CS 348B - Computer Graphics: Image Synthesis Techniques
Stanford University

Marc Levoy
Spring, 1996
Handout #25

Written assignment #2 - texture and local illumination

Due Tuesday, May 21

(1) Paul Heckbert's survey paper on texture mapping (course reader, paper #6) discusses prefiltering using 3D, 4D, and 5D image pyramids. None perfectly match the quadrilaterals that result from perspective projections of square texture areas, as shown in his figure 4. How many dimensions are needed for a perfect match? Ignore errors introduced by discretization of the pyramid. Defend your answer.

(2) Problem 16.1 in Foley, van Dam, Feiner, Hughes. An equivalent restatement follows:

- (a) Describe the difference in appearance you would expect between a Phong illumination model that uses $(\mathbf{N} \cdot \mathbf{H})^n$ and one that uses $(\mathbf{R} \cdot \mathbf{V})^n$.
- (b) Show that $arccos(\mathbf{R} \cdot \mathbf{V}) = 2\, arccos(\mathbf{N} \cdot \mathbf{H})$ when all vectors are coplanar.
- (c) Show that this relationship is *not* true in general.

(3) Consider arrangements of identical triangular glass prisms having internal angles of 45°, 45°, and 90°.

- (a) Sketch an arrangement of two of these prisms such that a beam of white light enters the arrangement, passes through both prisms, and leaves undispersed, i.e. not as a rainbow.
- (b) Repeat the exercise for an arrangement of three prisms.
- (c) Repeat the exercise for an arrangement of four prisms.
  Do not use two instances of your solution to (a).

Avoid arrangments that depend on internal reflection.

(4) Consider a hemispherical sky above a surface patch.

- (a) Suppose the surface patch is tilted and makes an angle of $\alpha < \pi/2$ with respect to the zenith. Because of the tilt, only part of the sky is visible to the surface. Assume the radiance of the sky is uniform and equal to L. Show that the irradiance on the tilted surface due to a uniform sky is $E = L\pi \cos^2(\alpha/2)$.
- (b) In class, we approximated the radiance of a cloudy sky as uniform. That may be true in San Francisco where cloudy means foggy, but the radiance of an overcast sky in dry weather is non-uniform and may be approximated by a Cardioid distribution, that is, $L(\theta) = L \cos\theta$. Here θ is zero in the direction of the zenith. Thus, this radiance distribution is maximal straight up and zero at the horizon. Compute the irradiance from the cloudy sky (of an untilted patch).

(5) **For extra credit:** Suppose the moon is rising over a pond where all the waves are moving from left to right (i.e. think of the surface as being made of cylinders whose axis is in the direction from you to the moon). What does the reflection of the moon on the surface look like? How is it different if the waves are moving from you toward the moon?