Week 2

Rendered outdoor environments rarely look realistic until some sort of sky model is included. The easiest way to include a sky in a rendering is to take an image of the sky and insert it as a background texture. This approach is, however, fairly limited. And, in the long run, it would take a large database of high dynamic range sky images to make it useful as a general approach. Another solution is to physically simulate the appearance of the sky. This is, however, not a trivial task. The third option, the one that we are going to pick for this set of exercises, is to use an analytical model. There are CIE[1] standard models for the luminance of the sky, but they are not wavelength dependent, so they are not directly useful as appearance models. Some analytical models which include colour information have been suggested in the graphics community. We will use the Preetham sky model [Preetham et al. 1999, see reference below] and also try to set up a light source which resembles direct sunlight.

Learning Objectives

- Render the sky using an analytical model.
- Set up a light source corresponding to direct sunlight.
- Ensure that sky and direct sunlight correspond to each other.
- Make the rendered sky and sunlight change with location, time, and scene orientation.

Sun and Sky

One difficulty in creating a sky model is the transformation from light incident on the atmosphere at various wavelengths to the corresponding tristimulus (RGB) colour that we observe on Earth. In the following exercises, you will work with this problem when setting up a light source that should resemble direct sunlight. Another challenge is to have the direct sunlight match the output from the analytical model which provides the colours of the sky. In addition, these two models should depend on the location on Earth (latitude and longitude), the day of the year and the time of the day, and the orientation of the scene. The appendix in the paper by Preetham et al. [1999] is very useful in making sunlight and skylight work together.

- Load the Stanford bunny (`bunny.obj`) into your ray tracer. Render the bunny on a green plane with a clear sky in the background. (If you used the framework to complete the exercises for Week 1, all it takes to do this is to find the Boolean variable called `use_sun_and_sky` in `RenderEngine` and set it to `true`. Then load the bunny as in Week 1 and render it using the Lambertian shader.)
- Render a sequence of images from sunrise to sunset where the sun rises in front of the bunny and sets behind the bunny. Use the Julian date (the number of the day in the year), the solar time (the time of the day with 12 being solar noon), the latitude, and the angle with South to find the position of the sun in the sky (θ_s, ϕ_s). (In the framework, modify the initialization of the Preetham sky model (`sun_sky`). Do this in the function `init_tracer` of the file `RenderEngine.cpp`. Look for the first `if`-block that checks whether `use_sun_and_sky` was set true.)
- Model direct sunlight. Find or construct a model which determines the RGB emission of a directional sun which should resemble the direct sunlight received at Earth when the sky is clear. The "sun radiance" provided in Table 2 of the paper by Preetham et al. [1999] is in units $\mathrm{W/m^2/sr/nm}$. This is what you would observe if you look directly at the sun. A useful alternative for calculating direct sunlight is the work of Bird and Riordan [1984, see reference below]. Their model can be used to find the spectral solar irradiance (units $\mathrm{W/m^2/nm}$). Use your model to set the RGB power of a directional source and render a sample image.

[1] Commission Internationale de l'Eclairage, http://www.cie.co.at/

- Use the general up-direction in the scene to find a direction for the direct sunlight which matches the position of the sun in the sky. (In the framework, modify the second `if`-block that checks whether `use_sun_and_sky` was set true in the function `init_tracer` of the file `RenderEngine.cpp`.)
- Repeat the sequence of renderings where the sun rises in front of the bunny and sets behind it. Do a rendering for every two hours from sunrise to sunset. The illumination of the bunny should now follow the position of the sun in the sky.

Week 2 Deliverables

Renderings of the bunny on a green plane with an early autumn sky over Denmark (for example) and corresponding direct sunlight. The scene should be rendered every two hours from sunrise to sunset. The sun should rise in front of the bunny and set behind the bunny. Describe the input parameters used for the sky model and the model used for direct sunlight. Include relevant code and render log. Please copy everything into a document and upload at CampusNet under Assignments.

Reading Material

The curriculum for Week 2 is

- Preetham, A. J., Shirley, P., and Smits, B. A practical analytical model for daylight. In *Proceedings of ACM SIGGRAPH 1999*, pp. 91–100, 1999.
- Reinhard, E., Ward, G., Pattanaik, S., Debevec, P., Heidrich, W., and Myszkowski, K. *High Dynamic Range Imaging: Acquisition, Display and Image-Based Lighting*, second edition, Morgan Kaufmann/Elsevier, 2010. Excerpt: Sections 2–2.5 and 2.10–2.12.

Additional resources:

P Sections 5–5.3. *Color*.

- Bird, R., and Riordan, C. Simple solar spectral model for direct and diffuse irradiance on horizontal and tilted planes at the Earth's surface for cloudless atmospheres. Technical Report, SERI/TR-215-2436, Solar Energy Research Institute, U.S. Department of Energy, December 1984. http://rredc.nrel.gov/solar/models/spectral/