CS 4620/5620 Ray 2

due: Friday 5 December 2014

1 Warm Up Exercises

Suppose we are rendering an image for the IKEA catalog, showing a cylindrical coffee mug available in a few different materials. All of them have smooth surfaces that reflect light in a mirror-like way. The mug will be illuminated by an environment map of a room interior with a window, a directional light, and a ambient component.

The mug is available in three materials: gray glazed ceramic (diffuse reflectance 0.2, index of refraction 1.5), , white glazed ceramic (diffuse reflectance 0.85, index of refraction 1.5), and polished stainless steel (reflectance 0.65 at normal incidence, no diffuse or ambient term). Ambient and diffuse coefficients are set identically.

The environment map is represented in spherical coordinates using ϕ and θ, as is shown in figure 1 (e.g. point (1, 0, 0) is ($\phi = 90°$, $\theta = 90°$); point (-1, 0, 0) is ($\phi = 90°$, $\theta = -90°$)).

The camera is positioned at (0, 0, 20), viewing in direction (0, 0, -1) with up direction (0, 1, 0). The

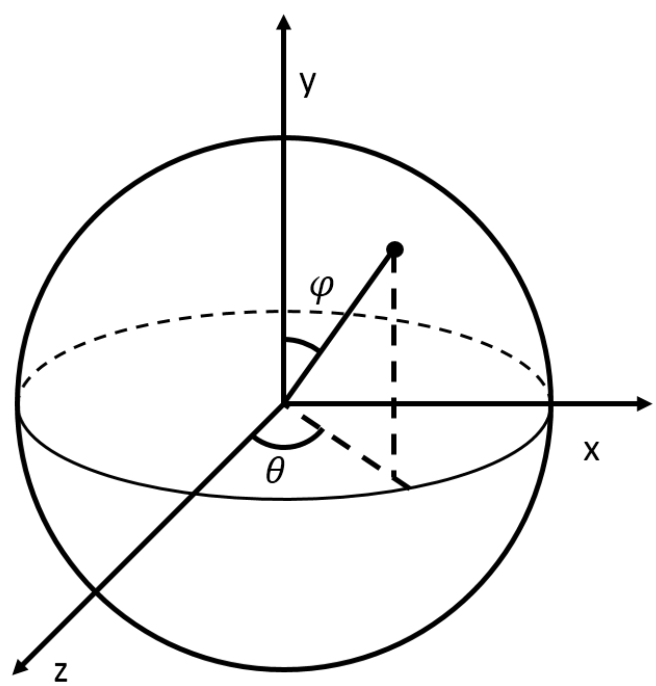

Figure 1: spherical coordinates

mug is centered at the coordinates origin, with height 10 and radius 5. The mug's axis is aligned with the y axis. And the whole mug can be captured in the image.

1. For a nice product photo we'd like to see the window reflected in the side of the mug. Where can the window be placed in the environment map where it will be reflected in the side of the cylindrical mug? What if the camera is positioned at (0, 0, 100)? Your answer should be a sketch in (ϕ, θ) space showing the region that is reflected in the mug. Compute the (ϕ, θ) coordinates of the corners of the region and of the highest and lowest phi and theta. As a simpler example of such problem, consider a camera positioned at (0, 0, 1), and looking at a mirror-like square in the x-y plane. The vertices of the square are at (1, 1, 0), (-1, 1, 0), (-1, -1, 0) and (1, -1, 0). See figure 2, the red arrows are the critical rays you need to consider in order to find the critical points on the boarder of the reflected region. The reflected region for this simple case is shown in figure 3.

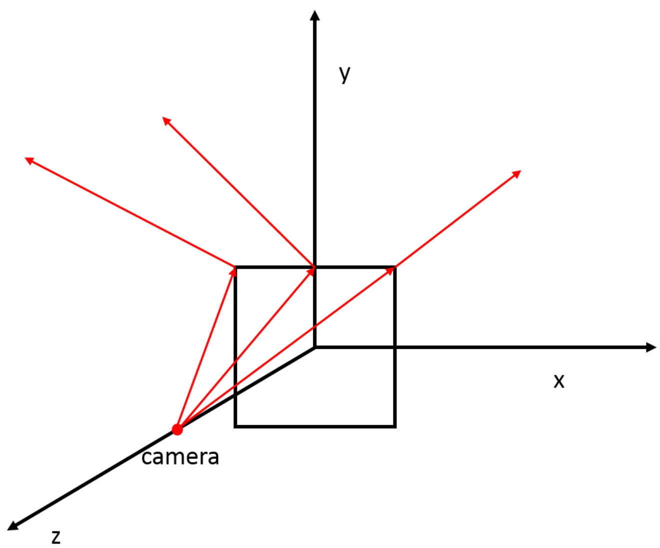

Figure 2: simple reflection example

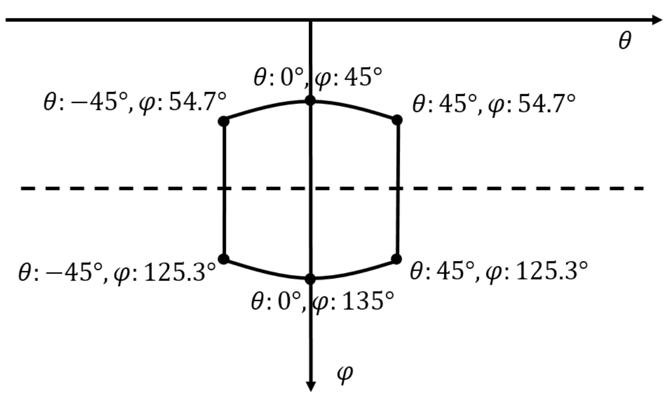

Figure 3: range of θ and ϕ

2. Ignoring specular reflection (and the stainless steel mug) for the moment, suppose the ambient light intensity is 1.0. Suppose the directional light is from (θ=60°, ϕ=90°). We'd like a 4:1 lighting ratio, meaning the brightest color produced by diffuse+ambient reflection is 4 times the brightness of ambient shading alone. How bright should the directional source be?

3. Suppose we position the window at the same height (y coordinate) as the camera. For estimation purposes assume the environment map has the constant value 1.0 everywhere outside the window, and a brighter constant value inside the window. Intensity of the directional and ambient light is the same with that in part 2. How bright does the window have to be to get 50% contrast at the edges of the window (that is, the pixels that reflect the window are 50% brighter than the pixels that don't), if the window is positioned behind the camera (on +z axis). What if the window is at a position such that the angle of incidence (θ_i in figure 4) is 30°? What if θ_i is 60°? Assume the window is small and the directional light is positioned at the center of the window. The answer in this case is different for each of the three materials. And note that directional light only interacts with the smooth term (diffuse part) of reflectance and smooth light (environment map) only interacts with mirror reflectance.

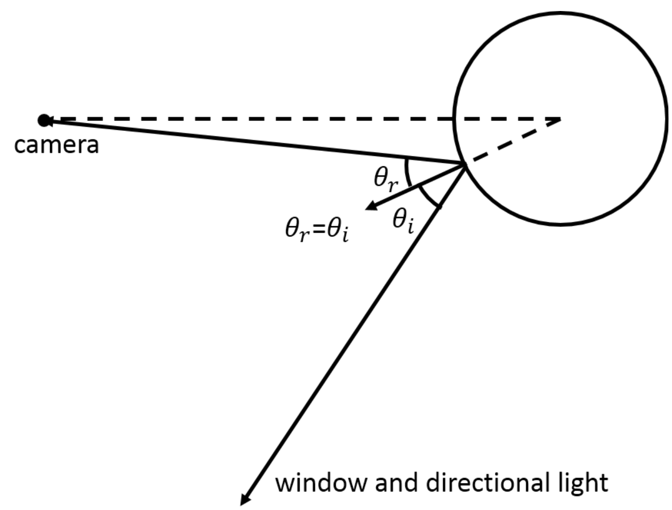

Figure 4: reflection