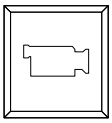
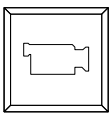
Image-Based Lighting

Greg Ward
Anyhere Software
Albany, California

Roll Inspirational Video



QuickTime



DVD Player

- "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:

Debevec, P. 1998. "Rendering Synthetic Objects Into Real Scenes: Bridging Traditional and Image-based Graphics with Global Illumination and High Dynamic Range Photography." In *Proceedings of SIGGRAPH 98*, Computer Graphics Proceedings, Annual Conference Series, 189-198.

Non-IBL Quick & Dirty Method

1. Photograph Scene

2. Capture Spheremap

3. Synthesize Objects

4. Composite Result

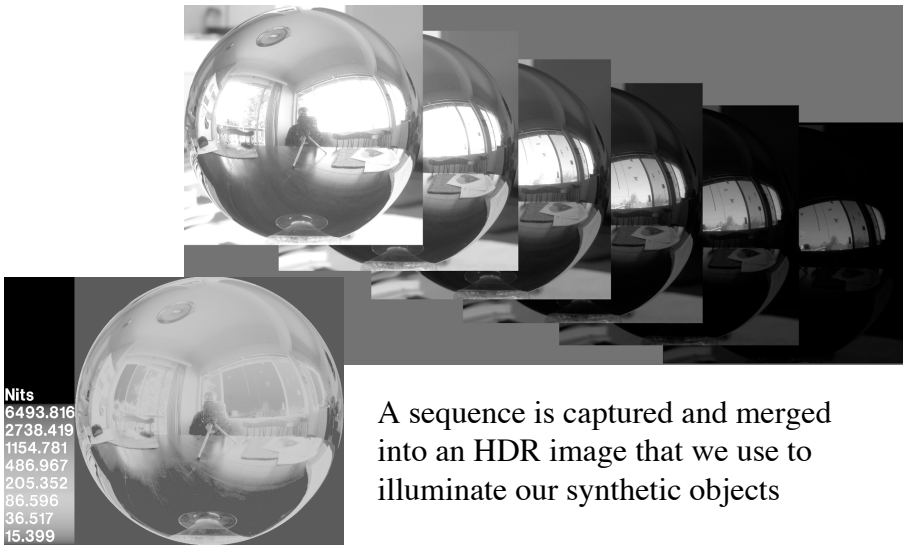
Quick & Dirty

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



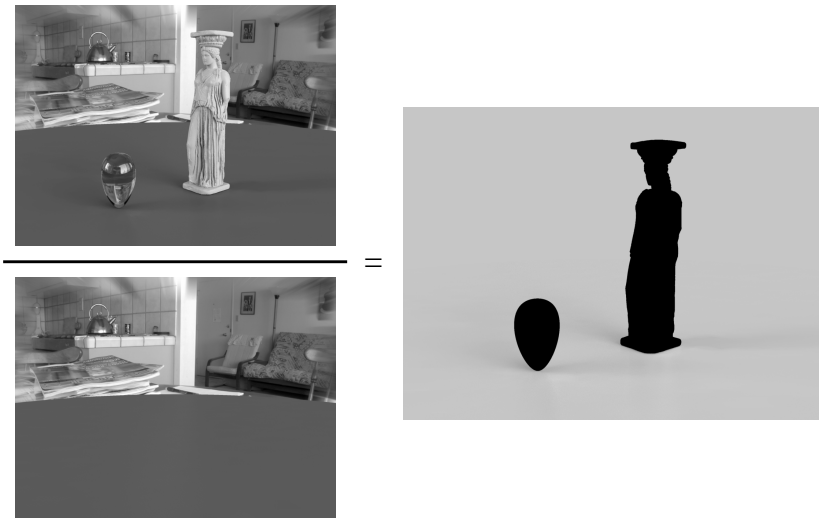
A sequence is captured and merged into an HDR image that we use to illuminate our synthetic objects

Rendering of Environment

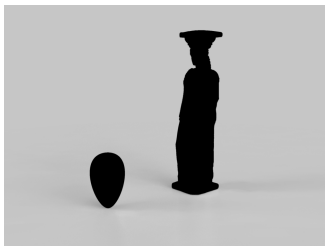
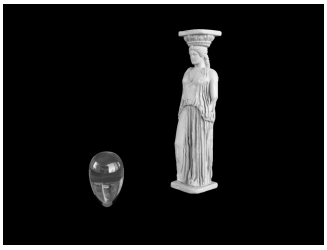
Information behind mirrored ball is missing, so replace it with HDR background plate

Render Synthetic Objects

Compositing of Shadows



Final Composite


*

+

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Final Composite Result

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

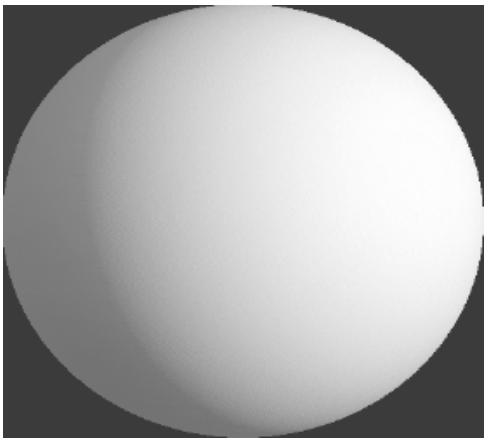
Light Probe

Need to Capture Sun

Over Gamut Regions

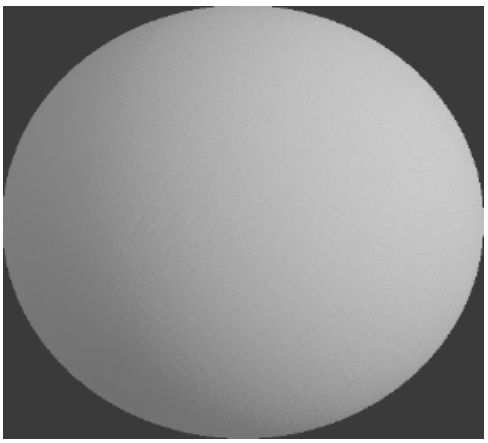
So, Capture a Diffuse Ball

Diffuse Probe, Same Lighting

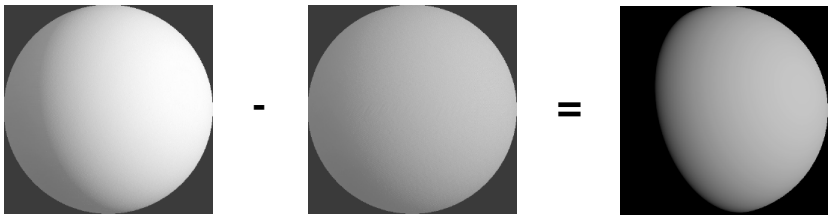


Simulate Light on Ball w/o Sun

Calculated from Light Probe



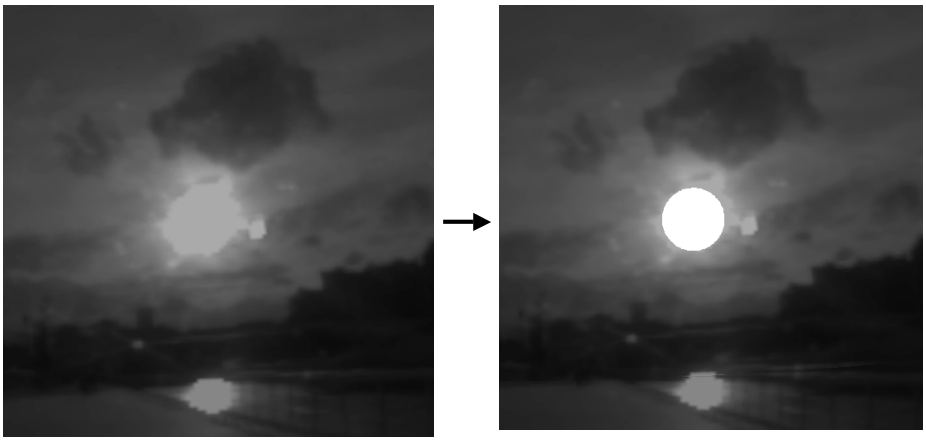
Subtract to Get Solar Component



Measured - Simulated = Virtual Measurement

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

Sun Replacement Therapy



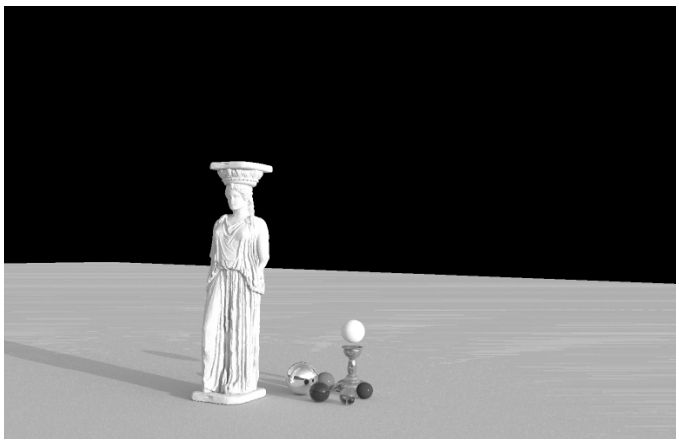
(Enlarged to reduce artifacts)

Differential Rendering (1)

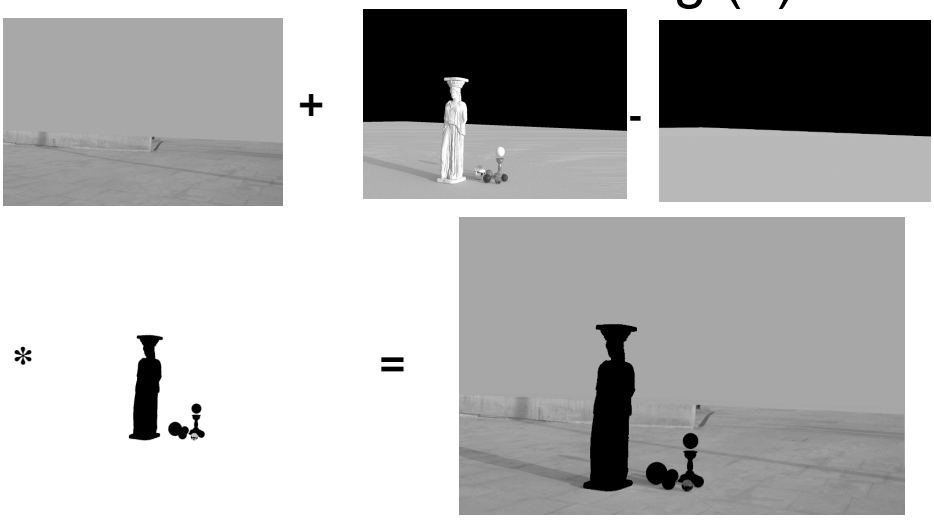
Render Local Reference

Differential Rendering (2)

Render New Objects



Differential Rendering (3)



Differential Rendering (4)

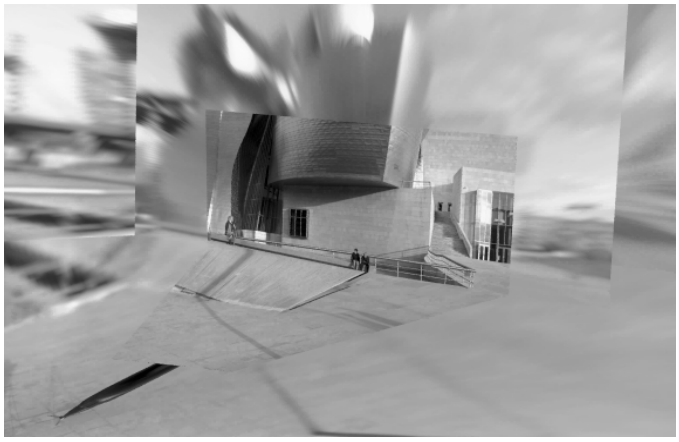
“Replace” Objects

Let's Do a Better Job

Full Background Plate

Project onto Approximate Geometry

Create Virtual Backdrop

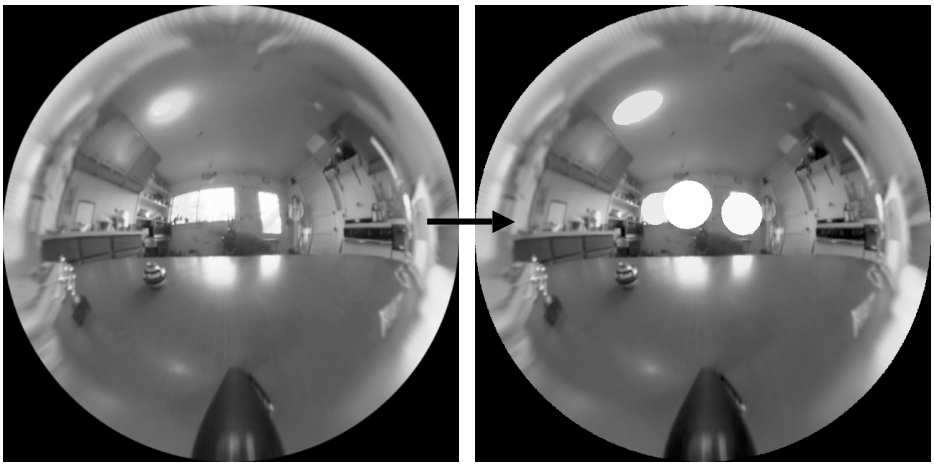


Final Image

Automatic Source Placement

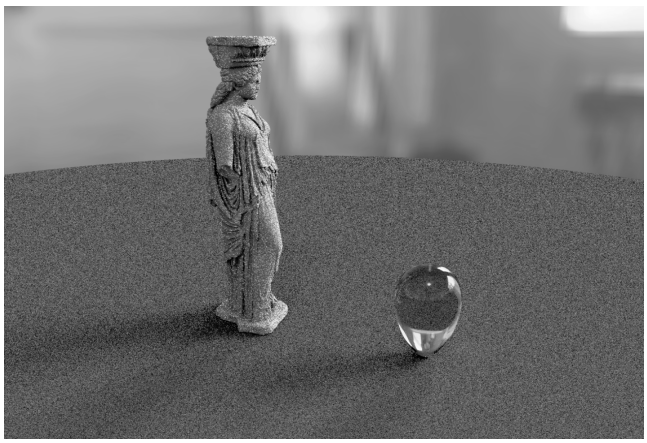
- Problem: Small, bright areas cause high variance in a standard Monte Carlo rendering
- Solution: Replace small, bright regions with equivalent light sources

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

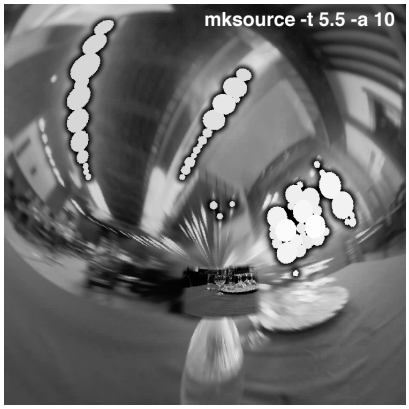
Result with Sources

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

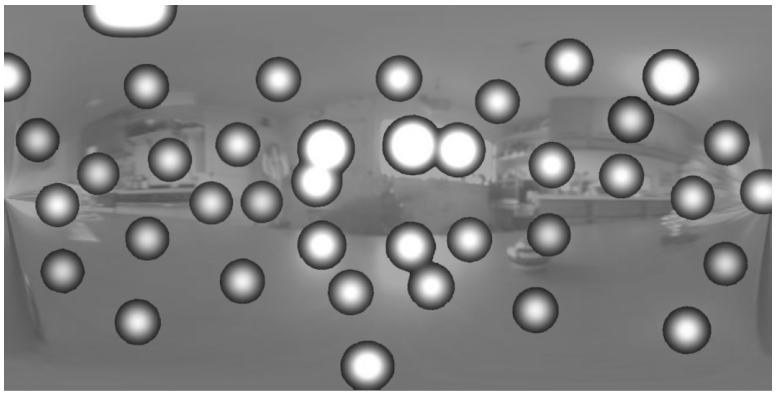


Next: Source Constellations

- 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



Cohen, J., and Debevec, P. 2001. "The LightGen HDRShop plugin." www.hdrshop.com/main-pages/plugins.html

Source Constellations (2)

Improved K-means clustering

Kollig, T., and Keller, A. 2003. "Efficient Illumination by High Dynamic Range Images." In *Eureographics Symposium on Rendering*, 45-51.

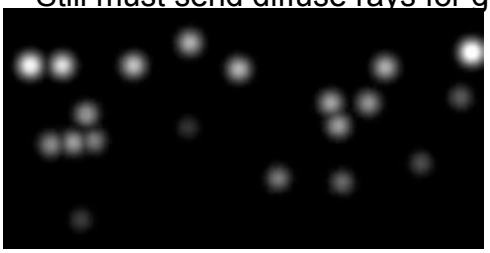
Source Constellations (3)

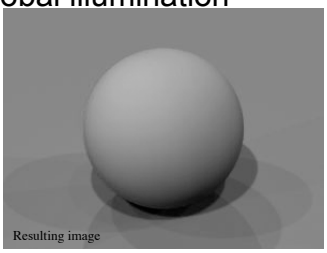
Geometric Penrose tiling

Ostromoukhov, V., Donohue, C., Jodoin, P.-M. 2004. "Fast Hierarchical Importance Sampling with Blue Noise Properties." *ACM Transactions on Graphics* 23, 3 (Aug.), 488-495.

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





Resulting image

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