


CS10
The Beauty and Joy of Computing



Lecture #2
HowItWorks : 3D Graphics

2012-06-19

UC Berkeley
Computer Science
Summer Instructor
Ben Chun

NEW FASTEST SUPERCOMPUTER IN THE WORLD!

An IBM machine at Lawrence Livermore National Labs just took the title

Date	System	Manufacturer	Country	Speed
June 2012	Sesquid	IBM	U.S.	16.32
June 2011	K Computer	Fujitsu	Japan	0.16
Nov. 2010	Tianhe-1A	NUDT**	China	2.57
Nov. 2009	Jaguar	Cray	U.S.	1.75
June 2008	Roadrunner	IBM	U.S.	1.026


*Measured in petaflops, or quadrillion calculations per second
**National University of Defense Technology
Source: Top500.org semiannual rankings

The Wall Street Journal

<http://on.waj.com/LUA5Cp>

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
- 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

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

Video Games

- Both "in-engine" graphics + pre-rendered cinematics
- <1/30 second / frame

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

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events.game-artist.net/scene_from_a_movie/winners.php
Aside: Scene from a Movie winner



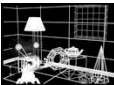
"Blade Runner" by The Replicants

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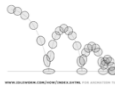
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web.engr.oregonstate.edu/~mjb/intro2009/
3D Graphics : How it's done (simplified)


Modeling → Animation → Lighting & Shading → Rendering




"Shutterbug Rendering Progression" by Pixar



"Squash & Stretch" by Idleworm.com



"Procedural Wood" by Pixar



"Shutterbug Rendering Progression" by Pixar

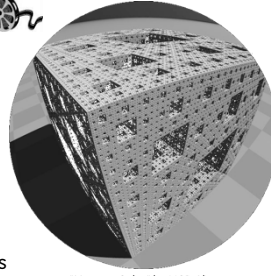
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www.youtube.com/watch?v=FOOynE1F4P4
www.cyberware.com

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=lwKLIxr-UmM

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

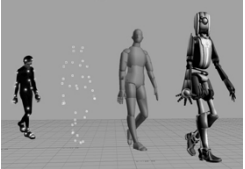



Image by Hipocrite (wikipedia)

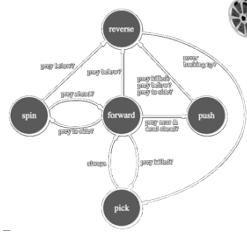



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www.kuffner.org/james/software/dynamics/mirtich/

Creature War... Automatic Animation!

- 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!





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www.red3d.com/cwr/boids/
tangible.media.mit.edu/project/pingpongplus/

Boids

- Craig Reynolds, 1986
- Realistic motion of flocks
- No leader
- Three simple rules
 - Separation
 - Alignment
 - Cohesion
- Implemented for PingPongPlus as undergraduate research



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web.genarts.com/karl/

Genetic Algorithms

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


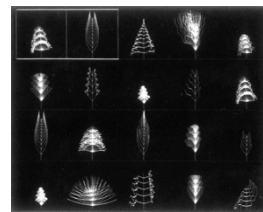


Photo by Hank Morgan




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!"...



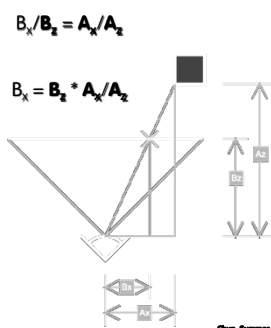
"Harvest Time" by Gilles Tran (POV-RAY)

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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 usually higher




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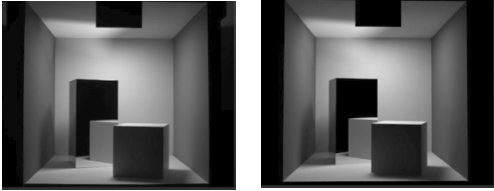
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www.graphics.cornell.edu/online/box/compare.html

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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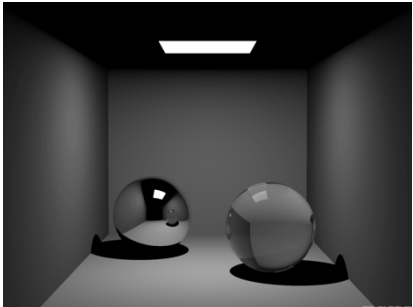



Image courtesy Henrik Jensen @ UCSD

Direct Illumination Image



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kevinbeason.com/smallpt/

Global Illumination Image



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


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 a 3D recreation of a famous Cal football play
- **CS184 : Intro to Computer Graphics**

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www.electricsheep.org/

Summary

- **Beauty and Joy of Computing!**
- **The field of 3D Graphics has transformed film, television & video games**
- **How does it work?**
 - Modeling
 - Animation
 - Lighting & Shading & Camera
 - Rendering (film, games different)
- **Allows people to exercise their right and left brains**
 - Opportunities @ Cal!

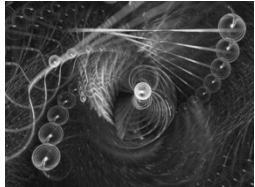


Image by Scott Drees

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