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!*

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)

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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

"Avatar" (wikipedia)

Video Games

- Both "in-engine" graphics + pre-rendered cinematics
- 30 frames / second

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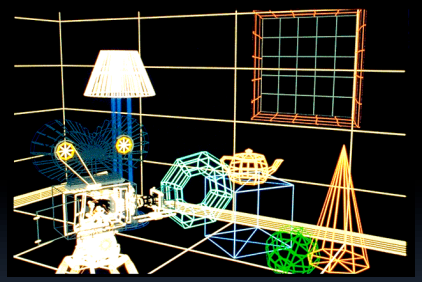
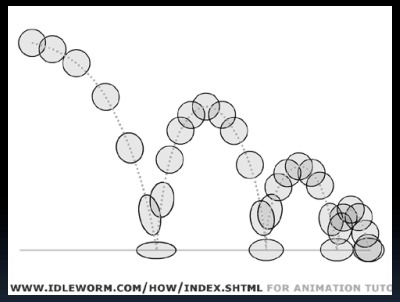
web.engr.oregonstate.edu/~mjb/intro2009/

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

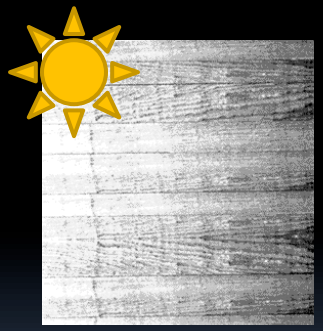
Modeling → Animation → Lighting & Shading → Rendering



"Shutterbug Rendering Progression" by Pixar



"Squash & Stretch" by idleworm.com



"Procedural Wood" by Pixar

"Shutterbug Rendering Progression" by Pixar

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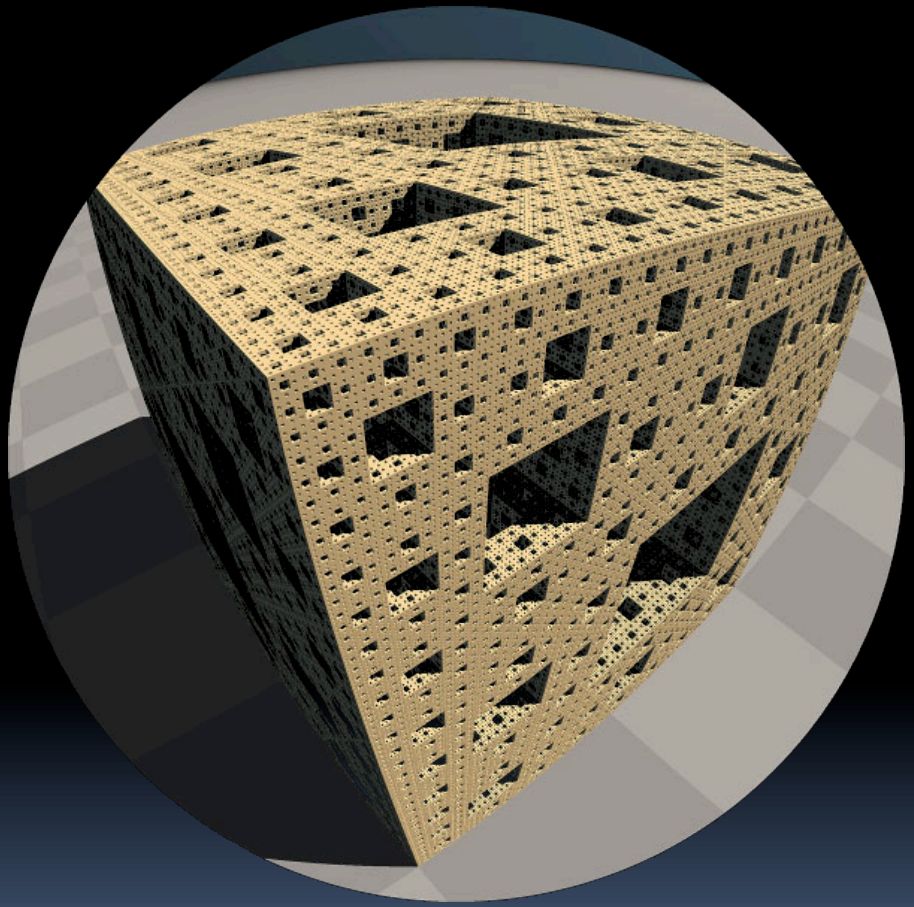
www.youtube.com/watch?v=FOOynE1F4P4
www.cyberware.com

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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Animation

web.engr.oregonstate.edu/~mjb/intro2009/
en.wikipedia.org/wiki/Motion_capture
www.youtube.com/watch?v=1wK1Ixr-UmM

- **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

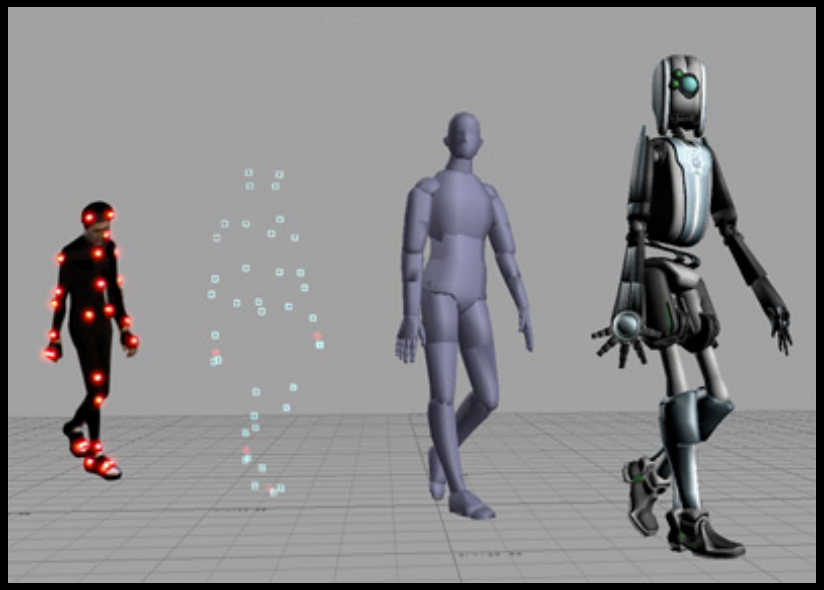

Image by Hipocrite (wikipedia)

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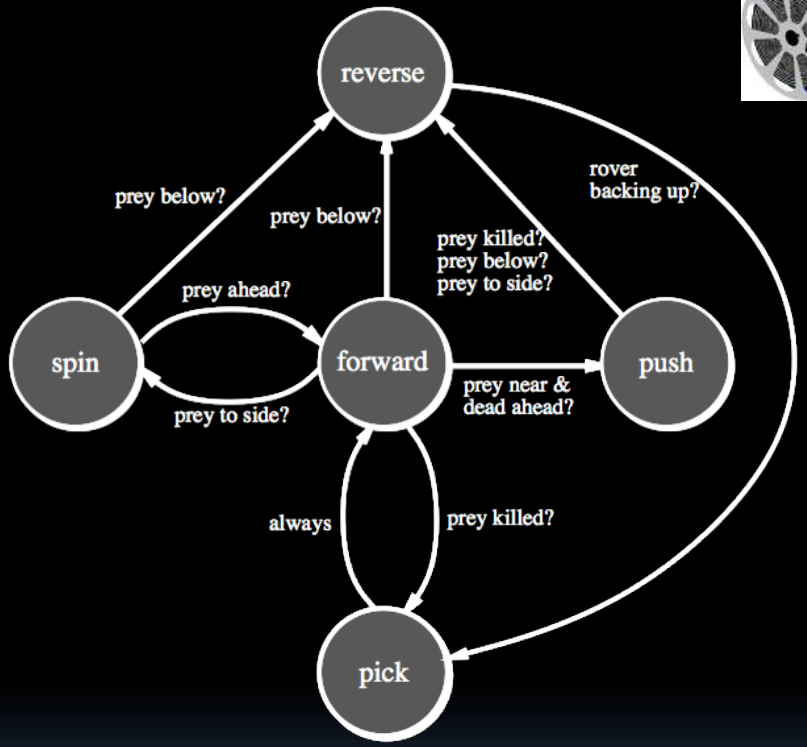
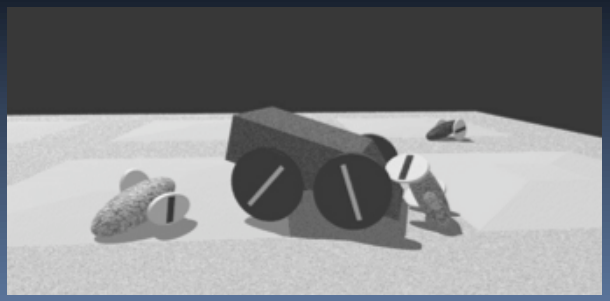
www.kuffner.org/james/software/dynamics/mirtich/

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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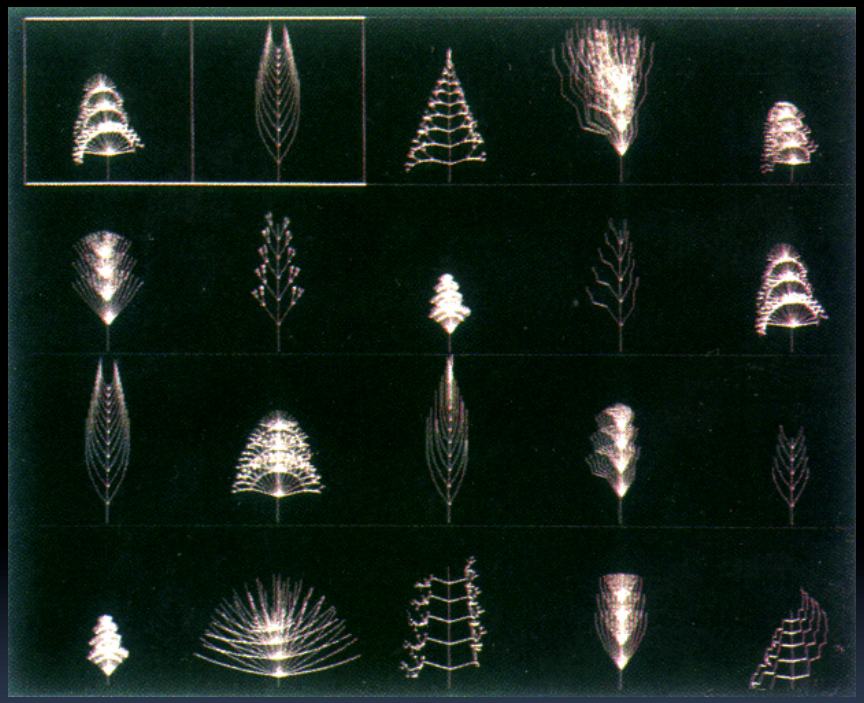
web.genarts.com/karl/

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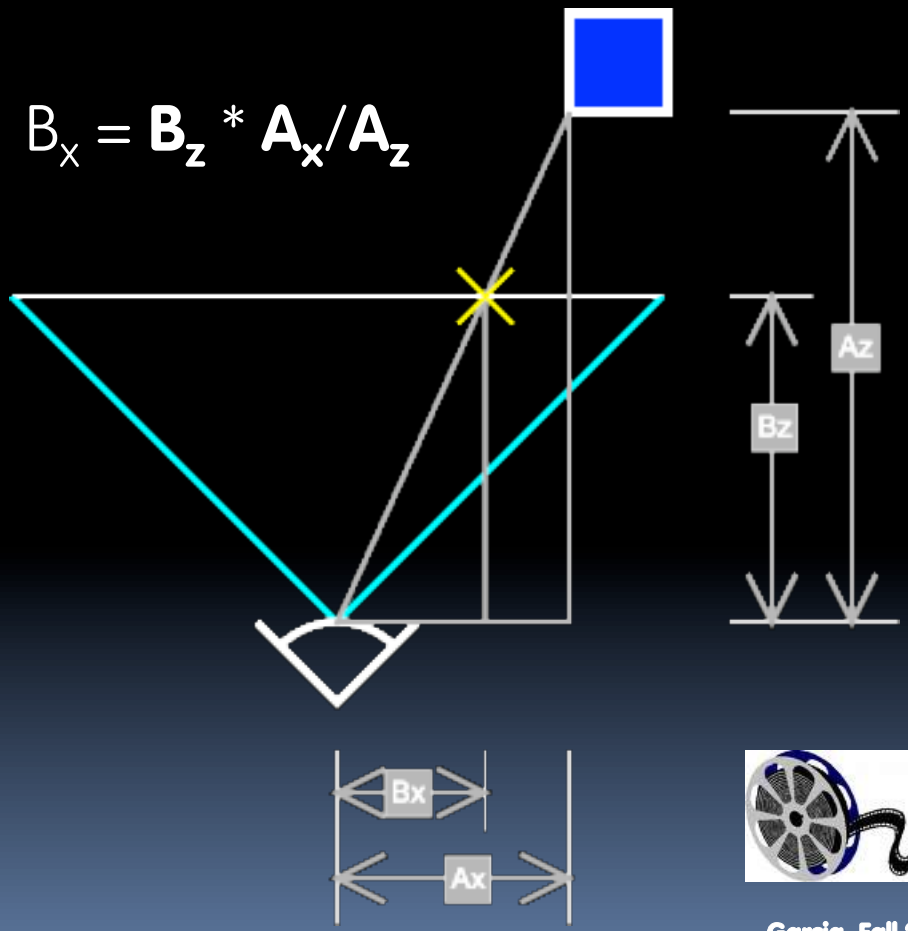
http://en.wikipedia.org/wiki/3D_projection

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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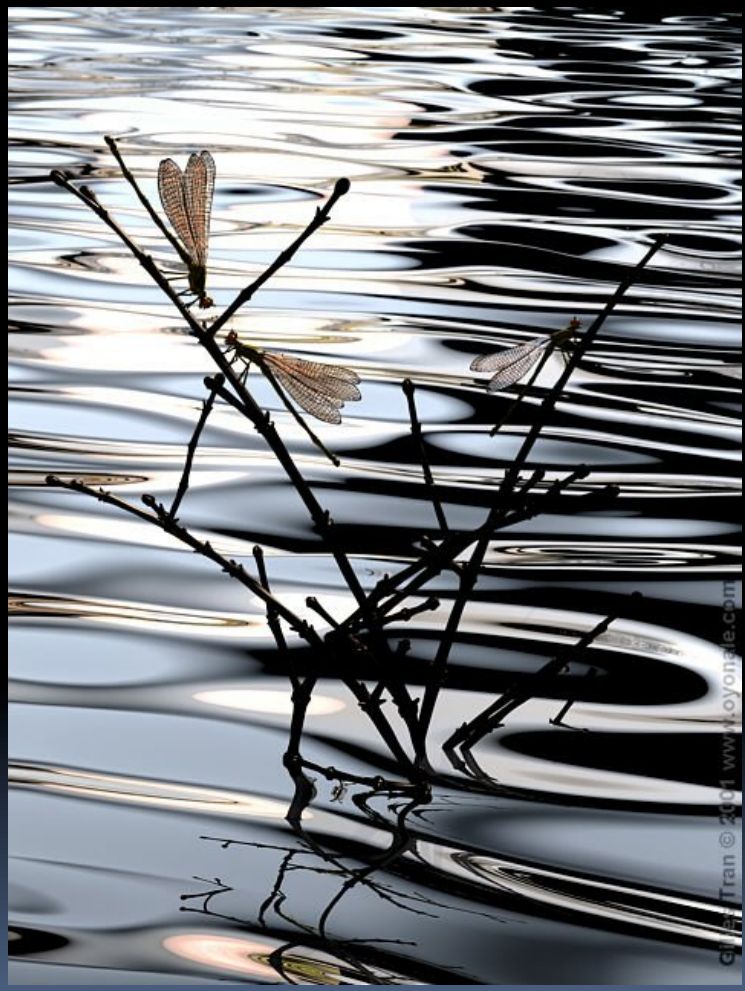
en.wikipedia.org/wiki/Global_illumination

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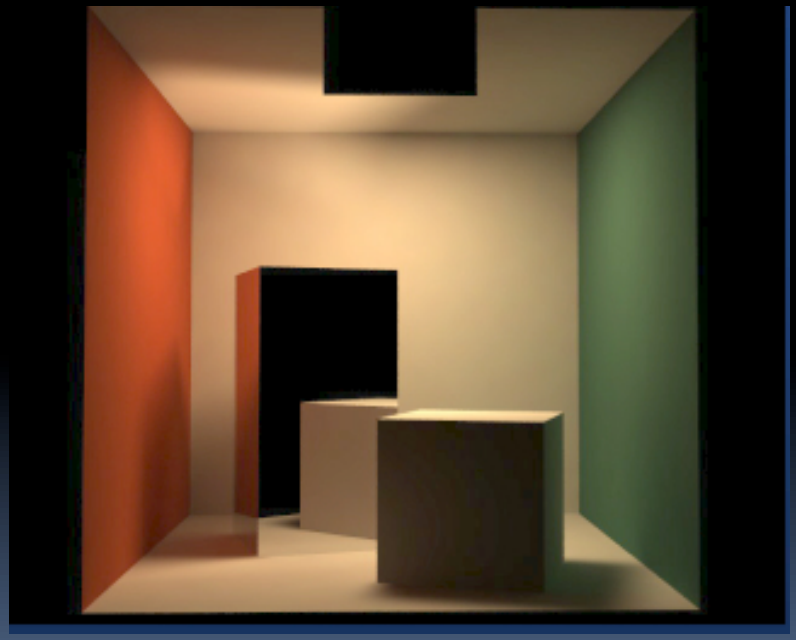
www.graphics.cornell.edu/online/box/compare.html

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

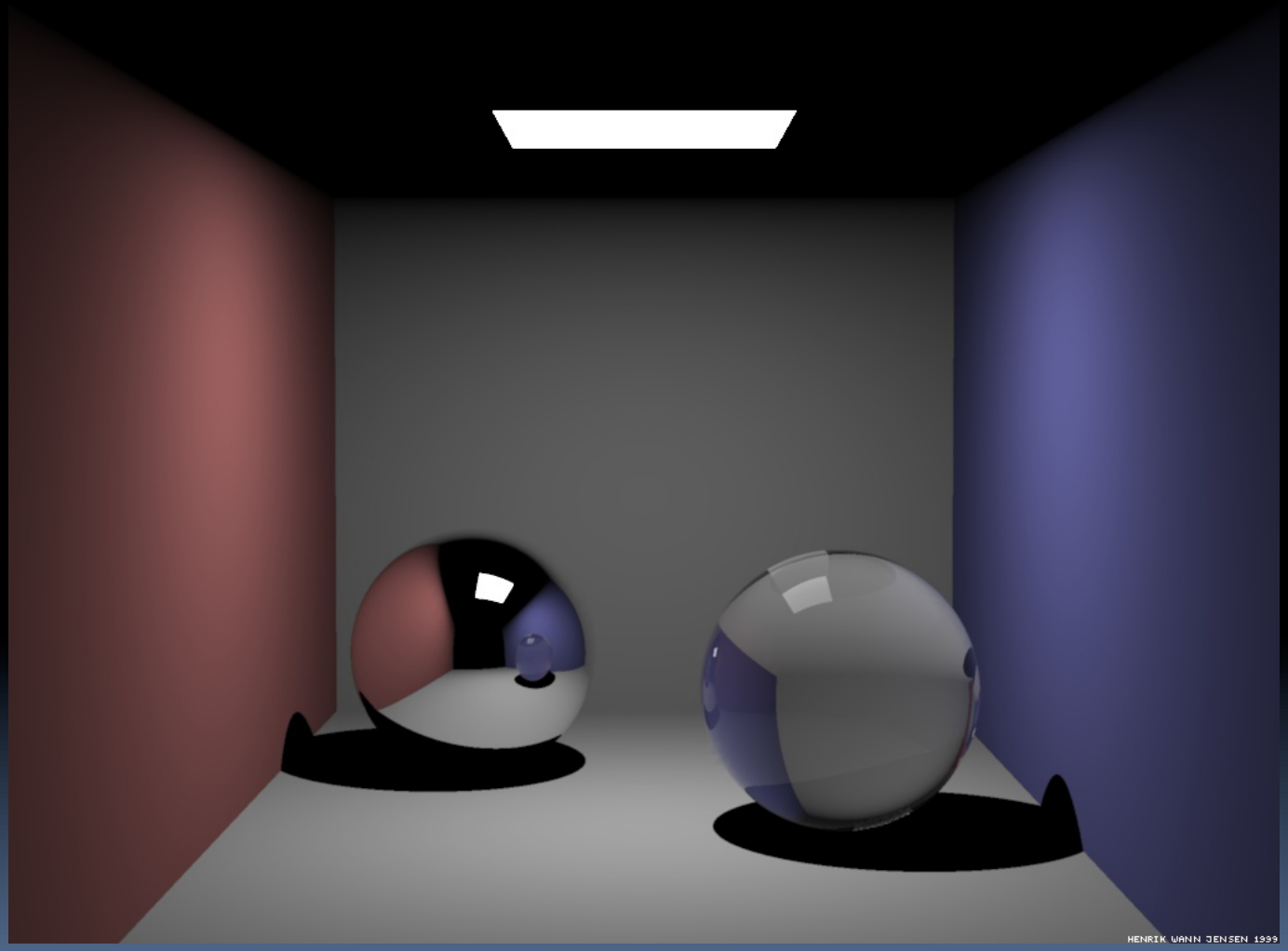

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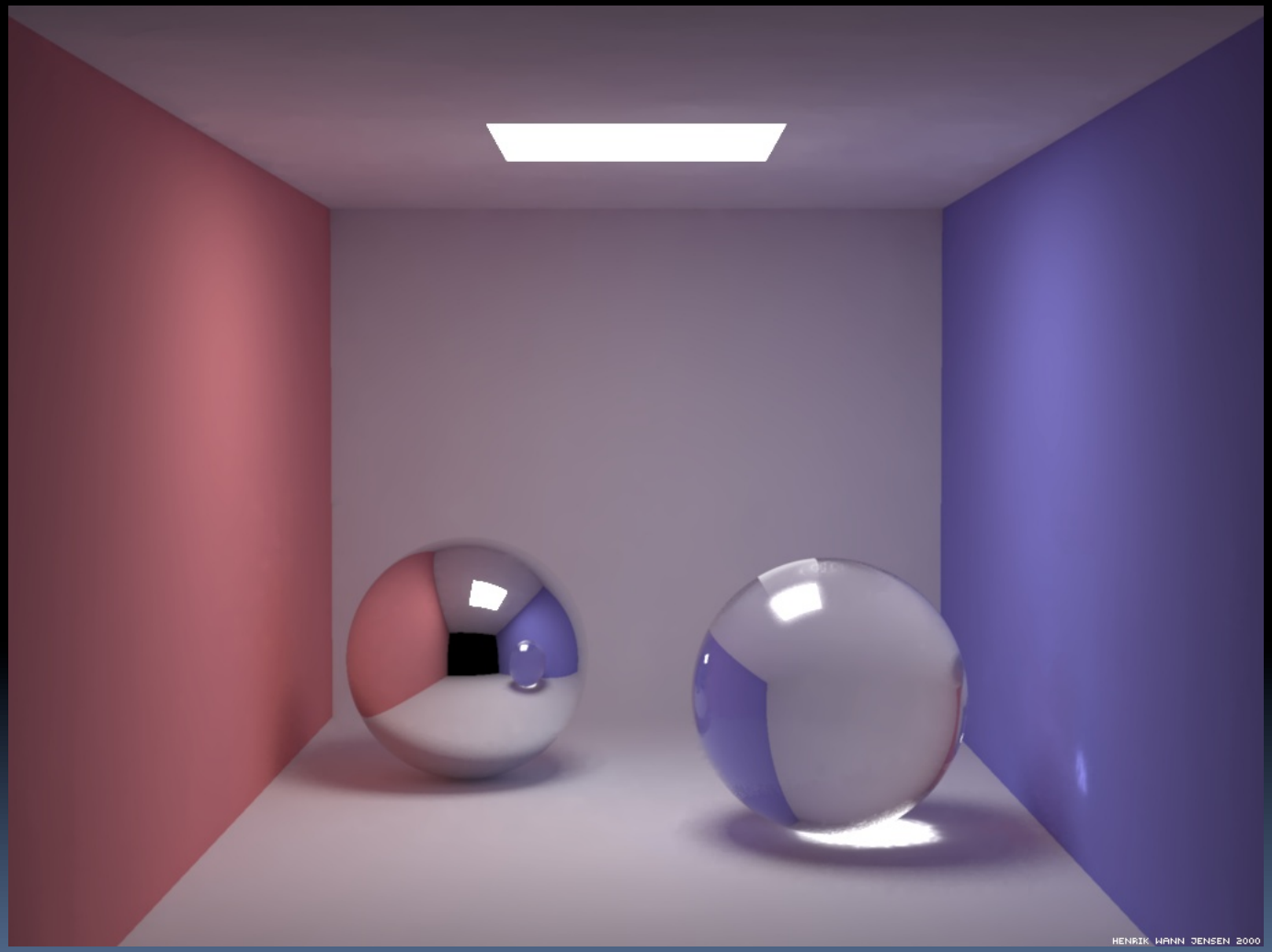
Image courtesy Henrik Jensen @ UCSD

Global Illumination Image



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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**

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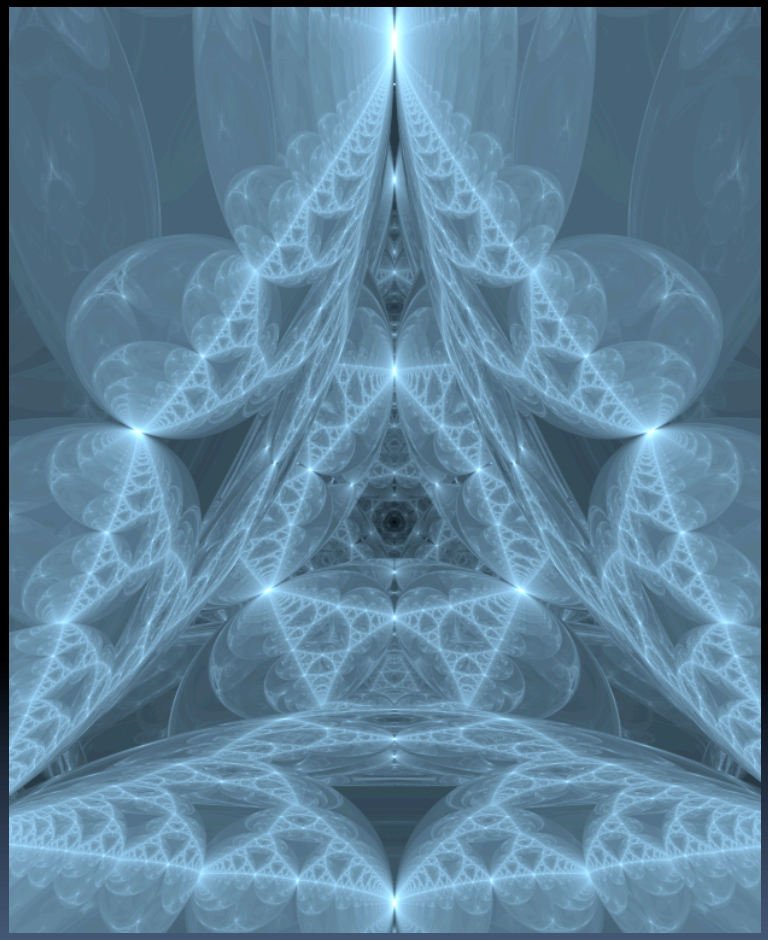
kevinbeason.com/smallpt/

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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