A null-scattering path integral formulation of light transport

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Unbiased rendering of heterogeneous media uses null-collision methods to generate free flight distances and estimate transmittance.

Challenge: Null-collision methods employ black-box rejection sampling algorithms such as delta tracking or ratio tracking. These algorithms do not provide path pdfs, making their combination via multiple importance sampling (MIS) difficult.

Our Approach: We derive a path integral formulation of light transport from the null-scattering radiative transfer equation (RTE). We then cast null-collision methods as path sampling techniques with known pdfs, which enables their straightforward MIS combination.

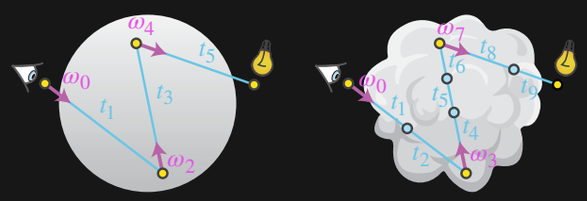
Previous Work:

MIS in piecewise homogeneous media:
[Krivenak et al. 2014], [Wilkie et al. 2014], [Georgiev et al. 2013]

Spectral tracking (derived from null RTE, forgoes complete MIS):
[Kutz et al. 2017]

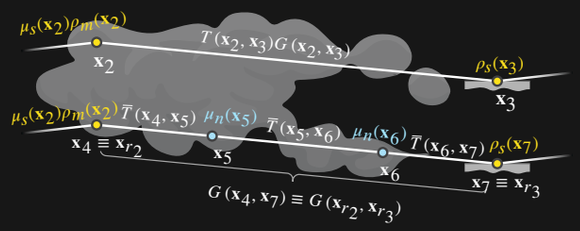
MIS through tabulated sampling:
[Szirmay-Kalos et al. 2017], [Gamito 2018]

Recursive estimation of the volume rendering equation can be done via a series of direction ω_i and distance samples t_i:



Classical RTE
[Chandrasekhar 1960]
Unable to adjust density.
Only can compute transmittance analytically in simple media.

Null RTE
[Galtier et al. 2013]
Able to add fictitious particles.
Always can compute transmittance analytically.



Classical path integral
Considers real scattering only
Evaluates heterogeneous transmittance

Our null-scattering path integral
Considers real and null scattering
Evaluates simple homogeneous transmittance

References:

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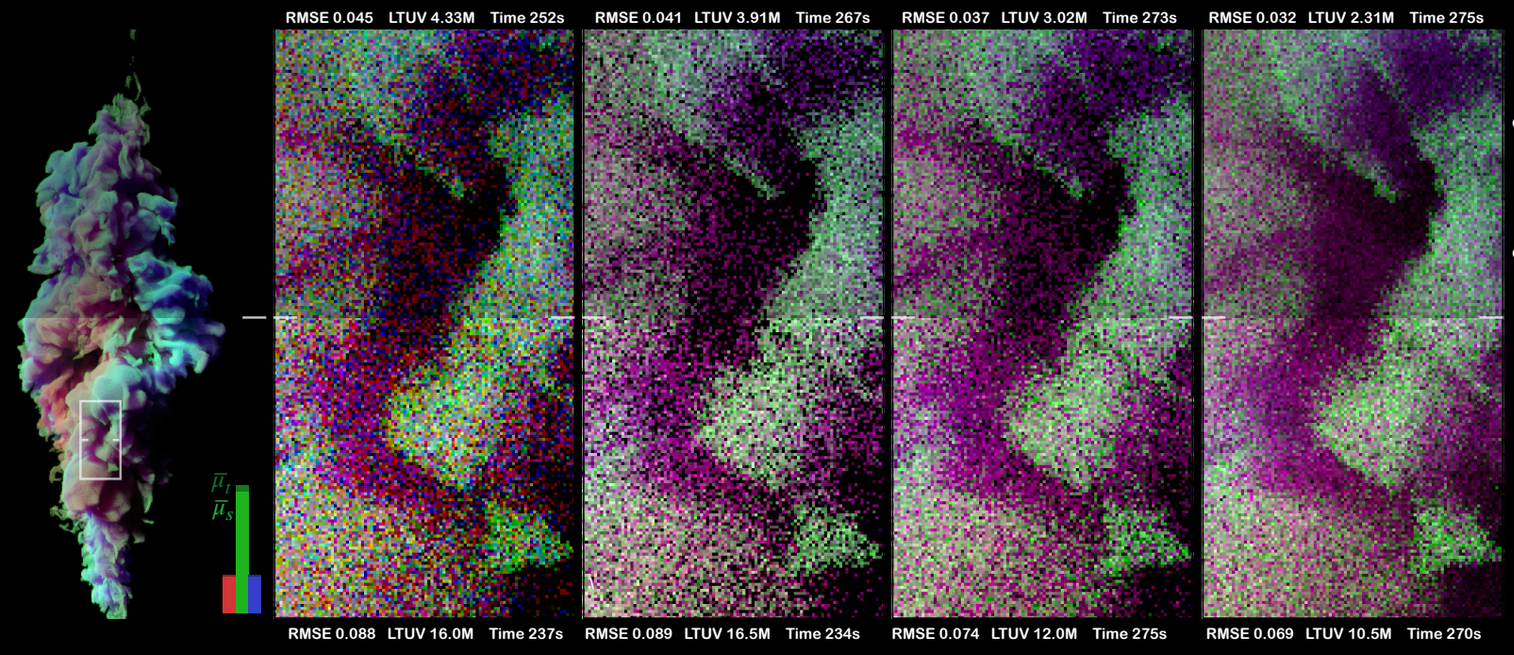
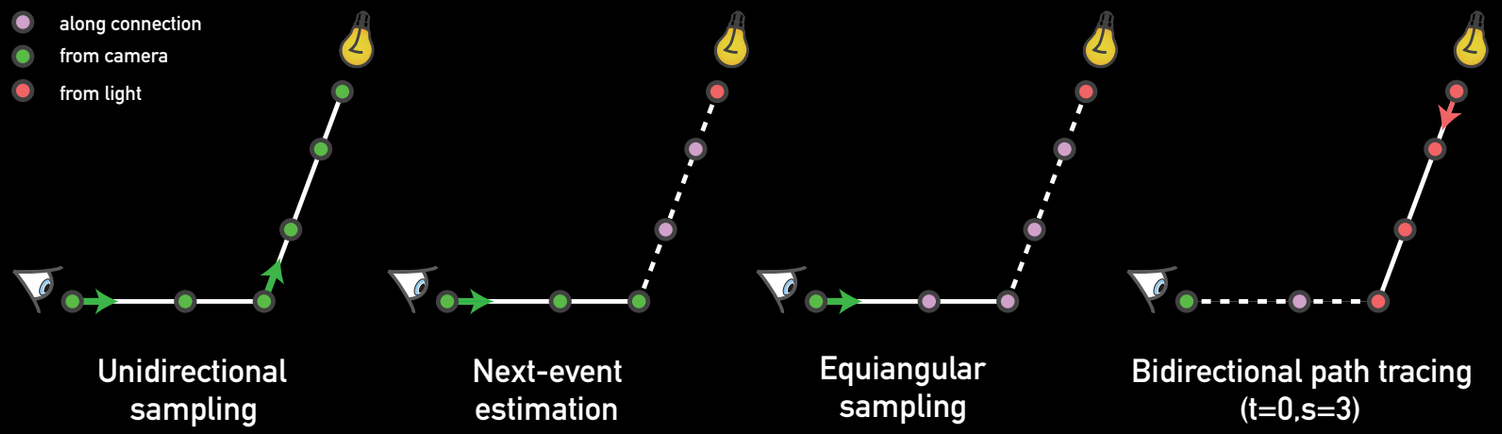
Alexander Wilkie, Sehera Nawaz, Mark Droske, Andrea Weidlich, and Johannes Hanika. 2014. Hero wavelength spectral sampling. *Computer Graphics Forum (Proc. Eurographics Symposium on Rendering*) 33, 4 (June 2014).

Come to our talk to learn more! Tuesday, 9 - 10:30 am in Room 152.



Our approach enables unbiased multiple importance sampling in heterogeneous media.



Our path integral formulation allows us to combine unbiased null-collision techniques and their spectral variants through MIS into more robust volumetric light transport estimators.

Project page: