論 文 の 内 容 の 要 旨

論文題目　Bridging Different Spaces in Light Transport Simulations
（異なる空間を繋ぐ光輸送シミュレーション）

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The light transport simulation has been one of the major topics in computer graphics from the very beginning of the field, supported by insatiable demand of photorealistic image synthesis in various industries including movie industries, game industries, etc. The light transport simulation is formulated as solutions of the equation called rendering equation. The problem of numerically solving the rendering equation is called the light transport problem. We focus on the two problem domains in light transport simulations: the simulation itself, and the modeling of the input of the light transport simulation. The simulation part of light transport simulations determines how we actually solve the rendering equation numerically, where the efficiency of the simulation is the major challenge. On the other hand, the modeling part of light transport simulations determines how the components of the input scene are mathematically defined, where the accuracy of resemblance to the actual physical objects is challenging.

Among the challenges of the light transport simulation, we focus on two problems. First, in the domain of simulation, we focus on improving efficiency of the light transport simulation using Monte Carlo methods, which is de facto standard approach for photorealistic rendering. Second, in the domain of modeling, we focus on improving accuracy of the spectral reflectance reconstruction from a tristimulus values, which is one of the important building blocks in spectral rendering because the commonly available data is defined in tristimulus values (e.g., RGB colors).

We tackled these problems by bridging different spaces in light transport simulations. In this thesis, we focus on three different spaces and proposed the methods to bridge the spaces using different approaches to achieve the goals.

1. The first method bridges the strategy spaces of light transport simulations which determine the solution space of the Monte Carlo rendering algorithms. The efficiency of the light transport simulation is known to be influenced by the selection of the rendering algorithms according to the input scene. However, the selection of the algorithms can be cumbersome because the users need to know the detail of each algorithm. The proposed method solves this issue by blending the solutions of the two different rendering algorithms using a machine learning approach.

2. The second method bridges the state spaces of Markov chain Monte Carlo (MCMC)

rendering. Current MCMC rendering is built upon the two different state spaces with different mathematical background. While the two approaches are related by the sampling of transport paths, all existing MCMC rendering algorithms are designed to work within only one of the state spaces. We propose the first framework to bridge two state spaces. Using this framework, we can use mutation strategies designed for one space in the other space.

3. The third method bridges the chromatic spaces which determines the representation of spectra to improve the accuracy in the spectral reflectance reconstruction. The existing approaches in computer graphics are only based on the simple heuristics and ignores the actual shape of the measured spectra. Based on the observation from the color science field, we propose a spectral reconstruction method that can faithfully reproduce the shape of the spectra as well as the converted tristimulus values. The method facilitates the bridge between the original and lower dimensional representation of the spectra obtained with the knowledge of the measured spectra.

From the results of three methods, we observed each of the methods faithfully achieve the goals of improving the efficiency or the accuracy in respective problem domains. We hope the insight from our study can be a step toward the future evolution of the light transport simulation.