

CS4620/5620: Introduction to Computer Graphics

Professor: Steve Marschner

Computer graphics: The study of creating, manipulating, and using visual images in the computer.

Or, to paraphrase Ken Perlin...

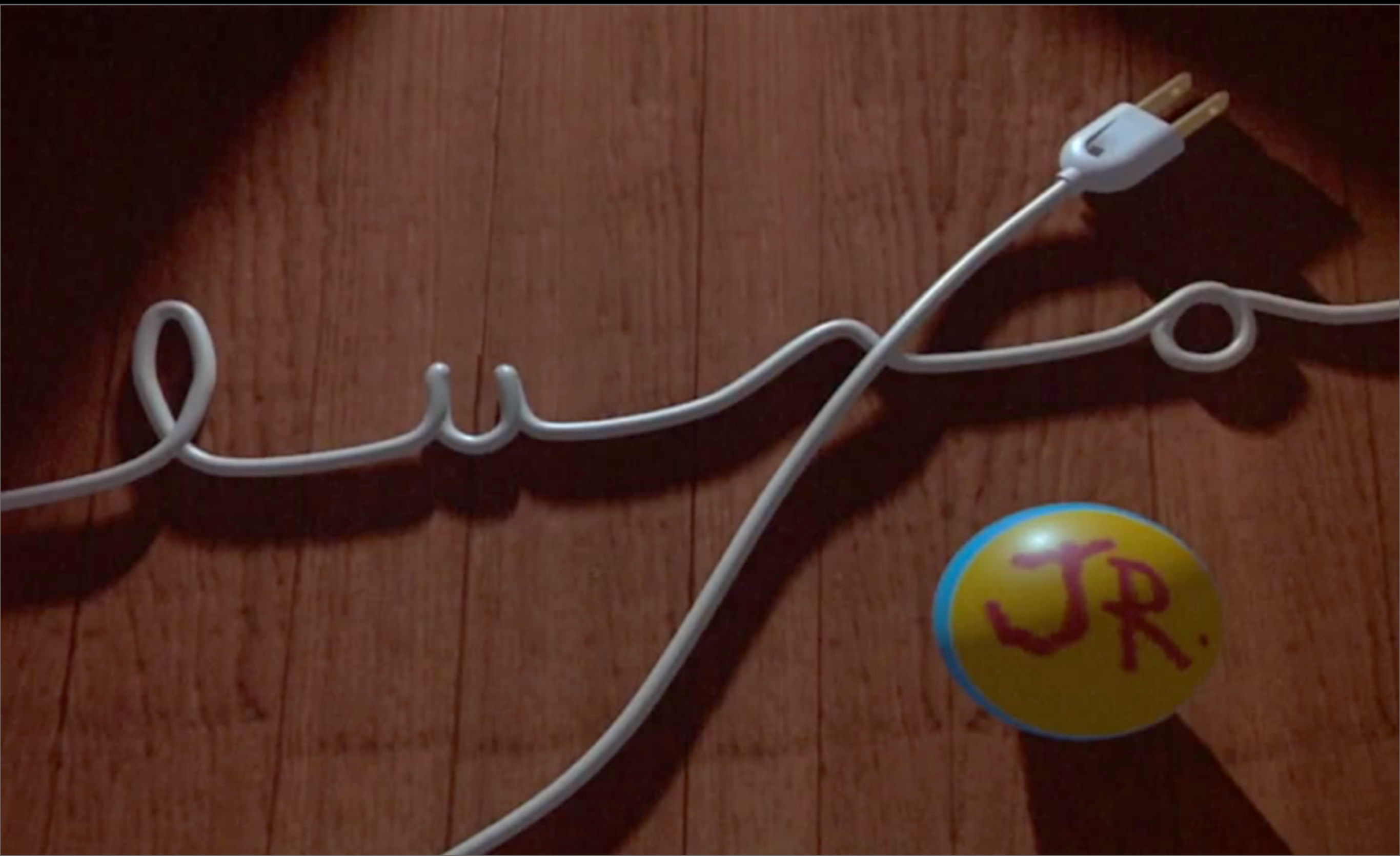
Computer graphics: What you
need to show other people your dreams.

Graphics Applications

- Entertainment
 - film production
 - film effects
 - games
- Science and engineering
 - computer-aided design
 - visualization (scientific, information)
- Virtual Prototyping
- Cultural Heritage
- Training & Simulation
- Graphic Arts, Fine Art

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Pixar—*Luxo Jr.* (1986)



Pixar—Toy Story

Disney • PIXAR

BRAVE

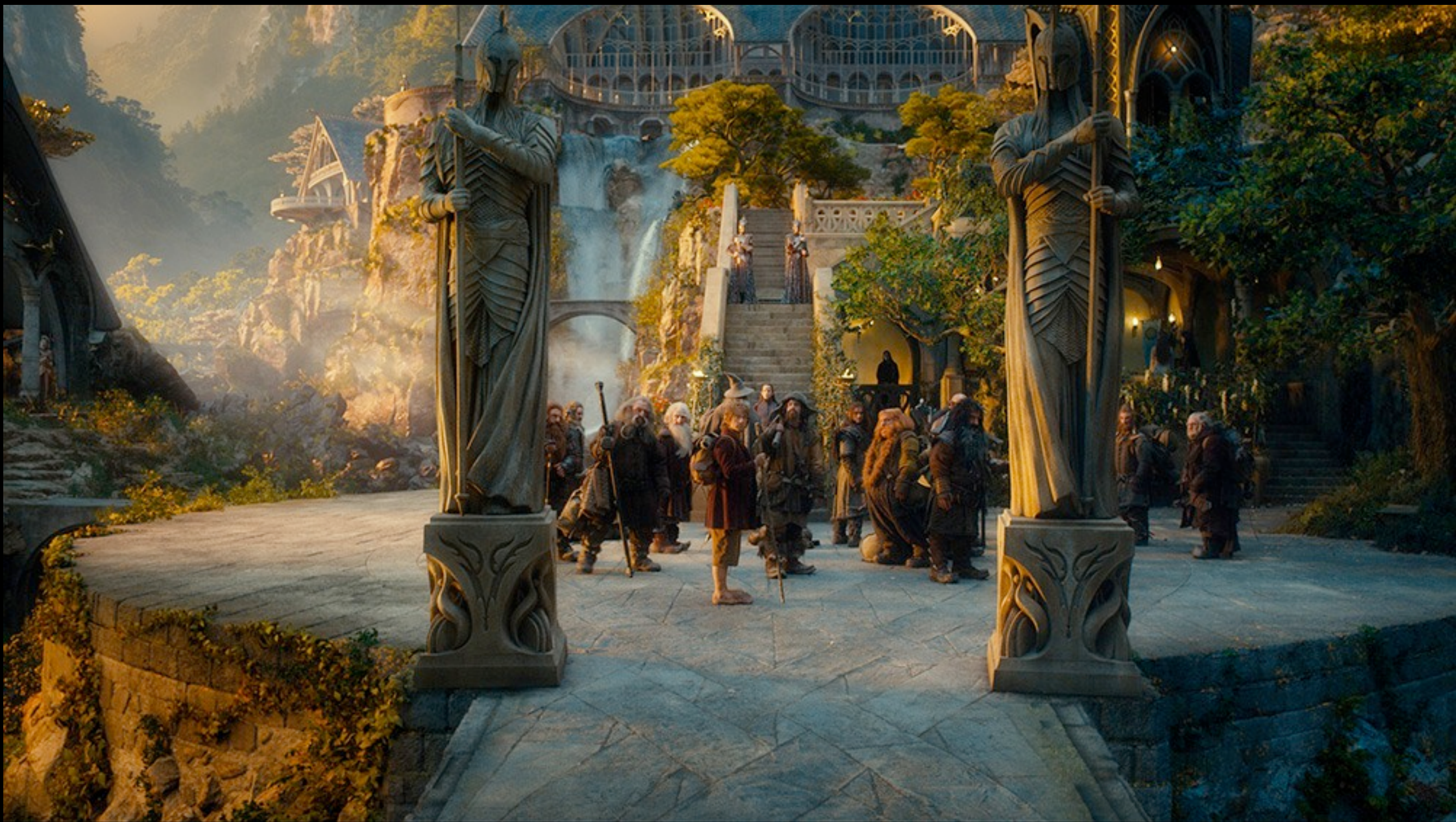
IN THEATERS JUNE 22



LORD MACGUFFIN

DISNEY.COM/BRAVE

© Disney/Pixar



The Hobbit: An Unexpected Journey (New Line Cinema, 2012)—visual effects by Weta Digital



KING KONG

© 2005 Universal Studios. Used With Permission.

CRYSIS 3



Crytek—Crysis 3 (2013)



Quantic Dream—*Two Souls* (2013)

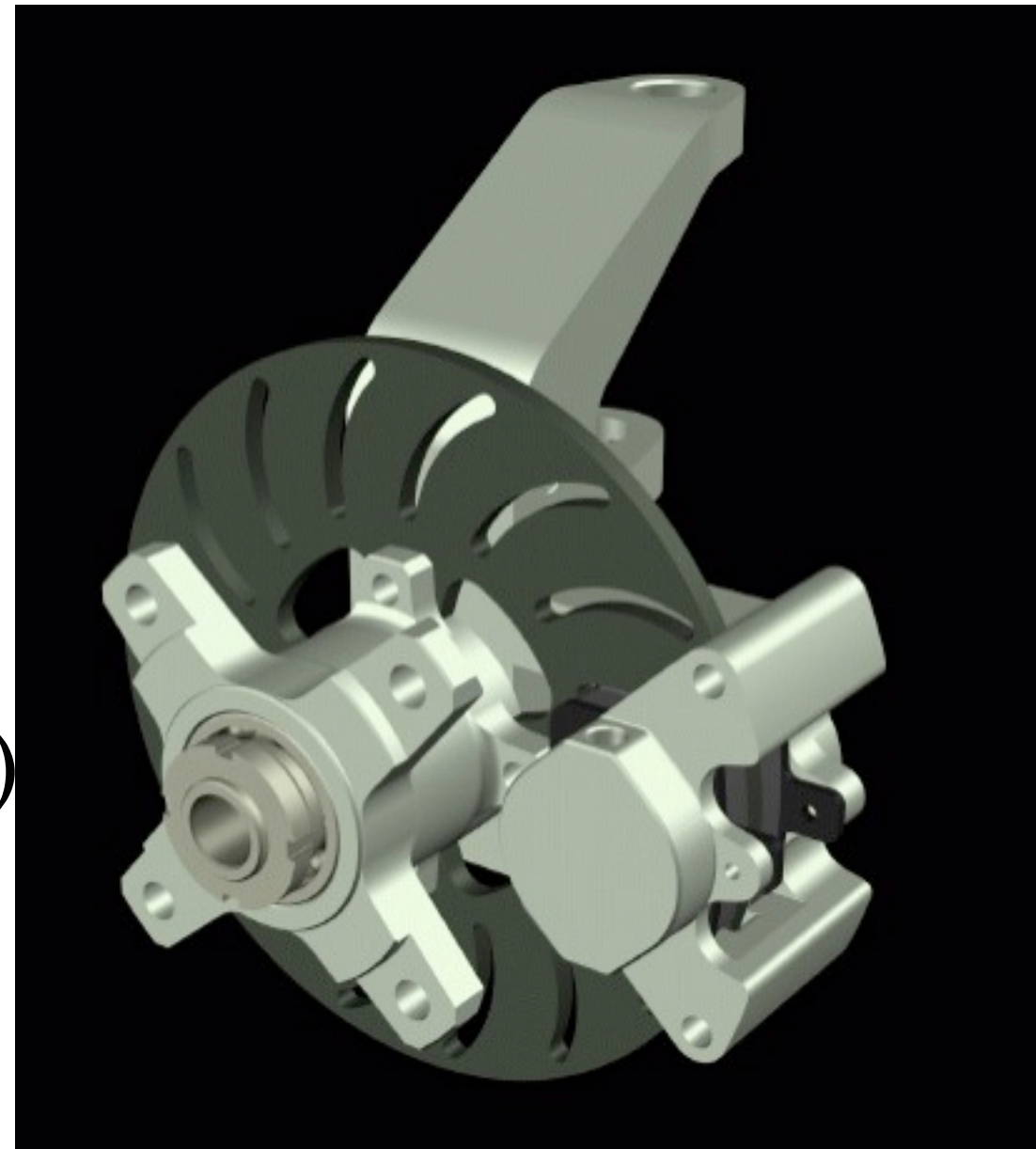
screenshot: videogamer.com



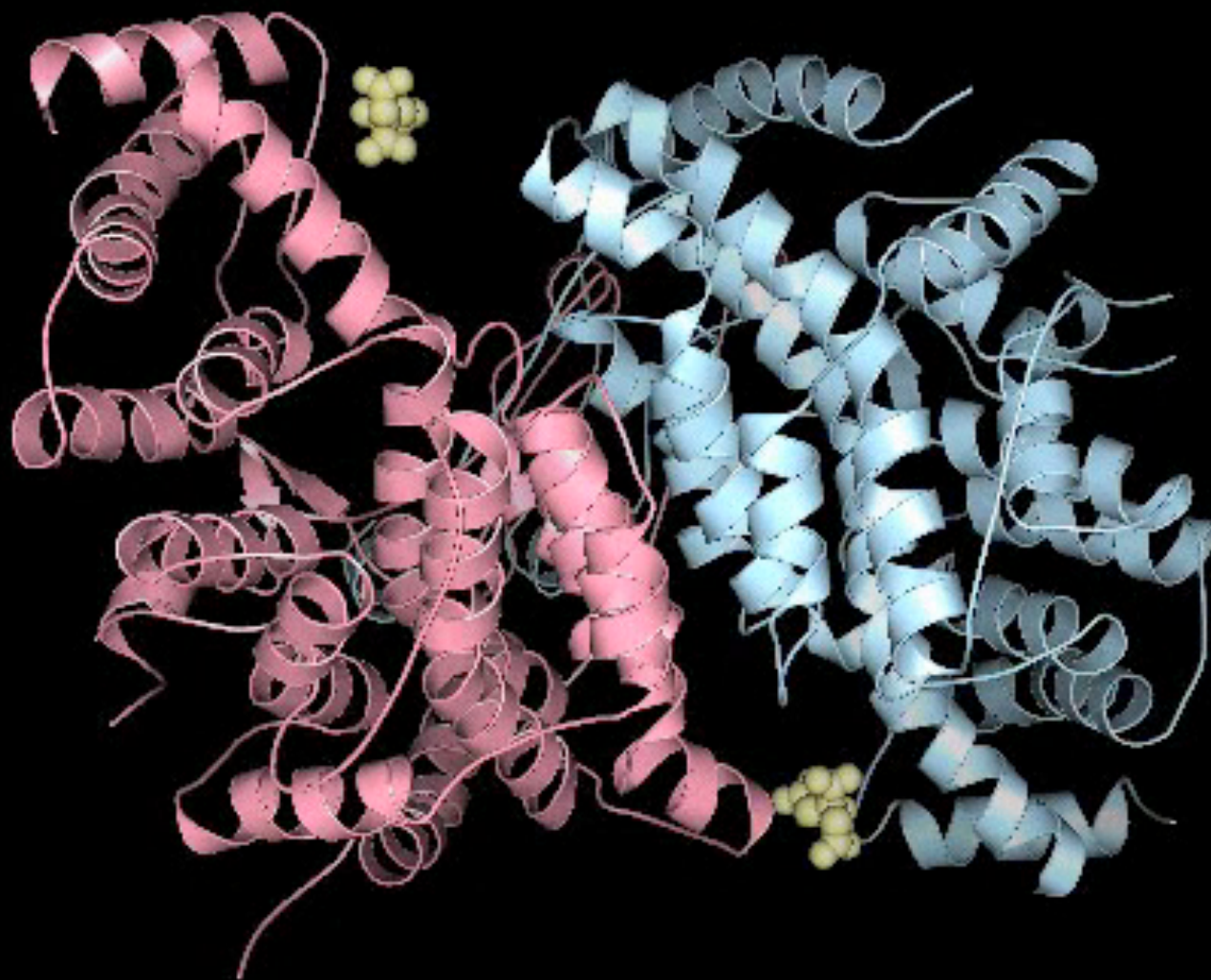
Polytron—*Fez* (2010)

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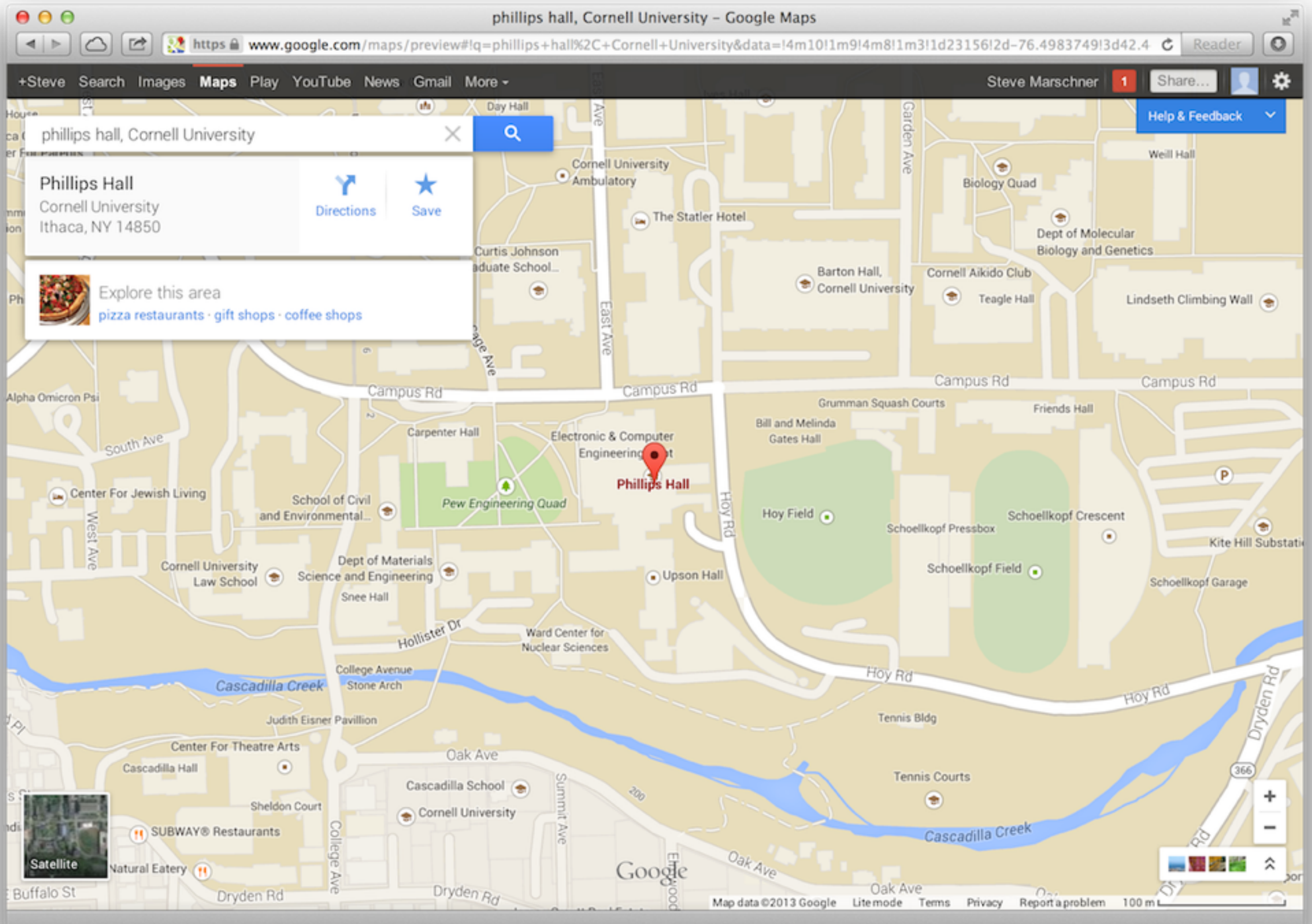


U. of Utah—Alpha I



Simulated
deformation of
citrate synthase
during substrate
binding

Kalju Kahn, UCSB



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Autodesk 360 Cloud Render

Autodesk® 360 Rendering

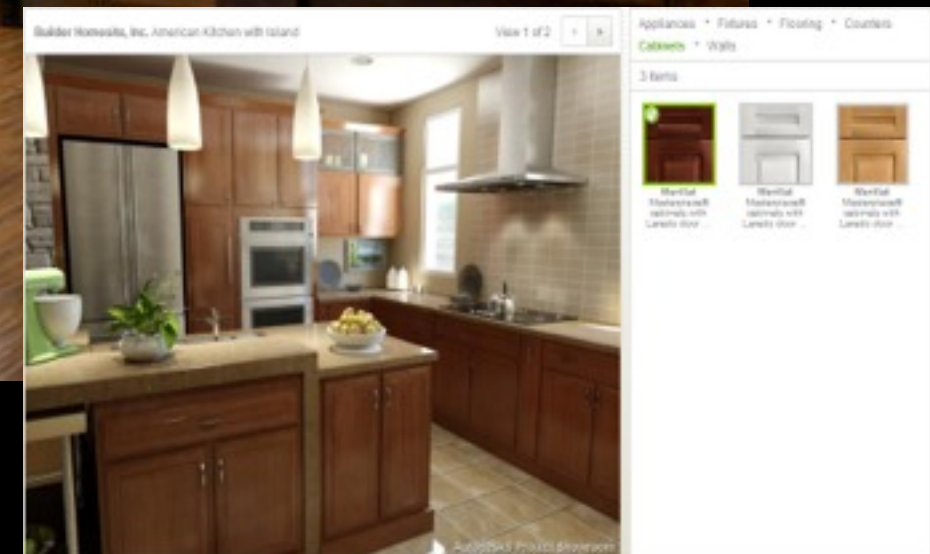
Create photorealistic Images and panoramas using our Rendering cloud services with your Autodesk® 360



Autodesk 360 Cloud Render



Autodesk 360 Cloud Render



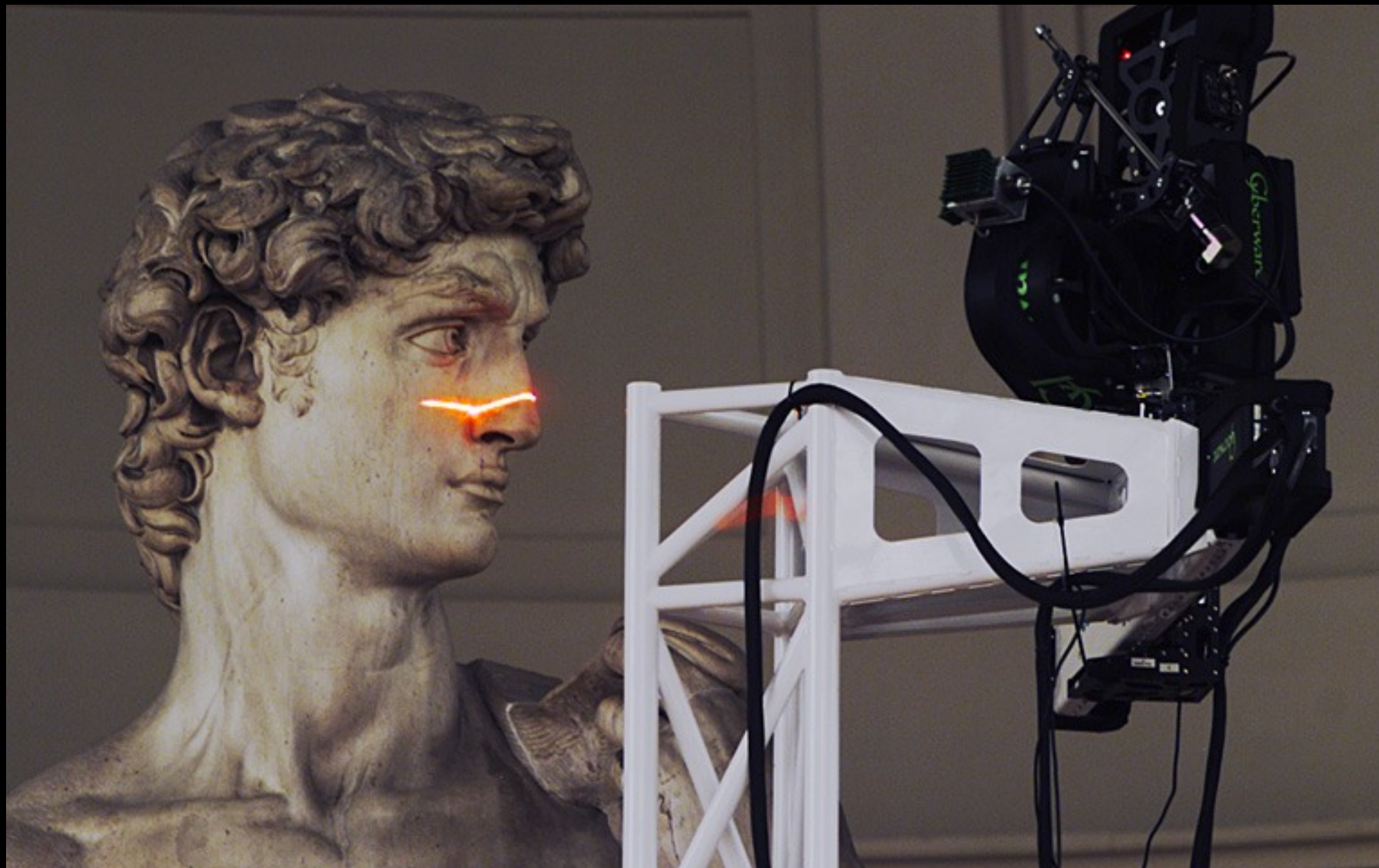


IKEA—rendered catalog image (2012)



[Walter et al. 2005]

model: University of Bristol



Digital
Michelangelo
Project
Marc Levoy, Stanford



Digital
Michelangelo
Project
Marc Levoy, Stanford

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NASA/Ames—ACFS

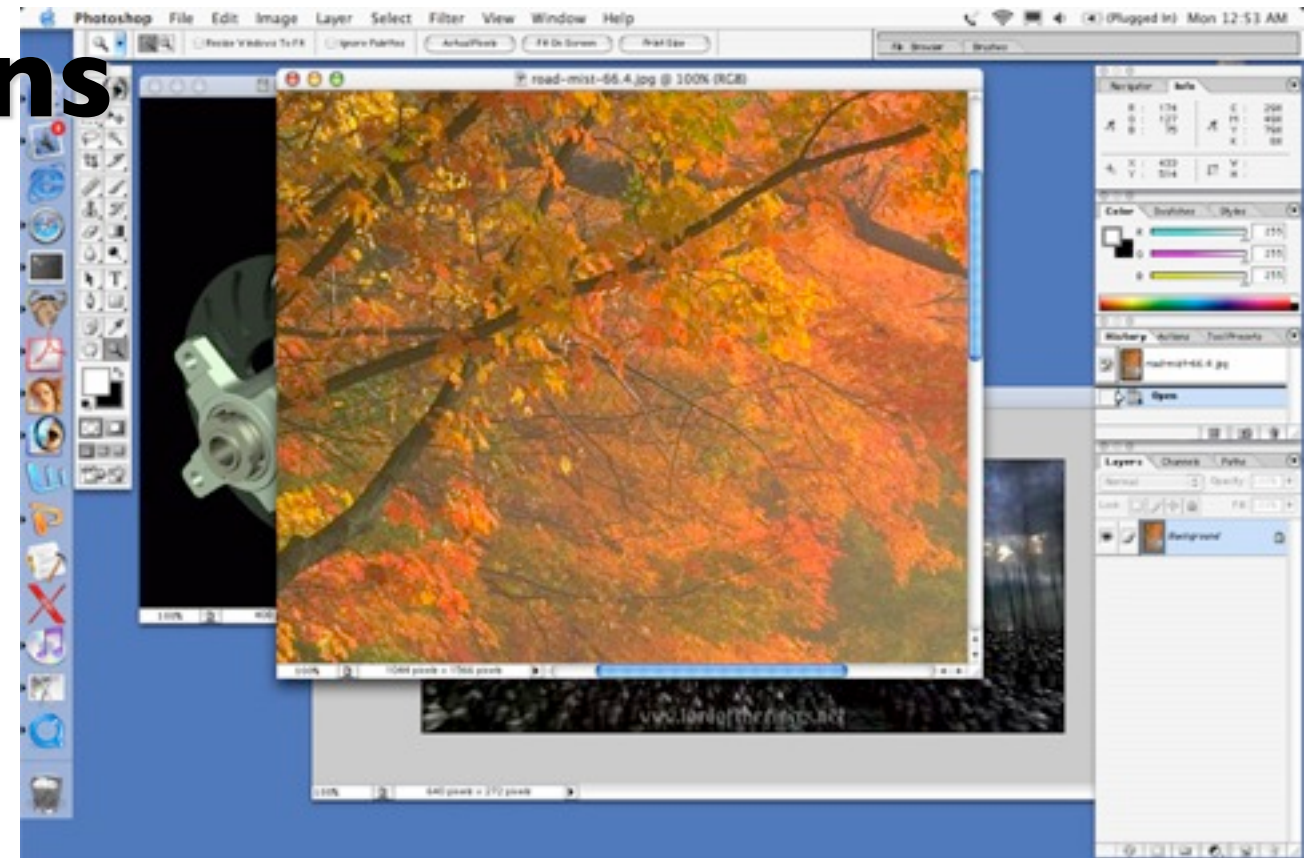


Army Research Lab—IES

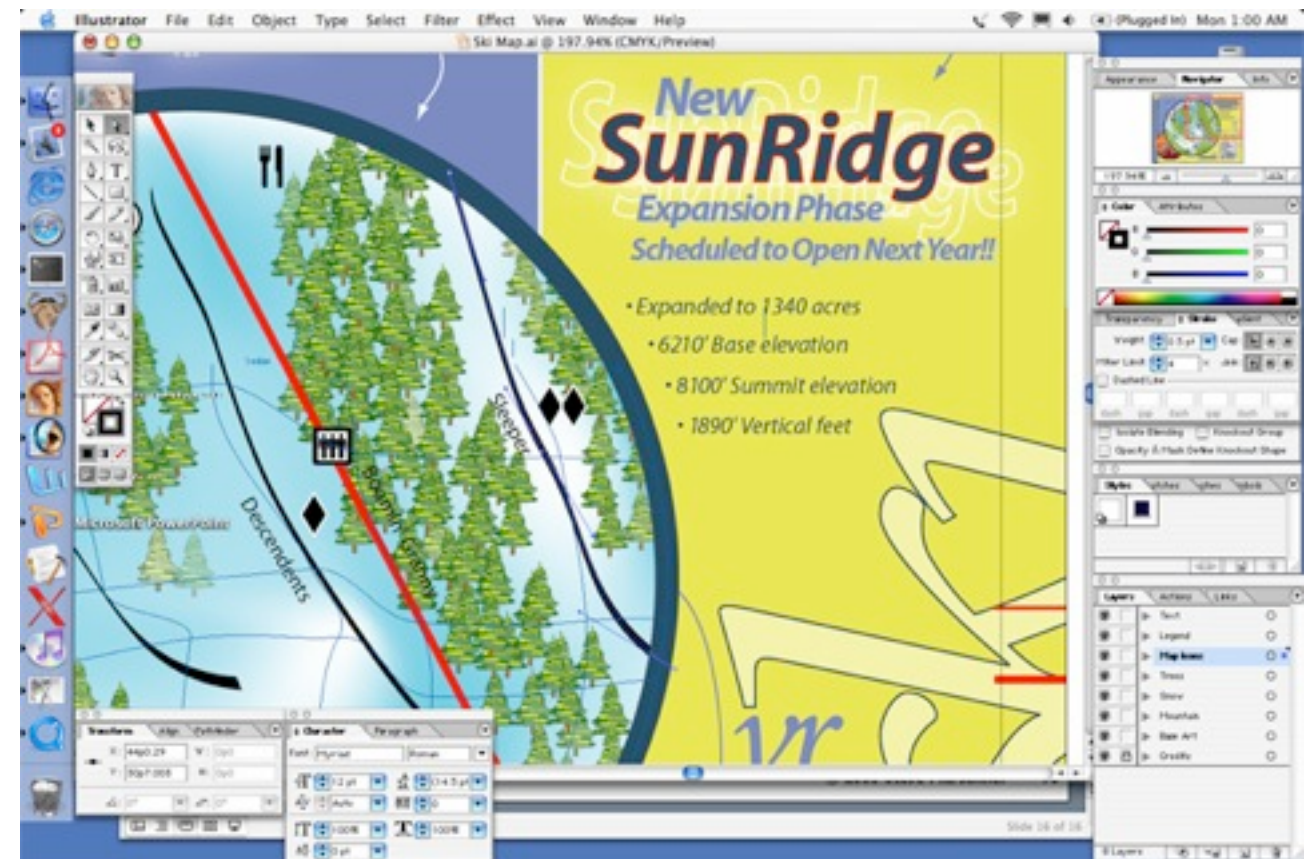


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Adobe Photoshop [Photo: P. Greenspun]



Adobe Illustrator

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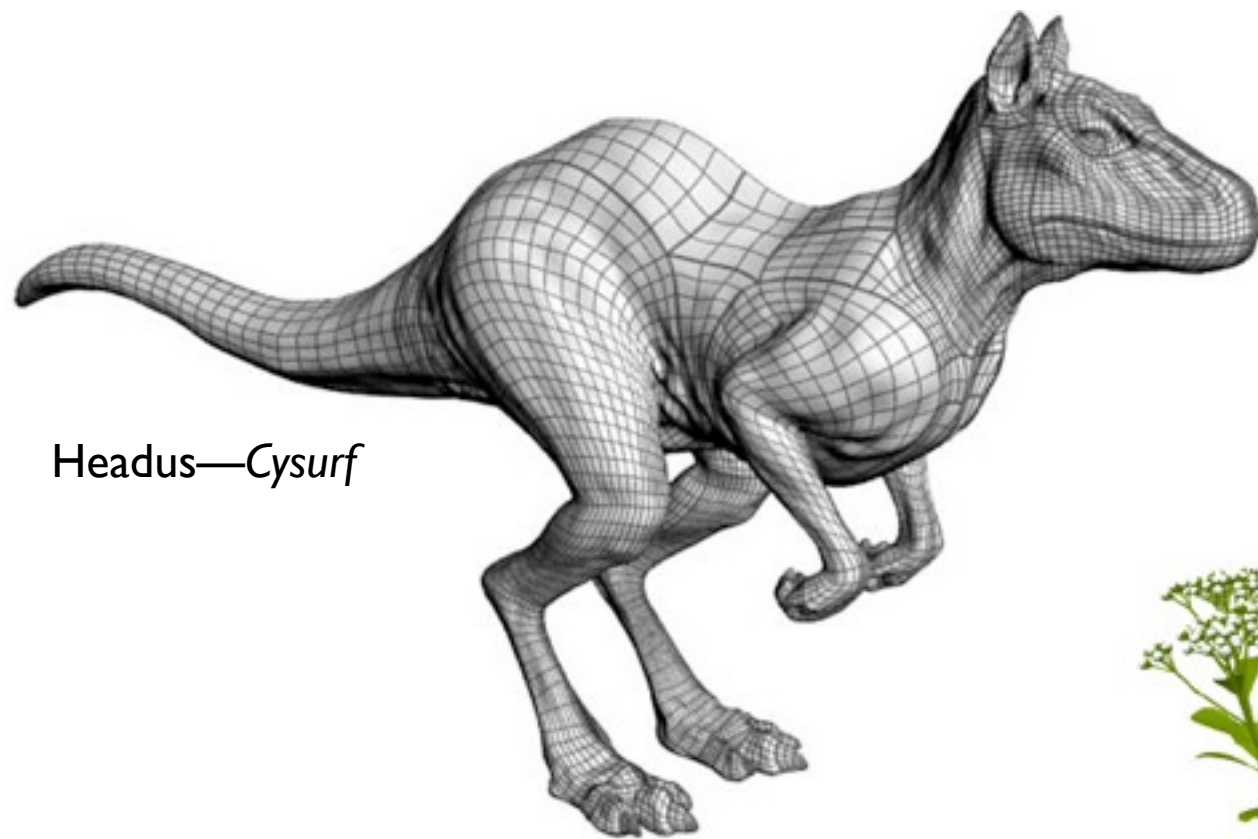
Computer aided sculptures
Ergun Akleman



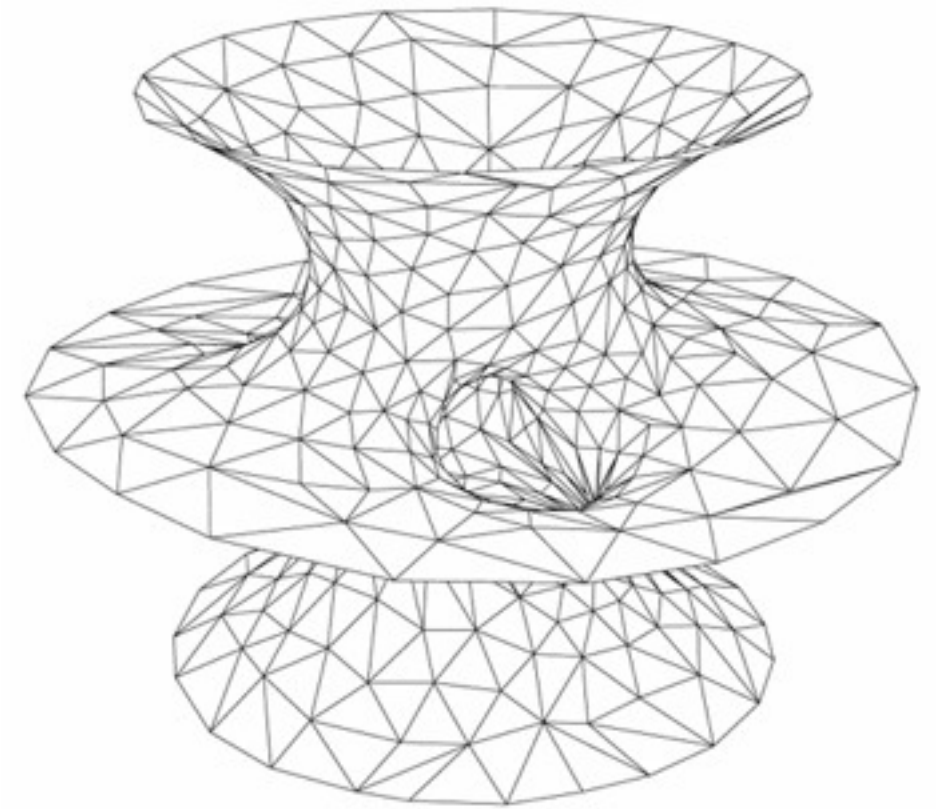
What is graphics about?

3D Modeling

- representing 3D shapes
- polygons, curved surfaces, ...
- procedural modeling



Headus—Cysurf



[Hoppe et al. 1993]

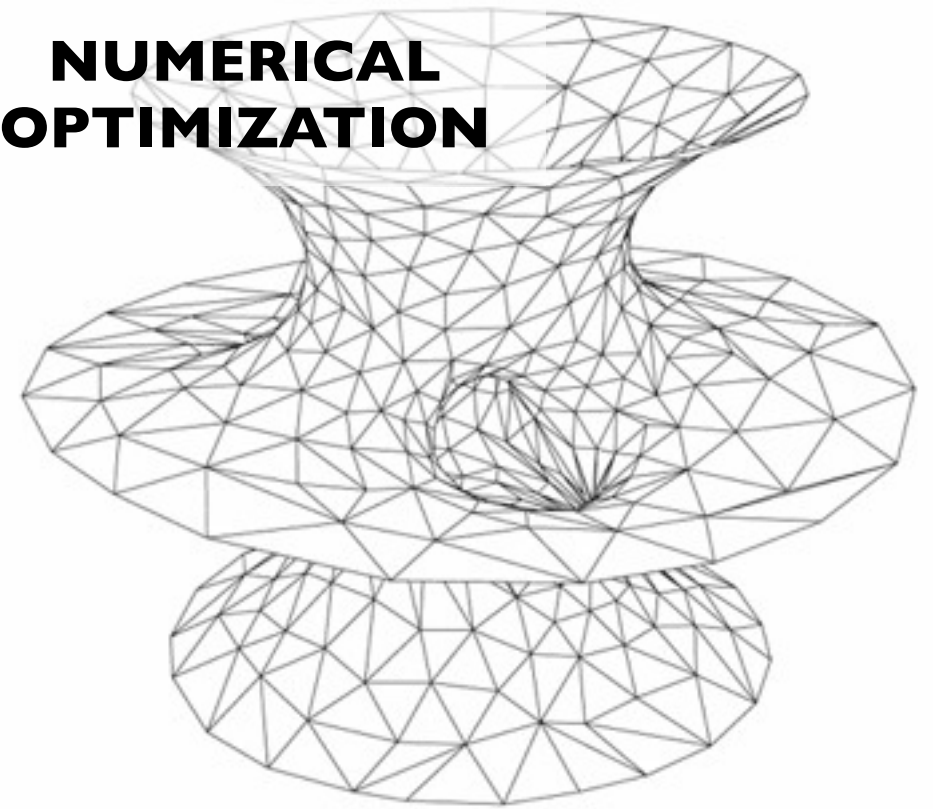


[Prusinkiewicz et al. 2001]

3D Modeling

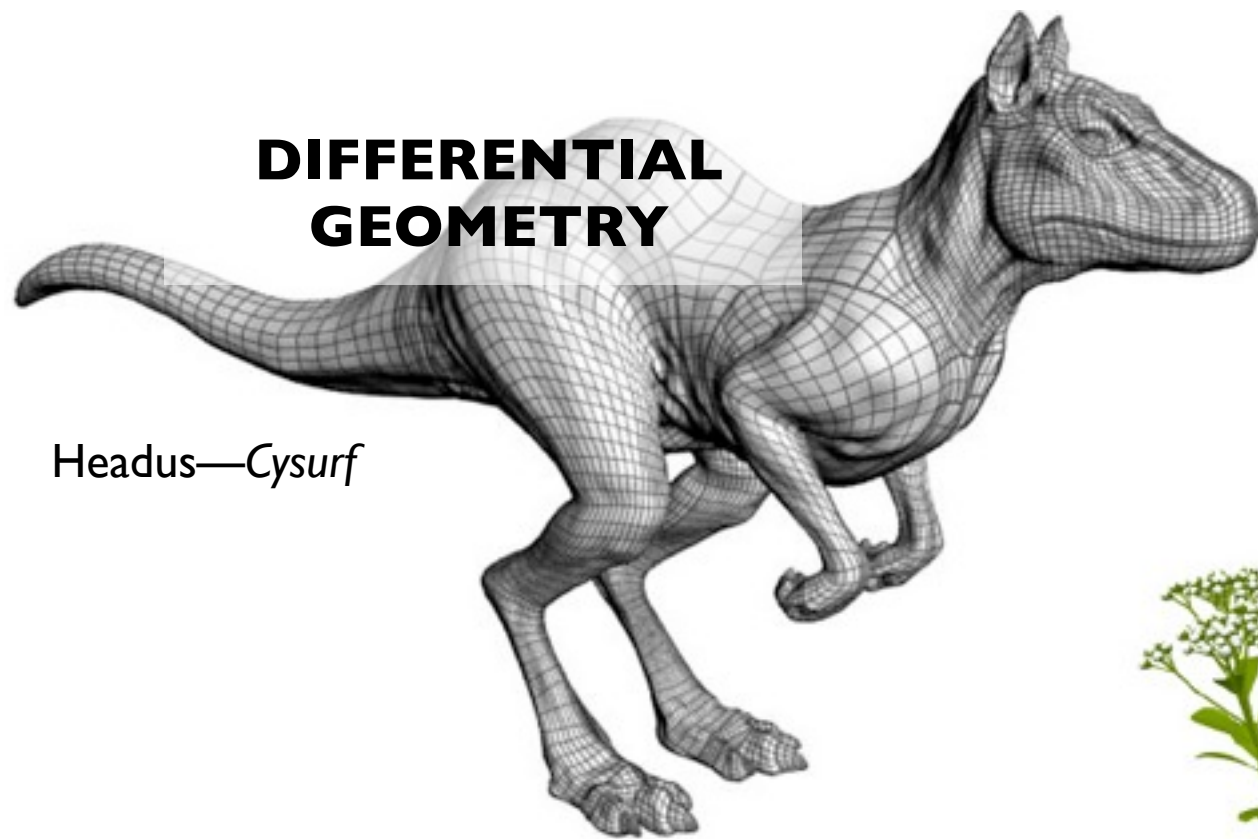
- representing 3D shapes
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- procedural modeling

**NUMERICAL
OPTIMIZATION**



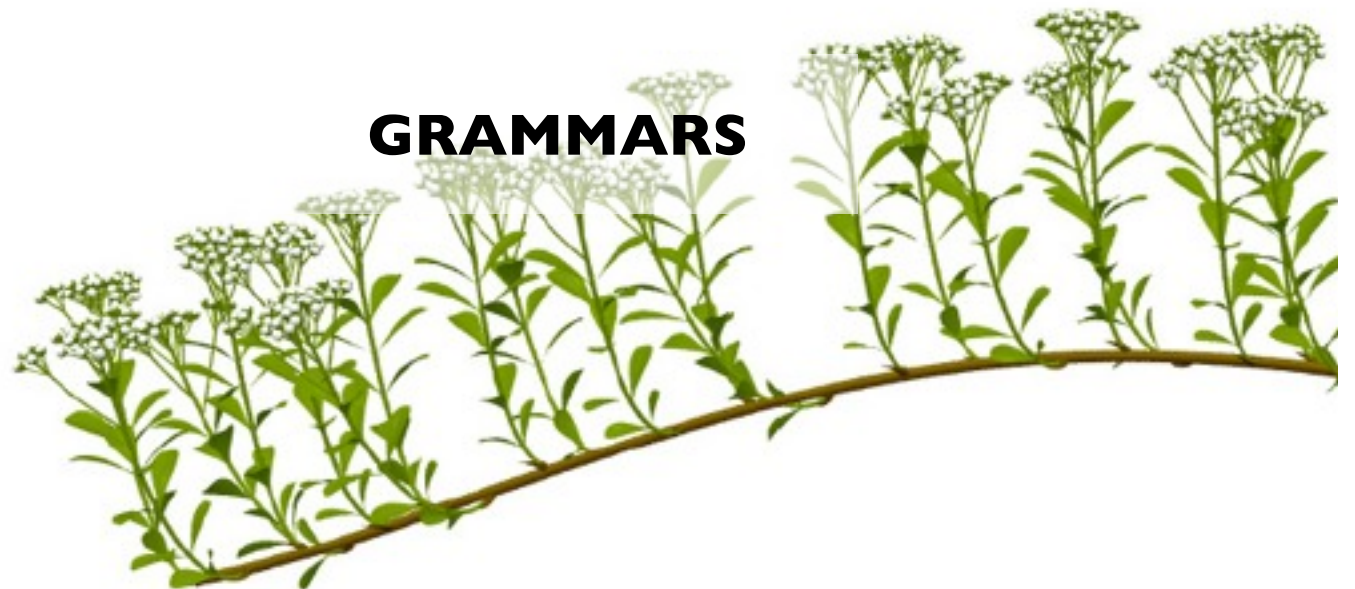
[Hoppe et al. 1993]

**DIFFERENTIAL
GEOMETRY**



Headus—Cysurf

GRAMMARS

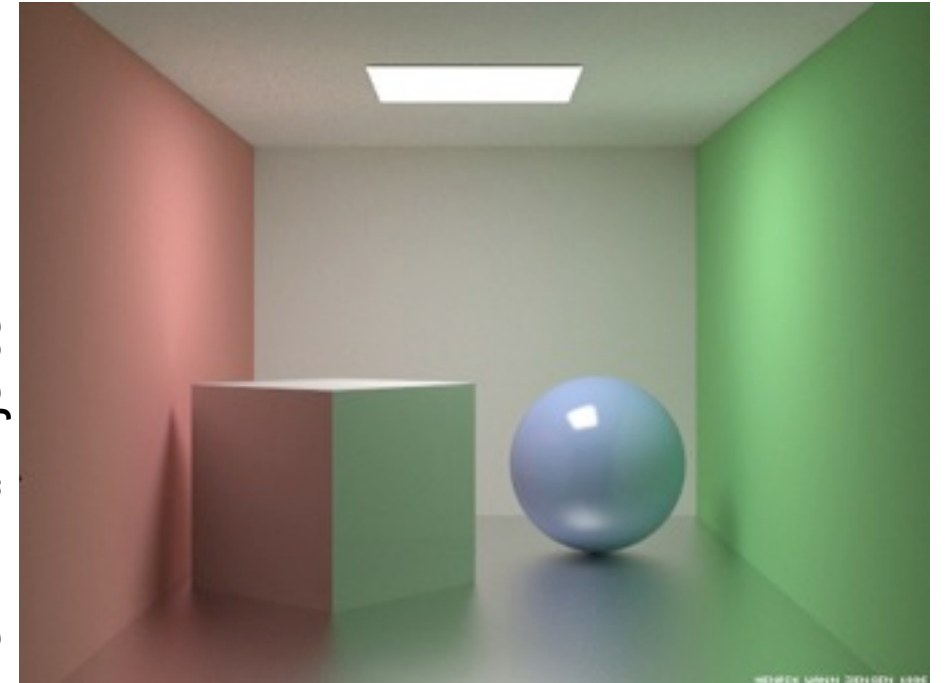


[Prusinkiewicz et al. 2001]

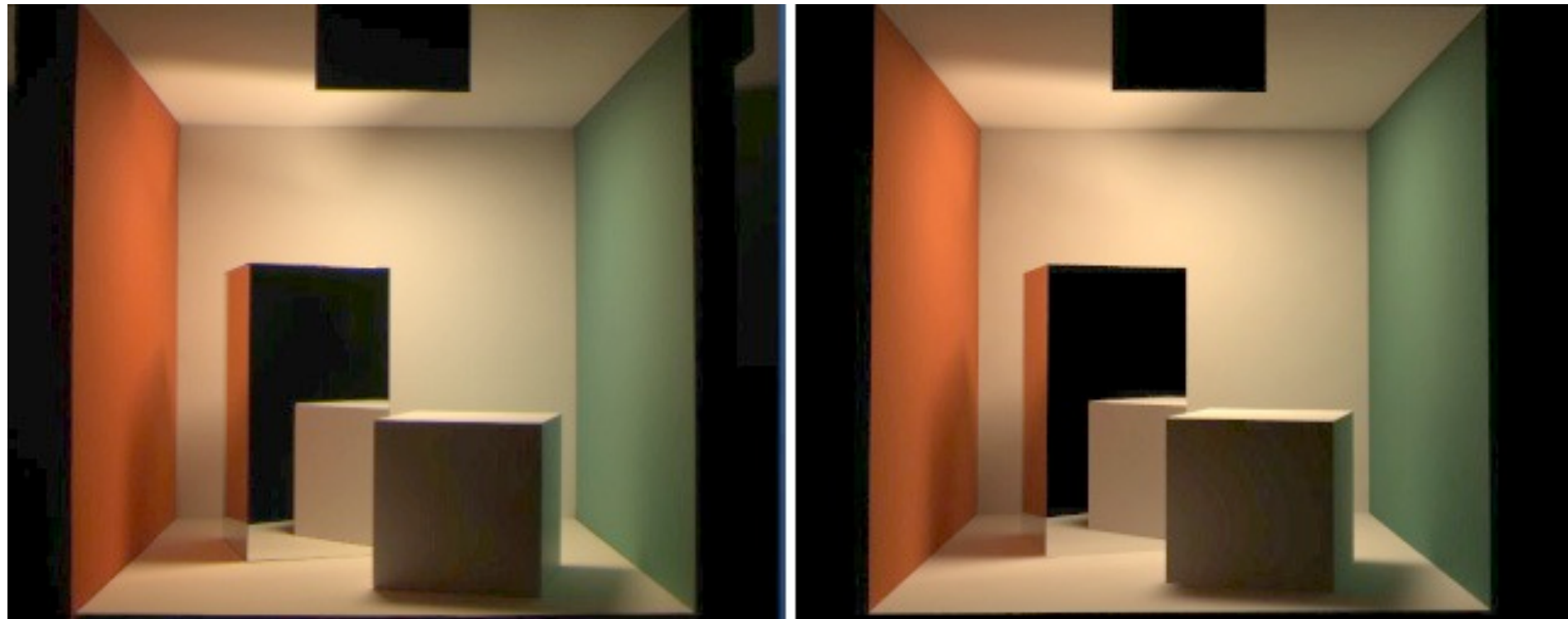
3D Rendering

- 2D views of 3D geometry
- projection and perspective
- removing hidden surfaces
- lighting simulation

Henrik Wann Jensen



Cornell PCG

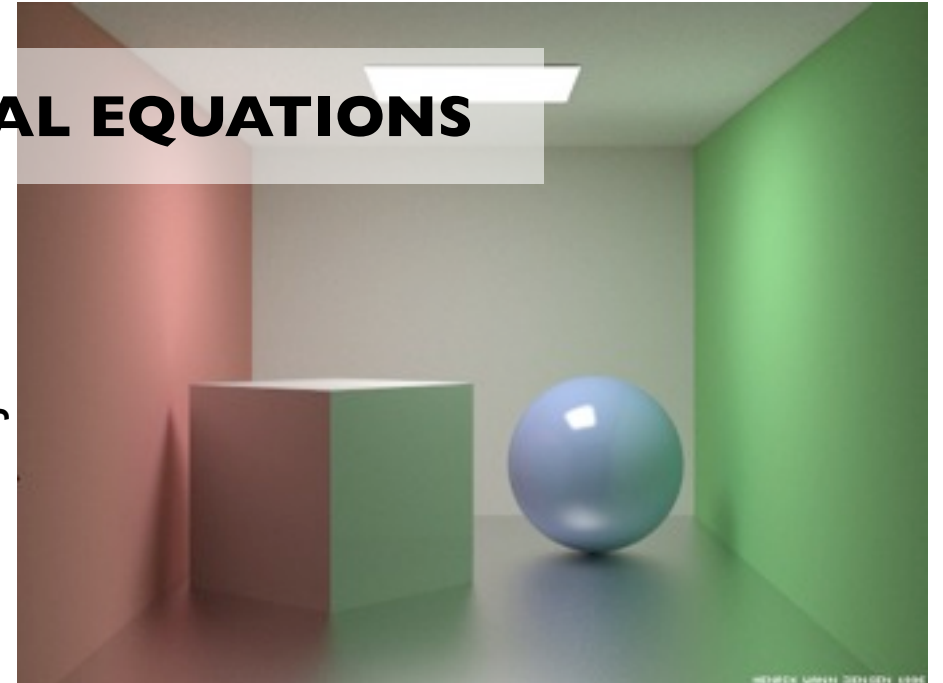


3D Rendering

- 2D views of 3D geometry
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INTEGRAL EQUATIONS

Henrik Wann Jensen



Cornell PCG





Kavita Bala, Bruce Wlaler



Animation

- keyframe animation
- physical simulation

Avengers (2012)

Animation

- keyframe animation
- physical simulation



Avengers (2012)



Pixar

Animation

- keyframe animation
- physical simulation



Avengers (2012)



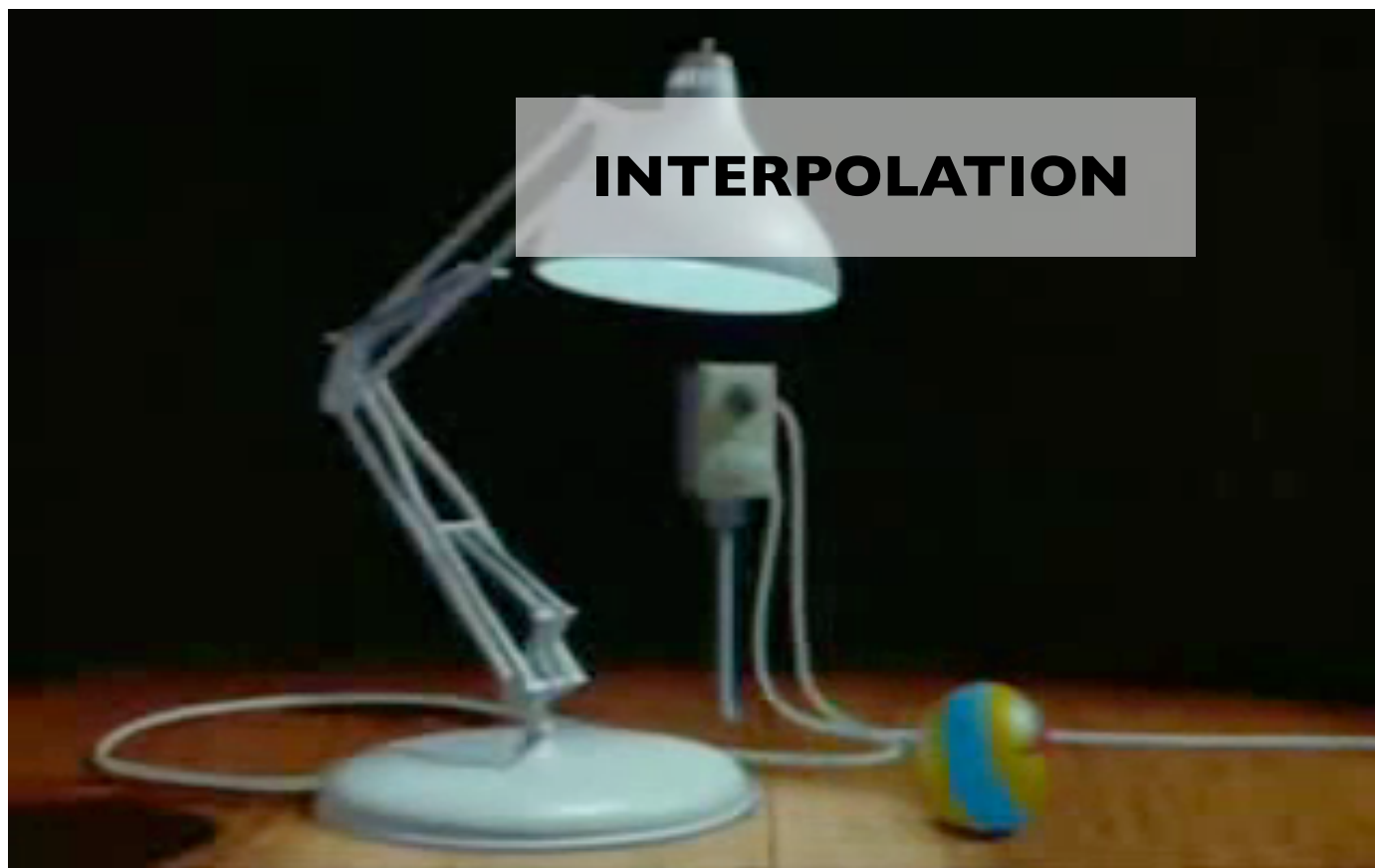
Pixar

Animation

- keyframe animation
- physical simulation



Avengers (2012)



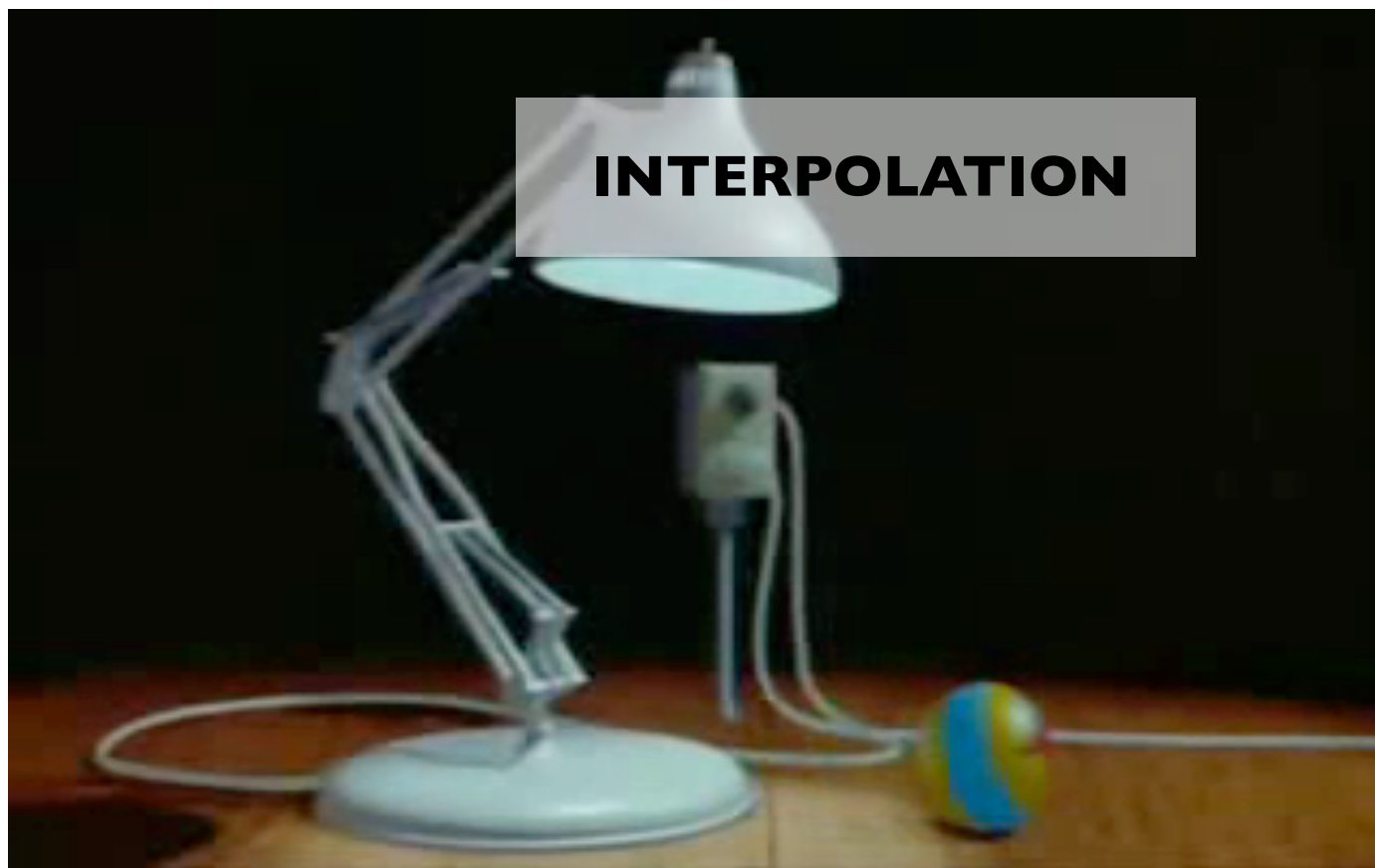
Pixar

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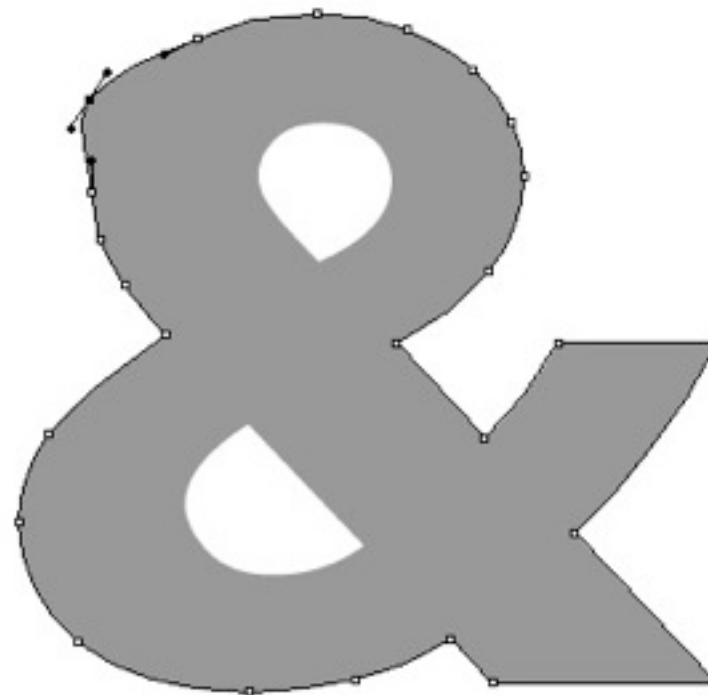
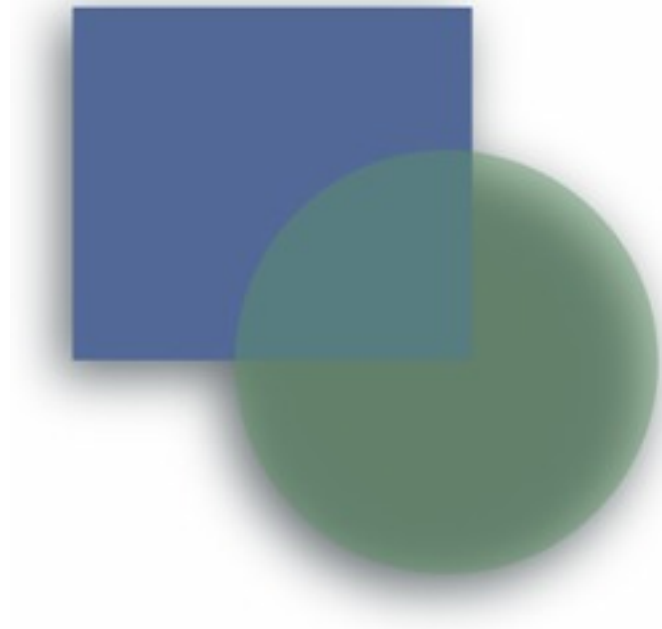
Avengers (2012)



Pixar

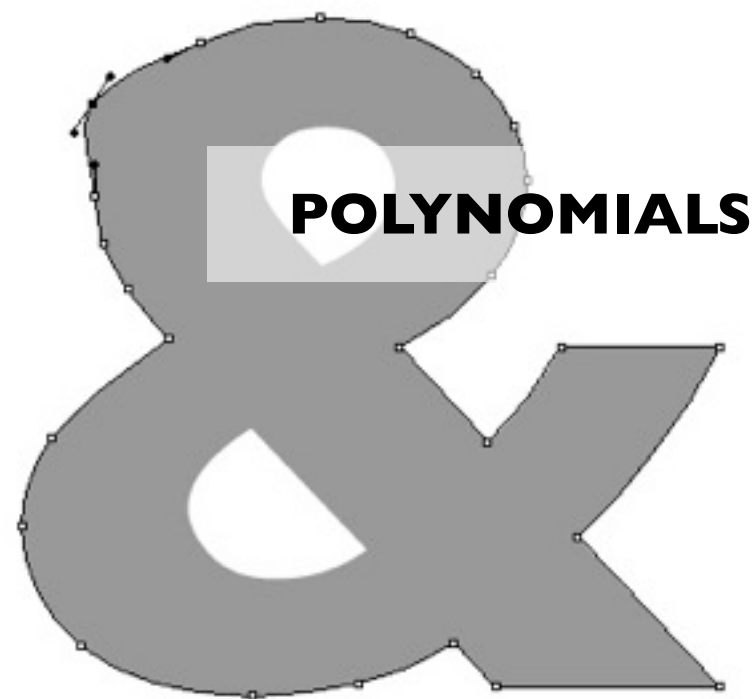
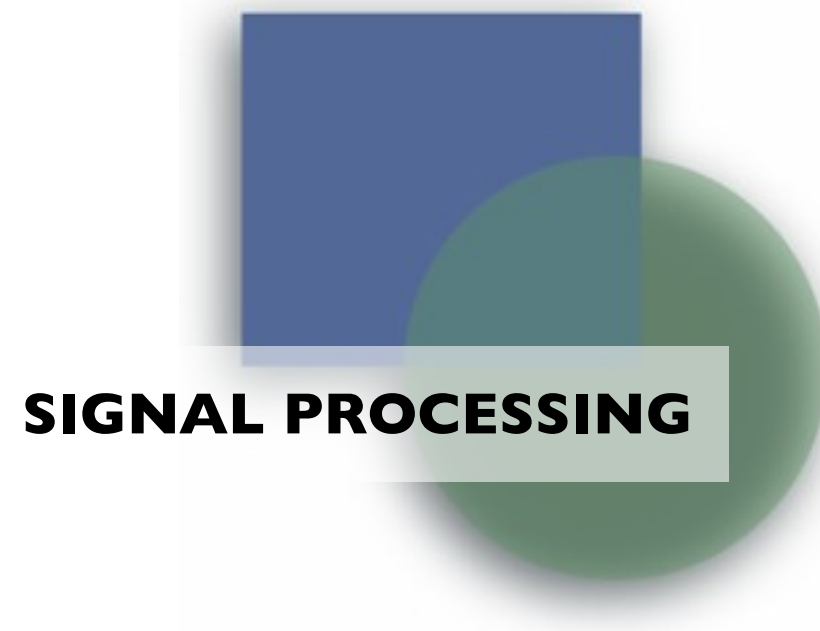
Images

- 2D imaging
 - compositing and layering
 - digital filtering
 - color transformations
- 2D drawing
 - illustration, drafting
 - text, GUIs



Images

- 2D imaging
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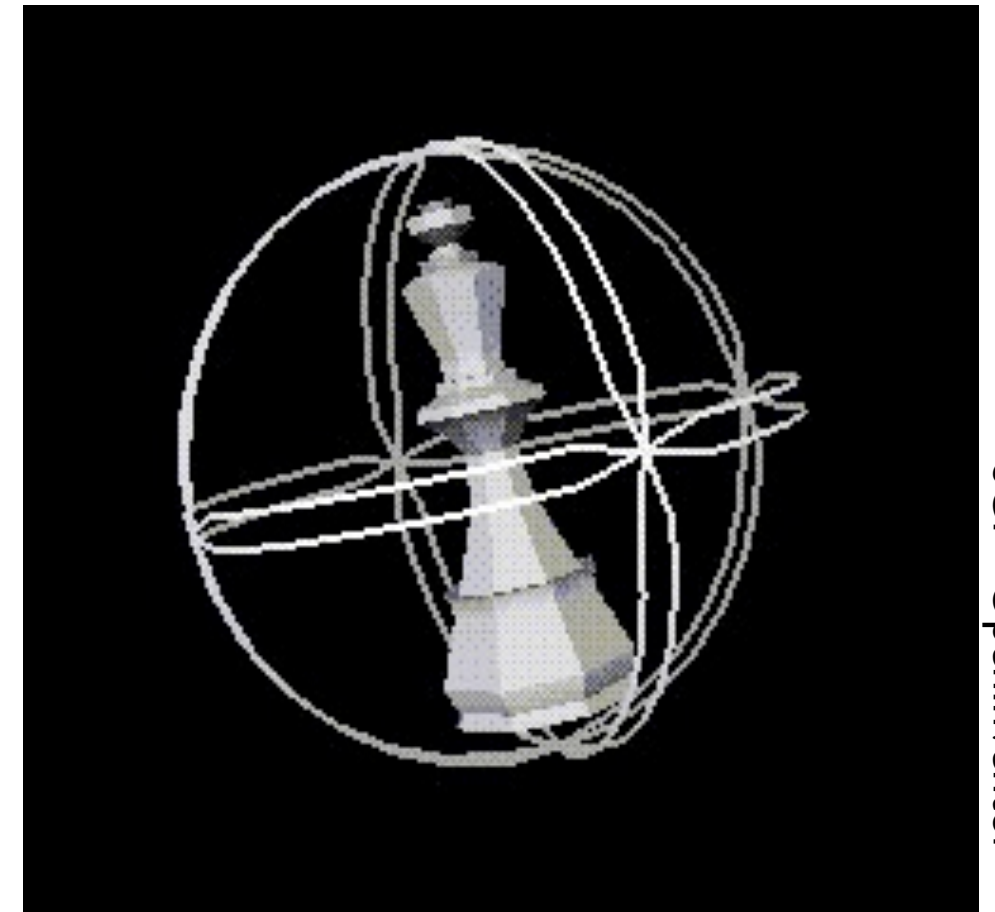
User Interaction

- 2D graphical user interfaces
- 3D modeling interfaces
- virtual reality



TU Berlin

Cornell CS462

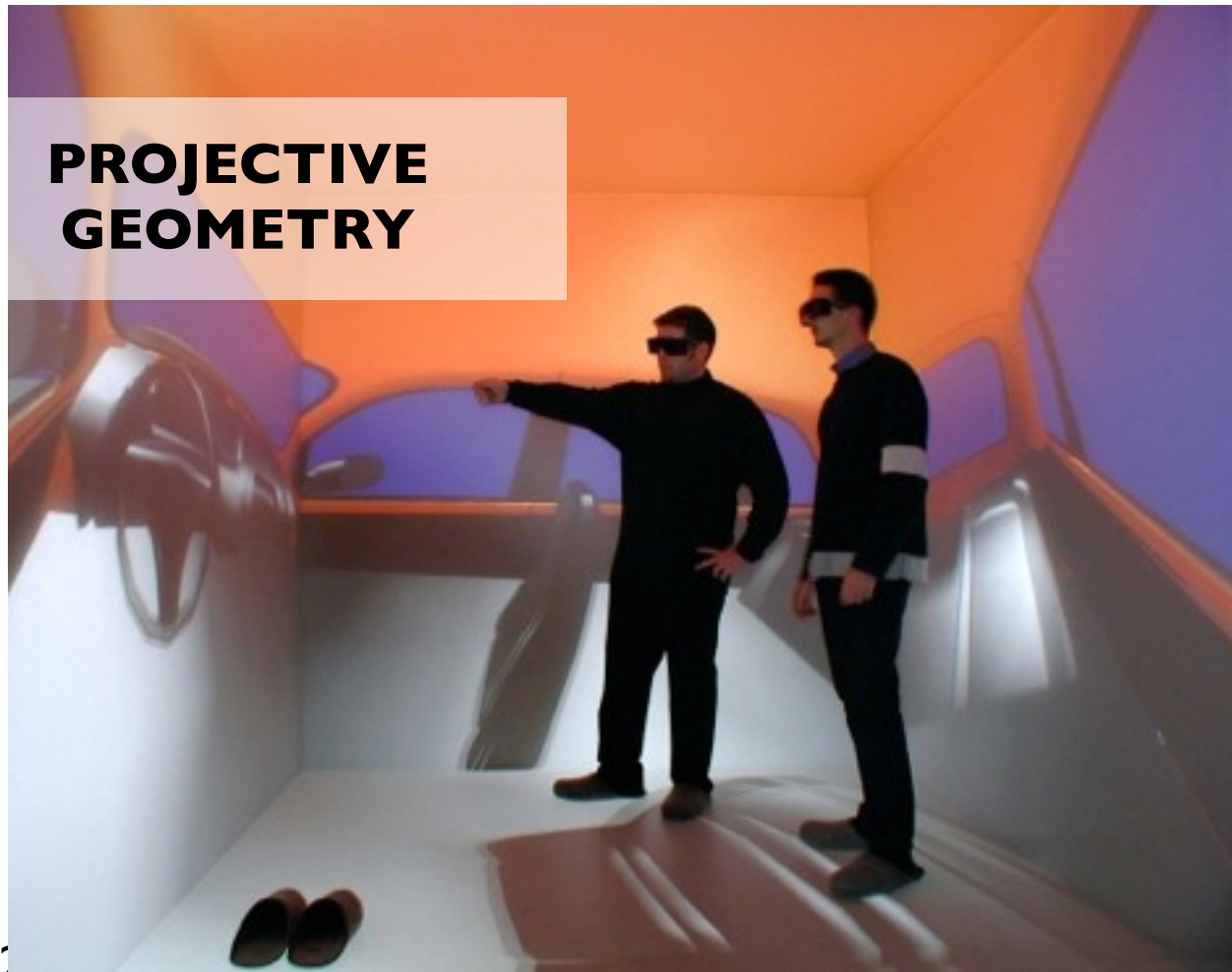


SGI—OpenInventor

User Interaction

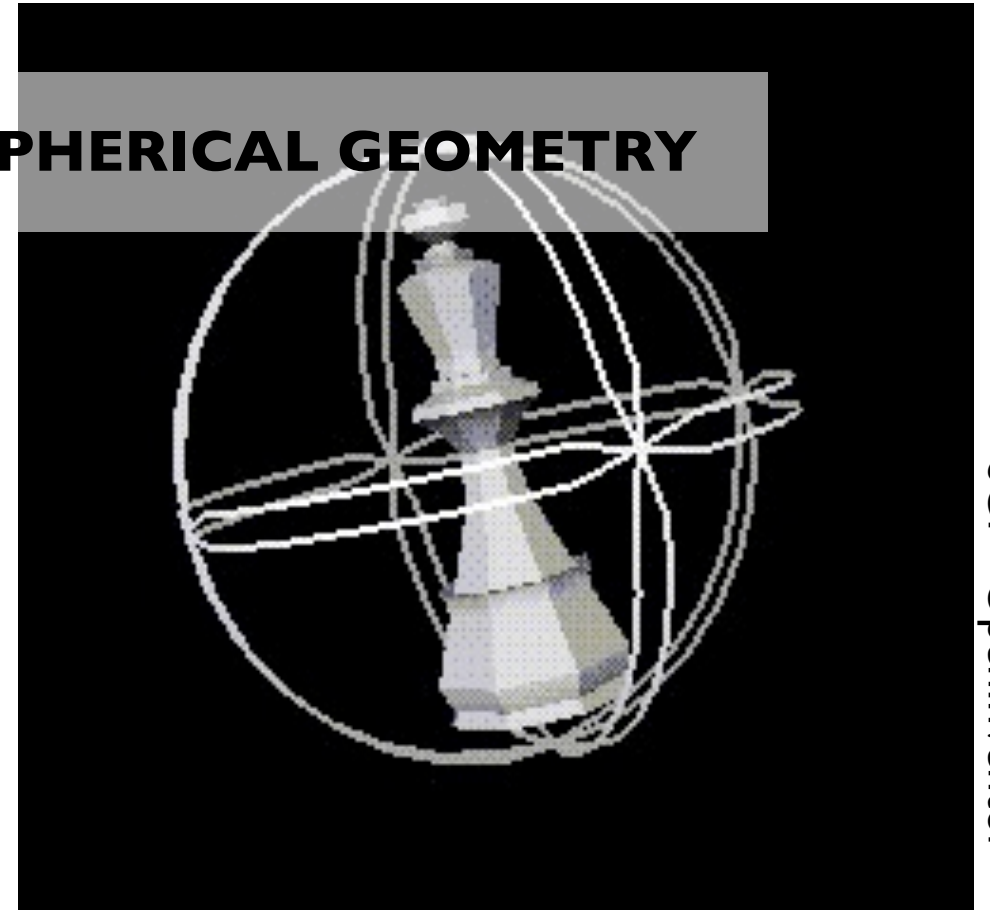
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PROJECTIVE GEOMETRY



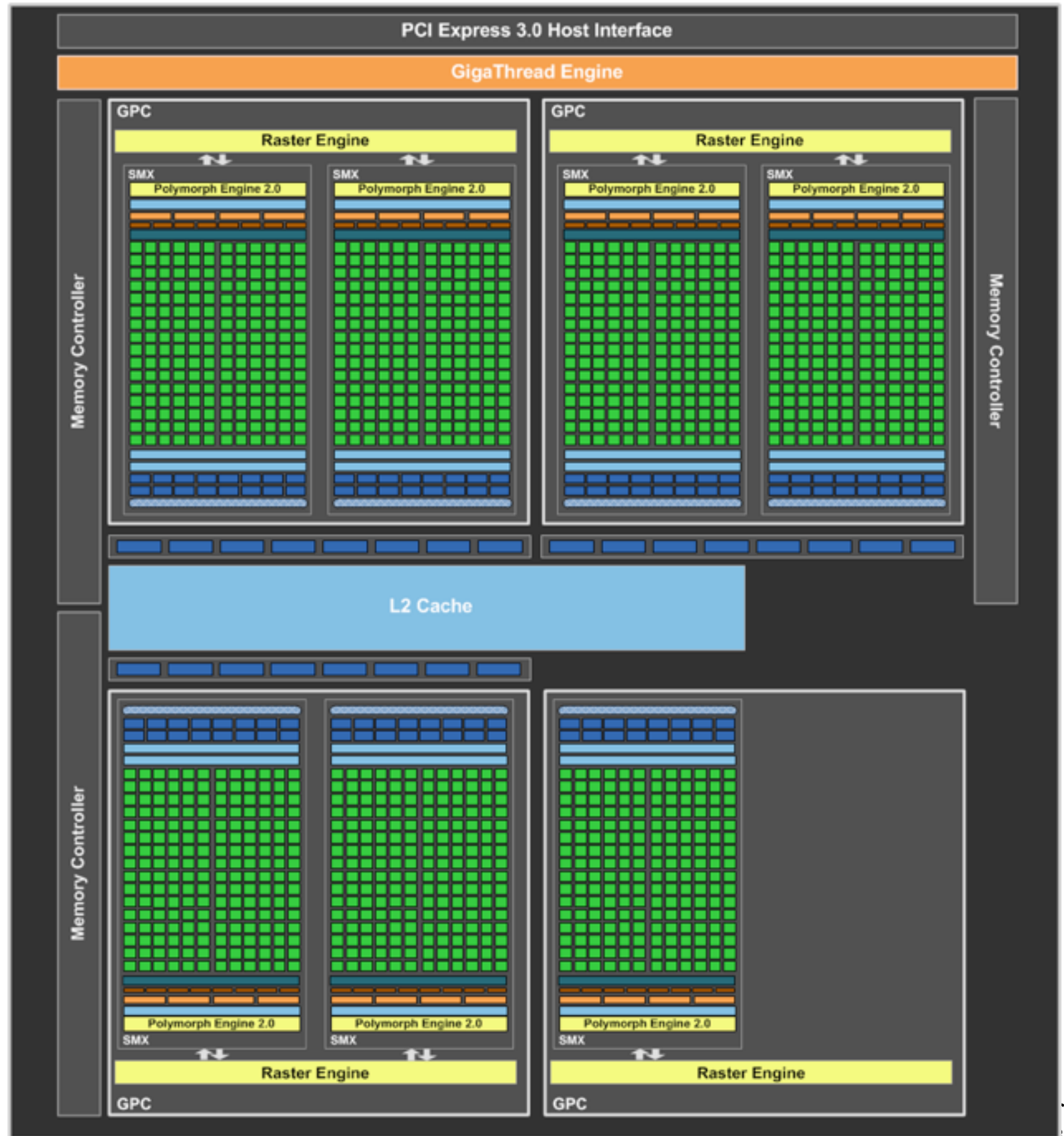
TU Berlin

SPHERICAL GEOMETRY



SGL—OpenInventor

Graphics Hardware



Computer graphics: Mathematics made visible.

Introductions...

Translucent materials



Diffuse “milk”

Translucent materials



Diffuse “milk”



Skim milk

Translucent materials



Diffuse “milk”



Skim milk



Whole milk

Digital characters



[New Line Productions]

Gollum from *The Lord of the Rings*: hair and skin are two major rendering challenges in film effects

Rendering hair

$a = 1.0$



Rendering hair

$a = 1.2$



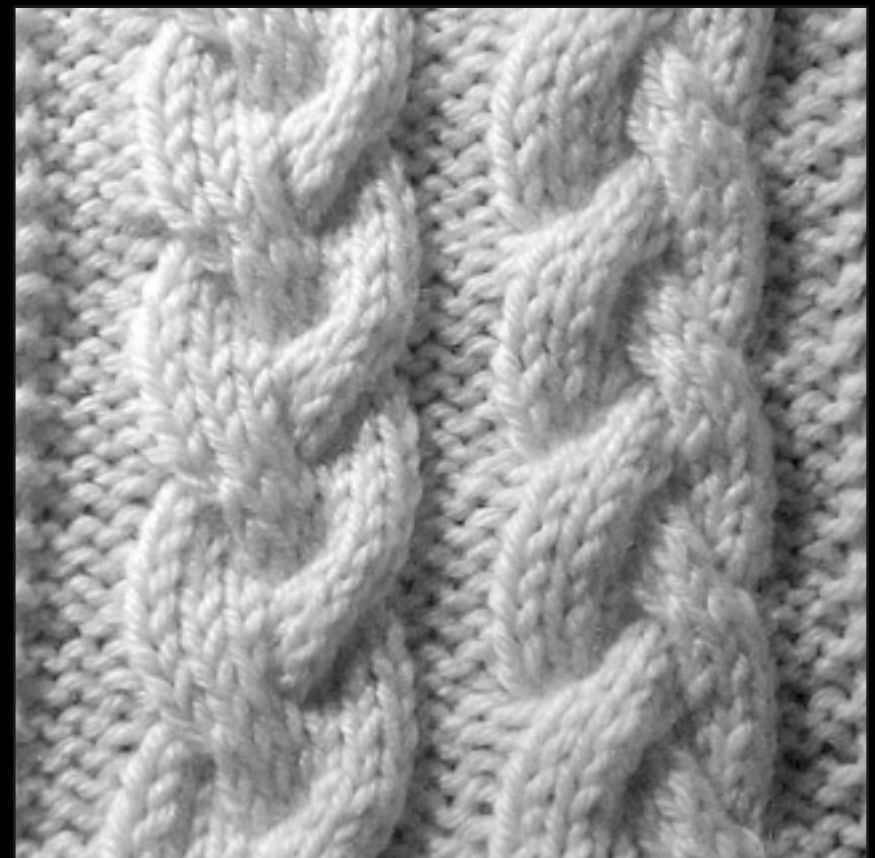
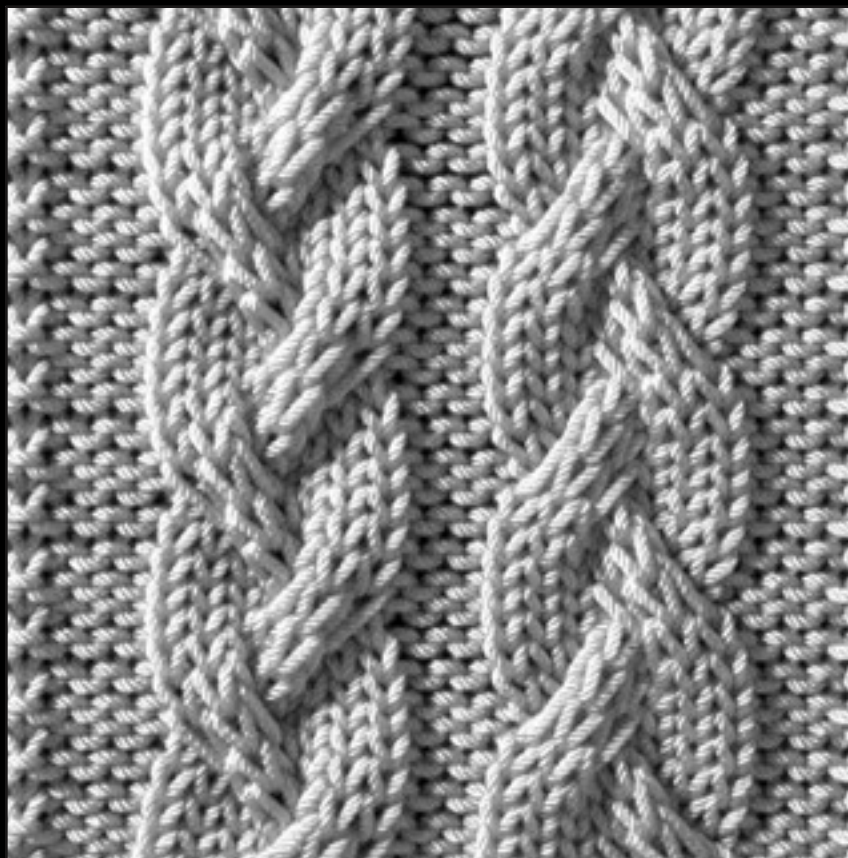
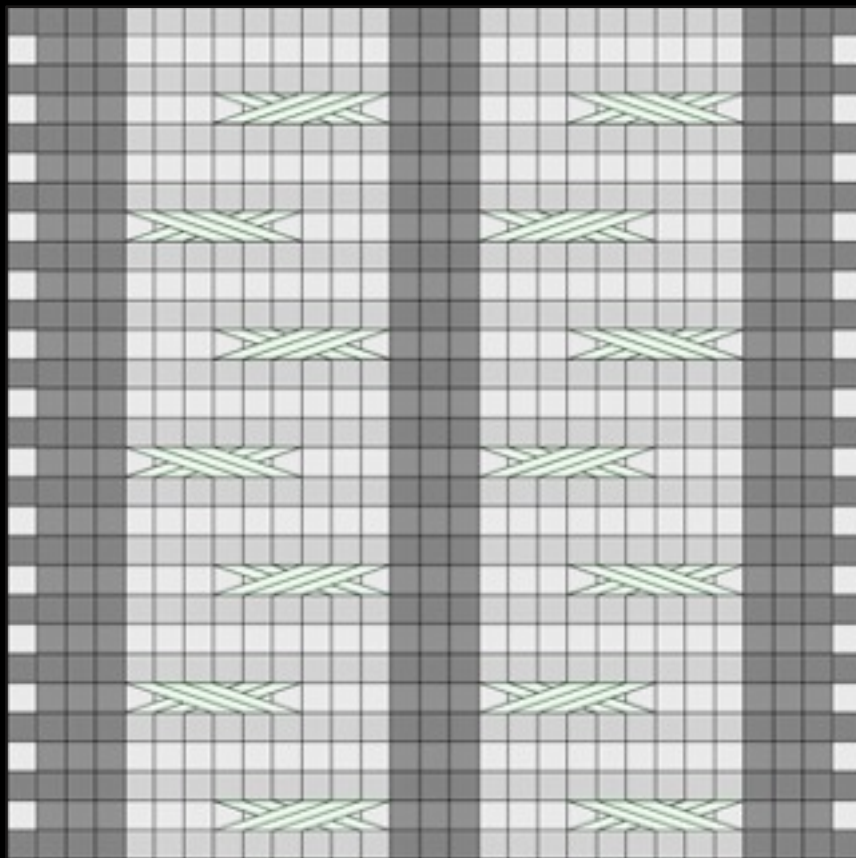
Rendering hair

$a = 1.5$



[Kaldor et al. 2008]

Modeling knit cloth



[Yuksel et al. 2012]



[Yuksel et al. 2012]

High-quality woven cloth appearance



[Zhao et al. 2012]

Course Overview

Course mechanics

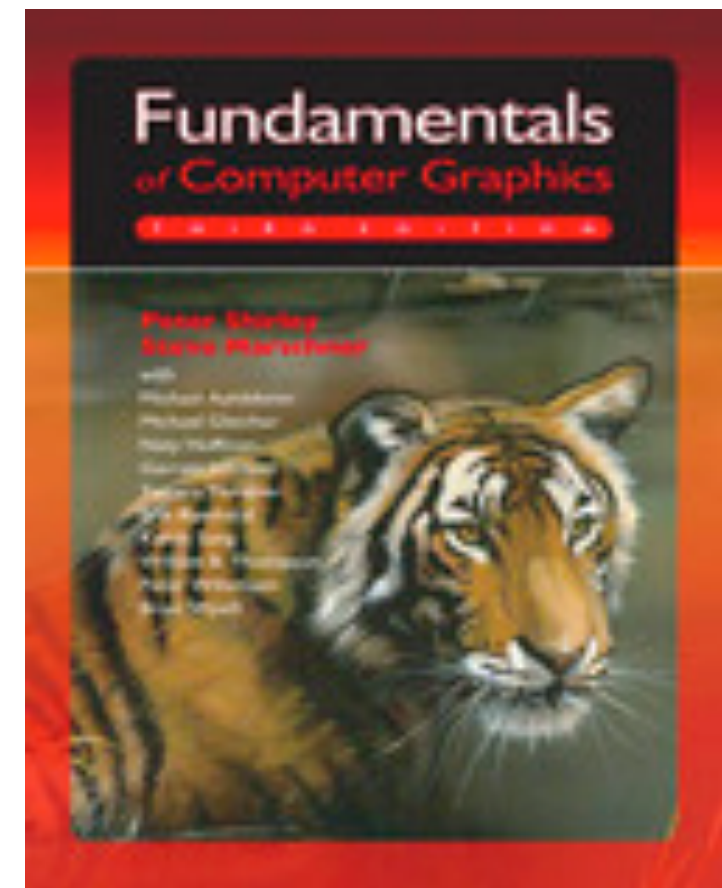
Web <http://www.cs.cornell.edu/Courses/cs4620>

Teaching Assistants (3 Ph.D., ≥ 2 ugrad, more coming)

- * Dan Schroeder
- * Eston Schweickart
- * Tim Langlois
- * Jeremy Feinstein
- * Nic Savva?
- * Debarghya Das?

Piazza

Please sign up!



In CS4620/5620

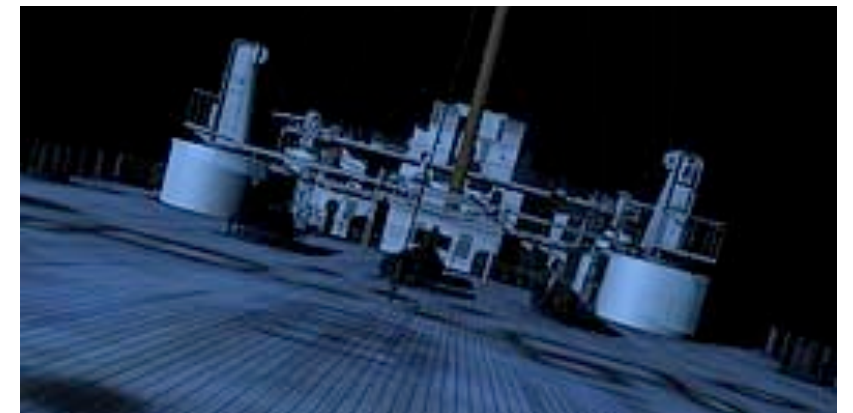
- You will:
 - explore fundamental ideas
 - learn math essential to graphics
 - implement key algorithms
 - write cool programs
 - learn the basics of OpenGL
- You will not:
 - write very big programs

Topics

- Images, image processing, color science
- Modeling in 2D and 3D
- Rendering 3D scenes
(using ray tracing and using the GPU)
- Geometric transformations
- The graphics pipeline
- Animation

Images

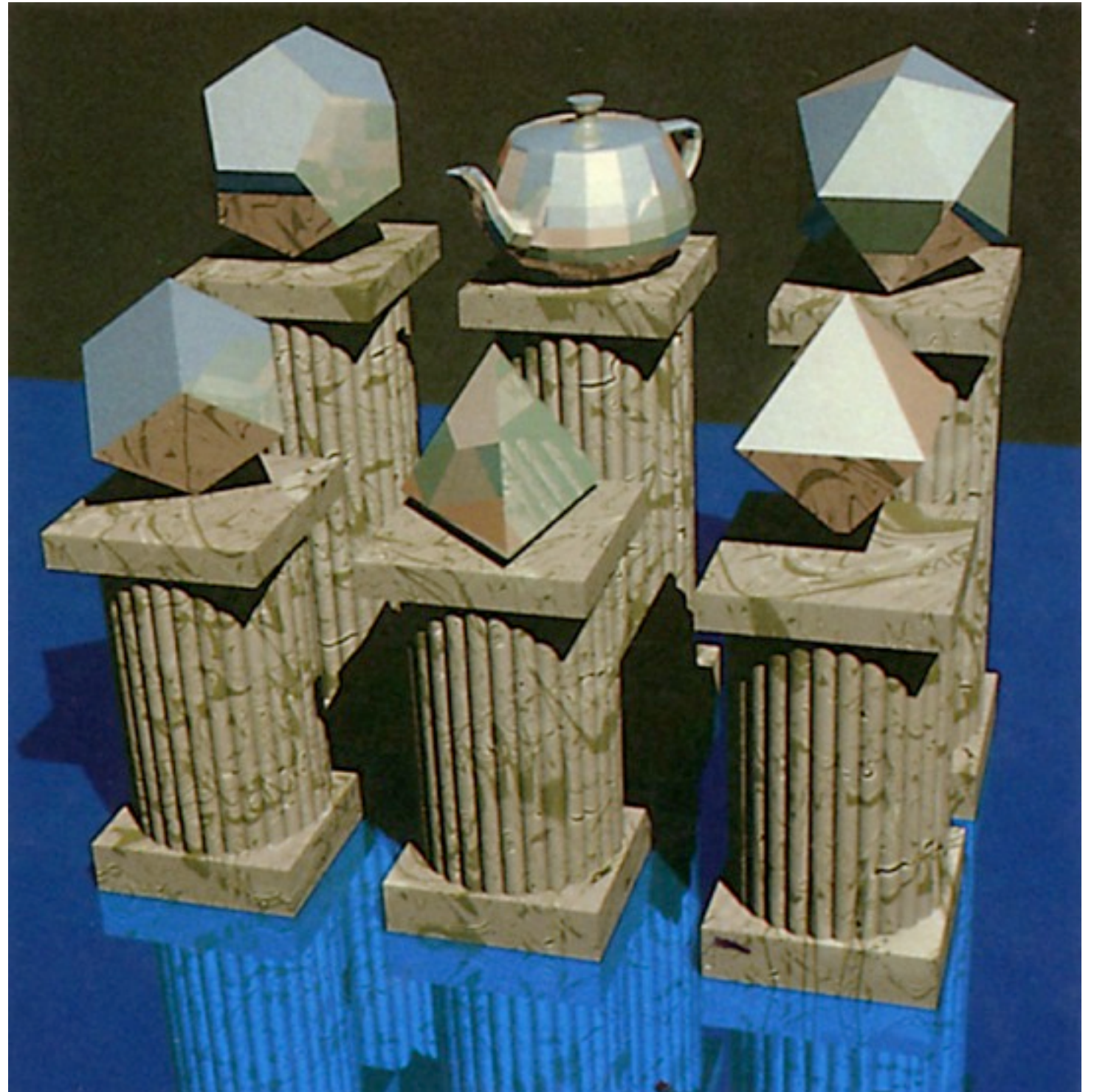
- What is an image?
- Compositing
- Resampling
- Color



[7]

Rendering

- ray tracing
- rasterization
- shading
- shadows
- texture mapping



[Glassner 89]

Geometric transformations

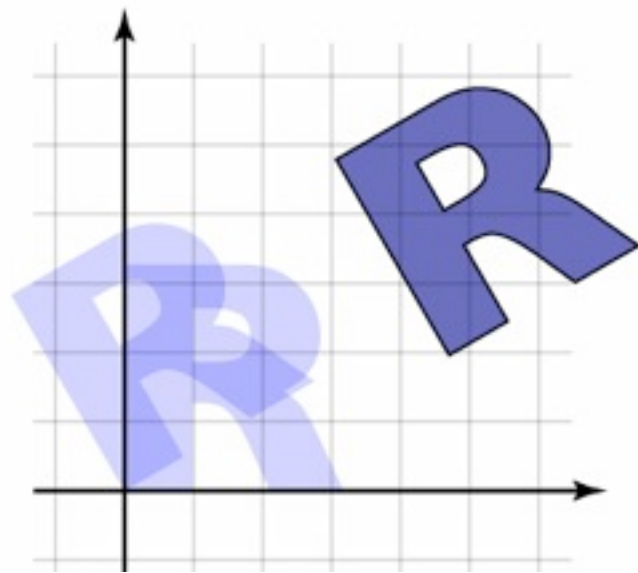
- affine transforms
- perspective transforms
- viewing

rotate, then translate

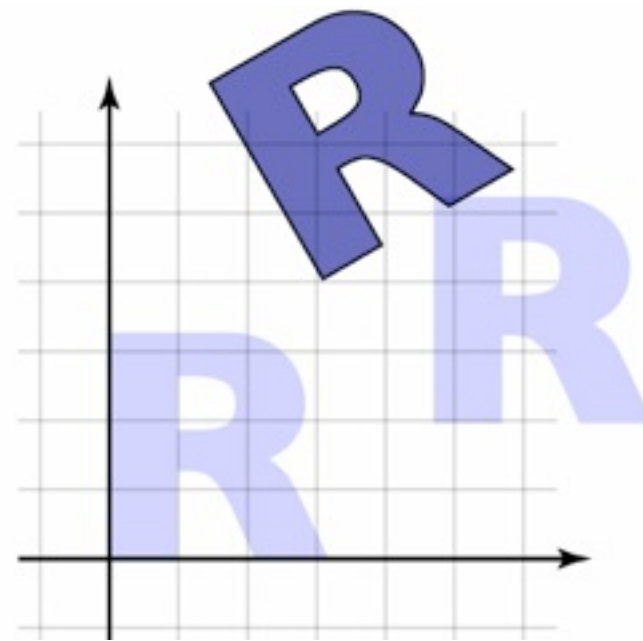
translate, then rotate

Geometric transformations

- affine transforms
- perspective transforms
- viewing



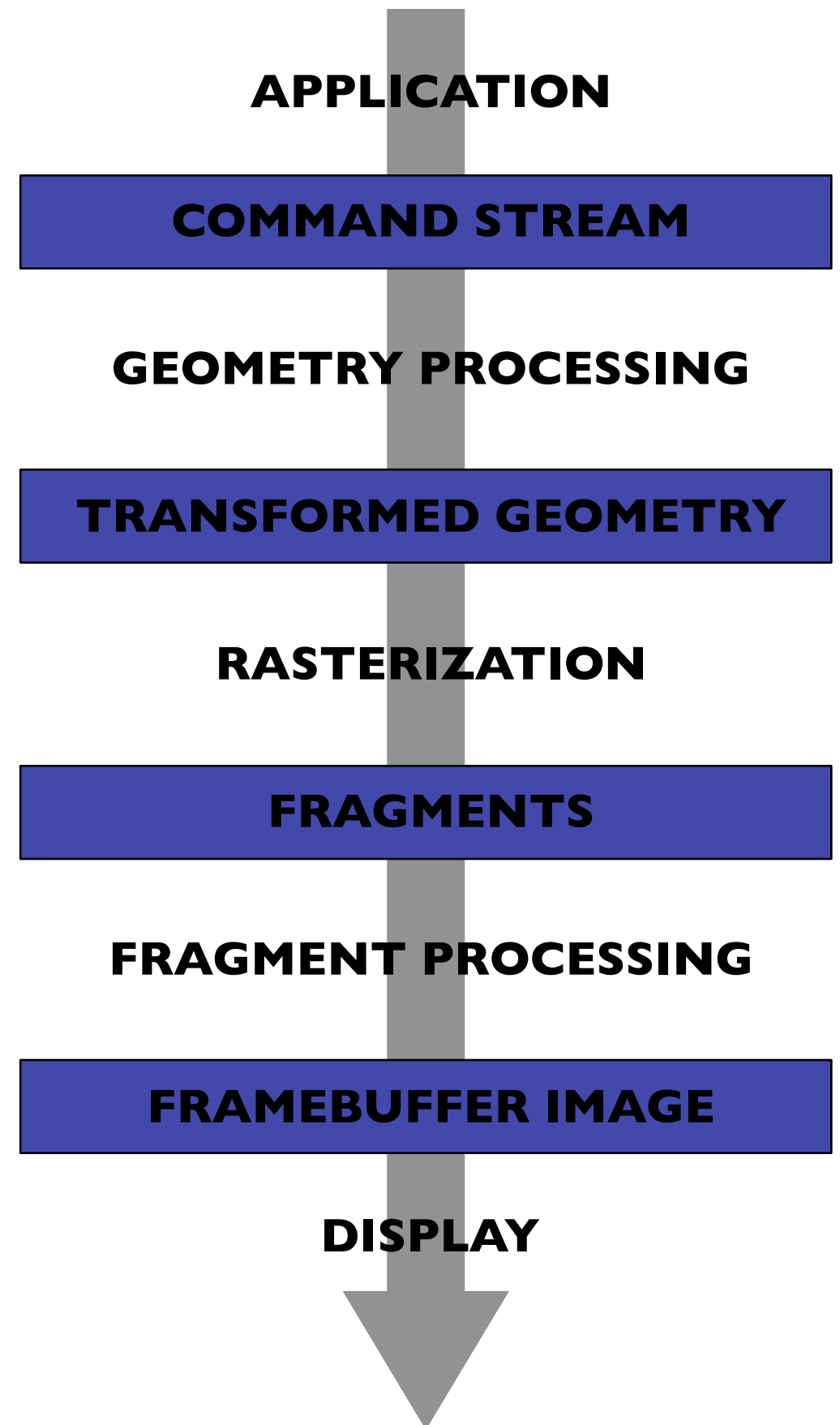
rotate, then translate



translate, then rotate

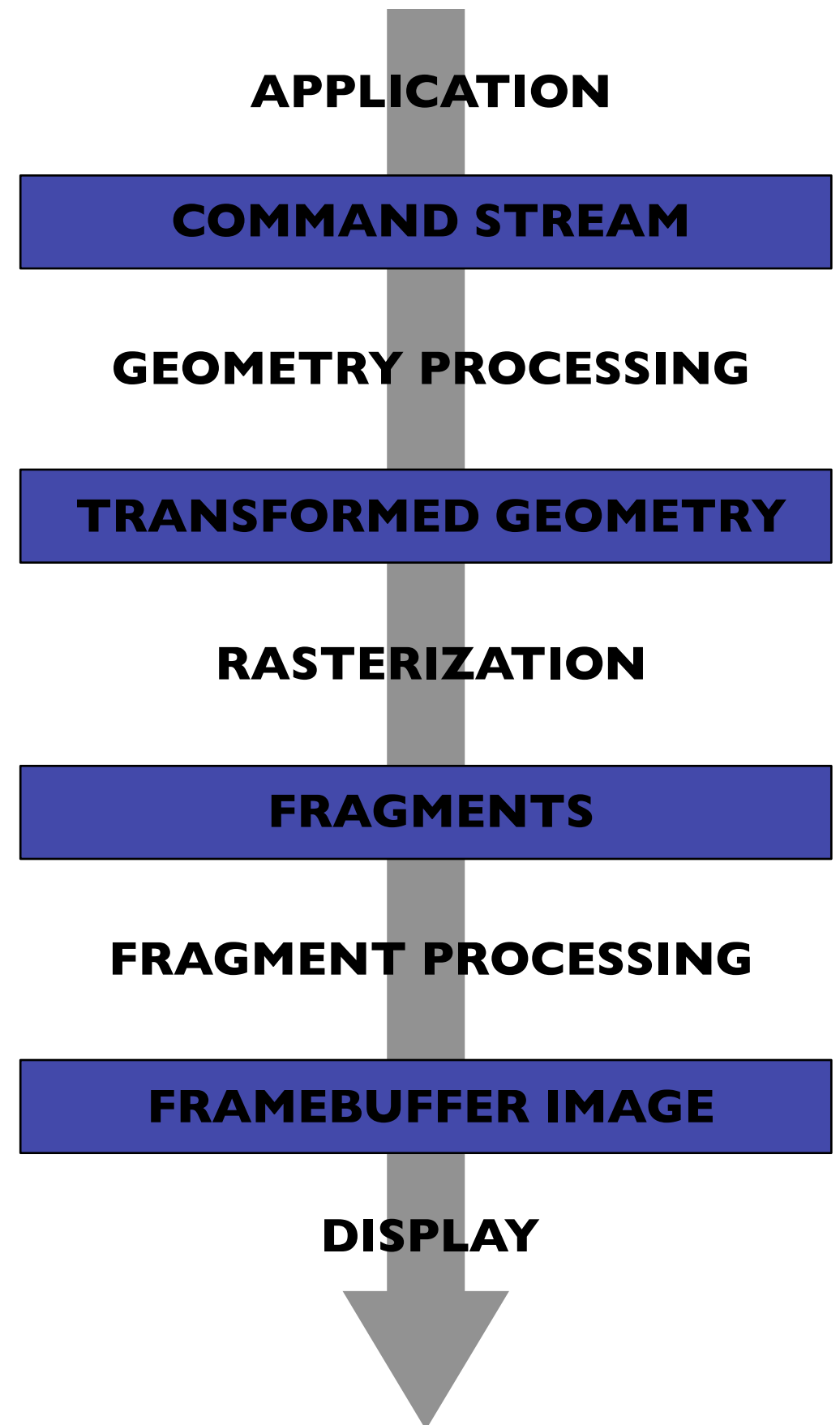
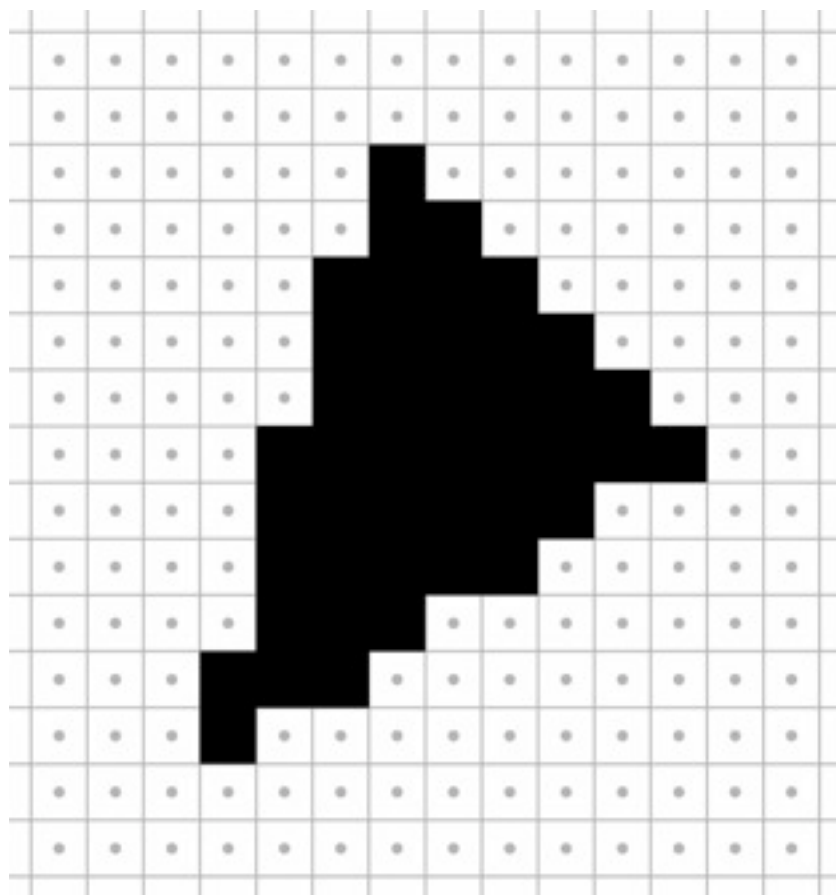
Graphics pipeline

- rasterization
- interpolation
- z-buffer
- vertex and fragment ops



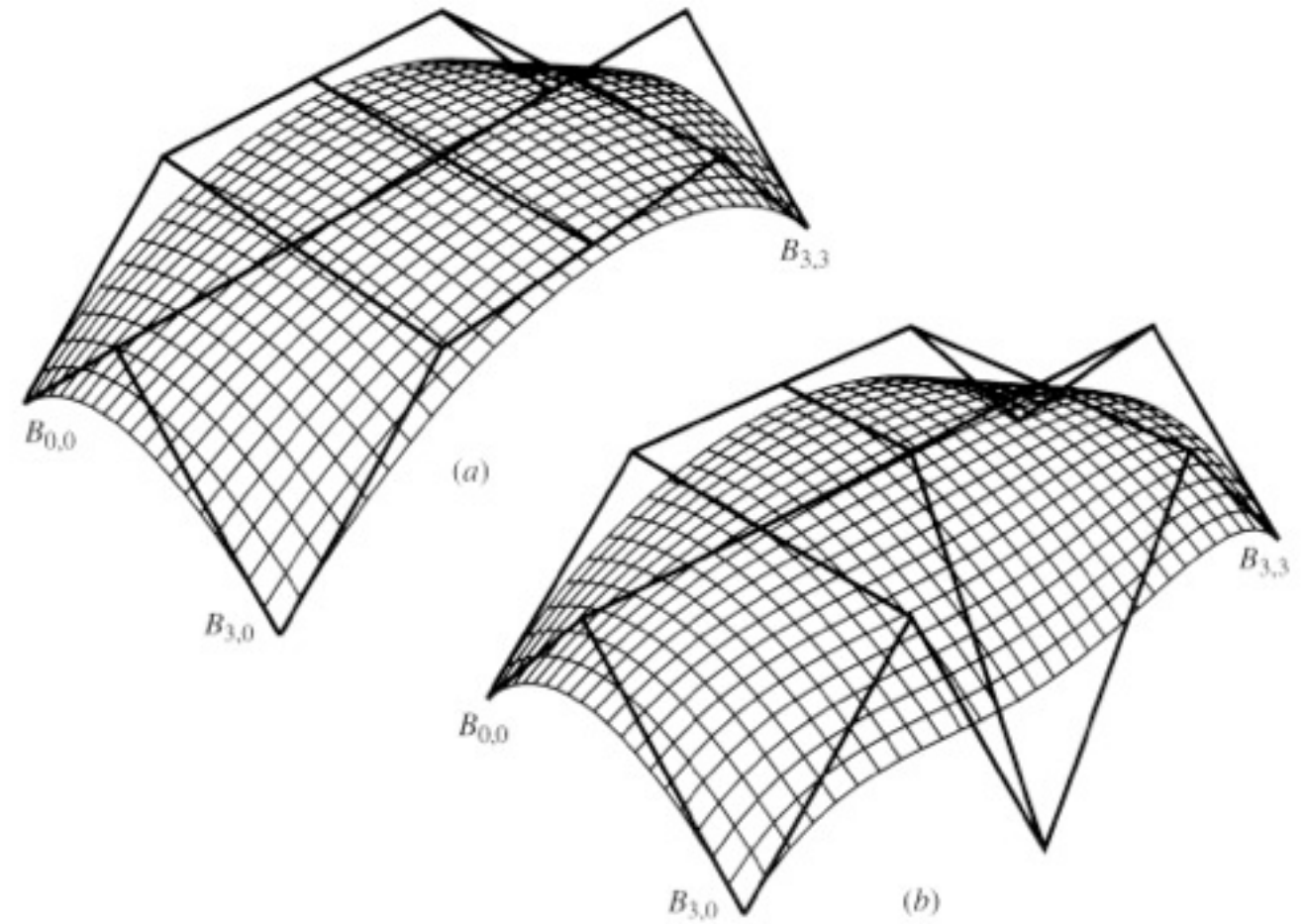
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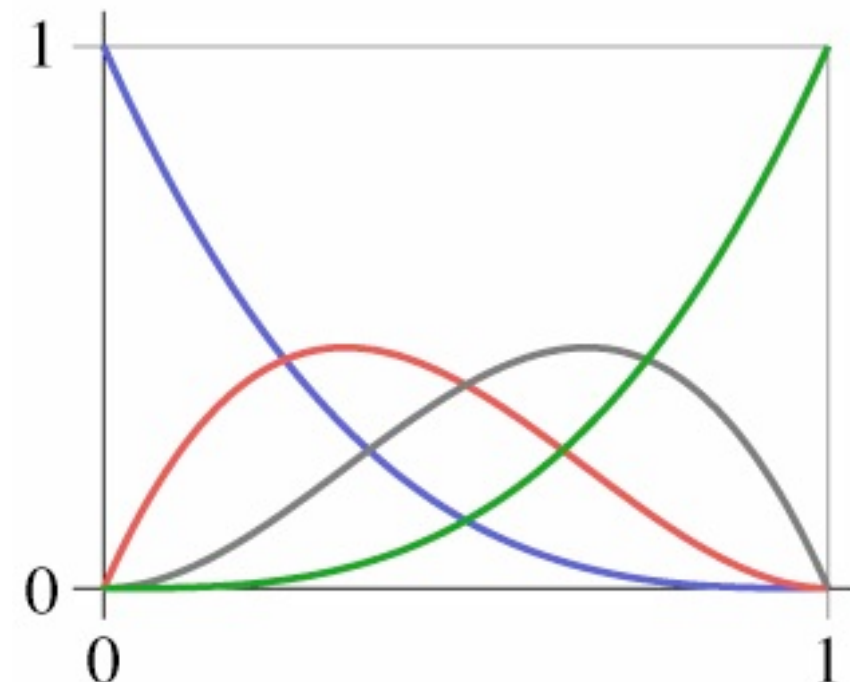
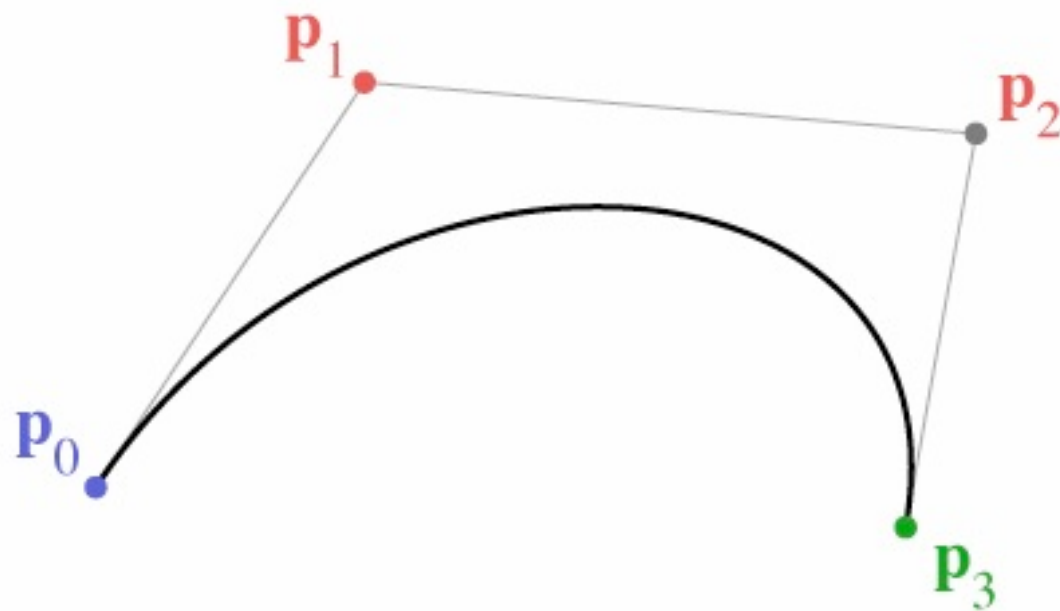


Modeling

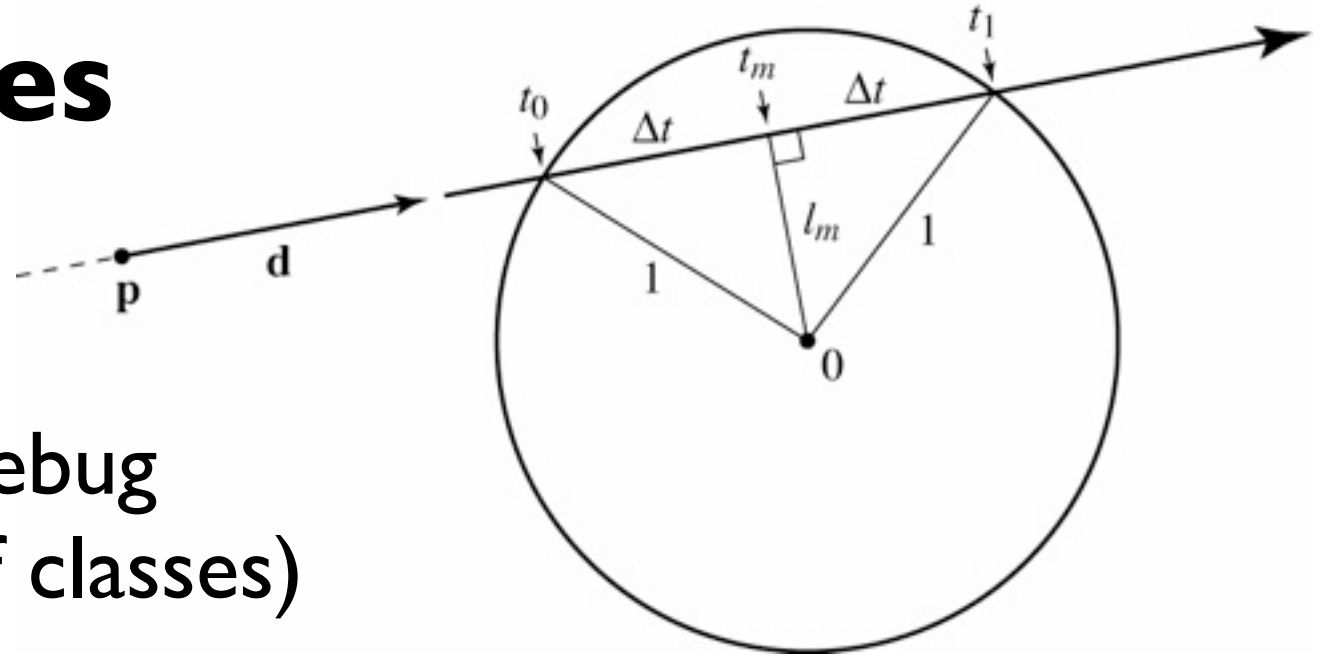
- splines
- parametric surfaces
- triangle meshes



[Rogers]



CS4620 Prerequisites



- Programming
 - ability to read, write, and debug small Java programs (10s of classes)
 - understanding of very basic data structures
 - no serious software design required
- Mathematics
 - vector geometry (dot/cross products, etc.)
 - linear algebra (just basic matrices in 2-4D)
 - basic calculus (simple derivatives)
 - graphics is a good place to pick up some, but not all, of this

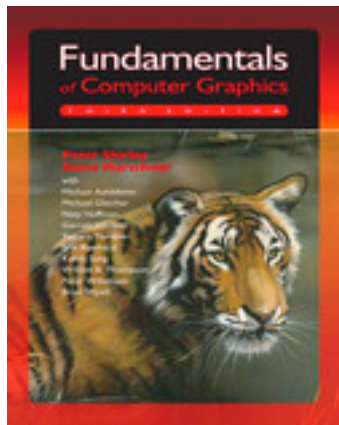
In CS462 I

- You will also:
 - implement a modeling, rendering, animation system
 - in groups
 - learn a lot about
 - architecting good-sized interactive programs
 - OpenGL
 - programmable shaders, textures, animation

Workload

- CS 4620/5620
 - 3 homeworks
 - 4 programming assignments
 - No penalty for 1 late homework, then 10% per day
- CS 4621/5621
 - 3-4 programming assignments

Textbook



Shirley & Marschner **Fundamentals of Computer Graphics** third edition

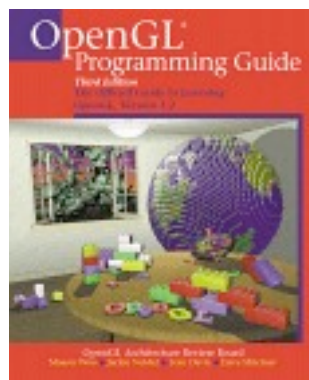
More books



Steven Gortler

Foundations of Computer Graphics

first edition

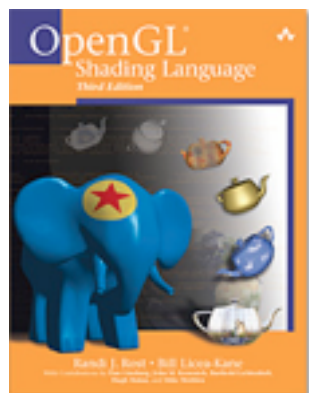


OpenGL Programming Guide

(a.k.a. the "Red Book")

Older version available online:

http://www.opengl.org/documentation/red_book/



GLSL Shading Language

(a.k.a. the "Orange Book")

Academic Integrity

Course mechanics

Web <http://www.cs.cornell.edu/Courses/cs4620>

Schedule, handouts, etc. all on the web page

Practicum

- Not this Friday
- Will send out mail when a practicum is planned