Estimating Lighting Environments Based on Shadow Area in an Omni-Directional Image

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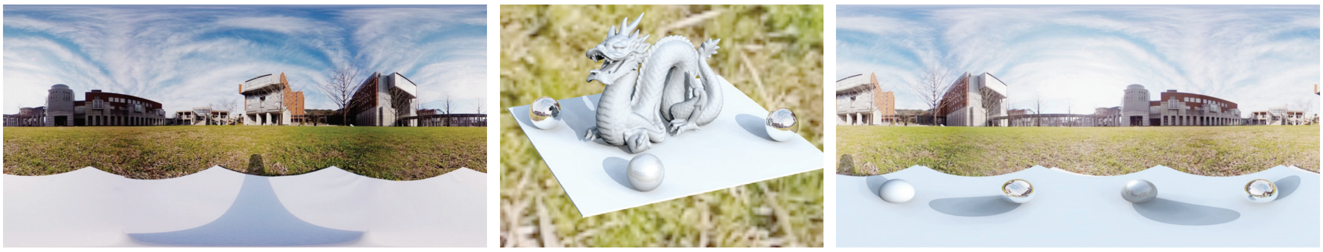

(a) (b) (c)

Figure 1: *(a) an original omni-directional image captured using RICOH THETA that is a small 360 degree camera, (b) a perspective image generated using the estimation results, (c) an omni-directional image generated using the estimation results.*

Keywords: image-based lighting, omni-directional image, lighting environment estimation

Concepts: •**Computing methodologies** → *Image-based rendering;* 3D imaging; Reconstruction;

1 Introduction

To create realistic CG images, the information about the lighting is very important. There are two ways to estimate the information of the light source. One is a direct measurement method using images captured with a fish-eye lens or a spherical mirror[Debevec 1998], and the other is an indirect measurement method to estimate positions and intensities of the light sources from the shadow information of objects[Sato et al. 2003]. In the direct measurement method, by concerning pixels of the captured image as light sources having corresponding intensities, it is possible to estimate the lighting environment densely. However, for a high-intensity light source like the sun, the dynamic range of the camera is insufficient, and the radiant intensity of the light source cannot be accurately estimated. So, we propose a method that combines a direct measurement technique and an indirect measurement method. In our proposed method, the light source information of the high-intensity area in the captured image is estimated by indirect measurement method. In the experiments using real images, even for outdoor scenes that contain the high-intensity light source like the sun, the measurement of the light source environment could be performed by the proposed method. Also, it was confirmed that images including realistic shadows equivalent to real images could be created.

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2 Proposed Method

In this study, we carried out an estimate of the light source information by a combination of direct measurement methods and indirect measurement methods. Except for the very high brightness areas, such as the sun, we measure the directions and intensities of virtual light sources by direct measurement method from the luminance values of the omni-directional image. For a high-brightness area, we estimate the brightness of the light source from the ratio of the luminance of the shadow area and the sun shine area.

The shadow region is caused since an object obstructs the sun. We assume that the obstacle object interrupts only the sun light and does not obstruct the skylight. From this assumption, the intensity of the sun shine area P_{max} is calculated as follows.

$$P_{max} = RL_x \cos\theta_x + R\sum_{i=0}^{n} L_i \cos\theta_i \quad (1)$$

where L_x is the brightness of the sun, L_i are the brightness of the skylight as shown in Fig. 2. θ represents the angle between the normal of the ground plane and the direction of the light, R is the reflectance of the ground. The intensity of the shadow area P_{min} is calculated as follows.

$$P_{min} = R\sum_{i=0}^{n} L_i \cos\theta_i \quad (2)$$

So, the brightness of the light source L_x can be calculated by the following equation.

$$L_x = \frac{P_{max} - P_{min}}{P_{min}\cos\theta_x} \times \sum_{i=0}^{n} L_i \cos\theta_i \quad (3)$$

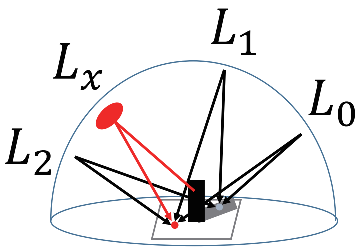
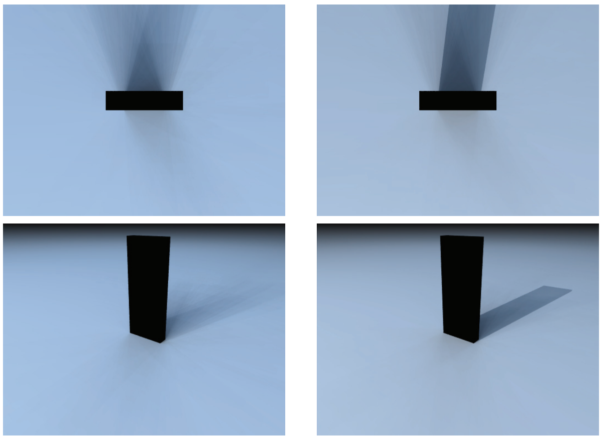


Figure 2: *Illumination model of the sun and the skylight.*

3 Results and Conclusion

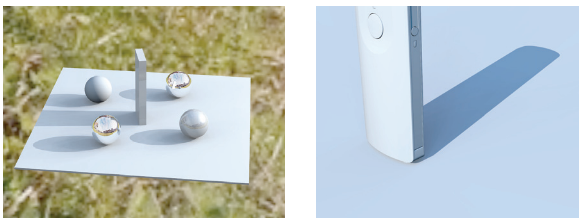
Figure 3 shows examples of generated images. We use POV-ray for image synthesis and 200 point lights to approximate the sun and the skylight. The images in Fig. 3 (a) are generated by using an ordinary structured sampling method. The images in Fig. 3 (b) are generated with our method. In Fig. 3 (b) , the shadow of the object is clear comparing to the previous method, and it shows the effectiveness of our method. Fig. 4 shows one of the cube map images converted from the omni-directional image for comparison. The shadow in Fig. 3(b) is very similar to Fig. 4. We show some other images generated using the estimated results in Fig. 5. These images have very realistic shadows as real images.



(a) (b)

Figure 3: *Image synthesis results.*

Figure 4: *Shadow in the real image.*



(a) (b)

Figure 5: *Other image synthesis results.*

References

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