CS 419 : Production Computer Graphics Fall 2018
In-class Worksheet 8

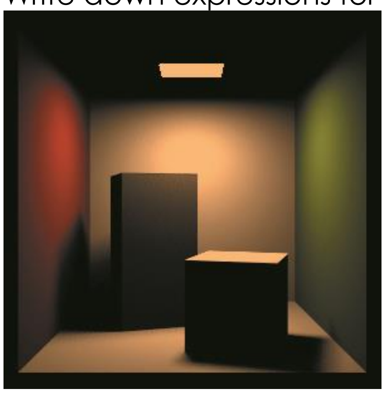
Global Illumination

1. Regular Expressions for Light Transport

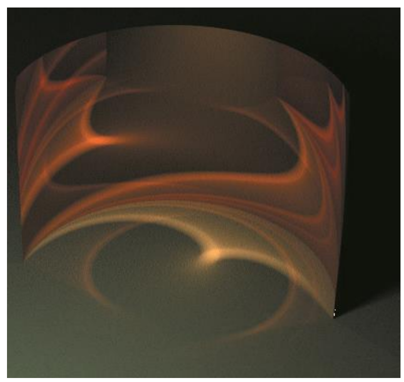
We can describe light transport paths using regular expressions.

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

Write down expressions for the light paths you can see in these images.



LD*E



LS*(DS)*E

2. Russian Roulette

The code below is based on *smallpt: Global Illumination in 99 lines of C++*
Complete it so that it correctly employs RR is the recursion depth is greater than 5. Why do we only start using RR at deeper levels?

```
// p = maximum reflectance of surface, fr = BRDF value, depth = recursion depth

double U=drand48();

if (  ++depth>5  )

    if (  U<p  )

        fr =  fr*(1/p)
        return obj.emission + compute_illumination(fr,…and other stuff);
    else
        return obj.emission;
```

3. Irradiance Caching

$$E(\mathbf{x}, \vec{\mathbf{n}}) \approx \frac{\sum_{i \in S} w_i(\mathbf{x}, \vec{\mathbf{n}}) E_i}{\sum_{i \in S} w_i(\mathbf{x}, \vec{\mathbf{n}})}, \qquad w_i(\mathbf{p}) = \frac{1}{\frac{\|\mathbf{p} - \mathbf{p}_i\|}{R_i} + \sqrt{1 - \mathbf{n} \cdot \mathbf{n}_i}} - \frac{1}{a},$$

$\mathbf{p}$ is the interpolation point,
$\mathbf{n}$ is the surface normal at $\mathbf{p}$,
$\mathbf{p}_i$ is the position of the i-th cached record (stored in the cache),
$\mathbf{n}_i$ is the surface normal at $\mathbf{p}_i$ (stored in the cache),
R_i is the distance to the surfaces visible from $\mathbf{p}_i$ (computed as the harmonic mean or, alternatively, the minimum of the ray lengths in hemisphere sampling and stored in the cache),
a is a user-defined constant specifying the allowed approximation error, discussed in more detail below.

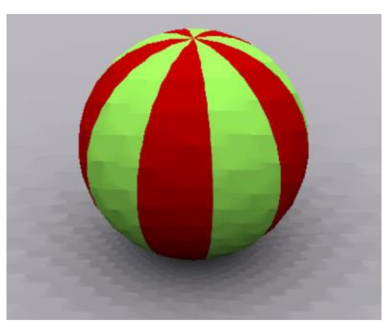
From *Practical Global Illumination with Irradiance Caching* by Krivanek and Gautron

For a given hit point x with normal n, an estimate of the irradiance produced by indirect illumination at x can be constructed based on a weighted average of the irradiance at previous hit points.

a. Acquire a worksheet partner and develop descriptions for the purpose of the two summands in the denominator of w_i. They diminish the weight as distance and curvature increase

b. The weights use $R_i = {}^{M}\!/\!{\sum {}^{1}\!/\!{r_i}}$ where M is the number of rays sampled around the hemsiphere and ri is the distance a ray travels before hitting a surafec. What would be a potential alternative to hemisphere sampling around p_i to construct a similar measure? Use your spatial data structure to do a distance query to a surface

c. The image below computed the radiance at each pixel in scanline order using irradiance caching. Suggest one possible source of the artifacts seen in the image. Suggest an alternative rendering strategy to resolve this issue.



The artifacts are likely from using a single pass to generate irradiance samples and render. So the rendering is done using incomplete sampling in some sense. A 2-pass strategy to generate samples and then gather would be better.