Robust light transport simulation in participating media

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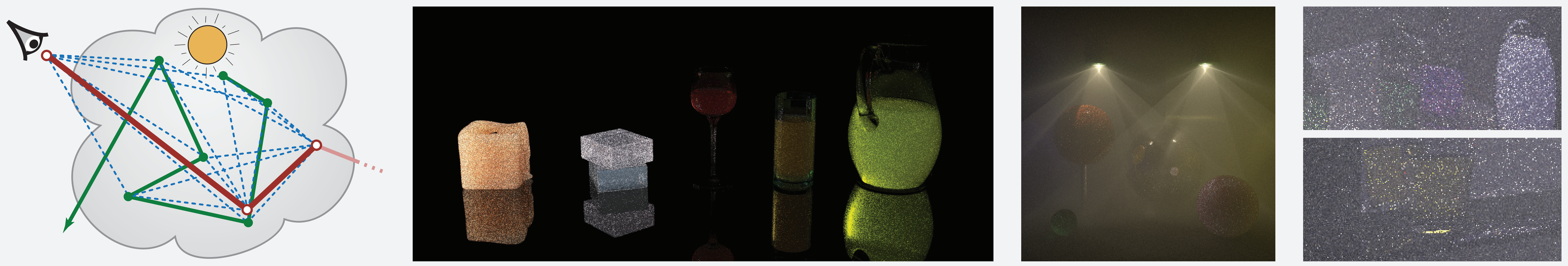
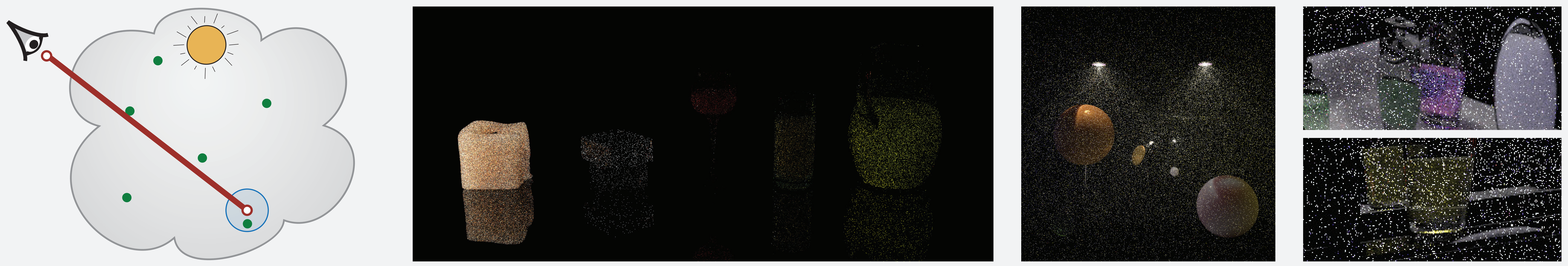
Previous Algorithms

Bidirectional path tracing [Lafortune and Willems 1996]

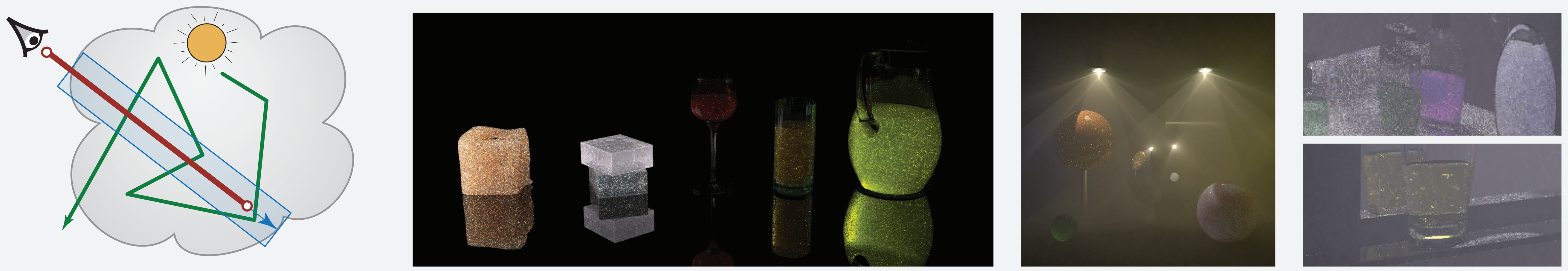


Volumetric photon mapping w/out ray marching [Jensen and Christensen 1998]



Beam radiance estimate [Jarosz et al. 2008]

Photon beams [Jarosz et al. 2011]



Our Combined Algorithm

Motivation

Modern realistic image synthesis aims to reproduce a wide range of lighting effects, including the interaction of light with participating media, e.g. light scattering in fog, smoke, wax, skin or liquids. However, faithfully simulating light transport in media can incur a large computational cost as variations in media density (e.g., haze vs. skin), scattering albedo (wine vs. milk), and scattering anisotropy (air vs. dust) result in significantly different light behavior. As such, designing a single light transport simulation algorithm that is robust to these variations remains an open problem, which is important not only in computer graphics but also across many other diverse fields, such as medical imaging or nuclear physics.

Solution

Two classes of widely adopted approaches excel at rendering complex volumetric shading effects: those based on path integral estimation (such as bidirectional path tracing) and those based on photon density estimation (such as photon mapping, beam radiance estimate or photon beams). None of them alone is perfect though so Krivanek et al. sought to combine their strengths. The resulting algorithm called unified points, beams, and paths (UPBP) excels at rendering scenes with different kinds of media, where previous techniques each fail in complementary ways.

Our work

We collaborated with Křivánek on the UPBP algorithm and created its implementation, which provided evidence for the qualities of the algorithm in practice and was used for generating results in the UPBP paper presented at the SIGGRAPH 2014 conference. The result of our work, a renderer called SmallUPBP, is released online on www.smallupbp.com and can be used and modified freely. Together with the text of the thesis which thoroughly describes both the algorithm and its implementation it provides a great foundation for further research.

Results example