More Ray Tracing!

- Efficiency
- Boolean operations
- Antialiasing

A comment on attenuation

- Attenuation
  - Light through air (as we use in OpenGL)
  - Refraction and reflection contribution
Efficiency:
Intersection Calculations

- Pre-computation
- Re-orientation
- Bounding volumes
  - For complex objects
  - Hierarchies of bounding volumes

Efficiency:
Intersection Calculations

- Spatial partitioning
  - Regular or unequal sized subdivisions
- Associate object with each partition
- Intersect rays with partitions
  - Intersect rays with object in partitions
Efficiency: Depth Control

- Maximum recursion depth
  - Usually have some fixed max

- Adaptive tree-depth control
  - Recurse only if contribution significant
  - Potential problem: sum of parts

Example: Depth Control
Other Efficiency Methods

- **Item buffers**
  - Pre-render scene, (ab)use z-buffer

- **Light buffers**
  - Bound light with grid box
    - Compute possible intersecting objects
    - Watch for opaque, full coverage objects
  - Shadow rays can determine which grid item they pass through
    - If farther than opaque object, stop
    - Only intersect list of possible objects
Boolean Sets

- Represent scene as solid objects
- Boolean ops: Intersect, union, difference
- Easy with ray tracing
  - Compute $t$ range for intersection with objects
  - Perform 1D Boolean Set ops on $t$ ranges

Antialiasing: Supersampling

- Regular supersampling
  - i.e. Ray trace $nm \times nm$ image
    - $n \times n$ image with $m \times m$ samples per pixel
    - average the $m \times m$ samples
- Adaptive supersampling
  - Start with $(n+1) \times (n+1)$ (pixel corners)
  - subdivide pixel if values are "different enough"
Antialiasing Example
Temporal Aliasing:
e.g. Small objects

- Object smaller than pixel
- Appear/disappear in moving scene
- One Solution
  - Surround by bounding volume that covers at least one pixel

Antialiasing:
Distributed Ray Tracing

- “Distributed”
  - Stochastically distribute rays
- Ideal: min spaced distribution of rays
- Approximation:
  - randomly jittered supersampled grid
Distribute various dimensions

- Depth of field
  - Camera position/orientation

Other dimensions

- Motion blur
  - Time: Position of moving objects affected

- Soft shadows
  - Angle subtended by extended light source
  - Soften puneumbra

- Gloss, Translucency
  - Material properties
Motion Blur

Shadows

Hard  Uniform sampling  Distributed (10)
Shadows (cont.)

Distributed (10)  Distributed (20)  Distributed (50)

Gloss

Traditional  Distributed 10 rays
Gloss (cont.)

Distributed 20 rays

Distributed 50 rays

Translucency

Traditional        Distributed (10)            Distributed(20)