Worksheet 9

Many objects take a lot of their appearances from their surroundings. In this worksheet, we will enable use of 360 degrees photographs for environment lighting.

Learning Objectives

- Load and use a high dynamic range image as a realistic lighting environment.
- Use a panoramic texture to insert a background environment map.
- Shade digital objects using a photographed environment.

Path Tracing

To improve the realism of our rendered images, we use an omnidirectional photograph to position a digital object in a natural lighting environment.

1. Load the Stanford bunny or the Newell teapot. Load the Pixar campus environment map (`luxo_pxr_campus`) as a texture. When no surface was hit, do the panoramic mapping from ray direction to uv-coordinates and use a look-up into the texture to get light from the environment instead of the previous uniform background color. Make a selection box, where the user can select between base color, mirror, and diffuse shading for the loaded object.
2. Load the same environment map but in high dynamic range (HDR) format. You can load the .hdr file using hdrpng.js or load the .hdr.png file available on DTU Learn. When sampling the texture, remember to convert to HDR using the alpha component as the base 2 exponent that it really is. Use gamma correction (e.g. with $\gamma = 2.2$) to get a crude tone mapping of the HDR environment. Note that diffuse objects get a much more plausible shading when we use an HDR environment map, but the rendering requires many samples to converge, and it becomes obvious that the object does not cast shadows on its surroundings. Insert a holdout plane in the scene and let the object cast shadows onto it. The holdout shader should compute ambient occlusion by tracing rays in directions sampled on the hemisphere over each surface point. The idea is essentially that the environment (the background) is an infinitely distant ambient area light.
3. Select a directional light that resembles the sunlight seen in the HDR environment map depicting the Pixar campus. Render your object with a low dynamic range environment map but a directional light to represent the sun. Ensure that the digital object casts shadows onto the holdout plane both due to partial masking of the environment map and due to the directional light being blocked or not.
4. Go to Poly Haven (https://polyhaven.com/) and choose a light probe (HDRI) that you would like to use as your environment map. Use hdrpng.js to load it or to convert it to the .hdr.png format. Change the render resolution to render a wide image and change the view to position the digital object in a good spot in the environment.

Reading Material

The curriculum for Worksheet 9 is

B Section 11.4.5. *Environment Maps*.

B Section 19.2.3, 20.2–20.3. *Dynamic Range*.

Additional resources:

- Landis, H. Production-ready global illumination. In RenderMan in Production, ACM SIGGRAPH 2002 Course Notes, Chapter 5, pp. 87-101, 2002.

- Pharr, M., and Green, S. Ambient Occlusion. In *GPU Gems: Programming Techniques, Tips, and Tricks for Real-Time Graphics*, Chapter 17, Addison-Wesley, 2004. https://developer.nvidia.com/gpugems/gpugems/part-iii-materials/chapter-17-ambient-occlusion
- Pharr, M., Jakob, W., and Humphreys, G. Infinite area lights. In *Physically Based Rendering: From Theory To Implementation*, Sec. 12.5. Fourth edition. MIT Press, 2023. https://pbr-book.org/4ed/Light_Sources/Infinite_Area_Lights