



The Beauty and Joy of Computing

Lecture #4
HowItWorks : 3D Graphics



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LEAP MOTION ... WOW!

The Leap Motion (\$80) is a new generation of input devices that stands to change the way people interact with 3D data, and provide input to the computer (significant advantages over mouse & tablet)

www.technologyreview.com/news/518721/leap-motions-struggles-reveal-problems-with-3-d-interfaces/

LEAP MOTION ... UGH!


Have they considered the damage they're doing to backs & shoulders by asking users to hold their hands outstretched for hours at a time? No consistent interfaces, it's the wild west of UI

www.leapmotion.com

http://en.wikipedia.org/wiki/3D_computer_graphics

3D Computer Graphics, 10 Miles Up

- Computer Graphics one of the sub-fields of research in Computer Science
- UC Berkeley's Graphics group is ranked in the top 10
 - I graduated from this group in 2000
- 2D Graphics often called "graphic design"; very different




"The Last Guardian" by Johnny Yip (POV-Ray)


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3D Graphics Used In...

Film, Television, Print	Video Games
<ul style="list-style-type: none"> Either pure CG (e.g., Pixar) or CG elements added to film plates hours / frame 	<ul style="list-style-type: none"> Both "in-engine" graphics + pre-rendered cinematics 30 frames / second



"Avatar" (wikipedia)




"Gran Turismo" (us.gran-turismo.com)

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events.game-artist.net/scene_from_a_movie/

...although that line is often blurred



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events.game-artist.net/scene_from_a_movie/winners.php

Aside: Scenes from a Movie winner



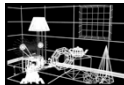
"Blade Runner" by The Replicants

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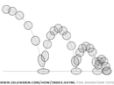
web.engr.oregonstate.edu/~mjb/intro2009/

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


Modeling → Animation → Lighting & Shading → Rendering




"Shutterbug Rendering Progression" by Pixar



"Squash & Stretch" by Idleworm.com



"Procedural Wood" by Pixar



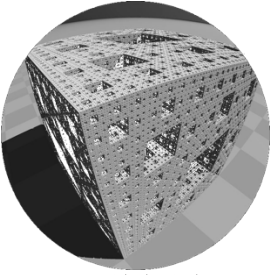
"Shutterbug Rendering Progression" by Pixar

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www.youtube.com/watch?v=FOOynE1F4P4
www.cyberware.com

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



"Menger Cube" by UCB Alum David Wallace (now at LucasFilm)

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web.engr.oregonstate.edu/~mjb/intro2009/en.wikipedia.org/wiki/Motion_capture
www.youtube.com/watch?v=1wK11xr-UmM

Animation

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

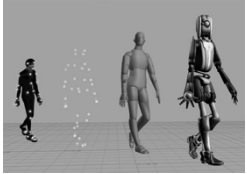



Image by Hipocrite (wikipedia)

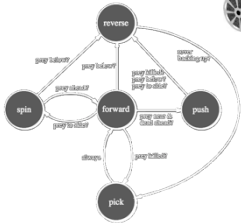


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www.kuffner.org/james/software/dynamics/mirtich/

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!



Creature "rules"



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web.genarts.com/karl/

Genetic Algorithms

- Karl Sims blew away his colleagues with his 1994 seminal work on evolved creatures


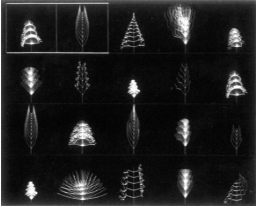


Photo by Hank Morgan




evolved virtual creatures

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hof.povray.org/2b.html

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!"...



"Harvest Time" by Gilles Tran (POV-RAY)

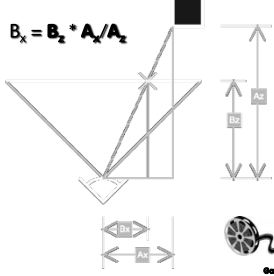
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http://en.wikipedia.org/wiki/3D_projection

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

$$B_x/B_z = A_x/A_z$$


$$B_x = B_z * A_x/A_z$$


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en.wikipedia.org/wiki/Global_illumination

Rendering : Global Illumination

- **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**



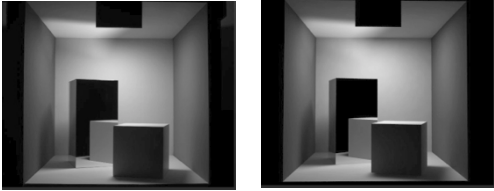
"The Lovers" by Gilles Tran. (POV-Ray)

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www.graphics.cornell.edu/online/box/compare.html

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."

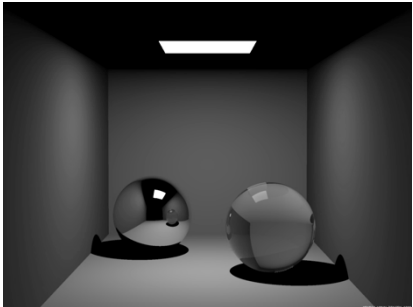


Photograph Rendering

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Image courtesy Henrik Jensen @ UCSD

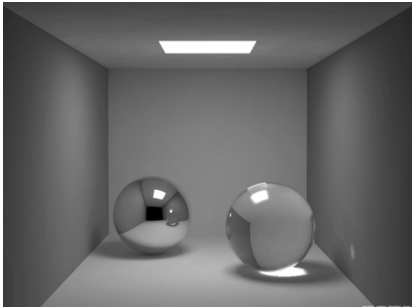
Direct Illumination Image



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Image courtesy Henrik Jensen @ UCSD

Global Illumination Image





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ucbugg.com

How to learn more? ... UCBUGG!

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

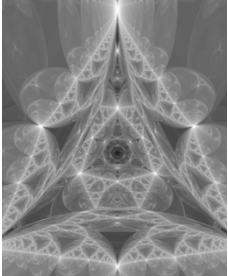
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kevinbeason.com/smallpt/

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!

Image by Kevin Beason



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