Abstract
（論文の内容の要旨）

Reflectance Modeling with Optimized Sampling Strategy
(最適なサンプリング戦略による反射モデリング)

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In everyday life materials play an important role in the perception of various objects around us yet we remain oblivious to the significant contribution they make in our decision making process. By utilizing the various cues and properties specific to certain materials we are able to understand and quantify entities. Likewise, in computer graphics materials play a central role in photorealistic appearance modeling of objects. Visual cues or optical properties of different materials are normally represented using the Bidirectional Reflectance Distribution Function (BRDF). Measuring these optical properties of materials in the form of BRDF is important for numerous applications and in this work we focus on developing sampling strategies for identifying suitable measurement directions for efficiently sampling the BRDFs and appearance of objects.

In the first part of this work we propose a method for measuring the reflectance of isotropic materials efficiently. Compared to earlier methods which require significantly large number of observations for measuring isotropic materials the idea is to provide a framework for sufficiently sampling a new material for modeling its BRDF using a small number of observations. We model the properties of an existing BRDF dataset using a compact representation essentially capturing the diversity in various materials. Using this representation and an optimization process whose objective is to minimize the uncertainty in modeling previously unseen materials an appropriate set of sampling directions necessary for acquiring reflectance of new materials are selected and used for reconstruction of bivariate BRDFs. The accuracy of proposed system is comprehensively evaluated and we demonstrate that comparative performance can be achieved compared to an exhaustively captured set of BRDFs.

In the second part of this work we develop a method for efficiently modeling the BRDF of materials comprising an object with uniform and isotropic reflectance using a small number of light source directions. Typically, different objects exhibit different kind of variations in surface normals which requires sampling strategies that can adapt to take advantage of these variations. Considering this the proposed approach utilizes together the knowledge of the objects shape along with the statistics of various BRDFs from a fixed view direction for analysis. Then using an optimization process which simulates the contribution of different light sources in modeling the objects appearance, the method identifies the most suitable set of light source directions for efficiently modeling the BRDF of the objects material. Experiments conducted using several

objects with varying shapes and a small number of light sources suggested by the method validate the effectiveness of the proposed approach in modeling object appearance.

In the third part of this work we propose a method for modeling appearance of objects composed of multiple materials and spatially varying BRDFs (SVBRDF). Often objects are composed of more than one material or exhibit variations within the material itself. In order to model the appearance of such objects for photorealistic rendering, dense sampling of objects appearance is necessary. However, by adaptively sampling the different materials using a suboptimal sampling strategy, it is possible to model the appearance of such objects using a small number of observations. To achieve this a complete framework which subdivides the reflectance estimation process into two phases is proposed for the reliable reconstruction of the appearance of such objects. Experimental results conducted using different objects with varying shapes and spatial appearances show promising results using a small number of observations.

Finally, I have developed several methods for efficiently sampling isotropic materials either from a single point on the surface or from objects with varying shapes and reflectance properties. The thesis as a whole presents a complete framework for modeling and synthesizing the appearance of objects for photorealistic rendering.