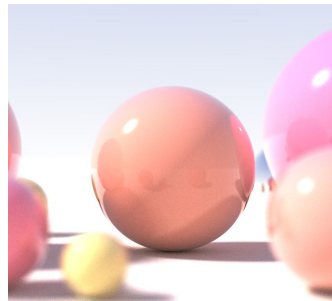




Raytracing

Version 1: Nov, 6 2017

What is ray tracing?



[6]

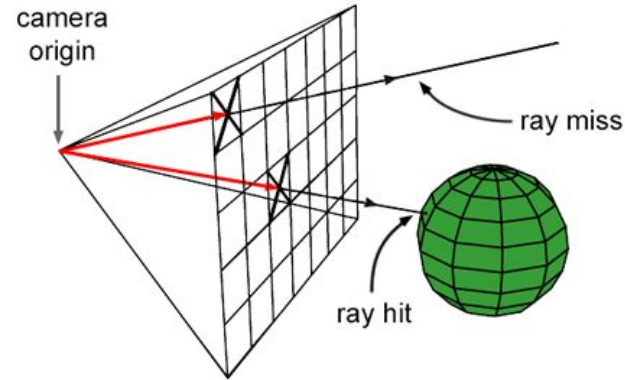
- A very simple way to render a 3D scene
- Conceptually easy to add advanced concepts such as shadowing and reflection
- Very computationally expensive, initially was laughed at for the absurd resource requirements.

“One algo, we all knew of it, but no one had the guts to publish it.

Because it takes so long to do” [4]

General Idea

- Imagine a 3D area with types of a things.
 - The camera
 - A 1000 by 1000 pixel screen
 - N objects
- The screen should be in between the camera, and the object.
- For each pixel, send out a ray originating from the camera, going through that pixel in the screen, and continuing until a certain distance, or the ray intersects an object.
 - As soon as the ray intersects an object, set the pixel color based on the objects color.



© www.scratchapixel.com

[5]

Shadows

Shadows are difficult. Ray tracing however, provides an easy solution to the problem.

When a ray hits an object, emit another ray! Call this a shadow ray.

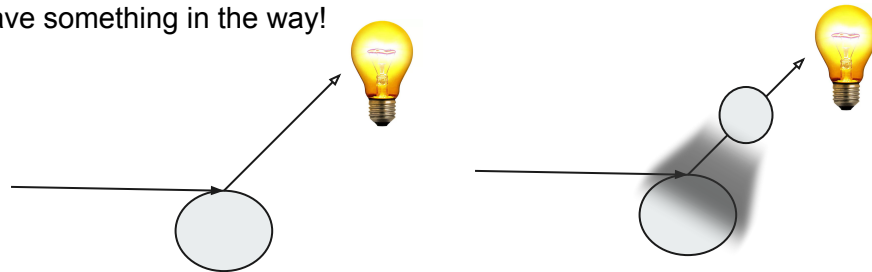
The shadow ray originates from the point the emitted ray hits the object, and goes to the light source.

We trace a ray from the point the emitted ray hits the object, to the light source!

If on the way to the light source, we hit an object, then we have something in the way!

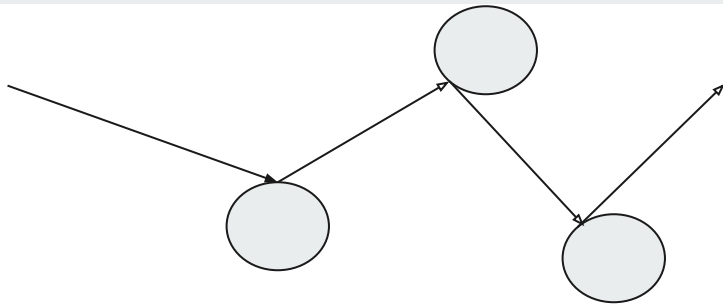
In this case, our pixel is in shadow, so color accordingly.

Alas, this method requires tons more rays!





Reflections



Reflections are also difficult. Ray tracing thankfully also provides a solution!

When a ray hits an object, emit another ray! Call this a reflection ray

The reflection ray originates from the point the emitted ray hits the object, and goes off at an angle. That angle is determined per object, and is the angle of reflection.

If the reflection ray hits an object before a certain distance, then we use that object to influence how the pixel will be colored.

Once again, tons more rays!



Similar to how we view optics in real life

Just backwards!



History

Overview:

- Rene Descartes (1637)
- Arthur Appel (1968)
- Turner Whitted (1980)
- Robert L. Cook, Thomas Porter, Loren Carpenter (1984)
- James Arvo (1986)
- ...

Rene Descartes

- *Dioptrics* (1637)
- Introduces the core concepts of ray tracing



Arthur Appel

- *Some techniques for shading machine renderings of solids* (1968)
- Applies ray casting techniques to rendering objects



Turner Whitted

- *An Improved Illumination Model for Shaded Display (1980)*
- Introduces recursive ray tracing



Robert L. Cook, Thomas Porter, Loren Carpenter

- *Distributed Ray Tracing* (1984)



Robert L. Cook



Thomas Porter



Loren Carpenter



James Arvo

- *Backward Ray Tracing* (1986)





Raytracing in Maya

Raytracing in Film





References (History: Papers)

- http://www.people.fas.harvard.edu/~jkmcdon/files/papers/Invited%20Articles%20and%20Contributions/06_Descartes%20Dioptrics%20and%20Optics%20together%20as%20single%20document.pdf
 - Cambridge paper discussing Descartes' *Dioptrics*
- <http://graphics.stanford.edu/courses/Appel.pdf>
 - Appel (paper)
- <https://excelsior.asc.ohio-state.edu/~carlson/history/tree/magi.html>
 - MAGI (website)
- <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.107.3997&rep=rep1&type=pdf>
 - Turner Whitted (paper)



References (History: Papers)

- <https://dl.acm.org/citation.cfm?id=808590>
 - Distributed Ray Tracing (paper)
- https://web.cs.wpi.edu/~matt/courses/cs563/talks/dist_ray/dist.html
 - More on Distributed Ray Tracing and its applications (WPI course page--more understandable than the paper)
- <https://pdfs.semanticscholar.org/c088/399ad6dc648647e0e19e01b5485925957681.pdf>
 - James Arvo (paper)
- <https://graphics.pixar.com/library/HQRenderingCourse/paper.pdf>
 - Ray Tracing and Photon Mapping (paper)



References (History: Images)

- [https://upload.wikimedia.org/wikipedia/commons/7/73/Frans Hals - Portret van Ren%C3%A9 Descartes.jpg](https://upload.wikimedia.org/wikipedia/commons/7/73/Frans_Hals_-_Portret_van_Ren%C3%A9_Descartes.jpg)
 - René Descartes
- [https://fthmb.tqn.com/AhO2_ufNnC5S1iBHBuNV9Nc2yyE=/768x0/filters:no_upscale\(\)/070715-Appel-58a29f175f9b58819c36ebe6.jpg](https://fthmb.tqn.com/AhO2_ufNnC5S1iBHBuNV9Nc2yyE=/768x0/filters:no_upscale()/070715-Appel-58a29f175f9b58819c36ebe6.jpg)
 - Arthur Appel (?)
- <http://hci.stanford.edu/courses/cs547/Resources/Pictures/whitted.jpg>
 - Turner Whitted
- https://en.wikipedia.org/wiki/Robert_L._Cook#/media/File:Rob_Cook.png
 - Robert L. Cook



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 - Thomas Porter
- <http://pixartimes.com/2014/01/14/the-pixar-perspective-on-loren-carpenter/>
 - Loren Carpenter
- <http://senate.universityofcalifornia.edu/files/inmemoriam/html/jamesrichardarvo.html>
 - James Arvo