Lace Curtain: Modeling and Rendering of Woven Structures using BRDF/BTDF

– Production of a catalog of curtain animations –

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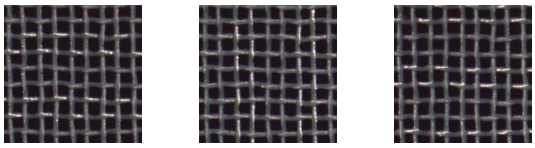
1 Introduction

The need for rendering woven fabrics arises frequently in computer graphics[N Adabala, N Magnenat-Thalmann, G Fei 2003]. Woven fabrics have a specific appearance, luster, and transparency. We have proposed a BRDF/BTDF model using the Henyey-Greenstein function and an algorithm for the real-time rendering of woven fabrics based on the texture look-up table[Uno et al. 2008]. However, in order to make the model more accurate, the microlevel BRDF/BTDF is necessary. The objective of this study is to express a more detailed texture of the cloth by creating a 3D model that especially takes into consideration the " twisted structure " of the yarn in the fine woven structure of the cloth and by making the rendering algorithm more precise.

2 Measurement of Woven Cloth

We measured the BTF for culculating the BRDF/BTDF of the woven fabrics by using a BRDF instrument (OGM-3, DFL), which consists of a fixed digital camera with a microlens, a movable light source (metal halide), and a movable sample plate. 1092 images per cloth were measured by repositioning the lamp. As shown in Figure1, we made an observation that yarn has a twisted structure.



$\theta 30°, \phi 45°$ $\theta 60°, \phi 55°$ $\theta 150°, \phi 45°$

Figure 1: The Twisted Structure of Yarn in the Woven Cloth

3 Recreation of the Woven Structure of Cloth

Here, we propose a 3D model of the woven structure of the cloth that takes into consideration the twisting of the yarn.

3.1 Parameters of the Woven Structure

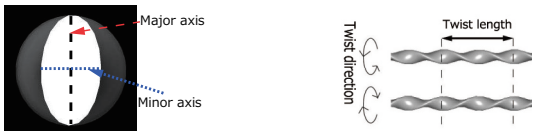
We extracted the intersections using thinning processing from the acquired BTF data . Furthermore, from the vertical and horizontal direction histograms, we determined the fluctuations of the vertical and horizontal threads and calculated the thickness of and the space between each thread.

3.2 Parameters of the Twisted Structure

We assumed a basic model for yarn in which the cross-section is elliptical and its structure has a twist direction (right twist, left twist) and a twist length. We separated the vertical threads and horizontal threads from the binary image and decided the height and width of the ellipse based on the fluctuations of thickness in the vertical and horizontal threads. Next, we used an autocorrelation function to calculate the length of the twist and determined the direction of the twist of the yarn from the vector direction of the highlighted areas. From the height and width of the ellipse and the length of the twist, we hypothesized that the threads intersect without being distorted and calculated the slope of the yarn.

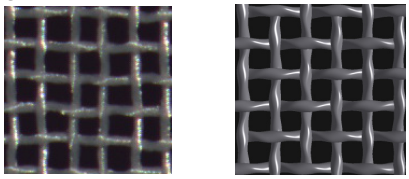
3.3 Generation of a 3D Model based on Woven Structures and Twisted Structures

The recreated woven structure of the cloth is shown in Figure3(b). Comparing this to the image of the actual cloth (Figure3(a)), we confirmed that the highlighted components originating from the twist are expressed in the same way in both directions and that the model of the twist used in this paper is appropriate.



(a) Elliptical Structure of the Yarn (b) Twist Direction and Length

Figure 2: Twisted Structure Model of the Yarn



(a) Photo (b) Recreated Image

Figure 3: Results of the Rendering

4 Making the Rendering Algorithm more Precise

In our previous BTDF model[Uno et al. 2008], we calculated the transmittance from the mean value per unit area, but this time we were able to introduce a microscopic geometrical structure, so it became possible to more appropriately express the directional transmittance components and the dispersed transmittance components. Furthermore, we introduced Global Illumination and performed the rendering by using Maya 's Mental Ray shader plug-in. The result of the rendering based on the BTDF model is presented in Figure4.

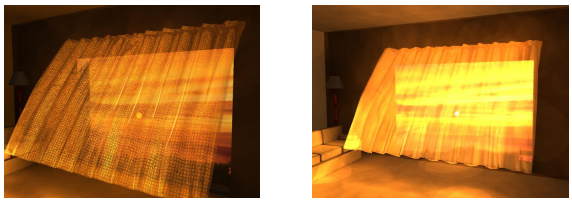


Figure 4: Results of the Rendering

5 Conclusions

We proposed recreating a 3D model that especially takes into consideration the twisted structure of yarn in the fine woven structure of the cloth and making the rendering algorithm more precise. Our goal is to generate a catalog of curtain animations that can express various types of woven fabrics under arbitrary light conditions.

References

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

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