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Progressive Transient Photon Beams

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Abstract: In this work, we introduce a novel algorithm for transient rendering in participating media. Our method is consistent, robust and is able to generate animations of time-resolved light transport featuring complex caustic light paths in media. We base our method on the observation that the spatial continuity provides an increased coverage of the temporal domain, and generalize photon beams to transient-state. We extend stead-state photon beam radiance estimates to include the temporal domain. Then, we develop a progressive variant of our approach which provably converges to the correct solution using finite memory by averaging independent realizations of the estimates with progressively reduced kernel bandwidths. We derive the optimal convergence rates accounting for space and time kernels, and demonstrate our method against previous consistent transient rendering methods for participating media.

Fourier Analysis of Correlated Monte Carlo Importance Sampling

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Abstract. Fourier analysis is gaining popularity in image synthesis as a tool for the analysis of error in Monte Carlo (MC) integration. Still, existing tools are only able to analyse convergence under simplifying assumptions (such as randomized shifts) which are not applied in practice during rendering. We reformulate the expressions for bias and variance of sampling-based integrators to unify non-uniform sample distributions [importance sampling (IS)] as well as correlations between samples while respecting finite sampling domains. Our unified formulation hints at fundamental limitations of Fourier-based tools in performing variance analysis for MC integration. At the same time, it reveals that, when combined with correlated sampling, IS can impact convergence rate by introducing or inhibiting discontinuities in the integrand. We demonstrate that the convergence of multiple importance sampling (MIS) is determined by the strategy which converges slowest and propose several simple approaches to overcome this limitation. We show that smoothing light boundaries (as commonly done in production to reduce variance) can improve (M)IS convergence (at a cost of introducing a small amount of bias) since it removes C_0 discontinuities within the integration domain. We also propose practical integrand- and sample-mirroring approaches which cancel the impact of boundary discontinuities on the convergence rate of estimators.