Is Spectral Lighting Environment Necessary for Photorealistic Rendering?

Megumi Miura
Kyushu Institute of Technology

Takahiro Okabe*
Kyushu Institute of Technology

Imari Sato
National Institute of Informatics

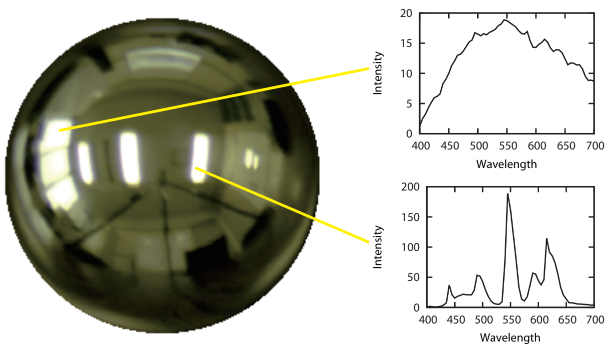

Figure 1: The spectral lighting environment of a real scene acquired by using a hyperspectral camera and a mirrored ball.

1 Motivation and Contribution

The appearance of an object depends not only on the geometric and photometric properties of the object but also on the light sources illuminating it. The technique that measures the omnidirectional lighting environment of a real scene and uses it for photorealistic image synthesis is called Image-Based Lighting (IBL) [Debevec 1998; Sato et al. 1999].

In conventional IBL, a 3-band RGB camera is used for measuring the lighting environment of a scene. Unfortunately, however, the spectral resolution of 3-band cameras is low, and therefore we cannot prevent the occurrence of so-called *metamerism* in general. Specifically, when two light sources with different spectral distributions are observed by using a 3-band camera, the apparent RGB values of those light sources could be the same. It is also shown that spectral rendering is of critical importance for subsurface scattering, dispersion, and volumetric effects [Wilkie et al. 2014].

Accordingly, in this study, we acquire the omnidirectional lighting environment of a real scene by using a hyperspectral camera, which has several tens of bands in visible spectrum, and then use the acquired spectral lighting environment for image synthesis. In particular, we compare the images synthesized by using the spectral lighting environment with those using the RGB lighting environment, and evaluate the difference between them. We demonstrate that spectral lighting environment is not necessarily important for rendering reflective materials, but is highly important for rendering fluorescent materials, which are common and present in 20 percent of randomly constructed scenes [Barnard 1999].

2 Highlight of Experimental Results

The HDR spectral lighting environment of a real scene was acquired from an image sequence of a mirrored ball with uniform reflectance in visible spectrum. Those images were captured by using a hyperspectral camera from EBA Japan, which has a sampling interval of 5 nm. The light source spectrum from each incident direction to the mirrored ball is obtained as shown in Figure 1.

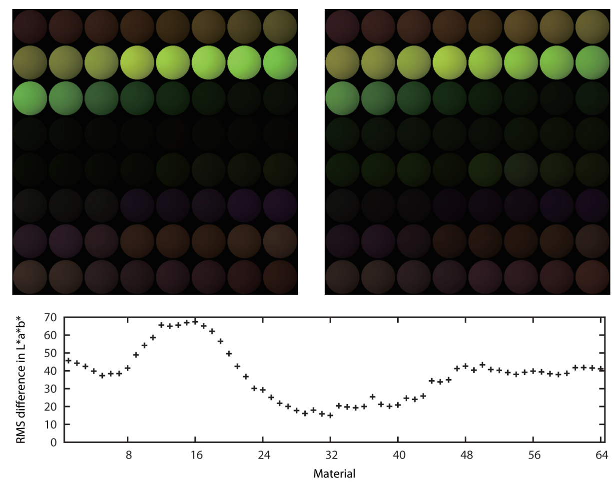

Figure 2: The images of 64 fluorescent spheres with different absorption and emission spectra synthesized by using the acquired spectral (top left) and RGB (top right) lighting environments. The RMS differences between the synthesized images in CIE-L*a*b* space (bottom).

Figure 2 shows the images of 64 fluorescent spheres with different absorption and emission spectra synthesized by using the acquired spectral (top left) and RGB (top right) lighting environments. Here, the spectral lighting environment is converted to the RGB lighting environment by using the CIE color matching functions. Figure 2 (bottom) shows the RMS differences between the synthesized images in the CIE-L*a*b* space. We can see both qualitatively and quantitatively that the difference between them is significant. The reason why fluorescent materials have large differences is that the absorption spectra are often narrow-band.

Other experimental results are shown in the supplementary material. In particular, we show that the RMS differences in the CIE-L*a*b* space are less than 7 for reflective materials when the same lighting environment is used.

*okabe@ai.kyutech.ac.jp

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