Ray-Tracing

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Figure 1: Reflection test: (left) with environment map. (right) with environment map and ray-traced interreflections.

[Pixar: Ray Tracing for the Movie 'Cars'
http://graphics.pixar.com/library/RayTracingCars/paper.pdf]

Ray-tracing Overview

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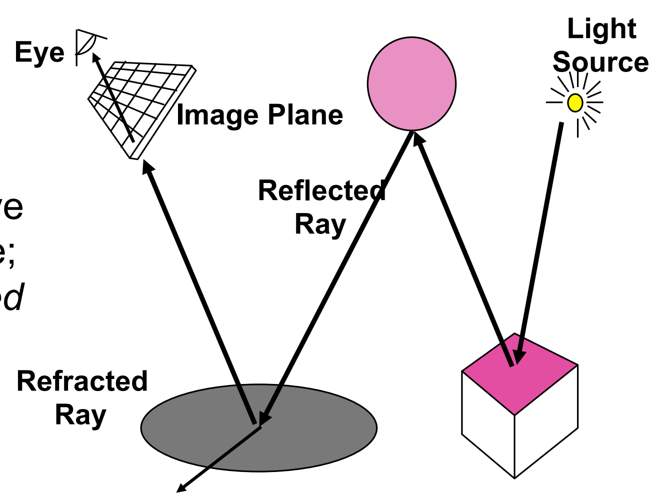
- handles multiple inter-reflections of light
- partly physics-based: geometric optics
- well suited to transparent and reflective objects

Trace light path from the eye backwards(!) into the scene; *recursively apply to reflected and refracted rays.*



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```
raytrace( ray ) {
   find closest intersection: P
   colour_local = (0,0,0);
   if visible(P,L)                         // cast shadow ray
        colour_local = Phong(N,L,rayDir)
   colour_reflect = raytrace( reflected_ray )    // if reflective
   colour_refract = raytrace( refracted_ray )   // if refractive
   colour = k1*colour_local +
                k2*colour_reflect +
                k3*colour_refract
   return( colour )
}
```

- “raycasting” : only cast first ray from eye

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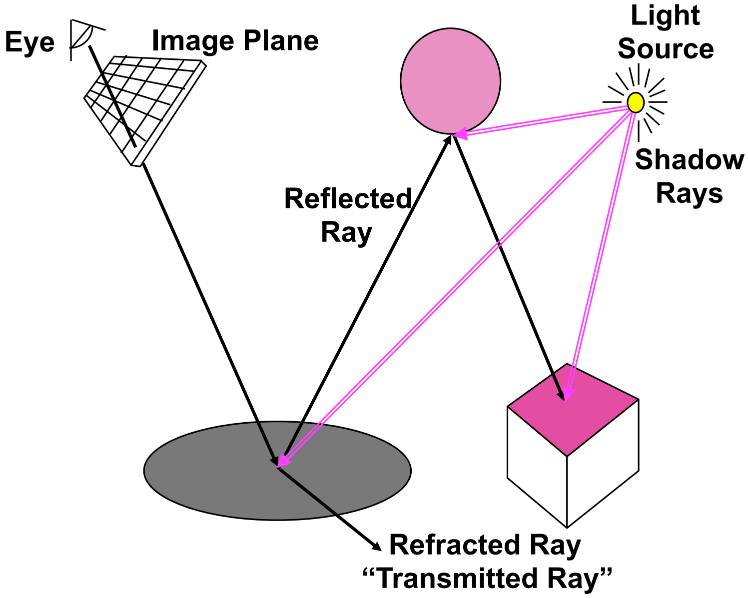

Ray termination

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- ray hits a diffuse object
- ray exits the scene
- when exceeding max recursion depth
- when final contribution will be too small

Generation of Rays

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- distance to image plane: d
- image resolution (in pixels): N_x, N_y
- image plane dimensions: $left, right, top, bot$
- pixel i, j

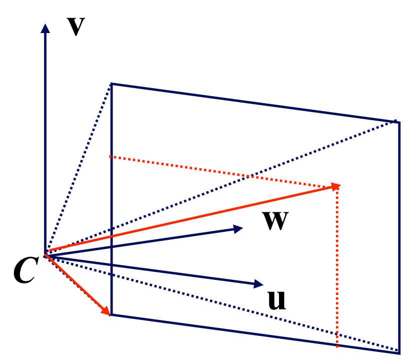
$$P_{0,0} = C + d\,\vec{w} + left\,\vec{u} + bot\,\vec{v}$$

$$P_{i,j} = P_{0,0} + i\Delta u\,\vec{u} + j\Delta v\,\vec{v}$$

where

$$\Delta u = (right - left) / N_x$$

$$\Delta v = (top - bot) / N_y$$



Ray-Sphere Intersections

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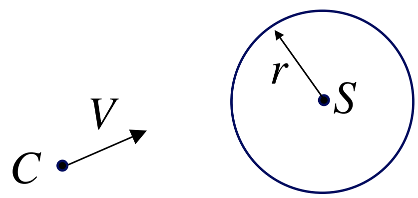
Ray $$\mathrm{R}_{i,j}(t) = C + t \cdot (P_{i,j} - C) = C + t \cdot \mathbf{v}_{i,j}$$

$$x(t) = C_x + V_x t$$
$$y(t) = C_y + V_y t$$
$$z(t) = C_z + V_z t$$

Sphere $$F(x,y,z) = r^2 - (x - S_x)^2 - (y - S_y)^2 - (z - S_z)^2$$



Ray-Triangle Intersections

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Ray-Tracing: Optimizations

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- process rays in parallel (multi-core, GPU, ⋯)
- efficient ray-object culling
  - hierarchical bounding volumes