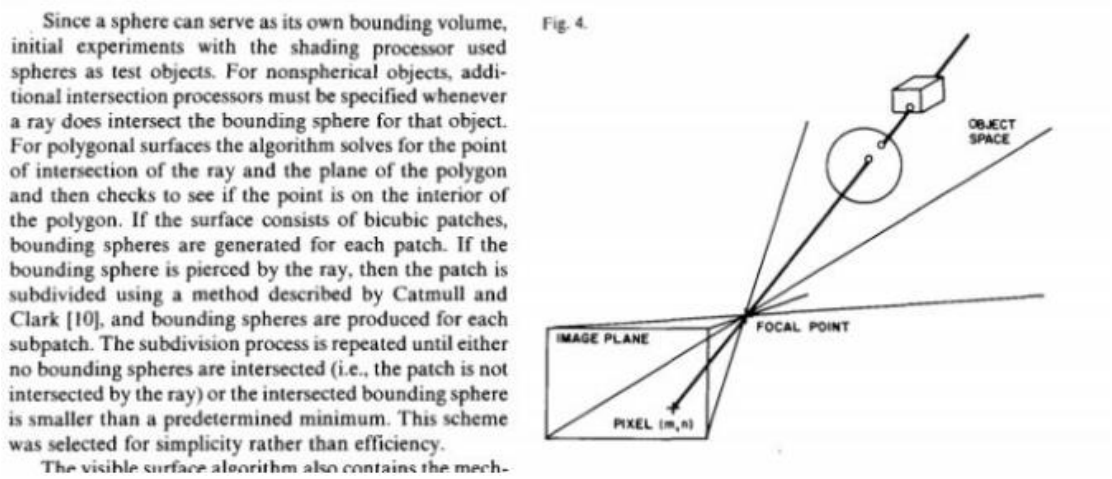
What is ray tracing and how will it change the future of video games?

What is ray tracing?

Ray tracing is a rendering technique that can produce incredibly realistic lighting effects. It provides an algorithm can trace the path of light, and then simulate the way that the light interacts with the virtual objects it ultimately hits in the computer-generated world. In fact, ray tracing is not new to our life. In 1979, J. Turner Whitted published *An improved illumination model for shaded display*, which explained how to capture reflection, refraction, and shadow.



Since a sphere can serve as its own bounding volume, initial experiments with the shading processor used spheres as test objects. For nonspherical objects, additional intersection processors must be specified whenever a ray does intersect the bounding sphere for that object. For polygonal surfaces the algorithm solves for the point of intersection of the ray and the plane of the polygon and then checks to see if the point is on the interior of the polygon. If the surface consists of bicubic patches, bounding spheres are generated for each patch. If the bounding sphere is pierced by the ray, then the patch is subdivided using a method described by Catmull and Clark [10], and bounding spheres are produced for each subpatch. The subdivision process is repeated until either no bounding spheres are intersected (i.e., the patch is not intersected by the ray) or the intersected bounding sphere is smaller than a predetermined minimum. This scheme was selected for simplicity rather than efficiency.

The visible surface algorithm also contains the mech-

Fig. 4.

Using Whitted's technique, when the light is projected onto an object in the scene, the color and illumination of the pixel can be calculated based on the color and illumination information at the point of impact on the surface of the object. If the light reflects or passes through the surface of a different object before it reaches the light source, the final pixel color can be calculated from the color and illumination information of all objects.

Based on this theory and the skyrocketing growth of computer graphics, modern movies benefit massively. We saw *Avatar*, *Frozen*, and *Warcraft*, etc using this technique to depict incredibly realistic scenes. The only problem is the amount of calculation for this technique is also very large. Because of this, film production talent relies on a large number of servers or rendering farms. Moreover, rendering complex special effects can take days or even weeks.

Yet this problem has also been the barrier for real-time interactive games running on console or PC because games are still using rasterization.

What is rasterization and how does it differ from ray tracing?

Real-time computer graphics have long used a technique called "rasterization" to display three-dimensional objects on a two-dimensional screen. The technology is fast and effective enough, although it still does not reach the level that ray tracing can achieve.

With rasterization technology, object 3D models can be created from virtual triangles or polygon meshes. In this virtual mesh, the vertices of each triangle intersect with the vertices of other triangles of different sizes and shapes. Each vertex is associated with a large amount of information, including its position in space and related color, texture, and its "normal" information that can be used to determine the orientation of the surface of the object.

The computer then converts the triangles in the 3D model to pixels or points on the 2D screen. Each pixel can be assigned an initial color value based on the data stored in the vertices of the triangle.

In 2018 Game Developers Conference, the situation has changed. Nvidia, Microsoft, and AMD announced that ray tracing technique is finally possible in real-time video games. Here is a demo from Nvidia.

https://www.youtube.com/watch?time_continue=93&v=jkhBlmKtEAk

Nvidia RTX and Metro: Exodus

10 years ago, Nvidia developed OptiX to introduce the programmable shader model for ray tracing. NVIDIA has continued to invest in hardware, software, and algorithms to accelerate that programming model on our GPUs.

The OptiX API is an application framework that leverages RTX Technology to achieve optimal ray tracing performance on the GPU. It provides a simple, recursive, and flexible pipeline for accelerating ray tracing algorithms. Additionally, the post-processing API includes an AI-accelerated denoiser, which also leverages RTX Technology. The post-processing API can be used independently from the ray tracing portion of the pipeline.

In 2018, Nvidia announced its new graphics card RTX 2080, and at the same time, *Metro:*

Exodus came out with its shocking new ray tracing feature.

https://www.youtube.com/watch?v=NuWfE9vQke4&t=1295s

In the video, we can take a peek where video games' graphics are heading to, the shadow behind the characters make the whole scene more lifelike. Ray tracing is bringing us the next level of realism in games even if this is just a start. Ray tracing technique might change the way environment designers build game scenes, and we may see some more vivid virtual worlds in the near future.