Angel and Shreiner: Interactive Computer Graphics, Eighth Edition

Chapter 7 Odd Solutions

7.1 The major problem is that the environment map is computed without the object in the scene. Thus, all global lighting calculations of which it should be a part are incorrect. These errors can be most noticeable if there are other reflective objects will now not show the reflection of the removed object. Other errors can be caused by the removed object no longer blocking light and by its shadows being missing. Other visual errors can be due to distortions in the mapping of the environment to a simple shape, such as a cube, and to errors in a two step mapping. In addition, a new environment map should be computed for each viewpoint.

7.3 Consider a single sine wave that is sampled at a rate just over the Nyquist rate with the first sample where the sine is zero. The next sample will be slightly greater than zero, the following slightly greater (in magnitude) than the second, and so until we get samples about equal to the maximum of the sine. Subsequent samples will get smaller and smaller until we get to the minimum of the sine, and then the values will slowly increase. This pattern will repeat, each cycle taking multiple periods of the original sine. Visually, this pattern looks like a modulated sine wave. This visual appearance is due to us seeing the energy of the original samples and those of the first replica which appears just over the Nyquist rate. Our eye is a low pass but imperfect filter that lets both pass through. If we add the two sinusoids using the trigonometric identity we see the sum and difference frequencies which explains this modulation. The higher frequency (the sum) gives the inner frequency while the difference generates the slowly varying envelope. These patterns describe the Moire patterns we see when we move past two fences, one behind the other, when driving in a car.

7.5 Once aliasing occurs, it is very difficult to remove because the data that has been aliased at another frequency is mixed with any unaliased data at that frequency. Thus, if we remove energy at that frequency, we remove both aliased and unaliased information. On the other hand, if we remove data at frequencies above the Nyquist frequency before sampling occurs, although we loose information, we are left with only unaliased data after sampling occurs.

7.7 Whenever we use regular patterns, we risk creating beat patterns or

Moire effects. Random jitter avoids the problem. Note that in a mathematical sense we are no better off using jitter. However, our visual systems are very sensitive to regular patterns so that jittering makes the images appear to be better.

7.9 There are a couple of ways to do this problem.Pre 3.1 OpenGL used the OpenGL function `glTexGen` to generate texture coordinates automatically. This function allowed the generation in either object space or eye space by computing texture coordinates based on distance from a plane specified by the application. This method can be done in a vertex shader.Another option is to use a matrix to scale the texture coordinates appropriately for each parallelogram.

7.11 Consider the side of the cube determined by the plane $y = 1$. The projector through a point $(x, 1, z)$ on this plane is on a line from the origin that intersects the unit sphere $x_p^2 + y_p^2 + z_p^2 = 1$. Points on this line are of the form $(\alpha x, \alpha y, \alpha z)$. Using the fact that the line passes though the plane $y = 1$ yields $\alpha = \frac{1}{y_p}$ and thus $x_p = xy_p$ and $z_p = zy_p$. We can now use the equation of the sphere to solve for $y_p = \frac{1}{\sqrt{1+x^2+z^2}}$ and then x_p and z_p.

7.13 The basic idea is that the dot product of the normal and other vectors such as the light vector must remain unchanged by an affine transformation. In matrix terms, consider a vector a that is transformed to Ta. if we transform another vector b to Sb. We want

$$a \cdot = Ta \cdot Sb$$

or

$$Ta^T Sb = a^T A^T Sb = a^T b = a^T Ib.$$

Hence

$$T^T S = I.$$

If a and b are the representations of vectors they need only be three dimensional and T can be the upper-left 3×3 submatrix of the model-view matrix.