

RGB/HSI Color Conversion

22 Jan. 1994

RGB_HSI.MCD

$i := 0..12$

$$a := \sqrt{\frac{1}{6}} \quad b := \sqrt{\frac{1}{2}} \quad c := \sqrt{\frac{1}{3}}$$

$$R := (1 \ 1 \ 1 \ .5 \ 0 \ 0 \ 0 \ 0 \ 0 \ .5 \ 1 \ 1 \ 1)^T$$

$$G := (0 \ .5 \ 1 \ 1 \ 1 \ 1 \ 1 \ .5 \ 0 \ 0 \ 0 \ 0)^T$$

$$B := (0 \ 0 \ 0 \ 0 \ 0 \ .5 \ 1 \ 1 \ 1 \ 1 \ 1 \ .5 \ 0)^T$$

First rotate the cube to x,y,z with diagonal on z-axis, R on x-axis.

$$X(R,G,B) := 2 \cdot a \cdot R - a \cdot G - a \cdot B$$

$$Y(R,G,B) := b \cdot G - b \cdot B$$

$$Z(R,G,B) := c \cdot R + c \cdot G + c \cdot B$$

$$x_i := X(R_i, G_i, B_i)$$

$$y_i := Y(R_i, G_i, B_i)$$

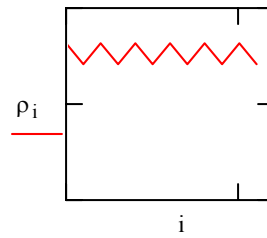
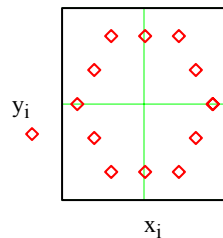
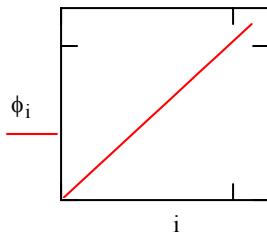
$$z_i := Z(R_i, G_i, B_i)$$

Then convert to cylindrical coordinates:

$$\phi_i := \text{angle}(x_i, y_i)$$

$$\rho_i := \sqrt{x_i \cdot x_i + y_i \cdot y_i}$$

The problem is that ρ is not independent of I, and ρ_{\max} describes a hexagon, not a unit circle.



$$(\rho_0 \ \rho_1 \ \rho_2 \ \rho_3 \ x_0 \ y_3) = (0.816 \ 0.707 \ 0.816 \ 0.707 \ 0.816 \ 0.707)$$

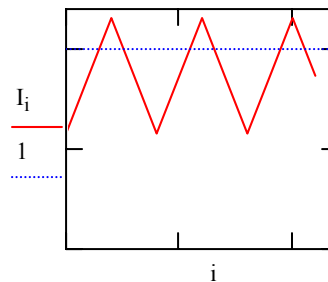
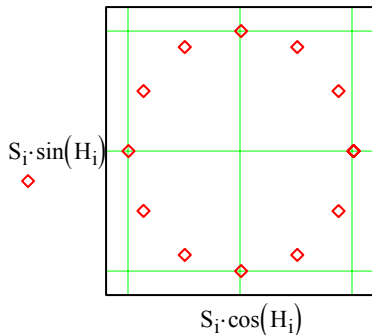
By definition, $S = 1$ if one of the primaries is zero.

Now normalize ρ to make it a circle, and independent of Intensity:

$$H_i := \phi_i$$

$$I_i := z_i$$

$$S_i := 1 - \frac{3 \cdot \text{Min}(R_i, G_i, B_i)}{R_i + G_i + B_i}$$



An equivalent computation for H is

$$\theta_i := \text{acos} \left[\frac{\frac{1}{2} \cdot [(R_i - G_i) + (R_i - B_i)]}{\sqrt{(R_i - G_i)^2 + (R_i - B_i) \cdot (G_i - B_i)}} \right]$$

$$H_i := \text{if}(G_i \geq B_i, \theta_i, 2 \cdot \pi - \theta_i) \quad \alpha \cdot H^T = (0 \ 30 \ 60 \ 90 \ 120 \ 150 \ 180 \ 210 \ 240 \ 270 \ 300 \ 330 \ 0)$$

=== HSI to RGB Conversion ===

(1) If $0 < H < 120$, then

$$\text{Blu}_i := I_i \cdot \frac{1 - S_i}{\sqrt{3}} \quad \text{Red}_i := \left(\frac{I_i}{\sqrt{3}} \right) \cdot \left(1 + \frac{S_i \cdot \cos(H_i)}{\cos\left(\frac{\pi}{3} - H_i\right)} \right) \quad \text{Grn}_i := \sqrt{3} \cdot I_i - \text{Red}_i - \text{Blu}_i$$

(2) If $120 < H < 240$, then

$$\text{Red}_i := I_i \cdot \frac{1 - S_i}{\sqrt{3}} \quad \text{Grn}_i := \left(\frac{I_i}{\sqrt{3}} \right) \cdot \left(1 + \frac{S_i \cdot \cos\left(H_i - 2 \cdot \frac{\pi}{3}\right)}{\cos\left(\frac{\pi}{3} - H_i\right)} \right) \quad \text{Blu}_i := \sqrt{3} \cdot I_i - \text{Red}_i - \text{Grn}_i$$

(3) If $240 < H < 360$, then

$$\text{Grn}_i := I_i \cdot \frac{1 - S_i}{\sqrt{3}} \quad \text{Blu}_i := \left(\frac{I_i}{\sqrt{3}} \right) \cdot \left(1 + \frac{S_i \cdot \cos\left(H_i - 4 \cdot \frac{\pi}{3}\right)}{\cos\left(5 \cdot \frac{\pi}{3} - H_i\right)} \right) \quad \text{Red}_i := \sqrt{3} \cdot I_i - \text{Grn}_i - \text{Blu}_i$$

===== RGB_HSI.MCD

$$\begin{pmatrix} R_j \\ G_j \\ B_j \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \quad \begin{pmatrix} \alpha \cdot H_j \\ S_j \\ I_j \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \\ 0.577 \end{pmatrix} \quad \begin{pmatrix} \text{Red}_j \\ \text{Grn}_j \\ \text{Blu}_j \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \quad j \equiv 12$$

$$\alpha \equiv \frac{180}{\pi}$$

Max(x, y, z) ≡ if(x > y, if(x > z, x, z), if(y > z, y, z))

Min(x, y, z) ≡ if(x < y, if(x < z, x, z), if(y < z, y, z))