Recent Advances in Light Transport Simulation: Some Theory and a lot of Practice

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This half-day course reviews some of the recent advances in light transport simulation algorithms, which have recently been a subject of renewed interest from the academia and especially the industry. We put emphasis on the various aspects associated with using advanced light transport in practice.

1 Introduction

We are witnessing a renewed research interest in robust and efficient light transport simulation based on statistical methods. This research effort is propelled by the desire to accurately render general environments with complex materials and light sources, which is often difficult with the industry-standard ad hoc solutions. In addition, it has been recognized that advanced methods, which are able to render many effects in one pass without excessive tweaking, increase artists productivity and allow them to focus on their creative work. For this reason, the movie industry is shifting away from approximate rendering solutions towards physically-based rendering methods, which poses new challenges in terms of strict requirements on high image quality and algorithm robustness.

Many of the recent advances in light transport simulation are made possible by interpreting light transport as an integral in the space of light paths. However, there is a great deal of confusion among practitioners and researchers alike regarding these path space methods.

2 Course Objective

The main goal of the theoretical part of the course is to present a coherent review of the path integral formulation of light transport and its applications, including the most recent ones. We show that rendering algorithms that may seem complex at first sight, are in fact naturally derived from this general framework. We also show that the path integral framework makes the extension of the surface-based algorithms to volumetric media extremely simple. The course includes an extensive empirical comparison of the various light transport algorithms. A substantial part of the course is then devoted to the application of advanced light transport simulation and path sampling methods in practical rendering tasks in architectural visualization and VFX.

3 Contribution for the Audience

The course is intended for industry professionals and researchers interested in solidifying their knowledge in physically based rendering, learning about the latest developments in the field, and especially with the issues associated with applying advanced light transport methods in practice. Rendering software architects and developers looking for the right global illumination solution for their application will also benefit from the course. We will make annotated presentation slides and additional material publicly accessible after the conference.

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4 Detailed Description

Our half-day course is organized into two blocks, the first of which focuses on theoretical aspects, algorithms, and their comparison, while the second (after the break) is devoted solely to the practical issues. After a short introduction, we first cover the theoretical foundations of physically based rendering, with a focus on the path integral formulation of light transport. We describe the bidirectional path sampling techniques and their efficient combination in bidirectional path tracing. We also give a brief sketch of some more advanced path sampling techniques for participating media. The second section is dedicated to the efficient combination of bidirectional path tracing and photon mapping, which relies on the path integral formalism. The third section then presents the recent work on reducing noise in the rendered images through filtering in the path space. In the last section before the break we present an extensive comparison of a number of ordinary MC and MCMC methods on various scenes with complex illumination.

The remainder of the course consists of four talks that focus on the applications of light transport in practical rendering tasks. First, we present some of the importance sampling techniques employed in the Arnold Renderer developed by Solid Angle SL. Second, we describe the lighting preview system developed at PIXAR Animation Studios. Third, we review the usability issues that have driven the design choices in the development of the Corona Renderer aimed at the architectural visualization segment. The last section of the course describes the use of advanced rendering methods in the Maxwell renderer, with a discussion on production requirements and necessary future developments.

This course is a substantial evolution of the SIGGRAPH 2013 course "Recent Advances in Light Transport Simulation: Theory & Practice". In this updated course we keep (but significantly compress) the general introduction to the theory of light transport and we also explain the combination of path sampling techniques with photon mapping. New is the expansion of these revised, condensed theoretical sections with material that covers participating media rendering and material showing how the path space formulation easily extends to consistent filtering algorithms in order to reduce noise. In the rest of the course we shift the attention to the different aspects of accurate light transport simulation in practical rendering applications in various companies and products (NVIDIA, PIXAR, Arnold renderer, Corona renderer, Maxwell renderer). This material is almost entirely new and did not appear in the previous version of the course.

Acknowledgments. This work was supported by the Czech Science Foundation grant P202-13-26189S.