Color Image Processing

6.7 How many different shades of gray are there in a color RGB system in which each RGB image is an 8 bit image?

A RGB image consists of three component images, one for each RGB. Each 8 bit image is 2^8. Therefore the three component images will be (2^8)^3 = 1677216. Each R,G,B channel separated from the RGB image is a gray image. So there are 1677216 different shades of gray in a color RGB system.

6.8 Consider the RGB color cube shown in Fig 6.8, and answer each of the following:

(a) Describe how the gray levels vary in the R,G and B primary images that make up the front face of the color cube.

The front face of the color cube is the plane (127,G,B) where G and B can vary between [0,255]. These two primary colors will cover the entire range of gray levels between black point [0 0 0] to white point [255 255 255]. The R channel is fixed at 127. It would correspond to grayscale point [127 0 0].

In other words, we have 2^8 shades of gray from the green channel and 2^8 shades of gray from the blue channel and 1 shade of gray from the red channel. The front face of the color cube will vary to a total 2^16+1=65537 gray levels.

(b) Suppose that we replace every color in the RGB cube by its CMY color. This new cube is displayed on an RGB monitor. Label with a color name the eight vertices of the new cube that you would see on the screen.

The eight vertices of the new cube would be
Old vertex → New vertex
Red → Cyan
Green → Magenta
Blue → Yellow
Cyan → Orange
Magenta → Green
Yellow → Purple

(c) What can you say about the colors on the edges of the RGB color cube regarding saturation?

The colors on the edges of RGB color cube are pure colors. Saturation gives a measure of the degree to which a pure color is diluted by white light. The pure colors are not diluted by white light hence they are fully saturated.

6.9

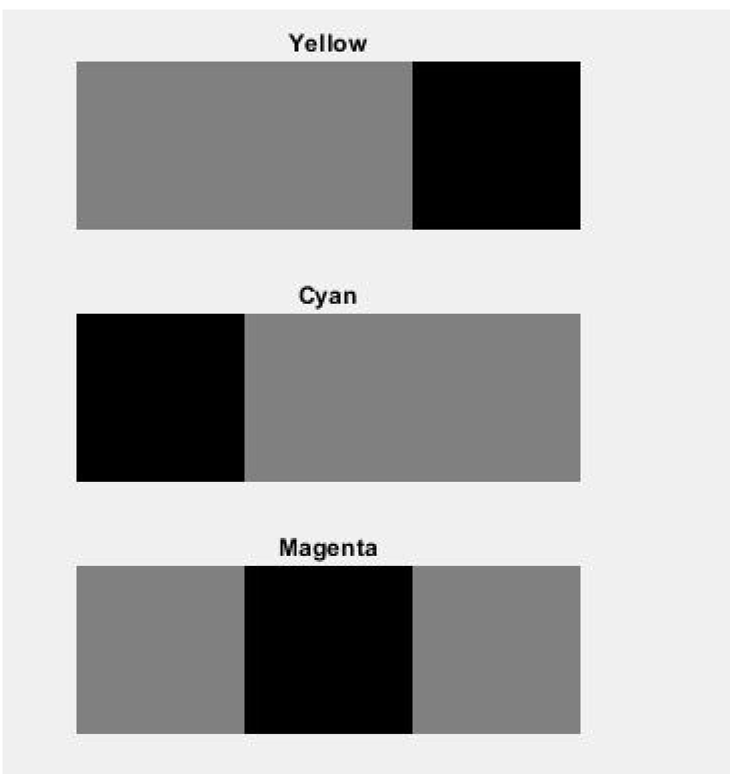
(a) Sketch the CMY components of the image in Problem 6.6 as they would appear on a monochrome monitor.

I used below Matlab script to code the color components in Problem 6.6 as they would appear on a monochrome monitor. Assumption is that the gray border has 50% black leading to each color being at its 50% intensity.

```
k=[0 0 0];
r = [0.5 0 0];
y = [0.5 0.5 0];
g = [0 0.5 0];
c = [0 0.5 0.5];
b = [0 0 0.5];
m = [0.5 0 0.5];
w = [0.5 0.5 0.5];

figure(1),
subplot(1,8,3),imshow(y),title('Yellow');
subplot(1,8,5),imshow(c),title('Cyan');
subplot(1,8,7),imshow(m),title('Magenta');
```

The results are shown below



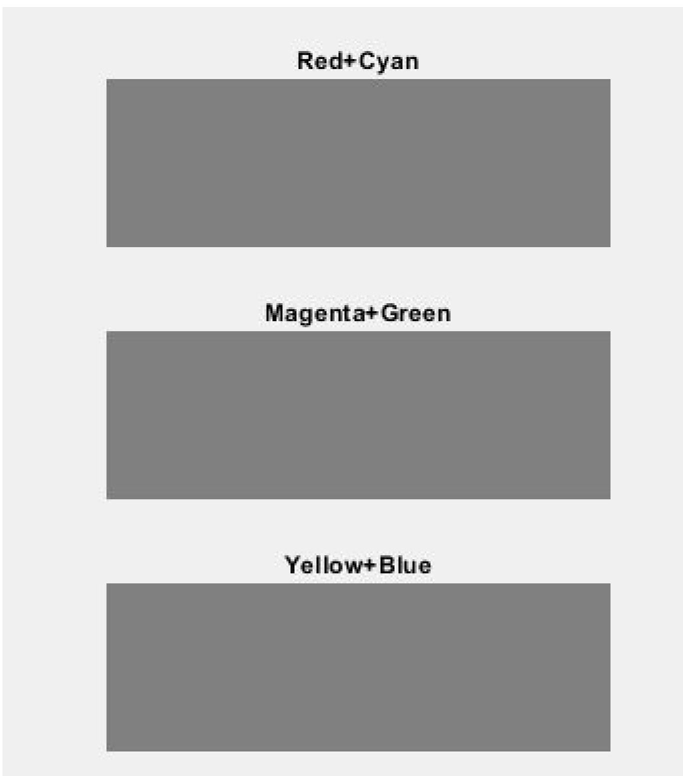
(b) If the CMY components sketched in (a) are fed into the red,green and blue inputs of a color monitor, respectively, describe the resulting image.

Resulting image is generated by below code

```
R1 = c+r;
R2 = m+g;
R3 = y+b;

figure(2),
subplot(3,1,1),imshow(R1),title('Red+Cyan');
subplot(3,1,2),imshow(R2),title('Magenta+Green');
subplot(3,1,3),imshow(R3),title('Yellow+Blue');
```

And looks like below



6.10 Derive the CMY intensity mapping function of Eq (6.5-6) from its counterpart in Eq (6.5-5)

Figure 6.4(b) shows a venn diagram of CMY colors and their intersection is black at center. This means that equal amounts of the cyan, magenta and yellow pigments should produce black. This black is muddy looking (while printed) hence true black is added in just the proportions needed to produce true black. This is how Eq (6.5-6) is derived from its counterpart in Eq (6.5-5).

6.11 Consider the entire 216 safe-color array shown in Fig. 6.10(a). Label each cell by its (row, column) designation, so that the top left cell is (1,1) and the rightmost bottom cell is (12,18). At which cells you find

(a) The purest green?
Purest green is found at (7,18).

(b) The purest blue?
Purest blue is found at (12,13).

6.12 Sketch the HSI components of the image in Problem 6.6 as they would appear on a monochrome monitor.

We found the HSI components using the Matlab command ‘rgb2hsv’.

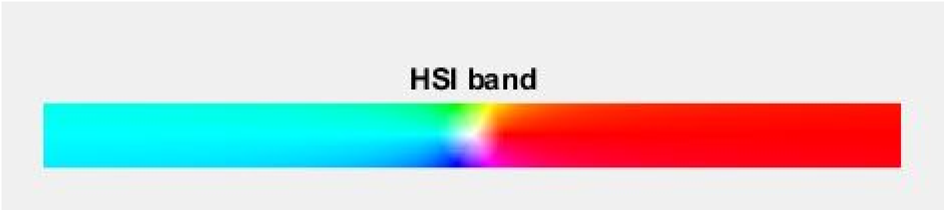
R = rgb2hsv(r);
K = rgb2hsv(k);
Y = rgb2hsv(y);
G = rgb2hsv(g);
B = rgb2hsv(b);
C = rgb2hsv(c);
M = rgb2hsv(m);
W = rgb2hsv(w);

Below are the HSI components of each color. First component of the row matrix describes the hue, the second component describes the saturation and the third one describes intensity.

R = [0,1,0.5]
K = [0,0,0]
Y = [0.167,1,0.5]
G = [0.33,1,0.5]
B = [0.67,1,0.5]
C = [0.5,1,0.5]
M = [0.83,1,0.5]
W = [0,0,0.5]

6.13 Propose a method for generating a color band similar to the one shown in the zoomed section entitled Visible Spectrum in Fig 6.2. Note that the band starts at dark purple on the left and proceeds towards pure red on the right. (Hint: Use the HSI color model)

See code file *‘hsvtest.m’* for the method. It generates below result



6.14 Propose a method for generating a color version of the image shown diagrammatically in Fig. 6.13(c). Give your answer in the form of a flow chart. Assume that the intensity value is fixed and given. (Hint: Use the HSI color model)

See file *'Q6_14.m'* for the code generating cube of Fig. 6.13(c). We assume the intensity value at 50% in the HSI model.

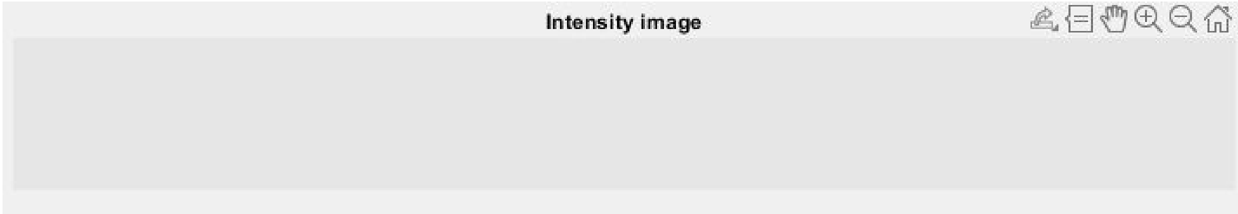
6.15 Consider the following image composed of solid color squares. For discussing your answer, choose a gray scale consisting of eight shades of gray, 0 through 7, where 0 is black and 7 is white. Suppose that the image is converted to HSI color space. In answering the following questions, use specific numbers for the gray shades if using numbers makes sense. Otherwise, the relationships 'same as,' 'lighter than,' or 'darker than' are sufficient. If you cannot assign a specific gray level or one of these relationships to the image you are discussing, give the reason.

See file *'Q6_15.m'* for the code to sketch hue, saturation and intensity.

(a) Sketch the hue image.

(b) Sketch the saturation image

(c) Sketch the intensity image.


Intensity image