Lace Curtain: Rendering and Animating Woven Cloth Based on an Impression-Evaluation Model

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1 Introduction

Woven fabric is frequently used in computer graphics. To express the realistic appearance of a woven fabric, it is important to represent its luster, transparency, and motion. In our previous study, we proposed a physically based BTDF model of woven cloth [Nomura et al. 2011] and a method of estimating the motion properties of woven cloth from subjective impression [Ishida et al. 2012]. However, for the further enhancement of the texture of materials in animations, it is necessary to construct a comprehensive impression model for the evaluation of woven cloth that includes the relationship between optics and motions, impressions and emotions that are evoked by the impressions. In this study, we propose an impression-evaluation model for the rendering of woven fabrics.

2 Impression-evaluation model for woven cloth

In order to clarify the relationship between impressions and physical characteristics, we measured optical and motion properties and performed experiments to evaluate subjective impressions.

Measurements of woven cloth To evaluate the six woven fabric samples, we measured BRDF/BTDF by using a BRDF instrument, the OGM-3 (Optical Gyro Measuring Machine), and we measured motion properties such as bend, shear, compression, and stretch by using a handle instrument, the KES (Kawabata Evaluation System). Then, we applied PCA (principal component analysis) to the measured BRDF/BTDF data to derive the major physical properties.

Experiments for impression evaluation We performed experiments to evaluate impressions using actual woven fabrics whose states are stationary or moving. We used adjective word-pairs related to the optical and motion properties. As a result of a factor analysis of the data obtained, we found out that the factors ”softness” and ”smoothness” for the optics and the factors ”flexibility” and ”weight” for the motions influence the emotions evoked by the texture of woven fabrics. Furthermore, the relationship between the measured data and the subjective impressions to weave structure were obtained using a multiple regression analysis.

3 Estimation of optical/motion properties using the impression-evaluation model

We estimated the physical parameters for rendering using the relationships between the optical and motion properties in the impression-evaluation model. For example, from the thickness of warp/weft, the optical/motion properties, such as the value of bend and the directional transmittance, were estimated.

4 Rendering with BTDF based photon sampling for global illumination

We used photon mapping for to determine global illumination. In order to represent realistic transmitted light, we introduced a photon sampling based on a woven cloth BTDF model similar to arbitrary BRDF based importance sampling[Montes et al. 2009]. Thus, it was possible to precisely express the BTDF properties of woven cloth, such as direct transmittance and scattering by the thread. We performed the rendering of animations with different subjective impressions using global illumination as see in Figure1.

(a)Stiff and rough impression.
The curtain motion is rigid and little influence of transmitted light.

(b)Pliable and smooth impression.
The curtain motion is wavy and influence of the transmitted light was confirmed in the direction of direct transmission.

Figure 1: Scenes of curtain animations with different impression (in the same flame time).

5 Conclusion

We clarified the structure of the impression-evaluation of woven fabrics and proposed a method to render such fabrics on the basis of the impression-evaluation model. By estimating the physical characteristics from impressions, the expression of texture of woven fabrics was improved. We are planning to apply our approach to various materials.

References

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