

Modeling and Rendering of the Anisotropic Reflection on Ukiyo-e

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Abstract: The Ukiyo-e is one traditional Japanese art. Some small bump structures on the paper are made by the special print technique. And the particle of the mica and the gold are used as the pigment also. As these reasons, the reflection of the Ukiyo-e shows variation of color according to the direction of the lighting and the viewpoint. This phenomenon is the anisotropic reflection of the Ukiyo-e. The subject of this research is representing this special phenomenon occur on the Ukiyo-e. At first, the segment of the bump and the gold are generated. Then, the normal of Ukiyo-e surface are computed from this segment result. Some rendering results of the ancient Ukiyo-e are given at the end.

1. Introduction

With the developing of the CG (computer graphics) technology, the NPR (Non-Photorealistic Rendering) techniques for the painting, watercolor were studied well. These studies mainly focused on simulating the particle of the pigment on the paper, and many types of the NPR were carried out. The Ukiyo-e is one traditional art of Japan. A photo of the Ukiyo-e is shown in Figure 1. With some special techniques, the anisotropic reflection phenomenon on the Ukiyo-e occurs if the direction of the viewpoint and the lighting change. In this paper, we present the technique that can model and render this phenomenon of the Ukiyo-e.

2. Previous work

The rendering of CG mainly include two types of rendering. One is the PR (Photorealistic Rendering) for getting real result; another is the NPR for get non-realistic result. The NPR mainly represent drawing such as painting, sculpture, block print, dyeing etc.. Salisbury[1] and Zhang[2] is the NPR studies in the early age. These studies simulated the stroke of the pen and represented the painting and the suibokuga. The 2D photos or the 3D model can be used for NPR technique. Johan[3] computed the color

segment of the photo and set the stroke of the pen for generating the effect of watercolor. Kawasaki[4] set the direction of the stroke on the 3D model surface and generated the effect of the suibokuga. These techniques mainly represent the isotropic reflection of the pigment and there is little study to represent the anisotropic reflection.

There are some studies exist to represent the Ukiyo-e. A famous Ukiyo-e artiste draw a lot of Ukiyo-e by computer from photos (Okamoto[5]). At first, he takes some photos. Then he processes the photos using software. Finally, the processed images are printed on the paper and the Ukiyo is finished. Okada[6] simulated the process of making the Ukiyo-e and printed the Ukiyo-e using the virtual woodcut in a virtual carve system. In fact, with special print technique, the colors on the Ukiyo-e surface change according to the lighting direction and the viewpoint. This is the anisotropic reflection of the Ukiyo-e. But there is no study to simulate this phenomenon of the Ukiyo-e.

In this paper, we propose a technique to represent the anisotropic reflection of the Ukiyo-e. The anisotropic reflection of the Ukiyo-e is mainly caused by the print techniques called the Karasuri and the Kirasuri (these will introduce detail in the chapter 2). The compute process is shown as the Figure 2. At



Figure 1. Photo of the Ukiyo-e

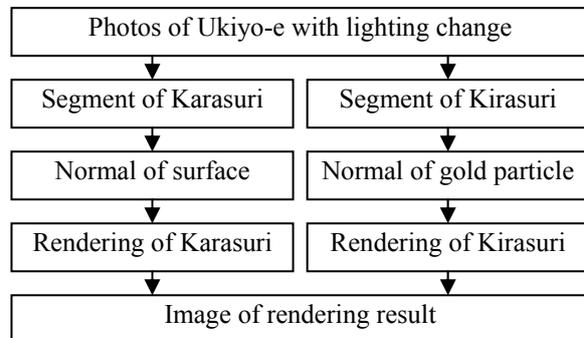


Figure 2. Compute process



Figure 4. Photos of the Ukiyo-e with the lighting change

first, some photos are taken and the segments of the Karasuri and the Kirasuri are got. Then the normal direction is computed. Using these computed normal information and the color information, we can render the Ukiyo-e using general CG rendering model.

3. Background knowledge of the Ukiyo-e

The origin of the Ukiyo-e is describing the life of Kyoto in 16 century. After that, the techniques of making the Ukiyo-e were developed and many works were made. Basically, the drawer, the engraver, and the printer need collaborating together to complete a work. At first, the drawer draws the picture. Then the engraver makes the woodcut based on the picture. Finally, the printer put the pigment on the woodcut and the Ukiyo-e is print out.

For getting special effect, some techniques were developed. The technique of the Karasuri and the Kirasuri are introduced here. The Karasuri do not use any pigment and put the woodcut on the paper by power, then the bump pattern on the surface paper are made. The Kirasuri use the pigment of the gold or the mica to represent the background of the Ukiyo-e. As the result of these special print techniques, the color of the Ukiyo-e changes according to the lighting direction and the viewpoint. Some photos are shown in the Figure 3. The pattern of the flower is made by the technique of the Karasuri. Some bump on the surface of the paper are generated, the pattern of flower is very difficult to be seen when the lighting come from the front and it is ease to be seen when the lighting come from side. The technique for drawing the background of the person is the Kirasuri using the gold particle pigment. The color of the gold particle



Figure 3. The reflection of the Ukiyo-e

can be seen when the lighting come from front and can not be seen when the lighting come from side.

4. Normal of the Ukiyo-e

The anisotropic reflection of the Ukiyo-e changes according to the normal of the Ukiyo-e. As this reason, we need computing the normal on the surface. At first an automatic technique is introduced. Because there are some bugs on using automatic method only, we propose a manual technique to get the segment of the Ukiyo-e, and then compute the normal from the segment result.

4.1 Automatic Computing the Normal

Paterson[7] present a technique which allows capture of 3D surface geometry from photos. We use this technique to compute the normal on the Ukiyo-e.

At first, we take photos use a measurement device which can put the lighting and the camera on arbitrary position on a semi-sphere. At first, 23 photos were taken shown as figure 4. The camera is set a fixed position from the direction perpendicular to the Ukiyo-e. And the lighting is set at a slant shown as the Figure 4. Using these photos, the normal of the Ukiyo-e can be computed.

As the direction of the incidence and the viewpoint is known, it is ease to compute the normal of the Ukiyo-e. Then the problem becomes to find the normal of Ukiyo-e (n in next) which can minimize the value of ρ in next.

$$\rho(n) = \sum_{i=1}^N |R_i - F_i(n)|^2$$

Here, R is measured value from photos and F is the

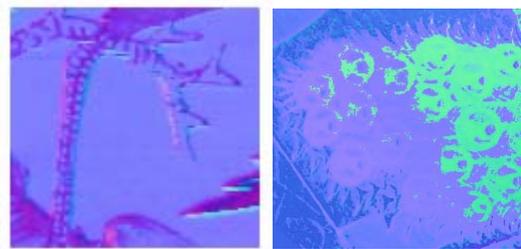


Figure 5. Automatic computing normal

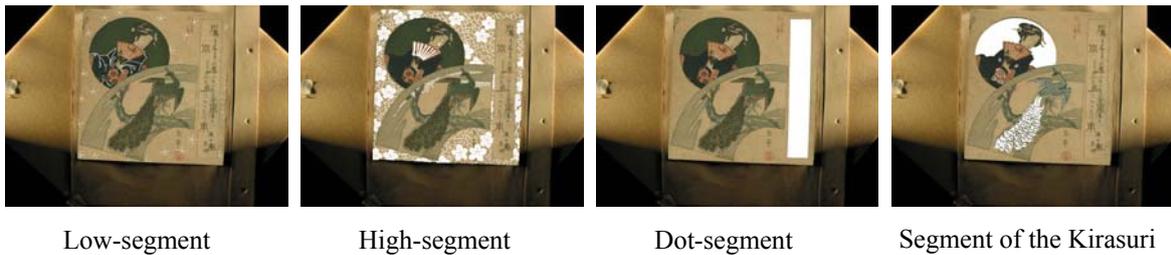


Figure 6. Segment of the Karasuri and the Kirasuri

value that computed by the model of Torrance-Sparrow same as paterson[7]. The F is nonlinear, so this is a nonlinear optimization problem. The initialization of the n is perpendicular to the surface of the Ukiyo-e. Then adjust the direction of n to let value of ρ become smaller. Repeat this operation and the normal of the Ukiyo-e are got. In the place where the specula part is not strong, this automatic method is very successful to compute the normal on the surface. But in the place where the specula part is strong, this method is failed. A successful case and a fail case are shown in the Figure 5. The values of RGB represent the value of xyz of the normal. The left one is the success one and the right one is the failed one. In section 4.2, we will introduce a manual technique to compute the normal of the Ukiyo-e.

4.2 Segment of the Karasuri and the Kirasuri

The reflection of the Karasuri and the Kirasuri are different. We introduce how to get the segment of these two print methods in this section. At first, change the lighting direction and some photos are taken. Then the segment of the Karasuri and the Kirasuri are got manually.

There are three types segment of the Karasuri. If the height is lower than around, it is the low-segment. By another hand, if the height is higher than around, it is the high-segment. If a lot of small high dots are put in order, it is dot-segment. For capturing there three types Karasuri segment and one type Kirasuri, some photos are taken shown as figure 4. When taking these photos, the camera is fixed, and the lighting

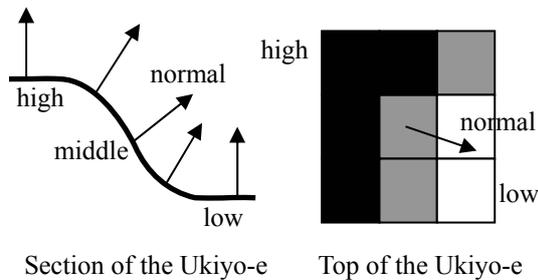


Figure 7. Compute the normal of surface

directions are changed. From these photos, the 4 types segment can be seen easily and the segment can be got manually. The segment result is shown in Figure 6. From left to right, the parts of white show the low-segment, the high-segment, the dot-segment and the kirasuri-segment.

4.3 Normal of the Karasuri

As the result of the Karasuri, the bump is made on the surface. In order to compute the normal of the surface, low part and high part need to be set. At first, the low-segment is set to the low part and the high-segment is set to the high part. Then, for the dot-segment, some sin functions are used to construct the lines by row and column. The cross of these lines is the high part and the other part is low part.

Now, the surface of the Ukiyo-e is set to the low part and the high part. We introduce how to compute the normal from these low and high parts. Shown as the Figure 7, the left one is the section of the Ukiyo-e. The normal of high part and low part is set to perpendicular to the horizontality. The normal of the middle position between the high part and low part is set to 45 degrees to the horizontality. The normal of other parts can be got by interpolation of these normal. The right one of the Figure 7 is seen from top of the Ukiyo-e. The black part is the high part and the white part is the low part. The gray part is the part

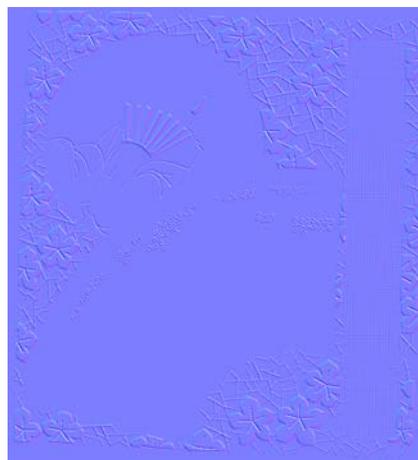


Figure 8. Normal of the Ukiyo-e

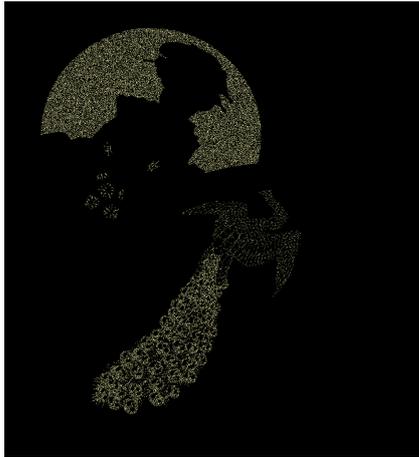


Figure 9. Distribution of the gold particle



Figure 10. Normal of the gold particle

between the high part and the low part. The normal of gray part is set from the center of high part to the low part shown as the Figure 7. At last, the normal is decided by the normal that computed from the section and from the top. The result is shown in the Figure 8. The xyz value of the normal is represented by the RGB color.

Using the normal information and the color information, the effect of the Karasuri can be represented. Currently, we use the Phong model to render the Karasuri. The rendered result is shown in the chapter 5.

4.4 Simulation of the Kirasuri

As the result of the Kirasuri, some small particles of gold are distributed on the paper. Here, the distribution of the gold particles are simulated and get the effect of the Kirasuri.

The distribution of the particle is not according to some special direction, so we can set the virtual particle of gold randomly in the segment of the Kirasuri. The color of the gold particle can be got from photo of gold. As the result, the color image of the Kirasuri is generated shown as the Figure 9.

The reflection of the particle of the gold is strong according to the special direction. To simulate this phenomenon, the virtual normal is used. Because the strongest reflection of the gold particle is near to the normal of the surface. The virtual normal of the gold particle is set near to the normal of the surface also. As this reason, the virtual normal of gold particle is limited in a range of 45 degrees around the normal of the surface. The generated normal of the gold particle is shown in the Figure 10. Same as the Karasuri, the effect of the Kirasuri can be represented by the Phong model. The implement result will show in the chapter 5.

4.4 Composition of the Karasuri and the Kirasuri

Introduce as before, the effect of the Karasuri and the Kirasuri are got. These two efficiency need to be composted together to get final rendering result.

It is easy to get final result by interpolating these two effects that got before. The effect of the Karasuri is I_a and the effect of the Kirasuri is I_i . The α is the parameter to control the interpolation and the value of it is from 0 to 1. Then the final efficient I can be got by next function.

$$I = \alpha \cdot I_a + (1 - \alpha) \cdot I_i$$

This computing is carried out on the RGB channel. As result, the final image of rendering of the Karasuri and the Kirasuri can be got.

5. Implementation

The implementation is carried out based on the GPU (Graphics Processing Unit) and can render the Ukiyo-e in real time. The graph card is NVIDIA GeForce 6800 GS. And, this implementation is carried out using the ancient Ukiyo-e.

The image shown in Figure 11 is the rendering result using the automatic generated normal introduced in the 4.1. When the viewpoint is different,



Figure 11. Rendering result using automatic generated normal

the color of the surface is different also. The left one is the rendering result using the success automatic generated normal. The right one is the rendering result using the failed automatic generated normal. In the failed case, there some gold particles on the feather and the normal got by the automatic technique is wrong. As the result, the color of the feather becomes black. We will introduce two implement results using the correct normal as follow.

One implementation is shown in the Figure 12. The flower pattern of this Ukiyo-e is made by the Karasuri. The background of the person and the part of the feather are made by the Kirasuri. The segments of the Ukiyo-e are got by manual. And rendering is carried out using the Phong model. The final rendering is shown in the Figure 12. The Ukiyo-e show different color according to the direction of the lighting. The flower pattern made by the Karasuri can be seen easily sometimes and difficult sometimes. The particles of the gold show an appearance with the variation of the gold color. This result is similar to the phenomenon that occurs on the real Ukiyo-e.

Another implementation is shown in the Figure 13. The image on the top left is the photo which is taken in an environment with some surface lighting. The other three figures are the rendering results. The snow on the ground and the umbrella is made by the Karasuri. Some lines on the cloth are made by the

Kirasuri. The variation of the snow can be seen and the variation of the lines on cloth is difficult to be seen as the line is thin.

In this paper, the phenomenon caused by the Karasuri and the Kirasuri is rendered. But there are some problems left. At first, the automatic computing for the normal of surface needs improving in future. In the 4.1, the model of the Torrance-Sparrow is used to compute the theory value. In future, more exact reflection model is needed to compute the normal on the Ukiyo-e. Another problem need to improve is rendering. The rendering model used in this paper is the Phong model. As the result, the final result looks like a little metal effect. In fact, the paper for printing the Ukiyo-e has some rough fiber. This means that we need model this fiber in the paper and rendering it using more exact model.

6. Conclusion

In this paper, a simple technique for modeling and rendering of the Ukiyo-e is proposed. The future subject is developing a new technique to capture the meso-structure of the Ukiyo-e automatically. And improve the rendering technique that considers the fiber in the paper.

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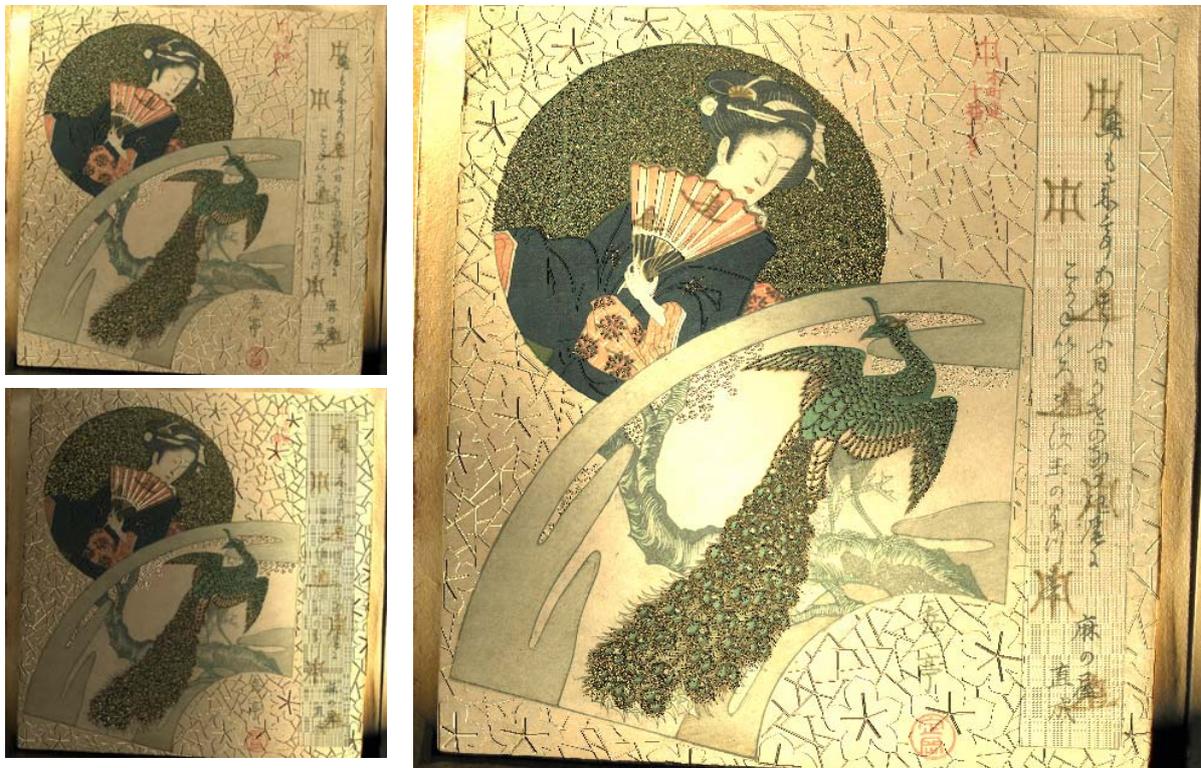


Figure 12. Implementation result 1

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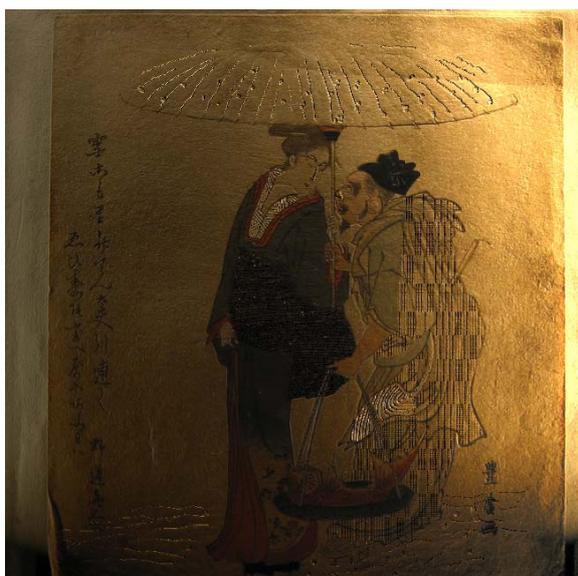


Figure 13. Implementation result 2