Ray Tracing

- Assignment #6

Computing Intersections

- Handout: Chapter 2 of
  "An Introduction to Ray Tracing", Andrew Glassner
- Sphere/Ray Intersections (section 2)
  - Algebraic Solution (2.1)
  - Precision Problems (2.4)
- Polygon/Ray Intersections (section 3)
  - Ray/Plane Intersection (3.1)
  - Polygon Intersection (3.2)

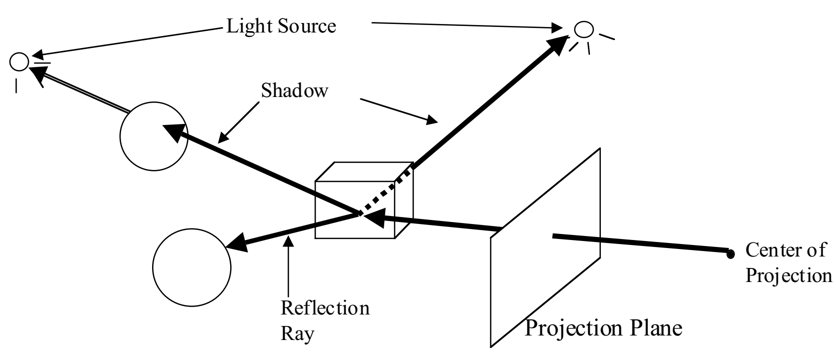
Illumination of a point

- Start with our illumination equation:

$$I = I_a k_a O_d + \sum_{1 \le i \le m} f_{att\,i} I_{p\,i} [\, k_d O_d (N \cdot L_i) + k_s (R_i \cdot V)^n]$$

- Change $R_i \cdot V$ to $N \cdot H_i$
  - See Section 16.1.4, p 731 for why
- Shadows and reflection?

Reflection, Refraction and Shadows: Recursion



Illumination of a point: Shadows

- If L_i hits an object before the light, we are in shadow (16.4, p 745)
  - Add S_i component before f_{atti}:
    - 0 if light i is blocked
    - 1 if light i is not blocked
    - Could be 0..1 if blocked by transparent object

Illumination of a point: Reflection

- Compute illumination of reflected ray I_r
  - Add $k_s I_r$
  - Attenuate for distance

Illumination of a point: Transparency

- Compute illumination of transmitted ray I_t
  - May refract V to get I_t
  - Add $k_t I_t$
    - k_t is the transmission coefficient
  - Attenuate for distance

Illumination of a point

- Illumination equation:

$$I = I_a k_a O_d + k_s I_r + k_t I_t + \sum_{1 \le 0 \le m} S_i f_{att\,i} I_{pi} [\, k_d O_d (N \cdot L_i) + k_s (N \cdot H_i)^n]$$

Ray/Plane Intersection

- Ray: $R_0 = [X_0, Y_0, Z_0]$
  $R_d = [X_d, Y_d, Z_d]$ (normalized)
  where $R(t) = R_0 + R_d t,\ t>0$
- Plane: $Ax + By + Cz + D = 0$
  $P_n = [A, B, C]$
- for any [x,y,z],
  $Ax + By + Cz + D$ = distance to plane

Ray/Plane intersection

- Substitute Ray eq. into Plane eq.
  $A(X_0 + X_d t) + B(Y_0 + Y_d t) + C(Z_0 + Z_d t) + D = 0$
- Solve for t
  $t = -(AX_0 + BY_0 + CZ_0 + C)/(AX_d + BY_d + CZ_d)$
  $= -(P_n \cdot R_0 + D)/(P_n \cdot R_d)$
- $v_d = AX_d + BY_d + CZ_d$
  - if 0, parallel
  - if > 0, plane facing away

Ray/Plane intersection

- $v_d = AX_d + BY_d + CZ_d$
  - if 0, parallel
  - if > 0, plane facing away
- Calculate $t = -(AX_0 + BY_0 + CZ_0 + C)/v_d$
  - if $t < 0$, plane intersects behind viewer
- Use t in ray eq. to compute intersection

Ray/Polygon Intersection

- Compute intersection with polygon plane

- Jordan Curve Theorem
  - Line from intersection point of ray/plane
  - Count number of poly edges
    - Even: outside
    - Odd: inside

Ray/Polygon Intersection

- Practical details
  - Project polygon onto 2D plane
    - Normal is [A B C], choose largest abs. Value
    - Area changes, *topology doesn't*
    - UV coordinates
  - Translate result so ray intersection point is at origin
  - Use +U axis as line to intersect
    - Look at lines that intersect it