Image-Based Lighting

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Roll Inspirational Video

• “Rendering with Natural Light”
  – By Paul Debevec, Kevin Deus, Tim Hawkins, Gregory Chew, David Metzger, Hal Wasserman, and Chris Wright
IBL: Essential Purpose

To add synthetic clutter to a naturally cluttered scene…

Go from This: To This:


Non-IBL Quick & Dirty Method

1. Photograph Scene 2. Capture Spheremap

Quick & Dirty

And it shows…

Debevec’s Method

- Capture HDR environment map
  - “Light Probe” image
- Use light probe for synthetic illumination
- Include approximate local geometry
- Improved composite step
- Augment light probe with HDR plate
Light Probe Image

A sequence is captured and merged into an HDR image that we use to illuminate our synthetic objects.

Rendering of Environment

Information behind mirrored ball is missing, so replace it with HDR background plate.
Render Synthetic Objects

Approximate local geometry

Compositing of Shadows

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Final Composite

Now let’s try it for real…
More Advanced Techniques

• Practical measurement of the sun

• Automatic light source placement

Sunlit Bilbao Museum

Example Courtesy Paul Debevec
Light Probe Capture

Light Probe

Need to Capture Sun

Over Gamut Regions
So, Capture a Diffuse Ball

Diffuse Probe, Same Lighting

Simulate Light on Ball w/o Sun

Calculated from Light Probe
Subtract to Get Solar Component

\[
\text{Measured} - \text{Simulated} = \text{Virtual Measurement}
\]

Virtual Measurement with known sun position tells us the solar direct we were missing.

Sun Replacement Therapy

(Enlarged to reduce artifacts)
Differential Rendering (1)

Render Local Reference

Differential Rendering (2)

Render New Objects
Differential Rendering (3)

\[ \begin{array}{ccc}
\text{Original Image} & + & \text{Added Image} \\
\text{Differential Image} & = & \text{Result Image}
\end{array} \]

Differential Rendering (4)

“Replace” Objects
Let’s Do a Better Job

Full Background Plate

Project onto Approximate Geometry

Create Virtual Backdrop
Automatic Source Placement

- Problem: Small, bright areas cause high variance in a standard Monte Carlo rendering
- Solution: Replace small, bright regions with equivalent light sources
Source Placement Example

Sources cover originals regions, but act as *imposters*

Monte Carlo w/o Sources

Noise caused by high variance in light probe samples
Result with Sources

Roughly the same number of samples

Greedy Source Algorithm

1. Determine luminance threshold based on expected variance contribution
2. Start with brightest unclaimed pixel
3. Grow source toward brightest unclaimed perimeter until:
   a) Source exceeds maximum size, or
   b) Perimeter values all below threshold, or
   c) Source average drops below threshold
4. Loop to step 2 until nothing over threshold
Example mksource Results

Next: Source Constellations

• Basic Idea: Replace entire light probe with point sources, not just brightest regions
• Eliminates the need for sampling to compute diffuse illumination
• A few algorithms have been published
Source Constellations (1)

K-means clustering


Source Constellations (2)

Improved K-means clustering

Source Constellations (3)

Geometric Penrose tiling

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Constellation Pros & Cons

- **Pros:**
  - Completely deterministic -- no sampling noise
  - Works reasonably with OpenGL and the like
- **Cons:**
  - Many sources needed to avoid false shadows
  - Still must send diffuse rays for global illumination
Check on Rendering

• Is it done?
• Is it beautiful?
• Did it crash and burn?

Conclusions

• See how easy IBL is?
  – Assuming it worked
• See how difficult IBL is?
  – If it didn’t
• Basic concept is straightforward
• The devil is in the details
  – View alignment
  – Local geometry to catch shadows
Additional Resources

- www.debevec.org
- www.hdrshop.com
- www.openexr.com
- www.idruna.com
- www.anyhere.com
- radsite.lbl.gov/radiance
- www.radiance-online.org
- www.sunnybrooktech.com