The RADIANCE Photon Map

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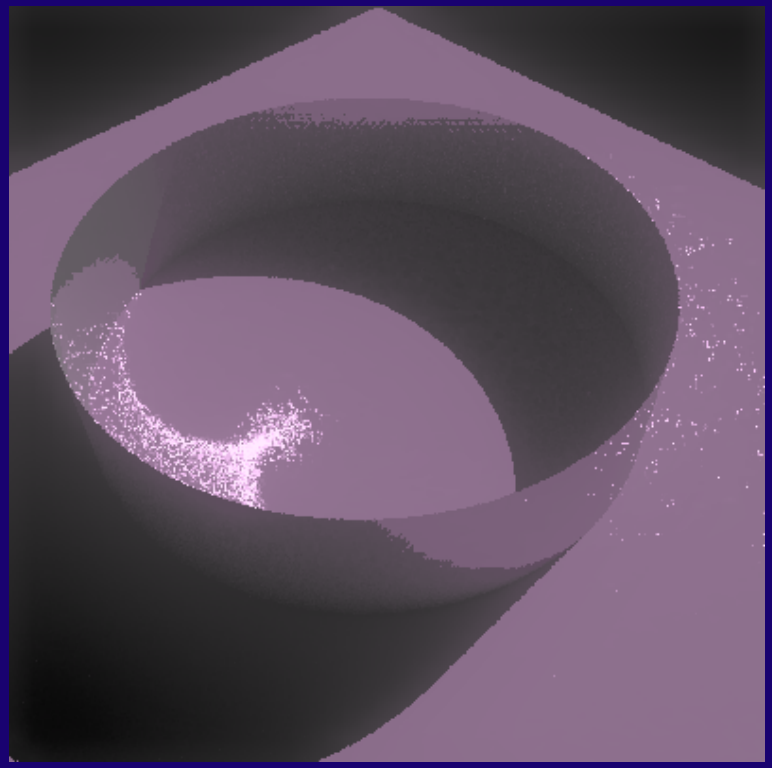
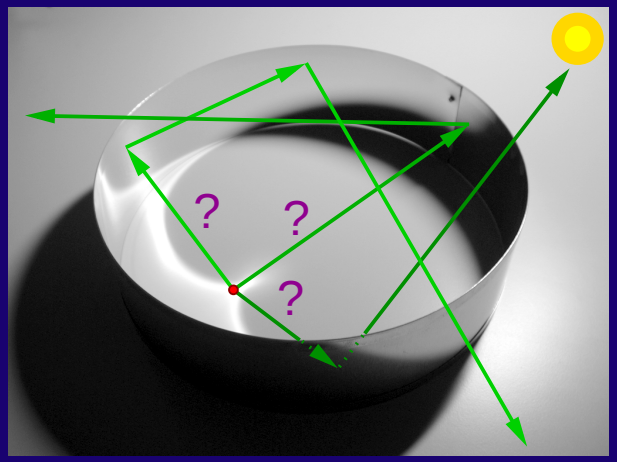
Motivation: Caustics



Motivation: Backward Raytracing

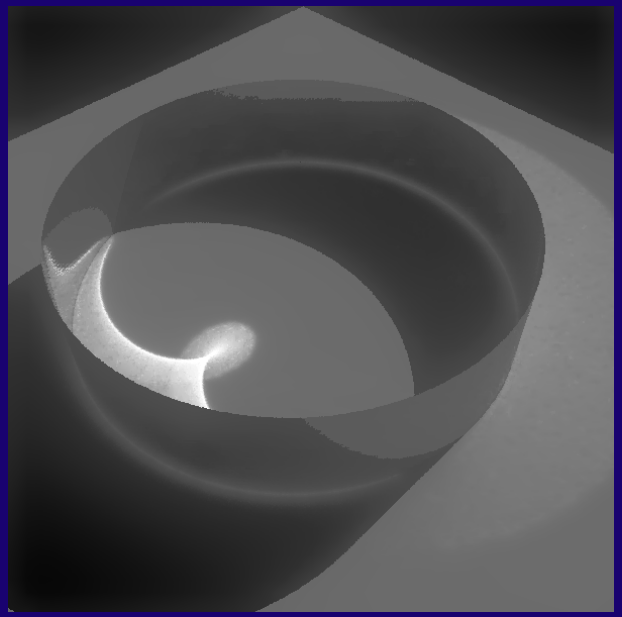


RADIANCE is a *backward* raytracer

- cannot simulate caustics adequately
- problems with specular daylight systems

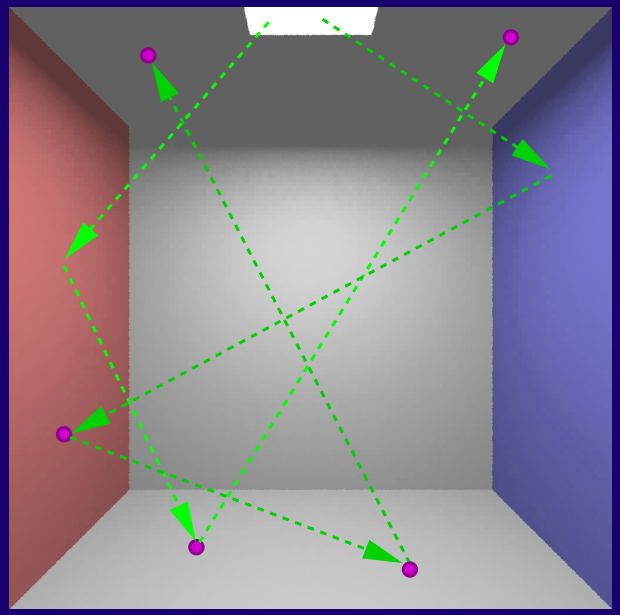
⇒ supplement with *forward* raytracer!

Photon Map (Wann Jensen, 1995)



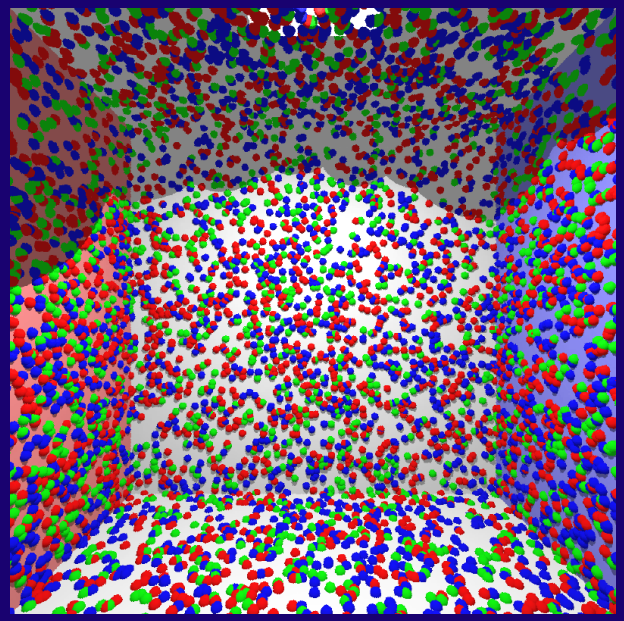
- Forward raytracer
- Monte Carlo (light) particle transport simulation
- Two pass method
- Couples to RADIANCE's ambient calculation (backward pass)

Photon Map: Forward Pass



- Photons emitted from light sources
- Scattered / absorbed at surfaces
- Indirect hits stored in space subdividing data structure (kd-tree)
- Photon attributes: flux Φ, position $\vec{x}$, normal $\vec{N}$

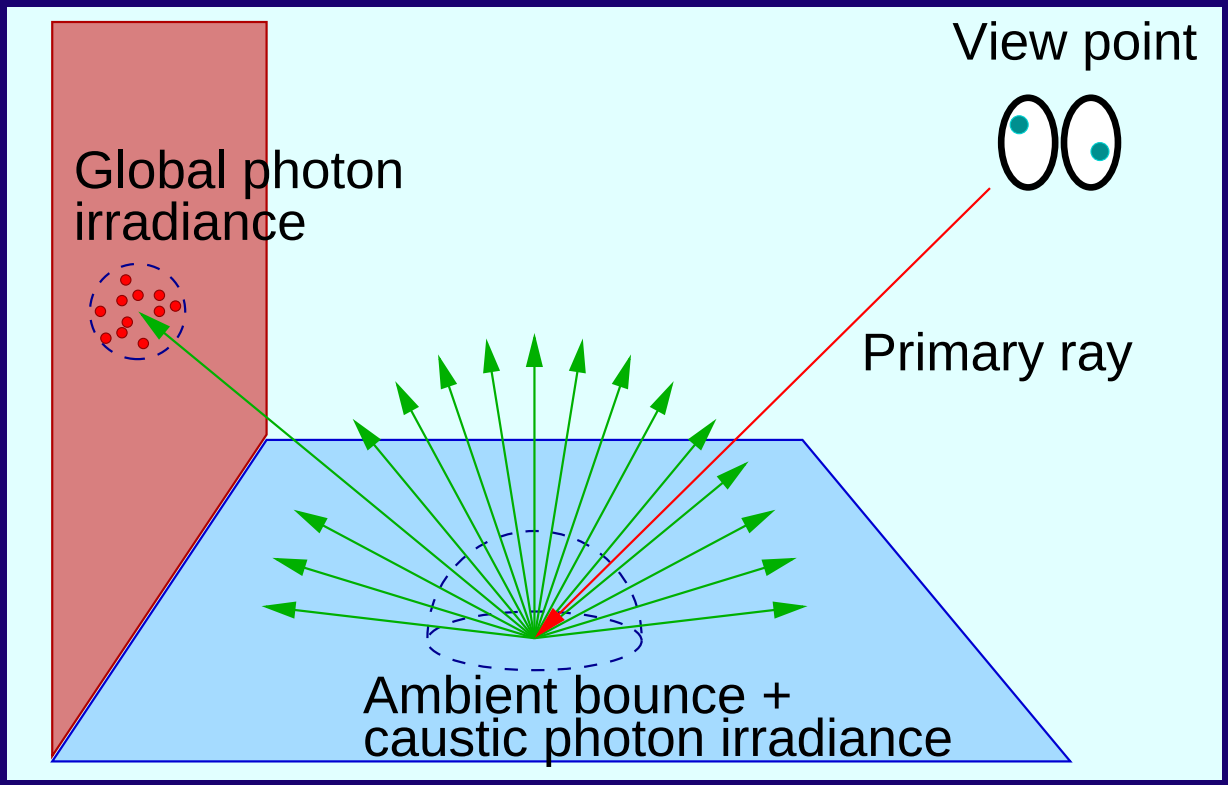
Photon Map: Forward Pass



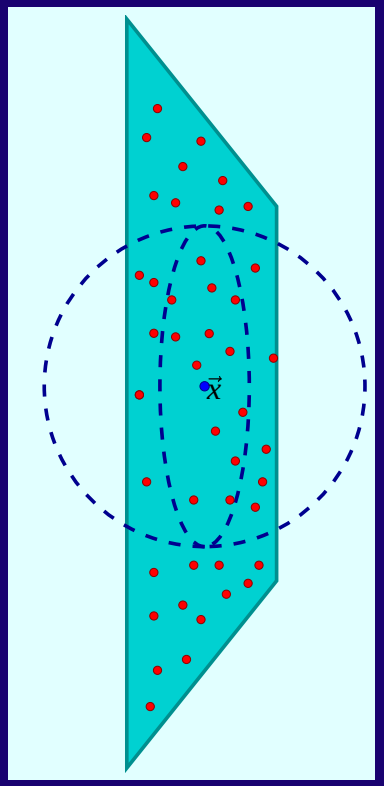
Three photon types:

- Global: (diffuse | specular) $\longrightarrow$ diffuse illumination
- Caustic: specular $\longrightarrow$ diffuse illumination
- Volume: global inscattering in *mist*

Photon Map: Backward Pass



Photon Map: Density Estimation



- Find N nearest photons to $\vec{x}$ in kd-tree
- Irradiance $E(\vec{x})$ proportional to (weighted) photon density

$$E(\vec{x}) \approx \sum_{i=1}^{N} K(\|\vec{x} - \vec{x}_i\|)\,\Phi_i, \qquad \int_0^r K(s)\,ds = 1$$

Epanechnikov kernel: $K_e(s) = \frac{2}{\pi r^2}\left(1 - \left(\frac{s}{r}\right)^2\right)$

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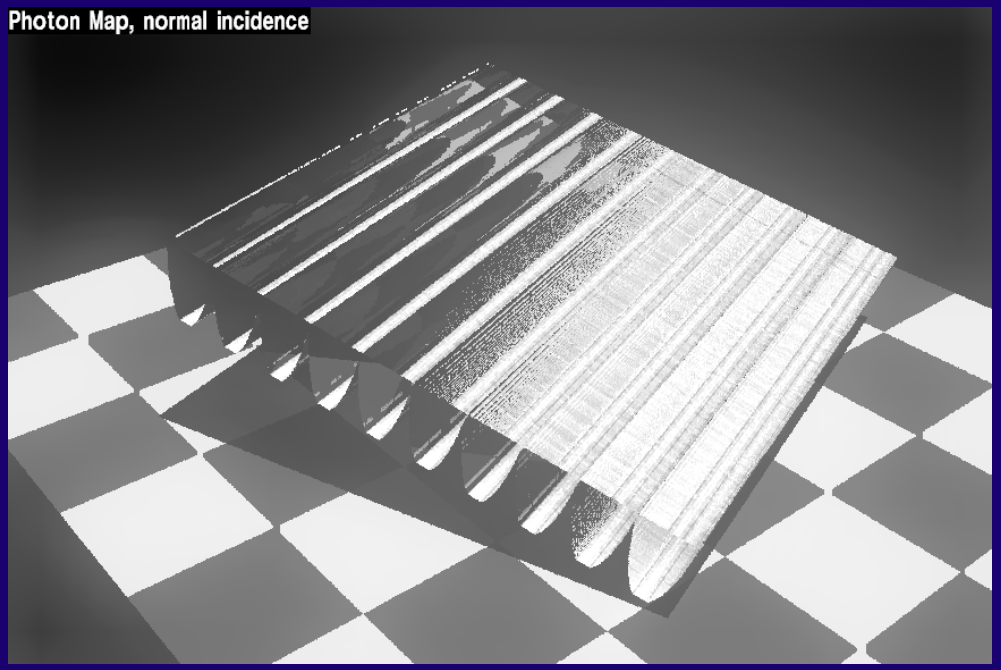
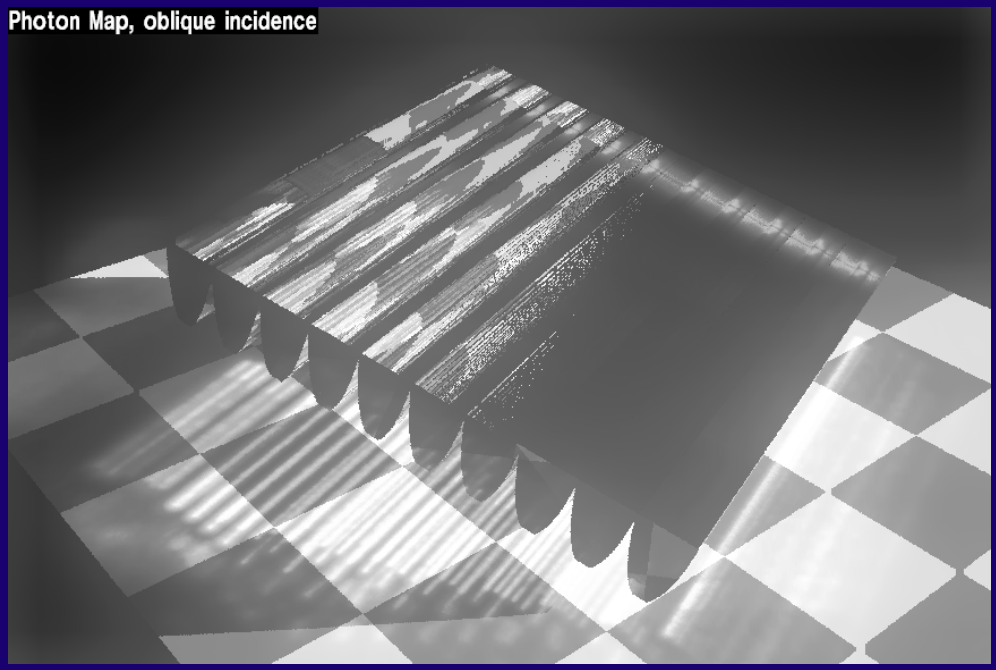
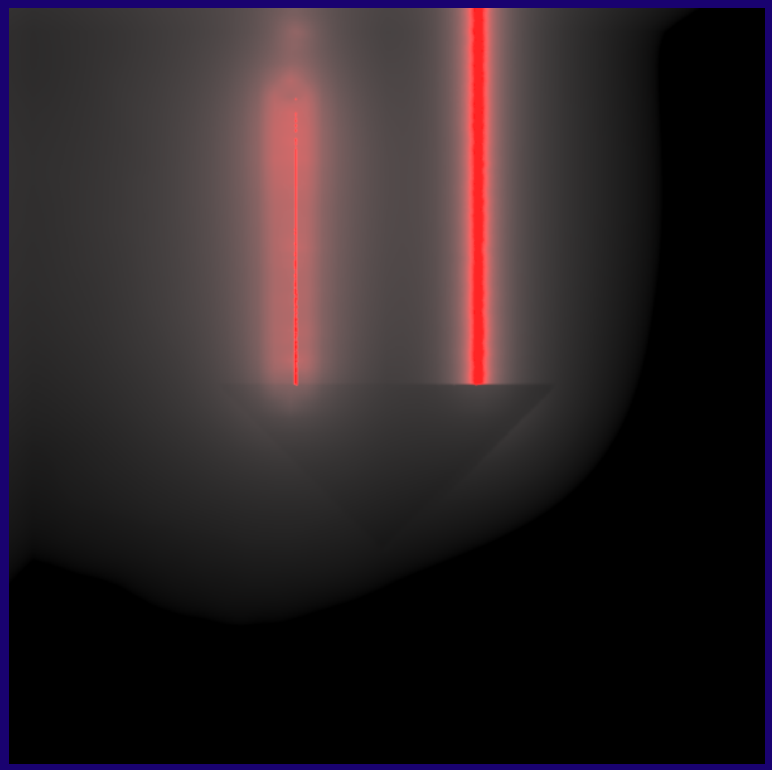
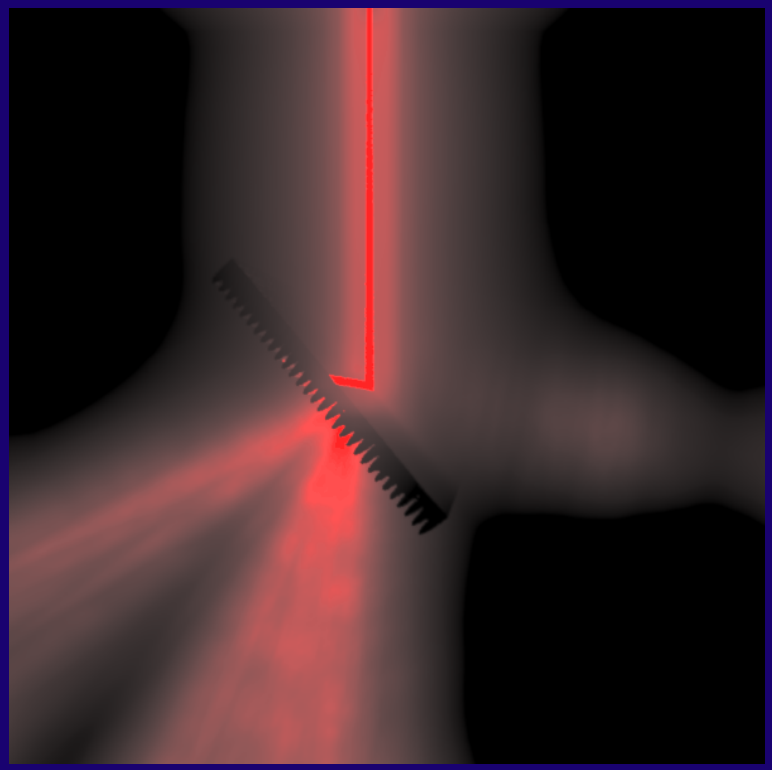
Results: Compound Parabolic Concentrator





Results: Volume Caustics

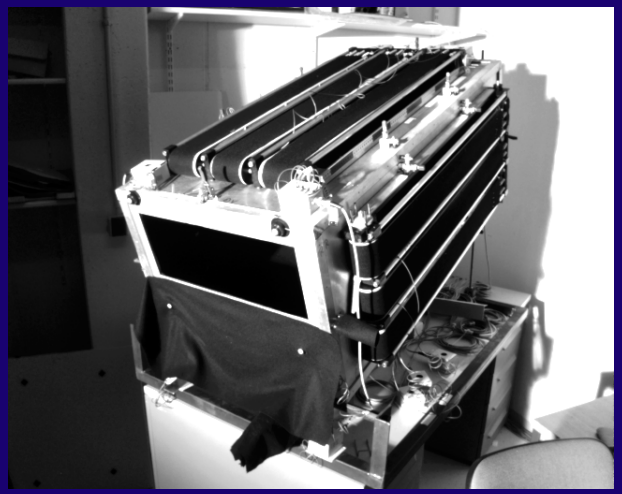




Results: Y-Glass

Results: Lightpipe

Validation



How does photon map measure up to theory and RealLife^{TM}?

- Analytical validation using simple geometry
  $\Rightarrow$ accurate within $\pm$ 0.5%
- Experimental validation using test box with illuminance sensors
  $\Rightarrow$ in progress...

Conclusion

- Photon map enables RADIANCE to efficiently simulate caustics
  - $\Rightarrow$ applicable to redirecting systems
  - $\Rightarrow$ greater simulation scope
- Faster than RADIANCE Classic^{TM}
- Already converged
  - $\Rightarrow$ no ambient bounce / value syndrome
- Validation indicates adequate accuracy