Advanced Graphics – Physically Based Rendering

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ABSTRACT

A video game without lighting is never going to look pretty and will rather look uninteresting. Real world lighting calculation are complex and expensive for video games to handle. Many modern video games make use of a lighting calculation technique called Physically Based Rendering (PBR) which mimics the real-world lighting in a digital world and makes it look realistic. PBR works on microfacet surface model, energy conversations and Bidirectional Reflective Distribution Function (BRDF) to make it happen.

This report explains the process to achieve the approximation of realistic views using PBR and future for the project in context of video game graphics.

**KEYWORDS**

PBR; BRDF; Lighting; Lights; Irradiance; Billboards; HDR; Tone Mapping; Realism

**INTRODUCTION**

In computer graphics, lighting plays a vital role of making the player/viewer believe the realism of the digital worlds. In old arcade style games like Pac-Man, Wolfenstein 3D, lighting was non-existent, and player can see the whole level or map even at huge distance (E.g., A corridor in Wolfenstein 3D). Even if expensive lighting algorithms existed, the CPUs of that era were not powerful enough to handle those lighting calculations in real time.

Later, as CPUs and GPUs become more powerful; “close-to” realistic lighting also became possible.

**RELATED WORK**

1. *Lighting in old video games*

One of the greatest games of all time – Doom and others like Heretic, Hexen did show some sort of dynamic lighting although not realistic which is called Sector-based lighting. In Doom game, the world is divided into sectors which are made by connecting line segments to form a polygon. Every sector had different properties like floor, ceiling, texture and most importantly the light levels. Every sector had a light level ranging from 0-255 with 0 being dark and 255 being very bright.

Lighting attenuation computations were done such that the light travel from one sector to its adjacent sectors and based on the distance of how much it traveled, the light level of current sector will be slowly attenuated. It did support additional light sources like lamp for doing light computation for that sector and its adjacent ones.

* 1. *Light Diminishing*

Another fine addition to lighting Doom introduced in “Light Diminishing”. Where the brightness of the area from the player’s point of view slowly decreases as the distance from the player increases. This did not create any realism as well, but it did create impressive scary atmosphere for the game. This same mechanism was also used to simulate fogs. [1]

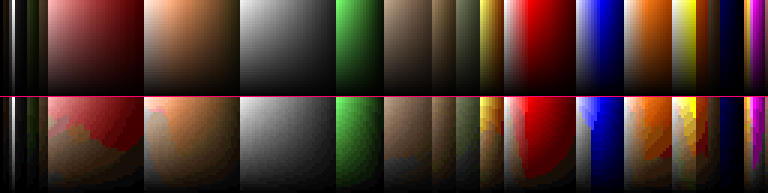
* 1. *Colormap implementation*

Before explaining Colormap, I need to first explain what color quantization is.

* + 1. *Color quantization*

Quantization in general is an image compression technique which is used to narrow down certain range of values to a single value. This also helps in reducing the file size. Moreover, color quantization works by reducing colors of the image such that the compressed is visually like its original.

In the PC port of original doom engine, it made use a Colormap which is a color quantized gradient texture which starts from a different color starting at top and slowly fades to black color as moving down. It is a precomputed lookup table which was used to fit in the game’s 256-color palette. The first 32 levels in the colormap were purely dedicated for implementing lighting. See Figure 1 for example.



**Figure 1: Top – Pure gradient. Bottom – Doom’s quantized colormap light levels**

Overall, the lighting calculations in Doom was simple and not realistic, but it did bring immersive gameplay which made the maps look and feel believable.

1. *Lighting in mid video games*

Games from Doom 3, Unreal Tournament onwards started introducing dynamic lighting and shadow casting. Different light sources were introduced like Point Light, Directional Light and Spotlight.

To quickly summarize these different light sources:

* 1. *Point Light:*

This type of light source emits lights in all directions. In technical details it contains the position in 3D world, color, intensity value and range.

* 1. *Directional Light:*

This light emits light in the single direction, and it has no attenuation and light travel infinitely in the game world. Just like a sun, however the sun in real life is one big point light in the solar system.

* 1. *Spotlight:*

This type of light emits light just like directional light, and it falls in a certain radius. Surfaces outside the radius are not lit at all. A good example of spotlight is flashlight which are common to use in horror games.

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1 Insert Heading Level 1

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Figure 1: Figure Caption and Image above the caption [In draft mode, Image will not appear on the screen]

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