Christian Robles
6804562459
roblesch@usc.edu

Russian Roulette: From Albedo to EARS

Directed Research Proposal

Introduction

Monte Carlo path tracing evaluates indirect lighting by sampling many random paths through a scene in search of light sources. In sparsely lit scenes many paths will yield insignificant contributions to the final result, increasing the overall time to converge on a solution. In 1990 Arvo & Kirk adapted the particle transport technique of Russian Roulette to the light transport problem. Their technique terminates paths which are less likely to provide a significant contribution based on local information about the albedo of the intersected surface [1]. Vorba & Křivánek later expanded this technique with Adjoint-Driven Russian Roulette and Splitting (ADRRS) [5], improving efficiency in rendering sparsely lit scenes by increasing survival probability for rays which would otherwise terminate too soon. ADRRS continues their previous work in path guiding [4] which pre-computes statistics on the scene to bias path creation in directions that will more likely terminate at a light source. In 2022 Rath et. al. further improved ADRRS with Efficiency-Aware Russian Roulette and Splitting (EARS), extending ADRRS with considerations of path variance and cost [2].

Project Goals

This Directed Research project will produce a report discussing the history and application of Russian Roulette and splitting techniques in light transport leading to state-of-the-art. It will implement Albedo Russian Roulette, ADRRS and EARS, extending a path tracer established in a previous project in importance sampling[3]. Ground-truth reference implementations are available by authors for the Mitsuba path tracer. This project will produce experimentation and figures comparing variance and runtime of each technique.

Notes

These techniques do not rely on complex material models, acceleration structures, or integration strategies. As such they are well suited to reimplementation and can be isolated in a purpose-built path tracing renderer. The authors' implementation provides a concrete reference and ground-truth.

Deliverables and Timeline

1/9 - 1/27 - Review and summarize relevant publications
1/30 - 3/17 - Path tracer implementation

- 1/30 - 2/10: Path tracer and base scene setup, Albedo Russian Roulette
- 2/13 - 3/3: ADRRS pre-computation (scene partition)
- 3/6 - 3/17: ADRR & ADRRS
- 3/20 - 3/31: EARS

3/20 - 3/31 - Experimentation & figures
4/3 - 4/28 - Report authoring & finalization

References

[1] James Arvo and David Kirk. Particle transport and image synthesis. *SIGGRAPH Comput. Graph.*, 24(4):63–66, sep 1990.

[2] Alexander Rath, Pascal Grittmann, Sebastian Herholz, Philippe Weier, and Philipp Slusallek. Ears: Efficiency-aware russian roulette and splitting. *ACM Transactions on Graphics (Proceedings of SIGGRAPH 2022)*, 41(4), jul 2022.

[3] Christian Robles. Shortest path to multiple importance sampling. `https://blog.roblesch.page/2022/02/08/multiple-importance.html`, feb 2022.

[4] Jiří Vorba, Ondřej Karlík, Martin Šik, Tobias Ritschel, and Jaroslav Křivánek. On-line learning of parametric mixture models for light transport simulation. *ACM Trans. Graph.*, 33(4), jul 2014.

[5] Jiří Vorba and Jaroslav Křivánek. Adjoint-driven russian roulette and splitting in light transport simulation. *ACM Trans. Graph.*, 35(4), jul 2016.