Capturing Light Probes in the Sun

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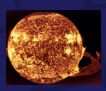
Guggenheim Museum, Bilbao

Shoot Background Plate

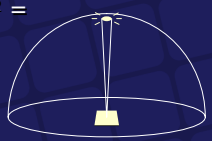
Shoot Light Probe

Problem: sun intensity and color are not captured even in shortest exposure

How bright is the sun?



- Radius = 695,000 km
- Distance = 149,600,000 km
- => 0.5323 degrees in diameter seen from earth
- = 0.00465 radians in radius
- => $1/0.00465^2$ = sun is 46,334 times brighter than "white"



Can we recover the sun?

Incomplete probe | alpha | Unit sun | Complete probe

After diffuse convolution:

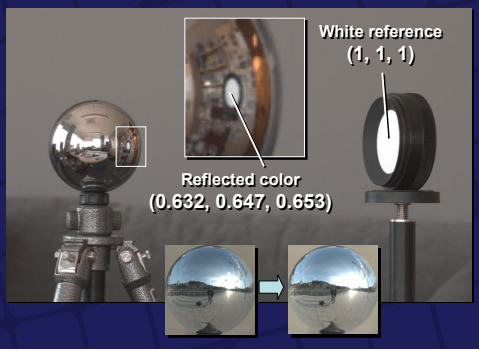
Convolved Incomplete probe | alpha | Convolved Unit sun | Convolved complete probe = Diffuse sphere!

Shoot Diffuse Sphere

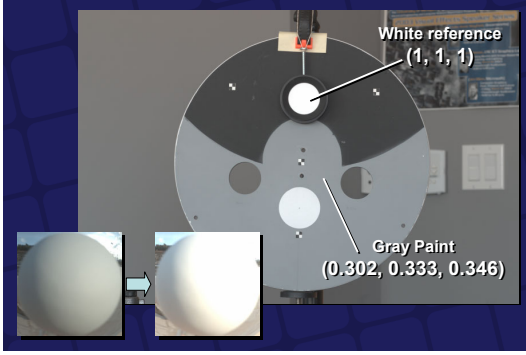
Even better: paint the back of the mirror sphere gray and just turn it around

Crop Diffuse and Probe Images

Scale Probe Image to account for less-than-100% Reflectance of the Sphere

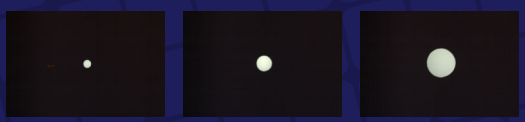


Convert Gray Sphere into a White Sphere using Reflectivity of Paint



Calibrate Lens Transmission Ratios

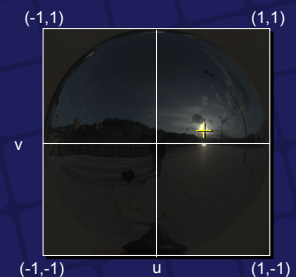
Diffuse white light at
160 cd/m^2 or
50 footlamberts

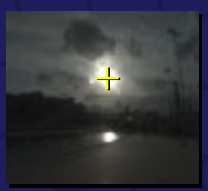


8mm	24mm	200mm
f/11, 1/60th sec	f/11, 1/60th sec	f/11, 1/60th sec
(1.43, 1.54, 1.30)	(1.73, 1.88, 1.52)	(1.22, 1.34, 1.10)

For better accuracy, should perform this measurement across entire field of view to obtain each lens's *flat field response*

Determine Sun Position in Probe





(u, v) = (0.414, 0.110)

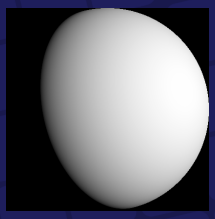
(Dx,Dy,Dz) =
(0.748, 0.199, 0.633)

$\theta = \arctan2(-v, u)$ $\quad \phi = 2 \arcsin((u^2 + v^2)^{1/2})$

$(Dx, Dy, Dz) = (\sin\phi \cos\theta, \sin\phi \sin\theta, -\cos\phi)$

Create a Unit Sun Source

```
# unitsun.rad

void light suncolor
0
0
3 46334 46334 46334

# Sun intensity chosen to light
# white diffuse surface at (1,1,1)

suncolor source sun
0
0
4 0.748 0.199 0.633 0.5323

# Sun subtended angle = 0.5323 deg.
```



RADIANCE file for unit sun

Create Probe Lighting Environment

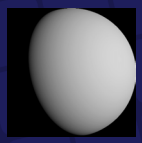
```
# Light Probe Environment probe.rad

void colorpict lightprobe
7 red green blue probe.hdr spheremap.cal u v
0
0

lightprobe glow lightprobeglow
0
0
4 1 1 1 0

lightprobeglow source sky
0
0
4 0 1 0 360
```

RADIANCE file for light probe

Solve for Sun Scaling Factor

Incomplete probe

$+ \alpha$



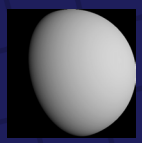
Unit sun

$\approx$

Diffuse Ball

Subtract incomplete probe from both sides to obtain:

α



$\approx$

Then solve for α = (1.166, 0.973, 0.701)

Adjust Sun Intensity

```
# sun.rad

void light suncolor
0
0
3 54006 45083 32464

# obtained sun intensity as:
# 46334*(1.165581,0.972998,0.700642)

suncolor source sun
0
0
4 0.748185858 0.198793344 0.633008
0.5323
```

Verify composite probe matches diffuse ball

Lit with Sun

$+$

Lit with Probe

$=$

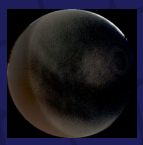
Rendered Diffuse

Real Diffuse

$-$

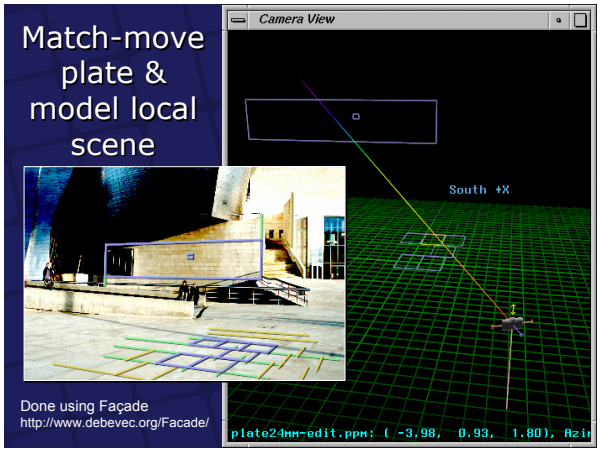
Rendered Diffuse

$=$

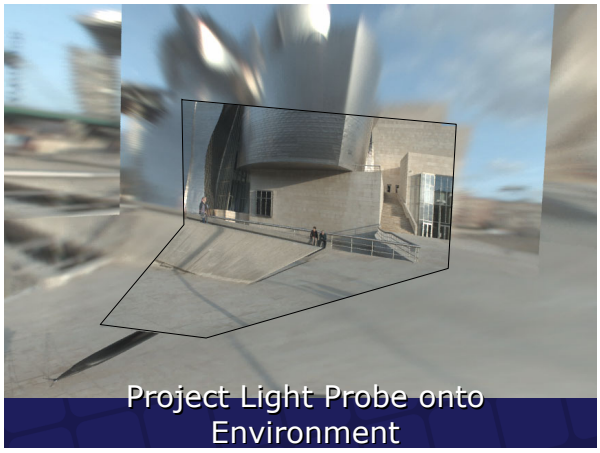


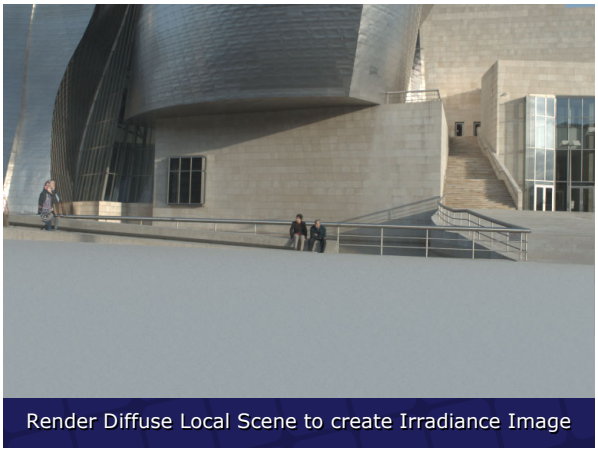
Avg. Error (0.5%, 0.3%, 0.2%) RMS Error = (2.2%, 1.8%, 1.3%)

Background plate

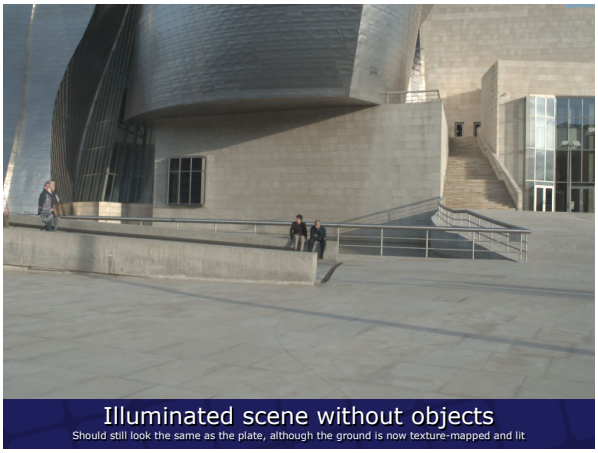

Match-move plate & model local scene
Camera View
South +X
Done using Façade
http://www.debevec.org/Facade/
plate24mm-edit.ppm: (-3.98, 0.93, 1.80), Azi


Project Background Plate onto Local Scene
Viewed from the original viewpoint, it should look the same

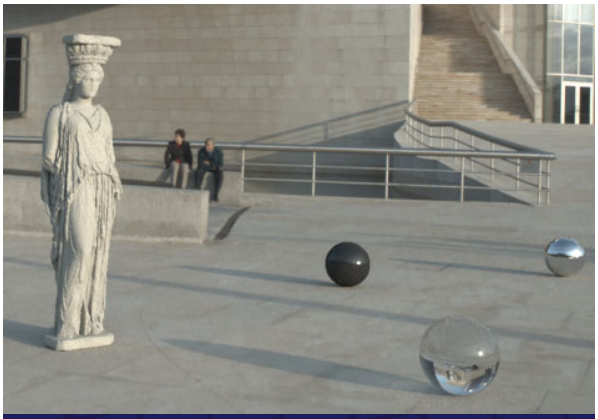

Project Light Probe onto Environment


Render Diffuse Local Scene to create Irradiance Image


Divide background plate by irradiance to produce local scene texture map
• Reflectance = radiance / irradiance
pcomb –e 'ro=0.5*ri(1)/ri(2);go=0.5*gi(1)/gi(2);bo=0.5*bi(1)/bi(2) ' back.hdr local.hdr > localref.hdr


Illuminated scene without objects
Should still look the same as the plate, although the ground is now texture-mapped and lit

Final render with objects
Virtual shadows should match the real shadows



Final render closeup

Thanks!

- Andreas Wenger – CRW converter
- Chris Tchou – HDRShop features
- Greg Ward – Radiance renderer
- Teddy Kim – Probe assistance
- Maya Martinez – Rendering composition
- ICT Graphics Lab – Presentation comments

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