Measured Curvature-Dependent Reflectance Function for Synthesizing Translucent Materials in Real-time

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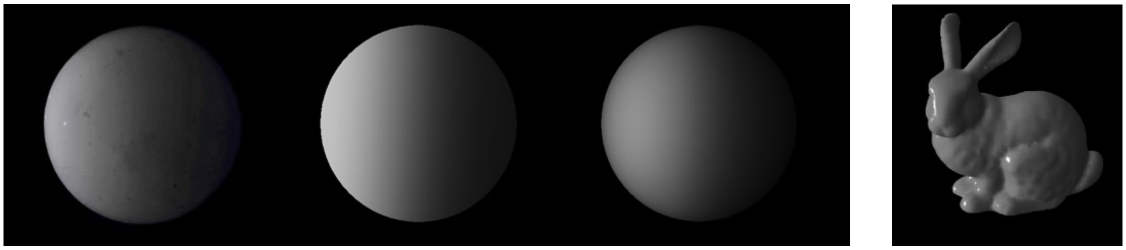

(a) Photograph of translucent sphere (b) Synthesized translucent sphere (CDRF) (c) Synthesized translucent sphere (Our method) (d)Synthesized translucent Bunny

Figure 1. Photograph of translucent sphere and result images

1. Introduction

Simulating the effects of sub-surface scattering is one of the most important factors for synthesizing realistic translucent materials. "Curvature-Dependent Reflectance Function (CDRF)" proposed by Kubo et al. [2010] enables to represent the effects of sub-surface scattering in real-time, according to the correlation between curvature and translucency. Since CDRF is an approximation of scattering effects using Gauss function, whole details of the effect cannot be represented.

To represent the effects of sub-surface scattering, that cannot be approximated using Gauss function, we propose measured CDRF, acquired from real objects. Using a digital camera and polarizers, we obtain the correlation between curvature and scattering effect, then store it as a look-up-table. As a result, we are able to realize real-time rendering of translucent materials from measured CDRF.

2. Acquiring Radiance by Measurement

To measure actual sub-surface scattering, we irradiate a directional light from the left side to several translucent spheres (made of wax) of varying radii (measured in [mm]); values of radii r included 50, 45, 40, 35, 30, 25, 20, and 15. Figure 1-(a) shows an example sphere with r=35. Analyzing this image, the effects of transmitted light can be measured in the regions not directly irradiated by light. Furthermore, it can also be measured that the effect of sub-surface scattering tends to show more noticeable on smaller sphere. From these images, for each radius, we acquire the correlation between radiance and θ :the angle between the normal vector and light vector over the sphere. However, because the feature of diffuse surface is not indicated in translucent materials, these data could contain errors based on the gradient of surfaces. As expected, according to our observations, the radiance of surfaces highly depends on φ:the angle between the normal vector and view vector. To remove these errors, we similarly acquired the correlation between radiance and φ; then, using the correlation, we recalculated radiance, which is uninfluenced by φ. Figure 2 shows an example which includes raw data and revised data about the correlations between radiance and the angle θ.

To synthesize 3D objects which contain a variety of different curvatures, we complement these data using Catmull-Rom Spline interpolation and store these correlations into a look-up-table. As above, we rapidly acquire the radiance from the curvature and angle θ. Consequently, for rendering a translucent object, we refer to the look-up-table using input curvature and θ, and then, revise the radiance corresponding to the angle between the view vector and normal vector of a drawing point.

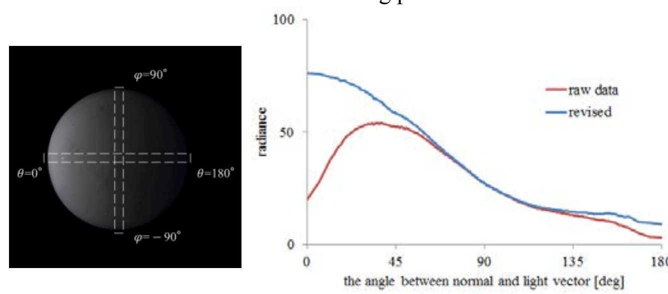

Figure 2. Radiance distribution with radius r =35[mm]

3. Results

Figures 1-(b) and 1-(c) show synthesized translucent models using conventional method and our method, respectively. Results show that our method succeeds in rendering realistic translucent materials and synthesizing a soft shade by analyzing actual measurement data.

An executive time for proposal method is 0.333 [ms] for the Bunny (16,301 vtx.), shown in Figure 1-(d). This computation is obtained from 3.4GHz Intel® Core™ i7-3770 with NVIDIA GeForce GT 640. Compared with conventional method, we realized almost the same run-time performance based on actual measurement.

4. Conclusions

In this paper, we proposed a method to acquire measured CDRF to synthesize realistic translucent materials in real-time. In addition, we are able to represent the effect of sub-surface scattering depending on view vector. Acquiring scattering effects from a single image is a future work.

References

KUBO, H., DOBASHI, Y., AND MORISHIMA, S. 2010. Curvature-Dependent Reflectance Function for Rendering Translucent Materials. SIGGRAPH'10, Article 46.

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