Full-dimensional Sampling and Analysis of BSSRDF

Chika Inoshita[1,a)] Seiichi Tagawa[1,b)] Md. Abdul Mannan[1,c)]
Yasuhiro Mukaigawa[1,d)] Yasushi Yagi[1,e)]

Overview

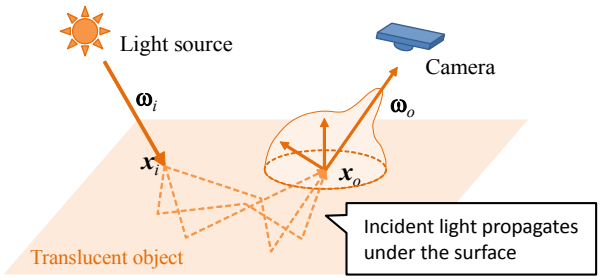
Full-dimensional (8-D) BSSRDF completely expresses various light interactions on object surface such as reflection and subsurface scattering. However, it is difficult to sample full-dimensional BSSRDF because it requires many illuminations and observations from various directions. There are many research which approximated BSSRDF as a low-dimensional function by only considering the medium as homogeneous or assuming isotropic scattering. Therefore, in this research, we show a novel sampling and analyzing method for full-dimensional BSSRDF of real scenes. We sample the BSSRDF using a polyhedral mirror system to place a lot of virtual cameras and projectors. In addition, we propose a method of decomposition of BSSRDF into isotropic and anisotropic components for scattering analysis. We show the empirical characteristics of subsurface scattering inside a real medium by analyzing sampled full-dimensional BSSRDF.

[1] The Institute of Scientific and Industrial Research, Osaka University, 8-1 Mihogaoka, Ibaraki-shi, Osaka, 567–0047, Japan
a) inoshita@am.sanken.osaka-u.ac.jp
b) tagawa@am.sanken.osaka-u.ac.jp
c) mannan@am.sanken.osaka-u.ac.jp
d) mukaigaw@am.sanken.osaka-u.ac.jp
e) yagi@am.sanken.osaka-u.ac.jp

Full-dimensional BSSRDF

BSSRDF represents light interaction such as subsurface scattering. This phenomenon is parameterized by incident position $\boldsymbol{x}_i$, incident angle $\boldsymbol{\omega}_i$, outgoing position $\boldsymbol{x}_o$ and outgoing angle $\boldsymbol{\omega}_o$.

BSSRDF: $f(\boldsymbol{x}_i, \boldsymbol{\omega}_i, \boldsymbol{x}_o, \boldsymbol{\omega}_o)$



Sampling system using polyhedral mirror system

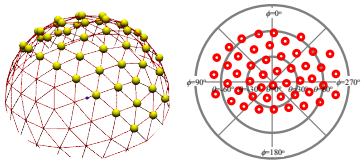
Requirements:

- Surrounding the target object with a lot of cameras and projectors
- Cameras/projectors must be distributed with uniform density at constant distance

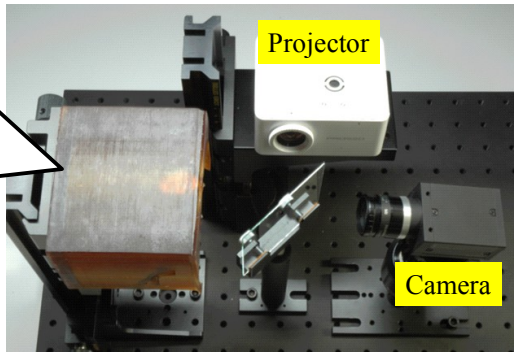
Our solution:

*Turtleback reflector**

Polyhedral mirror which distributes 48 virtual cameras and projectors on a hemisphere



Sampling positions on a hemisphere

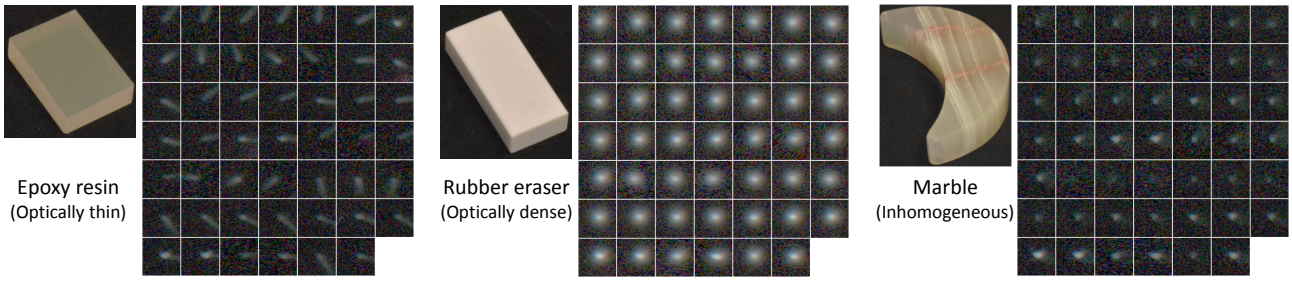


System overview

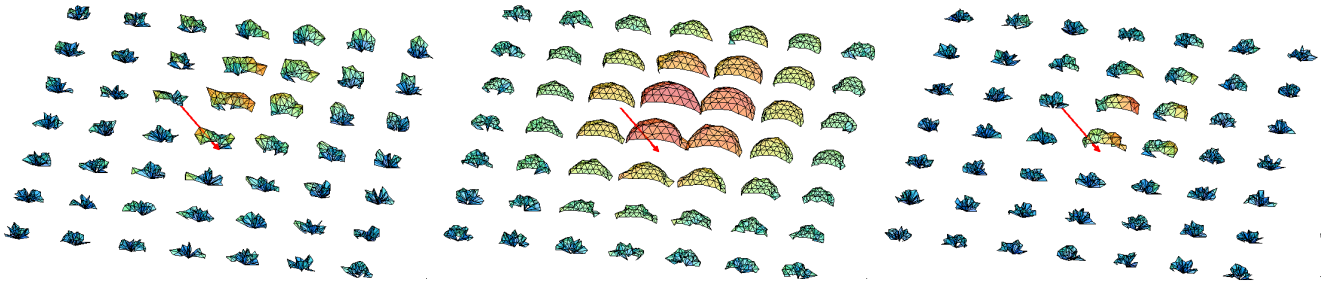
*Tagawa, S., Mukaigawa, Y., Kim, J., Raskar, R., Matsushita, Y. and Yagi, Y.: Hemispherical Confocal Imaging, *IPSJ Trans. on Computer Vision and Applications*, Vol. 3, pp. 222-235 (2011).

Sampled BSSRDF and its visualization

We sampled BSSRDF of three different types of target materials; epoxy resin (optically thin), rubber eraser (optically dense) and marble (inhomogeneous). We also visualize sampled BSSRDF as low dimensional slices.



Captured images with fixed illumination (θ_i, ϕ_i)=(44.9°, 74.8°) (γ=4.5)



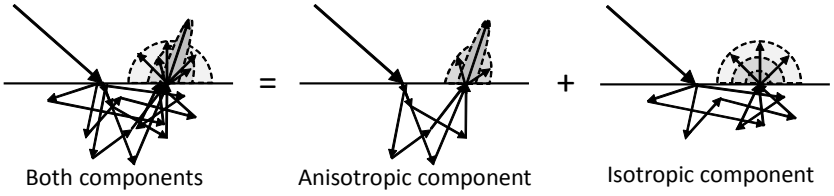
Visualized 4-D slices of BSSRDF $f(\boldsymbol{x}_o, \boldsymbol{\omega}_o)$ as angular distribution at each sampled position.

Decomposition of BSSRDF into isotropic/anisotropic components

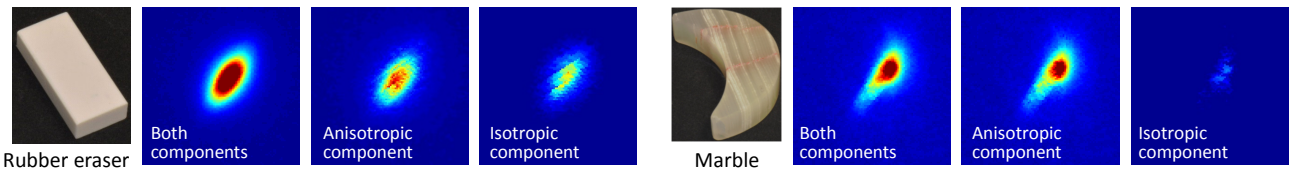
We decompose sampled BSSRDF into isotropic (angular independent) and anisotropic (angular dependent) components for scattering analysis.

Principle:

Scattering consists of anisotropic and isotropic components



Decomposed results:



Acknowledgement

This research is granted by the Japan Society for the Promotion of Science (JSPS) through the "Funding Program for Next Generation World-Leading Researchers (NEXT Program)," initiated by the Council for Science and Technology Policy (CSTP).