Worksheet 6

Path tracing starts at the eye and traces rays through the scene. Every position reached in the scene is connected to the light sources. In some cases this is not the optimal strategy. Sometimes it is beneficial to start from the light source, trace rays through the scene, and connect every encountered position to the eye. This procedure is called *light ray tracing* and it is, among other things, good for rendering caustics. Photon mapping (or vertex merging) is where you trace some rays from the light and some from the eye. The following exercises are about implementing photon mapping.

Learning Objectives

- Implement photon mapping.
- Do direct visualisation of a photon map.
- Do final gathering.
- Use a global photon map with final gathering and a separate photon map for caustics.

Photon Mapping

In Worksheet 5, you rendered the two classic Cornell box scenes using path tracing. This means that you have reference images for these two scenes that you can compare your photon mapping results with. Consequently, the following exercises will involve the same two scenes. The main problem in path tracing is bright dots (fireflies) that sometimes appear as a consequence of a low probability event being chosen by Russian roulette. These fireflies take "forever" to mean out. Soft caustics are particularly prone to this problem. In the following, the goal is to show that photon mapping is one way to overcome this path tracing problem.

- Build a photon map by emitting photons from an area light source. (In the `pathtrace` project of the course framework, implement the `emit` function in `AreaLight.cpp`. Set the desired number of photons in `RenderEngine.cpp`, lines 72–73, to ensure that some photons are emitted. The framework takes care of the tracing and the photon map construction.)
- Load the Cornell box (`CornellBox.obj`) and the blocks inside it (`CornellBlocks.obj`) into your renderer. Set the background illumination to 0 and visualize the photon map if possible. (In the framework, the photon map is rendered as dots in preview when you choose the `PhotonLambertian` shader. This shader is used when you press '5' on the keyboard.)
- Shade the scene using radiance estimation based on the global photon map (vertex merging only, no vertex connections). Your rendering works as expected when the result compares qualitatively to the path traced Cornell box. (In the framework, implement the `shade` function in `PhotonLambertian.cpp` and toggle off final gathering by pressing 'g' on the keyboard before you render the scene. Set the photon mapping parameters in the `Globals` section of `RenderEngine.cpp`.)
- Unless a very large number of photons is traced and stored, the radiance estimate has a lot of low frequency noise. Avoid the worst low frequency noise by implementing final gathering (or enable vertex connection). Render the scene using the complete photon mapping (or vertex connection and merging) algorithm. Note the rendering time, the number of samples, and the parameters used for radiance estimation. (In the framework, implement the `split_shade` function in `PhotonLambertian.cpp`.)
- Make sure that you renderer can deal with specular objects. When final gathering is used, caustics are handled separately by a caustics photon map. (In the framework, implement the `shade` function in `PhotonCaustics.cpp` to use the caustics photon map.)
- Replace the blocks in the Cornell box by a silver sphere (`CornellLeftSphere.obj`) and a glass sphere (`CornellRightSphere.obj`). Visualize the photons in your caustics photon map if possible. (In the framework, the `PhotonCaustics` shader is used when you press '4' on the keyboard.)

- Render the scene using the complete photon mapping (or vertex connection and merging) solution. Note the rendering time, the number of samples, and the parameters used for radiance estimation.

Worksheet 6 Deliverables

Renderings of the Cornell box with blocks and with two spheres. Ideally, provide two series of images showing the photons, the radiance estimation, and the final result. Include relevant code and render info (render time, number of samples, radiance estimation parameters). Compare the results to path traced reference images and discuss the reasons for the differences. Answer the following question:

Why is photon mapping a biased method?

Reading Material

The curriculum for Worksheet 6 is

P Section 16–16.2. *The Path-Space Measurement Equation* and *Stochastic Progressive Photon Mapping*.

Alternative literature available online or uploaded to CampusNet:

- Jensen, H. W., and Christensen, N. J. *A Practical Guide to Global Illumination Using Photon Maps*, ACM SIGGRAPH 2000 Course Notes, Course 8, 2000.