CS224

Photon Mapping Homework

Due: **5pm** on Friday, February 26

All work must be your own. You may use lecture notes, Jensen's paper, references, and the textbook. Please write legibly or type your answers. Justify all answers.

Problem 1

- Suppose that r and r_i $(i = 1, 2, \ldots)$ are independently identically distributed binary random variables. Show why $\lim_{n\to\infty} \sum_{i=1}^{n} \frac{r_i}{n}$ is equal to $P(r = 1)$.
- Is the summation a biased estimator of $P(r = 1)$?
- Is photon mapping's solution to the rendering equation biased?

Problem 2

Given that a photon is emitted, derive the probability density that the photon is emitted from point x on light L in direction ω, in terms of the power, area, and normal of L and of other emitters in the scene. Assume all emitters are uniform planar sources.

Problem 3

What are the probabilities of specular reflection, transmission, diffuse reflection, and absorption of a photon on a surface that is both specular and diffuse? Specular color is (S_r, S_g, S_b), diffuse color is (D_r, D_g, D_b), and transmissive color is (T_r, T_g, T_b). Also $S + D + T < (1.0, 1.0, 1.0)$.

Problem 4

When a probabilistic photon group ("photon" in photon tracing) is reflected, the energy of the photon is scaled by the probability of reflection. For example, when white light bounces off a blue surface it becomes mostly blue light. Given our Russian roulette setup, derive an expression for the energy of an outgoing photon given the energy of the incoming photon and the reflectivity of the surface. You can assume that there are only three wavelengths.

Problem 5

- Why do we store the *incoming* direction of photons and not the outgoing direction?
- When computing the radiance estimate at a point during the ray tracing phase, each photon within the radius acts like a little directional light. Why don't we divide by the number of photons in the radius?