

Image-Based Lighting



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*...with a lot of slides
donated by Paul Debevec*

15-463: Computational Photography
Alexei Efros, CMU, Fall 2005

Inserting Synthetic Objects



Why does this look so bad?

- Wrong camera orientation
- Wrong lighting
- No shadows

Solutions

Wrong Camera Orientation

- Estimate correct camera orientation and re-render object
- Use corresponding points to warp the object/scene
 - Only works for small warps and/or mostly planar objects

Lighting & Shadows

- Estimate (eyeball) all the light sources in the scene and simulate it in your virtual rendering

But what happens if lighting is complex?

- Extended light sources, mutual illumination, etc.

Environment Maps



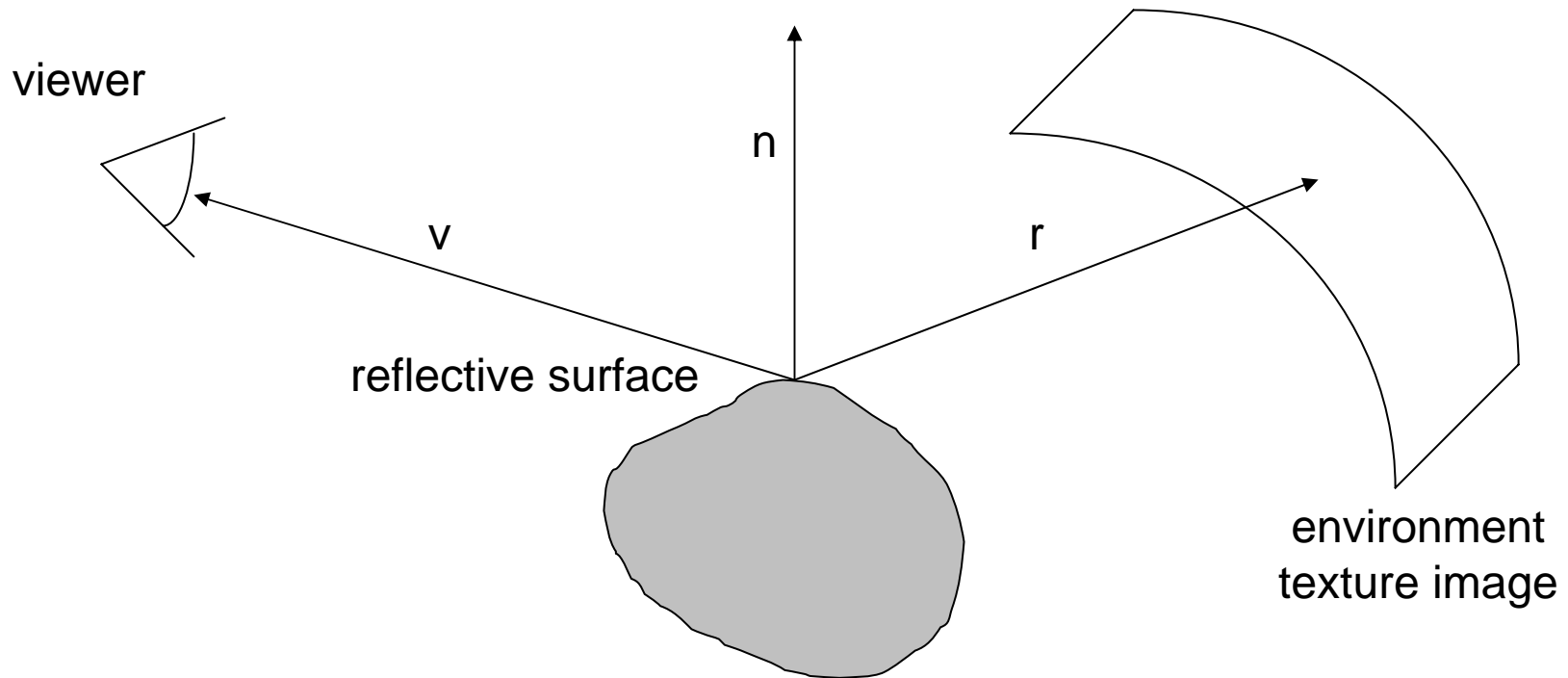
Simple solution for shiny objects

- Models complex lighting as a panoramic image
- i.e. amount of radiance coming in from each direction
- A plenoptic function!!!

Environment Mapping

projector function converts
reflection vector (x, y, z) to
texture image (u, v)

Reflected ray: $r = 2(n \cdot v)n - v$



Texture is transferred in the direction of the reflected ray
from the environment map onto the object
What is in the map?

What approximations are made?

The map should contain a view of the world with the point of interest on the object as the eye

- We can't store a separate map for each point, so one map is used with the eye at the center of the object
- Introduces distortions in the reflection, but we usually don't notice
- Distortions are minimized for a small object in a large room

The object will not reflect itself!

Environment Maps

The environment map may take one of several forms:

- Cubic mapping
- Spherical mapping
- other

Describes the shape of the surface on which the map
“resides”

Determines how the map is generated and how it is
indexed

Cubic Mapping

The map resides on the surfaces of a cube around the object

- Typically, align the faces of the cube with the coordinate axes

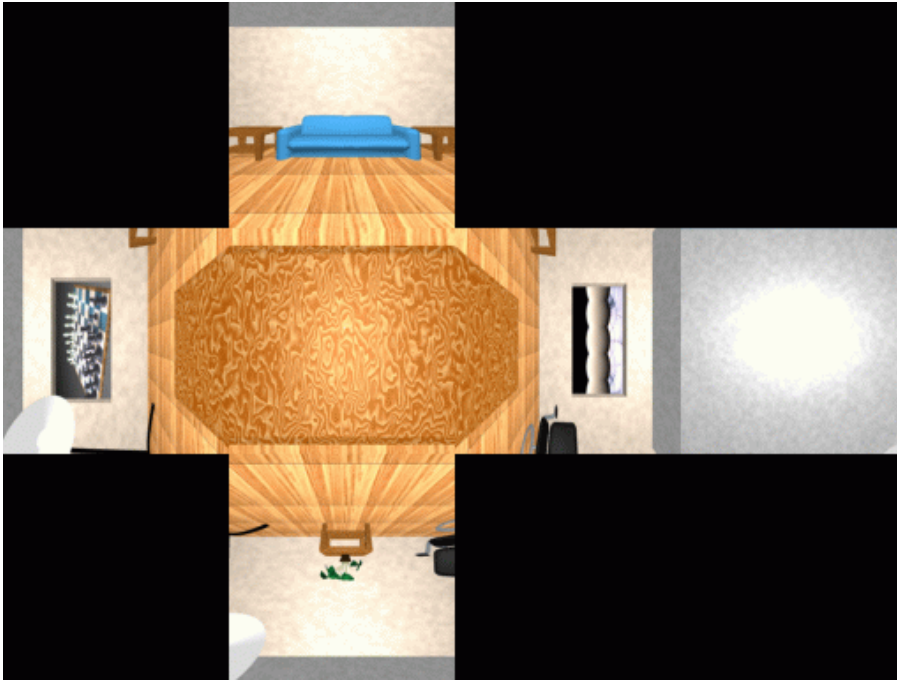
To generate the map:

- For each face of the cube, render the world from the center of the object with the cube face as the image plane
 - Rendering can be arbitrarily complex (it's off-line)

To use the map:

- Index the R ray into the correct cube face
- Compute texture coordinates

Cubic Map Example



Sphere Mapping

Map lives on a sphere

To generate the map:

- Render a spherical panorama from the designed center point

To use the map:

- Use the orientation of the R ray to index directly into the sphere

Example



What about real scenes?



from Terminator 2

Real environment maps

We can use photographs to capture environment maps

- The first use of panoramic mosaics

How do we deal with light sources? Sun, lights, etc?

- They are much much brighter than the rest of the environment

User High Dynamic Range photography, of course!

Several ways to acquire environment maps:

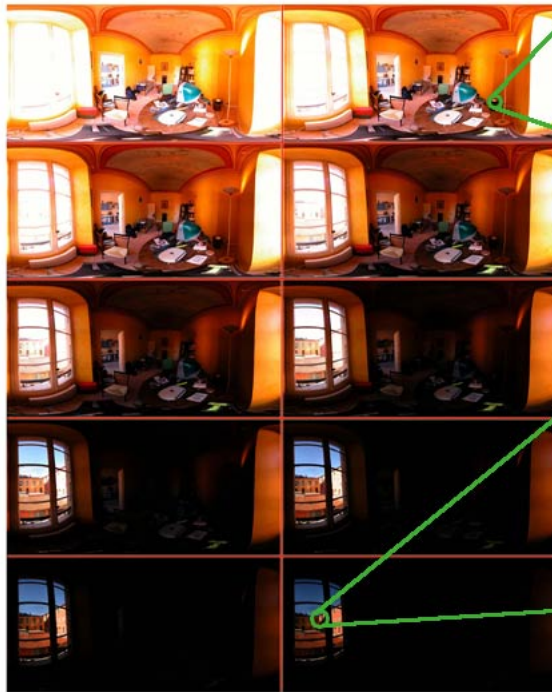
- Stitching mosaics
- Fisheye lens
- Mirrored Balls

Stitching HDR mosaics



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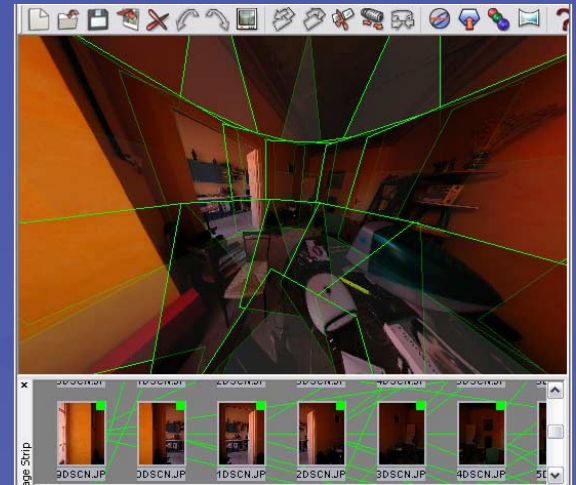
<http://www.gregdowning.com/HDRI/stitched/>



Shadow Detail



Highlight Detail



Scanning Panoramic Cameras

Pros:

very high res (10K x 7K+)

Full sphere in one scan – no stitching

Good dynamic range, some are HDR

Issues:

More expensive

Scans take a while

Companies: Panoscan, Sphereon

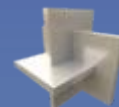




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See also www.kaidan.com

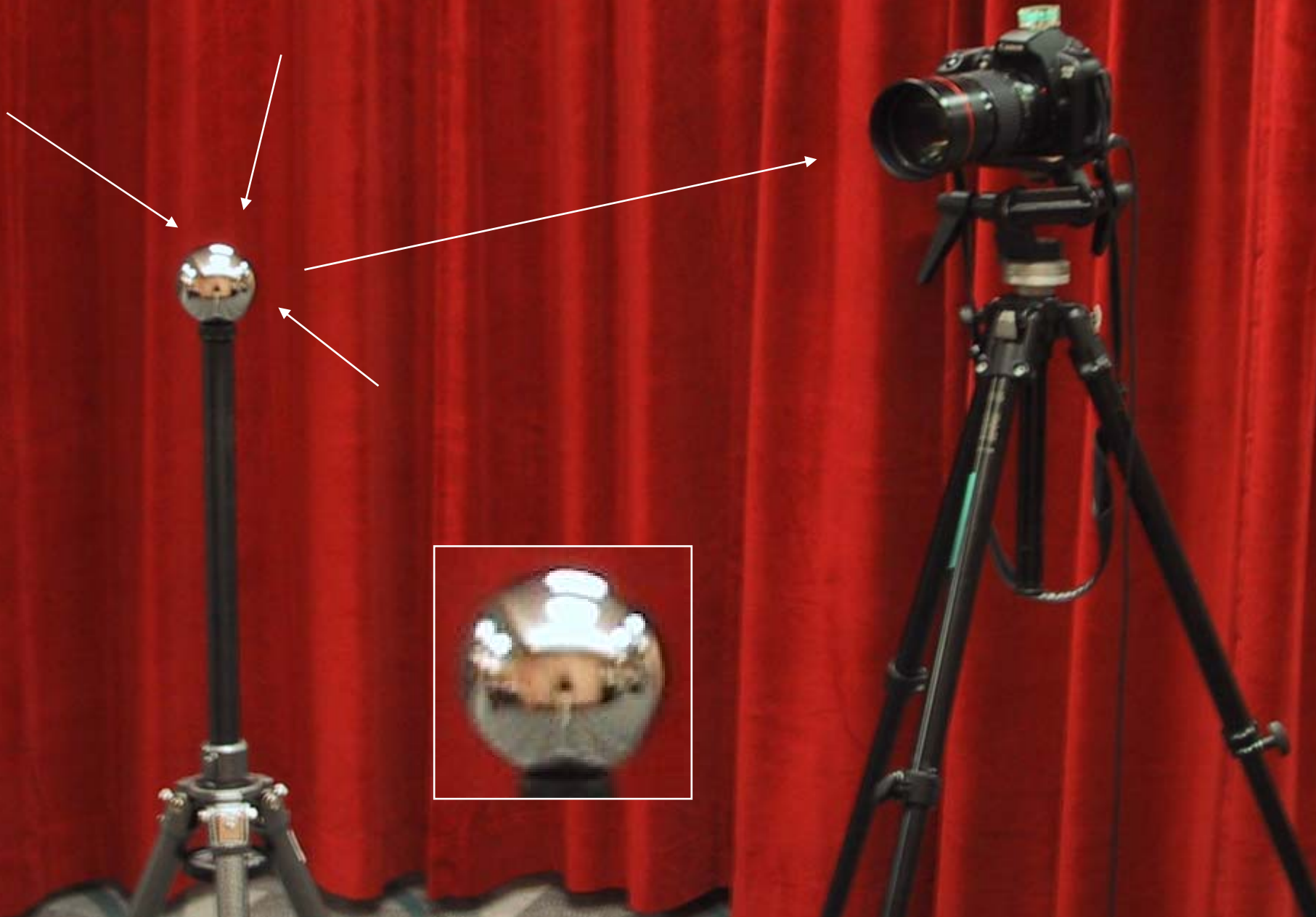




Fisheye Images



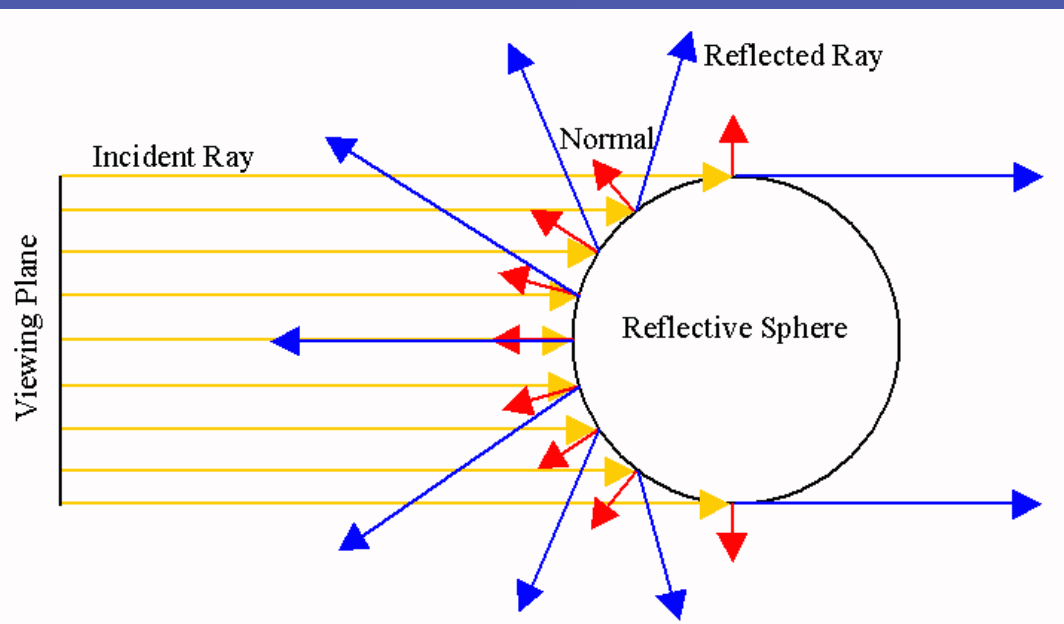
Mirrored Sphere







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Sources of Mirrored Balls



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- 2-inch chrome balls ~ \$20 ea.
 - McMaster-Carr Supply Company
www.mcmaster.com
- 6-12 inch large gazing balls
 - Baker's Lawn Ornaments
www.bakerslawnorn.com
- Hollow Spheres, 2in – 4in
 - Dube Juggling Equipment
www.dube.com
- **FAQ** on www.debevec.org/HDRShop/

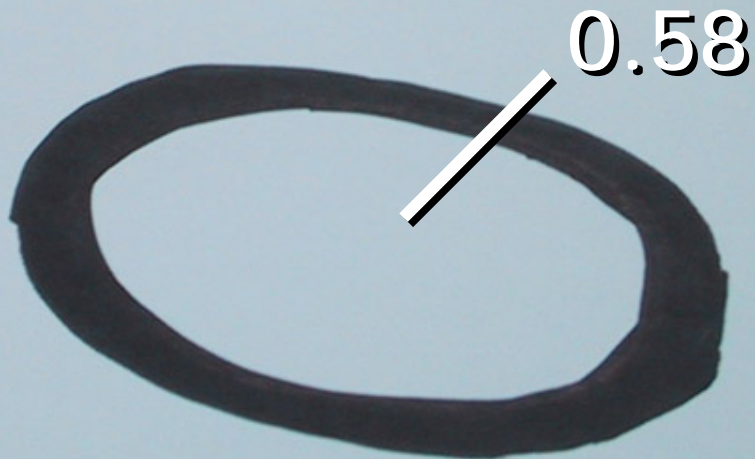




0.34

=> 59%
Reflective

Calibrating
Mirrored Sphere
Reflectivity



0.58

Real-World HDR Lighting Environments

Funston
Beach



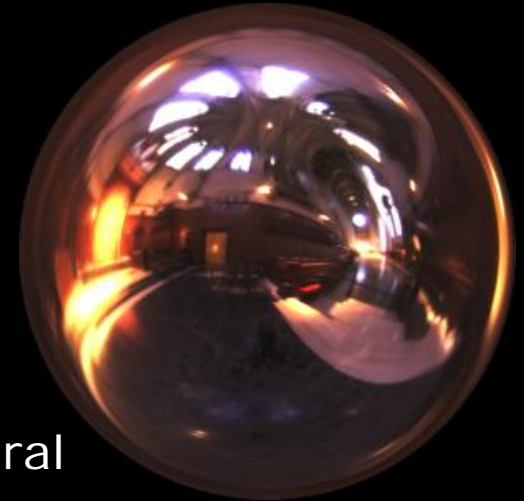
Eucalyptus
Grove



Uffizi
Gallery

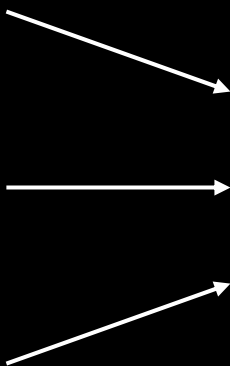
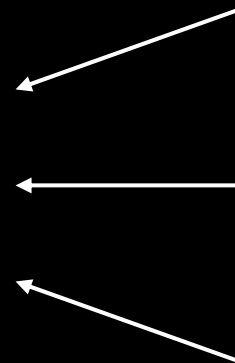


Grace
Cathedral

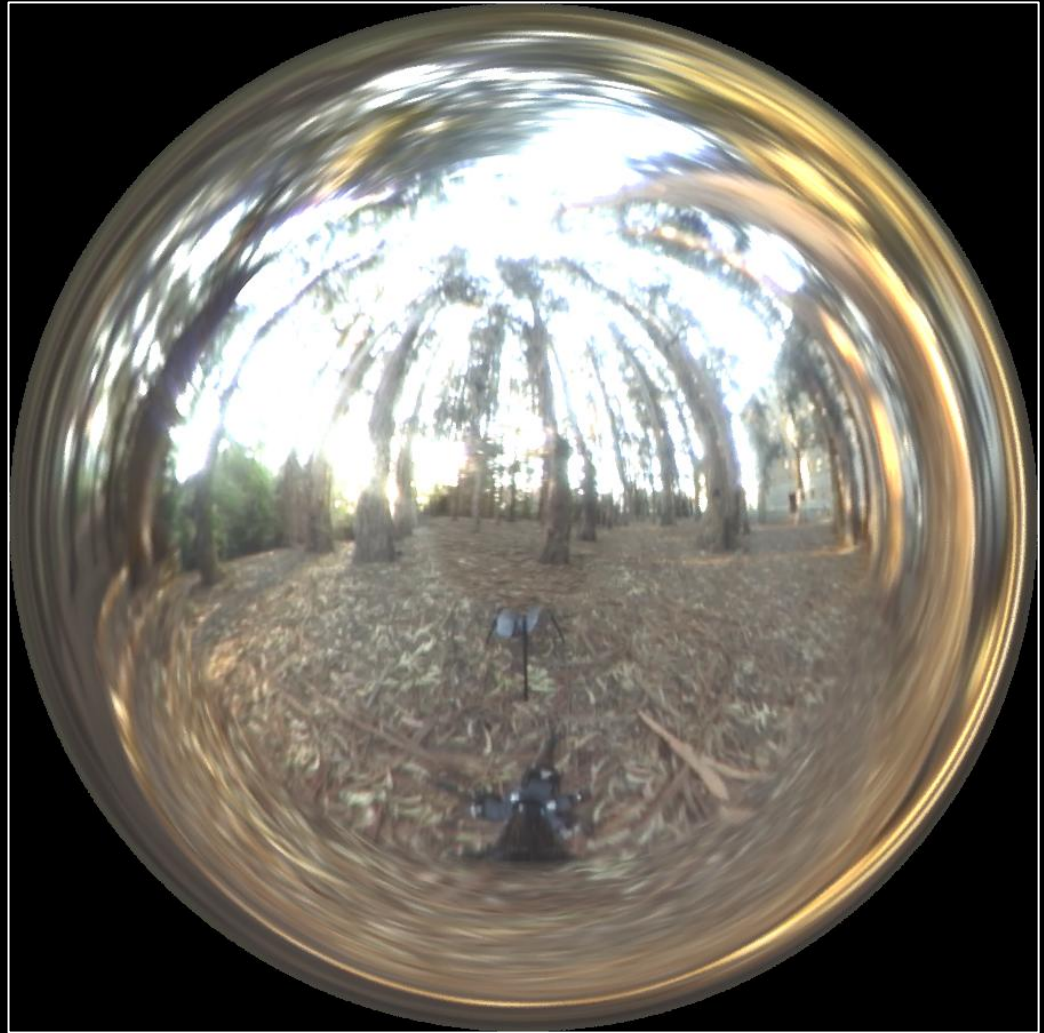


Lighting Environments from the Light Probe Image Gallery:
<http://www.debevec.org/Probes/>

Acquiring the Light Probe



Assembling the Light Probe





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Not just shiny...

We have captured a true radiance map

We can treat it as an extended (e.g spherical) light source

Can use Global Illumination to simulate light transport in the scene

- So, all objects (not just shiny) can be lighted
- What's the limitation?

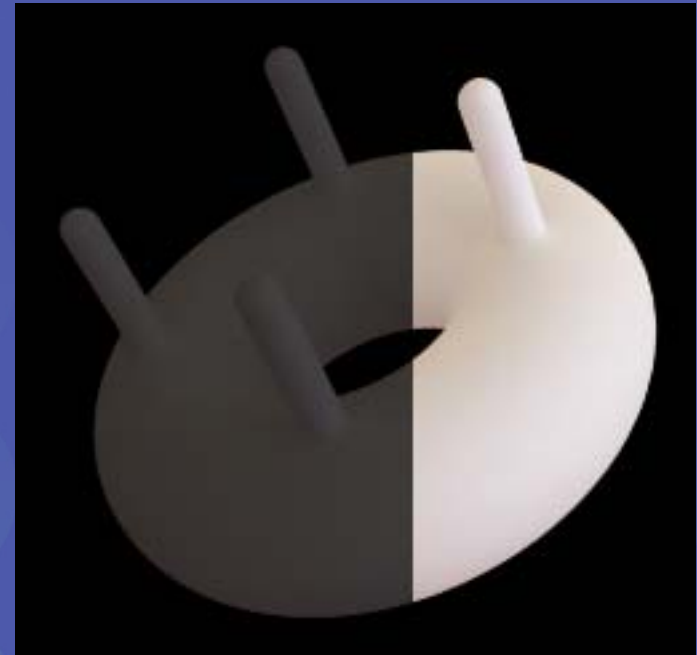
Illumination Results



Comparison: Radiance map versus single image



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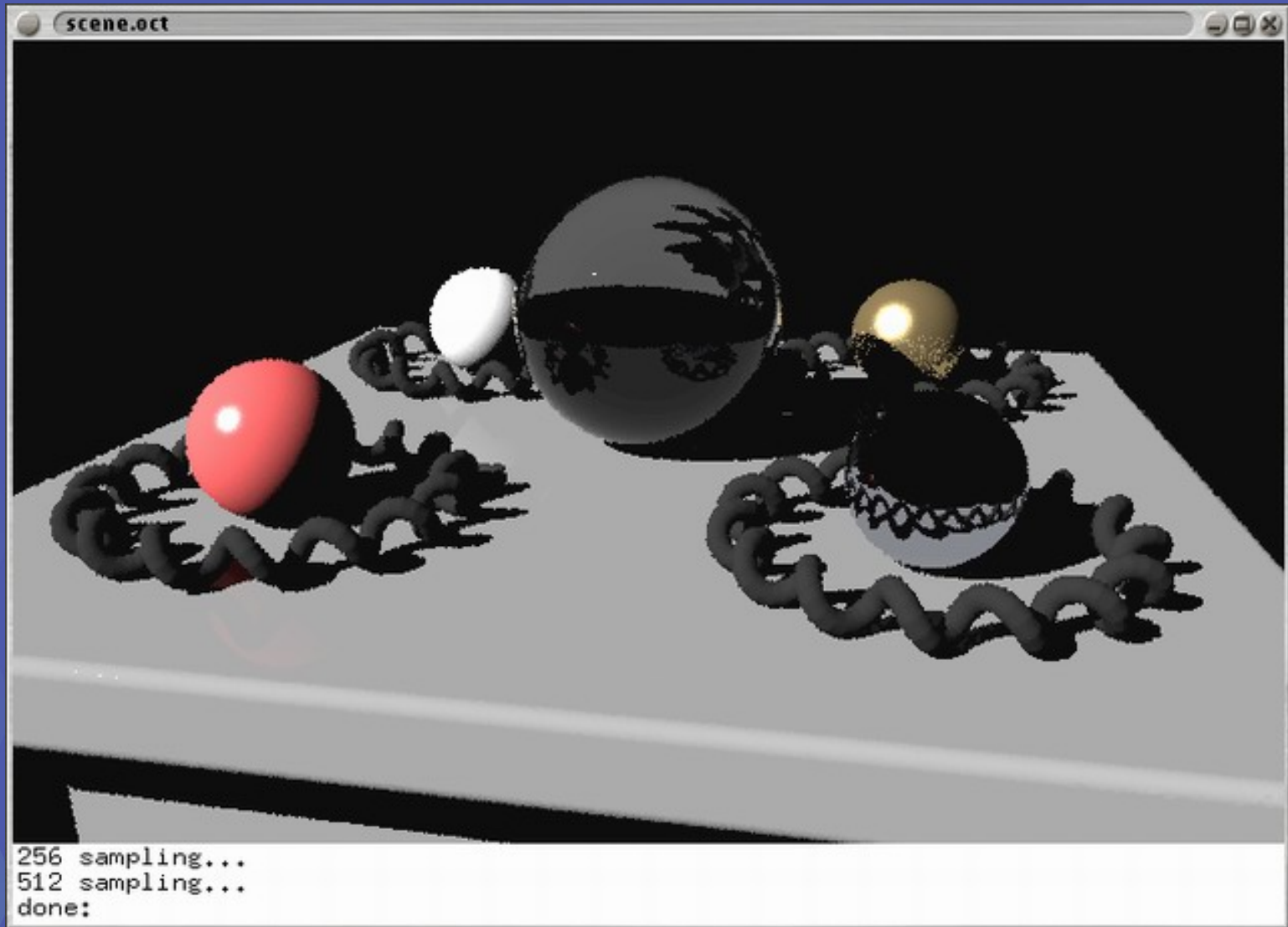
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Putting it all together

Synthetic Objects

+

Real light!



CG Objects Illuminated by a Traditional CG
Light Source

Illuminating Objects using Measurements of Real Light

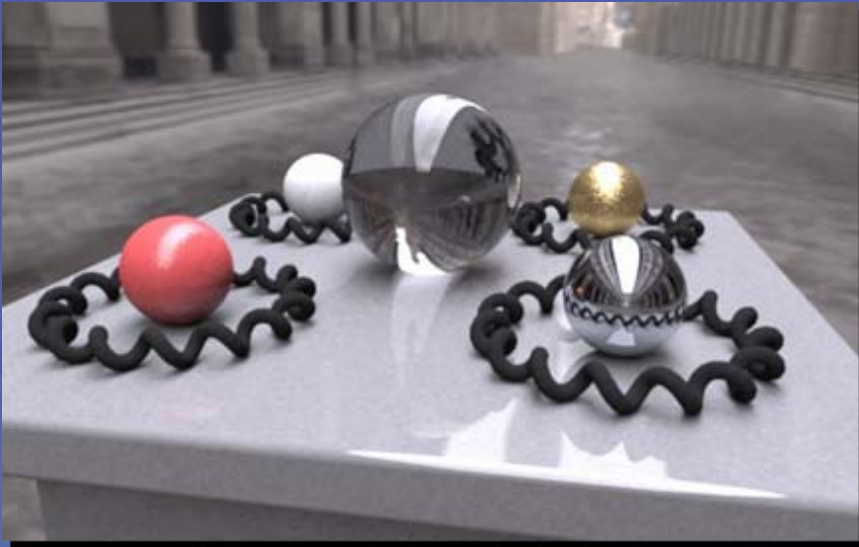
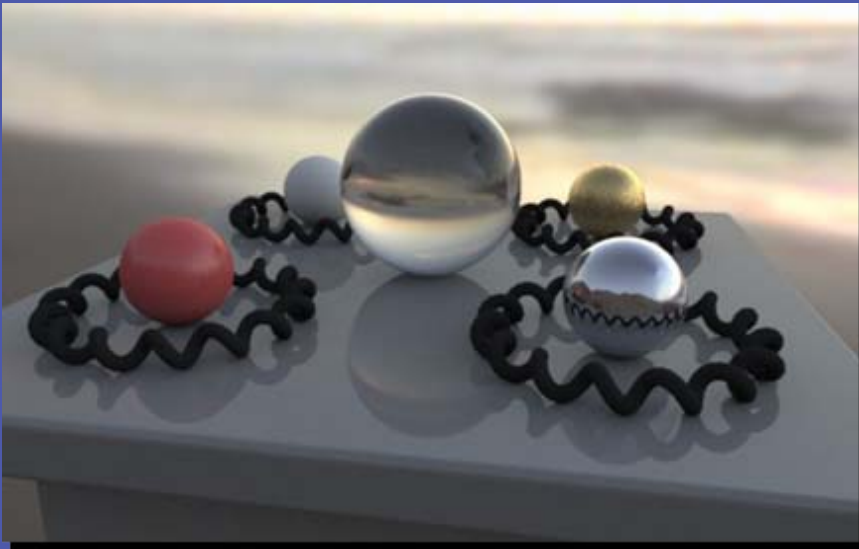


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Environment
assigned "glow"
material
property in
Greg Ward's
RADIANCE
system.

<http://radsite.lbl.gov/radiance/>



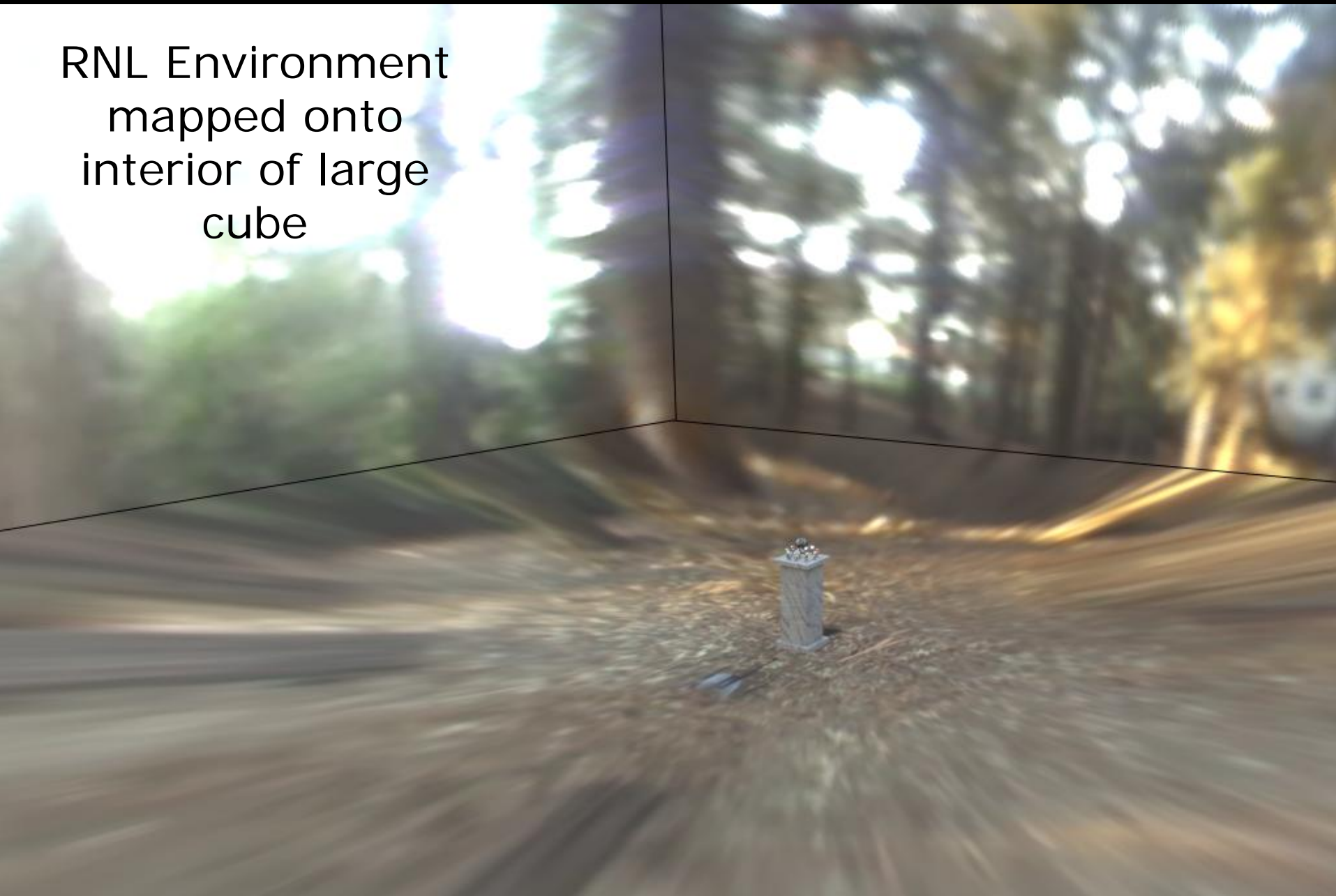
Paul Debevec. A Tutorial on Image-Based Lighting. IEEE Computer Graphics and Applications, Jan/Feb 2002.

Rendering with Natural Light



SIGGRAPH 98 Electronic Theater

RNL Environment
mapped onto
interior of large
cube





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MOVIE!