Ray Tracing in Gaming

[1]Mr. Kuljeet Singh, [2]Mr. Jaspreet Singh, [3]Mr. Gaurav Kumar Soni and [4]Mr. Sudhanshu Vshistha,

[1,2]B.Tech Student, Department of Computer Science & Engineering, Arya College of Engineering and Research Centre, Kukas, Jaipur, Rajasthan, India
[3]Assistant Professor, Department of ECE, Arya College of Engineering and Research Centre, Kukas, Jaipur, Rajasthan, India
[4]Assistant Professor, Department of ECE, Arya College of Engineering and Research Centre, Kukas, Jaipur, Rajasthan, India

***Abstract*-Ray tracing is a rendering algorithm that can produce realistic lightning effects that encounter with virtual objects for generating lifelike naturalistic graphic image. Over years tons of rendering algorithm have been developed but ray tracing is one of the most effective and flexible algorithm. Earlier artists relied on hand done drawing which is extremely difficult. Production of computer graphics images increase with new technologies and ray tracing is one of them.**

***Keywords*- Ray Tracing, RTX, DXR, DLSS, Ray Casting, Radiosity, Rasterization**

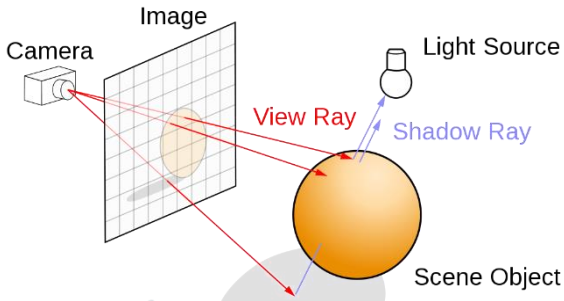


Figure 1 Ray Tracing algorithm builds an image by extending ray into 3D world from ray tracer (camera)

1. INTRODUCTION

Ray tracing technique is used to recreate realistic 3D images into 2D images by incredible lightning effects that bring realism. It has been traditionally used with animation movie with vfx, as a tool in engineering, architecture. With the help of ray tracing we can add some incredibly realistic effects like reflection and shadow.[7] Now it can experienced in games. Battlefield V was the first game to use ray tracing. NVIDIA RTX platform includes this technology to experience ray tracing in games. Ray Tracing can be classified into three divisions, light follows from light source to the object is called light ray tracing, light from eye bounce around and figure out colouring and shading is called backward ray tracing, last one is hybrid ray tracing which include both forward and backward ray tracing to increase speed and accuracy.[6][5]

2. RAY TRACING IN GAMING

Nvidia introduces a ray tracing technology named RTX that brings realistic and high quality rendering to game developers. Since 1990s developers have been using rasterization for 3D rendering. Rasterization is a technique of converting 3D models into pixels on 2D screen. InRay tracing algorithm the path of light traces and calculate colour ofpixel where light interacts with 3D objects.[1] Light may reflect, refract or combination of both of these interactions produces final colour of pixel that displays on screen. Due to hardware limitations RTX only allow to increase qualities of shadows and reflection to bring realism with the help of RTX APIs.[2][4]

3. RTX PLATFORM RAY TRACING APIs

Developers can access these APIs to produce incredible realistic graphics effects in games and cinematic films. NVIDIA optics is a framework that grasp RTX technology to enhance the performance of GPU. It also includes AI accelerated denoiser that reduce the time to render high fidelity image. DXR stands for MS DirectX Ray Tracing API extends DirectX 12 to supports ray tracing technology.[7] With the help of DXR and rasterization developers can add fancy effects such as reflection and shadowing. Vulkan is also a type of RTX

platform ray tracing API that targets high performance realistic 3D graphics.

4. ALTERNATIVE OF RAY TRACING

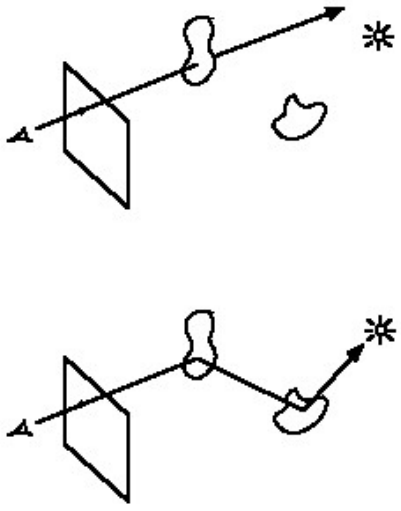
While ray tracing produce incredibly realistic lighting effects still it's not enough capable in the field of computer graphics. Some alternative of ray tracing like ray casting and radiosity are capable to remove limitations of ray tracing. Ray Casting allow to render realistic image of 3D world which is capable to render image at extremely high frame rates. In ray casting ray from viewpoint to object, distance between them are calculated and ray is not recast from that point. Some effects like mirroring, shadowing effects cannot be determined.

Figure 2 Casting vs tracing

Radiosity is a shortcut to ray tracing. It is a flow of light between two surfaces, it renders model containing area light sources. It is said to be that Radiosity is independent.

5. FEATURES OF RAY TRACING

Ray tracing technique can produce incredibly realistic effects that allows to create a realism scenes. Effects like Shadowing, Transparency, Reflection and Refraction can created with the help of this algorithm.[3]



5.1 SHADOW EFFECT

It is easy to see different objects in the figure 3 would be directly illuminated by the light source. Every illuminated surface in the space reflects a portion of light it receives result shadowed in space but not completely black.

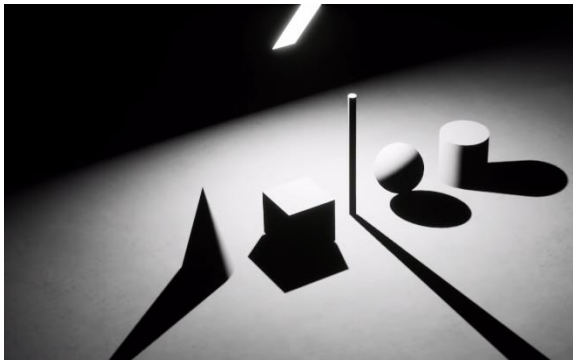


Figure 3 Shadow Effect

5.2 REFLECTION EFFECT

When a highly reflective surface added into a space. This surface allow other lights directly and indirectly illuminated reflected back into the 3D scene. In this 3D world we would notice reflected image of buildings, surface floor and even light source

Figure 4 Reflection Effect

5.3 REFRACTION EFFECT

Refraction brings realism in rendering by realistic transparency effects. When light ray intersects with refracted surface that has some degree of transparency, light ray is reflected and refracted. This means light is bent instead of bouncing back like reflection.

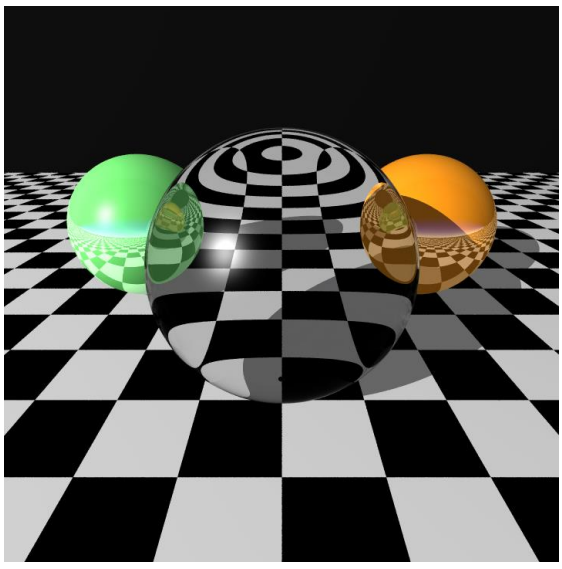


Figure 5 Refraction Effect

5.4 TRANSPARENCY EFFECT

Transparent object allow light to transmit as well as reflect. Some part of light continues through the material. This effect can produce incredibly realistic lightning and used to add fancy effects in gaming.

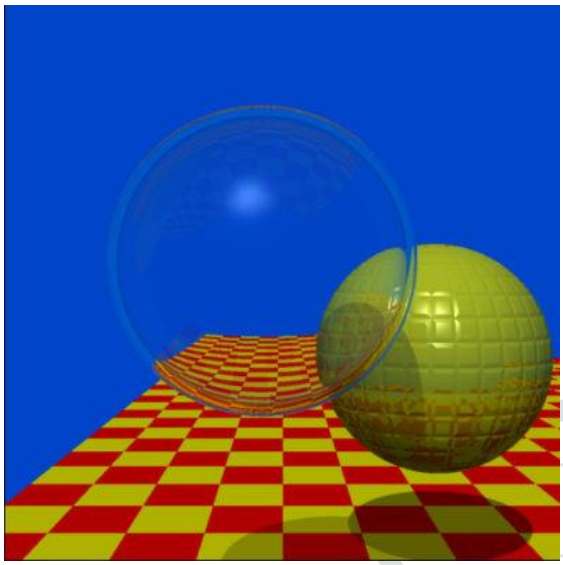


Figure 6 Transparency Effect

6. HARDWARE BEHIND THE RAYS

Nvidia recently introduces RTX platform that brings ray tracing technology of their Nvidia RTX GPUs. Developers can access this technology to create real time cinematic rendering with lots of realistic effects.The Turing architecture uses the Nvidia RTX RT Cores to handle the technique in real time and bring realism in games with optimized performance. Only RTX graphics cards like the 2060, 2070, 2080, 2080Ti all of which have RT cores can use ray tracing technology introduced by Nvidia. Along with ray tracing technology in theirs GPUs Nvidia also introduces Machine Learning technologies in it which is DLSS, stands for Deep Learning Super Sampling. Tons of computations run on hardware in a process to improve gaming performance or rendering performance. With many good things come many limitations such as increasing tons of computations also increase load on the GPU. The load is so high it results in decrease in frame rates. Therefore to experience real time ray tracing with better optimized performance it need a powerful graphics card.[7]

7. WHEN IS IT COMING IN GAMING?

Ray tracing is already in some games with DLSS support and AI-assist anti-aliasing to improve framerates in games. Nvidia's GeForce RTX graphics card powerful enough to use ray tracing technology. Here are some games that can support ray tracing by RTX graphics card

- Battlefield V – first game that brings ray tracing in gaming
- Control
- Metro Exodus
- Call of Duty Modern Warfare
- Minecraft
- Quake II – released in 1997 but recently it got ray tracing
- Wolfstine Youngblood – soon get release notes of ray tracing
- Shadow of the Tomb Raider
- Anthem
- Atomic Heart
- Final Fantasy XV has been endowed with DLSS support
- Witcher 3

Some upcoming games that support ray tracing technology

- Cyberpunk 2077
- Doom Eternal
- Watch Dogs: Legion
- Vampire: The Masquerad – Bloodlines 2
- Hellblade: Senua's Sacrifice
- Dying Light 2
- Synced - Off-Planet

CONCLUSION

Ray tracing is the best algorithm to render 3D world full of virtual objects into 2D images. So we can experience realistic images on our 2D screen in the form of pixels. Ray tracing has been used for several years in animation movies where they have rendering farms to render high quality of images. While in gaming it just began to show up only with shadowing and reflection effects because ray tracing rendering in games with a single GPU is not far enough to bring all ray tracing technologies. It needs some improvement and power to use ray tracing at full level. Nvidia is the only one company that brings real time ray tracing in gaming.

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