Lace curtain: Measurement of BTDF and rendering of woven cloth

– Production of a catalog of curtain animations –

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1 Introduction

The need for rendering woven fabrics arises frequently in computer graphics[Neeharika Adabala, Nadia Magnenat-Thalmann, Guangzheng Fei 2003]. Woven fabrics have a specific appearance, luster, and transparency. A BRDF model is well known as the basic technology employed for expressing the appearance of a woven fabric. In order to represent the transparency of a woven fabric, a BTDF (bidirectional transmittance distribution function) model is required in addition to the BRDF model. In this paper, we propose two rendering methods for woven fabrics, particularly transparent fabrics such as lace, based on a BTDF model.

2 Measurement of woven cloth

We measured the BTDF of the two woven fabrics by using a BRDF instrument (OGM-3, DFL), which consists of a fixed digital camera, a movable light source (metal halide), and a movable sample plate. 2400 points per cloth were measured by repositioning the lamp and the plate. As shown in Figure 1, we made the following observations: (1) a woven fabric has the property of bidirectional transmittance and scattering and (2) transmitted light consists of two components–diffusional and directional transmission.

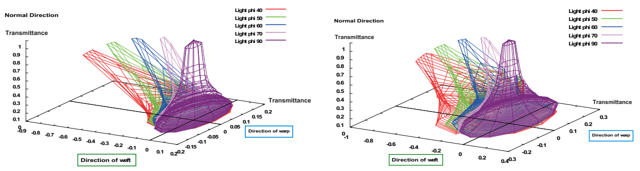
3 BTDF model and parameters estimation

In order to express various types of woven fabrics, it is essential to use a standardized BTDF model that can compress the measurement data. We propose a standardized model consisting of two components–diffusional and directional transmission–that are defined by the Henyey-Greenstein function.

A method for the automatic estimation of parameters is required in order to apply the proposed model to the measurement data. We estimated the parameters by using the Levenberg-Marquardt algorithm (LMA), which is one of the optimization algorithms. A comparison between the measured BTDF and the result of fitting the BTDF model with the estimated parameters is illustrated in Figure 2. On comparing the results of the proposed model with the measured values, we found that the peak of the specular transmittance of the model was in agreement with the measured value, and the curve of the diffusive transmittance of the model also corresponded with the measured value.

4 Rendering with the modeled BTDF

The results of rendering based on the measured BTDF and the modeled BTDF are presented in Figure 3 and 4. Both the rendering algorithms are implemented as shader plug-ins for Maya. In both the images, we can observe that the transmission factor differs according to the position of the curtains, and the resulting shadows feature uneven shading. These results demonstrate that the modeled BTDF is as effective in depicting the transmission property as the measured BTDF.



(a) Material A (b) Material B

Figure 1: Comparison of two woven fabrics

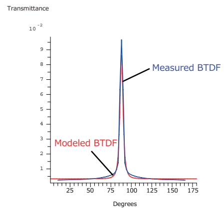


Figure 2: Comparison between measured BTDF and modeled BTDF

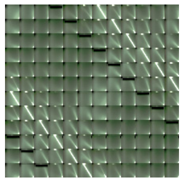


Figure 5: Lookup table as bitmap image translated from measured BTDF data

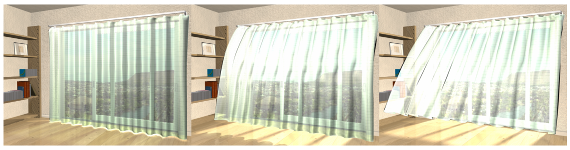


Figure 3: Rendering of images with the measured BTDF

Figure 4: Rendering of images with the modeled BTDF

5 Real-time rendering of the BTDF

A real-time rendering algorithm of this BTDF model was implemented by using a combination of OpenGL and Nvidia's Cg. The algorithm was programmed using texture sampling by means of an LUT, which was constructed as a two-dimensional bitmap image translated from the four-dimensional BTDF data (Figure 5). The transmitted and reflected light obtained from the LUT, the background light defined by cube mapping, and a texture element were added during rendering.

6 Conclusions

We have proposed a BTDF model and two algorithms for both the offline and real-time rendering of woven fabrics. Our goal is to generate a catalog of curtain animations that can express various types of woven fabrics under arbitrary light conditions.

References

NEEHARIKA ADABALA, NADIA MAGNENAT-THALMANN, GUANGZHENG FEI. 2003. Visualization of woven cloth. *EGRW '03: Proceedings of the 14th Eurographics workshop on Rendering*, 178–185.

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