CS 465 Prelim 1

Tuesday 7 October 2003

Problem 1: Images (24 points)

Suppose we have two monitors, A and B. Monitor A has $\gamma = 1.5$ while Monitor B has $\gamma = 3$. They both accept input quantized in the same way (if it helps, assume 256 equal steps from 0 to 1). Both monitors have the same maximum intensity, and they produce exactly zero light for pixels that are turned completely off.

1. If we display the same image on both monitors, which will produce a darker-looking output?
2. Which monitor gives better intensity resolution in the darkest parts of the image?
3. Suppose an image has been gamma corrected so that it will appear correct when displayed on monitor A.
   (a) Will it appear too dark or too bright when displayed on monitor B?
   (b) If a particular part of the image reproduces as 50% intensity on monitor A, how bright will it be on monitor B?

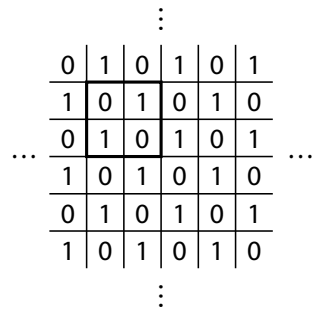
Problem 2: Compositing (24 points)

Consider the images F and B and the composite image $C = F \,\mathbf{over}\, B$. Each pixel of each image stores four numbers in the range $[0, 1]$; let the contents of image I be denoted by $(r_I, g_I, b_I, \alpha_I)$ (where I stands for one of B, F, or C). Assume we are using premultiplied alpha.

1. What values will be placed in r_C and α_C by the compositing operation under each of the following conditions?
   (a) $\alpha_F = 0$
   (b) $\alpha_F = 1$
   (c) $\alpha_B = 0$
   (d) $\alpha_B = 1$
   (e) $\alpha_F = \alpha_B = 0.5$
   (f) $r_B = 0$ and $\alpha_B = 1$

Problem 3: Resampling and Filtering (28 points)

Consider an image that consists entirely of zeros and ones in a checkerboard pattern:



Note that this pattern can be thought of as a bunch of tiled copies of the repeating cell that is outlined in black. For each of your answers below, give the array of numbers that makes up the unit cell—for instance, the answer to "what is the result of convolving with the identity filter" would be

$$\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$$

1. What is the result of blurring this image using discrete convolution with each of the following filters?

   (a) A box filter of radius 1 (filter size 3 by 3).

   (b) A gaussian-like filter that is separable and defined by the 1D filter

   $$\begin{bmatrix} \frac{1}{16} & \frac{1}{4} & \frac{3}{8} & \frac{1}{4} & \frac{1}{16} \end{bmatrix}$$

   (it may be easier to think of this filter as $\frac{1}{16} \cdot \begin{bmatrix} 1 & 4 & 6 & 4 & 1 \end{bmatrix}$).

2. What is the result of resampling this image to triple its resolution using each of the following resampling filters?

   (a) A box filter of radius $\frac{1}{2}$ (this is nearest-neighbor resampling).

   (b) A separable tent filter of radius 1. That is, the filter is separable and is defined by the 1D filter

   $$h(r) = \max(0, 1 - |r|).$$

   Note that the unit cell in this case is 6 by 6. Align your answer so that the upper left sample lines up with a sample with value 0 in the input image.

Problem 4: Parametric surfaces (24 points)

1. Give a parametric representation $f(u, v)$ of a sphere centered at $(1, 2, 3)$ that has the following properties:

   - $f(0, 0) = (2, 2, 3)$
   - $f(1, 1) = (0, 2, 3)$
   - $f(0.5, 0) = (1, 2, 4)$

   and is oriented so that the surface faces outward. As usual, u and v both range from 0 to 1.