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USING THE DIFFERENT LIGHTING MODELS DURING REALISTIC IMAGE CREATION

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Abstract. *The new methods for forming realistic scene is presented. According to this method for those parts of image were highlights is presented is used the Blinn lightning model and for the rest part the simple Lambert model is applied. Using this method the quality of scene stay the same when we use the complicated Blinn model and the scene creation speed is razed significantly.*
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Introduction

The basic purpose of Blinn [1] and Phong [2] lightning models usage is a increased colour intensity zone (sheen, highlight) on a surface realistic displaying. The sheen zone is observed only on the limited part of object. It accommodation depends on orientation of object in space, place of a presence of the observer and external light source, and the sizes depends on object specular characteristics, which are determined by coefficient n. The large values of n gives the focused distribution of shaeen, and small - wider distribution.
Usually as lightning model often Blinn model is used. At identical results of use the given model differs considerably by smaller computing complexity in comparison with Phong model. The formula, according to which the intensity of color is calculated has the following kind:

$$I_B = I_p(\lambda)\cdot k_p(\lambda) + I_l^{вх}(\lambda)\cdot k_д(\lambda)\cdot\left(\vec{N}\cdot\vec{L}\right)+ + I_l^{вх}(\lambda)\cdot k_{дз}(\lambda)\cdot\cos^n\gamma, \qquad (1)$$

where $I_p(\lambda)$, $I_l^{вх}(\lambda)$ - the intensity of ambient and external light source accordingly, $\vec{N}$ - normal vector to the surface, $\vec{L}$ - vector of a light direction , γ - size of a corner between normal vector $\vec{N}$ and vector $\vec{H}$, $\vec{H}$ is calculated according to the formula $\frac{\vec{L}+\vec{V}}{\left|\vec{L}+\vec{V}\right|}$, where $\vec{V}$ - vector of a direction of observer location, $k_p(\lambda)$, $k_д(\lambda)$, $k_{дз}(\lambda)$ - factors of ambient, diffuse and specular lights, n - factor of surface specularity.
The formula for colour intensity calculation in Lambert lightning model [3] is identical to the formula (1) with that difference, that $I_l^{вх}(\lambda)\cdot k_{дз}(\lambda)\cdot\cos^n\gamma$, which responds for sheen formation on a surface is equaled to zero:

$$I_L = I_p(\lambda)\cdot k_p(\lambda) + I_l^{вх}(\lambda)\cdot k_д(\lambda)\cdot\left(\vec{N}\cdot\vec{L}\right). \qquad (2)$$

Lambert lightning model does not allow to form sheen on a surface and consequently is suitable only for lustreless images formation.
Because of $I_l^{вх}(\lambda)\cdot k_{дз}(\lambda)\cdot\cos^n\gamma$ absence, the Lambert lightning model computing complexity is less for Blinn lightning model computing complexity.
The new method is presented, according to which, for those parts of object, where the sheen zone is observed, it is necessary to use Blinn lightning model and for all other parts of object – simple Lambert lightning model. The quality remains the same, as at use of Blinn lightning model and because the specular component

$I_l^{ex}(\lambda)\cdot k_{\partial з}(\lambda)\cdot\cos^n\gamma$ is computed only in case of necessity, the speed of shading process raises considerably.

The basic idea of a given method is to enter boundary value of zero for function $cos^n\gamma$. At enough large n, the function $cos^n\gamma$ quickly achieves practically zero value, from which the further account becomes inexpedient. For boundary value of zero it is offered to take the size 2^{-q}, where q gets out depending on necessary accuracy of colour intensity definition. We make the appropriate equation

$$\cos^n\gamma_n = 2^{-q}, \tag{3}$$

where γ_n - size of a corner, at which the function $\cos^n\gamma_n$ accepts the zero value.

Taking into account equation (3) we calculate corner γ_n value:

$$\gamma_n = \arccos\left(2^{\left(-\frac{q}{n}\right)}\right). \tag{4}$$

The size q computation is offered to do in a way than difference between real zero value of specular color intensity component $I_l^{ex}(\lambda)\cdot k_{\partial з}(\lambda)\cdot\cos^n\gamma$ and received as a result of zero threshold value usage for function $\cos^n\gamma$, was in borders from zero to one:

$$0 \le I_l^{ex}(\lambda)\cdot k_{\partial з}(\lambda)\cdot\cos^n\gamma_n \le 1.$$

Having replaced value of function $\cos^n\gamma$ on size 2^{-q} we will receive

$$0 \le I_l^{ex}(\lambda)\cdot k_{\partial з}(\lambda)\cdot 2^{-q} \le 1. \tag{5}$$

The value of $k_{\partial з}(\lambda)$ is in a range [0,1], whence maximal value of factor $k_{\partial з}(\lambda)=1$.

The value $I_l^{ex}(\lambda)$ can vary from zero to infinity, depending on how powerful the light source is. For convenience the given size is offered to be presented by the nearest number, which is a degree of two as follows:

$$I_l^{ex}(\lambda) \le 2^t.$$

Substituting unknown sizes in the equation (5) receive, that

$$q = t.$$

In practice at realistic images formation, as a rule, intensity of a light source does not exceed 500.

Substituting the given size in the equation (5) we will get

$$q \approx 9.$$

Thus corner threshold value γ_n, after which there is no necessity to calculate specular component ${}_l^{ex}(\lambda)\cdot k_{\partial з}(\lambda)\cdot\cos^n\gamma$, is

$$\gamma_n = \arccos\left(2^{\left(-\frac{9}{n}\right)}\right) \Rightarrow \cos\gamma_n = 2^{\left(\frac{-9}{n}\right)}. \tag{6}$$

The researches necessity of above mentioned lightning models usage is offered to be carried out not for each pixel separately, and for groups of pixels. The basic figure, which is shading is the triangle. Accordingly the researches will be carried out for pixels groups limited by a triangle.

All triangles are divided on two types:

1) triangles, where the sheen or part of it is observed;
2) triangles, where the sheen zone is not observed.

The triangles can be carried out to the first group, if for all pixels or part them, the corner γ is in a range:

$$0 \le \gamma \le \arccos\left(2^{\left(-\frac{9}{n}\right)}\right).$$

For shading of such triangles the Blinn lightning model will be used.

To the second group concern a triangle, at which the size of a corner γ for all or some part of pixels is more for size $\arccos\left(2^{\left(-\frac{9}{n}\right)}\right)$ and for such triangles will be used simple Lambert model.

There is no sense to analyze size of a corner γ for each of pixels of a triangle, it is enough to carry out such analysis only for pixels, which are placed on triangle edges.

All possible variants of middle way vector accommodation concerning to normal vectors of edge pixels in triangle is possible to divide in two groups:

a) The middle way vector is placed in such a manner that has the least corner γ with normal vector for one of the last edge pixels.

в) The middle way vector is placed in such a manner that has the least corner γ with normal vector for one of pixels witch is situated in edge middle.

For definition of the fact to which of variants of middle way vector accommodation can be carried out the triangle edge is offered to use spherical trigonometry.

In a fig. 1 the spherical triangle is submitted, in which basis make two normal vectors $\vec{N}_A$, $\vec{N}_B$ of edge AB final points and vector $\vec{H}$.

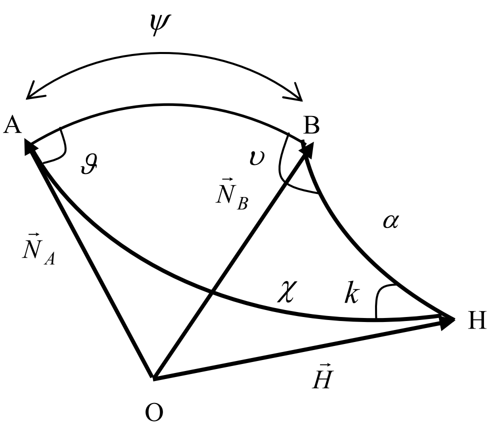

Figure 1. Spherical triangle in which basis lays vectors $\vec{N}_A$, $\vec{N}_B$ и $\vec{H}$.

In case one of corners ϑ, υ is more then 90°, such edge concerns to group a), if both corners ϑ, υ are less 90°, such edge concerns to group в).

Using properties of a spherical triangle receive, that

$$\cos\vartheta = \frac{\cos\alpha - \cos\chi\cos\psi}{\sin\psi\sin\chi}. \quad (7)$$

$$\cos\upsilon = \frac{\cos\chi - \cos\alpha\cos\chi}{\sin\psi\sin\alpha}. \quad (8)$$

At positive values of $\cos\vartheta$ and $\cos\upsilon$, $<\upsilon$ and $<\vartheta$ less 90°, and at negative - is more.

The account of the minimal value of a corner γ is made for group a) as follows.

From two corners $<\upsilon$ and $<\vartheta$ (fig. 1) is finded out the greatest by comparison cosine marks of the appropriate corners calculated according to the formulas (7) and (8). If a corner $<\upsilon$ greater for a corner $<\vartheta$, there is a size $\cos\gamma$ is calculated:

$$\cos\gamma = \vec{N}_A \cdot \vec{H}. \quad (9)$$

For a case, when a corner $<\vartheta$ greater for a corner $<\upsilon$, the size $\cos\gamma$ is equal to:

$$\cos\gamma = \vec{N}_B \cdot \vec{H}. \quad (10)$$

The received value $\cos\gamma$ is compared with $\cos\gamma_n$, which.

If the edge is corresponded to group в) (fig. 2), the calculation of the minimal corner value will be carried out in the next way.

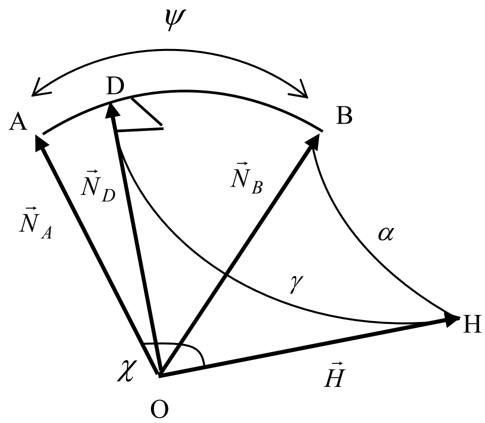

Figure 2. Calculation of angle γ cosine

Let's designate $\vec{N}_A \times \vec{N}_B$ as a vector $\vec{G}$. From here corner γ cosine

$$\cos\gamma = \sin\left(\frac{\pi}{2} - \gamma\right) = \frac{\vec{G}\times\vec{H}}{\vec{G}}$$

$$= \frac{\sqrt{\left(\vec{N}_A\cdot\vec{H}\right)^2 - 2\left(\vec{N}_A\cdot\vec{N}_B\right)\left(\vec{N}_A\cdot\vec{H}\right)\left(\vec{N}_B\cdot\vec{H}\right) + \left(\vec{N}_B\cdot\vec{H}\right)^2}}{\sin\psi}$$

$$= \sqrt{\frac{\cos^2 \chi - 2 \cdot \cos \chi \cdot \cos \psi \cdot \cos \alpha + \cos^2 \alpha}{1 - \cos^2 \psi}} \quad (11)$$

The received value of size $\cos\gamma$ is compared to size $\cos\gamma_n$, which was calculated in formula (11).

Thus, if for each edge of a triangle is satisfied condition, that $\cos\gamma > \cos\gamma_n$, in this triangle is not observed sheen zones and it can be shaded with Lambert illuminatuion model usage (equation (2)). In case even for one of triangle edges $\cos\gamma < \cos\gamma_n$, then in the given triangle the part of a sheen zone is located and for such triangle it is necessary to use Blinn model (equation (1)).

Example of object shading according to Phong method with use Blinn model and use of the adaptive approach are submitted in a fig. 3.

As it is visible from figure that results of shading are practically identical.

The usage of the adaptive approach for objects shading allows essentially lower computing expenses and by that to increase productivity. Thus the shading quality remains same as well as at use of model of Blinn lightning model for shading of all triangles, of which the object consists.

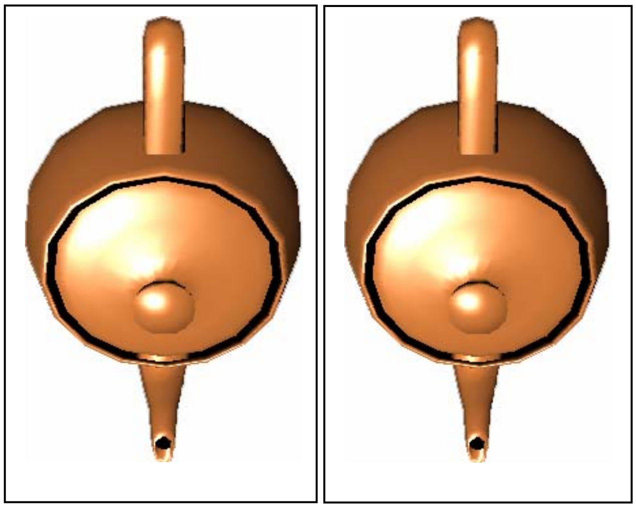

Figure 3. Example of object shading with Blinn illumination model (left) and with proposed adaptive shading (right)

References

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