

## Ray Tracing and Radiosity Methods

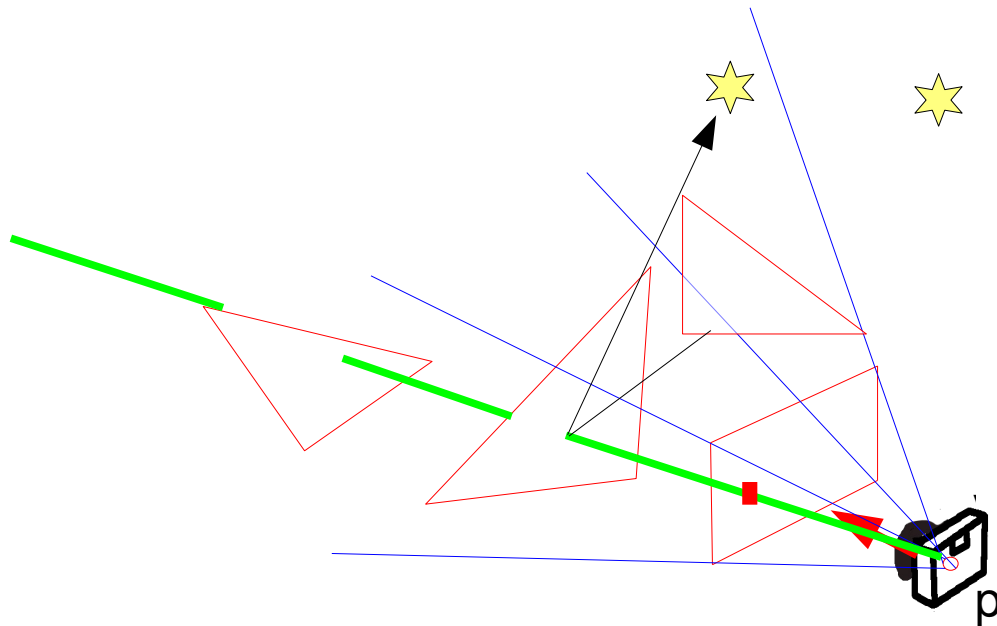
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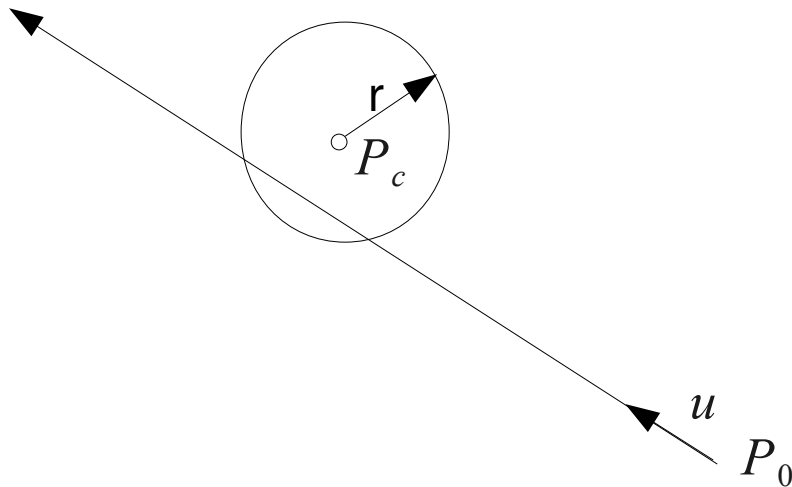
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- Rays
- Shadow Rays
- Radiosity Model
- Progressive Refinement Radiosity Method  
See Chapter 10

- Ray Casting – shoots rays through a pixel in the view plane into the scene. The first object that is struck is used for determine the pixel colour based on some reflection model.
- Ray Tracing – Extends this approach by: bouncing rays of reflecting/shiny surfaces, shoot rays to the light sources, and transmitting rays through clear objects(glass/water).



- Spheres turn out to be simple and quick objects to ray trace.



$$|P - P_c| = r \quad \leftarrow \text{sphere}$$

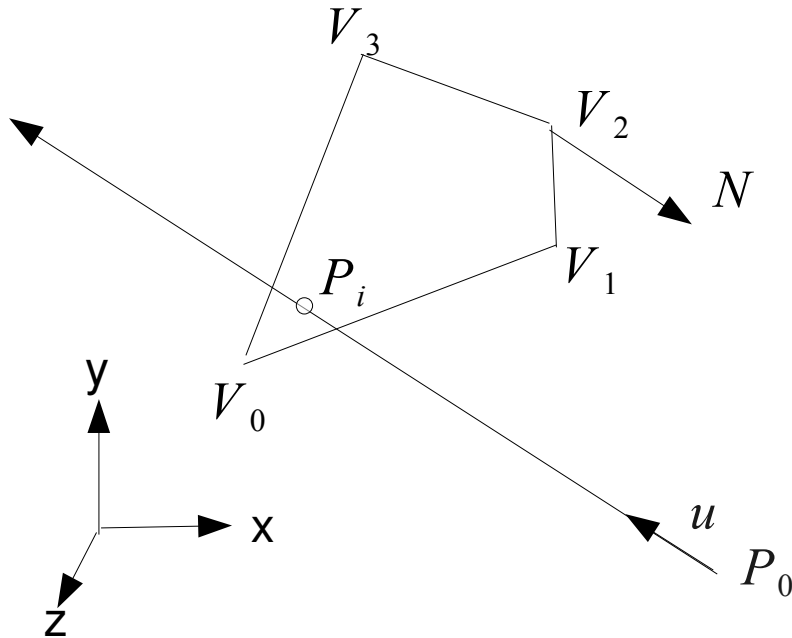
$$P = P_0 + s u \quad \leftarrow \text{ray}$$

$$\text{Let } \Delta P = P_c - P_0$$

$$s = u \cdot \Delta P \pm \sqrt{(u \cdot \Delta P)^2 - |\Delta P|^2 + r^2}$$

- Spheres can also be used to group other objects into a bounding area. If a ray does not pass through the bounding sphere then none of the objects within the sphere need to be checked.

- Rays are first intersected with the polygon's plane. Then it is determined if the point of intersection is within the polygon.



$$P = P_0 + s \mathbf{u} \quad \leftarrow \text{ray}$$

$$N \cdot P = d \quad \leftarrow \text{plane}$$

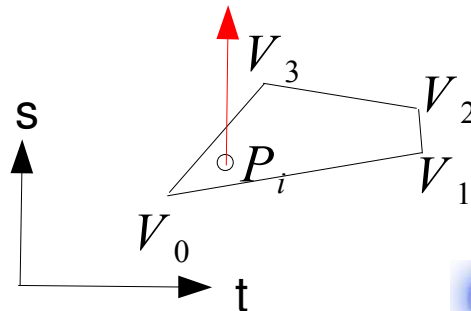
Solving these gives us:

$$s = \frac{d - N \cdot P_0}{N \cdot \mathbf{u}}$$

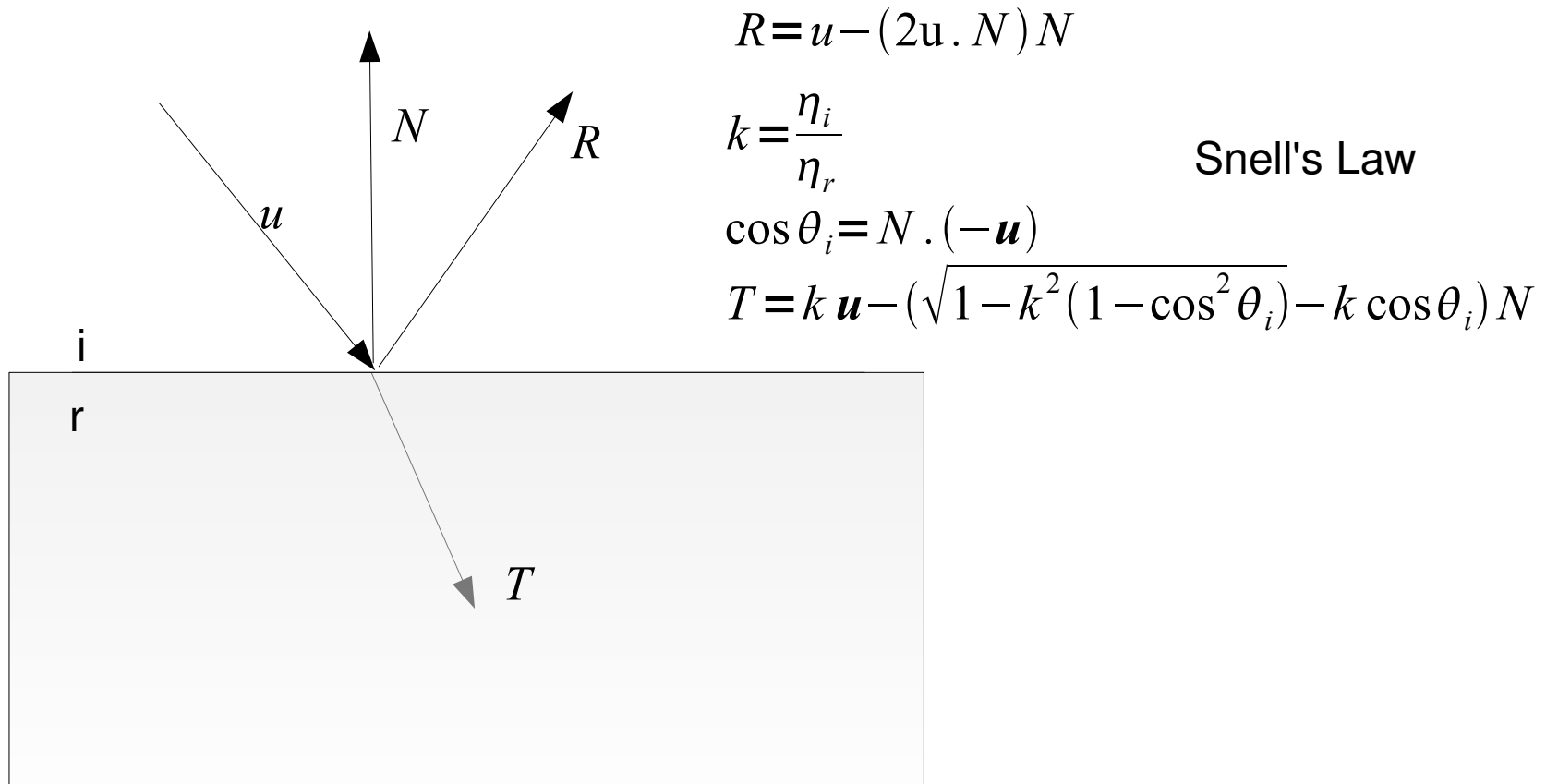
So the point of intersection is:

$$P_i = P_0 + \left( \frac{d - N \cdot P_0}{N \cdot \mathbf{u}} \right) \mathbf{u}$$

The vertices along with the intersection point can be projected onto an axis plane. Then we can perform an inside-outside test.

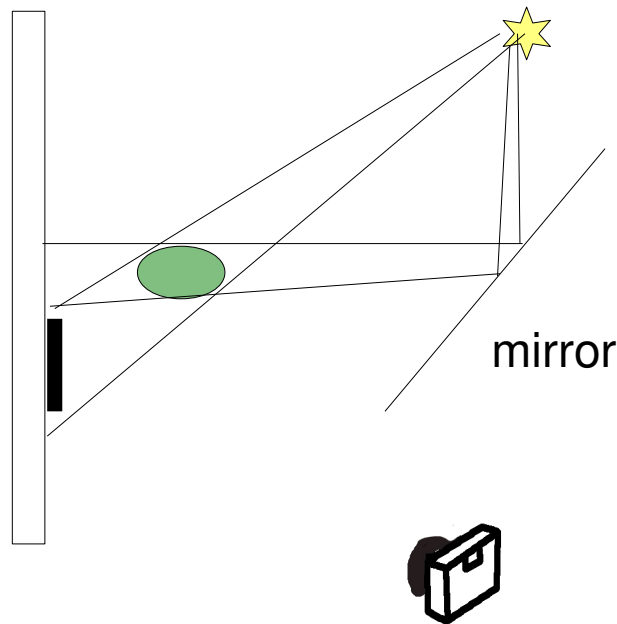


- Given unit vectors  $u$  and  $N$  the reflected vector  $R$  can be calculated. The transmission direction  $T$  also requires the indices of refraction.



Fresnel equations can be used to the intensity of light.

- Basic ray tracing still uses a simple ambient lighting model.
- Shadows from reflected or refracted sources are not visible.



- The energy one photo gives(joules):

$$E = h f$$

$$h = 6.6 \times 10^{-34}$$

- Sum them over all frequencies. This is know as spectral radiance(joules):

$$E = \sum_f \sum_{\text{photos}} h f$$

- The radiant flux or radiant power is(joules/sec or watts):

$$\Phi = \frac{dE}{dt}$$

- The radiosity is the radiant flux per unit area leaving a surface(watts/meter<sup>2</sup>):

$$B = \frac{d\Phi}{dA}$$

- Intensity(or radiance) is radiant flux in a particular direction per unit solid angle per unit projected area(watt/(meter<sup>2</sup> . steradians)).

$$L = \frac{d^2 \Phi}{dA d\Omega \cos \theta}$$

- Lighting is calculated in a closed surface in a viewer independent way.
- Assume all surfaces are: small, opaque, and ideal diffuse reflectors.
- The scene can be broken up into many small patches.
- Given  $n$  patches the radiant energy from patch  $k$  will be:

$$B_k = E_k + \rho_k \sum_{j=1}^n B_j F_{jk} \frac{A_j}{A_k}$$

emitted radiant energy

percent of incident light that is reflected in all directions.

form factor (fraction of energy leaving patch  $j$  and arriving at patch  $k$ )

$$A_i F_{ij} = A_j F_{ji}$$

- This can be changed into matrix form and solved. (note big matrix)

See Foley et al.

- Progressive refinement uses the following approach:
  - The radiosity values  $B_i$  are initialised to the emitter values  $E_i$  (or zero).
  - repeat
    - find a patch  $j$  which has had the greatest change in radiosity
    - spread effect of the change of the  $B_j$  patch out to all the other patches
  - until the change in values is within our tolerance.