CT5202: Photorealistic Rendering

Global Illumination

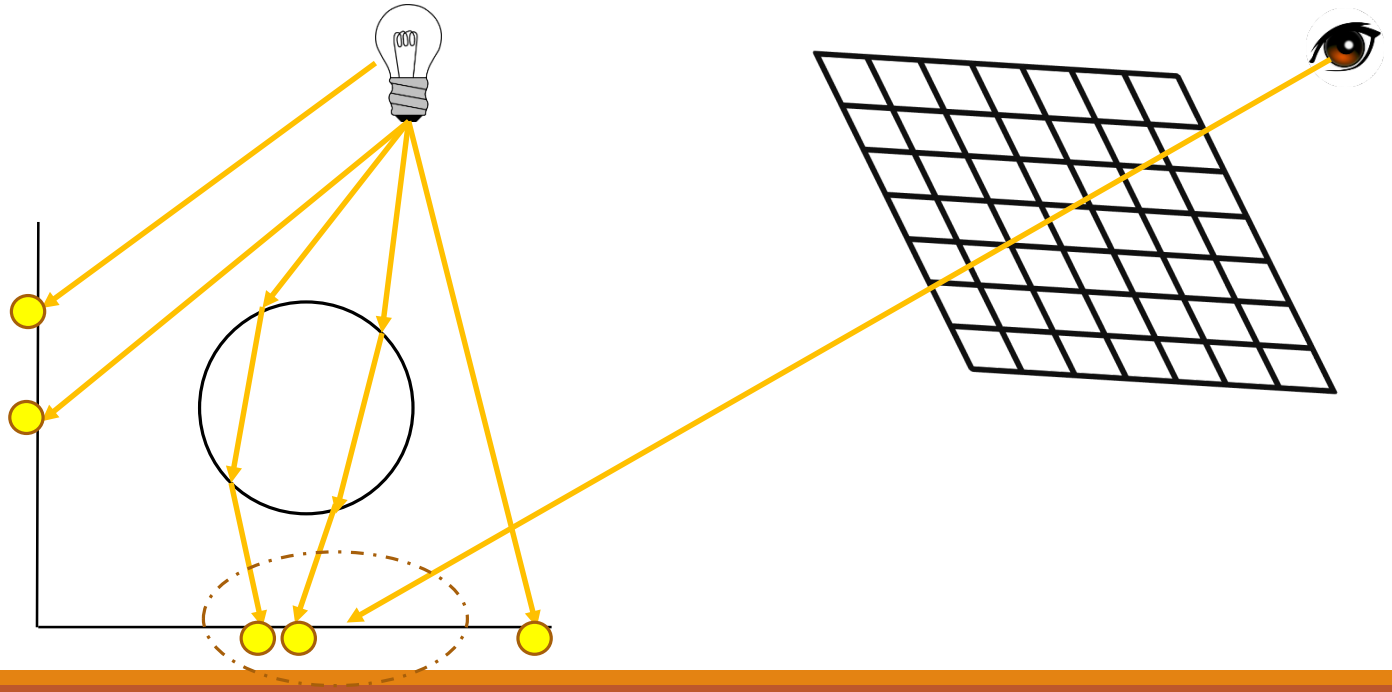
BOCHANG MOON

In the previous lecture,

- Photon Mapping (two pass rendering method)
  - 1. Generate photon maps
  - 2. Render an image using photon maps (radiance estimation)

Radiance Estimation

- $L_r(x, k_o) \approx \frac{1}{\pi r^2} \sum_{p=1}^{N} \rho(x, k_p, k_o) \Delta\Phi_p(x, k_p)$



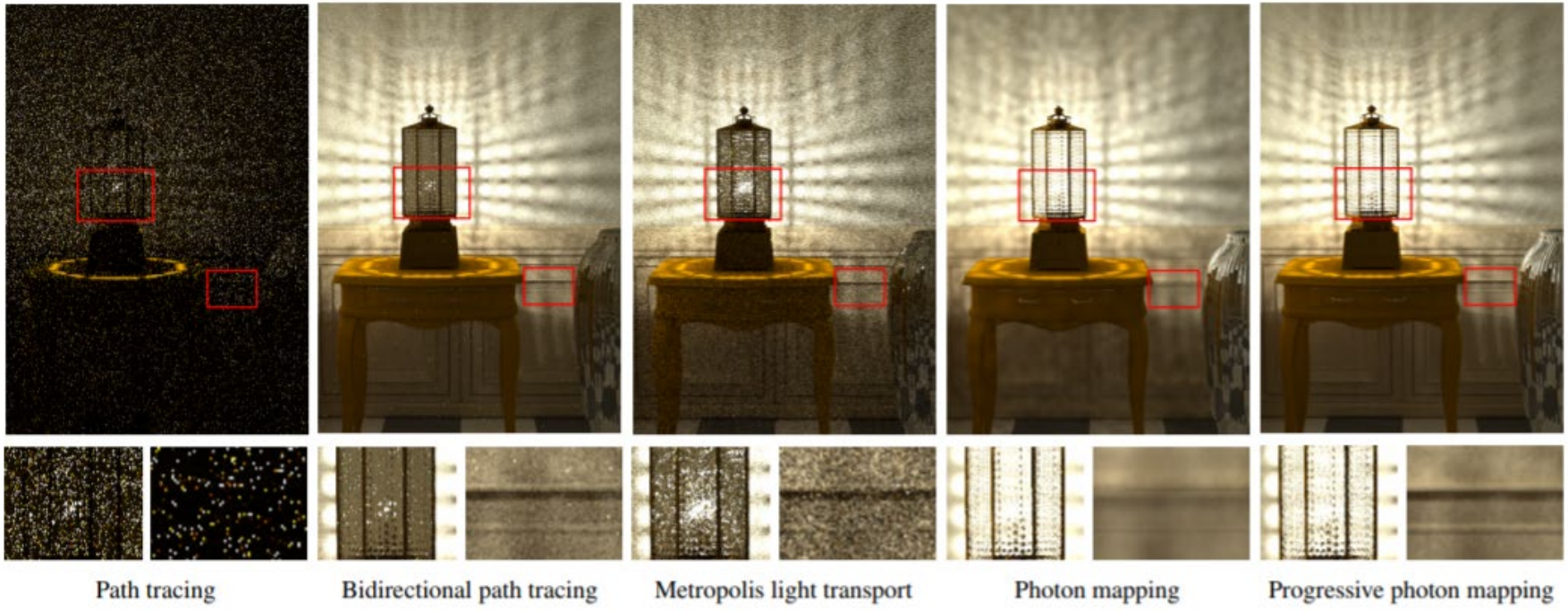
Radiance Estimation

- $L_r(x, k_o) \approx \frac{1}{\pi r^2} \sum_{p=1}^{N} \rho(x, k_p, k_o) \Delta\Phi_p(x, k_p)$

- When $N \to \infty, r \to 0$, it converges to the correct solution
  - In practice, we cannot store the infinite number of photons due to a finite memory space

Progressive Photon Mapping

- SIGA 2008, Hachisuka et al.



Images from [Hachisuka et al. 08]

Progressive Photon Mapping

- Multi-pass rendering method
  - 1st pass
    - Query points are generated from the eye
  - Refinement passes:
    - Photon tracing
    - Progressive radiance estimation

Progressive Photon Mapping

- Photon Mapping
  - $L_r(x, k_o) = \frac{1}{\pi r(x)^2} \sum_{p=1}^{N} \rho(x, k_p, k_o) \, \Delta\Phi_p(x, k_p)$

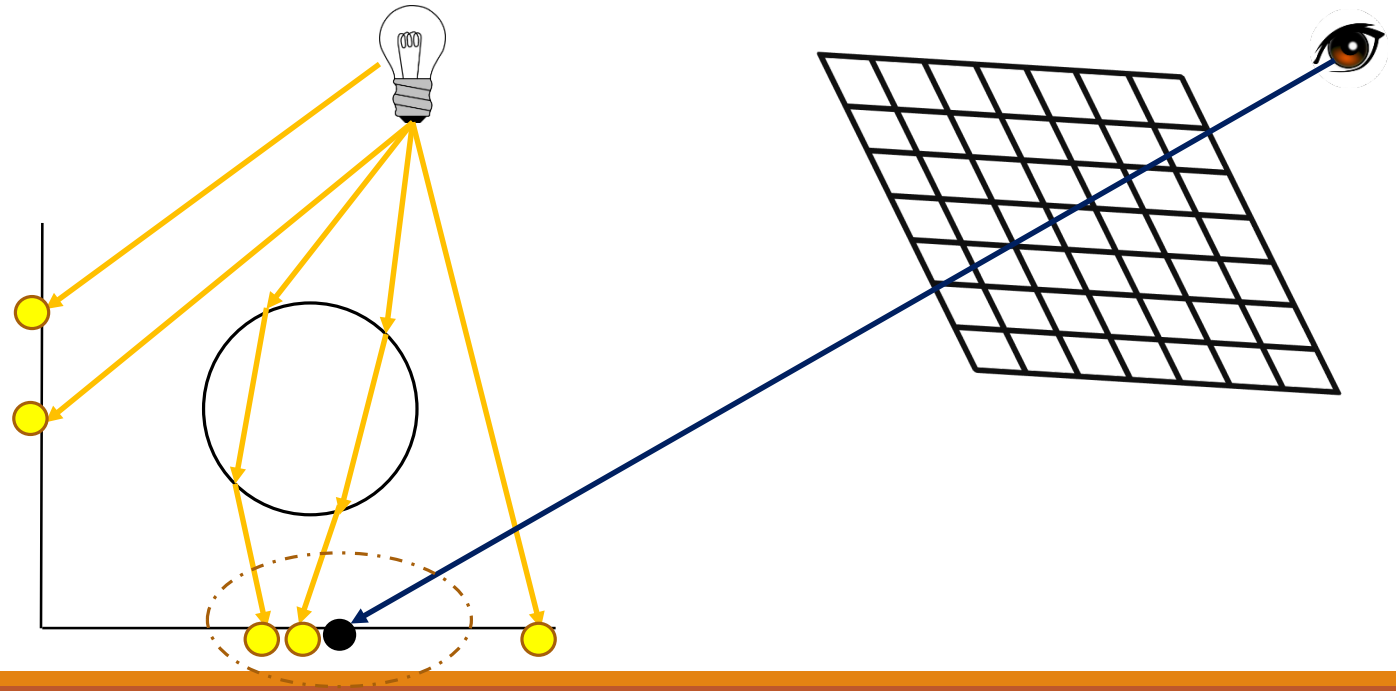
- Progressive Photon Mapping
  - $L_r^0(x, k_o) = \frac{1}{\pi r_0(x)^2} \sum_{p=1}^{N_0} \rho(x, k_p, k_o) \, \Delta\Phi_p(x, k_p)$
  - $L_r^1(x, k_o) = \frac{1}{\pi r_1(x)^2} \sum_{p=1}^{N_1} \rho(x, k_p, k_o) \, \Delta\Phi_p(x, k_p)$
  - …
  - $L_r^i(x, k_o) = \frac{1}{\pi r_i(x)^2} \sum_{p=1}^{N_i} \rho(x, k_p, k_o) \, \Delta\Phi_p(x, k_p)$
  - …

Progressive Photon Mapping

- Progressive Photon Mapping
  - $L_r^i(x, k_o) = \frac{1}{\pi r_i(x)^2} \sum_{p=1}^{N_i} \rho\left(x, k_p, k_o\right) \Delta\Phi_p\left(x, k_p\right)$
  - $\lim_{i \to \infty} L_r^i(x, k_o) = L(x, k_o)$
  - Key properties:
    - $r_{i+1}(x) < r_i(x)$
    - $N_{i+1} > N_i$

Progressive Photon Mapping

- PPM assumes the photon density is locally uniform
- Reduce the radius of each hit point while accumulating newly added photons



Progressive Photon Mapping

- PPM assumes the photon density is locally uniform
- Reduce the radius of each hit point while accumulating newly added photons
- $\frac{N_i+M_i}{\pi r_i^2} = \frac{N_{i+1}}{\pi r_{i+1}^2}$
- $N_{i+1} = N_i + \alpha M_i$
  - N_i: # of photons in the previous steps
  - M_i: # of photons in the current step
  - α: a fraction of newly added photons to keep
- $\frac{N_i+M_i}{\pi r_i^2} = \frac{N_i+\alpha M_i}{\pi r_{i+1}^2}$
- $r_{i+1} = r_i\sqrt{\frac{N_i+\alpha M_i}{N_i+M_i}}$

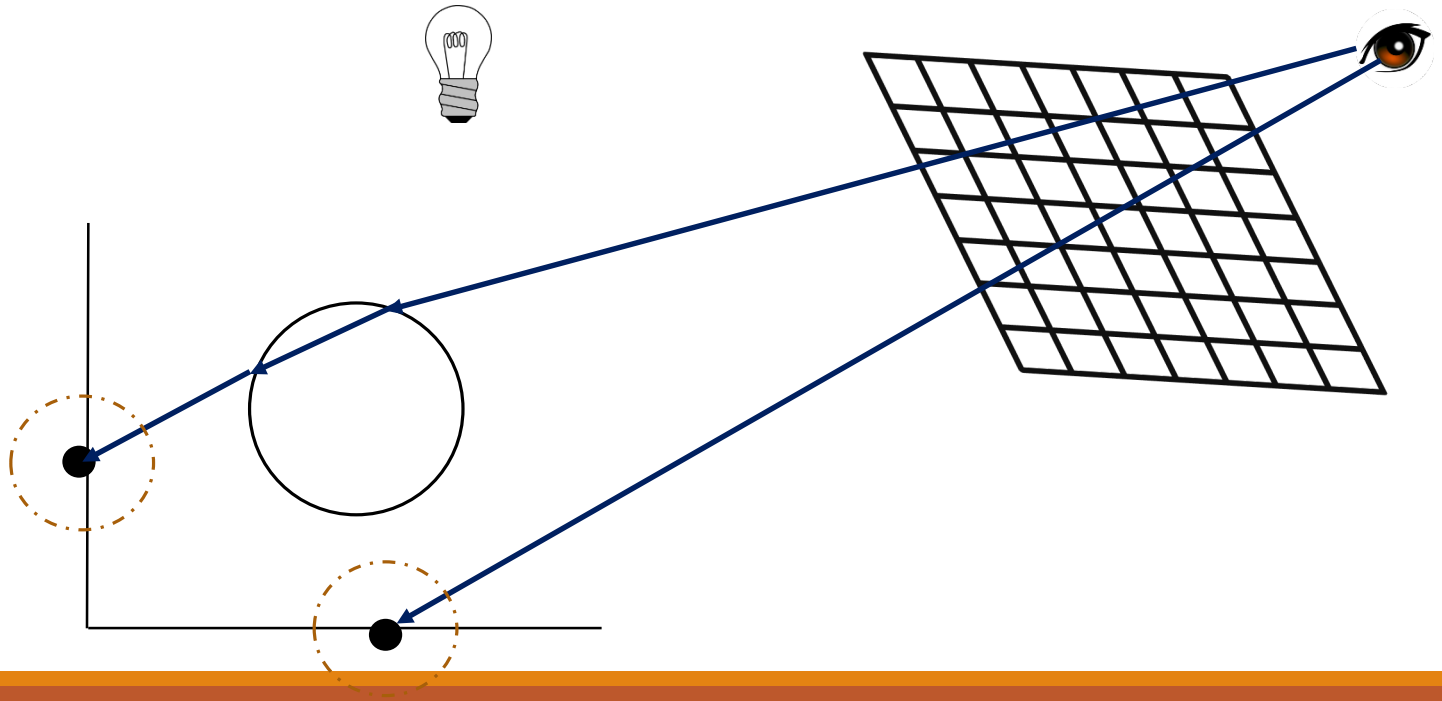
Progressive Photon Mapping

- Flux correction
  - $\tau_{N_i}(x, k_o) = \sum_{p=1}^{N_i} \rho(x, k_p, k_o)\, \Delta\Phi_p(x, k_p)$
  - $\tau_{M_i}(x, k_o) = \sum_{p=1}^{M_i} \rho(x, k_p, k_o)\, \Delta\Phi_p(x, k_p)$
  - $\tau_{N_{i+1}}(x, k_o) = \left(\tau_{N_i}(x, k_o) + \tau_{M_i}(x, k_o)\right) \frac{N_i + \alpha M_i}{N_i + M_i}$

- Radiance
  - $L_r^i(x, k_o) = \frac{1}{\pi r_i^2} \times \frac{\tau_{N_i}}{total\ \#\ of\ emitted\ photons}$

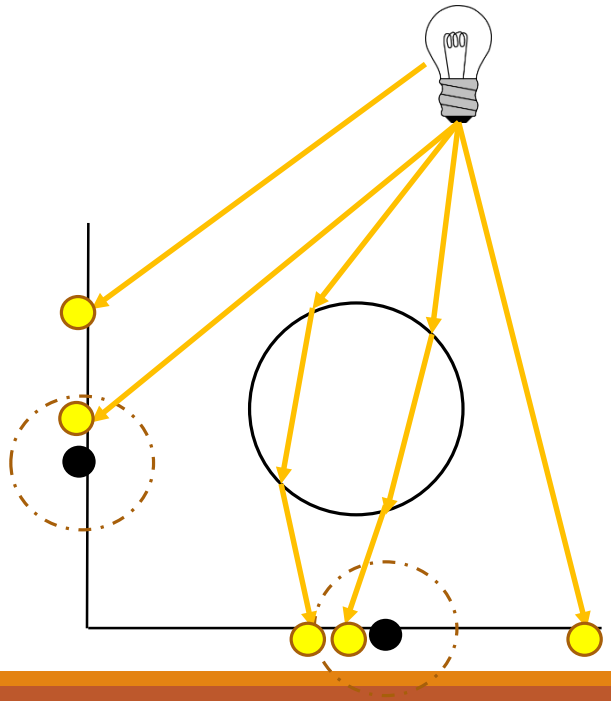
Progressive Photon Mapping

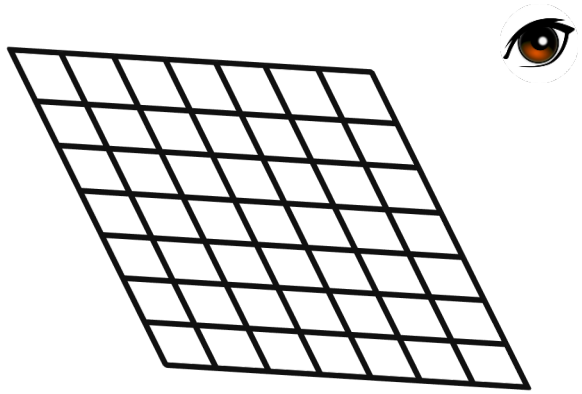
- 1st pass
  - Generate hit points



Progressive Photon Mapping

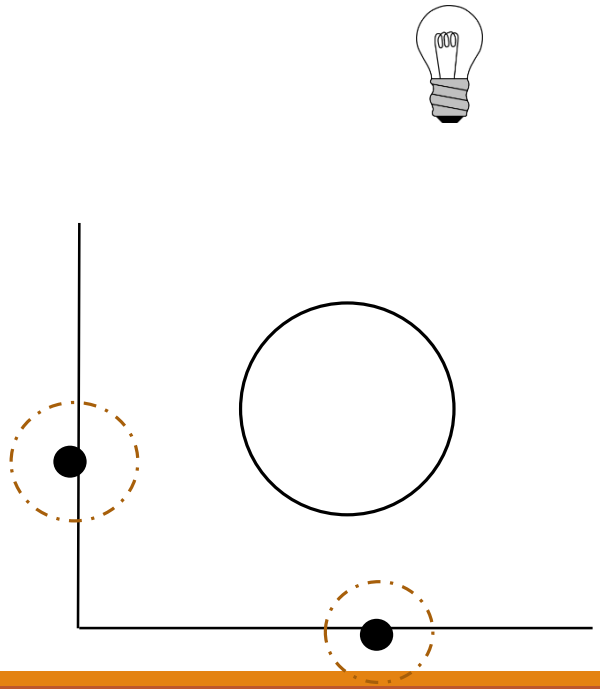
- 1st Refinement pass
  - Generate photons

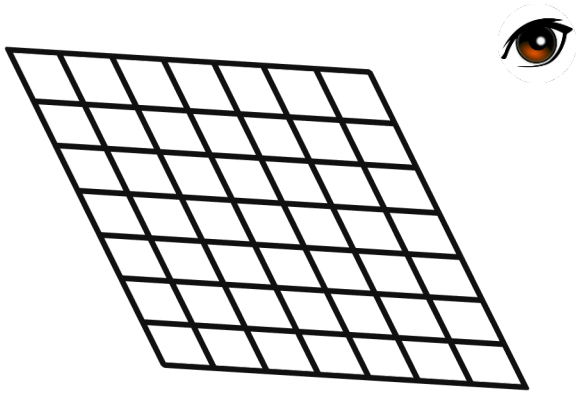




Progressive Photon Mapping

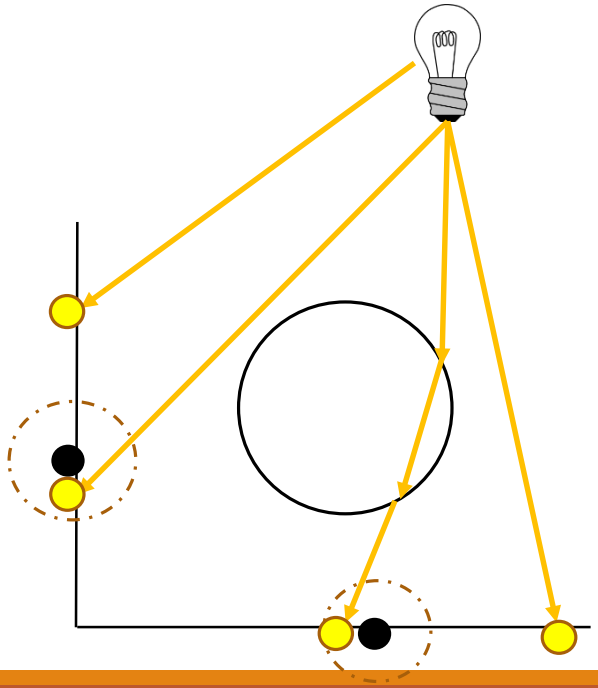
- 1st Refinement pass
  - Generate photons

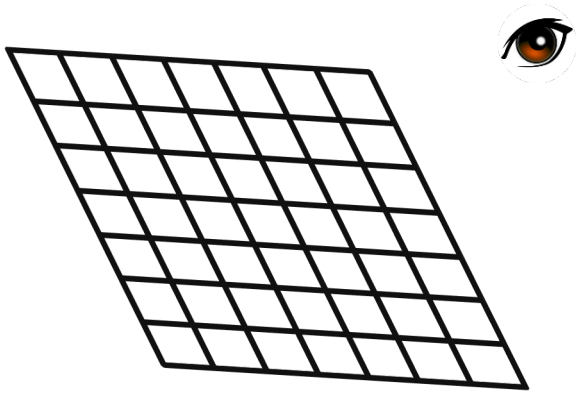




Progressive Photon Mapping

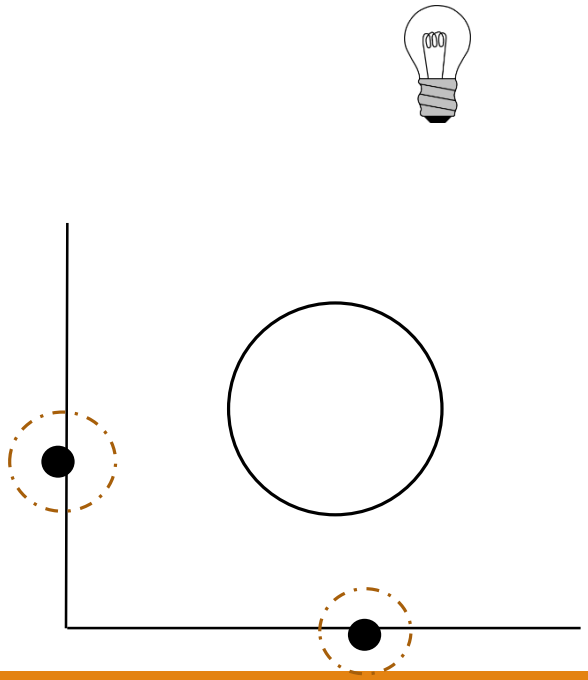
- 2nd Refinement pass
  - Generate photons

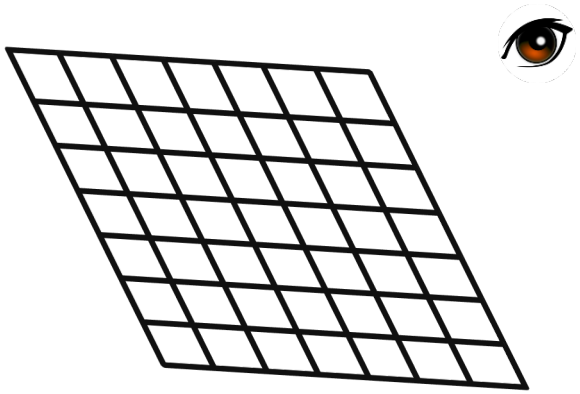




Progressive Photon Mapping

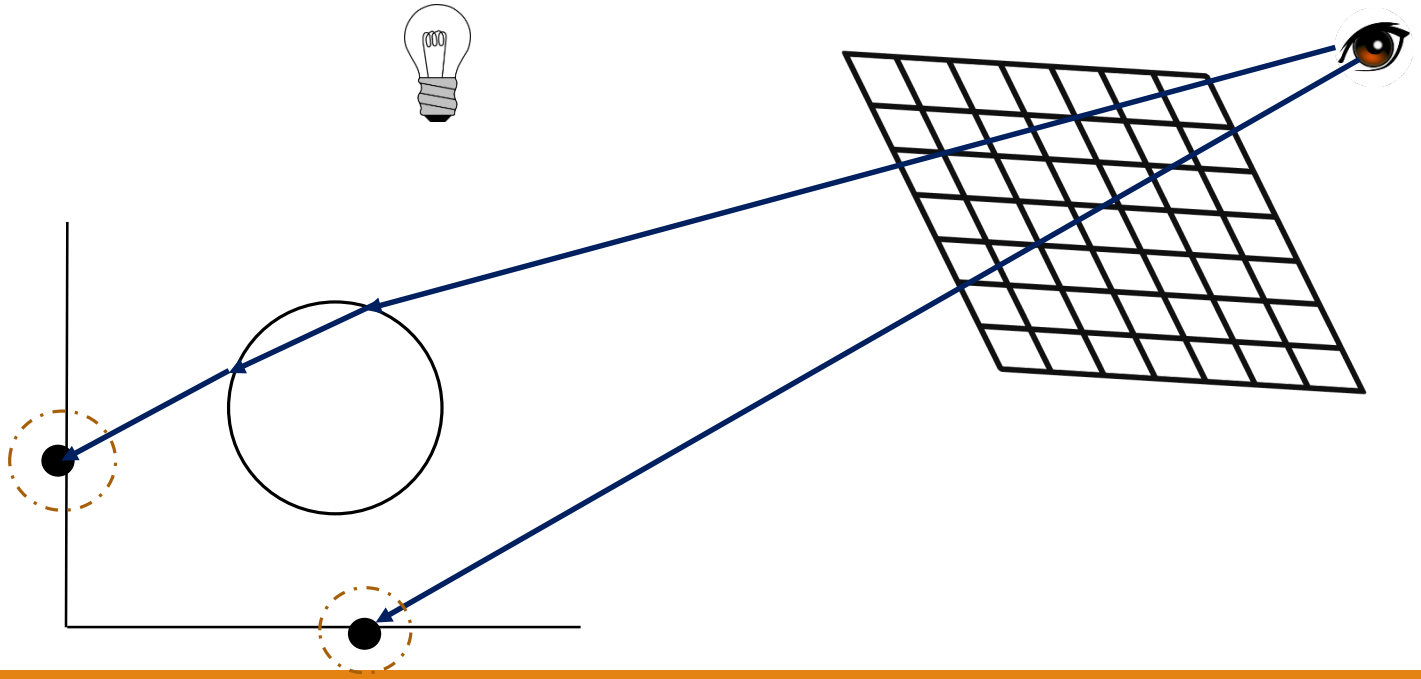
- 2nd Refinement pass
  - Generate photons



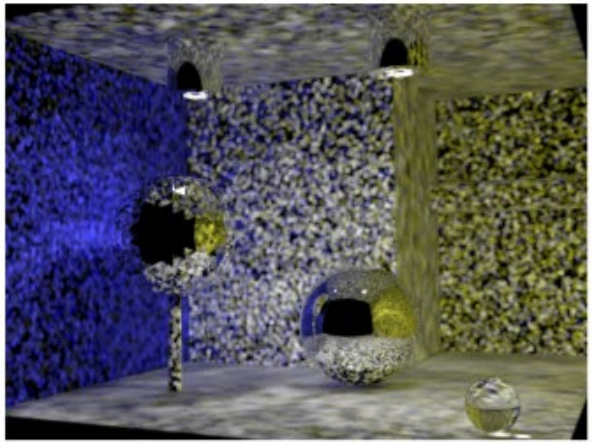


Progressive Photon Mapping

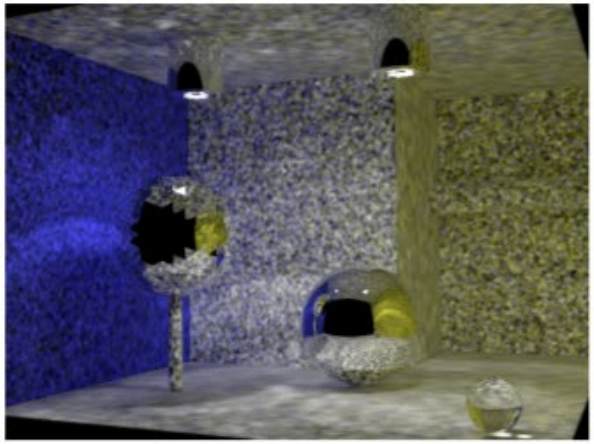
- Rendering



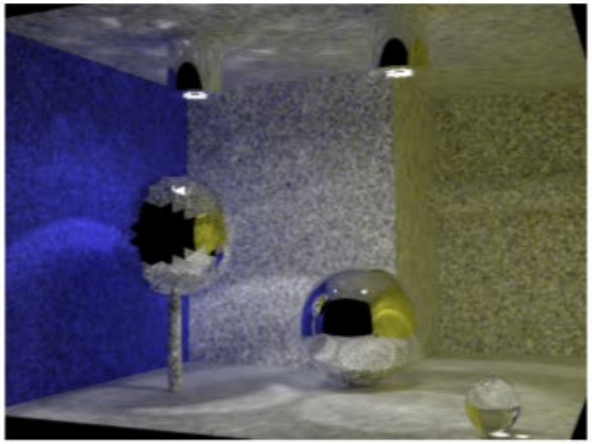
PPM Results



0.1M photons

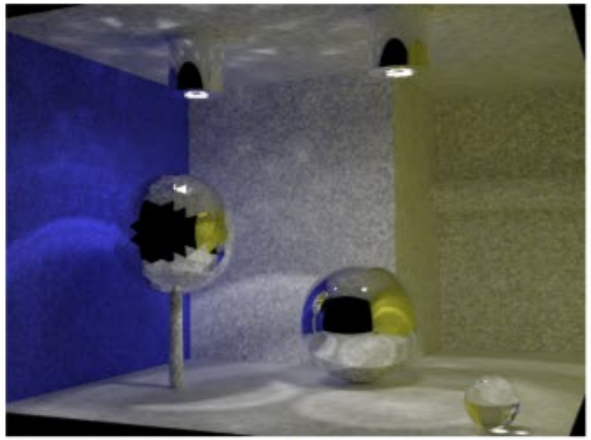


0.4M photons

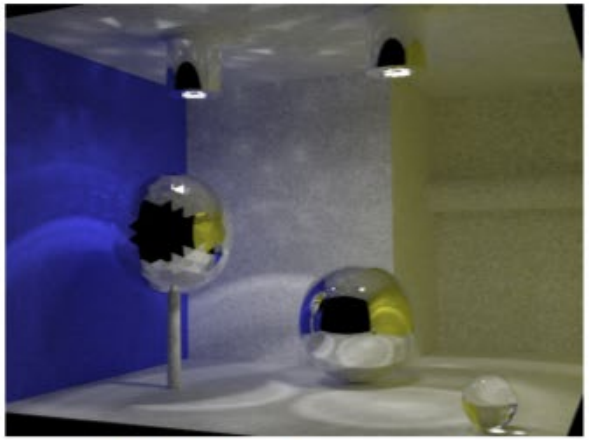


1.6M photons

PPM Results



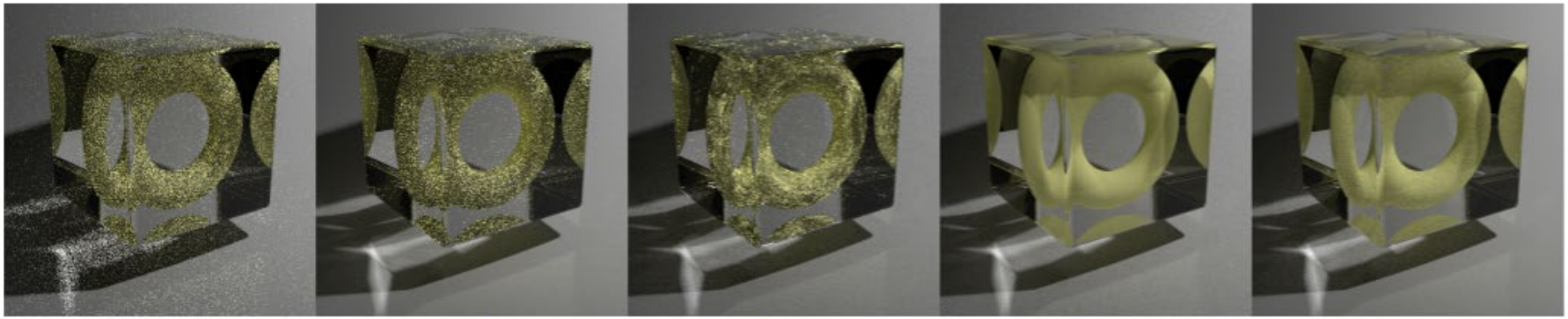
6.4M photons



25.6M photons

102.4M photons

PPM Results



PT BDPT MLT PPM Reference

Further Reading

- Distributed effects?
  - # of hit points can introduce a memory issue especially for distributed effects
  - Stochastic Progressive Photon Mapping, Hachisuka et al., SIGA09
- Progressive error estimation
  - A Progressive Error Estimation Framework for Photon Density Estimation, Hachisuka et al., SIGA10
- An alternative to PPM
  - Progressive Photon Mapping: A Probabilistic Approach, Knaus and Zwicker, TOG11