Computer Graphics -Introduction

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

About Me

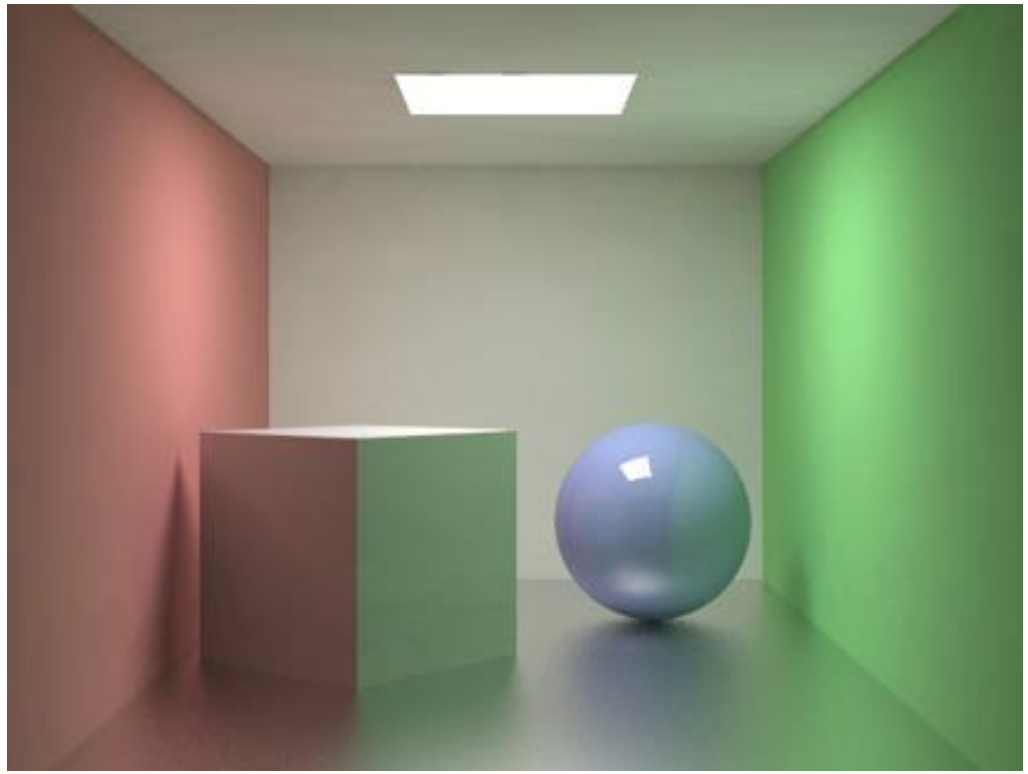
- jjcao.github.io
- CGGI: cggi.dlut.edu.cn

Context

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

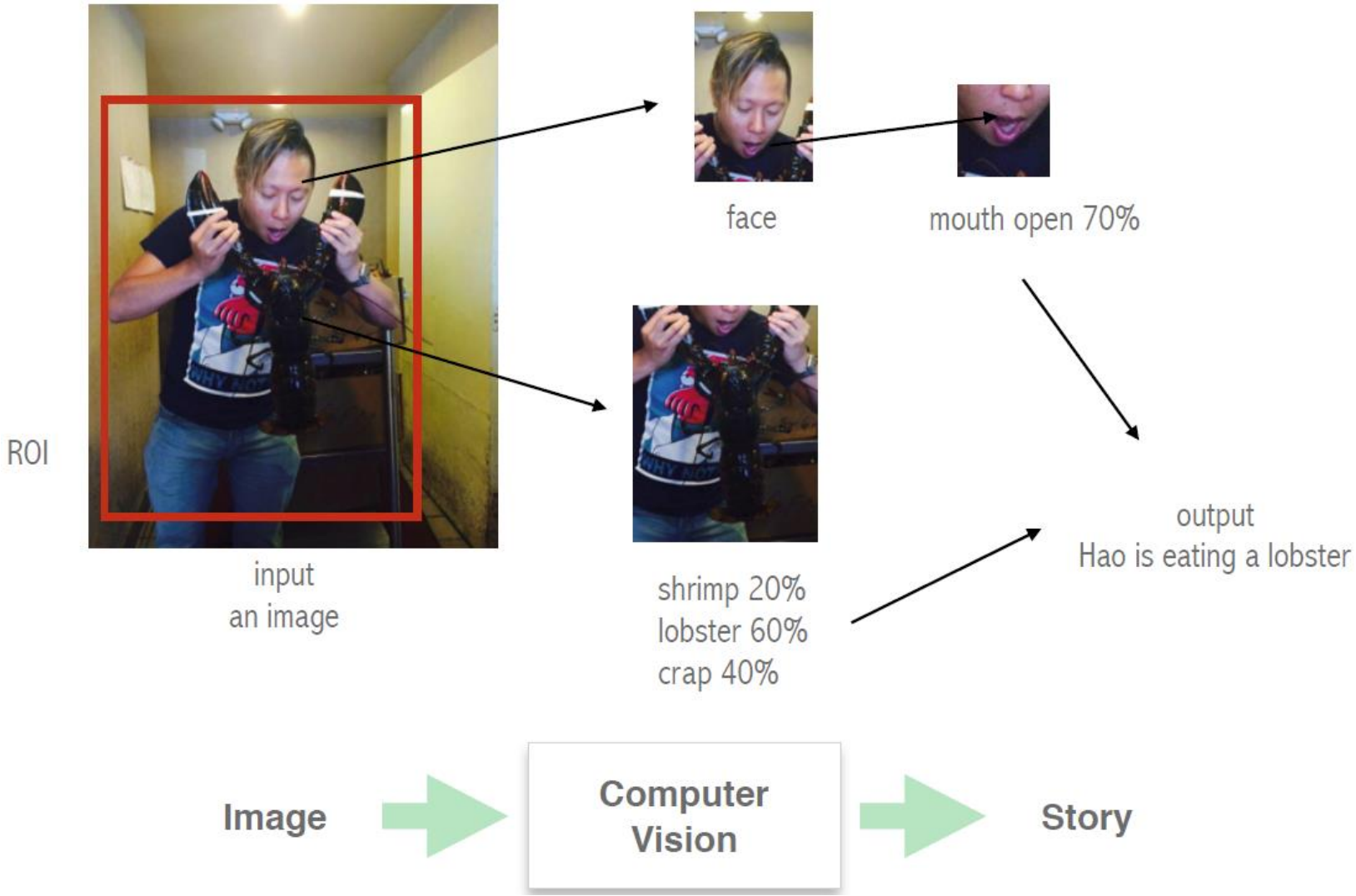
Computer Graphics

- 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



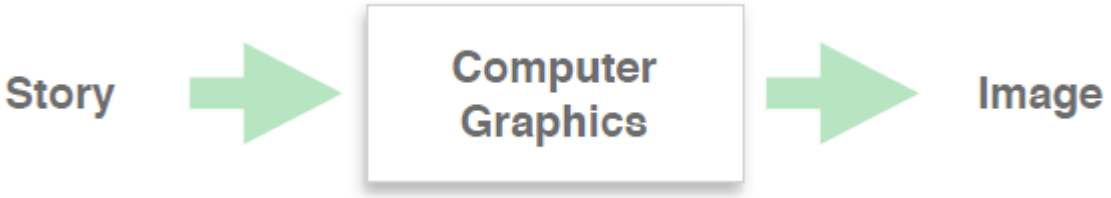
Computer Graphics vs. Vision

Computer Vision

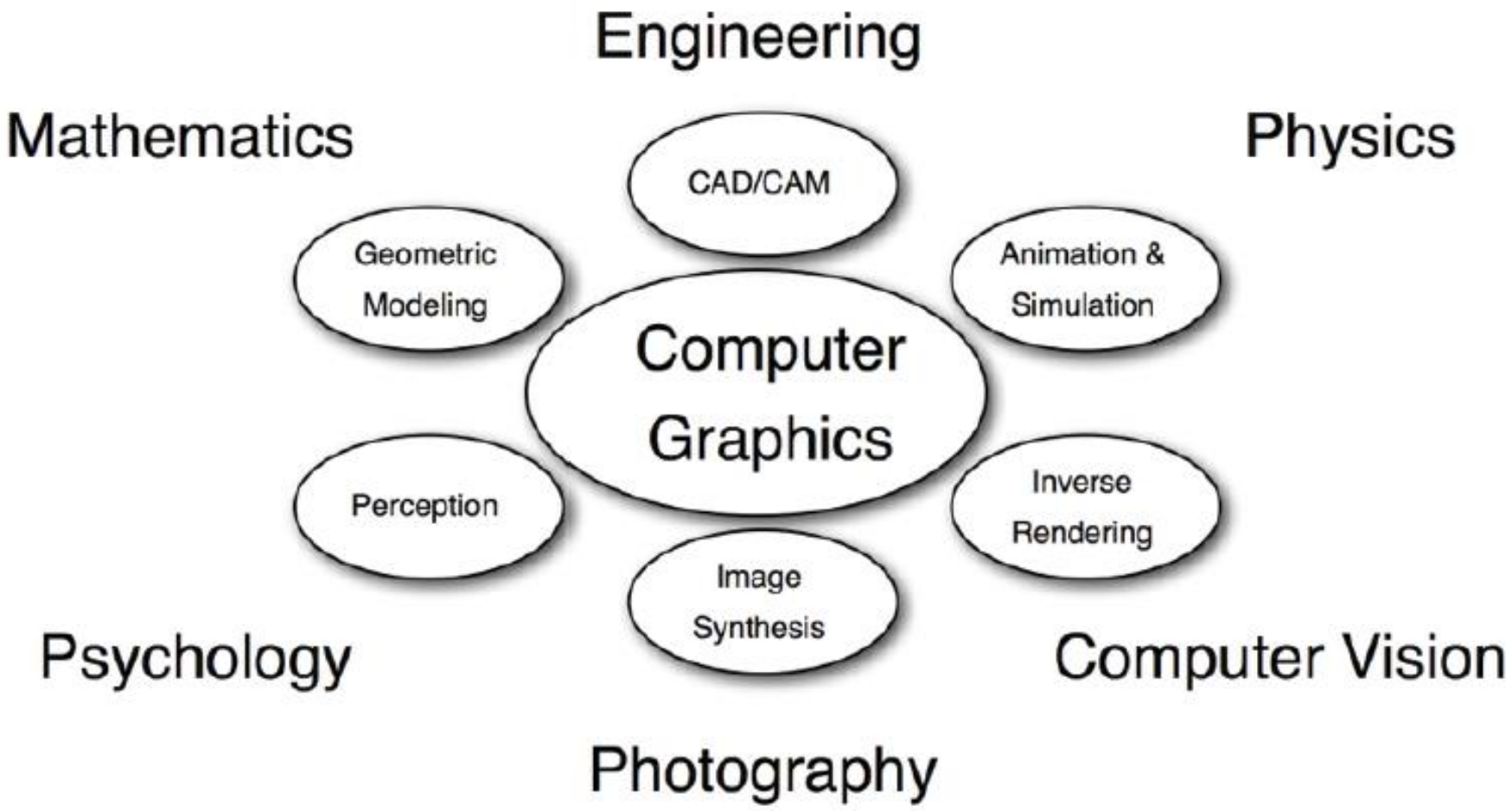


Computer Graphics

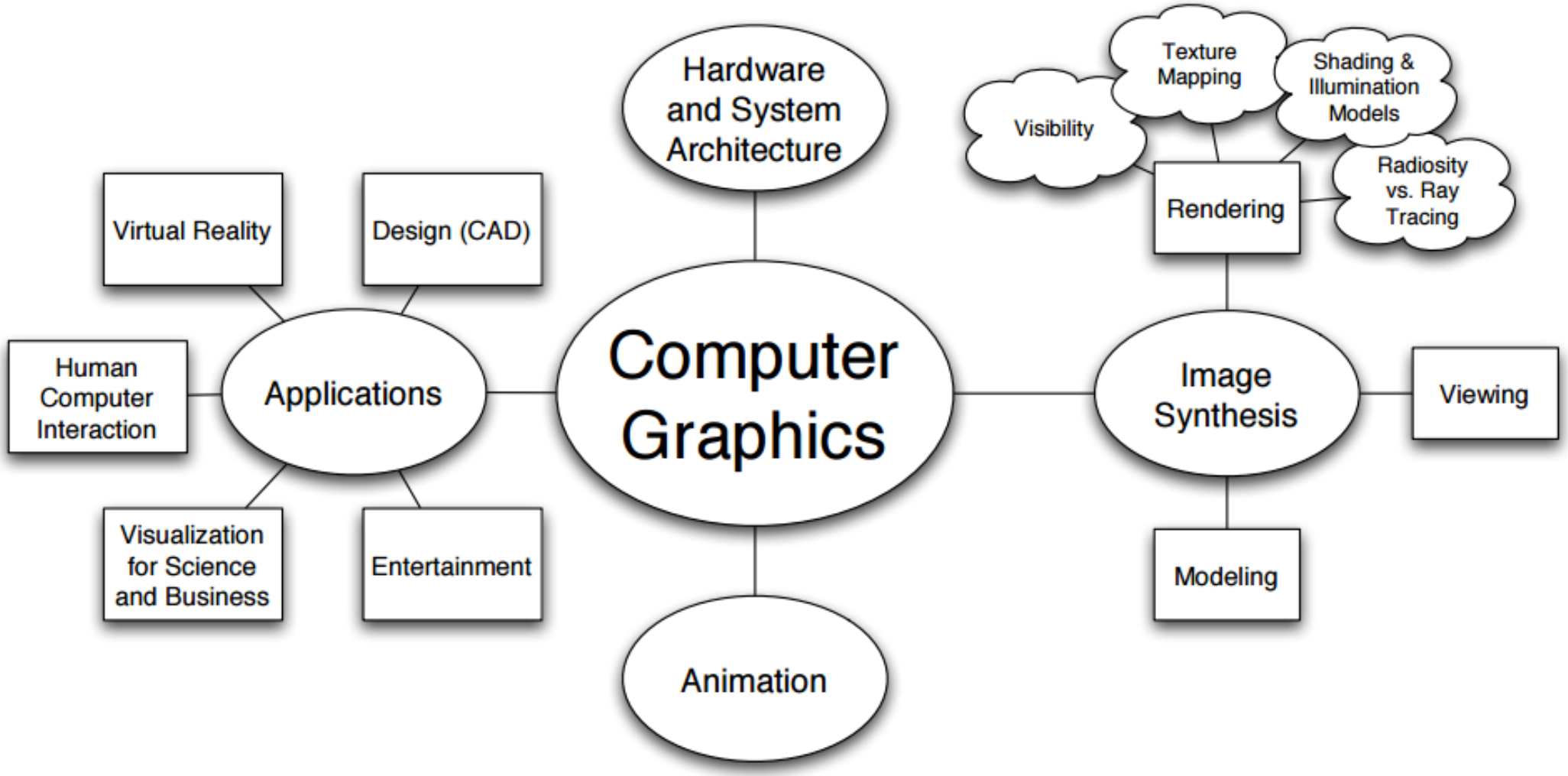
Action!



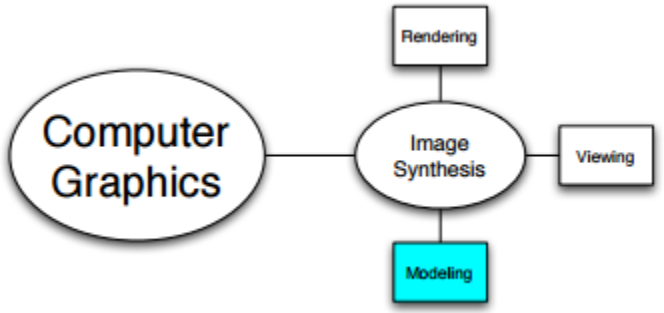
Related to many Disciplines



What Is Computer Graphics?

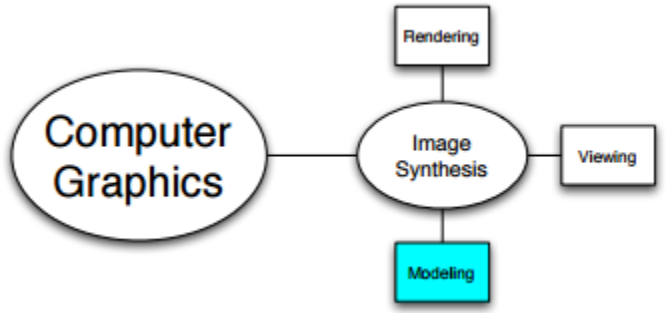


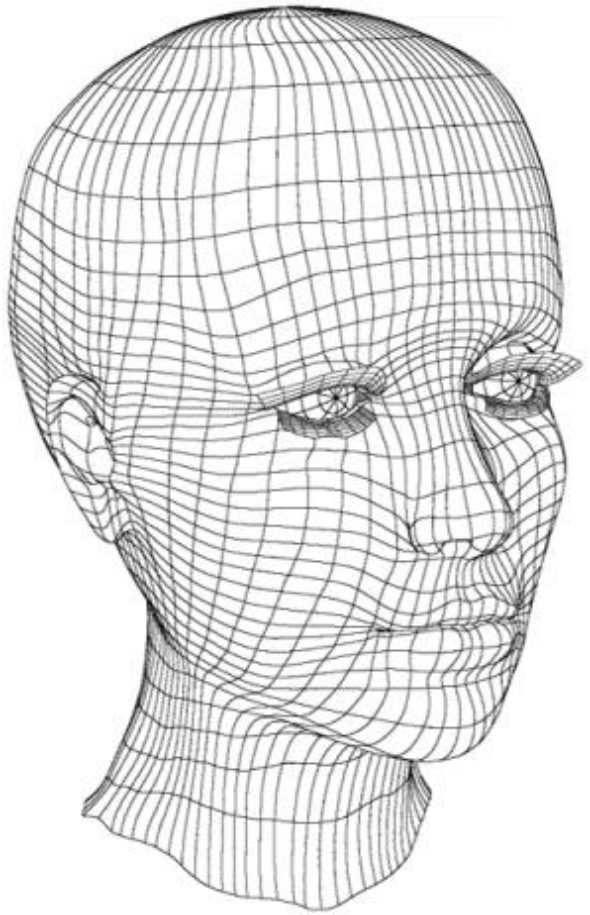
Modeling



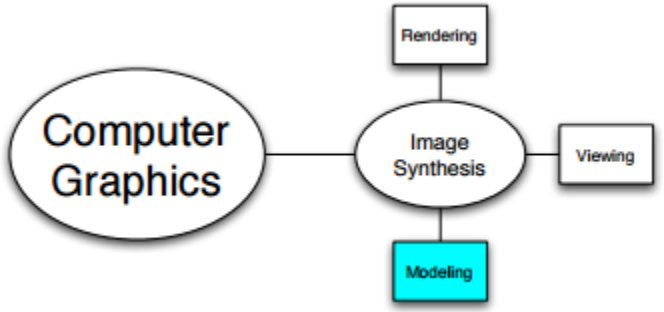
- How to represent real environments
  - Geometry: curves, surfaces, volumes
  - Photometry: light, color, reflectance
- How to build these representations
  - Interactive: sculpt it
  - Algorithmic: let it grow (fractals, extraction)
  - Scanning: via 3D sensing
- Generate primitives
  - Lines, triangles, quads, patches
  - Cylinder, spheres
  - Higher-order primitives

Modeling: Interactive

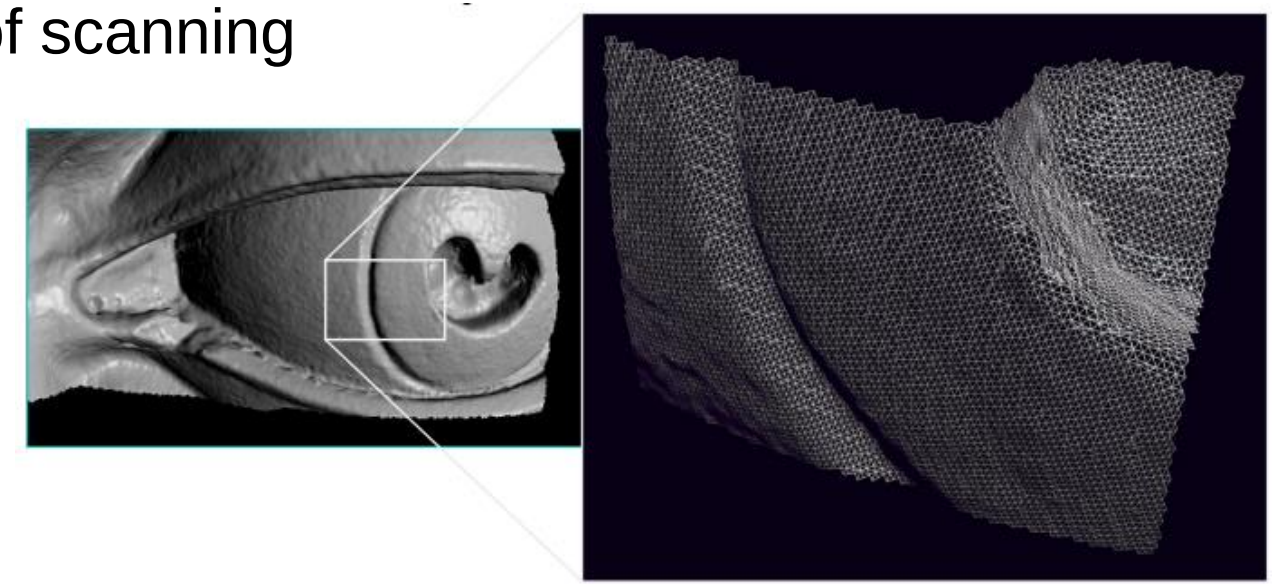




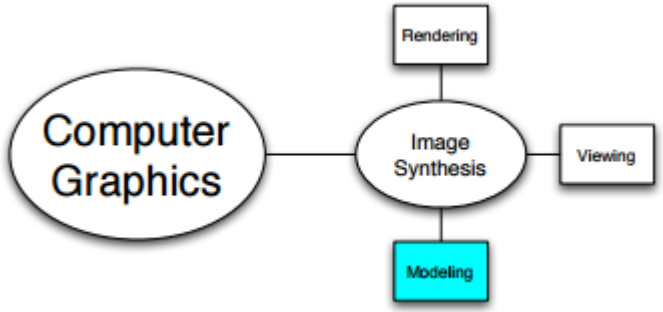
Modeling: Scanning

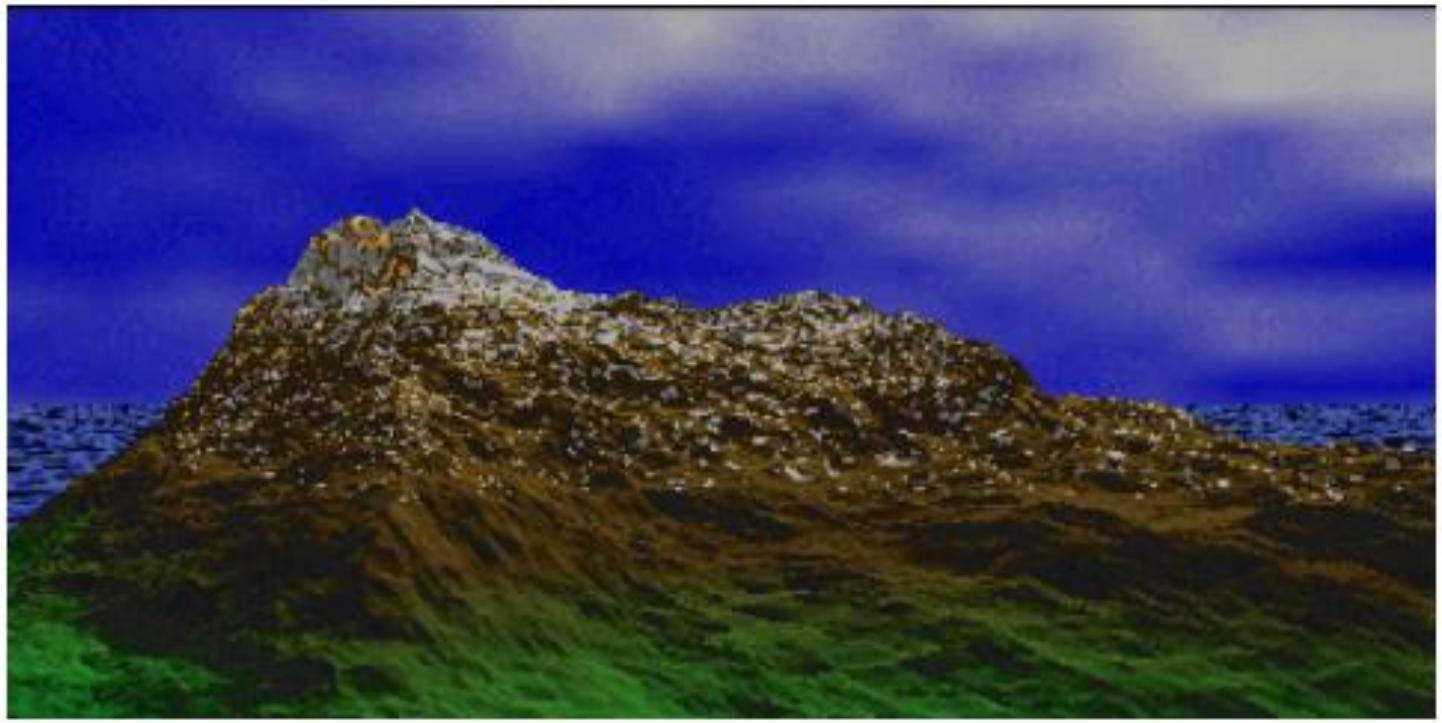


- David
  - 480 individually aimed scans
  - 2 billion polygons
  - 7,000 color images
  - 32 gigabytes
  - 30 nights of scanning
  - 22 people



Modeling: Algorithmic and Procedural

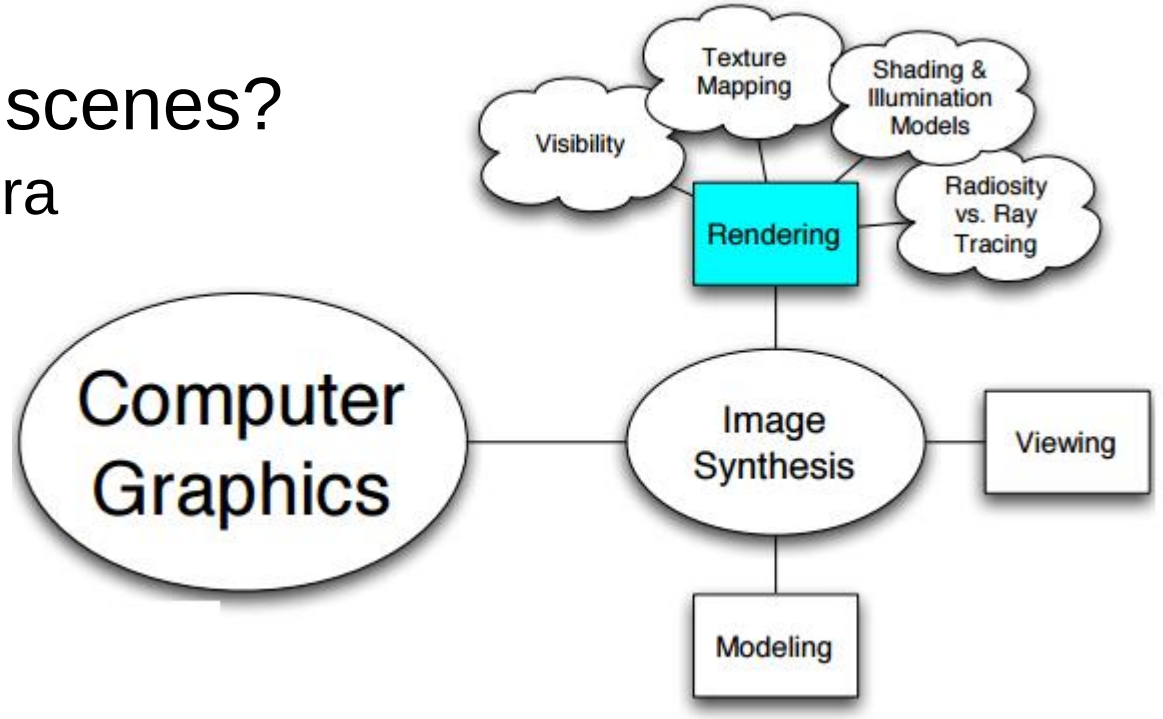




fractals

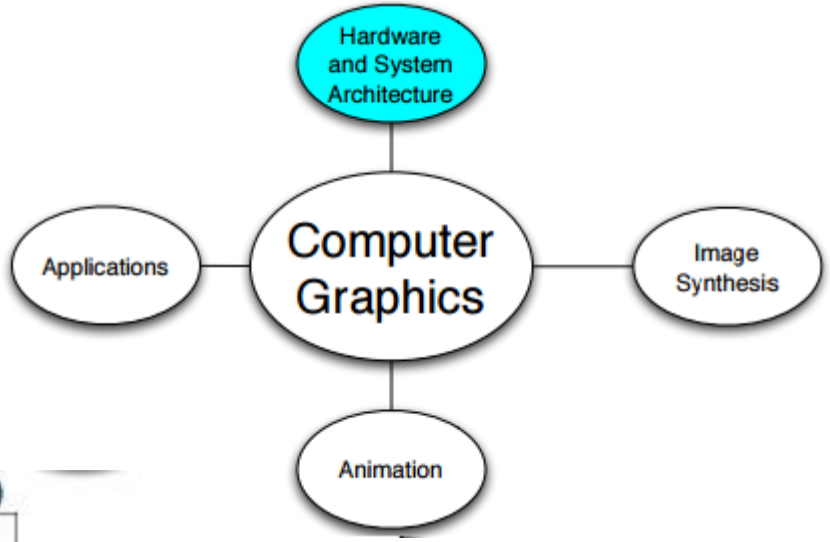
Rendering

- 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

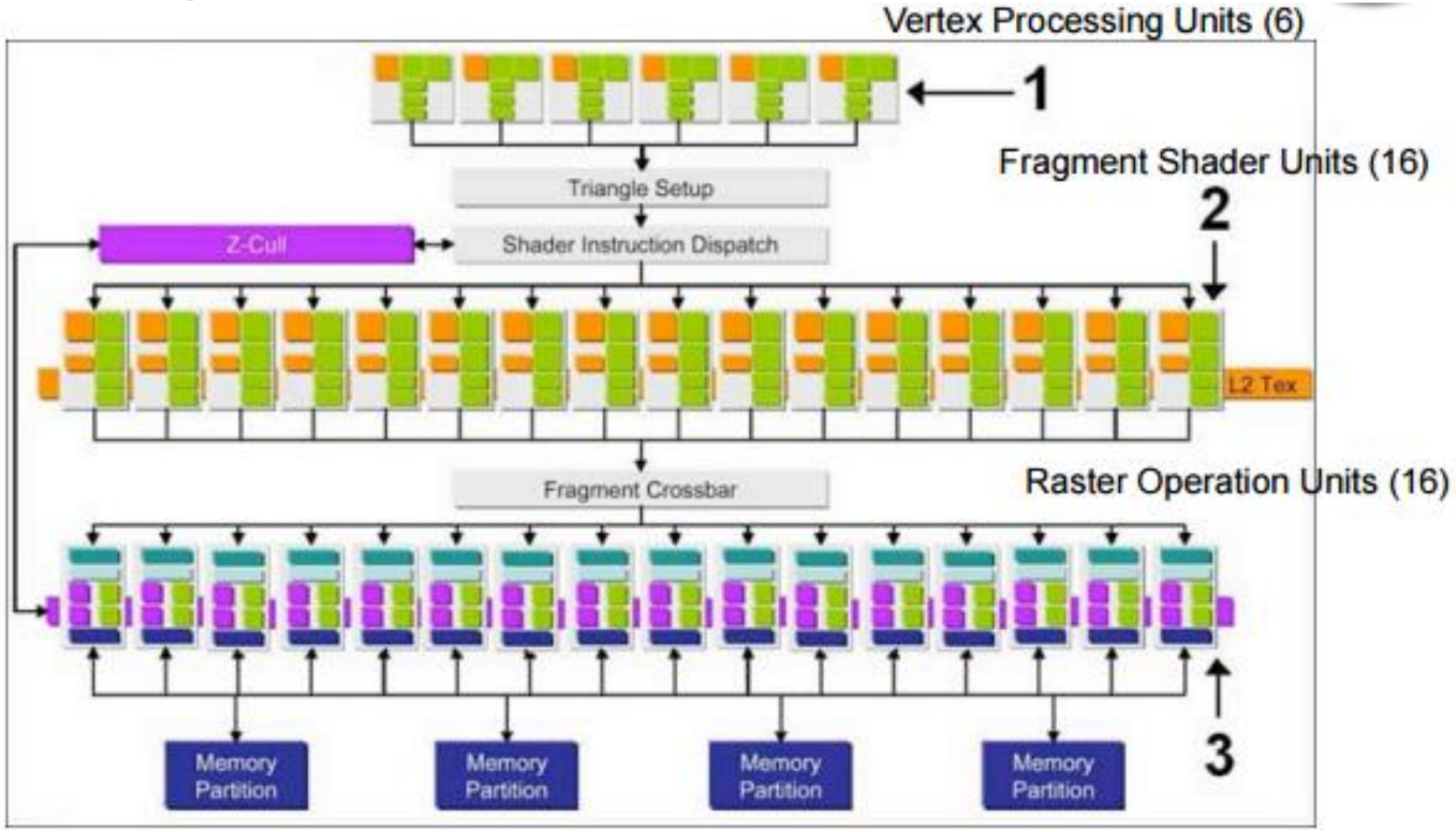


Realistic lighting environments

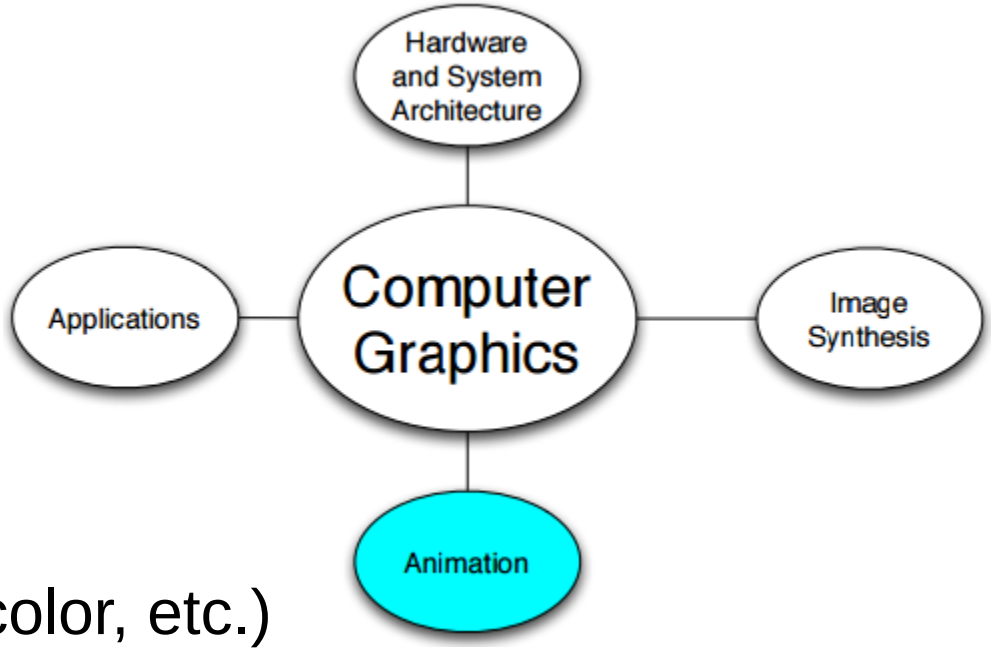
Hardware



- Example: NVIDIA GeForce 6800

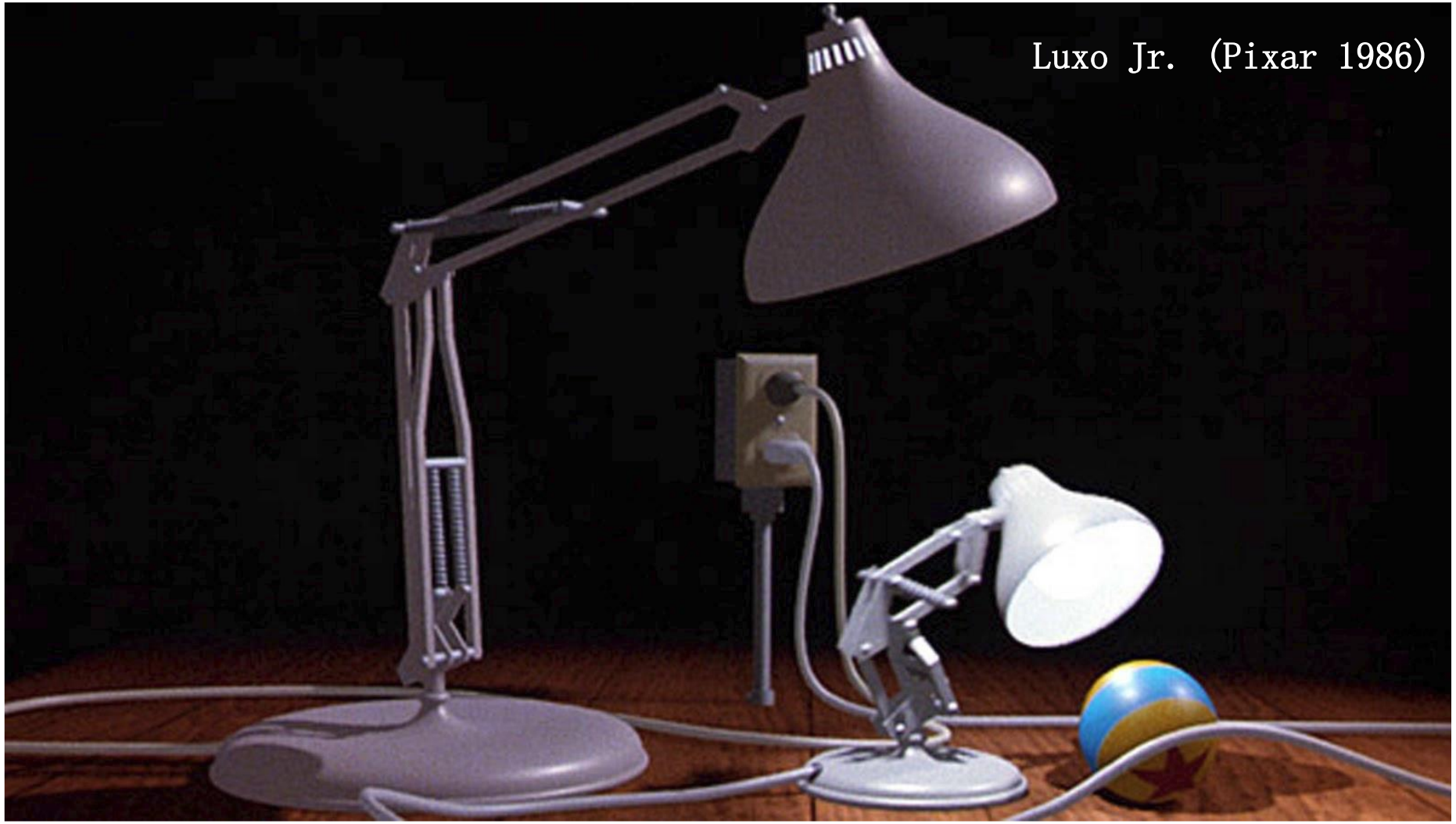


Animation



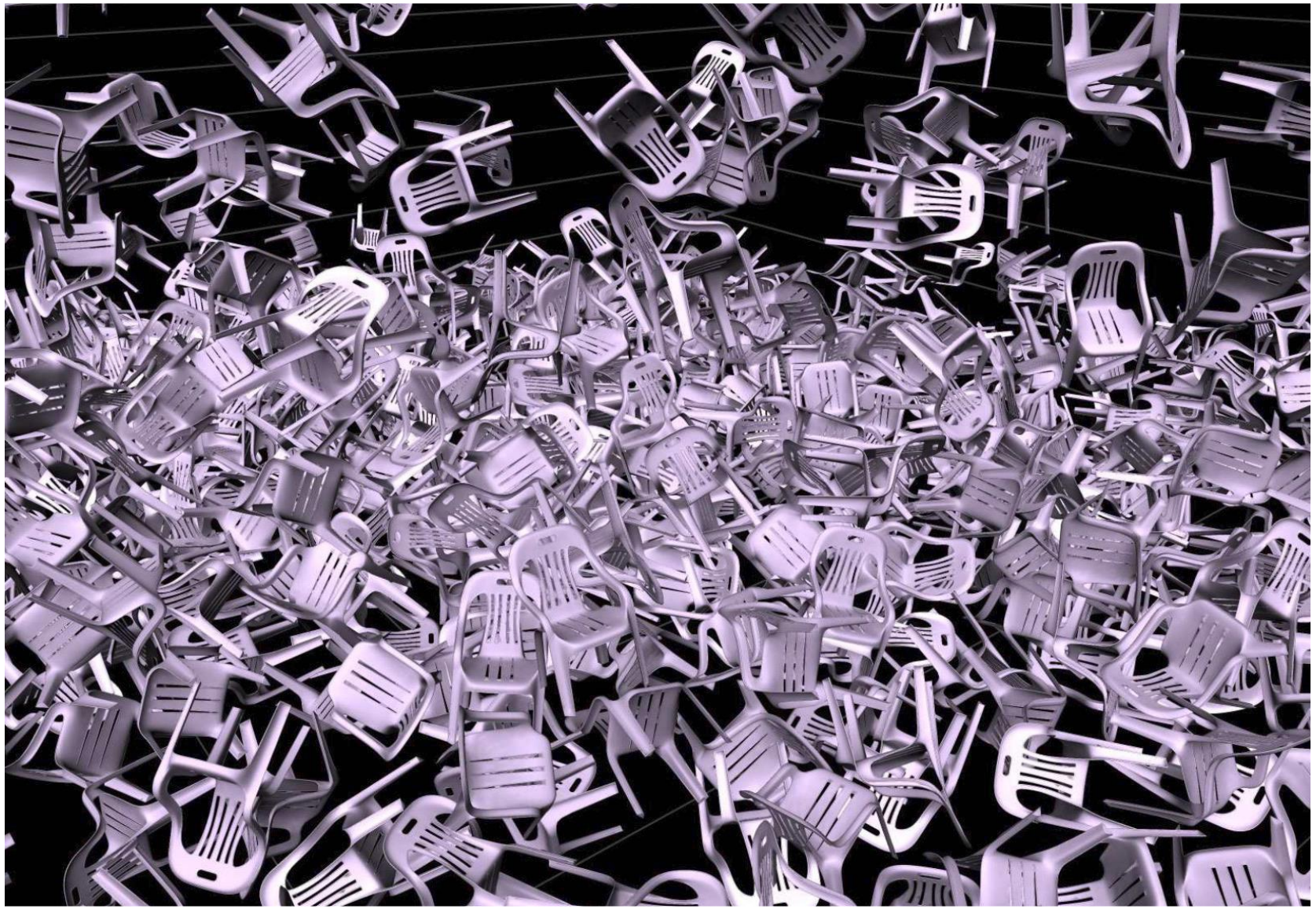
- Model how things move
- Temporal change of
  - Objects (position, orientation, size, shape, color, etc.)
  - Camera (position, direction, angle, focus, etc.)
  - Illumination (position, direction, color, brightness)
- Represent motion
  - Sequence of stills
  - Parameter curves

Animation: modeling motion



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

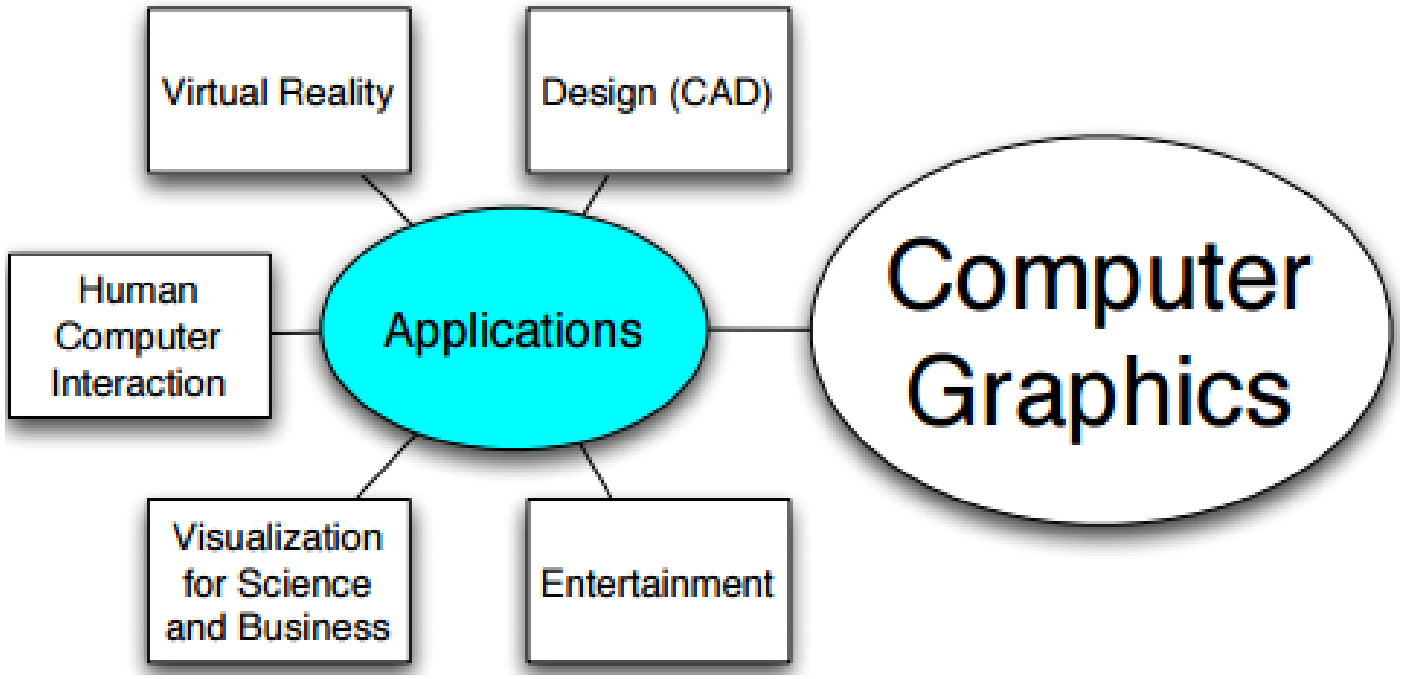
Physically-based simulation of motion



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

[James 2004]

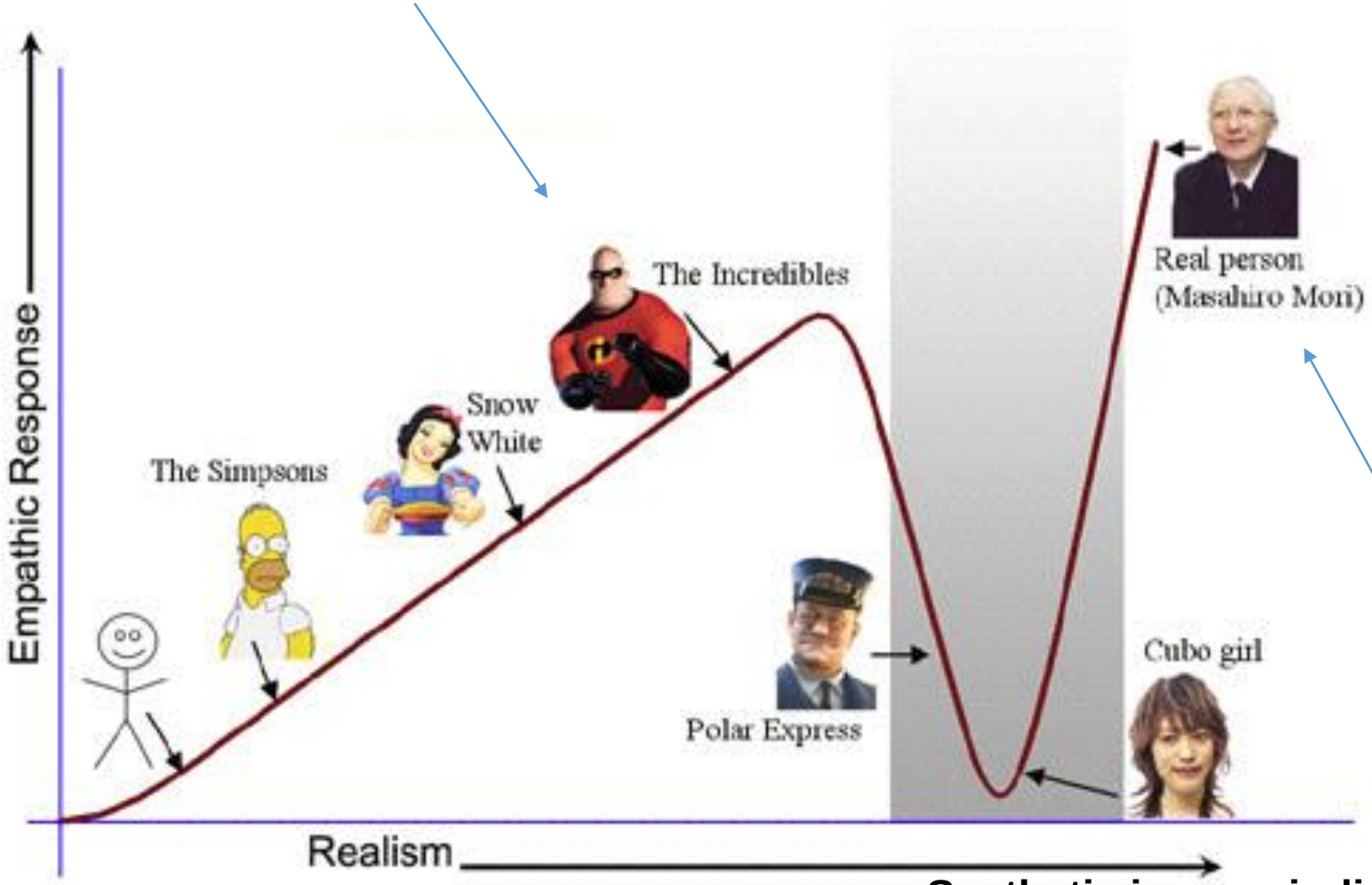
Uses Of Graphics



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

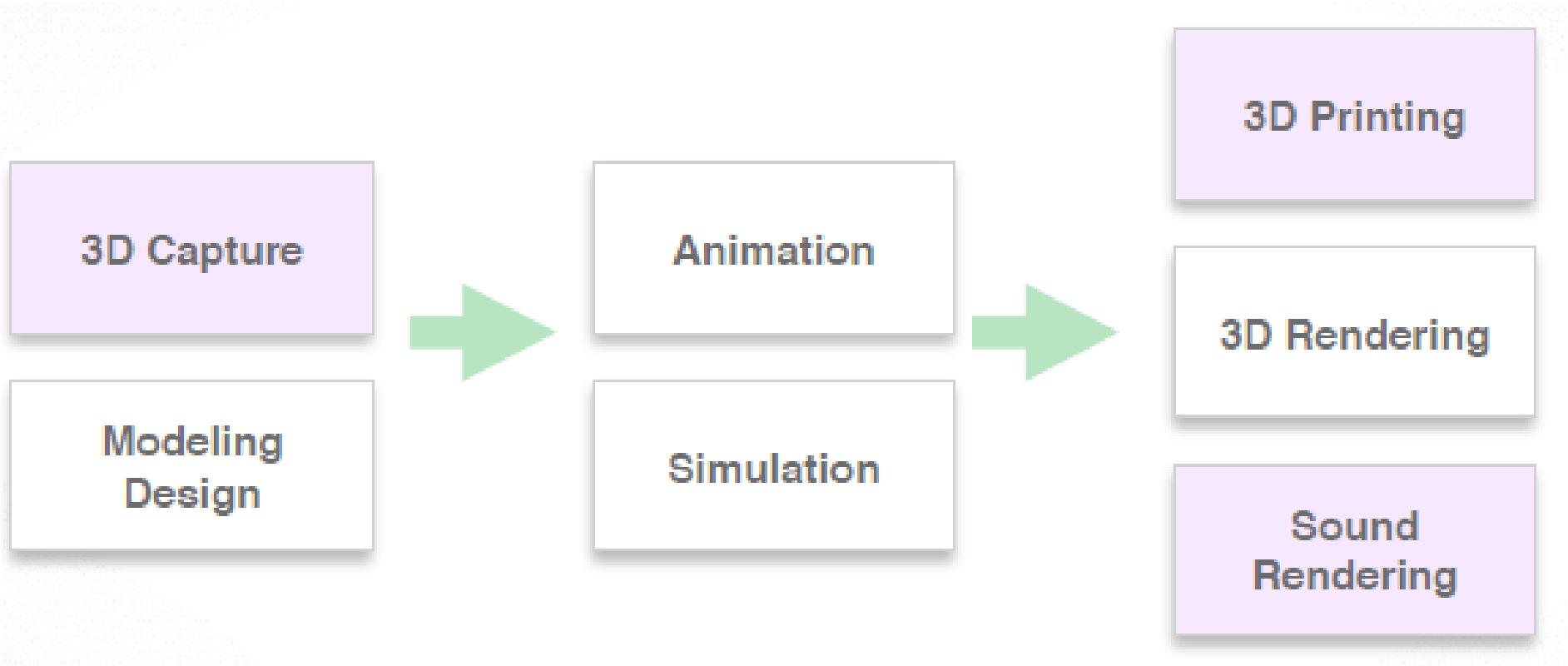
Goals in Computer Graphics

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



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

3D Computer Graphics Pipeline

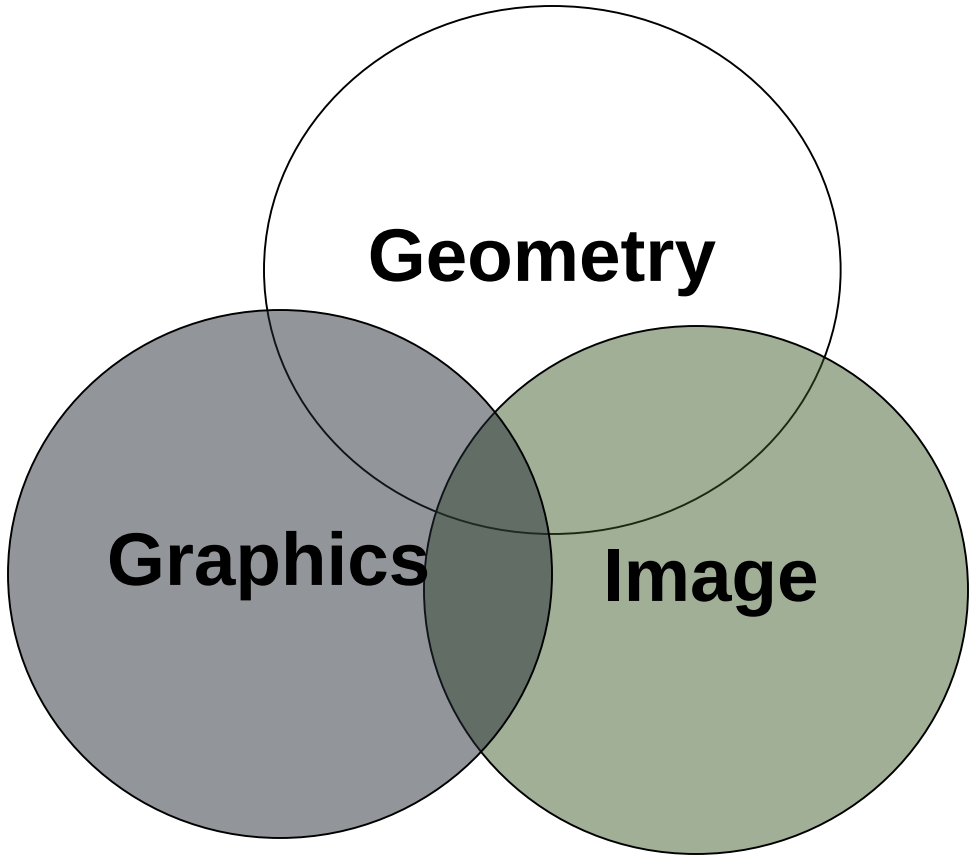


SIGGRAPH & SIGGRAPH Asia

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

SIGGRAPH & SIGGRAPH Asia

- SIGGRAPH 2014 Technical Papers Preview Trailer
- SIGGRAPH 2015 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

The team

- **Instructor**
  - **Zhixun Su, zxsu@dlut.edu.cn**
  - **Junjie Cao, jjcao@dlut.edu.cn**
- **Assistants**
  - **Yan Wang, 479823436@qq.com**

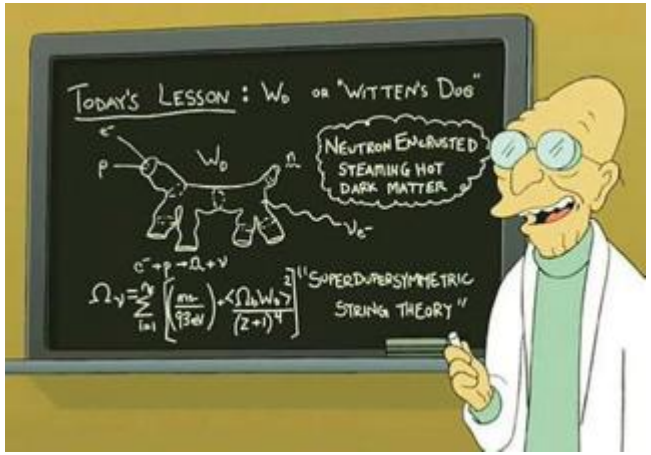
Course Information On-Line

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

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

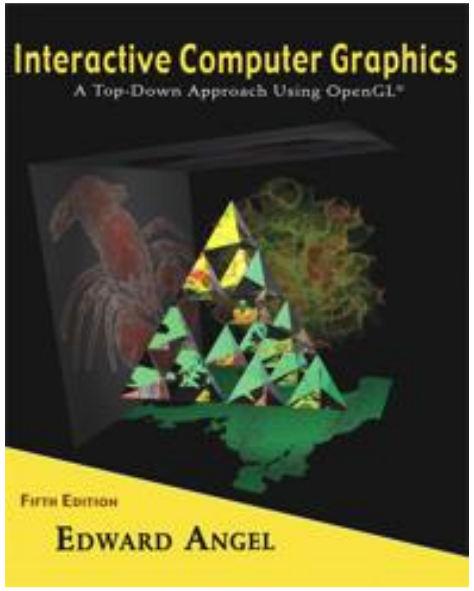
Prerequisites/What Is It I Expect?

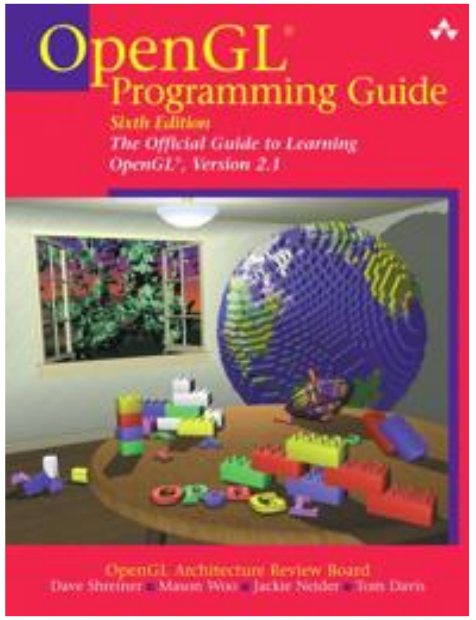
- Coding
  - C/C++
  - Preferably some previous OpenGL exposure
  - Data structures, algorithms
- Math
  - Linear Algebra
  - Differential Equations
- Keeping up with the text(s) is very important



Textbooks

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





Grading

- Assignments
  - As 1: 16 %?
  - As 2: 17 %?
  - As 3: 17 %?
- Final Assignments

?

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, mkay?

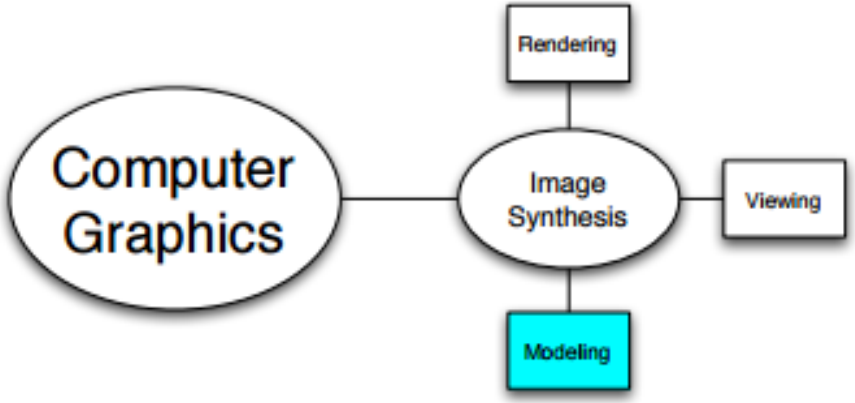
Assignment Policies

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

Introduction

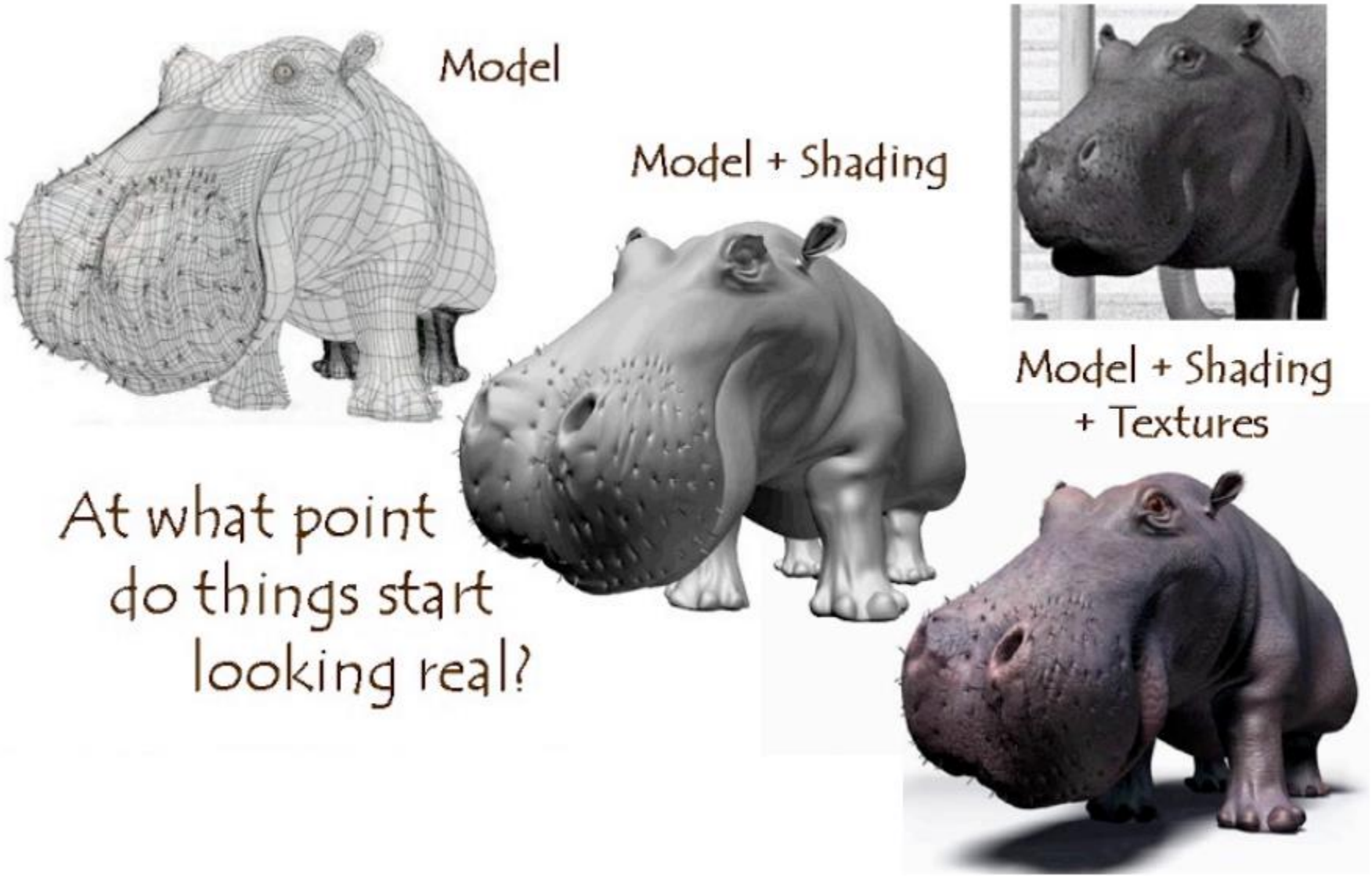
- What is Computer Graphics?
  - Applications
  - History
  - Relations with other Disciplines
- Administrative Stuff
- **Course Overview**
- Research Trends

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**
- **Not in this course:**
  - Human-Computer Interaction
  - Graphic Design

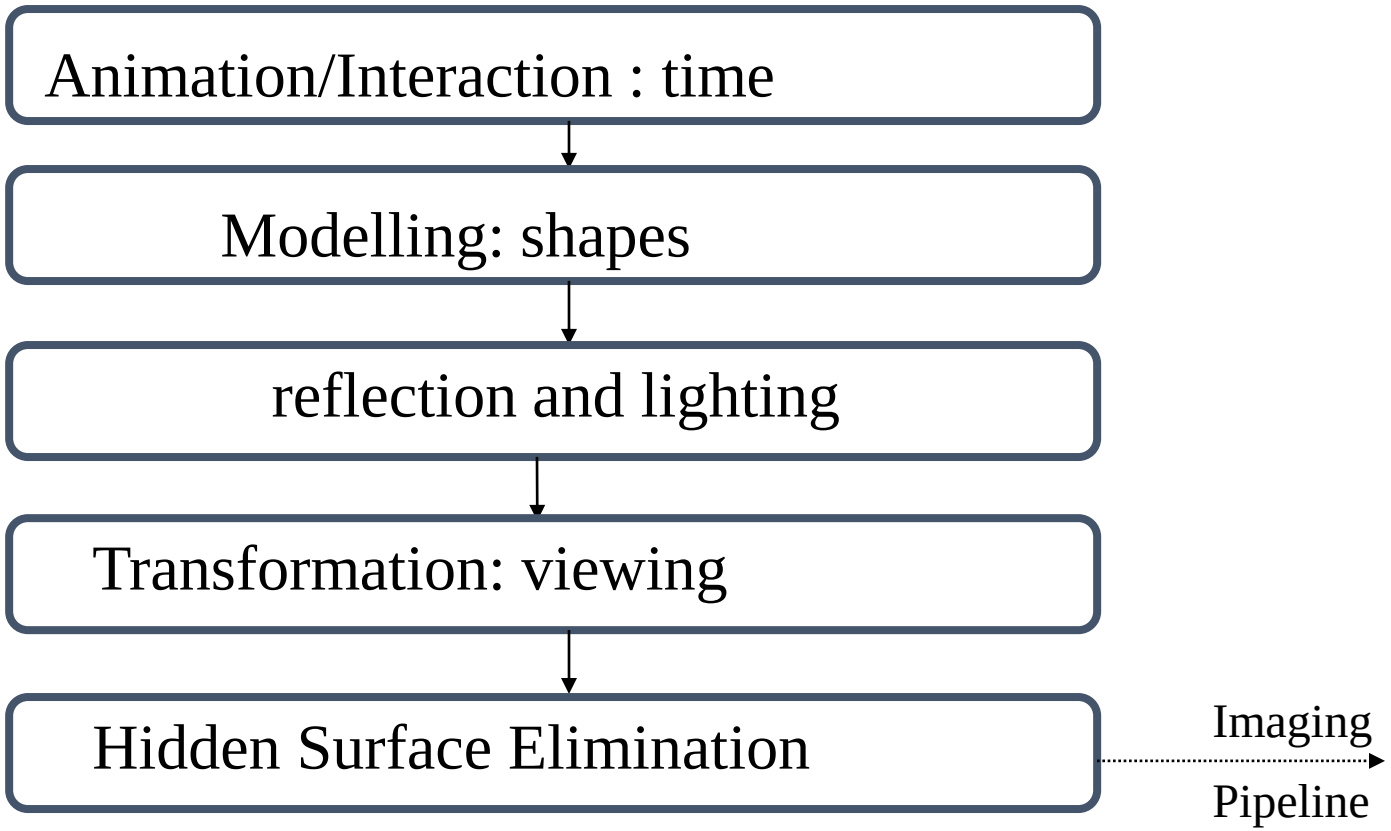
The Quest for Visual Realism



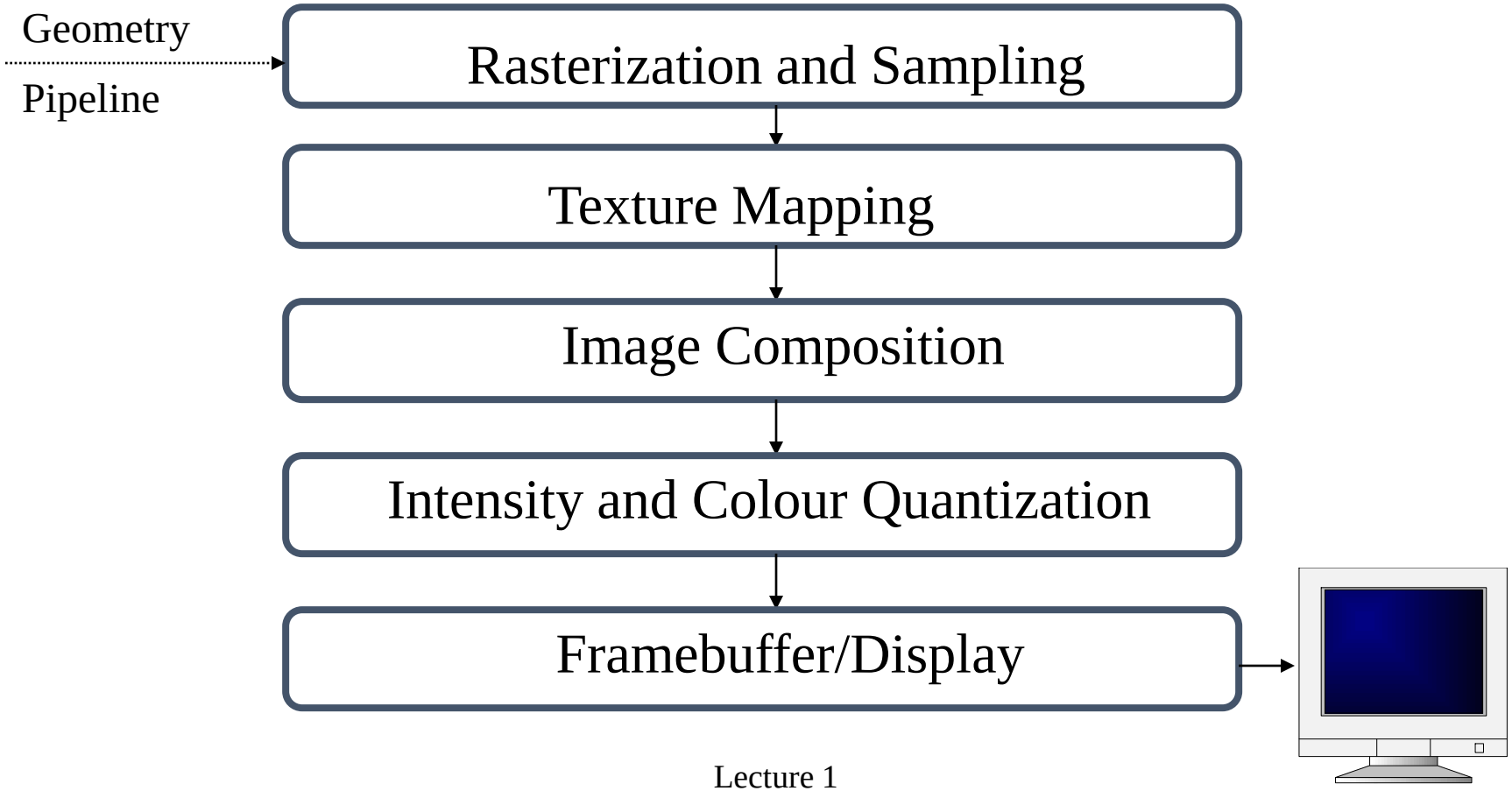
Graphics Pipelines

- Graphics processes generally execute sequentially
- Typical ‘pipeline’ model
- There are two ‘graphics’ pipelines
  - The Geometry or 3D pipeline
  - The Imaging or 2D pipeline

Geometry Pipeline

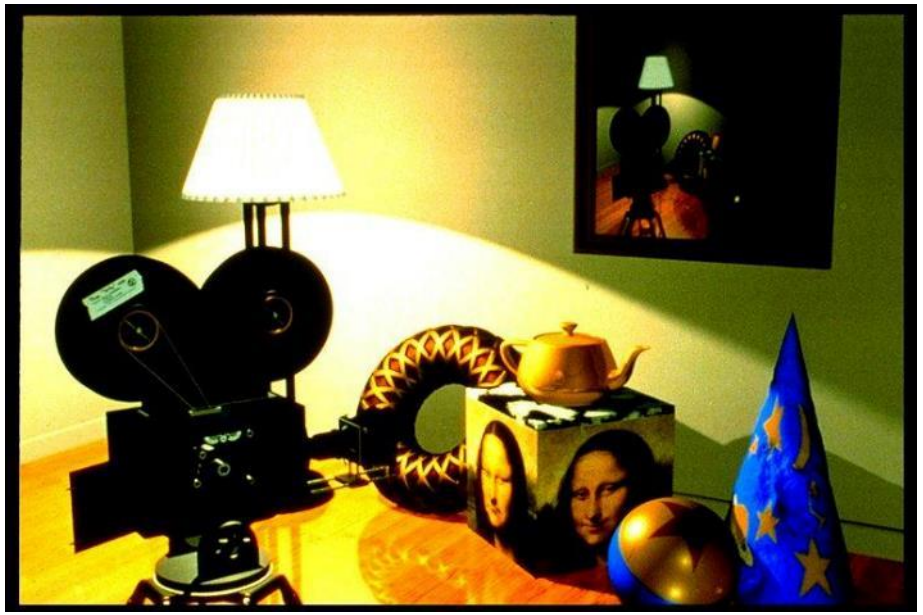


Imaging Pipeline

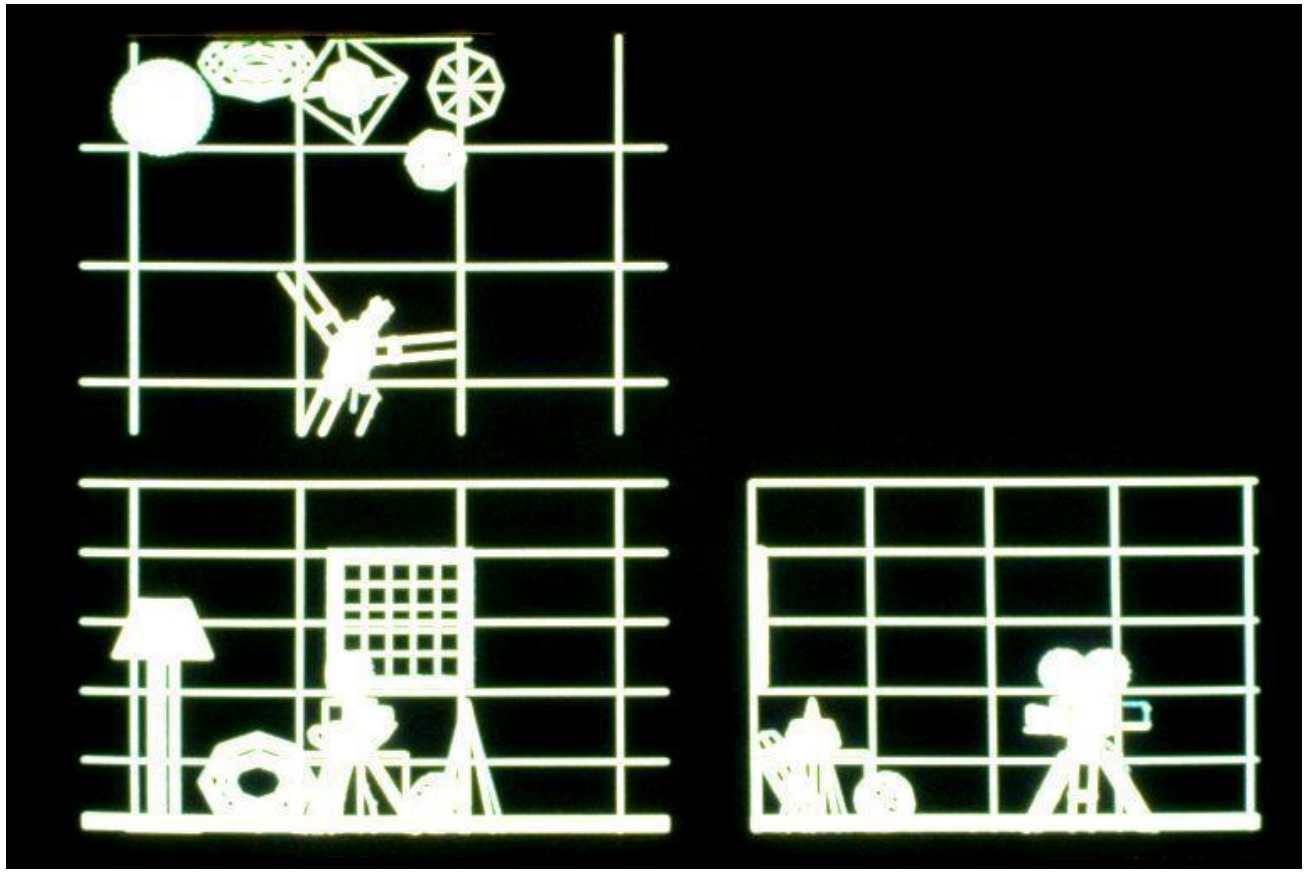


An example

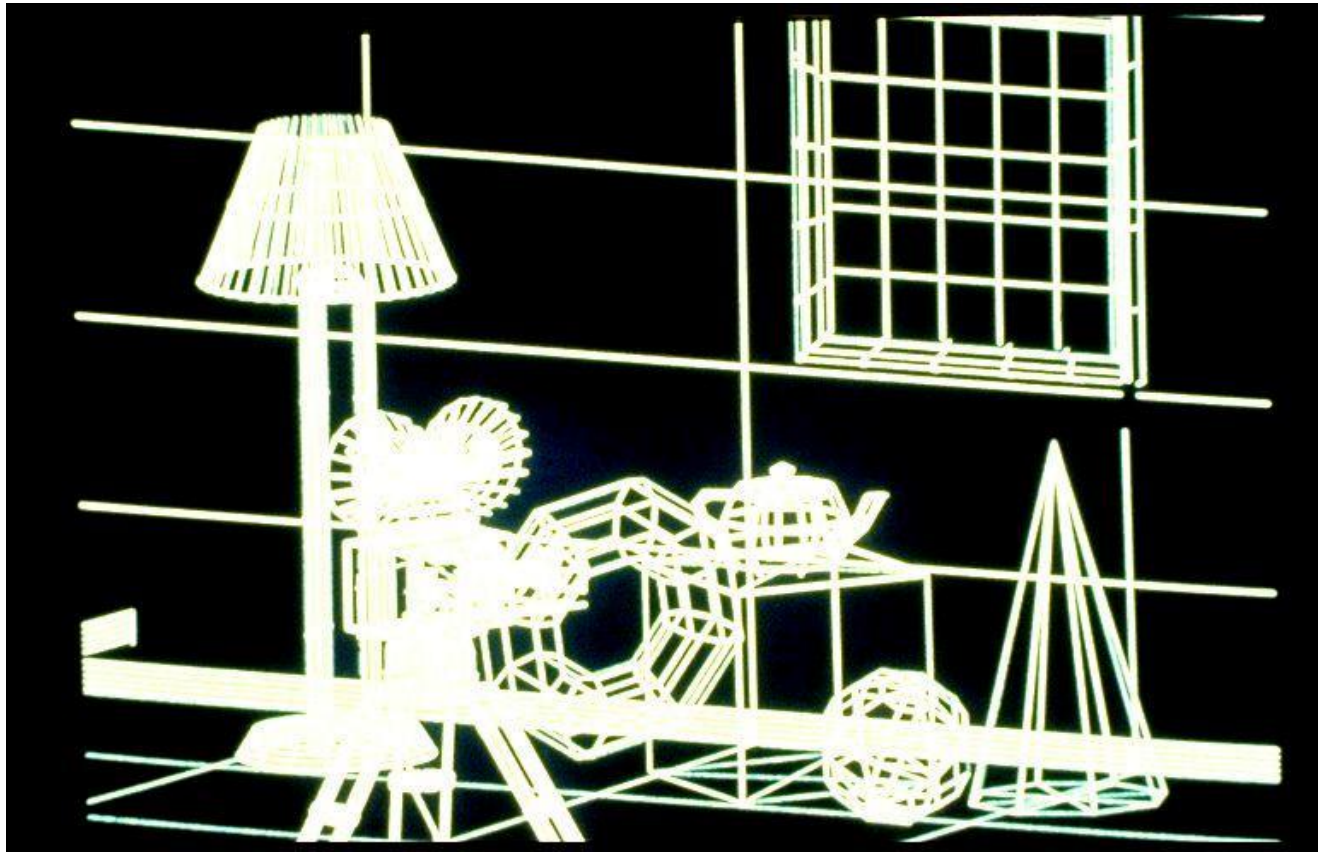
The scene we are trying to represent:



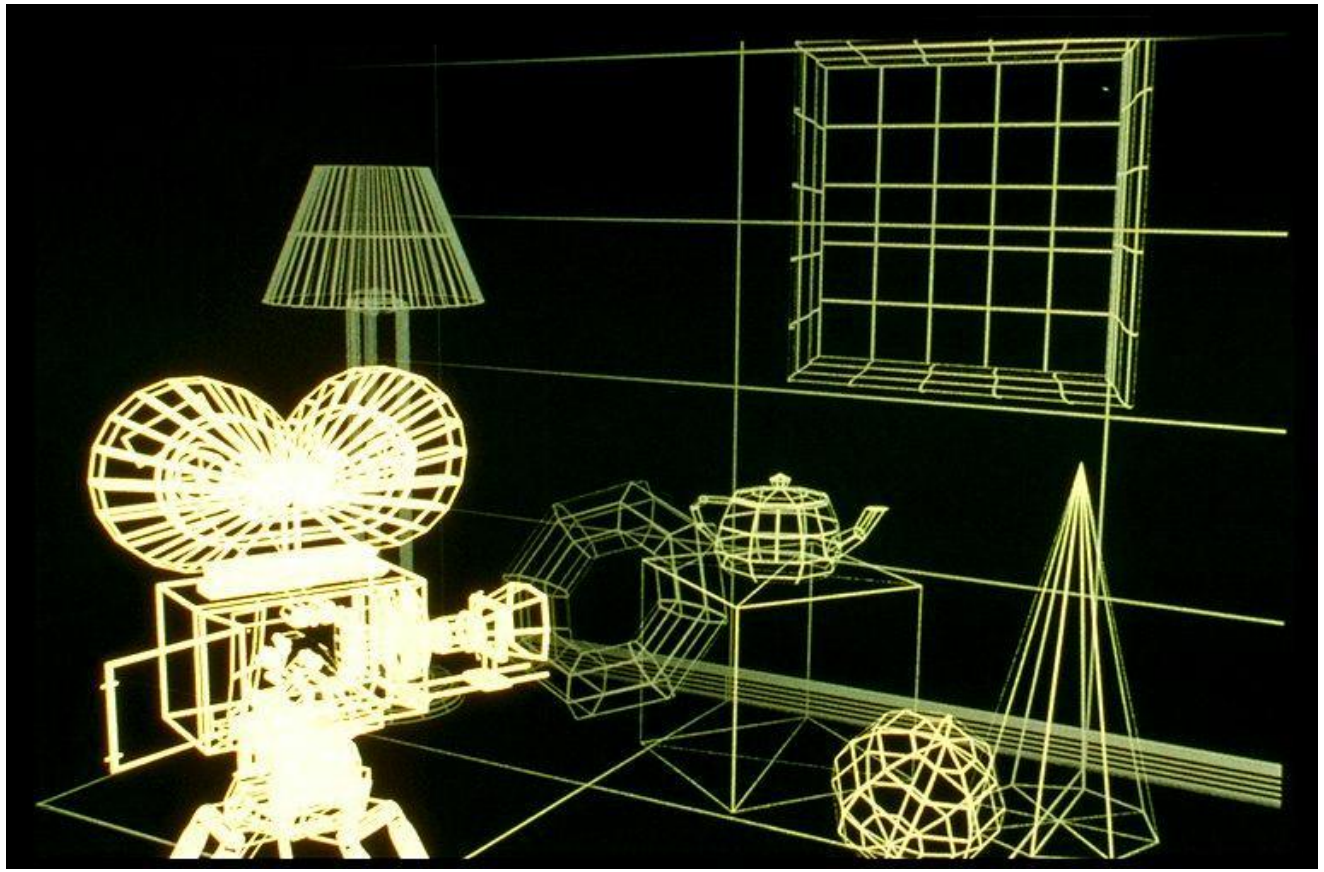
Wireframe model – Orthographic views



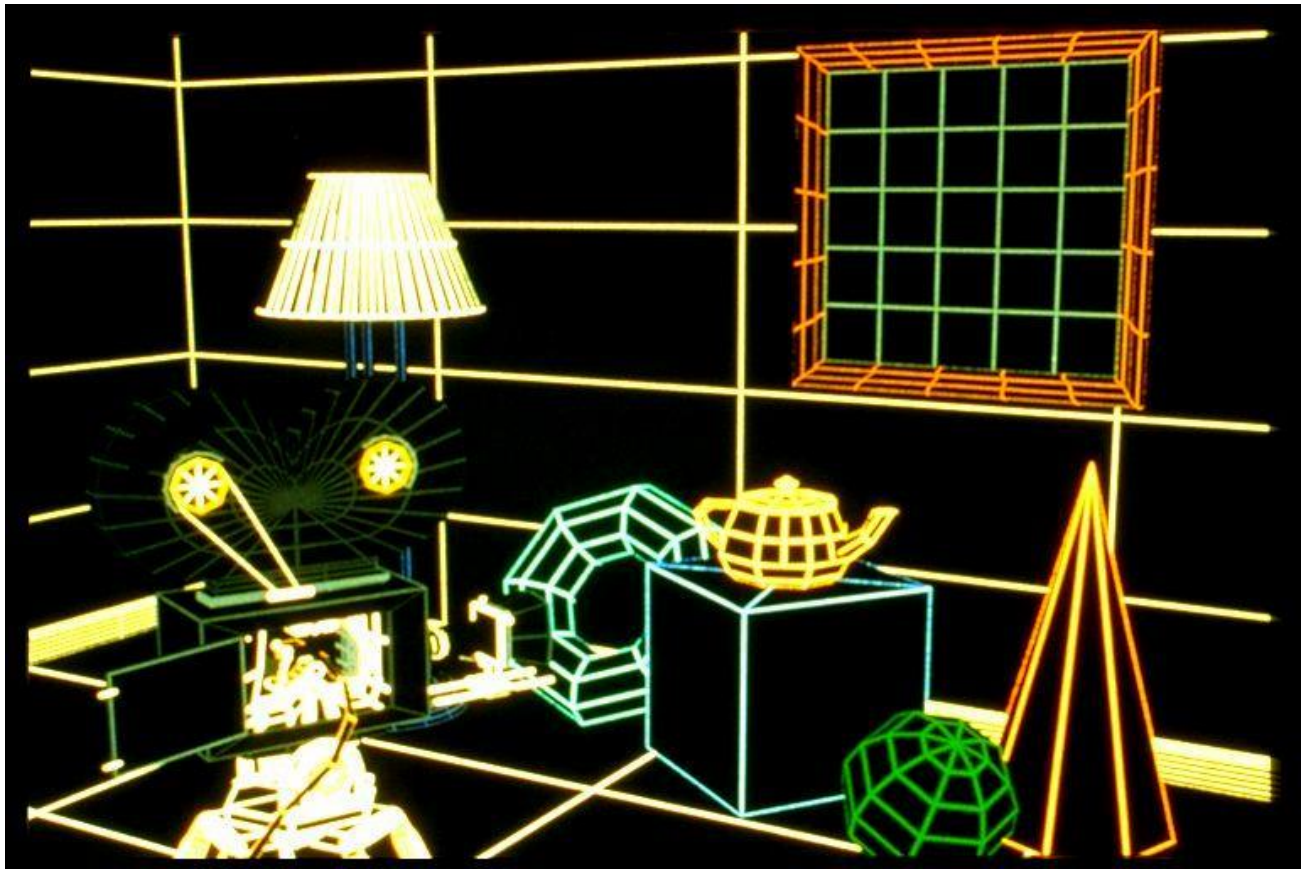
Perspective View



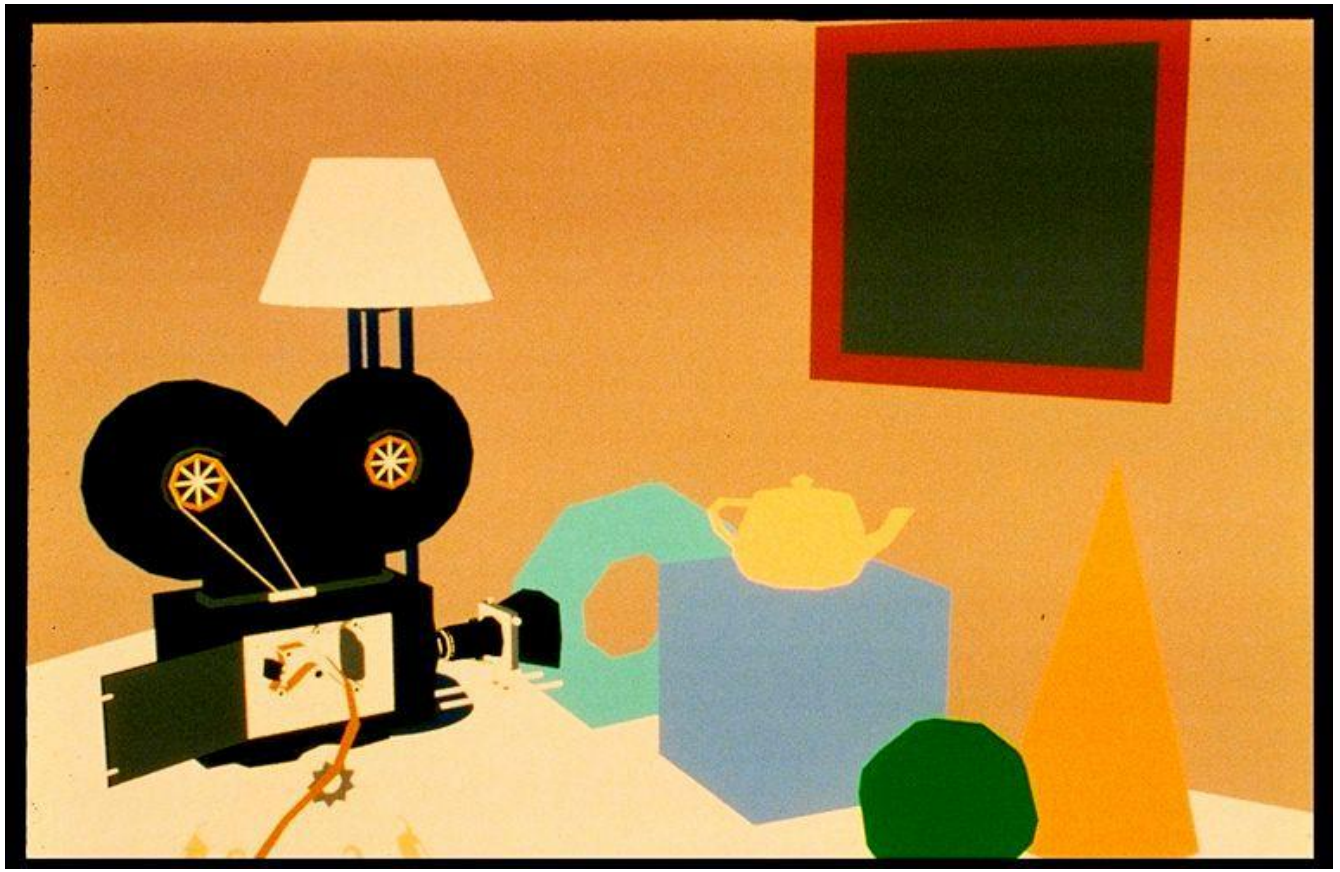
Depth Cue



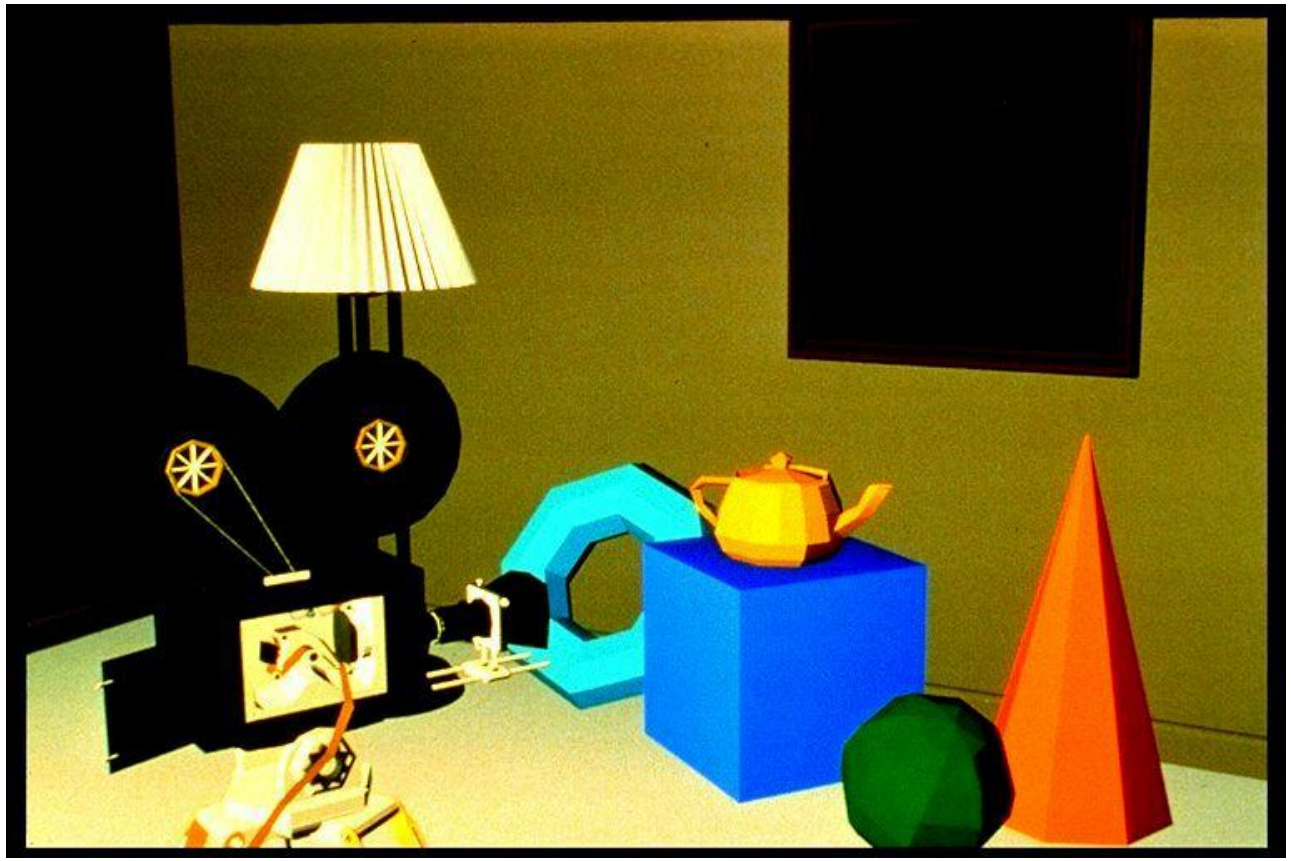
Hidden Line Removal – add colour



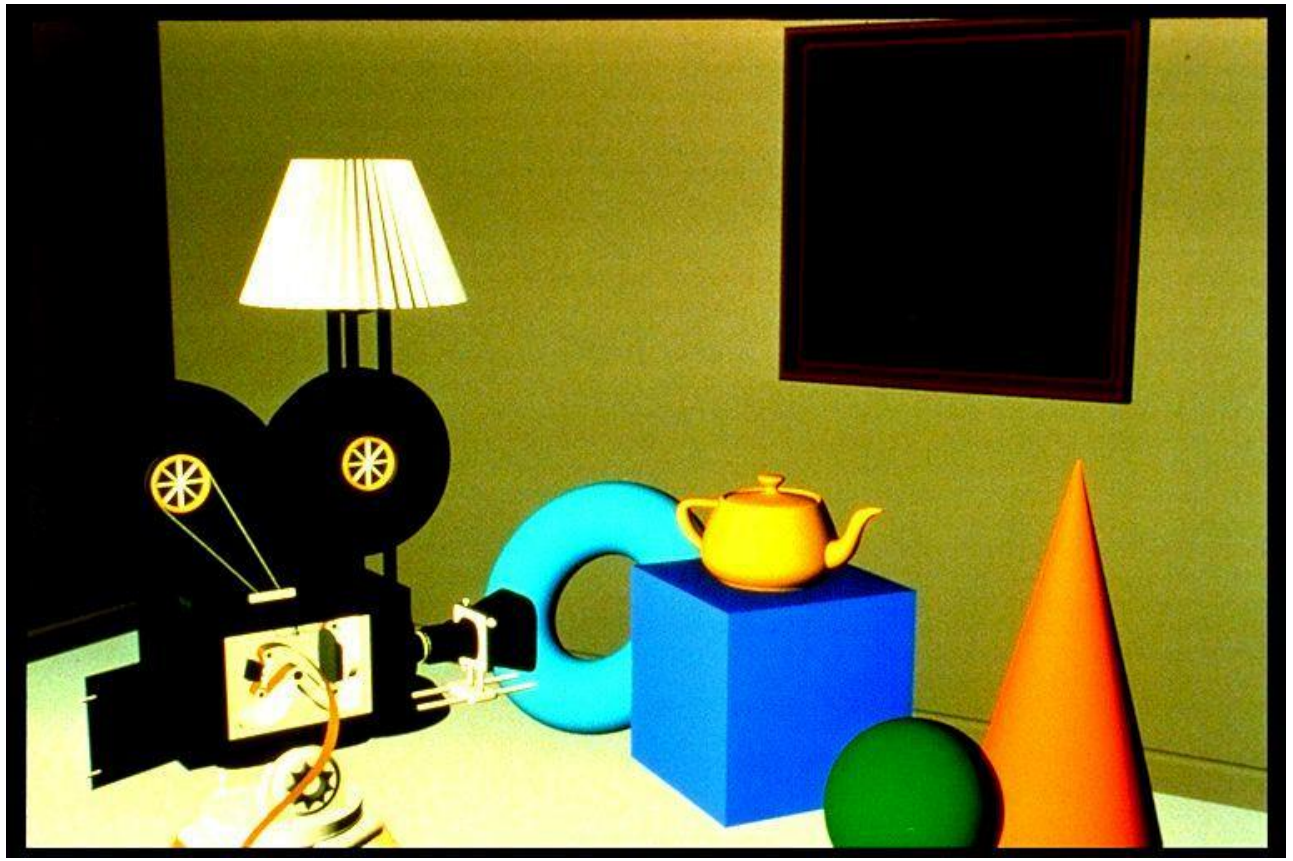
Constant Shading – Ambient



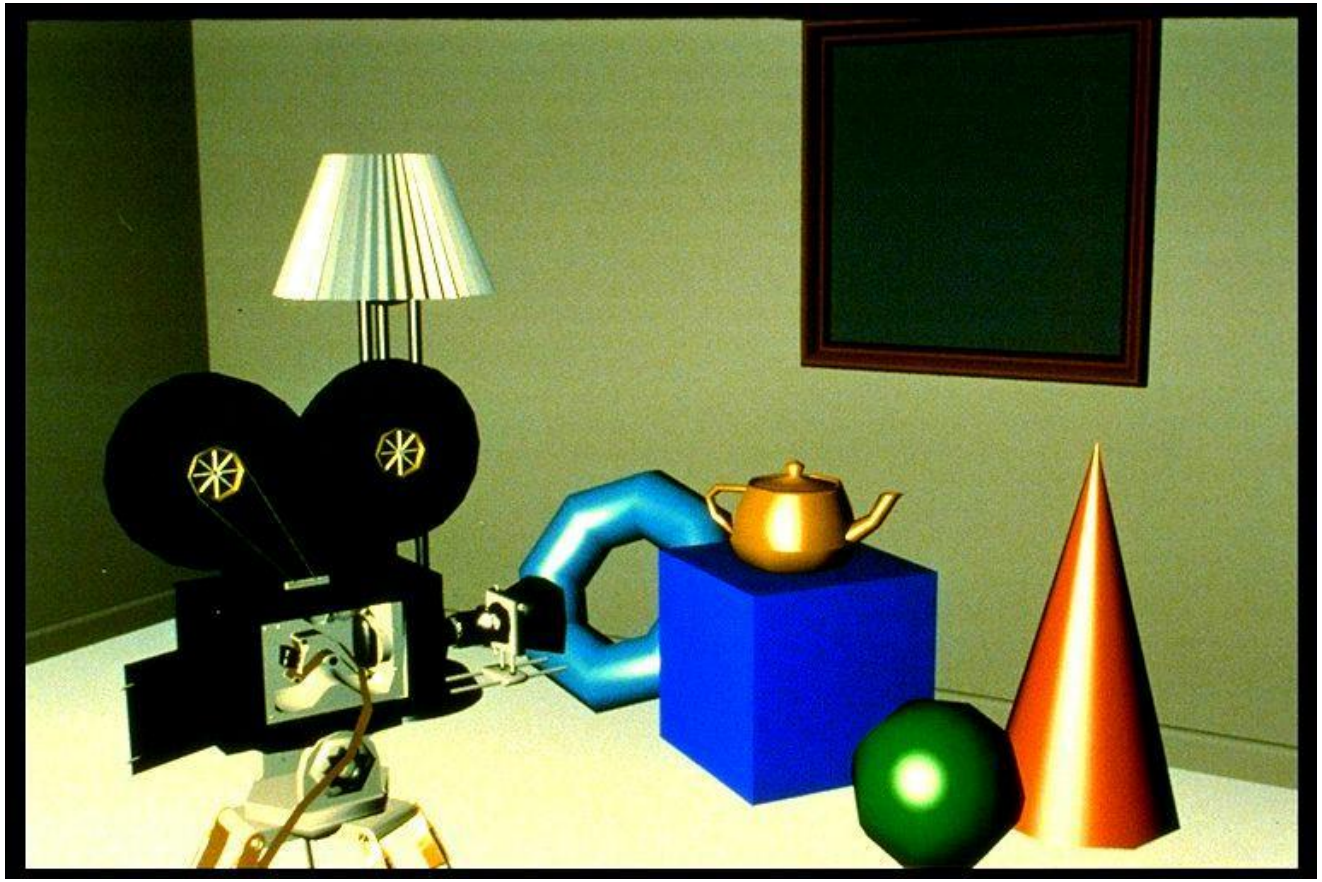
Faceted Shading – Flat



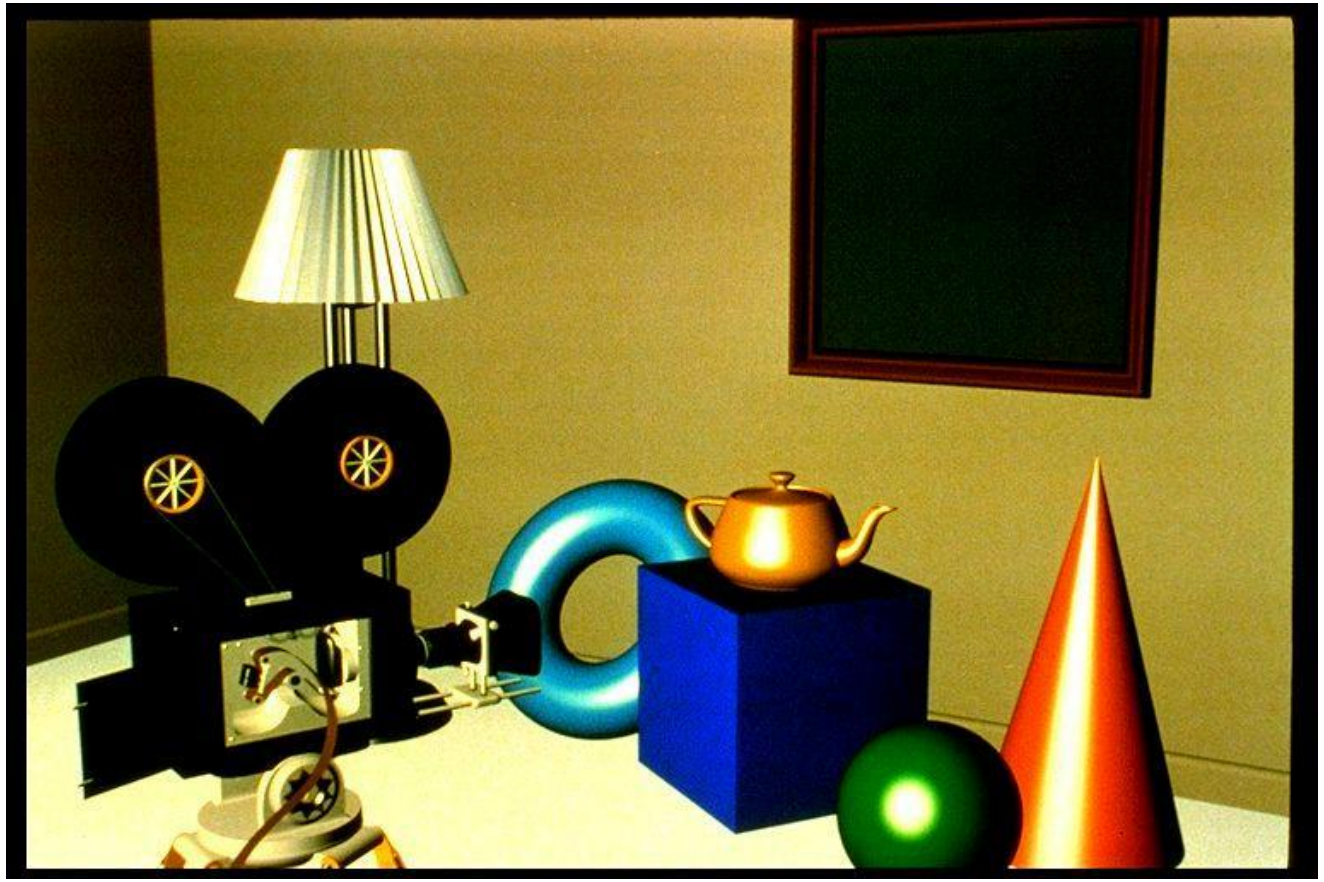
Gouraud shading, no specular highlights



Specular highlights added

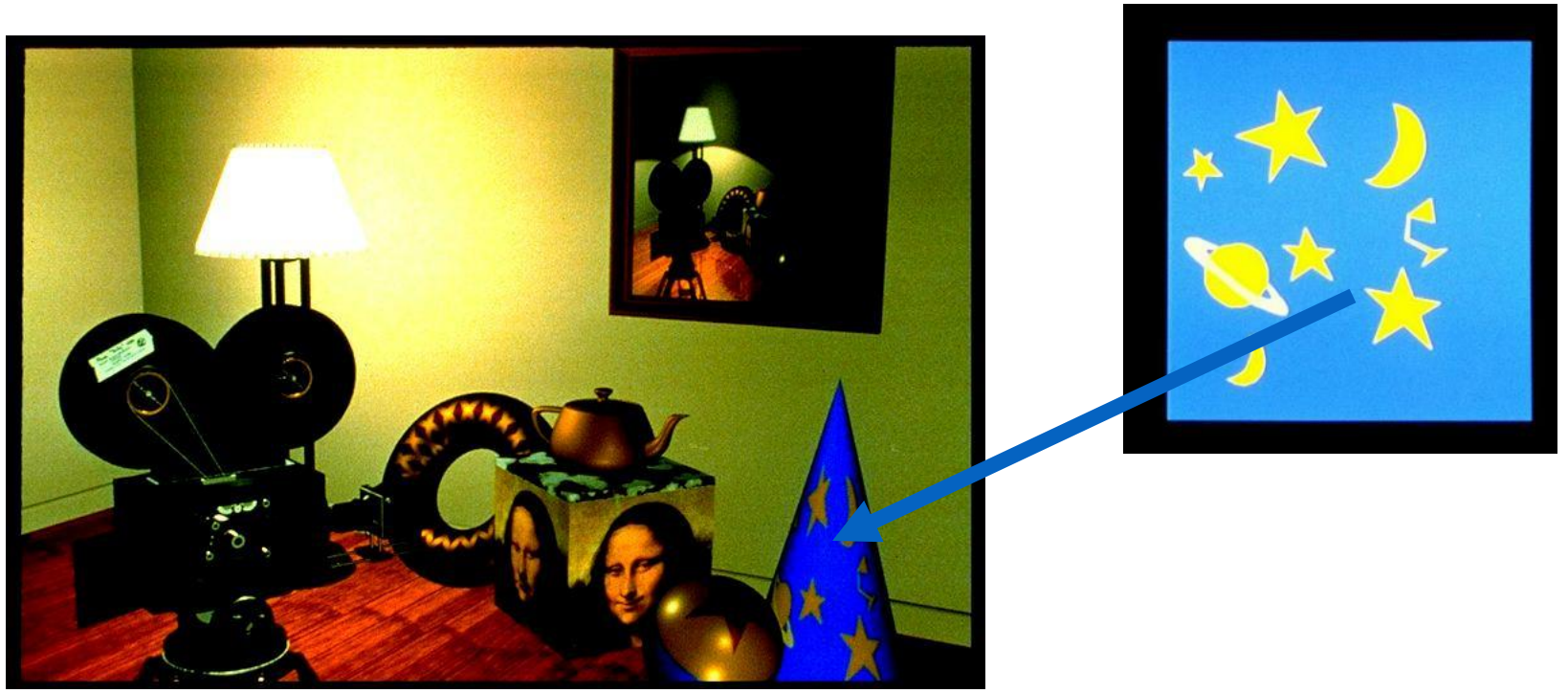


Phong shading

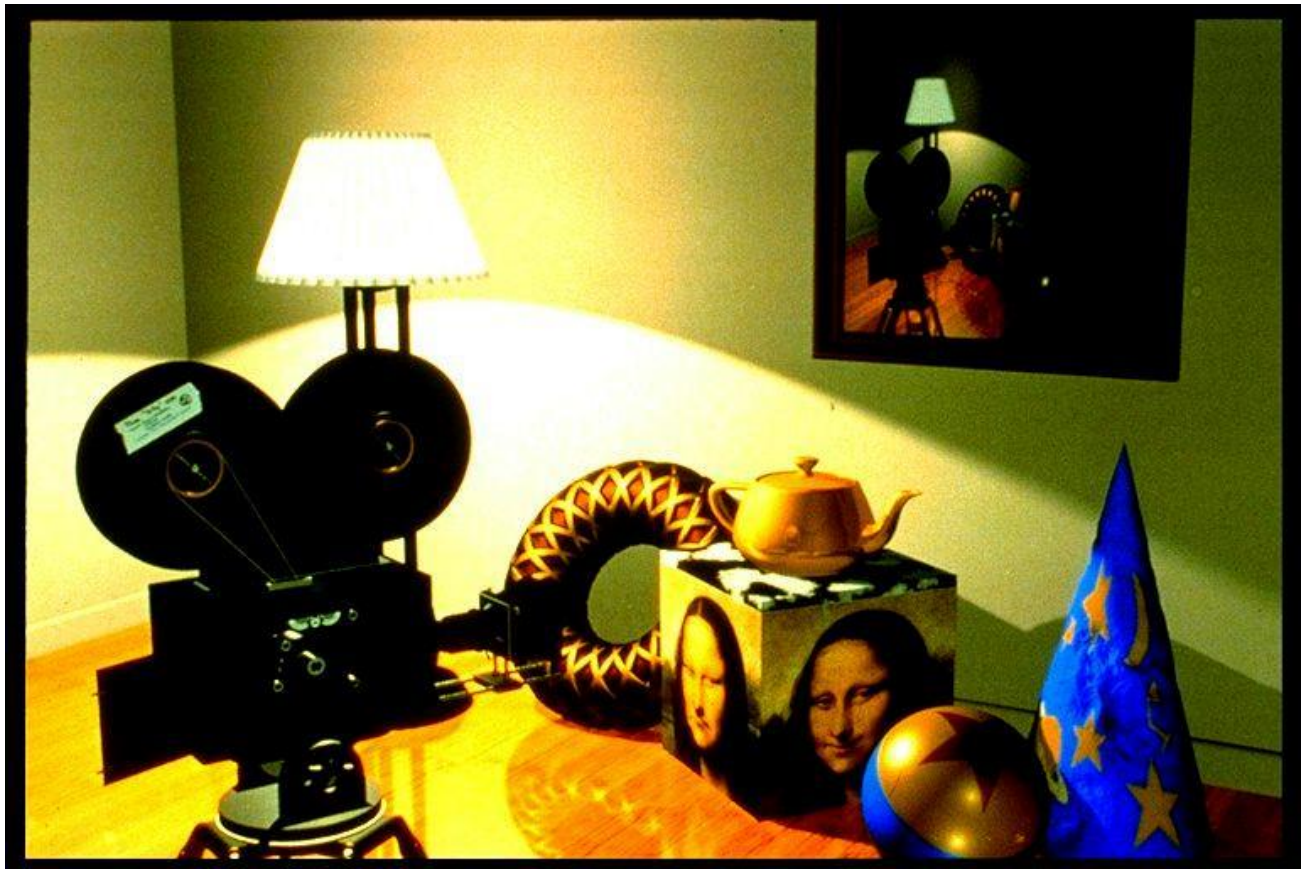


Texture mapping

Texture mapping



Reflections, shadows & Bump mapping

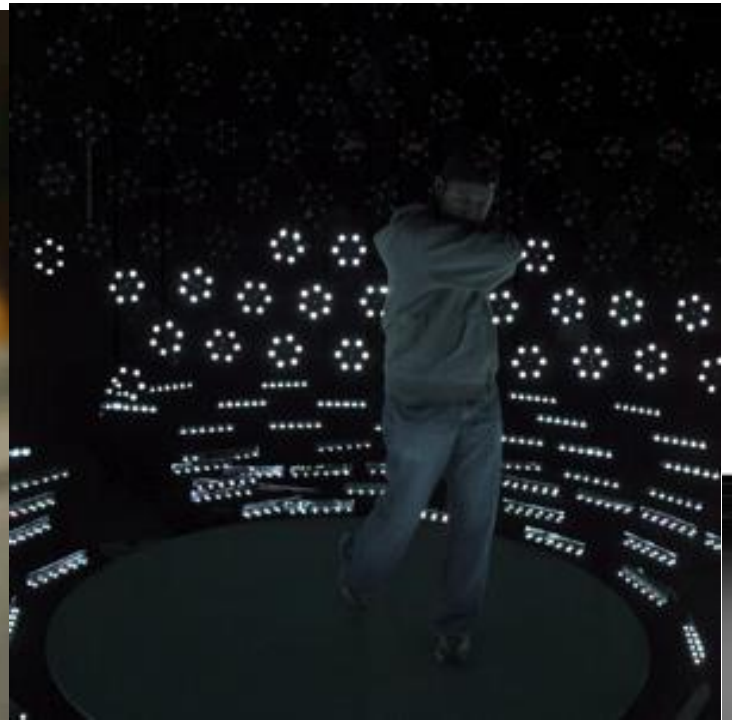


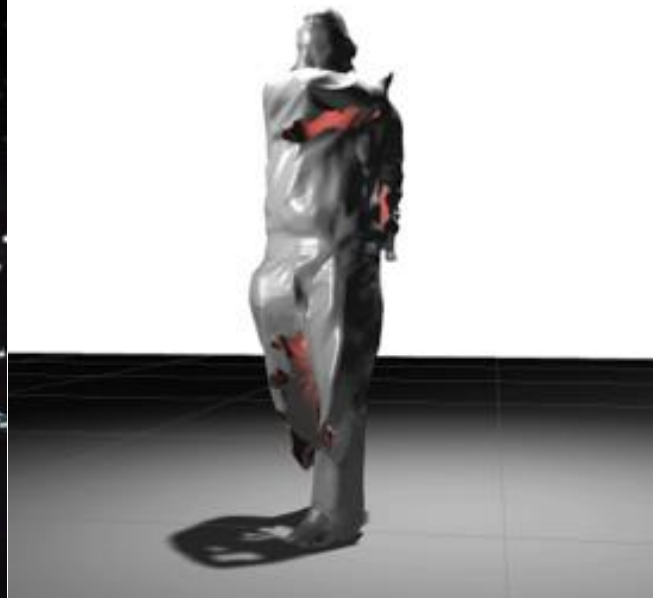
Research Trends

From Offline to Realtime

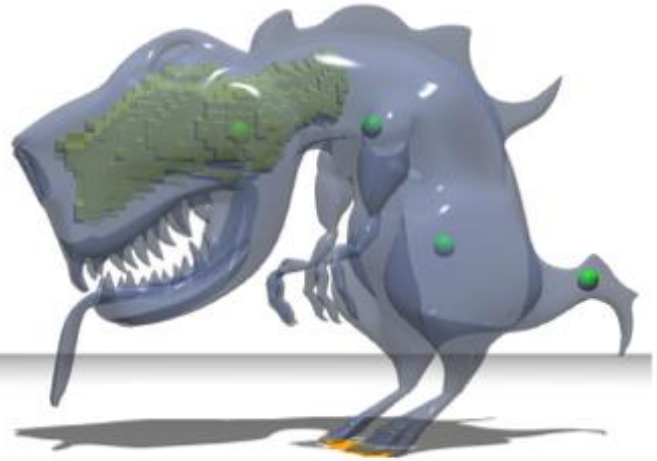
Unreal Engine Kite Demo (Epic Games 2015)

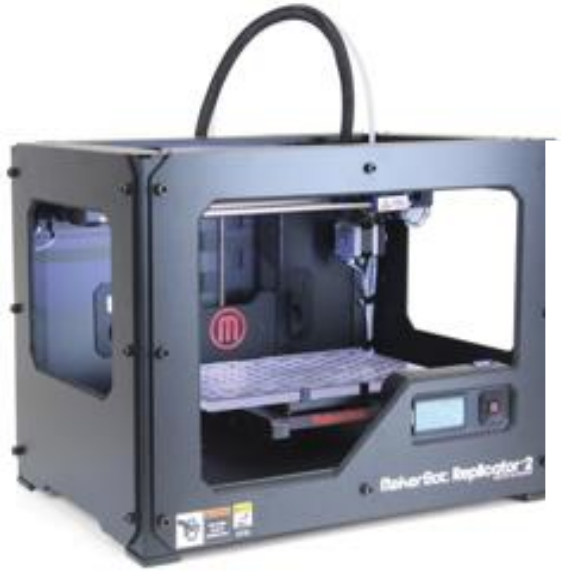
From Graphics to Vision

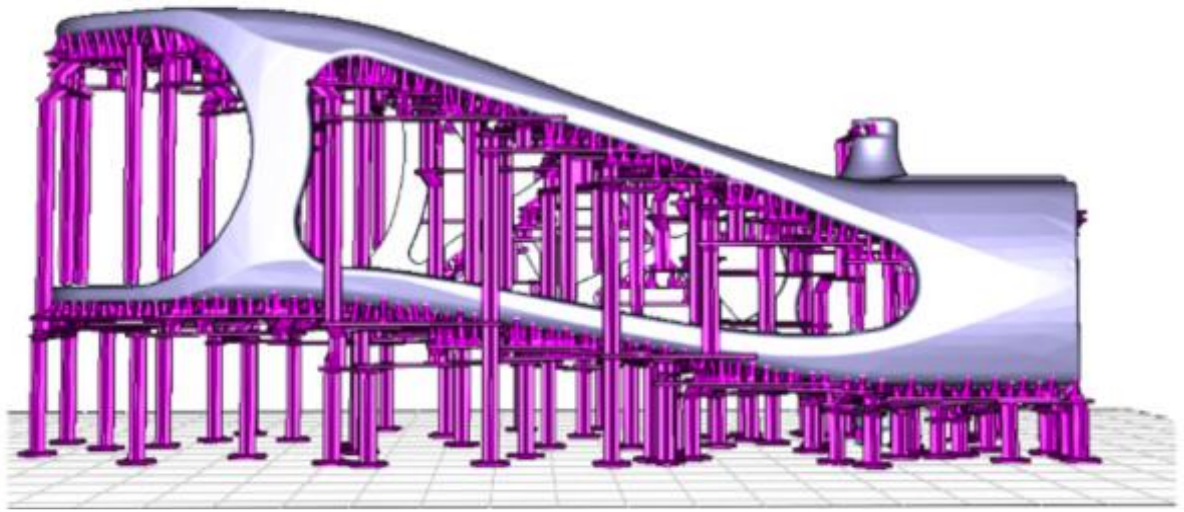




From Graphics to Fabrication

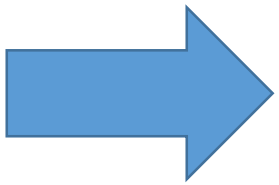






From Production to Consumers

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
  - CS 148 Introduction to Computer Graphics and Imaging (Fall 2015) @ stanford
  - 6.837 Computer Graphics (fall 2011) @ MIT
  - CMU 15-462/662 COMPUTER GRAPHICS (Fall 2015) @ CMU

Thank you