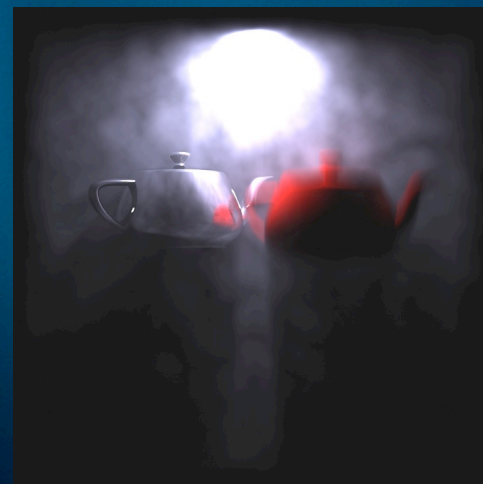
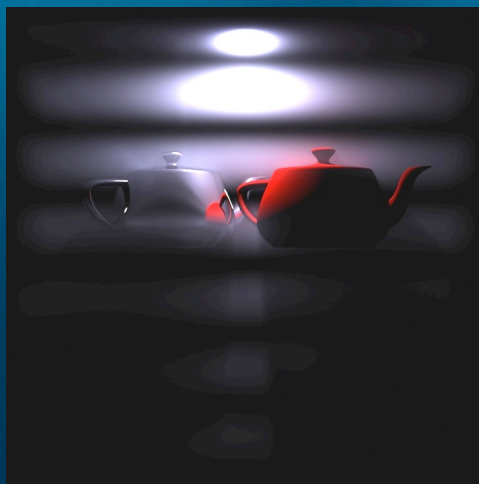
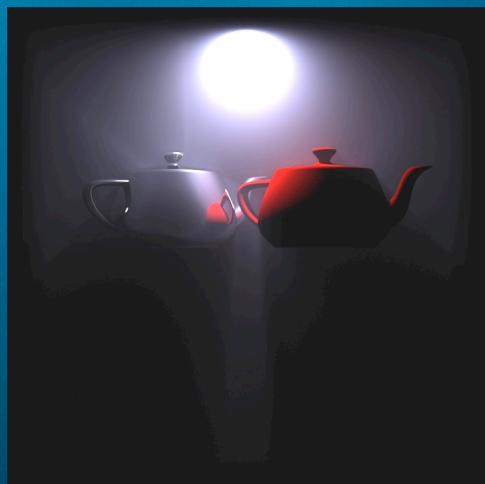


Photon Mapping in Pixar's RenderMan



Per Christensen

Pixar Animation Studios

SIGGRAPH 2012 Course:
State of the Art in Photon Density Estimation

PIXAR

Background

- PRMan has had photon maps implemented for ~ 10 years
- Currently undergoing a renewed development effort to make more programmable and implement new features
- Photons not for everything; use where advantageous

Overview

- PRMan uses photons several ways
 - for caustics
 - for irradiance estimate for global illum
 - for guiding diffuse rays -- NEW
 - for volume rendering -- NEW

Outline of talk

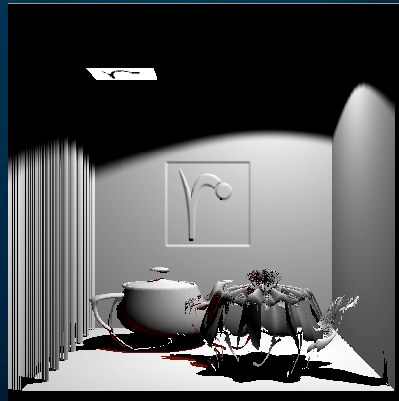
- Photon emission
- Photon scattering
- Rendering:
 - photon guiding
 - motion blur
 - mostly volumes

Photon emission: light sources

- General and programmable light sources are a pain:
 - barn doors, “cookies”, non-physical falloff, ...
- How can we match photon emission to direct illumination?

Photon emission: 3 methods

- Evaluate light source and emit accordingly
 - point/spot/directional, falloff; eval at hit point
- Generate direct illum point cloud; emit from points

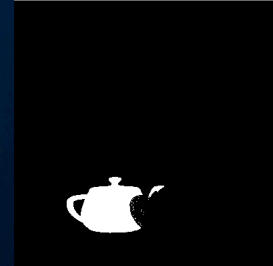


- generatePhoton() shader method: org, dir, power

PIXAR

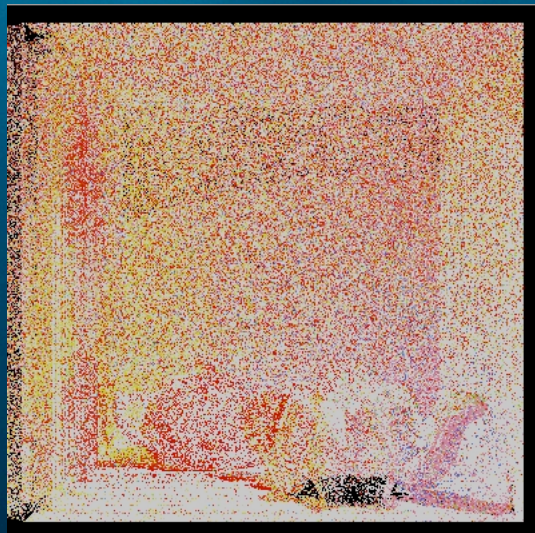
Photon scattering: 3 methods

- Built-in simple materials
 - matte, glass, chrome, dielectric, ...
 - isotropic, rayleigh, hazy mie, ...
- Read brdf scattering coeffs from point cloud



- Shader method (work in progress)

Photon map examples



photons (2.6M)



radiance estimates

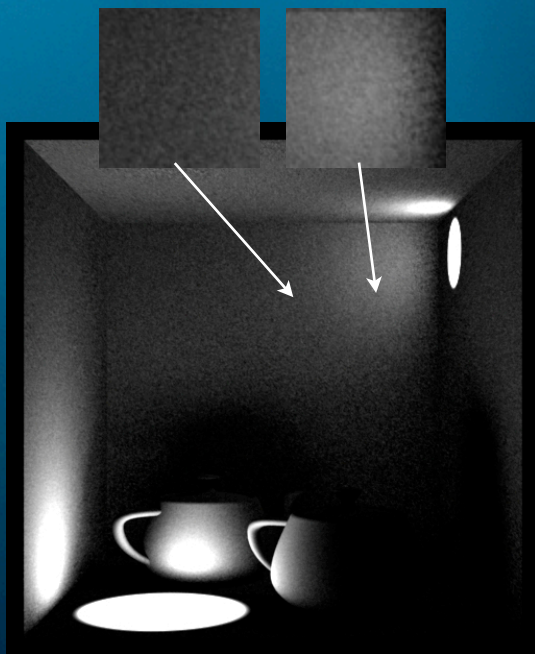
Rendering

- Photon-guided diffuse rays
- Motion-blurred photons
- Photon beams for volumes

Photon-guided indirect diffuse rays

- Helps when direct illum is very uneven
 - e.g. spotlights or sunspot on floor of room
- When sampling hemisphere above a point for indirect illum: “blind” sampling or use nearest photons to guide

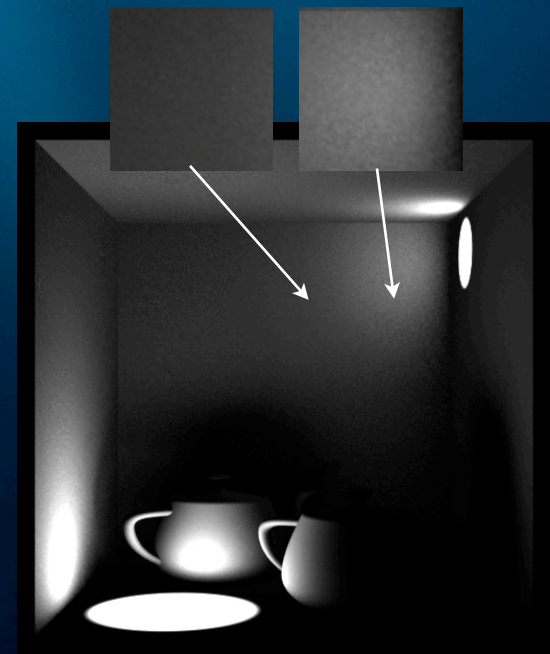
Photon-guided indirect diffuse rays



without guiding



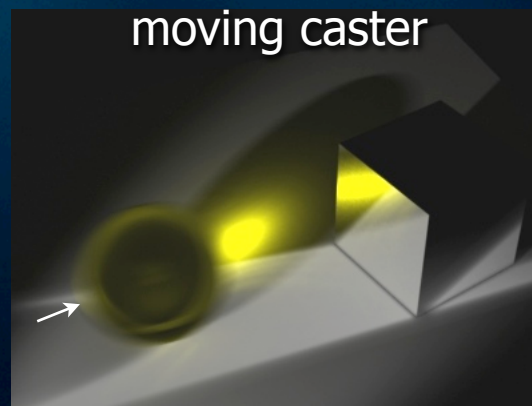
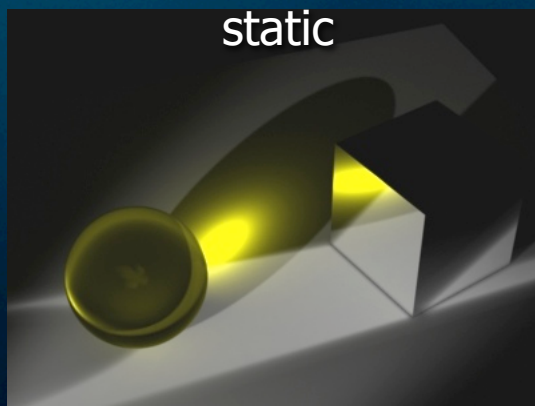
photon map



with guiding

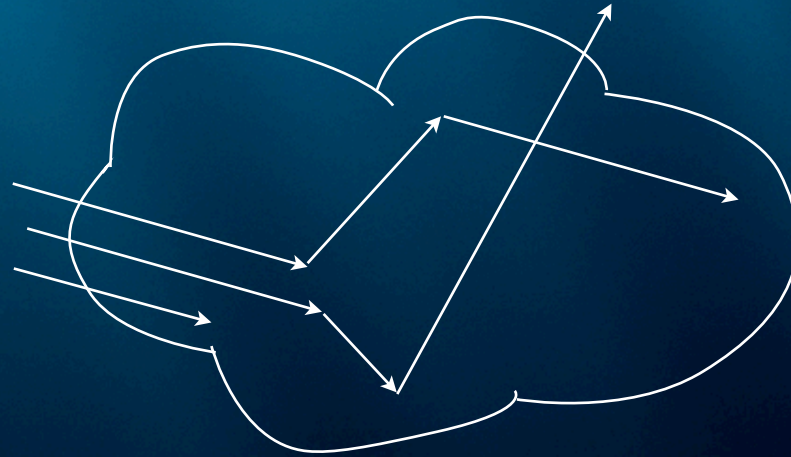
Motion-blurred photons

- Emit photons with random times t
- Lookups [Cammarrano02]:
 - reject photons with t outside shutter segment
 - divide radiance estimate by segment length



Photon beams for volumes

- Treat each photon in map as a beam instead of point [Jarosz08]



- Make better use of the information in the photon map

Photon beams for volumes

- Lookups: find nearest beams passing by shading point
- radiance = sum of (power * phasefunc) / area ("2D estimate")

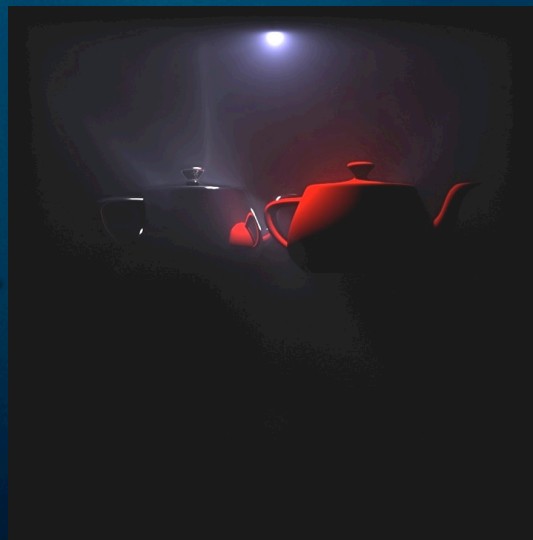
Rendering: volume examples

- Homogeneous volume, photon map for indirect illum



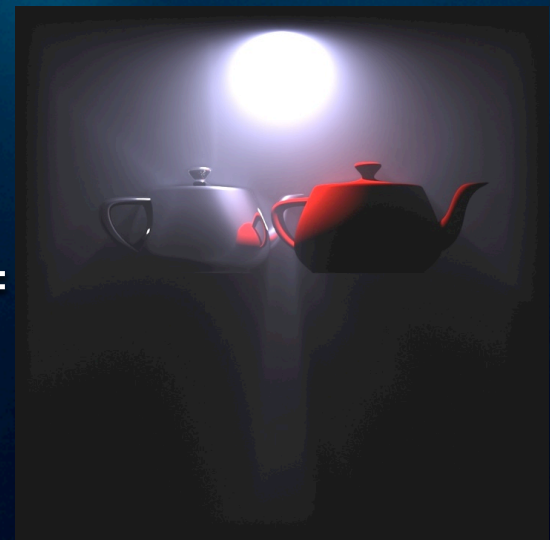
RT direct illum
(3 min)

+



pmap indirect
(1M photons, 3 min)

=

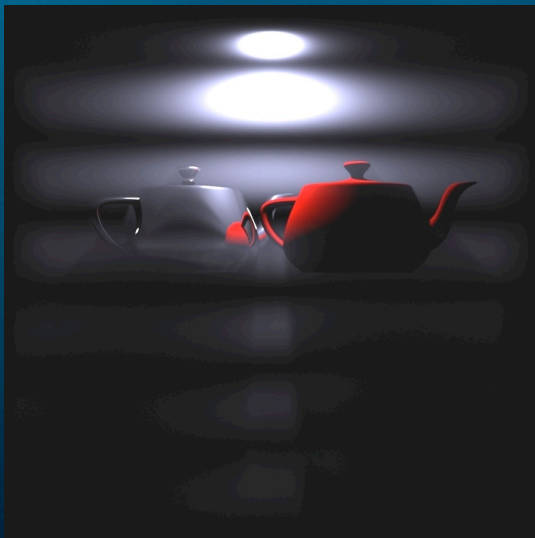


RT direct + pmap indir
(7 min)

PIXAR

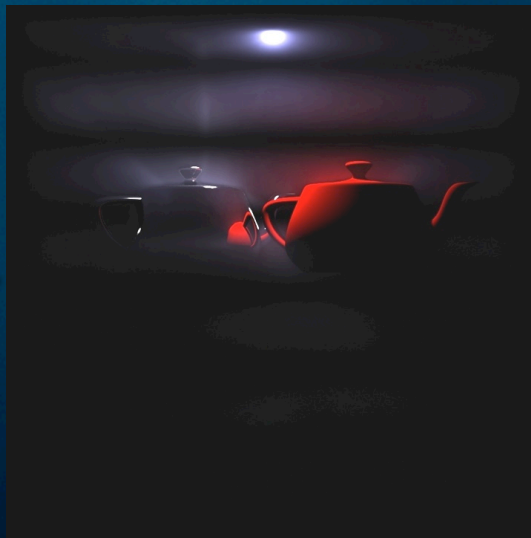
Rendering: volume examples

- Inhomogeneous volume (sine func), photon map for indirect illum



RT direct illum
(3 min)

+



pmap indirect
(1M photons, 3 min)

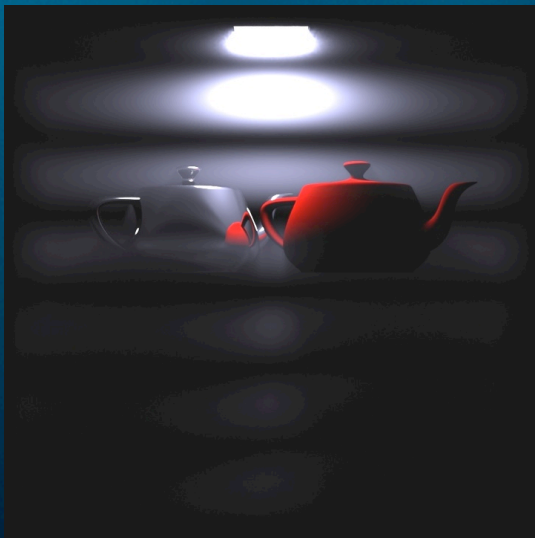
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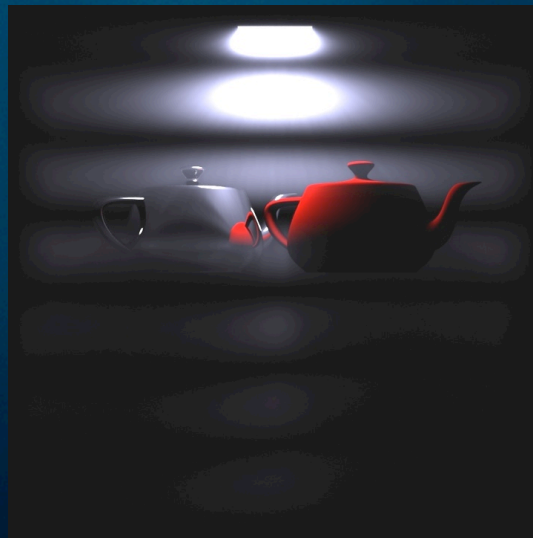
RT direct + pmap indir
(7 min)

Rendering: volume examples

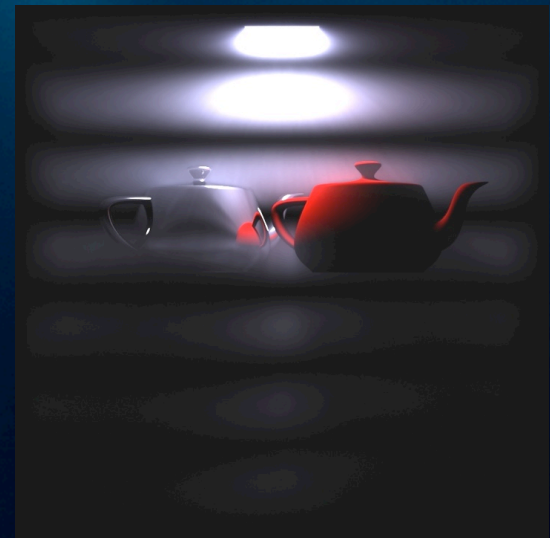
- Inhomogeneous volume (sine func),
pmap direct+indirect illum, soft shadow



Ref: RT direct illum
(7 min)



pmap direct illum
(8 min)



pmap direct + indir
(9 min)

Rendering: volume examples

- Inhomogeneous volume (turbulence), anisotropic scattering, pmap direct+indir



isotropic



hazy Mie



H-G 0.5



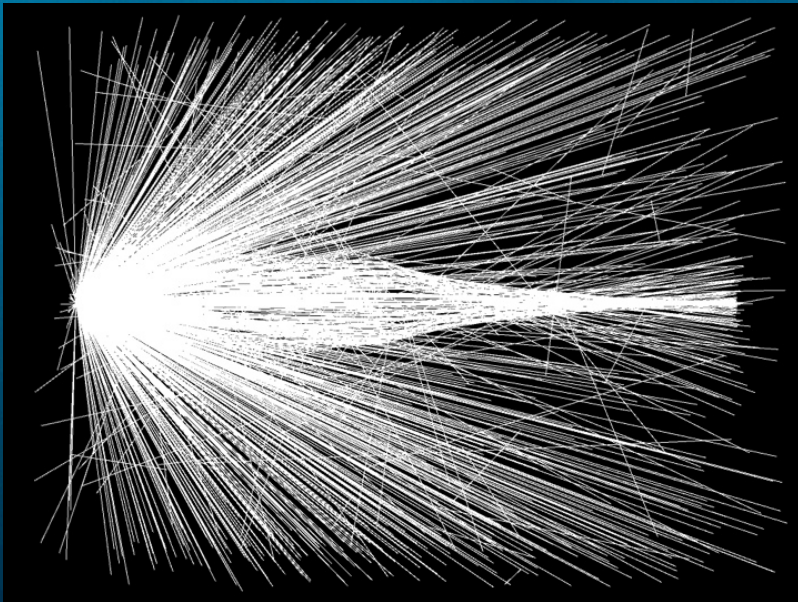
H-G 0.8

Rendering: volume + motion blur

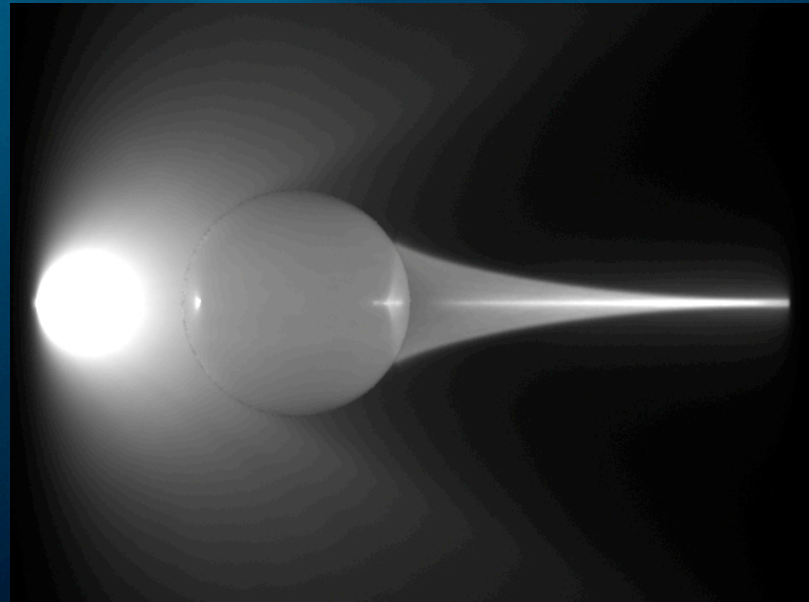
- Inhomogeneous volume (turbulence),
pmap direct+indir illum



Rendering: volume caustic



photon beams (1k)



volume caustic (100k)

Other new photon stuff

- Parallel photon tracing
- “Transient” photon maps: single-pass, in-memory instead of two-pass, file on disk

Conclusion

- Photon mapping in PRMan can be used for
 - caustics
 - global illumination
 - photon-guided indirect diffuse rays
 - volumes: direct, indirect, caustics

Acknowledgements

- RenderMan team
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Thanks!