Solutions to Optional Homework (Lecture 7)

Problem 6.21

The RGB transformations for a complement [see Fig. 6.31(b)] are:

$$s_i = 1 - r_i$$

where i =1, 2,3 (for the R, G, and B components). But from the definition of the CMY space in Eq. (7-5), we know that the CMY components corresponding to r_i and s_i, which we will denote using primes, are

$$r_i' = 1 - r_i$$
$$s_i' = 1 - s_i$$

Therefore,

$$r_i = 1 - r_i'$$

and

$$s_i' = 1 - s_i = 1 - (1 - r_i) = 1 - (1 - (1 - r_i'))$$
$$= 1 - r_i'$$

Problem 6.23

Based on the discussion on tone and color corrections is Section 6.5, and with reference to the color wheel in Fig. 6.30, we can decrease the proportion of yellow by (1) decreasing yellow, (2) increasing blue, (3) increasing cyan and magenta, or (4) decreasing red and green.

Problem 6.24

The simplest approach conceptually is to transform every input image to the HSI color space, perform histogram specification per the discussion in Section 3.3 on the intensity (I) component only (leaving H and S alone), and convert the resulting intensity component with the original hue and saturation components back to the starting color space.

Problem 6.25

The given color image is shown in Fig. P6.25(a). Assume that the component image values of the HSI image are in the range [0,1]. Call the component images H (hue), S (saturation), and I (intensity).

(a) It is given that the image is fully saturated, so image H will be constant with value 1. Similarly, all the squares are at their maximum value so, from Eq. (7-19), the intensity image also will be constant, with value 1/3 [the maximum value of any (normalized) pixel in the RGB image is 1, and it is given that none of the squares overlap]. The hue component image, H, is shown in Fig. P6.25(b). Recall from Fig. 6.12 that the value of hue is an angle. Because the range of values of H is normalized to [0, 1], we see from that figure, for example, that as we go around the circle in the counterclockwise direction a hue value of 0 corresponds to red, a value of 1/3 to green, and a value of 2/3 to blue. Thus, the important point to be made in Fig. P6.25(b) is that the gray value in the image corresponding to the red square should be black, the value corresponding to the green square should be lower-mid gray, and the value of the square corresponding to blue should be a lighter shade of gray than the square corresponding to green. As you can see, this indeed is the case for the squares in Fig. P6.25(b). For the shades of red, green, and blue in Fig. P6.25(a), the exact values are H = 0, H = 0.33, and H =0.67, respectively.

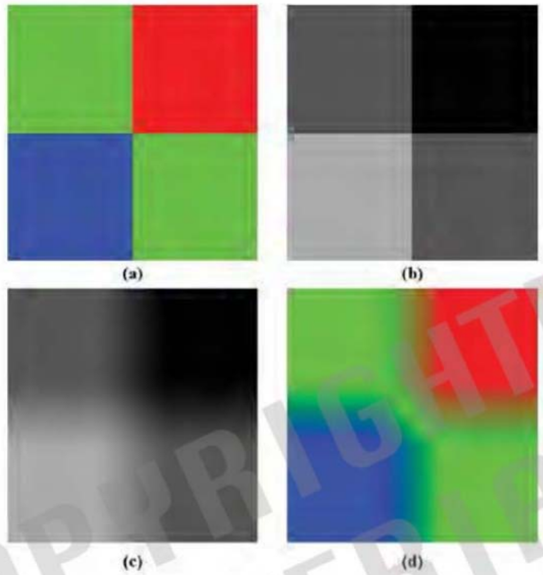

Figure P6.25

(b) The saturation image is constant, so smoothing it will produce the same constant value.

(c) Figure P6.25(c) shows the result of blurring the hue image. When the averaging mask is fully contained in a square, there is no blurring because the value of each square is constant. When the mask contains portions of two or more squares the value produced at the center of the mask will be between the values of the two squares, and will depend the relative proportions of the squares occupied by the mask. To see exactly what the values are, consider a point in the center of red mask in Fig. P6.25(c) and a point in the center of the green mask on the top left. We know from (a) above that the value of the red point is 0 and the value of the green point is 0.33. Thus, the values in the blurred band between red and green vary from 0 to 0.33 because averaging is a linear operation. Figure P6.25(d) shows the result of generating an RGB image with the blurred hue component images and the original saturation and intensity images. The values along the line just discussed are transitions from green to red. From Fig. 6.12 we see that those transitions encompass the spectrum from green to red that includes colors such as yellow [all those colors are present in Fig. P6.25(d), although they are somewhat difficult to see]. The reason for the diagonal green line in this figure is that the average values along that region are nearly midway between red and blue, which we know from Fig. 6.12 is green.