Unifying Points, Beams, and Paths in Light Transport Simulation

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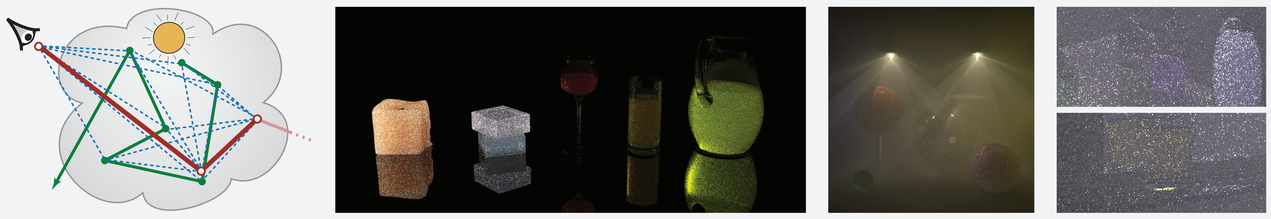
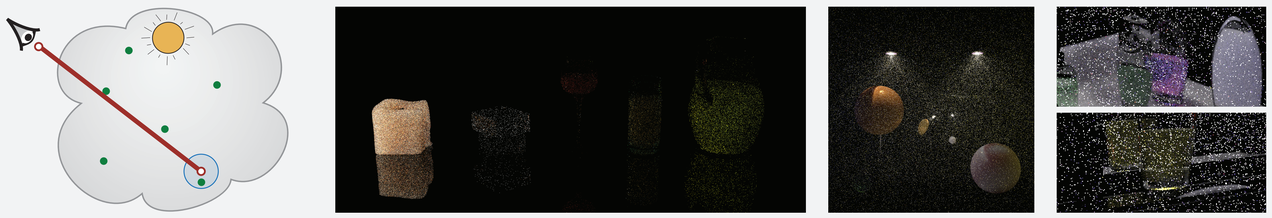
Different Volumetric Estimators

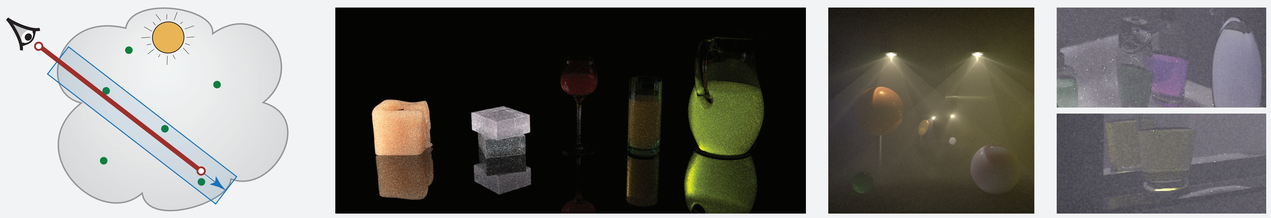
Bidirectional path tracing [Lafortune and Willems 1996]



Point-point estimator (Volumetric photon mapping w/out ray marching [Jensen and Christensen 1998])



Point-beam estimator (Beam radiance estimate [Jarosz et al. 2008])

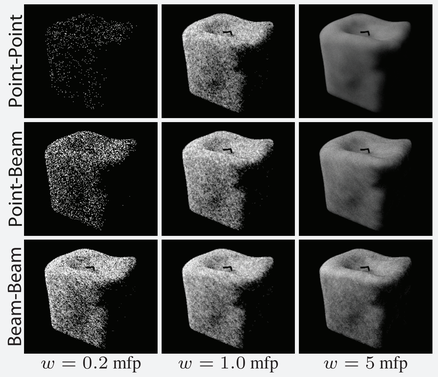


Beam-beam estimator (Photon beams [Jarosz et al. 2011])

Main Contributions

a) Theoretical variance analysis

We have derived analytic variance formulas for all the volumetric estimator variants in a canonical configuration. Variance critically depends on the ratio between the medium **mean free path** and the density estimation **kernel width.** Beams have lower variance in thin media and/or for small kernel widths. Points are better for thick media and/or large kernel widths.

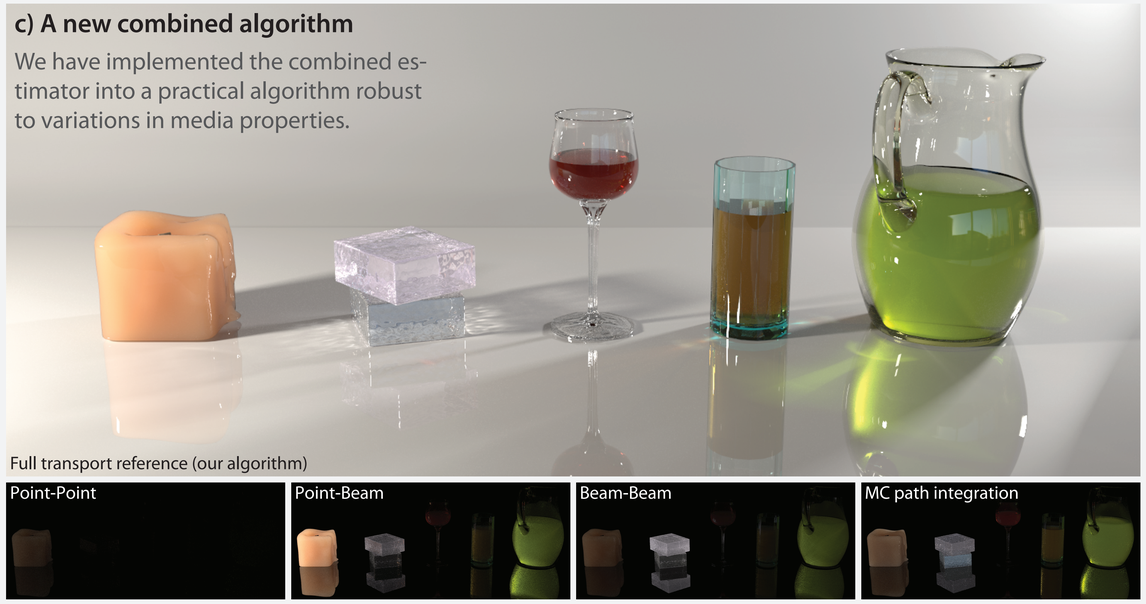


b) Extended multiple importance sampling

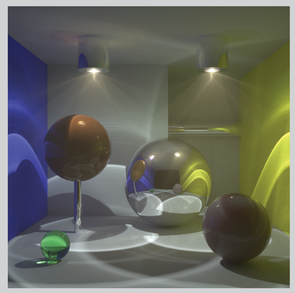
We have developed a new framework for combining estimators of integrals over spaces of different dimension. The extended MIS enables combining point- and beam-based volumetric estimator with Monte Carlo path integration (e.g. bidirectional path tracing).

c) A new combined algorithm

We have implemented the combined estimator into a practical algorithm robust to variations in media properties.



Our Combined Algorithm



Acknowledgments

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