

1.4

The Assignments & Eye Candy

In These Slides

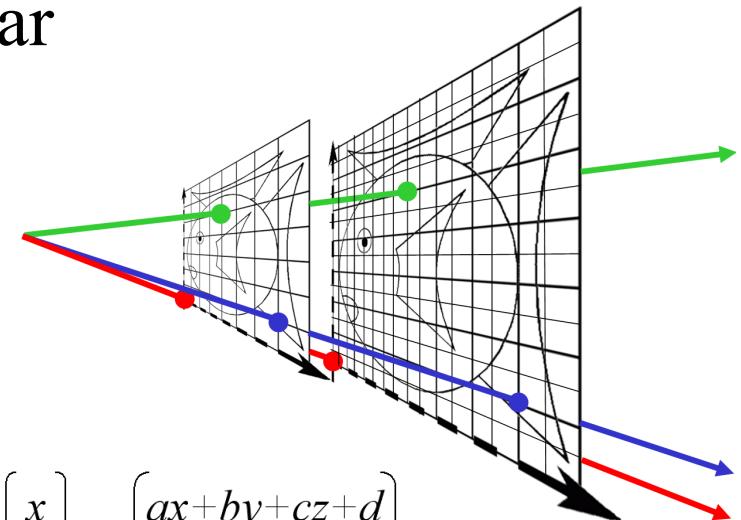
- A tour of the assignments

Overview of the Semester

- Modeling, Transformations (All Assignments)
- Animation (Assignments 3, 4)
- Ray Casting / Ray Tracing (Assignment 5)
- Lighting & Shading (Assignments 5, 6)
- Real-time Rendering (Assignment 6)

Coordinate Transformations

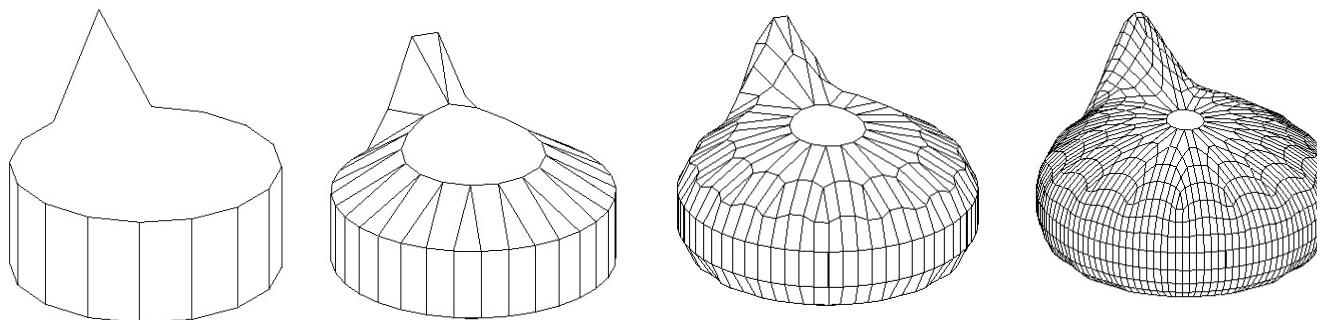
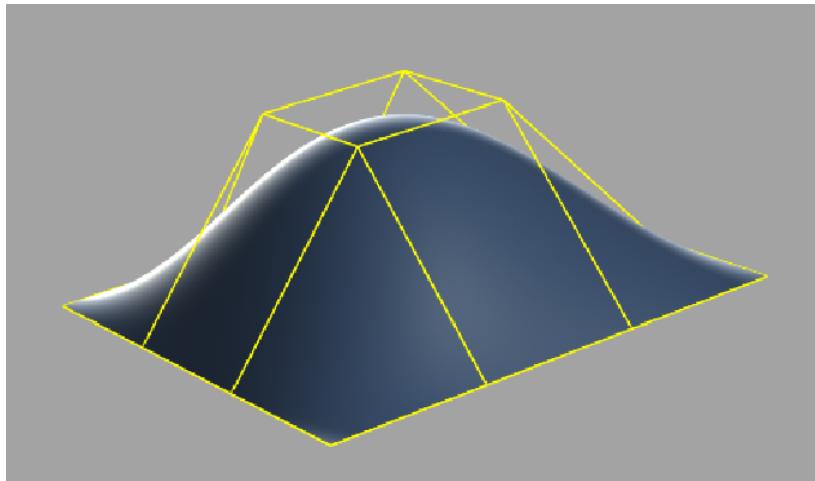
- Mostly linear algebra
- Homogeneous coordinates
 - Neat way of treating affine and perspective transforms as linear
- Perspective (for viewing)



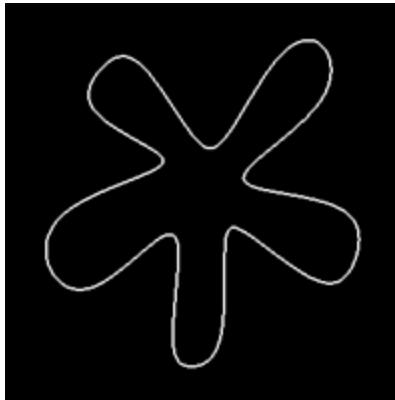
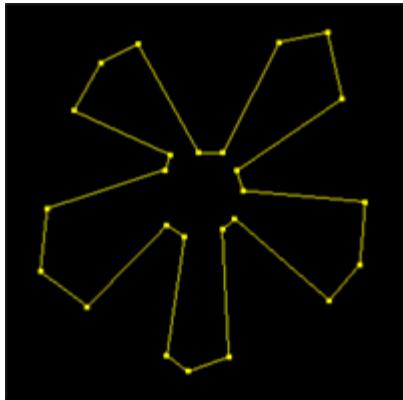
$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} a & b & c & d \\ e & f & g & h \\ i & j & k & l \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = \begin{bmatrix} ax+by+cz+d \\ ex+fy+gz+h \\ ix+jy+kz+l \\ 1 \end{bmatrix}$$

Modeling

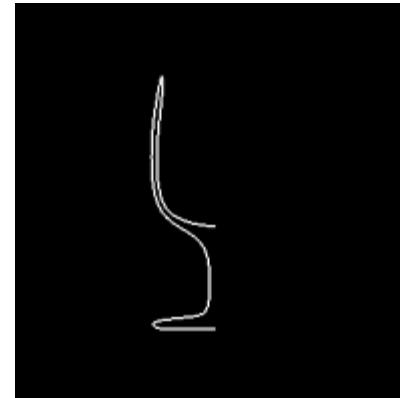
- 2D curves, triangle meshes, smooth surfaces (Bézier, splines), subdivision surfaces



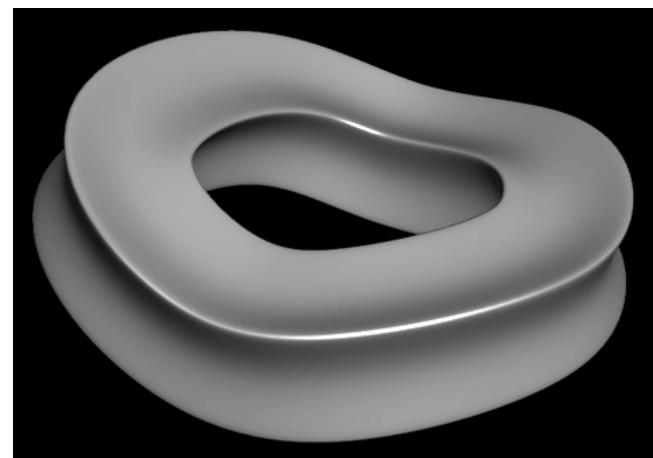
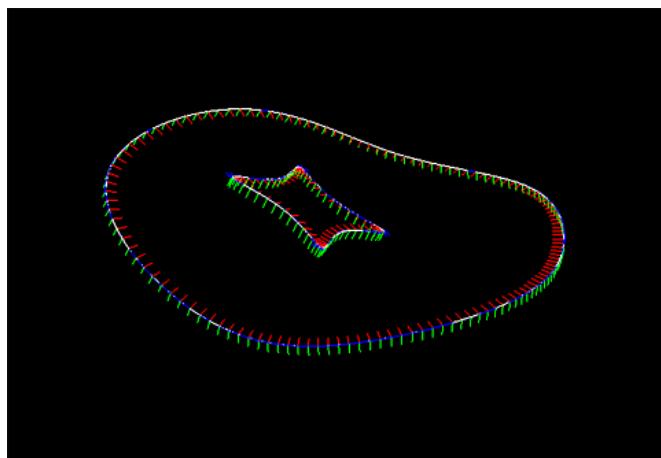
Assignment 2: Curves & Surfaces



Spline curves

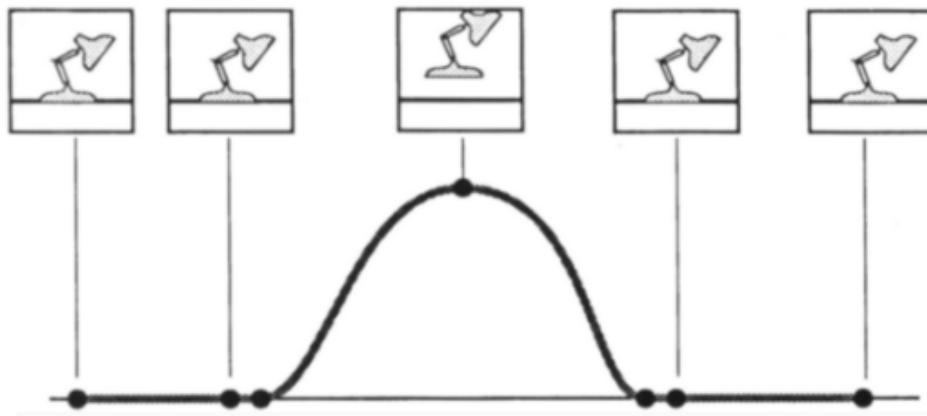


Surfaces of revolution



Sweep surfaces

Animation: Keyframing



ACM © 1987 "Principles of traditional animation applied to 3D computer animation"

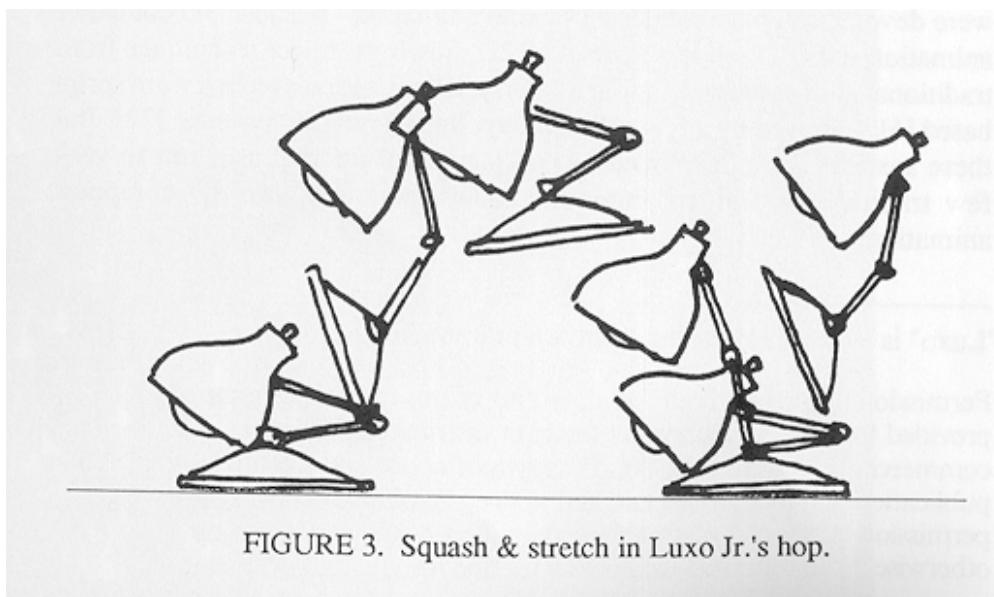
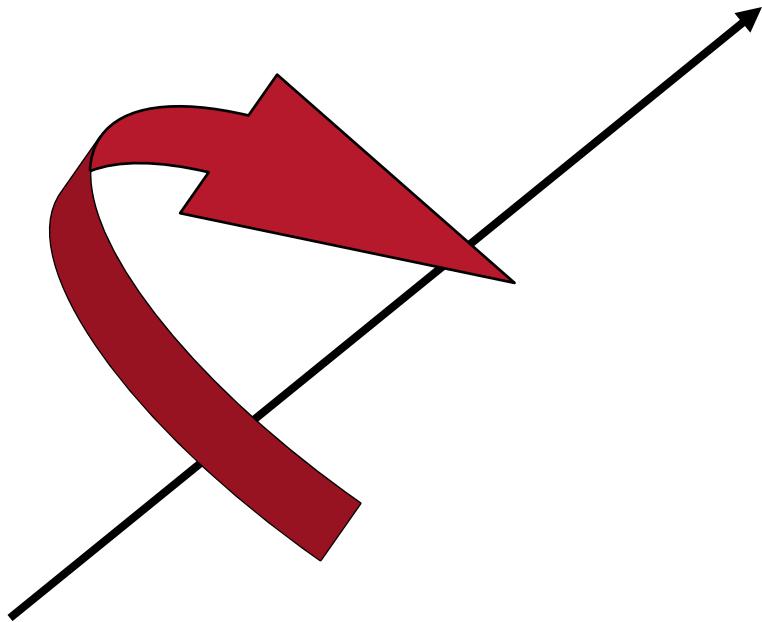
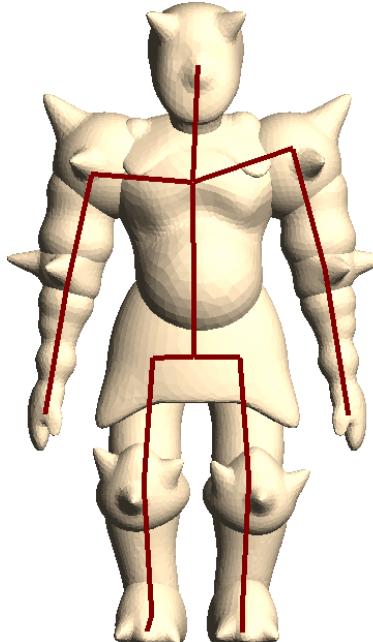


FIGURE 3. Squash & stretch in Luxo Jr.'s hop.



Character Animation: Skinning

- Animate simple “skeleton”
- Attach “skin” to skeleton
 - Skin deforms smoothly with skeleton
- Used everywhere (games, movies)



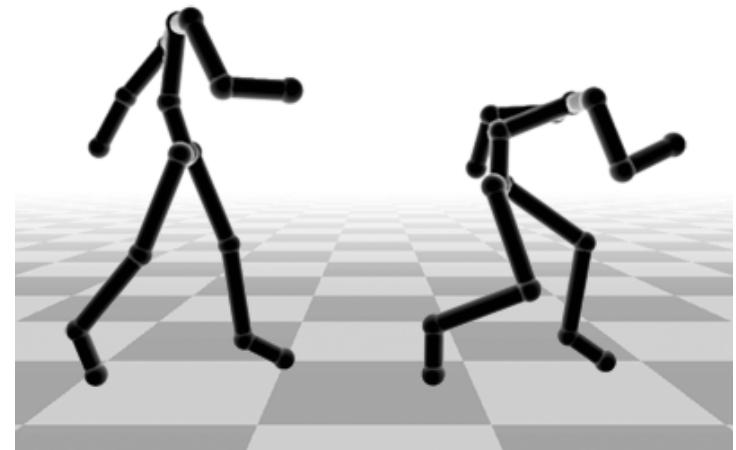
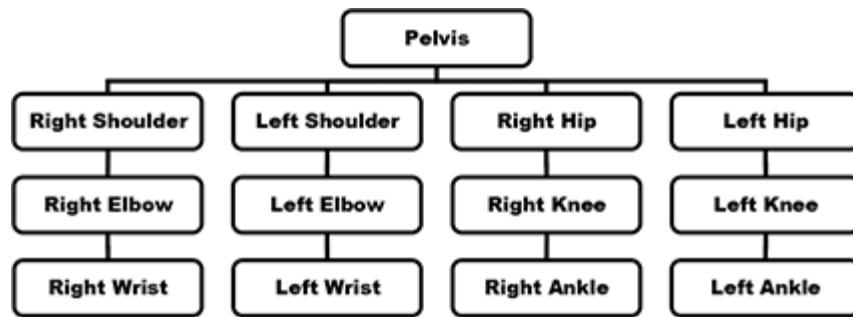
Ilya Baran



Epic Games

Assn. 3: Hierarchical Modeling + Skinning

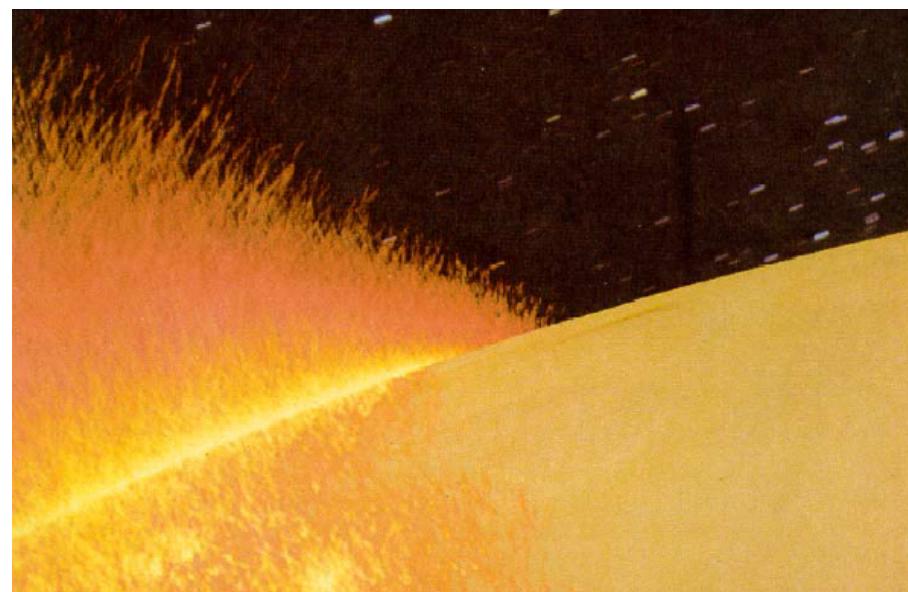
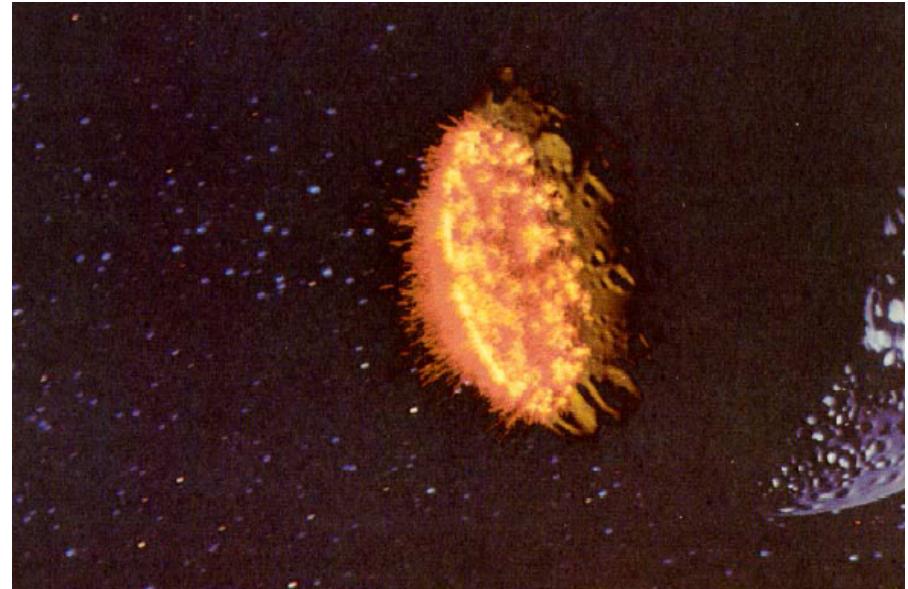
- Animate character skeleton as tree of transformations



- “Skinning”: smooth surface deformation based on animated skeleton

Particle systems (ODEs)

Star Trek 2

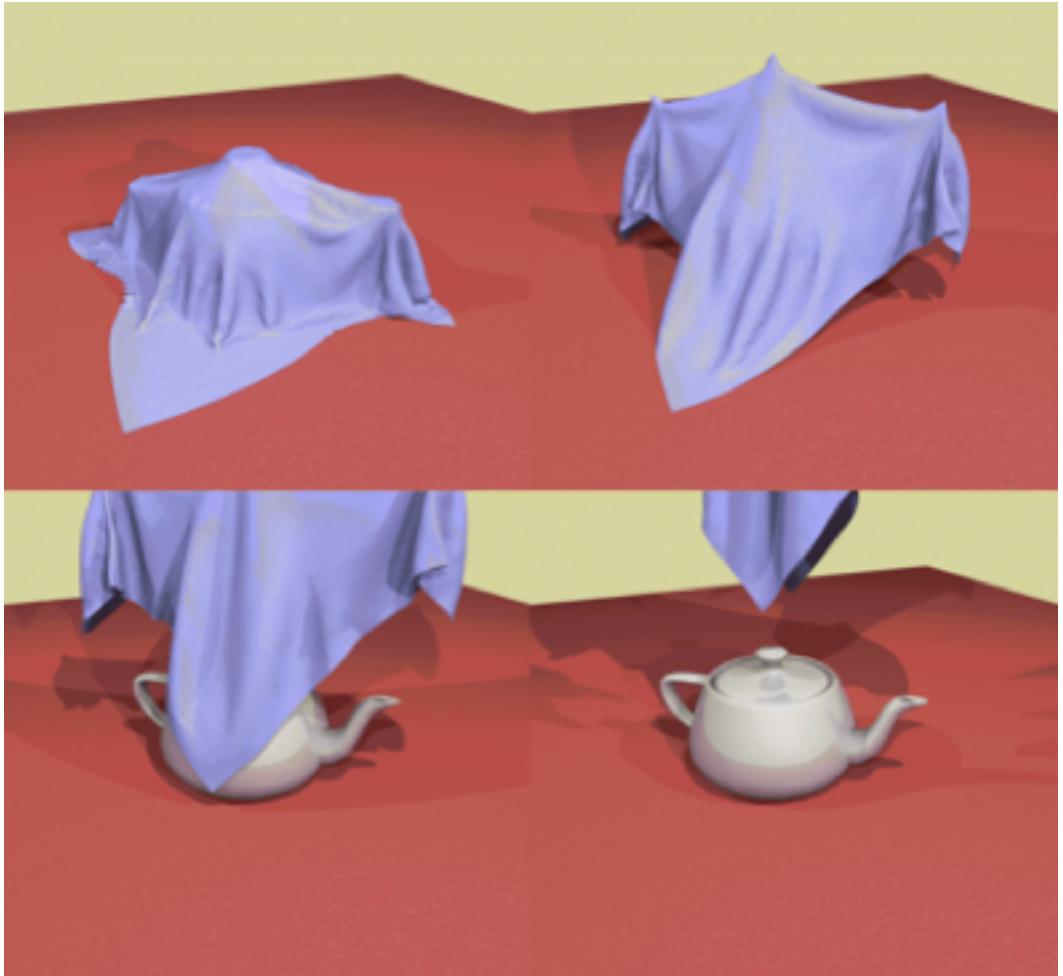




Ron Fedkiw & colleagues

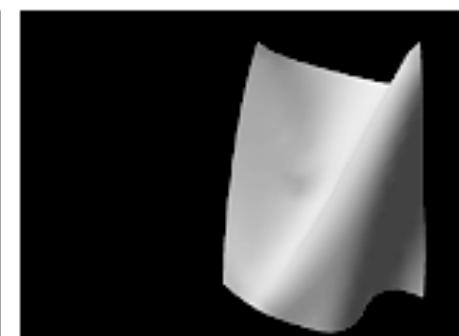
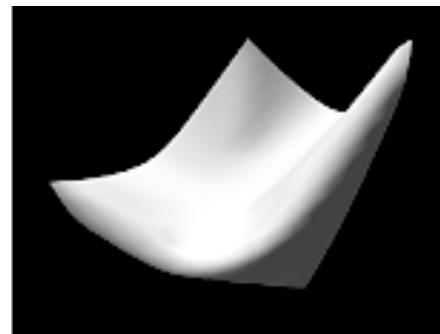
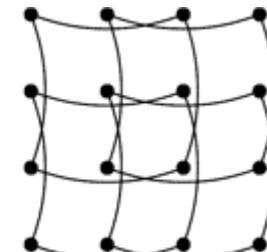
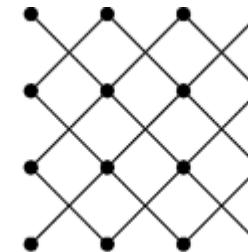
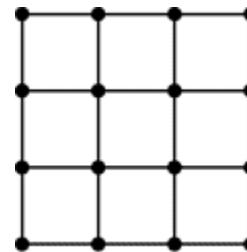
“Physics” (ODEs)

- Fire, smoke
 - Cloth
-
- Quotes because we do “visual simulation”



Assignment 4: Physics

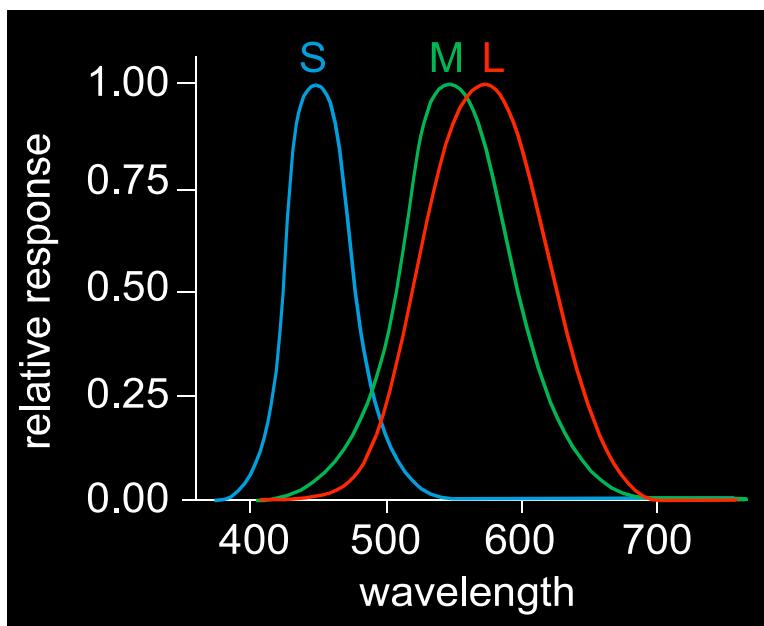
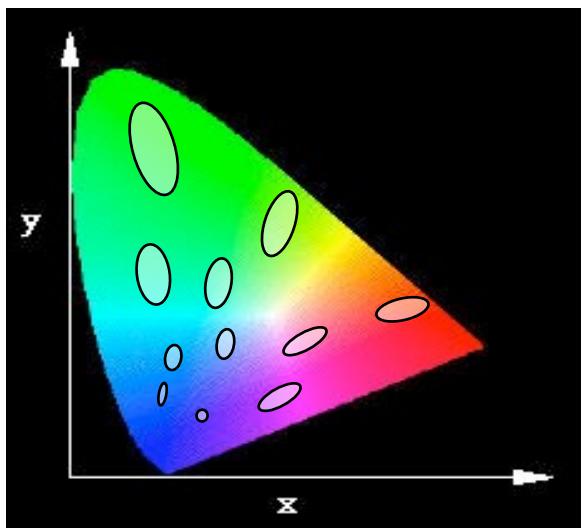
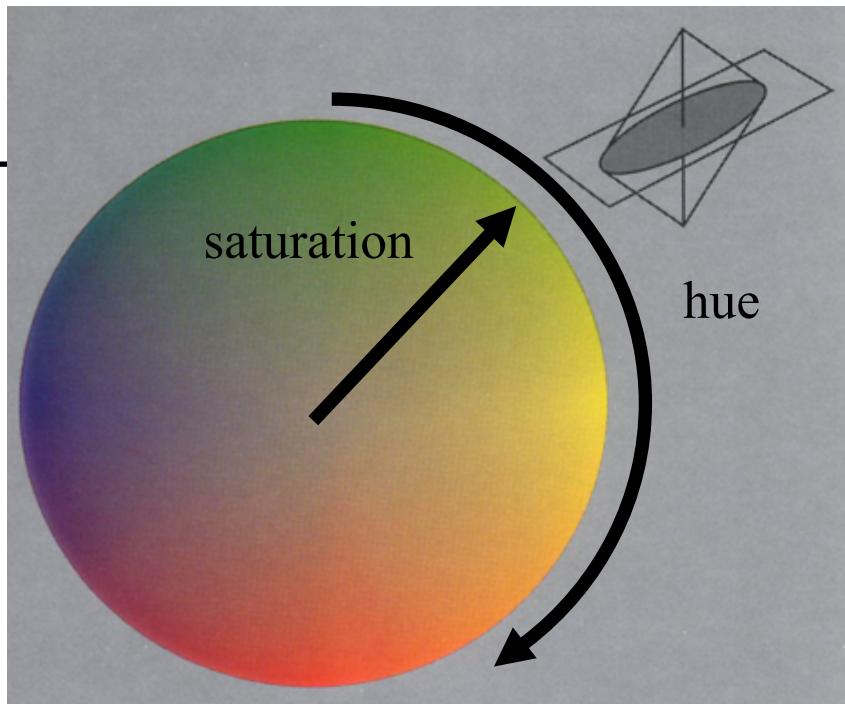
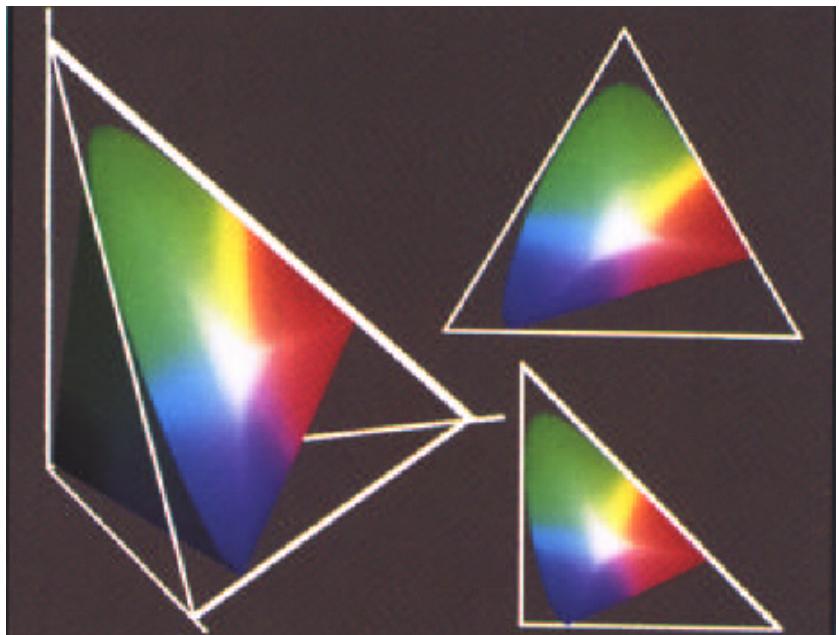
- Simulate cloth as a mass-spring network
 - ODE numerics



Eye candy: Real-time water

- Chentanez et al., Real-Time Eulerian Water Simulation Using a Restricted Tall Cell Grid, proc. SIGGRAPH 2011
- Why don't you try fluid simulation for extra credit in assignment 4? :)

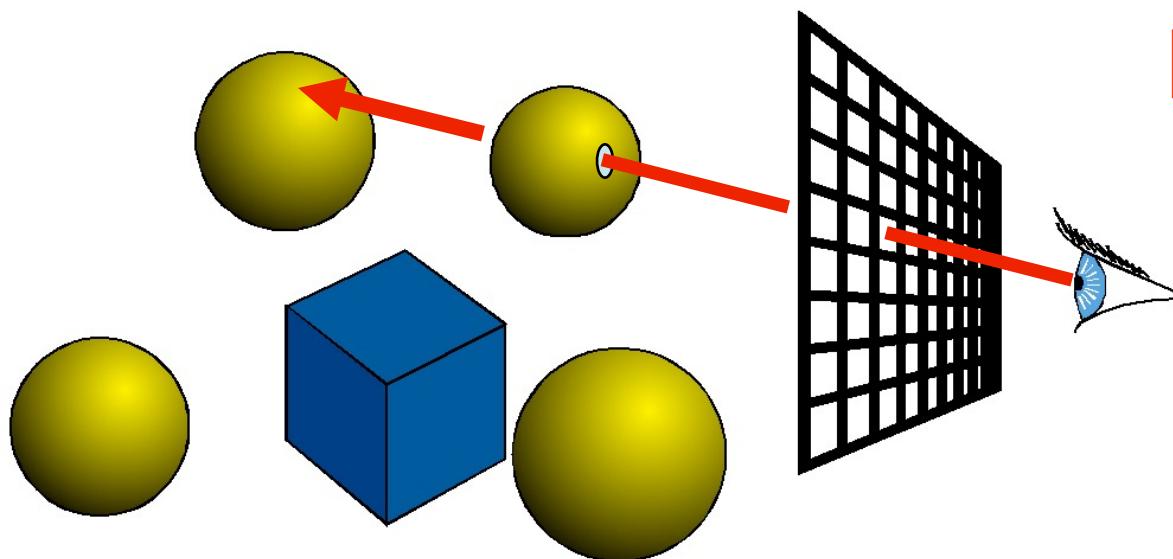
Color



Rendering: Ray Casting

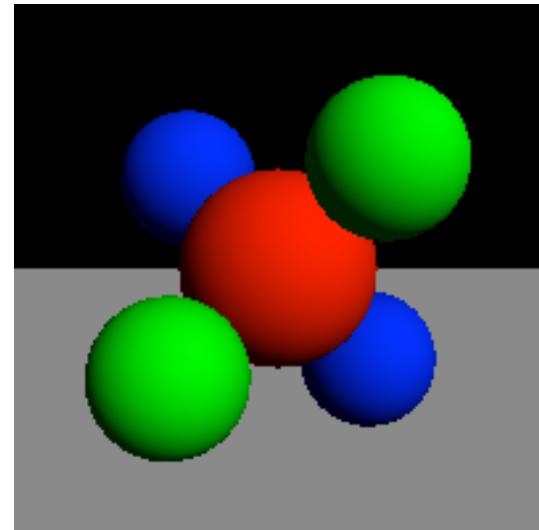
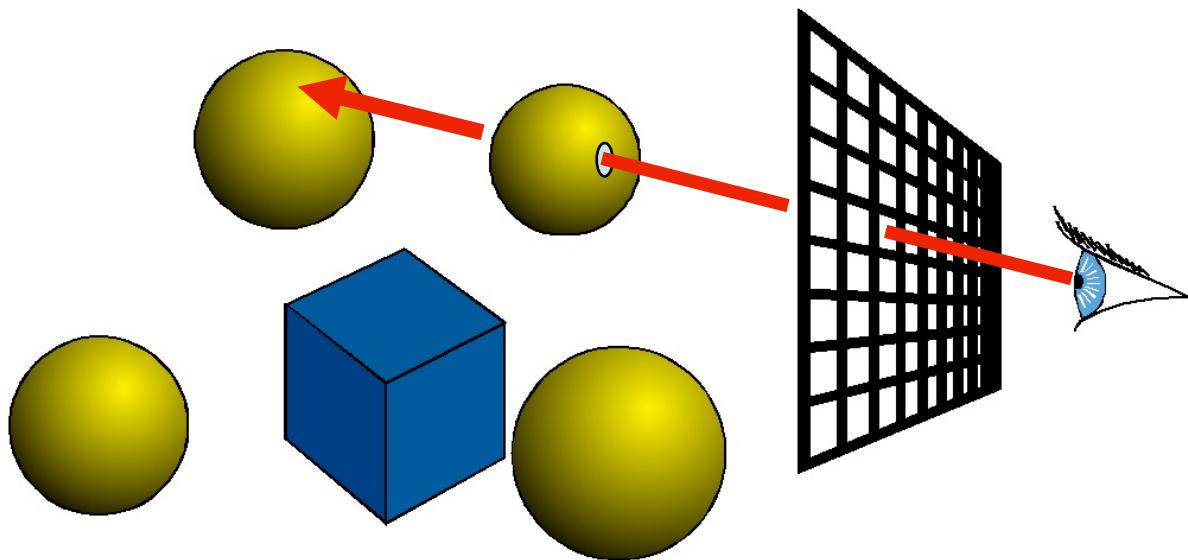
- For every pixel
construct a ray from the eye
 - For every object in the scene
 - Find intersection with the ray
 - Keep if closest

Visibility or
“hidden
surface”
problem



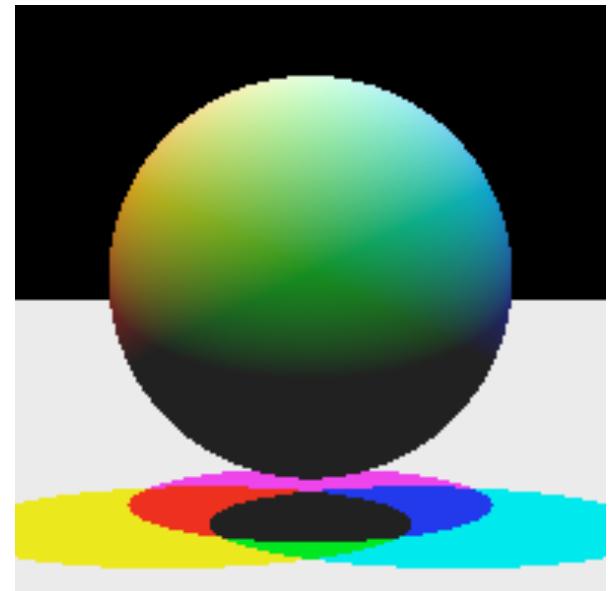
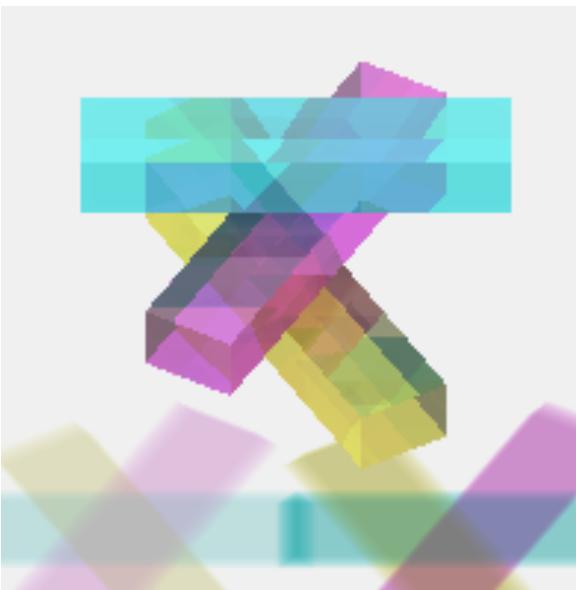
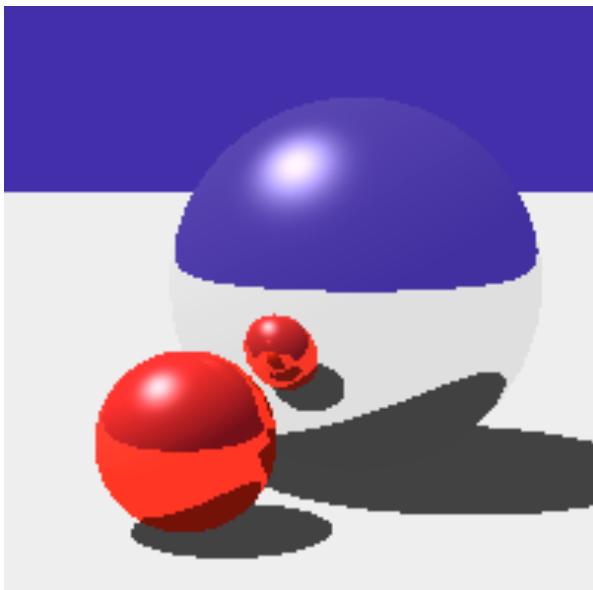
Assignment 5: Ray Tracing

- Cast rays from the viewpoint
- Intersect with scene primitives
- Compute simple shading



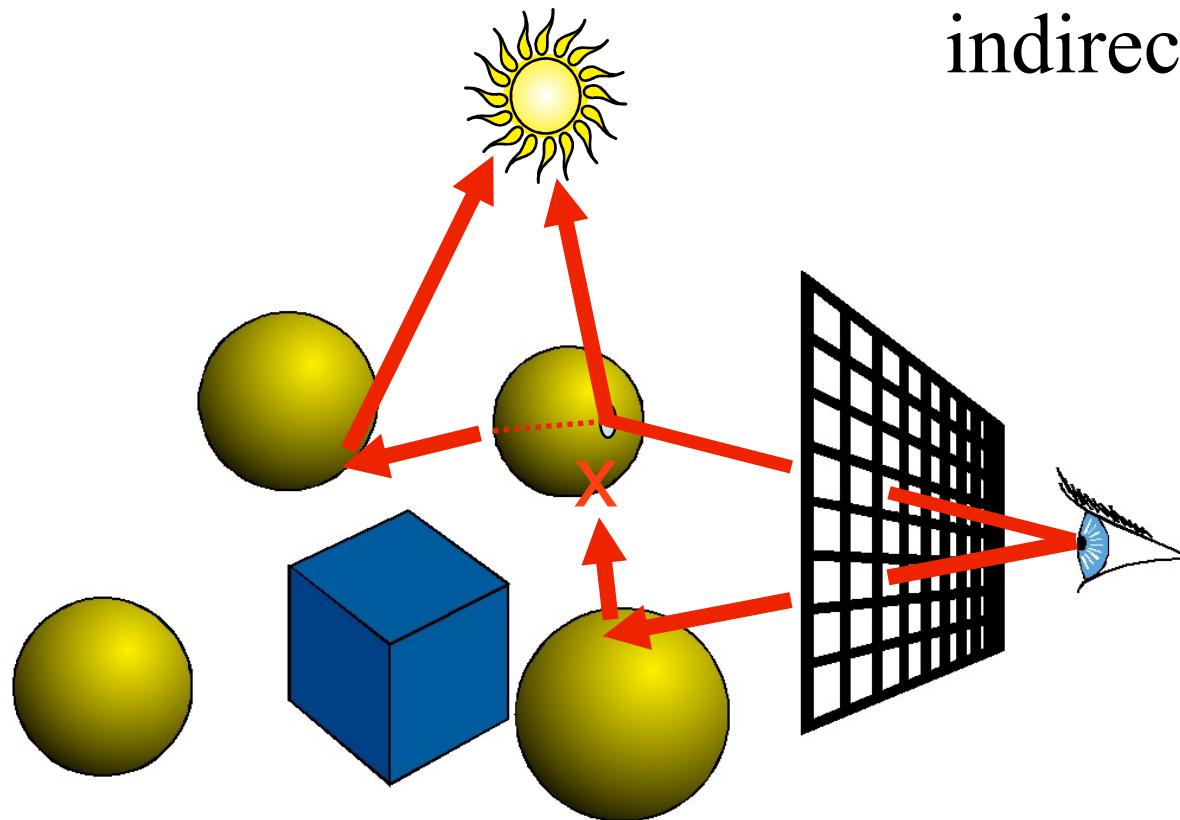
Assignment 5: Ray Tracing

- Shadows, reflection, refraction
- ..and extensions!
- Antialiasing
- Jittered Sampling



Rendering: Ray Tracing

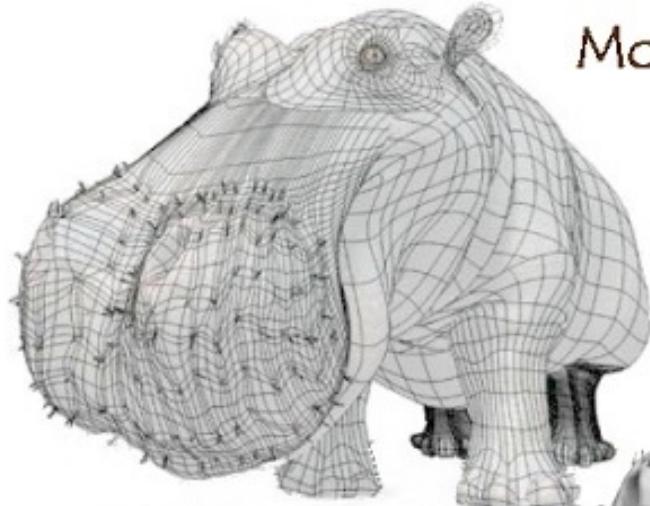
- **Shading:** Interaction of light and material
- Secondary rays (shadows, reflection, refraction, indirect lighting)



This is real-time now (!)



Textures and Shading



Model



Model + Shading



Model + Shading
+ Textures

At what point
do things start
looking real?



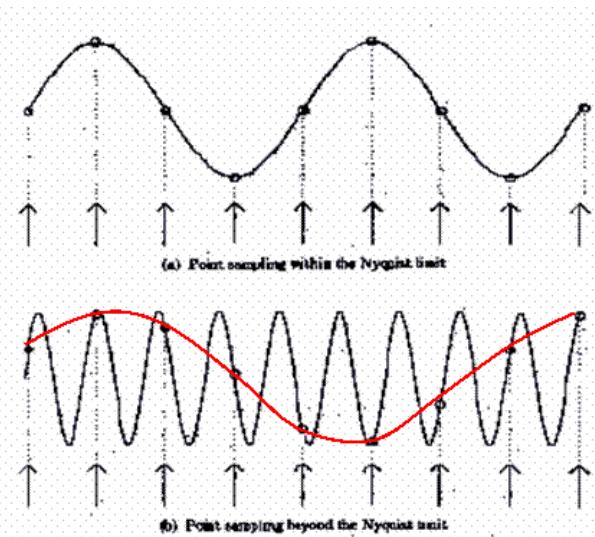
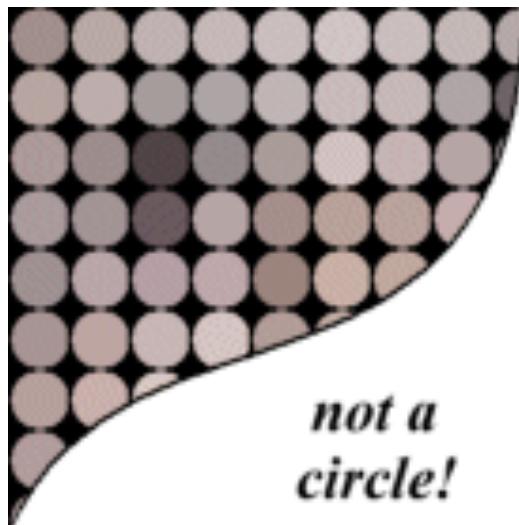
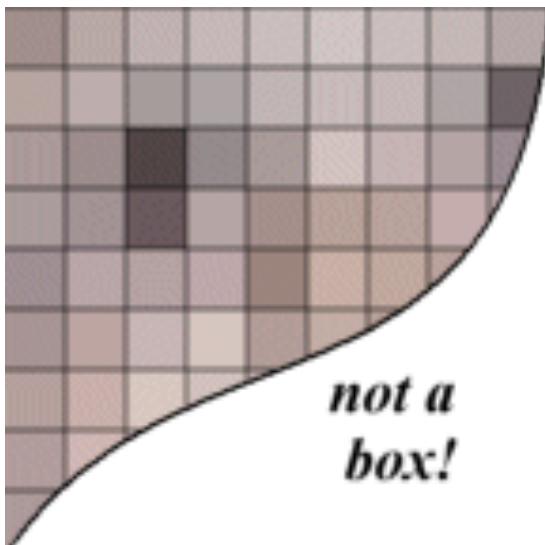
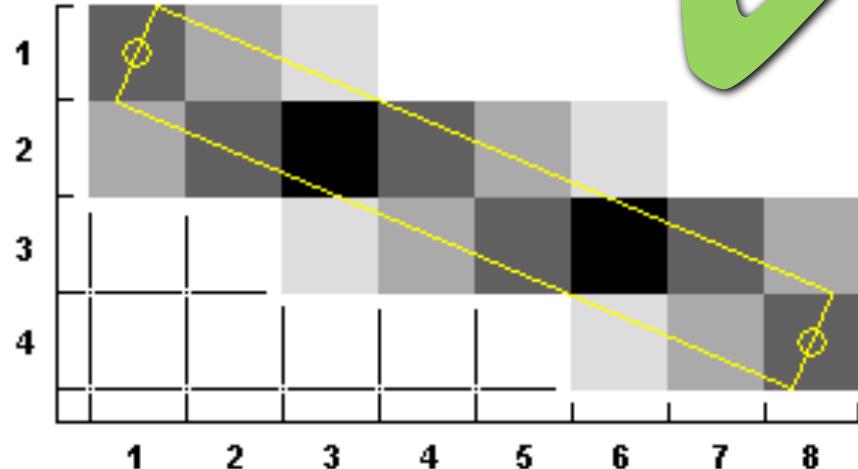
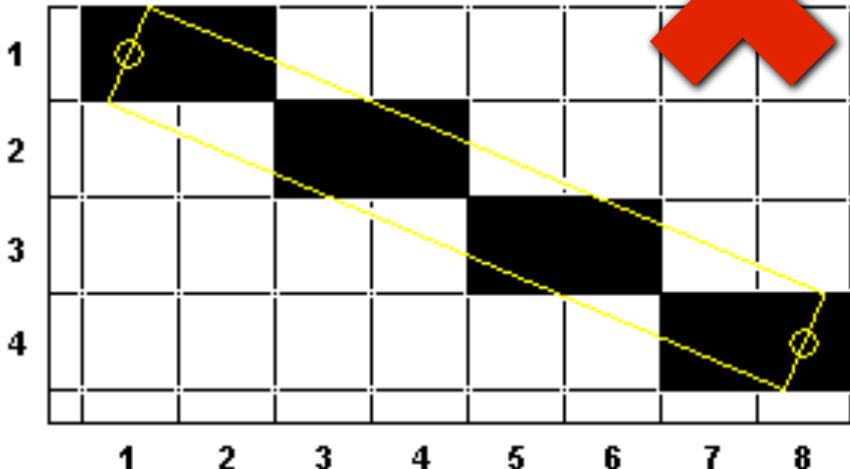
For more info on the computer artwork of Jeremy Birn
see <http://www.3drender.com/jbirn/productions.html>

Yes, it Works



winzenrender

Sampling & Antialiasing



Shadows



Figure 12. Frame from *Luxo Jr.*

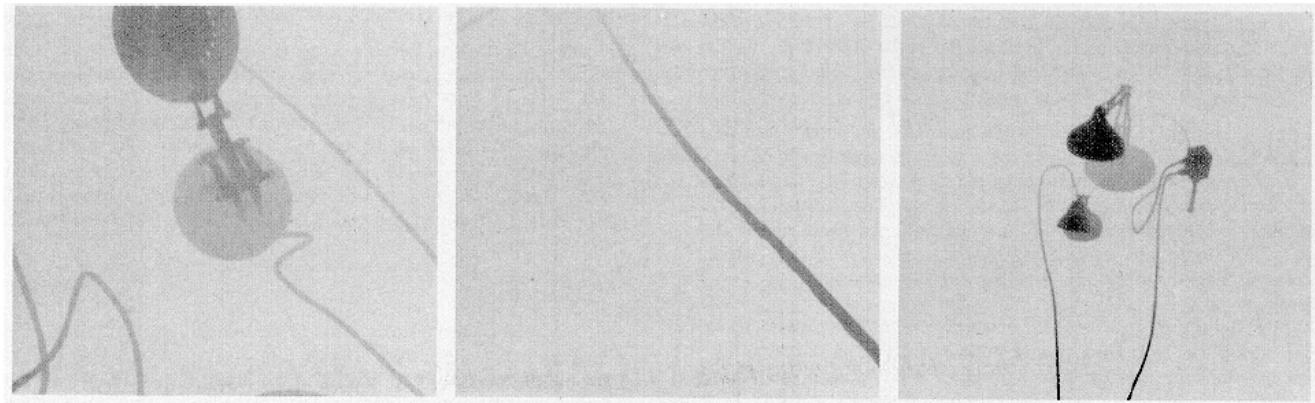


Figure 13. Shadow maps from *Luxo Jr.*

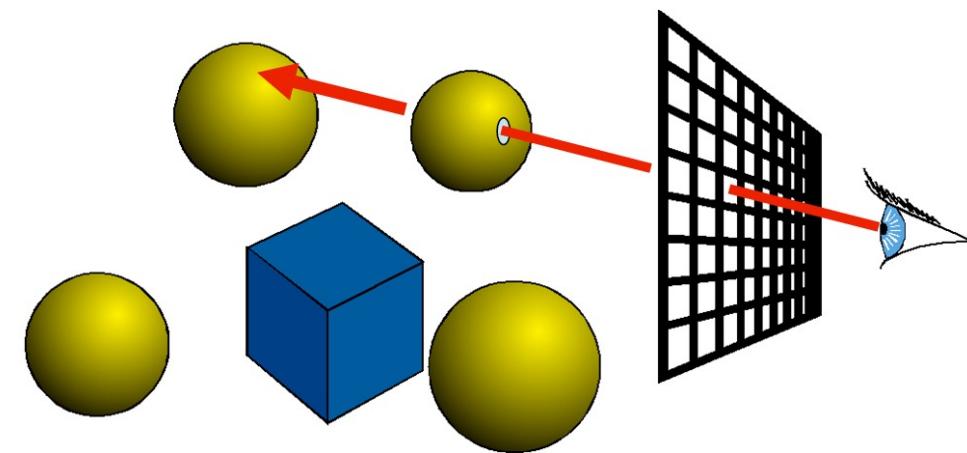
The Graphics Pipeline

Ray Casting

For each pixel

For each object

Does object hit pixel?

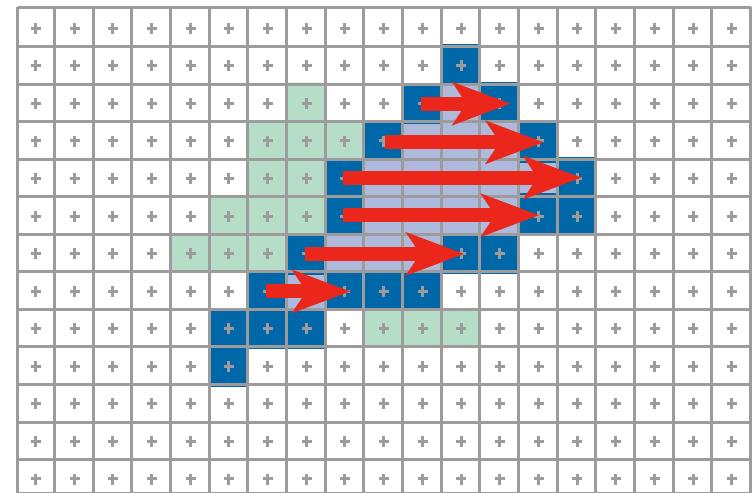


GPU

For each triangle

For each pixel

Does pixel hit triangle?



The Graphics Pipeline

Ray Casting

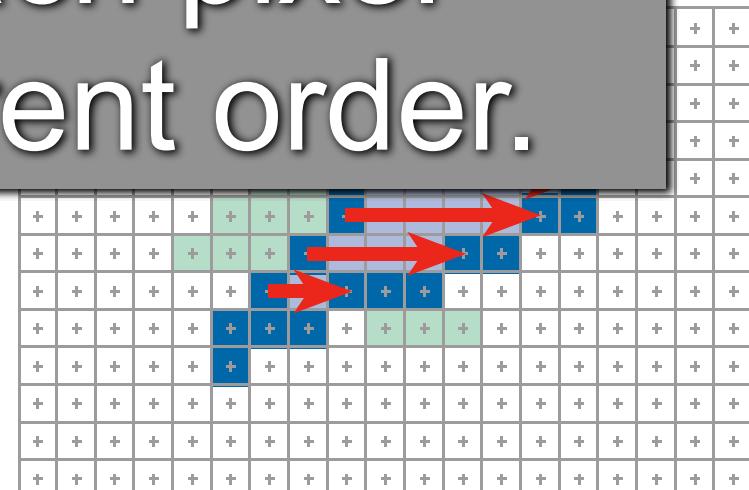
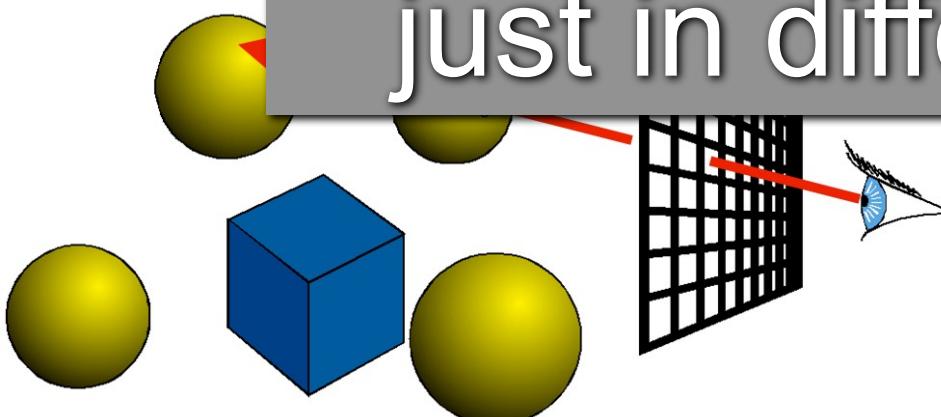
For each pixel:

For each ray:

Send ray

GPU

Both are ways of determining what is visible in each pixel – just in different order.



Assignment 6: Real-time Rendering



Jorge Jimenez

Phew! That's a lot of stuff!

- BUT: Mastering all this takes you a long way towards cool applications!



Little Big Planet

What Makes Graphics Fun?

- You can look at it from several angles
 - Anything that looks good will do in many applications...
 - Means you can really be creative once you know the basics.
 - ...but doing stuff “right” can be really involved.
 - Feels pretty nice when all that math and CS gives you a pretty picture or animation!
 - There is a continuum in between