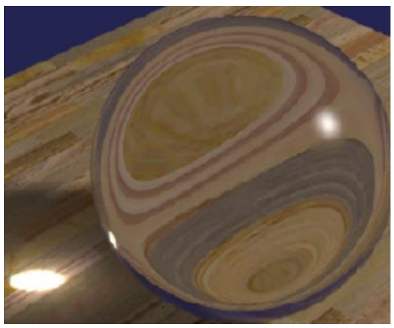
CS 419: Production Computer Graphics Fall 2018
In-class Worksheet

# Photon Mapping

1. **Caustics**

   Write out a plausible regular expression for the caustic seen in the image below. What regular expression is used in general to decribe caustics?



| | |
|---|---|
| L=light | E=eye |
| D=diffuse surface | S=specular surface |
| G=glossy surface | |
| * = 0 or more times | + = 1 or more times |

2. **Sampling Photon Directions**

   Suppose 100 photons are emitted from a light with power 10,000. The hemicube around the light is divided into 20 cells of which 15 are empty. Assume we do not emit photons in the direction of empty cells. What is the power of each emitted photon? And why?

### 3. Russian Roulette

Emitted photons are stored at non-specular surfaces (meaning surfaces that have some diffuse components). An emitted photon can be stored many times along its path. The paths are determined by Russian Roulette.

$$
\begin{array}{lcl}
\xi \in [0, P_d] & \longrightarrow & \text{diffuse reflection} \\
\xi \in ]P_d, P_s + P_d] & \longrightarrow & \text{specular reflection} \\
\xi \in ]P_s + P_d, 1] & \longrightarrow & \text{absorption}
\end{array}
$$

$$P_r = max(d_r + s_r, d_g + s_g, d_b + s_b)$$

$$P_d = \frac{d_r + d_g + d_b}{d_r + d_g + d_b + s_r + s_g + s_b} P_r$$

$$P_s = \frac{s_r + s_g + s_b}{d_r + d_g + d_b + s_r + s_g + s_b} P_r = P_r - P_d$$

Suppose we have surface with diffuse reflection coefficients (¼, ¼, ¼)
Suppose the specular reflection coefficients are (¼, 0, ½)
If a photon with power (1,1,1) hits this surface and we generate a random number of ½ is the photon absorbed or reflected diffusely or reflected specularly? If it is reflected, what is the power of the reflected photon?

### 4. Gathering Radiance

After generating the photon map(s), a scene can be ray-traced and the photon map can be used to provide estimates of reflected radiance for certain situations. The expression below is one possible formulation for estimating radiance by gathering photons. Can you explain meaning and motivation of each term? What information must each photon contain?

$$L_r(x, \vec{\omega}) \approx \frac{1}{\pi r^2} \sum_{p=1}^{N} f_r(x, \vec{\omega}_p, \vec{\omega}) \Delta\Phi_p(x, \vec{\omega}_p) .$$