Worksheet 9

So far you have been working with perfectly diffuse (Lambertian) and perfectly specular materials. Naturally, there are several models to describe *glossy* materials, that is, materials which are in-between perfectly diffuse and perfectly specular. These models are typically based on a microfacet distribution (see **P**: Sec. 8.4) or based on measurements. The following exercises are about implementing shaders for glossy materials.

Learning Objectives

- Render glossy metal and glass surfaces
- Use a microfacet BSDF model for simulating light scattering at an interface (material surface).
- Use importance sampling for improved convergence when rendering with glossy surfaces.
- Analyse the physical plausibility of a BSDF.

Ray Tracing

The Torrance-Sparrow microfacet model for computing the scattering of light at an interface has gained significant attention in recent years. We will therefore implement this model in the following exercises and use it for rendering glossy glass and metal surfaces.

- Return to the scene with a bunny in an outdoor environment (see Worksheet 2).
- Change the material used for the bunny, so that it uses a glossy material with a well-defined index of refraction and shininess parameter (In the framework, the shader in `MCGlossy.cpp` is used when the material is set to use `illum 2`. The index of refraction is set using the `Ni` option in the MTL material assigned to the bunny or using the additional data available in `media.mpml` as when rendering metals. The shininess is set using the `Ns` option in the MTL material.)
- Pick a normal distribution for your shader (Blinn, Beckmann, GGX) and implement a function that samples a normal according to the chosen distribution. A description of different normal distributions is available in the paper by Walter et al. [2007, see reference below]. (In the framework, implement the function for sampling a microfacet normal in `sampler.h`.)
- Implement a shader for glossy materials based on the importance sampling of the Torrance-Sparrow model described by Walter et al. [2007]. (Do this by implementing the `shade` function in `MCGlossy-.cpp`. Some helper functions for computing the geometric attenuation factor G are provided in the file `microfacet.h` available on DTU Inside File Sharing.) Unless you chose the Blinn distribution, which uses shininess as input parameter, use the reciprocal of the shininess as the roughness or the distribution width required as parameter for other models.
- Explore the parameter space (modify the shininess `Ns` in the MTL file) using an index of refraction (`Ni`) of 1.5 for something like glass and using an index of refraction (`Ni`) of 0.2 for something like silver. Store images illustrating the different effects that your BSDF model can capture. Discuss the physical plausibility of the model.
- (**Optional.**) Implement a shader that evaluates the microfacet BSDF model for direct sampling of light sources and include this illumination in your shader based on importance sampling. (In the framework, implement the `shade` function in `Glossy.cpp`. As indicated by the code in `MCGlossy.cpp`, the result from this shader can be added to the result obtained by the shader with importance sampling.)

Worksheet 9 Deliverables

Images of the bunny in an environment with different types of materials spanning from glass to diffuse-like to silvery. A discussion of the physical plausibility of the microfacet model as it is used here. Optionally, also images including illumination due to a directional sunlight.

Reading Material

The curriculum for Worksheet 9 is

P Sections 8.4–8.5. *Microfacet Models*.
P Sections 13.10, 14–14.1.3. *Importance Sampling*.

Alternative literature available online or uploaded to CampusNet:

- Walter, B., Marschner, S. R., Li, H., and Torrance, K. E. Microfacet models for refraction through rough surfaces. In *Proceedings of Eurographics Symposium on Rendering (EGSR 2007)*, pp. 195–206, 2007.

Additional resources:

- Torrance, K. E., and Sparrow, E. M. Theory for off-specular reflection from roughened surfaces. Journal of the Optical Society of America 57(9):1105–1112, September 1967.
- Meneveaux, D., Bringier, B., Tauzia, E., Ribardière, M., and Simonot, L. Rendering Rough Opaque Materials with Interfaced Lambertian Microfacets. IEEE Transactions on Visualization and Computer Graphics 24(3):1368–1380, March 2018.