Introduction to Ray Tracing

Ray Tracing
- Shoot a ray through each pixel;
- Find first object intersected by ray.

- Compute ray. (More linear algebra.)
- Compute ray-object intersection.

Example

Shade of Object at Point
- Ambient
- Diffuse
- Specular
- Shadows
- Material properties
- Texture
- Reflections
- Transparency (refraction)

Diffuse Reflection
- Light that gets absorbed into the objects surface
- Gets reflected equally in all directions
Diffuse Reflection
- Calculate amount/color of light shining on an object.
- Depends on angle between light ray and surface normal.

Example: Diffuse reflection

Specular Reflection
- Calculate light bouncing off object to your eye;
- Angle of incidence = angle of reflection.

Example: Specular Reflection

What’s wrong with this picture?

Shadows
- Determine when light ray is blocked from reaching object.
**Texture Mapping**

**Sampling and Aliasing**

Problem: Representing pixel by a single ray.

**Anti-Aliasing**

Solution:
- Use multiple rays;
- Average values calculated by rays.

**Efficiency**

- $1280 \times 1024 = 1,310,720 \approx 10^6$ pixels.
- $10^6$ initial rays.
- $10^6$ reflection rays.
- Potentially $10^6$ refraction rays.
- $3 \times 10^6$ shadow rays (3 lights.)

Next level:
- Potentially $4 \times 10^6$ refraction/reflection rays

1,000,000 polygons.
$10^6 \times 10^6 = 10^{12}$ ray-polygon intersection calculations.

**Random/Stochastic Sampling**

Randomly sample rays through pixel.
Intersection Data Structures

1. Coarse test to see if ray could *possibly* intersect object
2. Divide space up - sort objects into spatial buckets – trace ray from bucket to bucket

Bounding Boxes

Spatial Subdivision

Major Course Topics

- Object & coordinate transformations.
- Ray-object intersections.
- Diffuse & specular reflection.
- Shadows.
- Opacity & refractive index.
- Shadows.
- Recursive ray tracing.
- Polyhedral models.
- Texture mapping.
- Anti-aliasing and sampling.
- Bounding boxes and spatial subdivision.