

**UC Berkeley**  
EECS Lecturer SOE  
Dan Garcia

## CS10

# The Beauty and Joy of Computing

### Lecture #2

## HowItWorks : 3D Graphics

**2012-01-23**

**SOPA & PIPA DEAD (FOR NOW)**

Tension still exists – reason bills were introduced still relevant (piracy of copyrighted content) but most agree bill over-reached. *Stay tuned!*

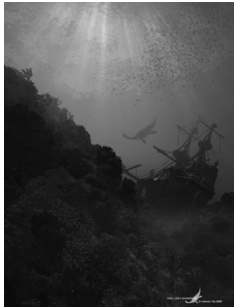
# SOPA PIPA

www.nytimes.com/2012/01/21/technology/senate-postpones-piracy-vote.html

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)  
 Garcia, Fall 2011

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (2)


## 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



"Avatar" (wikipedia)




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

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (3)

events.game-artist.net/scene\_from\_a\_movie/

## ...although that line is often blurred



SCENE FROM A MOVIE  
A REALTIME ENVIRONMENT COMPETITION  
16 FEB - 5 APRIL 2009

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (4)

events.game-artist.net/scene\_from\_a\_movie/winners.php

## Aside: Scenes from a Movie winner




"Blade Runner" by The Replicants

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (5)

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

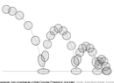
## 3D Graphics : How it's done (simplified)

Modeling




"Shutterbug Rendering Progression" by Pixar

Animation



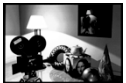
"Squash & Stretch" by Idleworm.com

Lighting & Shading



"Procedural Wood" by Pixar

Rendering



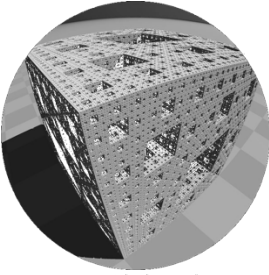
"Shutterbug Rendering Progression" by Pixar

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (6)

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)

Quads, Fall 2011

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (7)

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

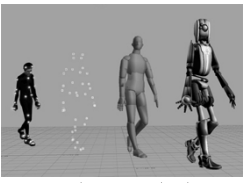



Image by Hipocrite (wikipedia)



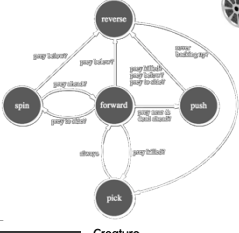
Quads, Fall 2011

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (8)


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"



Quads, Fall 2011

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (9)

web.genarts.com/karl/

## Genetic Algorithms

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


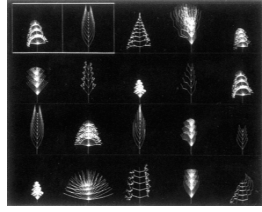


Photo by Hank Morgan



evolved virtual creatures


Quads, Fall 2011

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (10)

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)

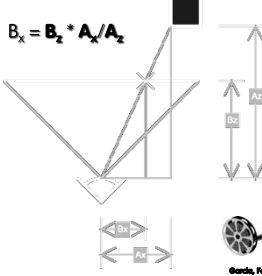
Quads, Fall 2011

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (11)

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




Quads, Fall 2011

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (12)

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**



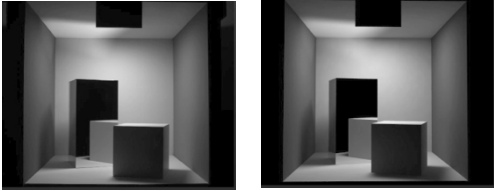
"The Lovers" by Gilles Tran. (POV-Ray)

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (16)

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."*

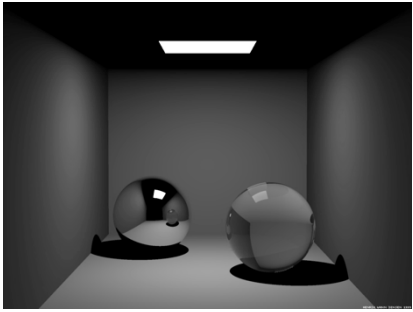


Photograph      Rendering

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (14)

Image courtesy Henrik Jensen @ UCSD

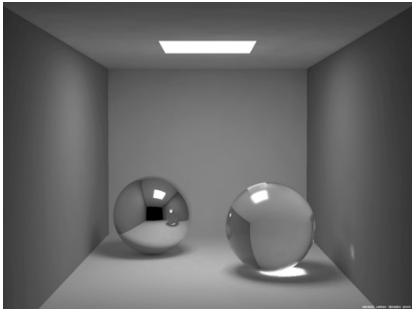
## Direct Illumination Image



UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (15)

Image courtesy Henrik Jensen @ UCSD

## Global Illumination Image





UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (16)

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

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (17)

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!

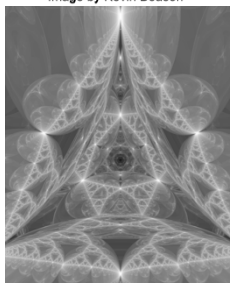


Image by Kevin Beason

UC Berkeley CS10 "The Beauty and Joy of Computing" : HowItWorks : 3D Graphics (18)