CAP 6701 Advanced Computer Graphics
Dr. Corey Toler-Franklin

Exercise #2
DUE: January 29th, 11:59 pm

Realistic Image Synthesis

Global illumination systems use physically-based methods to simulate complex interactions of light with surfaces.

1. The rendering equation can be written in the form:

$$L_o(\mathbf{x}, \omega_o, \lambda, t) = L_e(\mathbf{x}, \omega_o, \lambda, t) + \int_{\Omega} f_r(\mathbf{x}, \omega_i, \omega_o, \lambda, t) L_i(\mathbf{x}, \omega_i, \lambda, t)(\omega_i \cdot \mathbf{n}) d\omega_i \quad (1)$$

   (a) Explain the components of the *rendering equation*.

2. The *path tracing* algorithm uses the rendering equation to generate photorealistic images.

   (a) Describe *path tracing*. What determines path generation? When is shading computed? What condition terminates the algorithm?

   (b) Use the equation below to explain the role of *Monte Carlo Estimation* in path tracing.

$$L_o(p, \omega_o) = \frac{1}{N} \sum_{i=1}^{N} \frac{1}{p(\omega_i)} f_r(p, \omega_i, \omega_o) L_r(r_c(p, \omega_i), -\omega_i) \cos\theta_i \quad (2)$$

3. The ray tracing algorithm is another approach for simulating photorealism.

   (a) Compare and contrast *path tracing* and *ray tracing*.

   (b) Identify and describe two lighting effects that can be produced by path tracing but not by raytracing. What is the key limitation of raytracing that prevents this?

4. Bidirectional scattering distribution functions (BSDF) describe scattering above the surface (BRDF) and on the other side of the surface (BTDF).

   (a) Given a scattering surface with thickness t, scattering coefficient σ_s, absorption coefficient σ_a, and phase function $phase(cos\theta)$, derive a formula to describe a BRDF that can have it's incident and exitant directions on different sides of the surface. You should generate 2 equations, one that describes the BRDF when exitant and incident rays are on opposite sides, and one when they or on the same side. Be sure to give separate expressions for coherent transmission, scattering on the top of the surface and scattering on the bottom of the surface.