

**Problem**

a.

What are the characteristics of the RGB color model?

**Solution**

The RGB color model has three channels, red, green, and blue. Each color normally is stored in a byte for 256 different values for each color component. The total storage required for each point is three bytes. These are referred to as 24 bit color images.

b.

Why is the RGB model commonly used?

**Solution**

Most often image data are collected from an RGB device. The RGB system is dependent upon the imaging system. It is a device dependent system. Each imaging system has its own RGB color space that depends upon the spectral sensitivities of its color sensors and its settings.

c.

What is the disadvantage of the RGB color model?

**Solution**

A specific color is not easily described in this system. The RGB uses three components and is not intuitive for image processing operations.

**Problem****a.**

Describe the hue, saturation, and value color models.

**Solution**

A color can be described by its value or luminance, hue, and saturation. The luminance gives the brightness of a color. The hue refers to its wavelength, and the saturation gives the percentage of white in the color. The hue and saturation components are referred to as the chromaticity of a color. Hue is the attribute of a color such as blue or red. The dominant wavelength of the power spectrum.

**b.**

What are the advantages of the HSV color model?

**Solution**

The hue, saturation and luminance may be more easily related to the human vision system. Hue is the attribute of a color such as blue or red. The dominant wavelength of the power spectrum. It is the dominant wavelength of the observed light. Hue is a key component for human recognition of objects since changing the hue changes the color of an object. Saturation or purity is the degree of colorfulness from neutral gray to pastel to saturated colors. The more a color is concentrated at one wavelength the more saturated the color.

**c.**

What are the range of values for H,S, V in the MATLAB system? Describe any peculiarities about the H values.

**Solution**

In MATLAB as hue varies from 0 to 1.0 the colors vary from red, through yellow, green cyan blue magenta back to red. Therefore the value 0 and 1 are close together perceptually.

As saturation varies from 0 to 1.0 the colors vary from unsaturated (gray) to fully saturated ( no white). As value or brightness varies from 0 to 1.0 the colors become brighter.

## Problem

a.

What are typical ranges of values for the CIE  $L^*, a^*, b^*$  Model ?

## Solution

Typical values for CIE  $L^*, a^*, b^*$  components are  $L^* \in [0,100]$ ,  $a^* \in [-100,100]$ , and  $b^* \in [-100,100]$

b.

Why is the CIE  $L^*, a^*, b^*$  Model commonly used?

## Solution

The Euclidean distance between two colors  $L_1^*, a_1^*, b_1^*$  and  $L_2^*, a_2^*, b_2^*$  is given by [Haeghen, Naeyaert, Lemahieu, and Philips, 2000]

$\Delta E_{ab}^* = \left[ (L_1^* - L_2^*)^2 + (a_1^* - a_2^*)^2 + (b_1^* - b_2^*)^2 \right]^{\frac{1}{2}}$ . This distance is proportional to color difference as perceived by humans. The just noticeable difference (JND) is from 1 to 3  $\Delta E_{ab}^*$  units.

## $L^*, a^*, b^*$ Model

The CIE  $L^*, a^*, b^*$  is given in the following equations.

$$L^* = \begin{cases} 903.3 * (Y/Y_0) & , \text{for } 0 \leq Y < 0.008856 \\ 116 * (Y/Y_0)^{\frac{1}{3}} - 16 & , \text{for } Y \geq 0.008856 \end{cases}$$

If  $(X/X_0)$ ,  $(Y/Y_0)$ , and  $(Z/Z_0)$  are all greater than .008856 then

$$a^* = 500 * [(X/X_0)^{1/3} - (Y/Y_0)^{1/3}]$$

and

$$b^* = 200 * [(X/X_0)^{1/3} - (Z/Z_0)^{1/3}].$$

In these equations  $X_0, Y_0$  are the coordinates of the reference white point. The D65 white point that should be used that is the white point of the sRGB space. These values may be obtained by using  $R_{cie} = G_{cie} = B_{cie} = 1$  and the equations for conversion from sRGB to XYZ. This says the values of  $R_{cie}$ ,  $G_{cie}$ , and  $B_{cie}$  are in the range 0 to 1. Note that this is the same range as the MATLAB R,G,B color coordinate system. The corresponding values of  $(X_0, Y_0, Z_0)$  are (95.017, 100.0, 108.813). The values normalized to a sum of one are (.3127, .3290, .3582).