Image-Based Lighting

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

15-463: Computational Photography
Alexei Efros, CMU, Fall 2006
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 render object
    – Requires camera calibration to do it right

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

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

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

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 Center of Projection

- We can’t store a separate map for each point, so one map is used with the COP 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 various 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

http://www.gregdowning.com/HDRI/stitched/
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
See also www.kaidan.com
Fisheye Images
Mirrored Sphere
Sources of Mirrored Balls

- 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/
Calibrating Mirrored Sphere Reflectivity

Reflective

=> 59%

0.34

0.58
Real-World HDR Lighting Environments

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

Funston Beach
Eucalyptus Grove
Uffizi Gallery
Grace Cathedral
Acquiring the Light Probe
Assembling the Light Probe
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
Putting it all together

Synthetic Objects
+
Real light!
CG Objects Illuminated by a Traditional CG Light Source
Illuminating Objects using Measurements of Real Light

Object

Environment assigned “glow” material property in Greg Ward’s RADIANCE system.

Light

http://radsite.lbl.gov/radiance/
Rendering with Natural Light

SIGGRAPH 98 Electronic Theater
RNL Environment mapped onto interior of large cube
MOVIE!