Ray Tracing Guts

Ray Tracing Pseudocode

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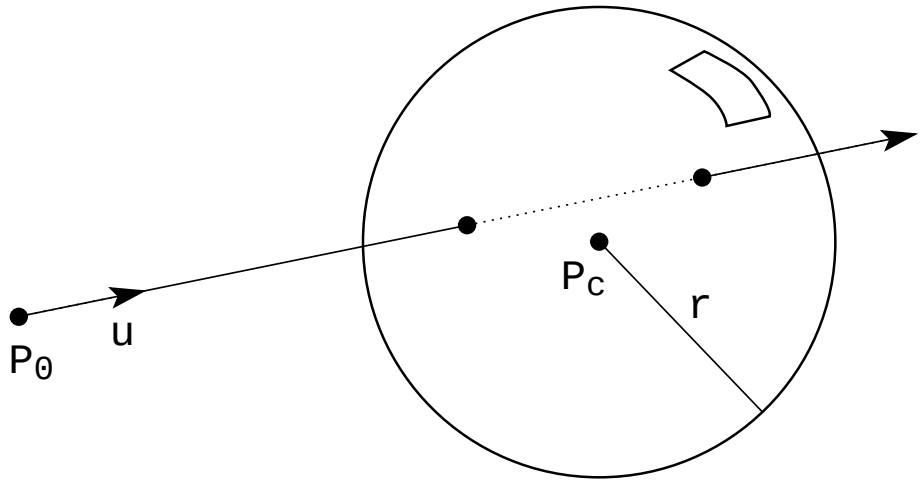
- What do we need to define?

Ray-Object Intersection

- Must define different intersection routine for each primitive
- The bottleneck of the ray tracer, so make it fast!
- Most general formulation: find all roots of a function of one variable
- In practice, many optimized intersection tests exist (see Glassner)

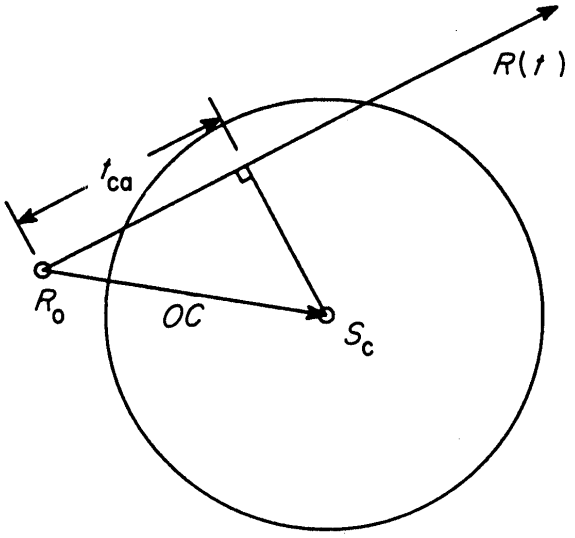
Ray-Sphere Intersection



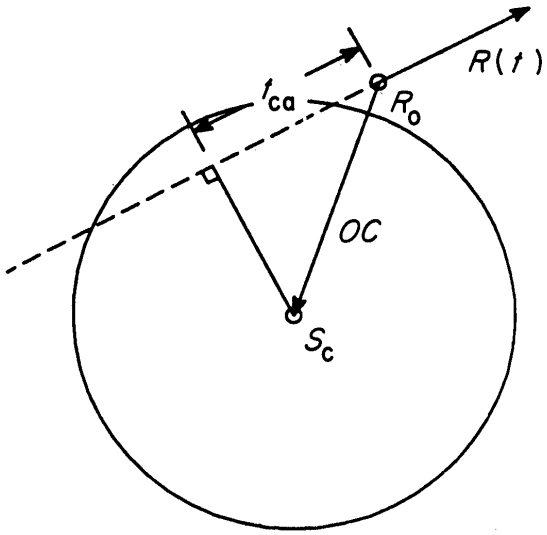
- Given a sphere centered at P_c with radius r and a ray $P(t) = P_0 + tu$, find the intersection(s) of $P(t)$ with the sphere.

Fast Failure

- We can greatly speed up ray-object intersection by identifying cheap tests that guarantee failure
- Example: if origin of ray is outside sphere and ray points away from sphere, fail immediately.



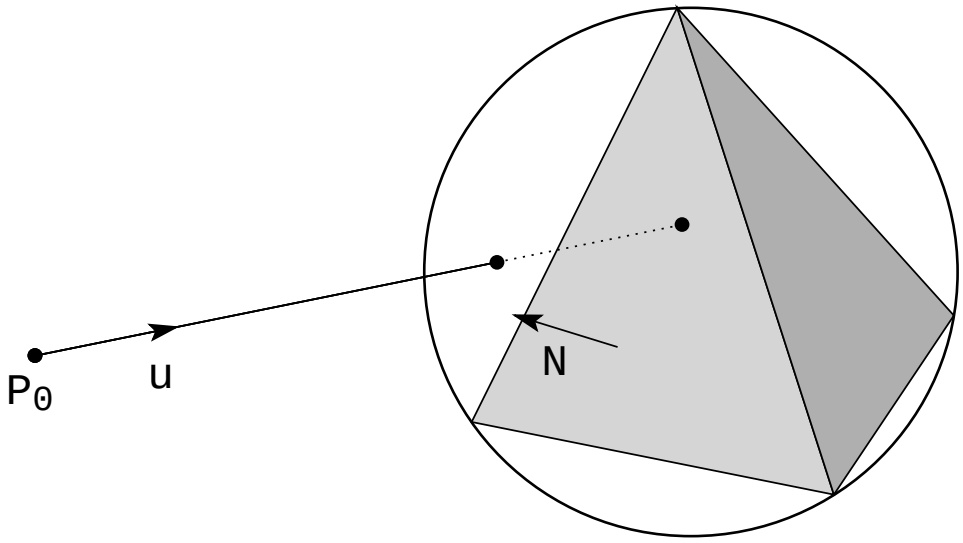
$t_{ca} > 0$, so the ray points toward the sphere



$t_{ca} < 0$, so the ray points away from the sphere

- Many other fast failure conditions are possible!

Ray-Polymesh Intersection



- Use bounding sphere for fast failure
- Can test only front-facing polygons
- Intersect ray with each polygon's supporting plane, then use a point-in-polygon test
- Intersection point is smallest t

Object Intersection in Project 3

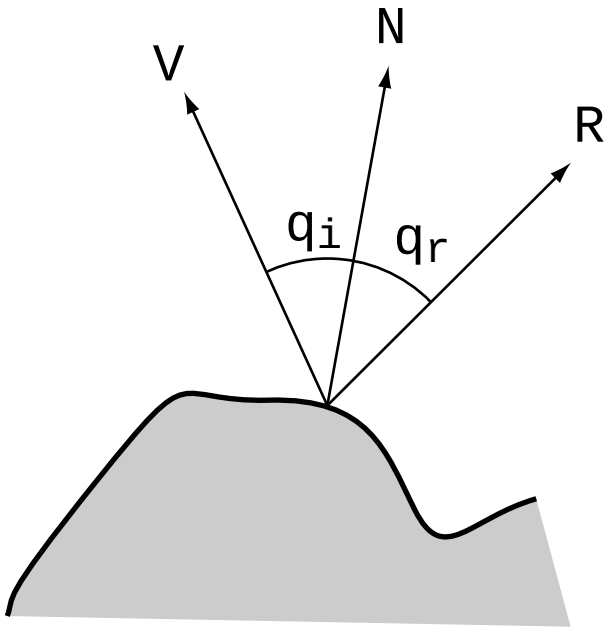
- In project 3, all spheres are unit spheres. We transform them using explicit transform matrices.
- How do we do this?
- Is it smart?

Shadow Rays

- A point on a surface is in shadow with respect to a light source if the ray from the surface to the light intersects an object.
- Easy solution: attenuate light's colour to black if intersection detected.
- Why is this inadequate?

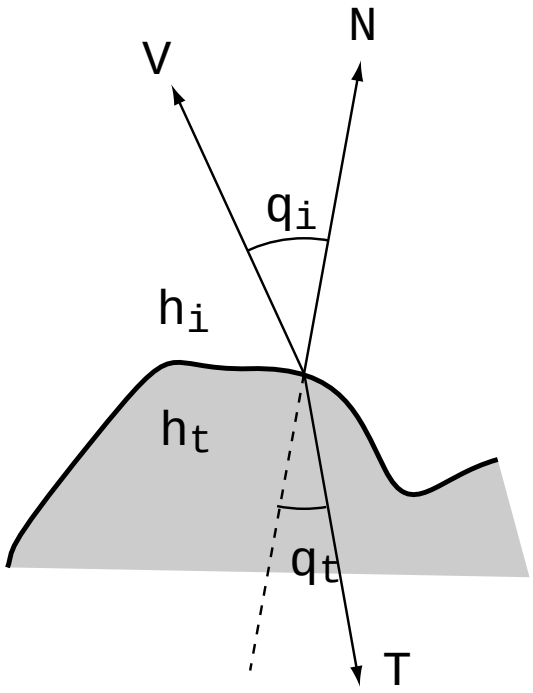
Reflection

- Reflected light from objects behaves like specular reflection from light sources
  - Reflectivity is just specular colour
  - Reflected light comes from direction of perfect specular reflection



- Is this model reasonable?

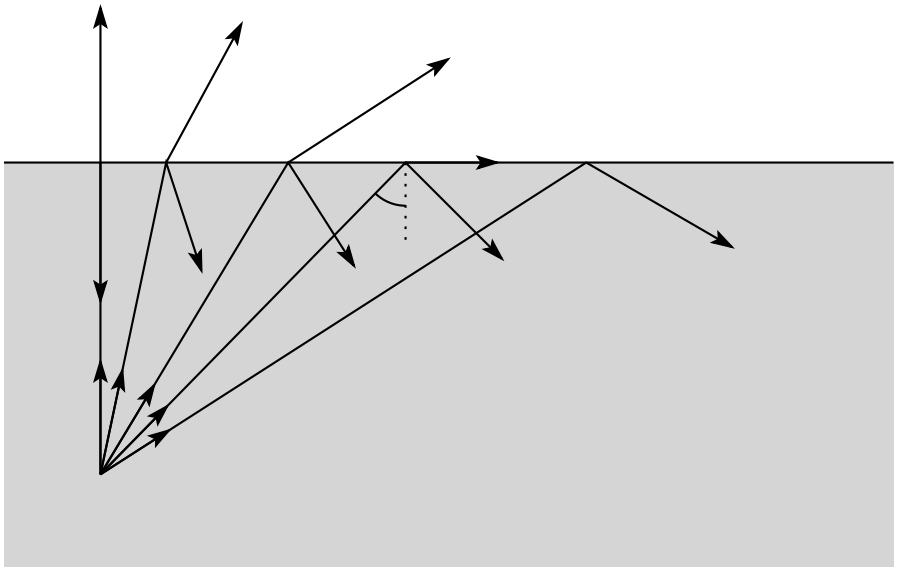
Refraction



- Amount to transmit determined by transparency coefficient, which we store explicitly
- T comes from Snell's law

Total Internal Reflection

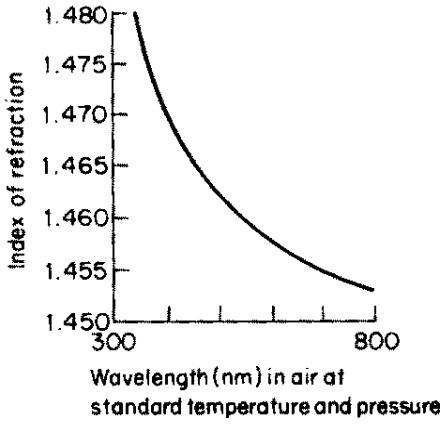
- When passing from a dense medium to a less dense medium, light is bent further away from the surface normal
- Eventually, it can bend right past the surface!
- The θ_i that causes θ_t to exceed 90 degrees is called the critical angle. For θ_i greater than the critical angle, no light is transmitted.
- A check for TIR falls out of the construction of T



Index of Refraction

- Real-world index of refraction is a complicated physical property of the material

Medium	Index of refraction
Vaccum	1
Air	1.0003
Water	1.33
Fused quartz	1.46
Glass, crown	1.52
Glass, dense flint	1.66
Diamond	2.42



Index of refraction variation for fused quartz

- IOR also varies with wavelength, and even temperature!
- How can we account for wavelength dependence when ray tracing?

Numerical Error

- Floating-point roundoff can add up in a ray tracer, and create unwanted artifacts
  - Example: intersection point calculated to be ever-so-slightly inside the intersecting object. How does this affect child rays?
- Solutions:
  - Perturb child rays
  - Use global ray epsilon

Summary

- The guts behind the ray tracing algorithm
- Familiarity with ray-object intersection routines
- Understanding of the ways that shadow rays, reflection rays and transmitted rays are constructed and used
- Appreciation for the problems of numerical error and strategies for dealing with it
- Properties of refraction: index of refraction and total internal reflection