Advanced Topics in Computer Graphics I

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Sheet R04 - Radiosity

Hand in your solutions via eCampus by Tue, 13.05.2025, **12:00 p.m.**. Compile your solution to the theoretical part into a single printable PDF file. For the practical part, hand in a single ZIP file containing only the exercise* folder within the src/ directory. Please refrain from sending the entire framework.

Assignment 1) Radiosity *(7 Pts)*

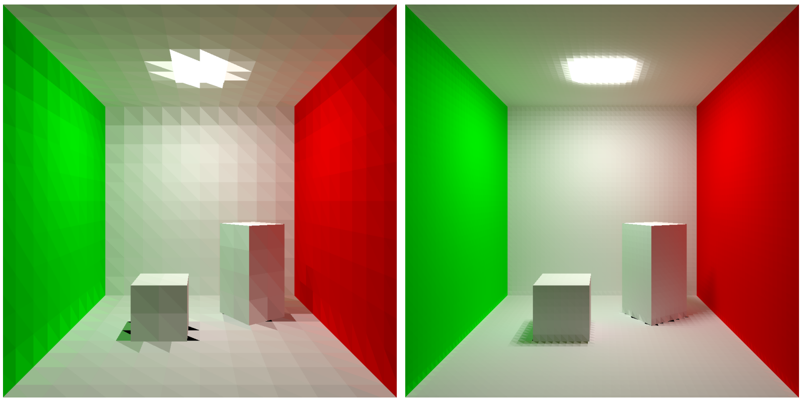

Figure 1: Cornell Box scene rendered with the Radiosity method. To obtain these renderings, run `./bin/exercise04_Radiosity -s data/exercise04_Radiosity/cornell_box.xml` and `./bin/exercise04_Radiosity -s data/exercise04_Radiosity/cornell_box_fine.xml` from the project root, respectively.

In this exercise, the Radiosity method has to be implemented. It is integrated into our framework using a `RadiosityEmitter` class and a `RadiosityRayGenerator`. The `RadiosityEmitter` is simply a surface emitter that wraps the surface parameters emission and albedo, as well as the per-triangle radiosity solution. The `RadiosityRayGenerator` is responsible for all computation in this case. It first computes the fundamental matrix, then solves a linear equation system for the radiosity and also generates images for a camera. We interpret each triangle primitive as a finite element in the radiosity method, so the radiosity is computed per triangle and not per vertex in a mesh.

a) Complete the `__raygen__generateRadiosity` program in `radiosityraygenerator.cu` by computing the entries F_{ij} of the form factor matrix F, taking the occlusion between two surface patches into account as described in the lecture.

b) Complete the `RadiosityRayGenerator::computeRadiosity()` method in `radiosityraygenerator.cpp` by solving

$$\underbrace{(\mathbf{I} - \mathrm{diag}(\mathbf{r}) \cdot F)}_{=:K} \cdot B = E \tag{1}$$

for each color channel, where $\mathbf{I}$ is the identity matrix, $\mathbf{r}$ is the albedo for each primitive, F is the form factor matrix and E describes the emission of each primitive in the scene. Inverting the matrix K is usually not feasible. Therefore a typical approach for solving this is the iterative Jacobi method[1]: After initializing $B^{(0)} = E$, iterate

$$B^{(i+1)} = B^{(i)} + \lambda \cdot (E - K \cdot B^{(i)}) \tag{2}$$

until convergence, where λ is a user defined parameter.

Theoretical Assignments

Assignment 2) Properties of Microfacet BRDFs *(2Pts)*

Figure 2: Renderings of a rough plane illuminated by an environment map. One of the images uses a Phong BRDF, and the other image uses a micro-facet BRDF.

In the lecture you have seen different BRDF models. The specular reflections shown in the two renderings in Figure 2 are produced by two different kinds of BRDF models. In one of the images a Phong BRDF was used, and the other uses a micro-facet BRDF. Identify which image uses which BRDF model and what the difference is. Explain how this difference arises.

Assignment 3) Refraction in Wedge *(3Pts)*

Consider the scene depicted in Figure 3 in which a laser is shooting unpolarized light rays into a wedge which is surrounded by air (refractive index $n_a = 1$). The light rays are hitting the wedge perpendicular to the surface.

a) Assuming the wedge has a refractive index of $n_w = \sqrt{3/2} \approx 1.225$, draw all light paths for the laser light into the scene (with correct angles!).

b) Consider the same scene but with a wedge consisting of a different material. The new material has a refractive index of $n'_w = 5$. Draw the new light paths into the scene.

c) Describe the difference between the two scenarios.

d) Calculate $\hat{n}_w$ which is the smallest refractive index, that leads to the same result as n'_w.

Good luck!

[1] https://en.wikipedia.org/wiki/Jacobi_method

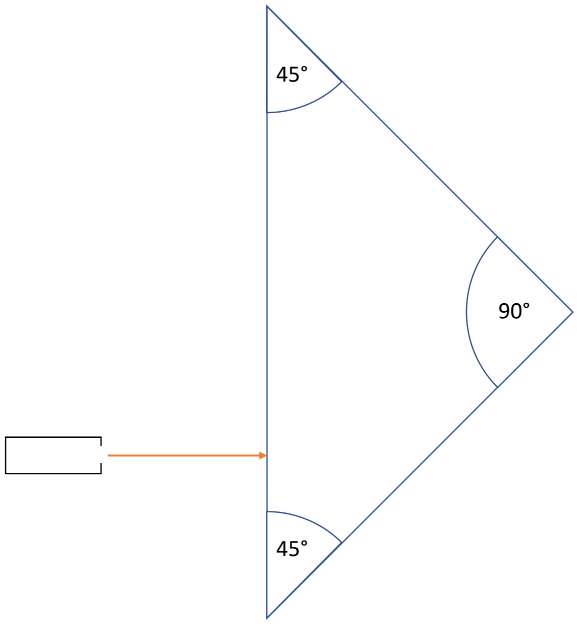

Figure 3: Wedge illuminated by a laser.