A study of incremental update of flobal illumination algorithms

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Overview of the talk

- Introduction
  - Photon Maps
  - Density Estimation on the Tangent Plane
  - Sphere Cache
  - Disc Indexing
  - Recalculation
- Theoretical Study
  - Basis
  - Notation
  - Recalculation Study
- Conclusions
- Future work

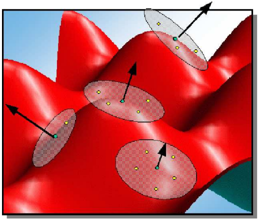
Photon Maps

- Photon Maps calculates global illumination using stocastic methods.
- Energy is calculated by adding energy of nearby photon IMPACTS.
- Variance can be reduced by using photon TRAJECTORIES
  - Density Estimation on the Tangent Plane by M. Lastra
  - Ray Maps by V. Havran
- The decrease in error more than compensates the increase in computation time which results from costly ray-disc and ray-sphere intersections.

DETP

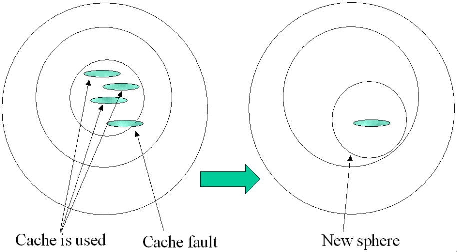
Based on the density estimation technique of Photon Maps, however DETP

- Stores the trajectories of the photons.
- To calculate irradiance at a point, a disc of fixed radius centered at the point and tangent to the surface is created, and the contribution of the rays intersecting the disc are added.
- Finally, the result is divided by the area of the disc.



DETP optimization: Sphere Cache

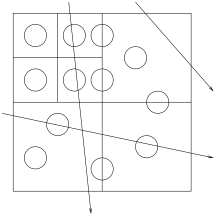
- A hierarchy of englobing spheres is created which allows for the rapid calculation of the rays intersecting a given disc.
- Inner spheres are recalculated when the disc leaves the sphere.
- This method is useful if the discs have spatial coherency: Point sorting.



Sphere Cache

Disc Indexing

- Photon Maps, DETP and Ray Maps index rays and process linearly the irradiance points.
- Disc Indexing indexes irradiance points and processes the ray list.
  - For each ray, the spatial indexing is traversed.
  - The ray contribution is added to each disc intersected.
  - Finally, each disc has the correct irradiance.
- Useful for relatively few rays, for example in recalculation.



Recalculation

Ray tracing pass:

- As the frames pass, dynamic vertexes move to a new position.
- Rays which intersected dynamic objects in the previous frame or do in this frame should be recalculated.
- The rest of the rays does not change their contribution to the static scene.

Density Estimation pass:

- Static vertices: DETP with the rays which changed; energy is added or substracted to previous value.
- Dynamic vertices: DETP with all rays.

Time efficiency

- There are different methods to calculate irradiance
- Each method has a different set of parameters, which affect performance
- Which is the best method and associated parameters?
- The theoretical study answers this question.

Theoretical bases

- Uniform distribution of rays
- Uniform distribution of irradiance points
- Integral geometry gives formulas for ray density
- The number of rays crossing a subset of the space can be calculated.
- Time complexity can be derived from this.

Notation

- n_R: number of Rays
- n_P: number of Irradiance points
- u, t: ray disc and ray sphere intersection time
- d: disc radius
- r_0: radius of the first sphere, bonding the scene
- Q: quotient between the radii of the spheres in Sphere Cache (2/3)

Recalculation study

- Notation: n_S static points, n_D dynamic points r_D radius of the sphere bonding the dynamic points
- Recalculated rays: $n_R^{(new)} \approx n_R^{(old)} \approx n_R \frac{r_D^2}{r_0^2} =_{def} n_{\tilde{R}}$
- Static points: Disc Indexing more efficient
  - Sphere Cache: $8{,}08 t n_{\tilde{R}} \sqrt[3]{n_S}$
  - Disc Indexing: $2 t n_{\tilde{R}} \sqrt[3]{n_S}$
- Dynamic points: Sphere Cache more efficient
  - Sphere Cache: $t n_{\tilde{R}} \sqrt[3]{n_D}$
  - Disc Indexing: $t n_R \sqrt[3]{n_D}$
- The experiments performed agree with the predictions.

Conclusions

- The theoretical study shows the most appropiate technique for each case
- The parameters of the algorithms can be optimized (example Q=2/3, see article)
- The error of the estimate is quite low (around 5 %)
- The theoretical study is independent on the Density Estimation method. To compare different algorithms:
  - Calculate the time complexity of the algorithms, as a function of the number of rays
  - Calculate the variance of the algorithms, as a function of the number of rays
  - Compose these formulas for a direct Error-Computation time comparison.

Future work

- Find distributions of rays which model real scenes better
- Study other algorithms, such as Ray Maps
  - Computation time
  - Automatic estimation of parameters
- More detailed modelling of DETP optimizations

Thank you for your attention

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