Lace Curtain: Rendering Animation of Woven Cloth using BRDF/BTDF - Estimating physical characteristics from subjective impression

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1 Introduction

The need for rendering woven fabrics arises frequently in computer graphics. Woven fabrics have specific appearances such as luster and transparency. To express realistic appearance, however, it is necessary to set various parameters ad hoc by trained users. In our previous study, we proposed one solution for issues of luster and transparency by using a physically-based BTDF model of woven cloth on the basis of the GGX [Nomura et al. 2011]. Additionally, rendering fabric motion properties is also significant to enhance the texture of materials in animations [Faure et al. 2009]. In this study, we propose a new method to render woven fabrics which have both realistic appearance and motion.

2 Experiment of impression evaluation

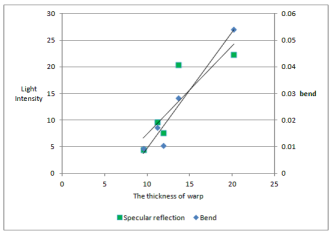
We performed an experiment to evaluate subjective impressions about relationships between the optic and the motion properties, and estimated the dynamic properties from the optic properties directly. The experiment was performed by using ten evaluative word pairs. All evaluative words were adjectives related to the optic and the motion properties (e.g. pliable or stiff, heavy or light, and so on). Experimental stimuli were eight curtain animations that differed in values of bend and shear. We adopted Scheffe's paired comparison method as an experimental method. Participants were required to compare eight paired curtain animations with each evaluative word pairs on a five-point scale. The participants were seven men and three women in their twenties.

3 Measurements of woven cloth

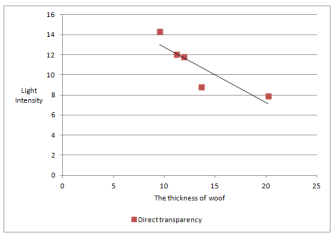
We measured the optic and motion properties of the three woven fabric samples. For optical properties, BRDF and BTDF were measured by using a BRDF instrument OGM-3 (Optical Gyro Measuring Machine). For motion properties, bend, shear and compression were measured by using a handle instrument KES (Kawabata Evaluation System).

4 Relationship between optics and motions

The results of the experiment on impression evaluation that revealed the impressions of flexibility (pliable or stiff) and weight (heavy or light) are influences on characteristics of curtain motion. The impressions of flexibility and of weight depend on the bend and the rate of specular reflection. For flexibility, curtain motions were evaluated as more stiff by people when the value of bend and rate of specular reflection were also higher. For weight, curtain motions were evaluated as lighter when the value of bend was lower and rate of diffuse transparency was higher. The value of bend increased in proportion to the thickness of warp. The specular reflectance and the directional transmittance decreased in proportion to the thickness of weft.



(a)Light intensity/bend and the thickness of warp



(b)Light intensity and the thickness of the weft

Figure 1: Relationship between optic and motion properties

5 Rendering animations

We performed the rendering of animations with different subjective impressions by using Maya's shader plug-ins, and compared in Figure 2. The rendering environments are a 3.40 GHz Intel Core i7 processor, 16 GB of RAM and nVIDIA Quadro 4000 graphics processor.

(a)Stiff and heavy impression. Both warp and weft are thick, the specular reflectance is high and the directional transmittance is low.

(b)Pliable and middle weight impression. The middle appearance of (a) and (c).

(c)Pliable and light impression. Both warp and weft are thin, the specular reflectance is low and the directional transmittance is high.

Figure 2: The results of curtain animations with different subjective impressions. These images are rendered in the same frame time.

6 Conclusion

The results of the evaluation on subjective impression showed the possibility of estimating the dynamic properties by the optic properties more directly. The rendering animation with the new method which adopted the evaluations of subjective impressions enhanced both realistic appearance and motions. We are planning to generate a catalog of curtain animations that can express various types of woven fabrics under arbitrary light conditions.

References

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