

# Paper Evaluation: Bidirectional Path Tracing

## 1. Paper Title, Authors, and Affiliations

**Title:** Bidirectional Path Tracing

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## 2. Main Contribution

The main contribution of this paper is a new Monte Carlo global illumination algorithm called bidirectional path tracing. It is different from classical path tracing by sampling light transport from both the light sources and the eye at the same time. It then connects points on these two paths using shadow rays to estimate the radiance contribution. Combining contributions from 2 directions, the algorithm is able to capture both direct and indirect illumination. The authors also introduce importance sampling, Russian roulette termination, and weighted estimators to reduce variance. Experiments show that this approach produces less noise and converges faster than standard path tracing, especially in indoor scenes where indirect lighting plays a major role.

## 3. Outline of the Major Topics

The paper first reviews previous work on global illumination, including radiosity and classical path tracing. It explains the limitations of purely view dependent or light dependent methods and motivates the need for a more balanced approach. Next, the authors introduce the idea of bidirectional path tracing. They describe how to generate random walks starting from both light sources and the eye. The probability distributions for sampling initial points and directions are defined using importance sampling. At each step, directions are sampled based on the BRDF, and Russian roulette is used to terminate paths. After that, the paper explains how to estimate pixel flux by connecting the light and eye paths. Different types of contributions are computed depending on how many bounces occur on each side. The authors also discuss how to choose weights to combine these contributions and how multiple samples are averaged to reduce variance. Finally, the implementation details and experiments are presented. The results compare bidirectional path tracing with classical path tracing and show that the proposed method achieves better image quality with fewer samples.

## 4. One Thing I Liked

I found it interesting that bidirectional path tracing improves coverage of the path space by constructing both light and eye paths and connecting them. I also like that it remains entirely within the Monte Carlo rendering framework. Rather than introducing a completely new formulation, it extends classical path tracing in a natural way. It makes the concepts easier to understand for people already familiar with Monte Carlo. I liked that the paper includes clear table comparisons with classical path tracing, providing a little quantitative evidence that the proposed method achieves faster convergence.

## 5. What I Did Not Like

The implementation details focus mainly on explaining with graphs, with little quantitative analysis of convergence behavior, variance reduction, or how performance scales with increasing path length and scene complexity. In particular, it would be helpful to better understand the computational overhead introduced by storing and connecting subpaths, as well as how the weighting strategy affects efficiency in practice. Furthermore, comparisons with alternative global illumination methods, such as photon mapping, would provide clearer insight into the strengths and limitations of BDPT.

## 6. Questions for the Authors

1. The algorithm combines multiple connections using weighted estimators. How sensitive is performance to the choice of these weights, and have you considered more systematic weighting strategies such as multiple importance sampling?
2. Compared to photon mapping, how does BDPT trade off convergence speed, variance, and memory usage? In which situations might the photon provide advantages over bidirectional path sampling?