Chapter-8

Colour Image Processing

1. Consider the following RGB triplets. Convert each triplet to CMY and YIQ.

   a. (1 0 1)

   b. (1 1 1)

   c. (1 0 0)

Solution: The formula for Converting RGB to CMY and YIQ are given below

$$\begin{pmatrix} C \\ M \\ Y \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} - \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

a. (1 0 1) = $\begin{pmatrix} C \\ M \\ Y \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} - \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$

$$\begin{pmatrix} Y \\ I \\ Q \end{pmatrix} = \begin{pmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.271 & 0.322 \\ 0.211 & -0.523 & 0.311 \end{pmatrix} \times \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} = \begin{pmatrix} 0.413 \\ 0.918 \\ 0.522 \end{pmatrix}$$

b. (1 1 1) = $\begin{pmatrix} C \\ M \\ Y \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} - \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$

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$$\begin{pmatrix} Y \\ I \\ Q \end{pmatrix} = \begin{pmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.271 & 0.322 \\ 0.211 & -0.523 & 0.311 \end{pmatrix} \times \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} = \begin{pmatrix} 1.003 \\ 0.644 \\ 0.001 \end{pmatrix}$$

c. (1 0 0) = $\begin{pmatrix} C \\ M \\ Y \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} - \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \\ 1 \end{pmatrix}$

$$\begin{pmatrix} Y \\ I \\ Q \end{pmatrix} = \begin{pmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.271 & 0.322 \\ 0.211 & -0.523 & 0.311 \end{pmatrix} \times \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} 0.299 \\ 0.596 \\ 0.211 \end{pmatrix}$$

2. Let the RGB values of a point is given as $(0.2, 0.4, 0.6)$ **. Find the HSV equivalent of RGB? Also verify whether the original point can be obtained by the inverse transform from HSV to RGB?**

Solution: Given RGB values are R = 0.2, G = 0.4, B=0.6.

$$k_{\max} = \max\{R, G, B\} = \max\{0.2, 0.4, 0.6\} = 0.6$$
$$k_{\min} = \min\{0.2, 0.4, 0.6\} = 0.2$$
$$k = 0.6 - 0.2 = 0.4$$

Therefore,

$$V = k_{\max} = 0.6$$

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$$S = \frac{k}{k_{\max}} = \frac{0.4}{0.6} = 0.666$$

$$R' = \frac{k_{\max} - R}{k} = \frac{0.6 - 0.2}{0.4} = 1$$
$$G' = \frac{k_{\max} - G}{k} = \frac{0.6 - 0.4}{0.4} = 0.5$$
$$B' = \frac{k_{\max} - B}{k} = \frac{0.6 - 0.6}{0.4} = 0$$

Finally, $H' = G' - R' + 4 = 0.5 - 1 + 4 = 3.5$

Since $H' > 0$
$H = \frac{1}{6} \times 3.5 = 0.58.$

Finally the HSV point corresponding to the given RGB point is $(0.5, 0.66, 0.6)$. This can be converted back to RGB. Since $\lfloor H' \rfloor = \lfloor 3.5 \rfloor = 3$, for case 3, the resultant (RGB) is (x,y,v). Here v = V. Therefore V = 0.6. The remaining x and y can be calculated using the formula given

$$x = (1 - S) \times V = (1 - 0.66) \times 0.6 \cong 0.2$$
$$y = (1 - (S \times (\text{H}' - \lfloor H' \rfloor))) \times 0.6 = 0.67 \times 0.6 \cong 0.4$$

Therefore the original values of RGB are obtained exactly.

3. Determine the CIE chromaticity coordinate of a point given these details - $C_1 = (0.24, 0.6, 2)$ and $C_2 = (0.6, 0.8, 1)$. Find the third colour C_3?

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Solution: There are two colours given with three coordinate points. Since chromaticity diagram is 2D, the intensity is aligned with Y axis. The resultant coordinate for the third colour point is given as

$$x_3 = \frac{x_1 k_1 + x_2 k_2}{k_1 + k_2};$$
$$y_3 = \frac{y_1 k_1 + y_2 k_2}{k_1 + k_2};$$
$$L_3 = L_1 + L_2$$

Here $k_1 = \frac{L_1}{y_1}$ *and* $k_2 = \frac{L_2}{y_2}$.

The given details are $x_1 = 0.24, y_1 = 0.6, x_2 = 0.6, y_2 = 0.8, L_1 = 2, L_2 = 1$

Therefore, $k_1 = \frac{L_1}{y_1} = \frac{2}{0.6} = 3.33, k_2 = \frac{L_2}{y_1} = \frac{1}{0.8} = 1.25$

Now the third colour coordinates can be obtained as

$$x_3 = \frac{x_1 k_1 + x_2 k_2}{k_1 + k_2} = \frac{(0.24)(3.33) + (0.6)(1.25)}{3.33 + 1.25} = 0.338$$
$$y_3 = \frac{y_1 k_1 + y_2 k_2}{k_1 + k_2} = \frac{(0.6)(3.33) + (0.8)(1.25)}{3.33 + 1.25} = 0.65$$
$$L_3 = L_1 + L_2 = 2 + 1 = 3$$

Therefore the coordinate of the third colour point will be $(0.338, 0.65, 3)$.

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