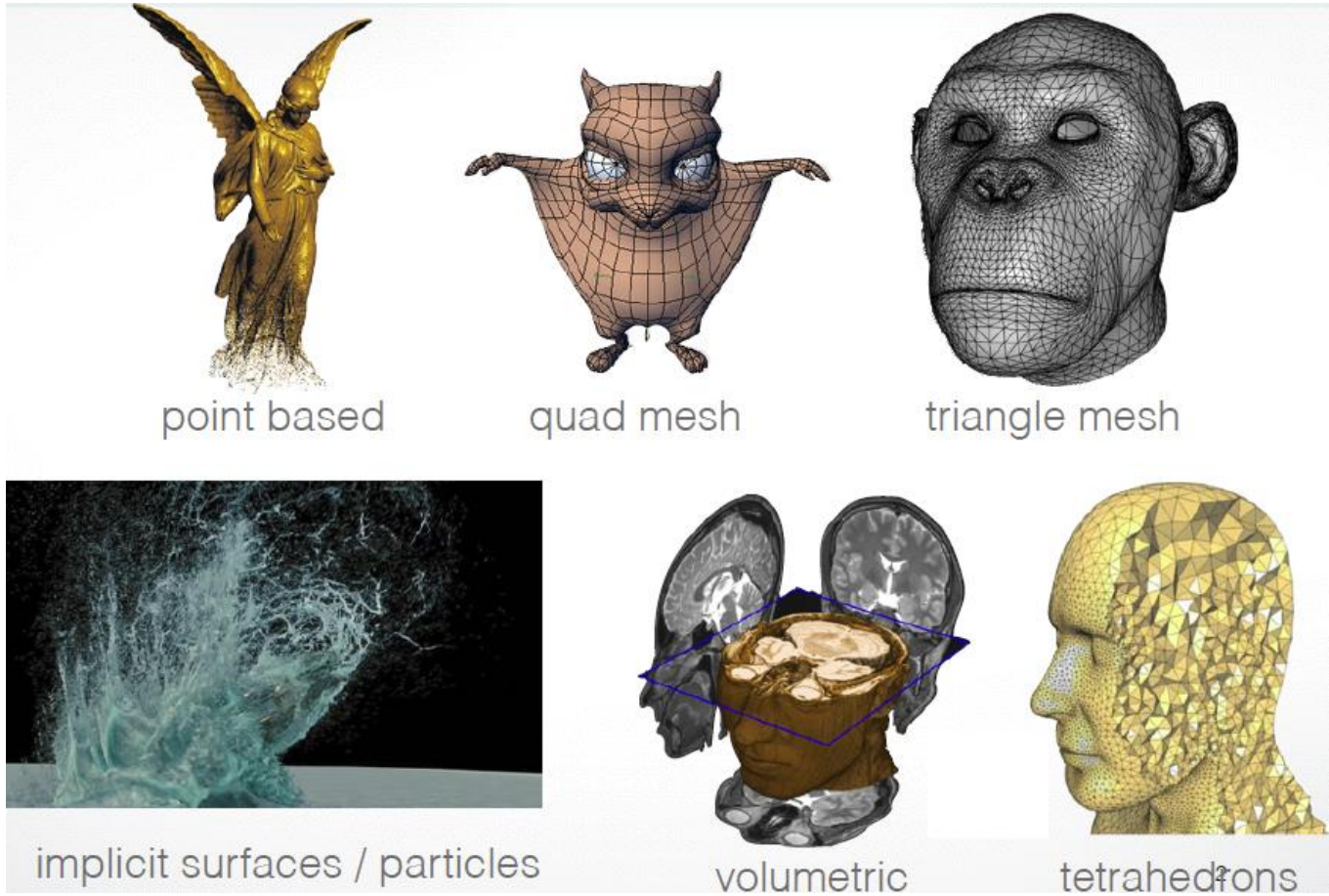
Viewing and Projection

- Orthographic projection
- Perspective projection
- Camera positioning
- Projection in OpenGL
- Hidden surface removal
- [Angel, Ch. 4]



Curves & Surfaces

- Recall 3D calculus
- Explicit representation: triangular mesh
- Implicit representation
- Parametric curves & surfaces
  - Hermite curves and surfaces
  - Bézier curves and surfaces
  - Splines
- Curves and surfaces in OpenGL
- [Angel, Ch. 10]

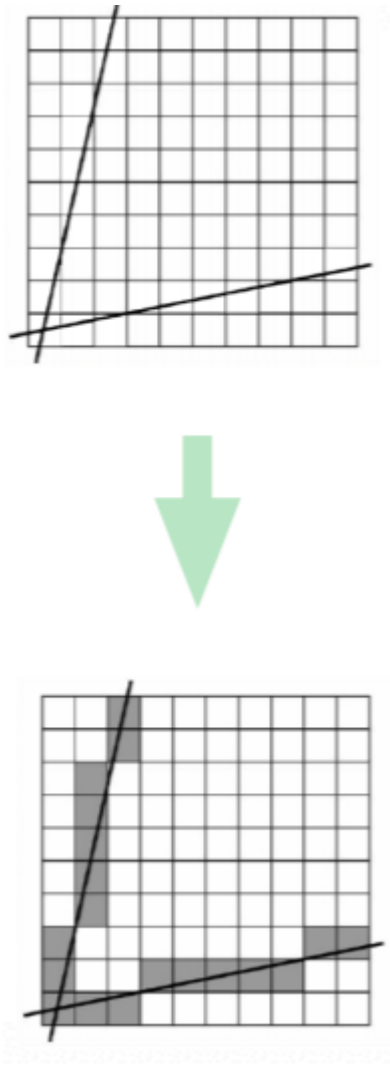


Light & Shading

- Light sources
- Ambient, diffuse, and specular reflection
- Normal vectors
- Material properties in OpenGL
- Radiosity
- [Angel, Ch. 5]

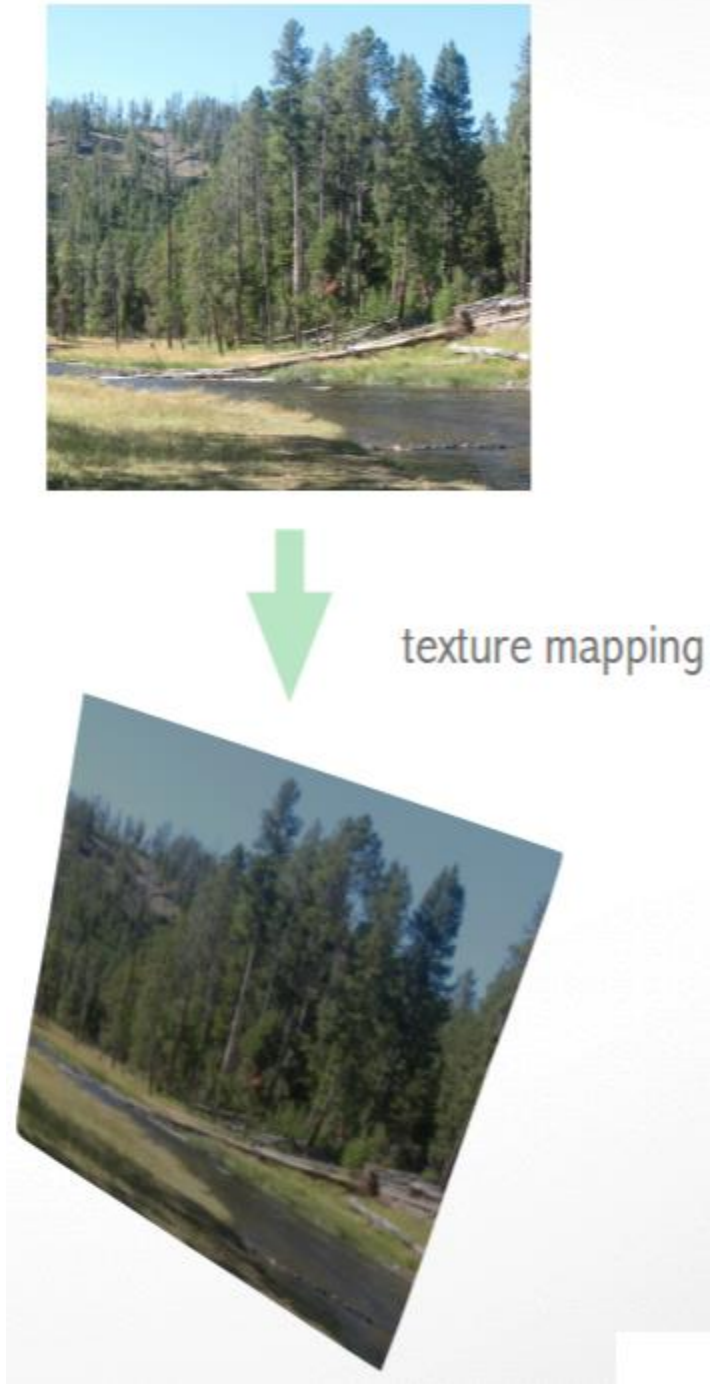
Rendering

- Clipping
- Bounding boxes
- Hidden-surface removal
- Line drawing
- Scan conversion
- Anti-aliasing
- [Angel, Ch. 6]



Textures and Pixels

- Texture mapping
- OpenGL texture primitives
- Bump maps
- Environment maps
- Opacity and blending
- Image filtering
- [Angel, Ch. 7]

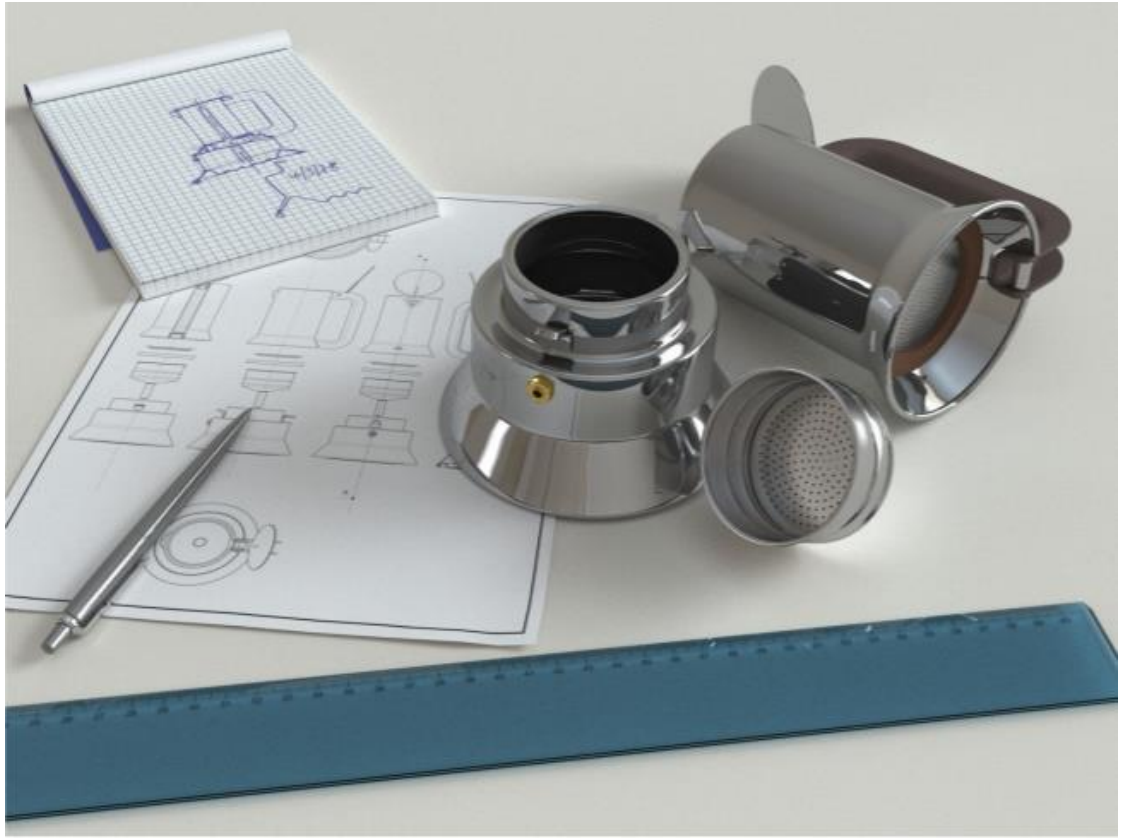


Hierarchical Models

- Re-using objects
- Animations
- OpenGL routines
- Parameters and transformations
- [Angel, Ch. 8]

Advanced rendering - Ray Tracing

- Basic ray tracing [Angel, Ch. 11]
- Motion blur
- Soft shadows
- Local vs global illumination
- Interreflections
- Radiosity equation
- Solution methods



Physically Based Models

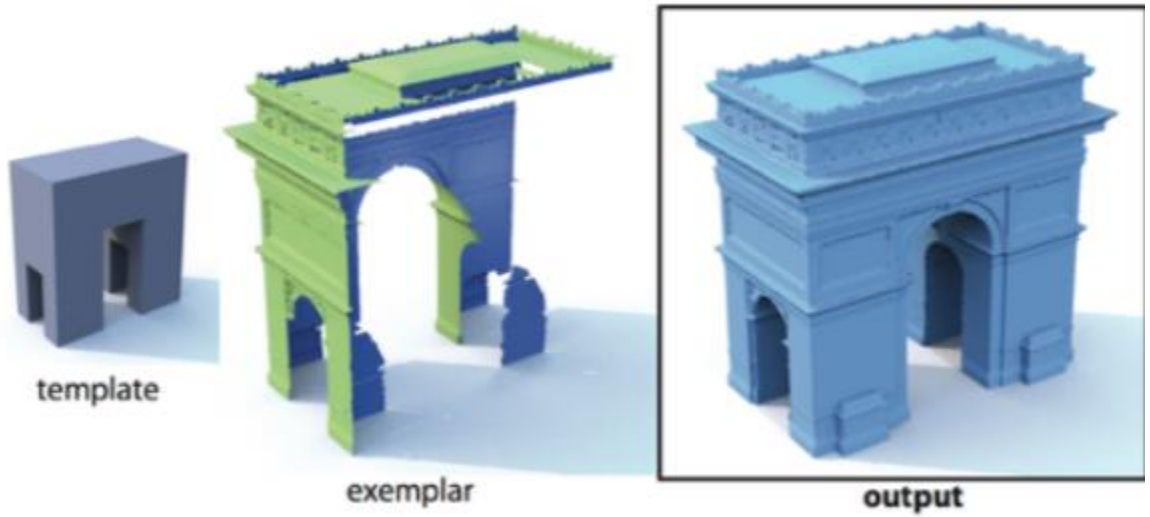
- Particle systems
- Spring forces
- Cloth
- Collisions
- Constraints
- Fractals
- [Angel, Ch. 9]

Image Processing

- Filters
- Dithering
- Blending
- Display Color Models

“Wildcard” Lectures

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

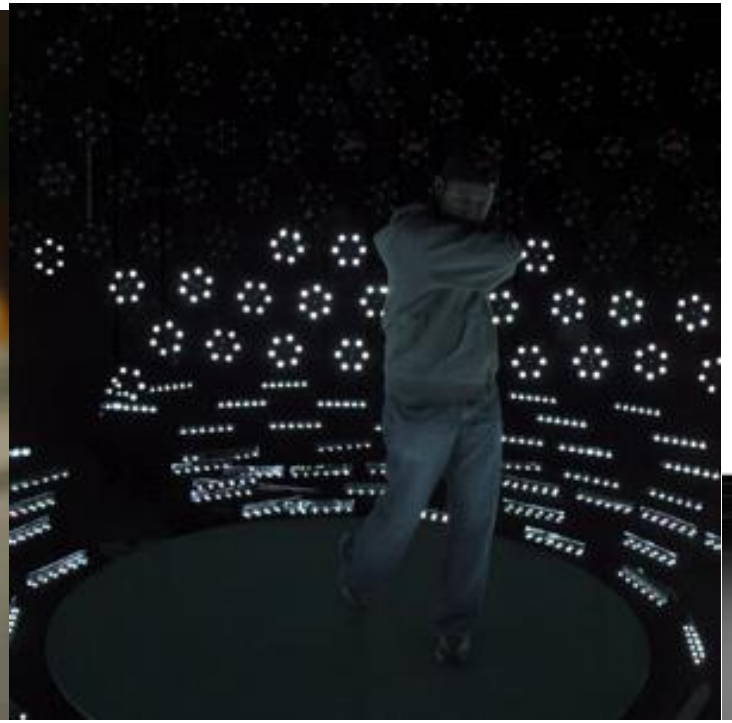


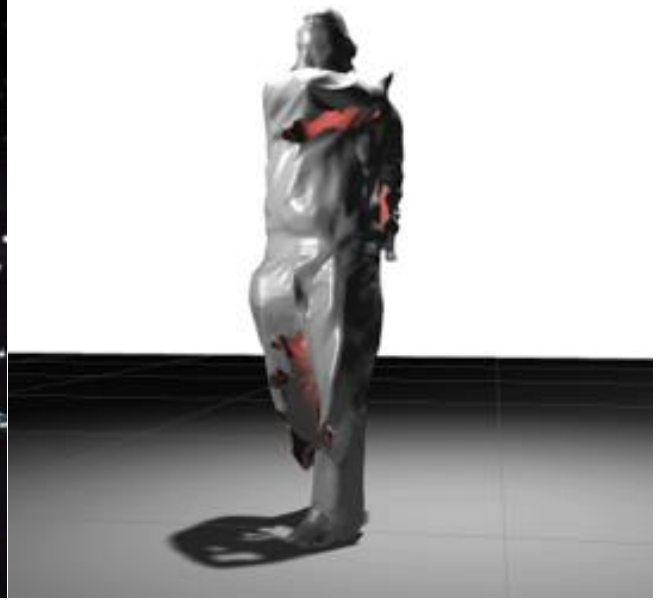
Research Trends

From Offline to Realtime

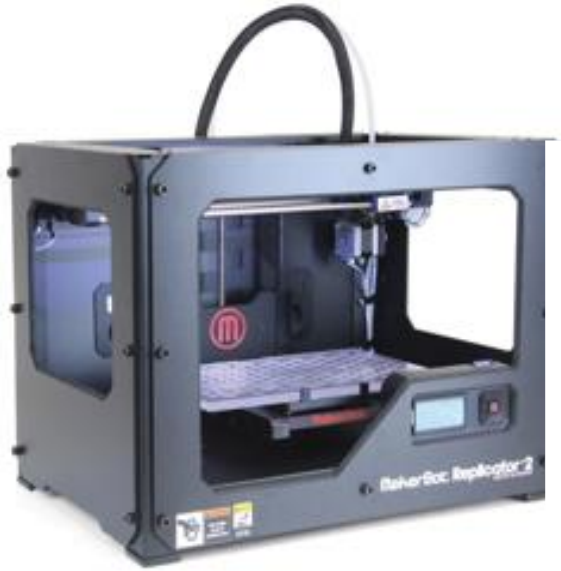
Unreal Engine Kite Demo (Epic Games 2015)

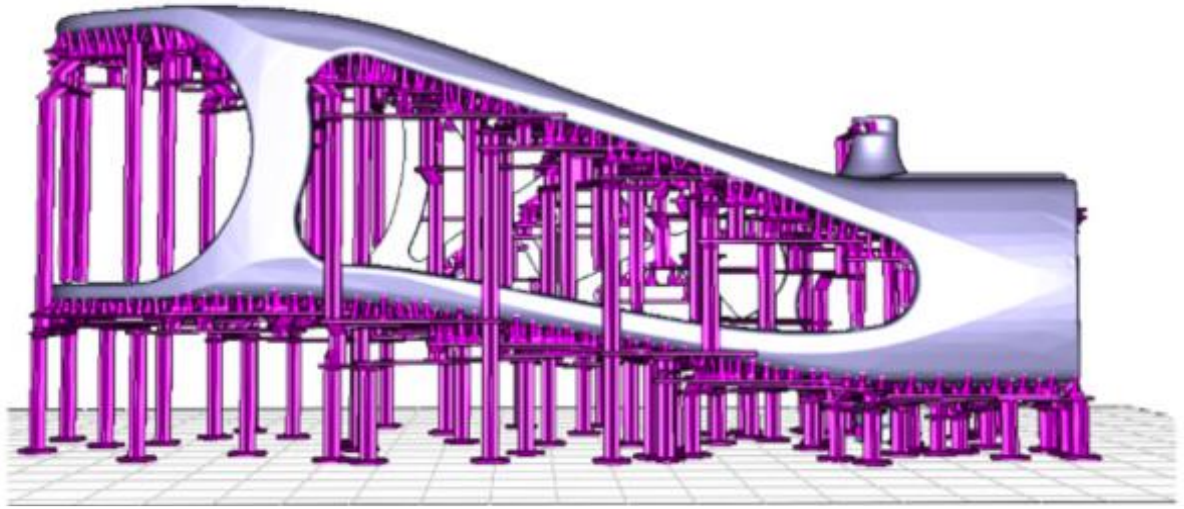
From Graphics to Vision





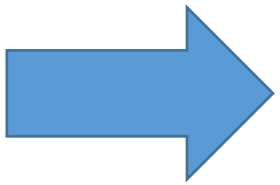
From Graphics to Fabrication





From Production to Consumers

VFX



online shopping

Realtime Facial Animation

- **Live Demo**

Acknowledgements

- **Lecture based on material from:**
  - CSCI 420: Computer Graphics FS 2015, by Hao Li, execllent slides and assignments: image 2 height fields, Simulating a Roller Coaster, ray tracing
  - Computer Graphics : 15-462/662 Fall 2016 - Carnegie Mellon University @ CMU

  - CS 148 Introduction to Computer Graphics and Imaging (Fall 2015) @ stanford
  - 6.837 Computer Graphics (fall 2011) @ MIT

Thanks