Week 7

Over the last few weeks you have implemented different rendering techniques that make you able to render realistic images. However, interaction is essential to many graphics applications and unfortunately every frame takes a long time to render. The next step is therefore to obtain realistic images in real-time. Having off-line techniques for realistic rendering in hand, an idea that naturally springs to mind is to use precomputation. In the exercises for this week and the next, the path tracing developed in Week 5 will be used to precompute radiance transfer for realistic real-time rendering.

Spherical Harmonics Lighting

Any function with a directional dependency may be expanded in spherical harmonics. The exercises for this week are about computing the expansion coefficients using path tracing. Of course, we can pack any lighting environment into the spherical harmonics expansion, but the spherical harmonics are only advantageous if the light source and the geometry are represented each by their own expansion. Then we can interact with the light source while reusing the precomputation for the geometry.

- To decouple light sources from the geometry, disable all light sources and set the background illumination to 1 in your ray tracer. (In the `pathtrace` project of the framework, do this in lines 83 and 86 of `pathtrace.cpp`.)
- Load a scene that resembles the scene in **SH** (`shl_room.obj`) into your ray tracer. Render a reference image using path tracing. Save the image and use the same view when rendering images in the following. (In the framework, you can save and load a view by pressing 'S' and 'L' respectively.)
- Implement a sampling scheme which computes the expansion coefficients for a two-bands spherical harmonics representation of the radiance transfer in the scene. Because the lights have been turned off and only the unit background illumination is left, you can use your shader for path tracing of Lambertian surfaces to compute the light incident from an arbitrary direction over a surface point. (In the framework, implement the `shade` function in `RadianceTransfer.cpp`.)
- Make sure that your program stores the expansion coefficients in a file for later use. You need to store one set of coefficients for every vertex in the scene. (This is already part of the framework. The data is stored in a binary file called `scene.prt`.)
- To check that you got the correct coefficients, reconstruct the lighting using the spherical harmonics basis functions with your newly found expansion coefficients. (In the framework, implement this as the final step of the `shade` function in `RadianceTransfer.cpp`.)
- Ray trace an image where lighting is reconstructed using spherical harmonics. Your implementation works when the image compares to the path traced reference. Save the resulting image.
- Expansion coefficients are stored per vertex during preview computation, so the vertex shaded result (the preview) is particularly interesting. It reveals the quality of the precomputed coefficients. Compute expansion coefficients using 10, 50, and 100 PRT samples across the hemisphere. (You can choose the number of samples in line 109 of `pathtrace.cpp`.) Store the coefficients in different files. Save the resulting preview images.

Week 7 Deliverables

Five images showing the scene (`shl_room.obj`) from the same view: A path traced reference; a ray traced image where the spherical harmonics expansion coefficients were used to reconstruct the lighting in each pixel; and three preview images of improving quality where the expansion coefficients were used for

each vertex. Compare the images computed using spherical harmonics lighting to the path traced reference. Describe artifacts (if any) caused by the limited band width.

Reading Material

The curriculum for Week 7 is

P Section 18.2.4. *Precomputation for Interactive Rendering*.
SH Pages 1–36. *Spherical Harmonic Lighting: The Gritty Details*. (Repetition: Pages 1–7.)

Additional resources:

- Peter Pike Sloan is the father of precomputed radiance transfer (PRT). Check out his publications: http://www.ppsloan.org/publications/