3D Graphics Used In…

**Film, Television, Print**
- Either pure CG (e.g., Pixar) or CG elements added to film plates
- hours / frame

**Video Games**
- Both “in-engine” graphics + pre-rendered cinematics
- 30 frames / second

...although that line is often blurred

Aside: Scenes from a Movie winner

3D Graphics: How it's done (simplified)

- Modeling
- Animation
- Lighting & Shading
- Rendering

“Shutterbug Rendering Progression” by Pixar
“Squash & Stretch” by Illdeworm.com
“Procedural Wood” by Pixar
“Shutterbug Rendering Progression” by Pixar
Modeling
- Could come from
  - 3D Scanners
  - Interactive modeling
  - Model libraries
  - Procedural techniques
- This also involves
  - Attaching animation variables to model, allowing animator to control a very complex model w/a few controls
  - Representation: Lots of options, math

Animation
- Could come from
  - Interactive keyframing
  - Procedural motion
  - Motion capture
    - This has put some animators out of a job
    - Used in Avatar, LoR...
    - Physics
    - Evolution, Rule systems
- Emotions conveyed!
  - Humans are very good at reading bad motion

Creature War … Animation automatic!
- Brian Mirtich, 1996 UCB Ph.D.
  - Thesis: "Impulse-based Dynamic Simulation of Rigid Body Systems"
  - Very cool work!
- "Creature War" demo
  - His purpose: show off his simulator
  - Great example of rule-drive motion!

Genetic Algorithms
- Karl Sims blew away his colleagues with his 1994 seminal work on evolved creatures
  - His purpose: show off his simulator
  - Great example of rule-drive motion!

Lighting and Shading (and Camera...)
- Just like in a movie...
  - Artist sets up lights in the shot for mood
  - Teams of artists apply hand-drawn and procedural textures, called "shaders"
    - There are layers of them
    - The virtual 3D camera (and its movement) set
  - But "render!" instead of "action!"...

3D Projection Basics (in Rendering)
- For each frame...
  - Take 3D geometry (and lights and surface shaders) and figure out what color each 2D pixel should be
  - The math is simply similar triangles
- There are lots of algorithms to do this
  - "Expensive" = slower, but quality usu higher

www.youtube.com/watch?v=FO0ynElFm44
www.cyberware.com

kuffner.org/james/software/dynamics/mirtich/

www.genarts.com/karl/

hof.povray.org/2b.html

http://en.wikipedia.org/wiki/3D_projection
What's our goal?
- Find rendering algorithms that simulate what real light does in real world
- "Photo-realism"

Limitations
- There are way too many photons to simulate all of them at once!
- Every technique is a different way to simulate the real world
- Each has costs & benefits

Direct vs Global Illumination

Rendering: Global Illumination

- "The Lovers" by Gilles Ten: (POV-Ray)

Cornell Box

"The Cornell Box experiments have come to symbolize our approach to physically based rendering. The Cornell box is a simple physical environment for which we have measured the lighting, geometry, and material reflectance properties. Synthetic images of this environment are then created, and compared to images captured with a calibrated CCD camera. In this way, we can confirm the accuracy of our simulations."

Direct Illumination Image

Image courtesy Henrik Jensen @ UCSD

Global Illumination Image

Image courtesy Henrik Jensen @ UCSD

How to learn more? ...UCBUGG!

- UCB Undergrad Graphics Group
  - No prereqs!!!
  - Student-led DeCal
  - Students make animated short films
    - Example: The Play3D
    - In 2002, made 3D recreation of famous Cal football play
- CS184: Intro to Computer Graphics

Summary
- Beauty and Joy of Computing? You bet!
- The field of 3D Graphics has transformed film, television & video games
- How does it work?
  - Modeling
  - Animation
  - Lighting & Shading & Camera
  - Rendering (film, games different)
- It allows people to exercise right and left sides of brain
  - Opportunities @ Cal!