An Improved BRDF Method for 3D Textile Simulation

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ABSTRACT

There are some methods suggested by researchers were used to simulate one or two characteristics of textile in the past few years. With 3D geometry models, most of these methods are somewhat complex, and it is difficult to simulate fabric attributes. This paper represents a method for textile simulation based on improved BRDF illumination models. As one simple type of BRDF model, Phong illumination model can be used to simulate fabric 3D geometry model. The more complex BRDF illumination model may be used to simulate fabric 3D structure. The pixel color values, derived from simulating fabric 3D structure, is taken as the parameters to be entered into Phong illumination model. And thus both the fabric 3D geometry model and structure can be achieved, based on which the textile can be simulated successfully and obtain a perfect display effect.

Keywords

3D textile, BRDF model, illumination model, simulation

1. INTRODUCTION

The representation of 3D textile model is one of the important techniques in the fashion CAD. The structure of 3D textile was one of research emphases. With the development of computer technology and the improvement of simulation for textile, more and more researchers use computers to represent 3D textile structure. There are some methods to simulate textile, such as Phong illumination model [1] and BRDF model [2].

Phong illumination model and BRDF model are popular techniques in computer graphic field. More specifically, the former is the simplest type of the latter.

Phong illumination model is suitable for simulating those materials with smooth surface.

It has been improved by some researchers [1] by means of controlling some parameters, such as the proportion coefficients of circumstance, diffuse and mirror reflection. They calculated the values of the angle of light source incidence and that between the mirror reflection and the sight direction according to the structure of the yarn and woofs [3].

BRDF model was widely applied to simulate material with coarse surface. It can produce the effect of microscopic features shadowing certain directions or reflecting light to another specific direction [4].The models, based on BRDF model, could be used to simulate textile microscopic feature in the plane surface without winkles. These models cannot be combined with the 3D textile geometric model.

In this paper, the improved BRDF model is suggested to describe 3D textile structure while the Phong illumination model is used to represent 3D geometry illumination effect. The integration of these two kinds of models is done by method of synthesis. The pixel color values, derived from simulating fabric 3D structure, is taken as the parameters to be entered into Phong illumination model.

According to the textile material and 3D geometry model, we can adjust its structure to achieve a good simulation effect.

2. BRDF MODEL

In the computer graphic field, BRDF models are four-dimensional functions, which can be used to describe the reflection distribution at a surface point depending on incoming and outgoing light directions. There are various strategies for modeling BRDF. This paper implements Schlick's BRDF Model, which is simple and easy to realize. It can be represented as

$$f = \frac{1 - G(u)G(v)}{\pi} + \frac{G(u)G(v)}{4\pi uv}\left(\frac{\partial}{(1+\partial t^2 - t^2)^2}\right) \quad (1)$$

Where,

t, u and v are the cosines of α, θ and θ' (shown in Fig.1),

$G(u)$ and $G(v)$ can be defined as in Eq.(2), f is the reflection intensity received by observers.

$$G(x)=\frac{x}{\partial-\partial x+x} \tag{2}$$

Where ∂ ($0\le\partial\le1$), shown as in Eq.(2), is the roughness of the surface. If $\partial=0$, there is no diffuse but mirror reflection on the surface. And if $\partial=1$, only diffuse reflection exists.

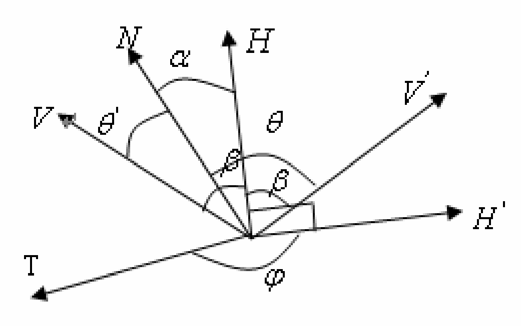

Figure 1. BRDF model.

In Fig.1,

V is the reflect light,

V' is the incident light,

N is the surface normal,

H is the internal bisector of incident light and reflex light,

α is the angle between H and N,

θ is the angle between V' and N,

θ' is the angle between V and N.

We make some improvement on this BRDF model for its disadvantages of complex modeling, large numbers of parameters, endless of calculations and poor real-time ability.

3. INTEGRATED MODEL IN THIS PAPER

In this Sector, Phong and BRDF Illumination model are made some improvement. The new model used in this system can be done by integration of the two improved models.

Improvement of Phong illumination model

This paper improves Phong illumination model based on the characteristics of 3D fabric model. According to the textile material simulated, the values of parameters can be defined as follows:

$$k_a=0.1, k_d=0.7, k_s=0.3, n=5, I_{pa}=0.1I_{pd}.$$

Where I_{pd} is color value of the simulated point. We assume I_{pd} =1. As there is only one light source in the model, then Eq.(1) can be turned into

$$I=0.01I_{pd}+0.7I_{pd}\cos i+0.3\cos^5\theta \tag{3}$$

The improved Phong Illumination model can be used to represent the textile 3D geometry illumination effect. It can be integrated with the following improved BRDF model used to simulate textile structure by the method of integration.

Improvement of BRDF model

The process is used to imitate textile structure. In order to imitate textile more vividly and efficiently, we make some improvement on the BRDF model.

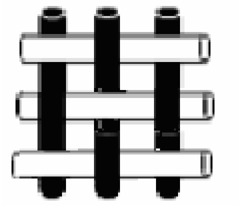

Figure 2. Structure of textile.

The textile structure in this paper is shown in Fig.2.

Where, the relationship of Warp and woof can be obtained, shown as in Fig.3.

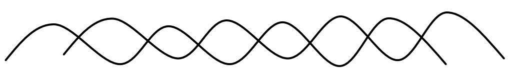

Figure 3. The fluctuation relationship of yarns.

As a result, we can get

$$f(w)=\sin(lw/360) \tag{4}$$

Where $lw/360$ varies from $(2k+1)\pi$ to

$2k\pi$ (k =0,1,2,...30), l is the distance between two adjacent yarns and w is that between the point imitated and the initial state. The initial value of $f(w)$ is assumed as 0.

Here, if $f(w)$ of Eq.(4) times f of Eq.(1), we will obtain

$$I = f(w)f \quad (5)$$

Where I is reflection intensity received by observers.

Integration of Phong illumination model and BRDF model

The image generated from the improved BRDF model can be used as the texture. We use integration to obtain the integration of the two improved models presented above. The simulation effect can be shown efficiently, from which we can see the textile structure, bumps and winkles clearly.

The illumination model of the 3D structure may be got from Eq.(6). Textile structure light intensity value, generated from BRDF model, is defined as I_{ph} . And the formula (3) can be obtained

$$\mathrm{I} = 0.1 \times 0.1 I_{pd} \times I_{ph} + 0.7 I_{pd} \times I_{ph} \cos i + 0.3 \times 0.1 \cos^5 2i \quad (6)$$

Where I_{ph} is the structure color value of each pixel.

4. SIMULATION RESULT

The simulation is completed on a single 2.4GHz CPU of a PC system. In this 3D fabric simulating system，it reduces the simulation time to less than 0.1second. The result is vivid as following Fig.4 to 6:

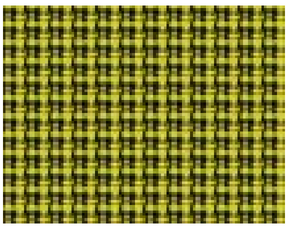

Figure 4. Textile structure imitated in BRDF model.

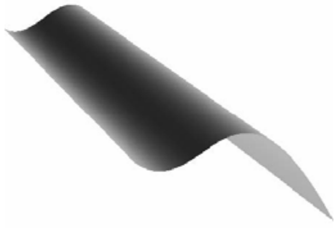

Figure 5. 3D model imitated in Phong illumination model.

Figure 6. Integration of BRDF model and Phong illumination model.

Fig.4 shows the textile structure simulated by the improved BRDF model. It is used as the texture pattern in the process of integration.

We can see the simulation effect of textile geometry model by improved Phong Illumination model. It is used as the curved surface in the process of integration.

Fig.6 shows the effect of integration, from which we can see the textile structure, bumps and winkles clearly.

In computer simulation and animation, depending on the simulation speed, only 3D geometry model can be simulated if the Phong Illumination model is adopted while only the 3D structure can be simulated if the BRDF model is applied.

In this method, textile 3D geometry model and structure can be simulated on the base of computer simulation speed considered.

5. CONCLUSION

The imitation of 3D textile is a complex system, covering many kinds of technologies, and it is of great importance in many fields, such as fabric designing, movie making, animation studios, virtual reality, etc.

In this paper, we propose a 3D textile imitation algorithm based on the two improved models of BRDF and Phong. It is an efficient method for the real-time simulation for fabric features. We first simulate the textile microscopic features using improved BRDF model. According to the material and structure, parameters can be controlled to simulate microscopic feature. The improved Phong illumination model is then used to simulate the textile macroscopic geometry features, such as bumps and winkles. We use integration to integrate the display effect of the micro- and macroscopic features mentioned above. Experiments demonstrate that our method is efficient and effective. As the arithmetic avoids recursive calculation, the simulation has a fast speed. The algorithm proposed will contribute to the 3D textile design greatly. Future work will therefore concentrate on the real-time dynamic simulation for textile in our system.

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