Toward Validation of a Monte Carlo Rendering Technique

Paul Kilgo* and Jerry Tessendorf†
School of Computing, Clemson University

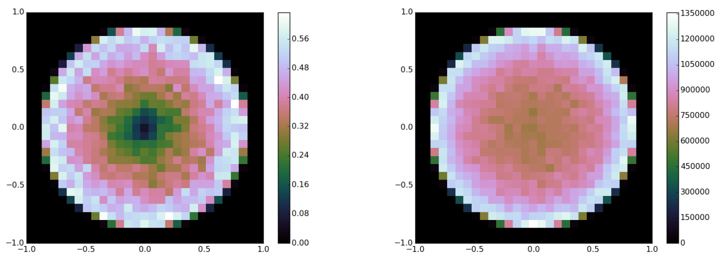

Figure 1: *(Left) Normalized intensity plot (a "rendered image") of a numerical calculation of a point spread function. This includes path lengths slightly longer than a direct path. (Right) Path sample pattern.*

Abstract

A Monte Carlo multiple scattering technique for participating media is extended. Validation against an experimentally well-studied optics problem is discussed. Designing initial paths for a numerical integration of Feynman path integrals is posed. A plot of the resulting integration is discussed.

Keywords: monte carlo, multiple scattering

1 Introduction and Motivation

We outline ongoing work to validate a Monte Carlo multiple scattering technique [Tessendorf 2009] against experimental data. Monte Carlo rendering techniques have long been known to the computer graphics community. If done correctly, they avoid bias that is introduced by deterministic techniques, though in practice they are computationally expensive. Our technique differs from others in that sampling paths are generated and assigned a weight. It is defined in terms of the mathematical construct of Feynman path integrals. Recent results [Kilgo and Tessendorf 2015] have shown how to asymptotically speed up its path perturbation algorithm. Recently we have started to make progress in numerically computing a point spread function to validate the technique.

2 Technical Approach

Point spread functions are a familiar concept in optics. A typical scenario is a fixed emitter at $\vec{x}_0$ which emits a signal in some direction $\hat{n}_0$ through a uniform scattering media. A semi-spherical receiver at $\vec{x}_1$ then receives the transmission over a range of directions $\hat{n}_1$ and can measure how much of the intensity has scattered during the transmission. A physical interpretation of this is a laser suspended in ocean water which is received on-axis by a pinhole-shaped camera. We can model this situation in our technique by generating paths from $\vec{x}_0$ to $\vec{x}_1$ having a fixed direction $\hat{n}_0$ and a random direction $\hat{n}_1$. As well, we must consider paths of all possible lengths s.

3 Implementation and Future Work

We have developed a means of constructing initial paths to use in the path perturbation algorithm. Using Bézier curves allows precise control of both the end points and end orientations of the paths. We use $\vec{x}_0$, $\vec{x}_0 + a\hat{n}_0$, $\vec{x}_1 - b\hat{n}_1$, and $\vec{x}_1$ as the control vertices, where a and b are arbitrary constants. We can introduce as the third control vertex $(\vec{x}_0 + \vec{x}_1)/2 + c\hat{n}_2$ for an optional additional means to vary the path length. Here again, c is an arbitrary constant and $\hat{n}_2$ is a spherically-uniform unit vector. This defines a path according to the constraints of the problem, but it is required that the path be expressed in terms of a discrete Frenet-Serret formulation with constant step size Δs. Therefore, it is necessary to find an arc length parameterization of the Bézier curve numerically. For our application we can tolerate a high amount of error as the first few samples in the numerical integration are discarded. We compute a low-resolution arc length parameterization of the Bézier curve using traditional root-finding methods and interpolate in between. Often this will have significant error in the resulting path's $\vec{x}_1$ and $\hat{n}_1$. Our path perturbation algorithm completes the task and finds an appropriate $\vec{x}_1$ and $\hat{n}_1$ with very little error. Relative intensity plots and sampling patterns are produced such as those seen in Figure 1. Path lengths here are slightly longer than a direct path. There is an expected dip in the intensity at the center of the image. In future work we will analyze our numerical results against experimentally acquired data.

References

KILGO, P., AND TESSENDORF, J. 2015. Accelerated path generation and visualization for numerical integration of Feynman path integrals for radiative transfer. In *Joint International Conference on Mathematics and Computation, Supercomputing in Nuclear Applications and the Monte Carlo Method*.

TESSENDORF, J. 2009. Numerical integration of the Feynman path integral for radiative transport. In *International Conference on Mathematics, Computational Methods and Reactor Physics*.

*e-mail: pkilgo@clemson.edu
†e-mail: jtessen@clemson.edu

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