RGB/HSI Color Conversion

22 Jan. 1994 RGB_HSI.MCD

$i := 0 .. 12$

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

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

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

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

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

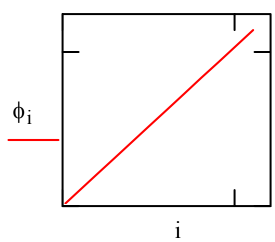
$X(R,G,B) := 2\cdot a\cdot R - a\cdot G - a\cdot B$ $\quad Y(R,G,B) := b\cdot G - b\cdot B$ $\quad Z(R,G,B) := c\cdot R + c\cdot G + c\cdot B$

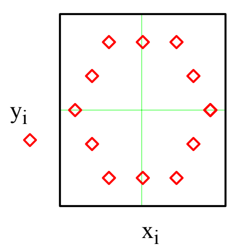
$x_i := X(R_i, G_i, B_i)$ $\quad y_i := Y(R_i, G_i, B_i)$ $\quad z_i := Z(R_i, G_i, B_i)$

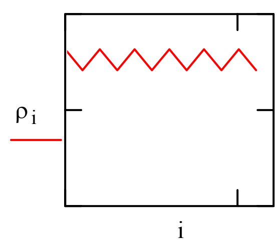
Then convert to cylindrical coordinates:

$\phi_i := \text{angle}(x_i, y_i)$ $\quad \rho_i := \sqrt{x_i\cdot x_i + y_i\cdot y_i}$

The problem is that ρ is not independent of I, and ρmax describes a hexagon, not a unit circle.



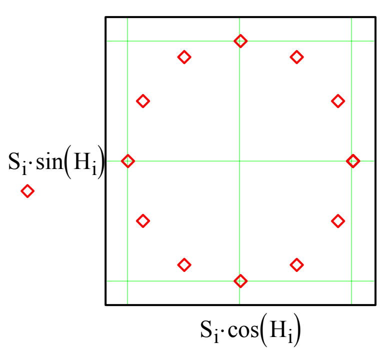


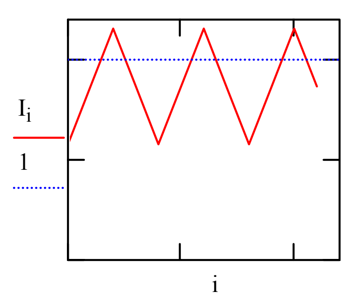


$(\rho_0\ \ \rho_1\ \ \rho_2\ \ \rho_3\ \ x_0\ \ y_3) = (0.816\ \ 0.707\ \ 0.816\ \ 0.707\ \ 0.816\ \ 0.707)$

By definition, S = 1 if one of the primaries is zero.
Now normalize ρ to make it a circle, and independent of Intensity:

$H_i := \phi_i$ $\quad I_i := z_i$ $\quad S_i := 1 - \dfrac{3\cdot \text{Min}(R_i, G_i, B_i)}{R_i + G_i + B_i}$





An equivalent computation for H is

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

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

=== HSI to RGB Conversion ===

(1) If 0 < H < 120, then

$$Blu_i := I_i\cdot\frac{1 - S_i}{\sqrt{3}} \qquad Red_i := \left(\frac{I_i}{\sqrt{3}}\right)\cdot\left(1 + \frac{S_i\cdot\cos(H_i)}{\cos\left(\frac{\pi}{3} - H_i\right)}\right) \qquad Grn_i := \sqrt{3}\cdot I_i - Red_i - Blu_i$$

(2) If 120 < H < 240, then

$$Red_i := I_i\cdot\frac{1 - S_i}{\sqrt{3}} \qquad Grn_i := \left(\frac{I_i}{\sqrt{3}}\right)\cdot\left(1 + \frac{S_i\cdot\cos\left(H_i - 2\cdot\frac{\pi}{3}\right)}{\cos\left(\frac{\pi}{1} - H_i\right)}\right) \qquad Blu_i := \sqrt{3}\cdot I_i - Red_i - Grn_i$$

(3) If 240 < H < 360, then

$$Grn_i := I_i\cdot\frac{1 - S_i}{\sqrt{3}} \qquad Blu_i := \left(\frac{I_i}{\sqrt{3}}\right)\cdot\left(1 + \frac{S_i\cdot\cos\left(H_i - 4\cdot\frac{\pi}{3}\right)}{\cos\left(5\cdot\frac{\pi}{3} - H_i\right)}\right) \qquad Red_i := \sqrt{3}\cdot I_i - Grn_i - Blu_i$$

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$$\begin{pmatrix} R_j \\ G_j \\ B_j \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \qquad \begin{pmatrix} \alpha\cdot H_j \\ S_j \\ I_j \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \\ 0.577 \end{pmatrix} \qquad \begin{pmatrix} Red_j \\ Grn_j \\ Blu_j \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \qquad j \equiv 12$$

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

$\text{Max}(x,y,z) \equiv \text{if}(x > y, \text{if}(x > z, x, z), \text{if}(y > z, y, z))$

$\text{Min}(x,y,z) \equiv \text{if}(x < y, \text{if}(x < z, x, z), \text{if}(y < z, y, z))$