Acquiring Perceptually Diffuse Shading from General Objects in Actual Scenes

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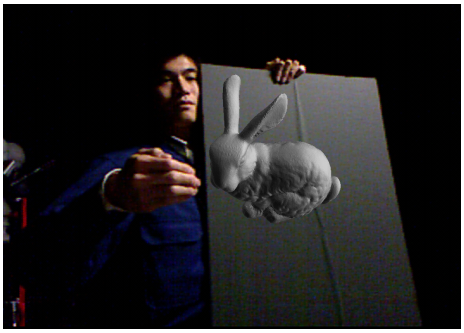


Figure 1: *Synthesized bunny objects rendered with shading derived by referring to a plaster figure (left) and a human hand (right). In both cases, we did not use any specific light probe such as a mirrored sphere to derive the shading.*

1 Introduction

Recently, augmented reality has started to be used in interactively simulating clothes, furnitures, and so on in actual scenes. In such applications, the shading of synthesized CG objects should be matched to those scenes to achieve a sense of reality. Although many techniques have been proposed to match the shading of CG objects to actual scenes, typically they require the use of light probes such as mirrored spheres [Debevec 1998]. However, such light probes are not always available in interactive simulation situations.

In this paper, we introduce a method to acquire perceptually diffuse shading matched to actual scenes by referring to general objects in the scene. Our method does not require specific light probes and utilizes only a commercial RGB + depth sensor which is increasingly being used in interactive simulations.

2 Our Approach

Our method is based on our discovery that we can acquire perceptually diffuse shading by approximating Phong shading as a weighted sum of the first nine spherical harmonics (sphs). Motoyoshi et al. showed that humans perceive a surface as diffuse if the skewness of its luminance histogram is negative. We use skewness as a measure of perception of surface reflection in this research.

The aforementioned discovery was made through a CG experiment we conducted. In the experiment, we first approximated the luminance of shading rendered by Phong reflection model as a weighted sum of the first nine sphs on the basis of their surface normals. We then calculated the skewness of the resultant shading's luminance histogram. The results showed that skewness become negative regardless of the specular reflection shininess. An example is shown in Figure 2, where the resultant shading shows negative skewness and is very similar to diffuse shading. This suggests that we can derive perceptually diffuse shading by obtaining the luminance and surface normals of actual objects, assuming the objects' shading is based on the Phong reflection model.

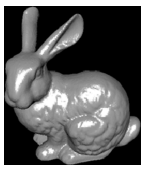
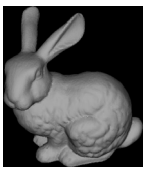
	Phong Shading	Shading Derived by Our Method	Correctly Rendered Diffuse Shading
Skewness	1.42	-0.32	-0.36
Image of Shading			

Figure 2: *The middle result is derived by referring to Phong shading (left). It shows negative skewness and is very similar to correctly rendered diffuse shading (right).*

On the basis of our discovery, we implemented our method in the form of a system that uses simple instructions to derive perceptually diffuse shading by referring to general objects in actual scenes. The system comprises a PC and a commercial RGB + depth sensor. It first uses the sensor to capture the scene and calculates the luminance values and corresponding surface normals. The user then selects a reference object (merely by clicking it in the image) and the shading is derived automatically. Segmentation thresholds for identifying objects can be adjusted interactively. Figure 1 shows examples of synthesized CG objects rendered with derived shading.

Although reference objects currently need to have half omnidirectional surface normals, our method can reference many types of objects, including the human body. This implies that our method can be integrated into augmented reality simulations involving humans in the scenes.

References

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SIGGRAPH 2012, Los Angeles, California, August 5 – 9, 2012.
ISBN 978-1-4503-1435-0/12/0008