Laboratoire d'Informatique Graphique et Géométrique

Advanced Computer Graphics
Exercise 3 - Area Sampling of Lights

Handout date: 05.10.2015
Submission deadline: Monday, 12.10.2015, 11:00pm

Note

Undeclared copying of code or images (either from other students or from external sources) is strictly prohibited! Any violation of this rule will lead to expulsion from the class. No late submission allowed.

What to hand in

Solve the exercise in groups of 3. Hand in a `.zip` compressed file renamed to `Exercise3_#id.zip` where `#id` is your group number. It should contain the following files:

- `light_integrator.cpp`: an integrator that performs area sampling on the lights,
- A `readme.pdf` containing a description of your solution approach, your rendered images, how much time you needed and encountered problems (use the same numbers and titles), and providing answers to the questions.

3.1 Before Starting

Open the file `src/ex3/light_integrator.cpp` and put your group number in `#define GROUP_NUMBER`.

3.2 Area Sampling

Make sure to study and understand the course slides about area sampling as we use the same notations and definitions. You are asked to complete a new integrator to perform light area sampling. So far you only used the reflection equation in its directional form that integrates over the hemisphere:

$$L_r(\mathbf{x},\overrightarrow{\omega}_r) = \int_{H^2} fr(\mathbf{x},\overrightarrow{\omega_i},\overrightarrow{\omega_r}) L_i(\mathbf{x},\overrightarrow{\omega_i}) \cos(\theta_i) d\overrightarrow{\omega_i}$$

For area sampling, however, it is easier to do a change of variables to work with the surface formulation that allows to integrate over the lights' surfaces:

$$L_r(\mathbf{x}',\mathbf{x}) = \int_A fr(\mathbf{x}'',\mathbf{x}',\mathbf{x}) L_i(\mathbf{x}'',\mathbf{x}') G(\mathbf{x}'',\mathbf{x}') dA\mathbf{x}''$$

Using the area formulation, the Monte Carlo integral looks as follows:

$$\frac{1}{N}\sum_{j=1}^{N} \frac{fr(\mathbf{x}'',\mathbf{x}',\mathbf{x}) L_e(\mathbf{x}'',\mathbf{x}') V(\mathbf{x}',\mathbf{x}'') \frac{\cos\theta''\cos\theta'}{||\mathbf{x}''-\mathbf{x}'||^2}}{p(\mathbf{x}'')}$$

You have to implement two methods in `src/ex3/light_integrator.cpp`:

3.2.1 1. Method - `sampleLights` (20 points)

```
inline Color3f sampleLights(const Scene *scene,
                            LuminaireQueryRecord &lRec,
                            const Point2d &_sample) const;
```

In this method you have to implement the following steps:

1. Choose one light at random.
2. Receive a random sample position on the light mesh using `Mesh::samplePosition(const Point2d, Point3f, Normal3f)`.
3. Compute the visibility term V (by casting a shadow ray), a part of the geometry term G (without $\cos\theta'$, it's easier to weight by that term in the second method), and the probability of the sample point being found (using `Mesh::pdf()`).
4. Return the radiance emitted from the light source multiplied by the appropriate terms from $G, V, \ldots$

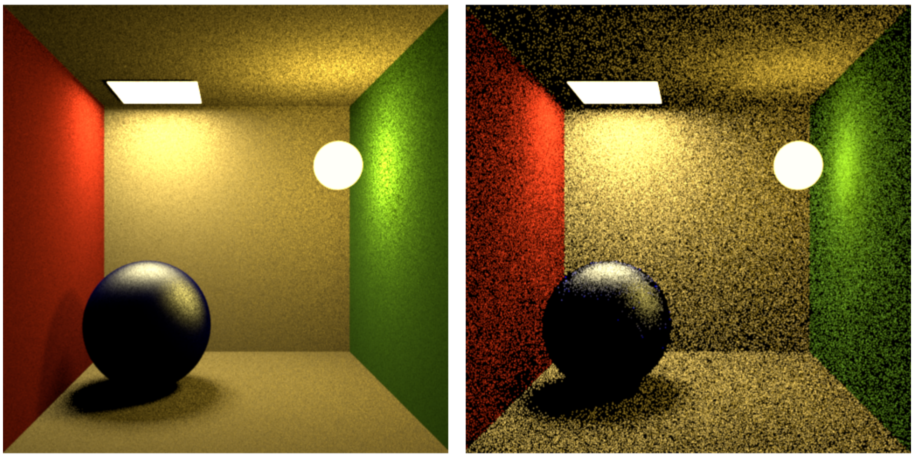
Hint: make sure to avoid contributions from lights that are facing away from $\mathbf{x}'$.

3.2.2 2. Method - `Li` (15 points)

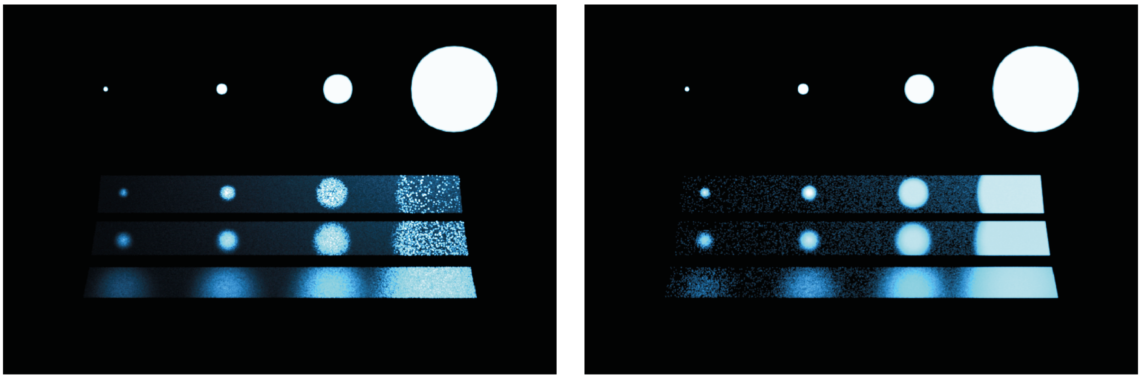
```
Color3f Li(const Scene *scene,
           Sampler *sampler,
           const Ray3f &ray_) const;
```

Complete the implementation of direct lighting. To this end, you have to call your first method `sampleLights`. Use its return value and the given BRDF to compute `Li`'s return value (the reflected radiance of the sample).

Use the example scene `area_sampling.xml` in (`scenes/ex3/`) to verify your implementation. It should look like the rendering on the left in the following figure (the image on the right is for comparison, it uses the directional BRDF sampling strategy introduced in Exercise 2):



3.3 Directional Sampling versus Area Sampling



The above figure shows two renders of the same scene using two different sampling methods: directional (BRDF) sampling and area sampling. This scene contains 4 light sources and 3 Phong plates.

3.3.1 2 points

Identify the sampling method used for each image.

3.3.2 3 points

What can you say about the material properties of the plates? Justify your answer.

3.3.3 5 points

In the left image, rendering artifacts are most noticeable in the top plate on the right, in the right image on the bottom plate on the left. Explain why this happens.

3.3.4 5 points

In the above scene, both of the sampling methods give artifacts. Can we get the “best of both worlds” by simple averaging both images? Discuss and explain.