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Acquisition and display of reflectance field

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1. Introduction

Reflectance field is an eight-dimensional function, which represents incoming light rays from illumination toward an object and outgoing light rays from the object. It is also known as the bidirectional scattering surface reflectance distribution function (BSSRDF). The reflectance field is important in the field of analysis and display of material perception because it can express subsurface scattering and translucent materials. We recently have developed systems to acquire and display the reflectance field, respectively [1, 2].

2. Compressive reflectance field acquisition

Acquisition of the reflectance field generally requires a long observation time because it needs scanning along the eight dimensions. We applied a method in the compressive sensing, which is a powerful framework to observe a data by fewer measurements compared with the sampling theorem, to acquire the reflectance field [1, 3]. The schematic diagram is shown in Fig. 1. The incoming light rays toward the object is angularly modulated by the projector and the diffuser and spatially modulated by the spatial light modulator 1 (SLM1). The outgoing light rays from the object are angularly modulated by the SLM 2. Then the modulated rays are multiplexed onto the image sensor. The patterns of the projector and SLMs 1 and 2 are changed multiple times and each modulated signal is captured by the image sensor. The reflectance field is retrieved from the measurements by using a reconstruction algorithm with a sparsity constraint. In Ref. [1], the number of measurements was reduced by less than half from the conventional non-multiplexed approach.

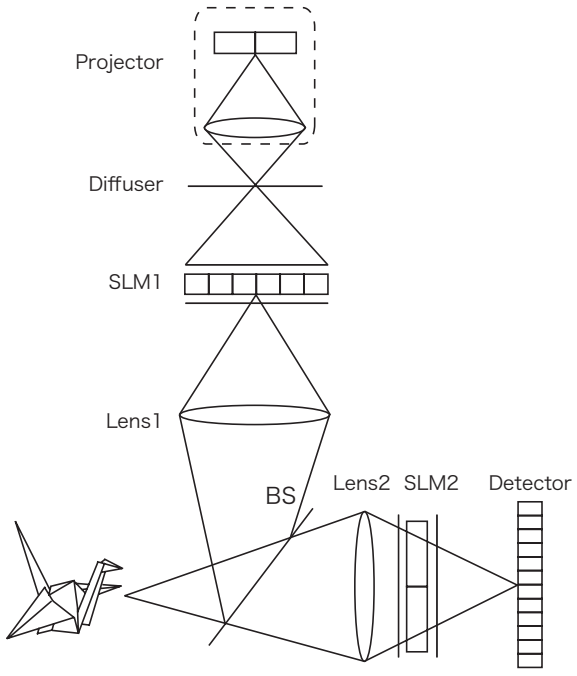

Fig. 1. Optical setup for compressive reflectance field acquisition.

3. Reflectance field display

As an application of the reflectance field, we have presented a system capable of displaying stereoscopic objects responding to the ambient illumination [2]. The system is composed of the integral photography unit, the integral display unit, and the processor connecting these units as shown in Fig. 2. The integral photography unit observes the incoming light rays from the illumination, the processor calculates the outgoing light rays with the reflectance field measured preliminary. The integral display unit emitts the calculated outgoing light field, which reproduces the object illuminated by the incoming light. This display can represent an object including subsurface scattering and translucent materials illuminated by arbitrary light sources. In Ref. [2], the fundamental function of the display was experimentally demonstrated.

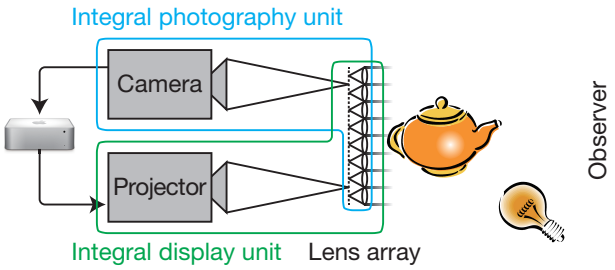

Fig. 2. Optical setup for reflectance field display.

References

[1] Y. Tampa, R. Horisaki, and J. Tanida, "Experimental verification of compressive reflectance field acquisition," Appl. Opt. **53**, 3157-3163 (2014).
[2] R. Horisaki and J. Tanida, "Reflectance field display," Opt. Express **21**, 11181-11186 (2013).
[3] D. Donoho, "Compressed sensing," IEEE Trans. Info. Theory **52**, 1289-1306 (2006).