

A null-scattering path integral formulation of light transport

Bailey Miller^{1*} Iliyan Georgiev^{2*} Wojciech Jarosz¹
¹Dartmouth College, ²Autodesk *authors with equal contributions

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.

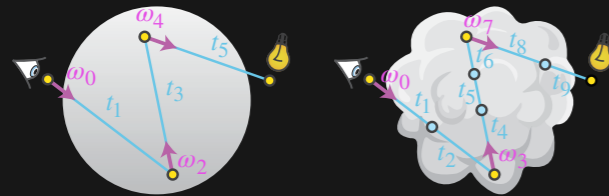
Our Approach: We derive a path integral formulation of light transport from the null-scattering radiative transfer equation (RTE). We then cast null-collision methods as path sampling techniques with known pdfs, which enables their straightforward MIS combination.

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]

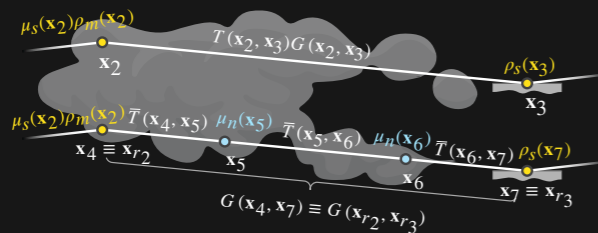
Unable to adjust density.

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

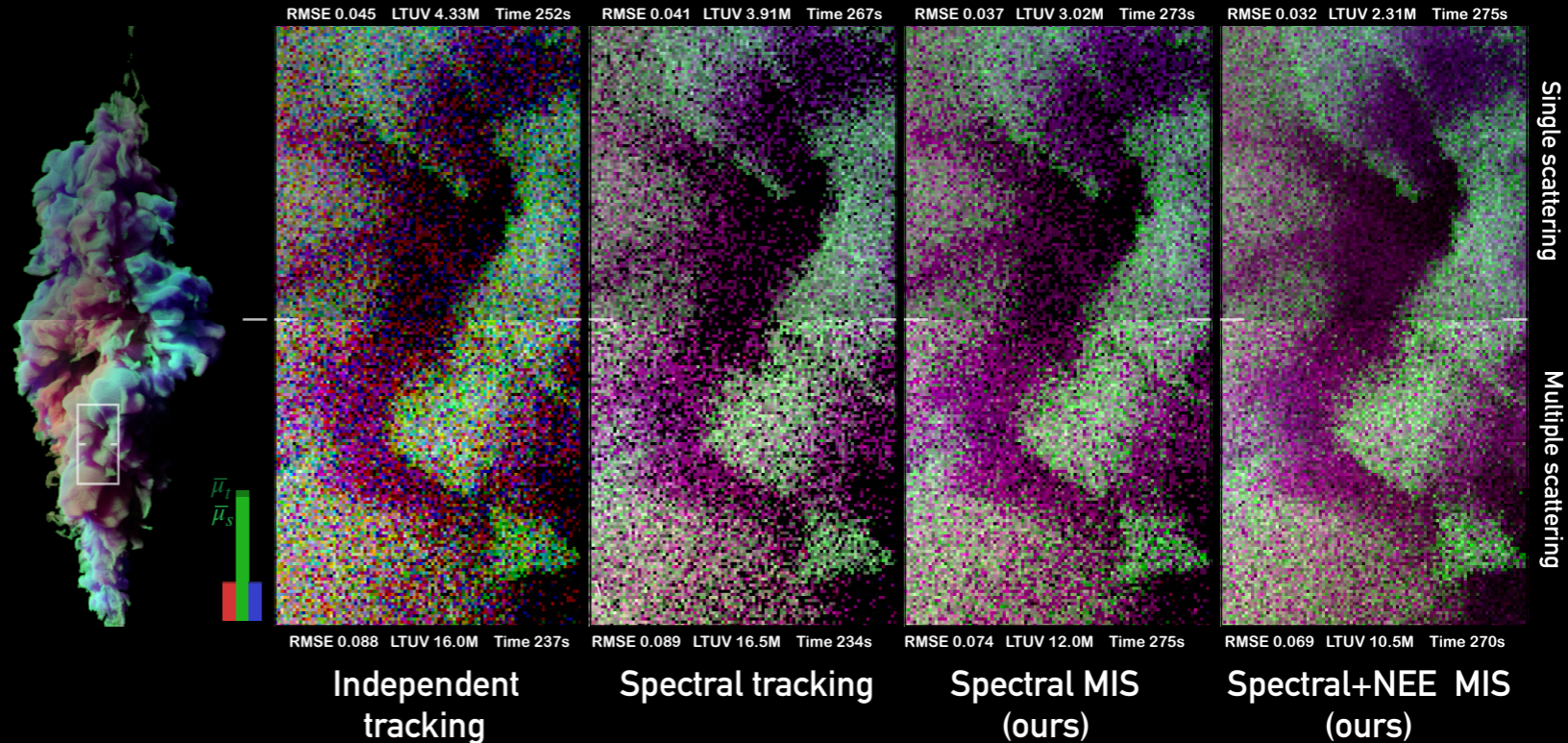
Our null-scattering path integral
 Considers real and null scattering
 Evaluates simple homogeneous transmittance

References:

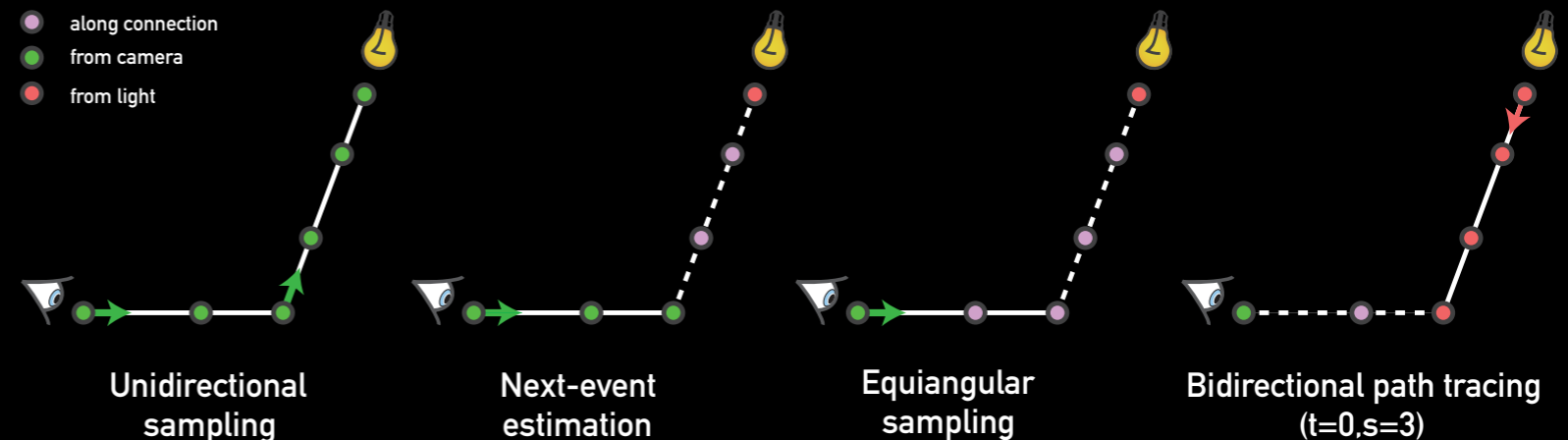
Subrahmanyam, Chandrasekhar. 1960. *Radiative Transfer*. Dover Publications.
 Manuel Gamito. 2018. Path Tracing in Production: Path Tracing the Framestore Way. In *ACM SIGGRAPH 2018 Courses*. ACM, New York, NY, USA, Article 15.
 Iliyan Georgiev, Jaroslav Křivánek, Toshiya Hachisuka, Derek Nowrouzezahrai, and Wojciech Jarosz. 2013. Joint Importance Sampling of Low-Order Volumetric Scattering. *ACM Transactions on Graphics (Proc. SIGGRAPH Asia)* 32, 6 (Nov. 2013).
 Peter Kutz, Ralf Habel, Yining Karl Li, and Jan Novák. 2017. Spectral and Decomposition Tracking for Rendering Heterogeneous Volumes. *ACM Transactions on Graphics (Proc. SIGGRAPH)* 36, 4 (July 2017).

Jaroslav Křivánek, Iliyan Georgiev, Toshiya Hachisuka, Petr Vévoda, Martin Šik, Derek Nowrouzezahrai, and Wojciech Jarosz. 2014. Unifying Points, Beams, and Paths in Volumetric Light Transport Simulation. *ACM Transactions on Graphics (Proc. SIGGRAPH)* 33, 4 (July 2014).
 László Szirmay-Kalos, Iliyan Georgiev, Milán Magdics, Balázs Molnár, and Dávid Légrády. 2017. Unbiased Estimators to Render Procedurally Generated Inhomogeneous Participating Media. *Computer Graphics Forum (Proc. Eurographics)* 36, 2 (2017).
 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:

