A Modified Phong-Blinn Light Model for Shadowed Areas

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ABSTRACT

The human visual system makes use of the information that shadows provide in order to determine the location of objects. In computer graphics rendered scenes, it can sometimes be difficult to determine whether an object is floating in the air or is placed on the ground. There are two types of shadows. One occurs when an object occludes another object so that light cannot reach it. Instead of using ambient light, as the Phong-Blinn model suggests, for these shadows, the light intensity is decreased making an impression of a shadow. This will prevent the shadow from appearing flat, as it would if only ambient light where used. The other type of shadow, is visible on all polygons facing away from the light source and are therefore not lit. Usually, ambient light only is used for these shadows. We propose an improvement to the Phong-Blinn model, which will make these shadowed polygons more realistic and not appear so flat. This will especially improve the visual appearance of bump mapped objects where the bumps will be visible also on the back-faces.

Keywords

Shadows, Phong-Blinn light model.

1. Introduction

Shadows give an important cue. Without shadows, it is difficult to determine the location of objects in 3D-space. The Shadow map technique introduced by Williams [6] is a simple technique producing real-time shadows and it has recently been introduced in hardware.

There are two types of shadows. The shadow map technique makes it possible to render shadows that are cast on another object. The other type of shadows occurs when a polygon facing away from the light source is rendered. Since it is not lit, it is usually rendered using ambient light only [2]. There is of course no specular light on a shadowed object using the Phong-Blinn light Model [1] [5]. Furthermore, the diffuse light is not used since it is negative on these back-facing polygons. However, the shadowed area produced by the first type of shadows can be lit using ambient and diffuse light. In this case the intensity is decreased, giving the impression of a shadow. The advantage by this approach is that the form of the underlying surface is preserved, since it is the diffuse light, which gives the impression of a curved surface [3]. The back-facing polygons will on the other hand look dull and flat. This is especially true for bump mapped objects [4], where the surface normal changes more rapidly.

We propose a modification to the Phong-Blinn Model, which preserves the underlying surface form for shadows on polygons facing away from the light source.

1.1 Shadow Maps

Williams showed how the shadow map technique works in two steps:

In the first step a view of the scene is constructed from the point of view of the light source. No shading values are computed, only z-values (depth) are stored which are needed in the subsequent step. The z-buffer of the light source view is called the shadow map. Figure 1 shows the shadow map of a Torus. It can be seen from the figure that the Torus casts a shadow on itself. This part is shown in black in figure 2. The polygons facing away from the light source is shown in medium grey in the same figure.

In the second step when the actual rendering of the scene is done, the coordinates for each pixel in the view space, is transformed into the light source space. The x- and y-coordinate is used to retrieve the z-value from the shadow map. The transformed z-value is compared to the retrieved z-value in order to determine if the current pixel is lit or lies in shadow.

If the two z-values are equal then the pixel is lit. If they are not equal, then the pixel lies in shadow, i.e. the z-value for the pixel must be further away from the light source than the z-value from the shadow map.

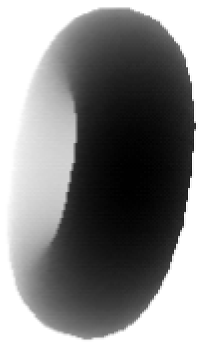

Figure 1. The view from the light source, i.e. the shadow map.

Figure 2. A pseudo colored Torus, where the darkest part lies in shadow. The brightest part is lit. And the medium part is polygons facing away from the light source.

2. A modified Light Model

In figure 3, the same Torus as the one rendered in figure 2, is rendered using ambient light only for both types of shadows. Shadows which are cast on another object, can be rendered using the Phong-Blinn Model. However, the intensity is decreased to give the impression of a shadow as shown in Figure 4. We shall show how we can improve the other type of shadow as well.

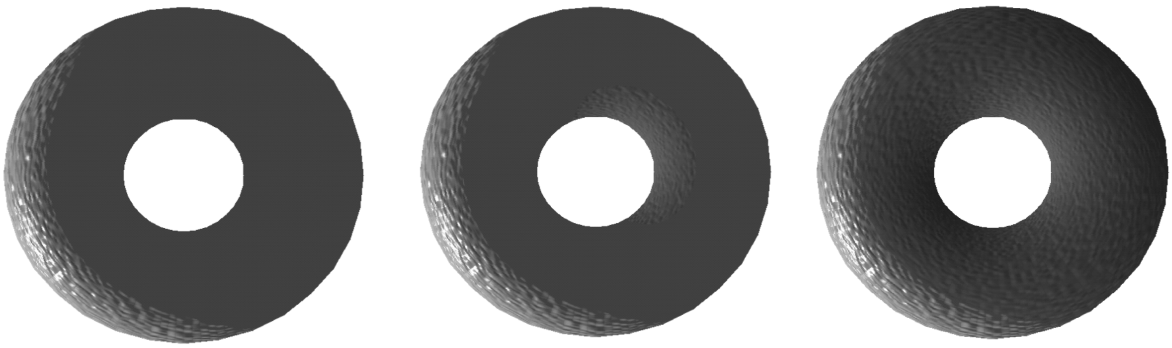

Figure 3. A bump mapped Torus, where ambient light is used for all shadowed areas.

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Figure 4. A bump mapped Torus, where the area shadowed by the object itself is lit using ambient and diffuse light, and the other shadow is rendered using ambient light only.

Figure 5. A Bump mapped Torus, where the new technique has been used for the back-facing polygons. The area shadowed by the object itself is lit using ambient and diffuse light

The diffuse term $I_d = N \bullet L$ cannot be used when it is negative. Therefore, the back-facing polygons are usually rendered using ambient light only, when using the Phong-Blinn model

If we could use the diffuse light for back facing polygons as well, the back sides would not appear that flat, since the diffuse light gives the viewer information about the form of the object. Actually this is possible with some modification. If the polygon is not back-facing then use the Phong-Blinn model as usual:

$$I = \min(1, I_a + I_d + I_s) \qquad (1)$$

where I_s is the specular light and I_a is the ambient light.

However, if it is back facing, i.e. $I_d = N \bullet L < 0$ then use:

$$I = I_a + I_d I_a q\, , \qquad (2)$$

where $q \in [0,1]$ determines the range of ambient light.

The equation tells, that we shall use ambient light I_a as usual, but then some part of the diffuse light should be added. Whatever value for q we choose, I will be equal to I_a on the contour of the shadow, where $I_d = 0$. This is just the same as the ordinary model would yield and it assures that the intensity will be continuous over the shadow contour (if no specular light is visible there).

However, inside the shadowed area the intensity depends on the normal at each point. Therefore q will determine how much the shadowed area will be affected by the underlying surface. Since I_d is negative on the backside the intensity varies from $I_a(1-q)$ to I_a. The result of using this model is shown in figure 5. In figure 6 a series of shaded Toruses using the proposed method is shown. The value for q is varied so that the changes in the shadowed area, is clearly visible. The value of q should be chose so that the shadow will look natural together with the first type of shadow shown in figure 4.

3. Discussion

It could be argued that the ambient light does not have a general direction. However, ambient light is a theoretical simplification. In real life, the light hitting the backsides of an object is the result of several inter reflections. Nonetheless, the backsides of a wrinkled object will not appear flat. Instead, we can see the geometry of the backsides. The proposed method will mimic this phenomenon. By using the negative diffuse light, we are actually supposing that the ambient light does have a main direction, which is opposite to the light source direction. We could choose another main direction. However, then we could get problems, since the diffuse term will not be zero on the contour of the shadow, yielding mach bands.

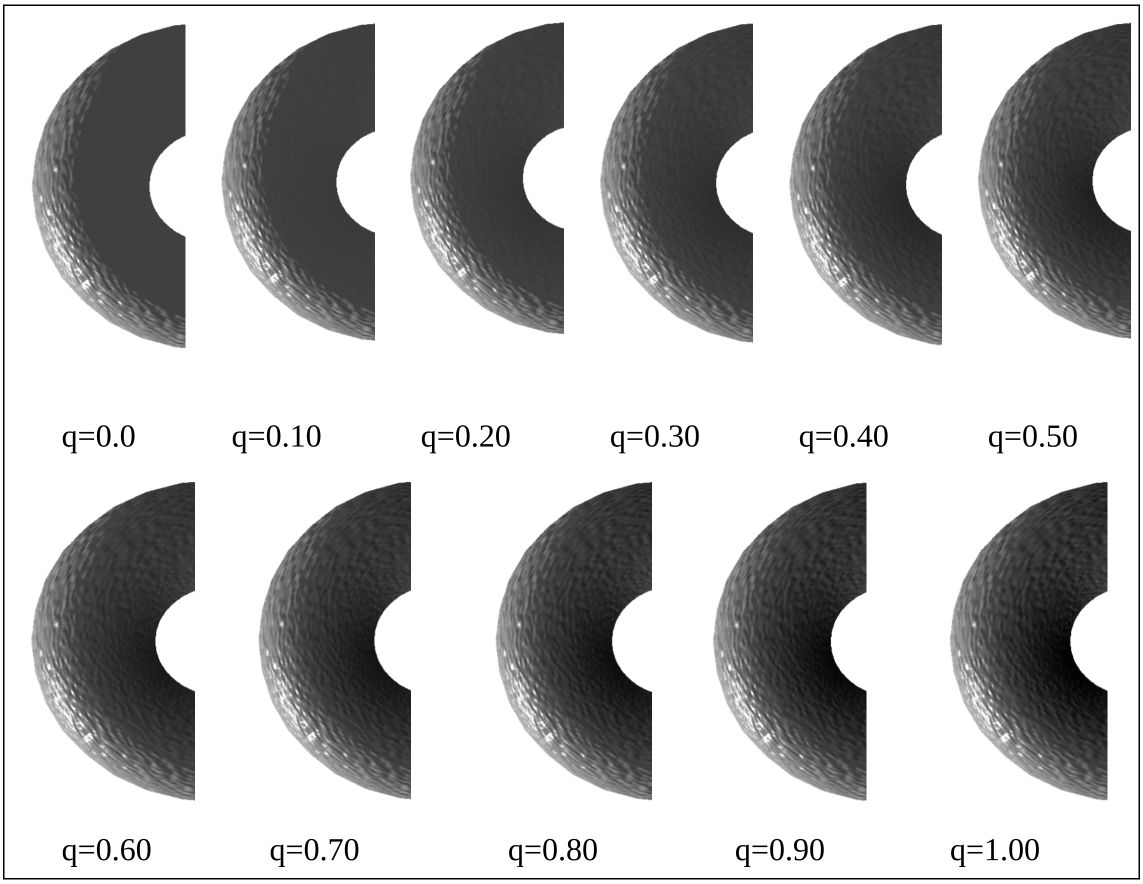

Figure 6. The right part of a shaded Torus using the proposed method with different values for q.

4. Conclusions

The polygons facing away from the light source should be rendered, not only by using ambient light, but also by using the proposed modified Phong-Blinn model. The result is a much more natural looking rendering. The proposed model uses the negative diffuse light to modify the ambient light. This can be done since the diffuse light depends on the underlying normals and therefore contains information about the geometry. This assures that the geometrical information produced by the diffuse light is preserved also for this shadowed area. Moreover, it will be fast to compute since we only use a modification of the local light model, which means that we do not have to take several inter reflections into account like in a global light model.

References

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