Lace Curtain: Interactive Animation of Transparent Woven Fabric Based on Microfacet BSDF Model

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1. Introduction

Realistic and interactively generated computer graphics are needed in various fields, such as for CGI-animated movie and in education. To express the realistic appearance of various materials, it is important to represent the specific optical properties for each material.

In this study, we focus on woven fabric, which is frequently expressed in computer graphics. Woven fabrics such as lace curtains have specific transparency, and change their appearance drastically by their deformation. To express the specific factors of woven fabrics under any environment, we proposed the microfacet BSDF model [Nomura et al. 2011]. We also generate animation with interactive frame rate using a ray tracing engine to express the realistic appearance caused by the deformation.

2. Physically based model for woven cloth

2.1 Measurements of woven cloth

To compare the BTDF model with measurement BTDF, we measured optic properties of the four fabrics samples using the BRDF instrument OGM-3 (Optical Gyro Measuring Machine). Measurement was performed to utilize metal halide as light source which is similar to natural light. 4800 points were measured by changing the angle of camera and light.

2.2 Woven cloth microfacet BSDF model

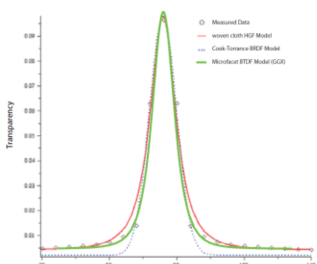

Figure 1. *Comparison between the measured BTDF and BTDF model (elevation angle of camera is* 0° *and light is* 0°*, azimuth angle of camera is* 180° *and light is* 90°*)*

To estimate the best-fit model for measurement BTDF of fabrics, we compared the approximate curves calculated from six typical models (Phong, Ward, Ashikhmin-Shirly, Cook – Trance, HGF, and GGX) with the measured BTDF curves. Figure 1 showed the result of comparison between the measured BTDF and the modeled BTDF. We can observe that the GGX model is the best-fit model for measurement BTDF data. Therefore, we proposed a new microfacet BSDF model based on the GGX model in order to represent the transparency of woven fabrics. The micorofacet BTDF model has newly added specific parameters for woven fabric such as density of threads.

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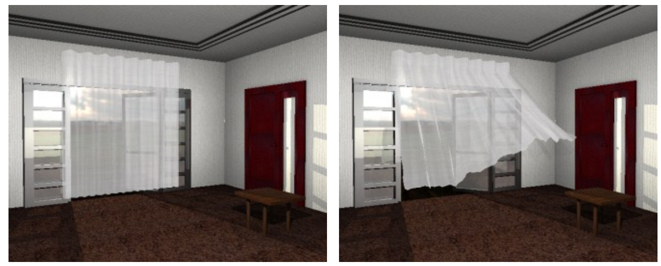
I3D 2015, February 27 – March 01, 2015, San Francisco, CA.

ACM 978-1-4503-3392-4/15/02 $15.00
http://dx.doi.org/10.1145/2699276.2721399



(a) Rendering image in a state of rest (b) Rendering image in a state of motion

Figure 2. *Results of rendering based on the microfacet BSDF model.*

3. Interactive animation of woven fabric

We used ray-tracing as the rendering algorithm to express the realistic reflected and transmitted light, and used ambient occlusion for global illumination. To achieve the interactive frame rate with ray-tracing, rendering algorithm was implemented by using Nvidia's OptiX ray-tracing engine [Steven et al. 2010]. The microfacet BSDF model was directly implemented in the closest hit program as shading function in order to represent the specific appearance of woven fabric. We also implemented particle based cloth simulation for the fabric behavior.

Figure 2 showed the results of rendering. The rendering environments are a 3.40 GHz Intel Core i7 processor, 8GB of RAM and Nvidia Quadro K4000 2 GB graphics processor. We have achieved a frame rate of 10.5 fps under a resolution of 800 × 600. We can observe that the transmitted light of woven fabric under the deformation, and the transmission factor differs according to the region of curtains.

4. Conclusions

We proposed microfacet BSDF model to express the specific transparency of woven fabric, and generate animation with cloth simulation in order to represent the changing appearance under the fabric behavior. In this study, we used ambient occlusion to determine global illumination. However, ambient occlusion cannot simulate the caustics of lace curtain. As future works, we intend to use photon mapping for the global illumination that was improved to sample photon based on a woven cloth BTDF model.

References

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