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COMPARATION OF PHYSICALLY BASED REDNDERING AND PHOTO REALISTIC RENDERING

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ABSTRACT

Generation of realistic images is one of the main challenges in computer graphics. This area is improved to the point where the mathematical modeling of physical processes, objects and phenomena resulting in the creation of realistic images that are difficult to distinguish from photographs of the real world. The basis of all these mathematical models is linear transport theory of light converted into a so-called rendering equation. It covers methods of rendering, mathematical procedures that they use and the factors that determine the quality of the rendering picture. Special place is given to algorithms for generating line, objects, interactions of light with objects and texture. Analyzed are all aspects of photo realistic rendering. Finally is made an example of the scene with the software package 3D Studio Max and made a comparison between physical based rendering and photo realistic rendering. Physically Based Rendering requires more computer memory and longer time for rendering. Rendered picture is more realistic, with real and soft shadows. Photo realistic rendering depends on the skill of the designer to capture the right lighting and final appearance on stage. There are reflections and seems to have the same surface brightness.

Key words: Computer design, Realistic images, Physically based rendering, Photo realistic rendering.

1. INTRODUCTION

Rendering is the process of generating images using a computer. Rendered pictures are digital or raster images. Physically based rendering is based on a mathematical model of physical rendered scene that is defined by various information about the geometry of objects, the appearance of surfaces, lighting etc. By solving the mathematical model and its visualization, computer gets an image that is realistic and close to the quality of photography. Rendering is used in creating video games, various simulations and visualizations, film and television special effects, in design, architecture, etc. In each of these areas use different rendering techniques and various computer programs.

The market may find more commercial computer programs for rendering. Some are embedded in larger, broader and more complex software packages, such as those for modeling and animation, and some are free again (open-source).

2. PHOTO REALISTIC RENDERING

Photo realistic rendering is a computer generating of images of 3D scenes that are difficult to distinguish from photos of the same scenes. It is high quality rendering and is usually very slow. It is used in animations that haven't interactive nature.

2.1 Camera

Virtual camera creates images based on her position on the scene. How much of the scene will be covered on the image depends on that how much of the the scene is in the range of view. This coverage does not extend to infinity, but ends with a back plane.

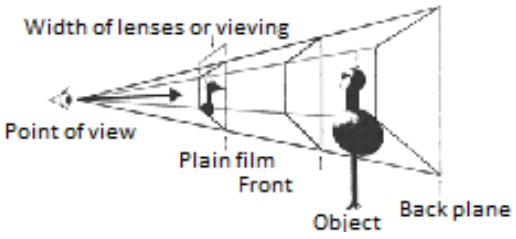

Figure 1. A bird in the volume of view projected on the plane of the film

The real camera always creates a perspective projection. In it we have a unique point of view, reduction of the objects when they distancing and lines that are not mutually parallel.
Virtual camera offers a choice of perspective or parallel projection. In parallel projection all lines and planes of 3D objects that are parallel to each other remain parallel also in the projection and they not reduce with distancing. Although perspective projection offers effective illusion of 3D space, the parallel projection may be a better choice in cases when the dimensions of objects are important. The parallel projection is particularly useful during the modeling process because easily and accurately can determine the relative alignment of objects.

2.2 Intersect ray wit object

When we generate a beam, we should determine which object he will first cuts and where. To do this we should examine the intersection of the ray with all objects in the scene and choose the one that is first.
Beam is given in parametric form

$$r(t) = o + td$$

Here o is light source, d is vector direction , a t is parameter whose value ranges in the interval $[0,\infty)$. Let the object is implicitly defined by equation $F(x,y,z) = 0$. If the equation of the beam replace with the implicit equation of the object is getting a new equation in which the only unknown is the parameter t. This equation is solved by t and the smallest positive root is replaced in the equation of the beam. For example, the implicit equation of the sphere with radius r is

$$x^2 + y^2 + z^2 - r^2 = 0$$

By replacing the equation of the beam is getting

$$(0 + td)_x^2 + (0 + td)_y^2 + (0 + td)_z^2 - r^2 = 0$$

This is a quadratic equation for t and can be easily solved. If the equation has real roots the beam does not cut the sphere. If it have real roots is chosen the smallest positive root.

2.3 Distribution of light

The intersection of the beam with an object gets the point of intersection. The goal is to find the amount of light that leaves this point in the direction of the eye. To calculate that amount we need to know the amount of light that arrives at that point. For simple light sources, geometric

distribution of light is simple, requiring only knowledge of the position of the source. But in the real world there is no point sources of light. This means that the light source is a geometric object that emits light from its surface.

So, we need to know the amount of light energy that falls on a small differential area in which is the point of intersection. If the source of light radiating in all directions and have the strength Φ then the total light energy that falls on the sphere that surrounding the source is $\Phi/(4\pi)$.

If we have two spheres with different radius then it is clear that the energy which falls on the point of the bigger sphere is smaller than the energy that falls on the point of smaller sphere. The energy that falling on the point of sphere with radius r is proportional to $1/r^2$. If the surface dA declines for angle θ, the energy that falls on the surface dA will be proportional to $\cos\theta$.

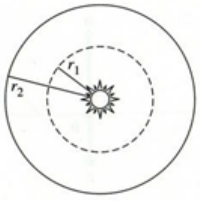

Figure 2. The light energy is distributed equally in all directions

The total light energy dE that falling on the surface dA is $dE = \frac{\Phi \cos\theta}{4\pi r^2}$

2.4 Visibility

The distribution of light that previously discussed does not given attention to visibility. Does anyone beam is overshadowed or not is an important issue in the process of rendering. Hidden rays do not contribute to the brightness of the object in the scene.

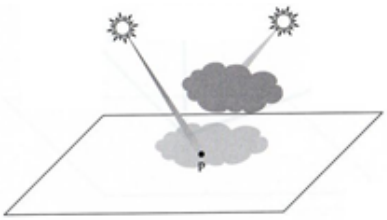

Figure 3. Hidden and unhidden rays

2.5 Reflection

Each object in the scene is made from some material that has its own beam characteristics. They define the function of Bidirectional Reflectance Distribution Function $f_r(p,\omega_o,\omega_i)$ which tells us how much energy that comes from ω_i direction is reflected toward a direction ω_0.

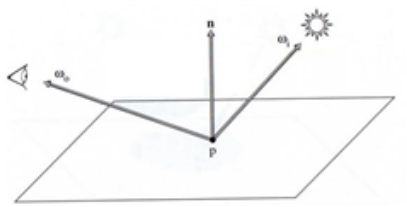

Figure 4. Geometry of reflection

2.6 Propagation of rays

Our assumption was that the rays travel through a vacuum. But often the presence of some media in the atmosphere such as smoke, fire, fog, rain, dust, etc., makes this assumption incorrect. The present medium in the atmosphere can increase or decrease the lighting along the path of the beam. Decreasing of the ligthing becomes of its absorption or reflection in different directions.

If the medium emitting light, such as fire, or reflective light, it increases the lighting.

3. MATHEMATICAL FUNDAMETALS IN THE PROCES OF RENDERING

Most rendering techniques require a good knowledge of mathematics and computers. Knowledge of mathematical procedures is particularly necessary when we work with the most advanced rendering techniques such as dynamic simulations. Physically Based Rendering is a very complex area which today is intensively research. Attention is placed on mathematical procedures and the factors that determine image quality. Attention is given to algorithms for generating lines, objects, lighting, material and texture because of them depends on the quality of rendering and the final performance of the finished object, scene or character.

3.1 Generating lines

Straight line segment in the scene is defined by coordinates of endpoints. To be projected line on the screen, graphics system must first projected endpoints in all digit coordinate system on the screen and find the closest pixels along the line between them. Then is loading the color line in the buffer of the codes and coordinates of pixels which is the part of the display memory for storing the contents of the picture. By reading the data, video controller is drawing the pixels on the screen.

3.2 Light sources and properties of the surface

Any object that emits light energy is the source of light. It depends on the ligthing effects on the scene. The source is defined by several parameters: position, color, light direction, shape.

The simplest object that emits light is point source of light. The light is emitted from a point equally in all directions.

A remote light source simulates light that coming from one direction. Radiating parallel rays it illuminates all objects in the scene under the same angle. In modeling, remote light sources require less processing power because it calculates only one direction.

The light source can be modified and it can radiating focused light. Focused light source is defined by the direction vector V_{light} and angular limit θ_l.

$$V_{obj} \cdot V_{light} = \cos\alpha$$

Figure 5. Focused light source

3.3 Diffuse, ambient and reflected light

The overall illumination of the objects in the scene can be described as a linear combination of three components: diffuse, ambient and reflected.

If we make a comparison between the three models of lighting, we will see that somehow diffuse lighting is reduced and there is no glare like reflected lighting. When the surface is illuminated with a ambient lighting, the surface looks equally bright from all sides. Reflected lighting gives the area more realistic look.

3.4 Texture

In computer graphics texture is shadings that is added to the graphic image and aim to get the effect of physical substance. The texture is based on one basic elements called texels (texture pixels) which is repeated. Texels consists of elements that are organized and frequently distributed.

An alternative procedure for modeling of global reflection is the defining values of the intensity of light around the object. So the problem is reduced to simple copying of the environment on the object. This procedure is called a replication on environment.

To be rendered surface of the object, first is projected surface of the pixel on surface of the object. Then each projected area is reflected in the environment and determines the intensity of that pixel.

Texture mapping is a procedure of making the texture and its applying on the surface of the object. This allows applying of 2D images on 3D objects.

4. COMPARATION AND RESULTS

To fully realize the characteristics of Physically Based Rendering is made comparation between Physically Based Rendering with Photo Realistic Rendering. With 3D Studio Max computer package were made two images of same scene. In the first case is used Physically Based rendering, and in second Photo Realistic.

Physically Based Rendering follows the physical behavior of light through the scene. Here accent is put on mathematical models of the scene and other factors that determine quality of the image. Great attention is given to algorithms for generating various details of the image: objects, materials, texture, light effects etc. Here the designer has no influence on image quality. The resulting image has a real and soft shadows. Reflections from the surface make spillage of the colors and the image gets more realistic look.

With Physically Based Rendering making of the picture is longer, 30 minutes on a computer with a Pentium 4 processor with 2 GHz. The program used more memory space, 5 MB. The scene was illuminated by three light sources, two lamps and solar radiation that enters through the window. The resulting image has the quality of real photography.

Photo Realistic Rendering is a computer generated images that are difficult to distinguish from

photographs of the same scenes. It is rendering with high quality, emphasizes the external appearance of the scene and does not use real physical values for brightness, surface reflections and other light effects. This way of rendering depends on the skill of the designer to capture the true value of light. These surfaces are painted with no sense of reflection or spillage of colors like in Physically Based Rendering. It seems that all surfaces of the scene have the same lighting.

In Photorealistic Rendering making of the picture is shorter, 5 - 10 minutes. The program used less memory space, 3 MB. It used the same lighting on the scene like in the Physically Based Rendering. The picture quality is lower.

Table 1 Comparation between Physically Based Rendering and Photo Realistic Rendering

	Phisically Based Rendering	Photo Realstic Rendering
Advantages	• Picture with realistic soft shadows which has quality like real photography. • Scene has more realistic look because of the physical behavior of light. • Spillage of the colors as a result of surface reflections of the light. • Does not depend on the skill of the designer.	• Shorter time of preparation of the picture. • The program covers a small random access memory.
Disadvantages	• Making of the picture takes more time. • The program covers more random access memory.	• The designer himself creates the brightness. • There are no clearly expressed reflections. • The surfaces have the same brightness. • The picture is not very realistic.
Rendering time	30 minutes	5 - 10 minutes
Random Access Memory	5 MB	3 MB

5. DISCUSSION

The figure 6 shows the comparation of the rendered scene between Physical Based Rendering (left) and Photo Realistic Rendering (right). The figure show us that scene rendered with Phisycally Based Rendering has realistic soft shadows like real photography. Also scene has more realistic look because of the physical behavior of light and spillage of the colors as a result of surface reflection of the light.

Figure 6. Phisycally Based Rendering vs. Photo Realistic Rendering

6. CONCLUSION

Photo Realistic Rendering generally depends on the skill of the designer to capture the right lighting. Compared with Physically Based Rendering, image quality is lower. There are no clearly expressed reflections and seems to have the same surface brightness. The preparation of the images takes less time. Physically Based Rendering follow physical laws of light behavior. It is not idea of designer, but a pure numerical simulation. We getting a realistic picture with not less quality then photography. Rendered scenes are realistic with soft shadows, color spillage between surfaces, realistic lighting effects.

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