CS 395/495-26: Spring 2002

IBMR: Week 8A

Light Probes
$P^3 \rightarrow P^2$: The Camera Matrix

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## Reminders

- **HW1 delayed: due Today, May 21**
- Proj3 Due Thurs May 23
                HW2 posted on website.
- HW2 due Thurs May 30
                Proj4 Assign Thurs May 23
                HW 3 Assign Tues May 28
- Proj4 Due Tues June 11
- HW3 Due Tues June 11

Practical Panoramas: 'Box Cross'

- Spherical maps oversample near poles;
- Cylindrical maps can't see floor, ceiling spot
- Nice solution: 'Box Cross'
  - 'unwrap' a cube around origin
  - 6 square planar images
  - Easy!
    - for each image,
    - for each box side,
    - find reprojection **H**
    - find pixels on box
    - rewarp as needed (cyl,sphere, etc.)
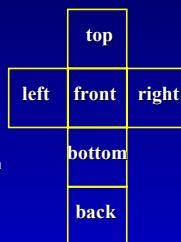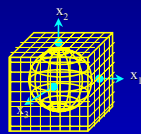
Panoramic Cameras
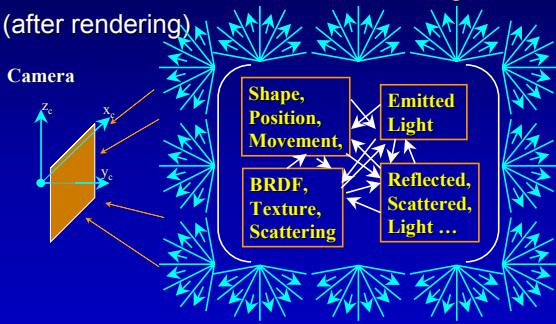
Panorama without 'stitching':
- 'Fisheye' Lenses, conics,…
- Slit-scan: (WideLux, Noblex, PanoScan…)
  - cyl. or spherical image
  - slow! no action shots
- Multiple Planar Cams
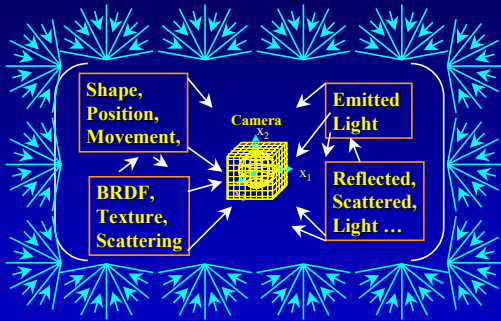 - Fast, flexible, expensive
  - can do panor. movies
- History: 1843…http://www.panoramicphoto.com/timeline.htm

'Rendering' from a camera?

Conventional: external camera reads light field (after rendering)

Camera

z_c x_c y_c

Shape, Position, Movement,

Emitted Light

BRDF, Texture, Scattering

Reflected, Scattered, Light …

'Rendering' from a camera?

IBMR: Let camera measure light inside scene

Shape, Position, Movement,
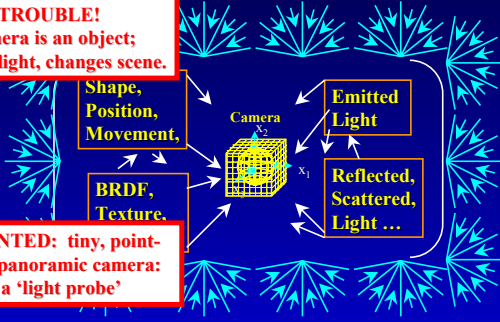
Camera x_2

Emitted Light

x_1

BRDF, Texture, Scattering

Reflected, Scattered, Light …

Render from camera images?

IBMR: Camera measures light inside scene

TROUBLE!
Camera is an object; reflects light, changes scene.

Shape, Position, Movement,

Camera x_2

x_1

Emitted Light

BRDF, Texture,

Reflected, Scattered, Light …

WANTED: tiny, point-like panoramic camera: a 'light probe'

One Answer: Light Probe

Photograph a small mirror sphere

Camera x_c

y_c

Shape, Position, Movement,

Mirror Sphere

BRDF, Texture, Scattering

Emitted Light

Reflected, Scattered, Light …
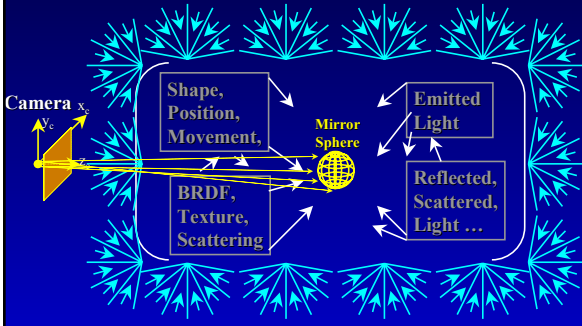
Light Probes: How?

- Tele-photo a mirror sphere (narrow FOV)
- warp image to find irradiance .vs. direction

High contrast?
Higher resol.?
More positions?
More Pictures!

Paul Debevec, SIGGRAPH2001 course "Image Based Lighting"

A multi-image filter and varying levels of neutral density gel simultaneously produce five differently exposed images of the mirrored ball.

Jamie Waese and Paul Debevec. A Real Time High Dynamic Range Light Probe. SIGGRAPH 2001 Technical Sketch.
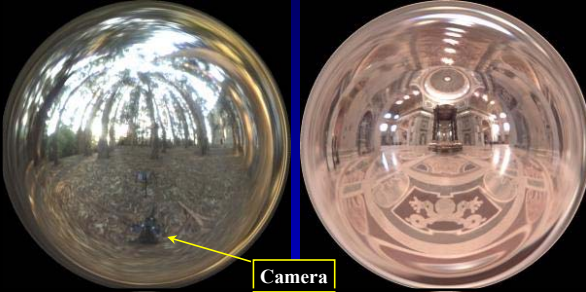
Light Probe Images

- Example images
  (see Debevec's site)

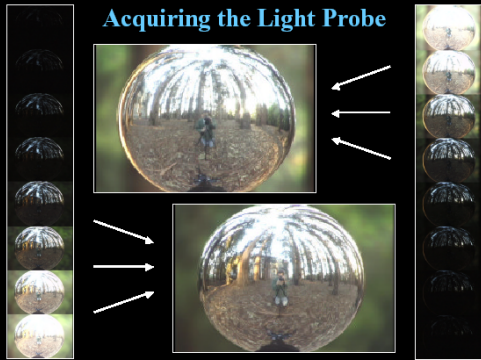 Paul Debevec, SIGGRAPH2001 course "Image Based Lighting"   (Retouched to remove camera)

  Camera

High Contrasts too!

Paul Debevec, SIGGRAPH2001 short course "Image Based Lighting"

Acquiring the Light Probe

(Try it yourself—I'd like to…)

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Paul Debevec, SIGGRAPH2001 short course "Image Based Lighting"

Sources of Mirrored Balls

2-inch chrome balls < $20 ea.
King Bearing, Inc.
Applied Industrial Technologies
(many locations nationally, check www.bigbook.com)

6-12 inch large gazing balls (blown glass)
Baker's Lawn Ornaments
 570 BERLIN PLANK ROAD
  SOMERSET, PA 15501-2413
  814-445-7028

Light Probes

- 'One-shot' panoramic camera
- Clever, fast, simple, cheap, flexible
- Probe position != Camera position; telephotos…
  - allows small probes in tight, risky spaces
  - Little/no image alignment / mosaicing
- Drawbacks:
  - Highly non-uniform sampling
  - Camera ALWAYS in the image
- Daydreams: a better probe?
  - Huge: mirrored weather balloon?
  - Tiny, stochastic: bubbles in a liquid?
  - Dynamic shapes: whirling mirror on arm?
  - Other shapes: Nayyar, Carlbom, ?He(MSRchina) etc.

Mirror Ball→Panorama Conversion

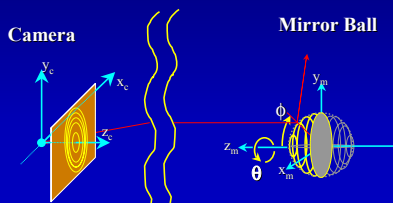Makes an offset 'virtual' sphere camera
    located at mirror ball center:

- ? How can we write this in P^2 and/or P^3?
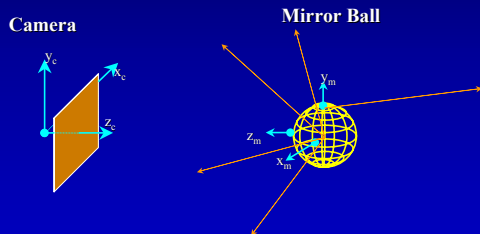
Camera   **Mirror Ball**

## Mirror Ball→Panorama Conversion

Not Documented?!? Then figure it out…
  - Parameterize ball as 'rings' of constant ϕ
  - (Ignore invisible backside of sphere)
  - Warp 1: get ring colors from camera image

Camera   **Mirror Ball**

Mirror Ball→Panorama Conversion

- Parameterize ball using 'rings' of constant ϕ
- Warp 1: read color from rings' camera image
- Find reflected ray angle ϕ' (constant on a ring)
  - (presume the ball diameter ~zero; then $\phi' = 2\phi$)
- Use ring at angle ϕ' on spherical projection
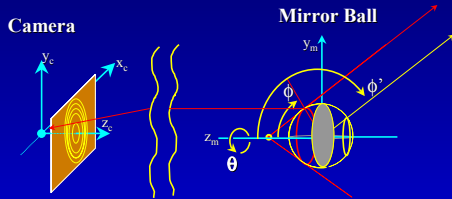
Light Probes: Daydreams

- Debevec: 'Light Stage 2.0'
  - Apply light probe data
  - Lighting basis fcns

- Go further!
  - Sphere of projectors sets incoming light field
  - CAVE / Light Stage corrupted by interreflections
  - Probe(s) measure ACTUAL incoming light
  - Math: Remove interreflected amounts from computed display

END