Other Color Models (HSV, HLS, YIQ)

Major points of these notes:

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Summary

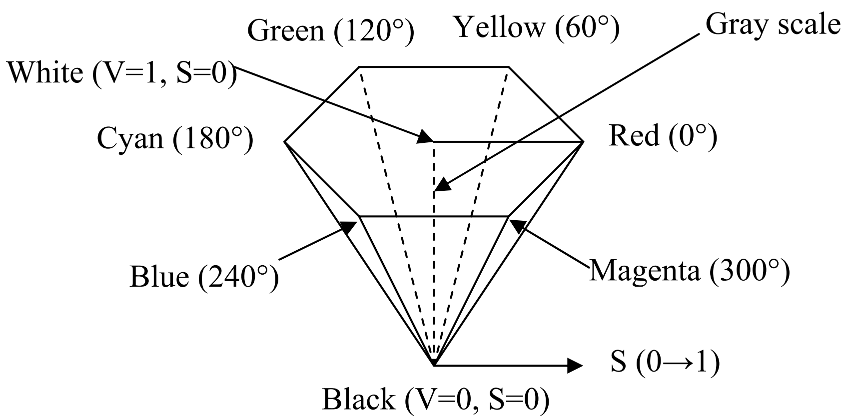
In other notes I've already described the RGB, CMY, CMYK, and CIE color systems. In these notes I'll describe three others, HSV, HLS, and YIQ.

As compared to specifying the three primaries individually, which is what happened in RGB and CMY(K), and also with different primaries in the CIE system, both HSV and HLS specify the hue with a single parameter, and then the saturation and intensity through two other parameters. In many ways this provides a much more intuitive user interface. The user can first move through the color spectrum until they find the pure color that they want, and can then modify the saturation and intensity of that color. YIQ is the US broadcast standard where *Y* provides the intensity which is the signal used for black and white TVs and *I* and *Q* encode chromaticity.

I'll describe HSV (Hue, Saturation and Value) first, then HLS (Hue, Lightness and Saturation), and finally YIQ.

HSV (Hue, Saturation, and Value) Color Model

The hue component in HSV is specified by an angle from 0° to 360°, where Red is 0°, Yellow is 60°, Green is 120°, Cyan is 180°, Blue is 240°, and Magenta is 300°, with all lying around a hexagon as shown in the very busy hexcone figure below. Note that complementary colors (e.g., yellow and cyan) are on opposite sides of the hexagon.

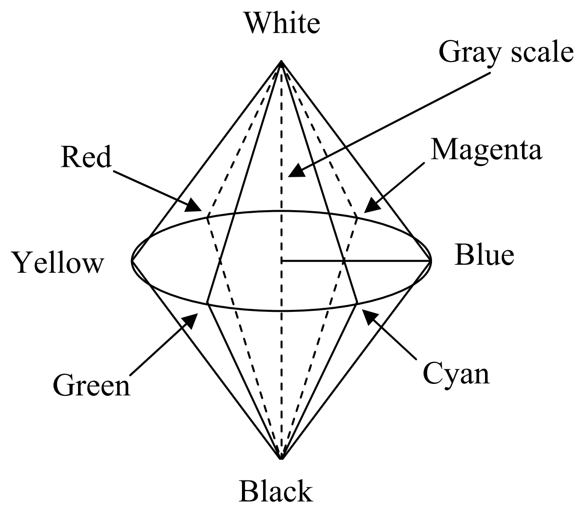


A color is specified with a triple, (H, S, V). H is an angle counterclockwise from above which begins at the line from white to red and works through the color spectrum. S gives the saturation which goes from 0→1, and is high for pure colors, and low as the color approaches the gray scale line. V gives the value, or intensity, of the color.

E.g., say that we want a full intensity orange. H will be half way between red and yellow, and so will be 30°, and this will specify that orange is our basic hue. S is slightly complicated because the model uses a hexagon on top (as we'll see, HLS avoids this problem). S is the length from the center of the hexagon to the middle of the line between red and yellow which is $\frac{\sqrt{3}}{2}$. For a full intensity color (at the top of the hexcone) $V = 1$. So the RGB value for pure orange, (1, 1, 0) converts to the HSV (30°, $\frac{\sqrt{3}}{2}$, 1). The advantage comes when we want a less saturated and less bright orange. With RGB the color will be something like (0.5, 0.5, 0.25), whereas for HSV it will be (30°, $\frac{\sqrt{3}}{4}$, 0.5).The strength of HSV (and also HLS) isn't, however, doing these specifications like this. It is best when the user is selecting a color interactively, where it usually much easier to get to a desired color as compared to directly using RGB. Converting to RGB for display is then easy.

HLS Color Model

This model, Hue, Lightness, and Saturation, was popularized by Tektronix who used it to define the color effects on its monitors. It uses a double cone, as shown below:



The hues are specifies by angles, as they were for HSV, but in this model Blue is at 0°, Magenta is at 60°, Red is at 120°, Yellow is at 180°, Green is at 240°, and Cyan is at 300°. So the order on which the colors appear is the same as before, and complementary colors are still on opposite sides of the circle, separated by 180°, but the color sequence begins with blue instead of red. The angle is measured from above, as before, beginning at the line shown from medium gray to blue.

The hue definitions now lie on a circle, as compared to the hexagon that was used for HSV. This is much easier to deal with since full saturation of any hue will now have an S value of 1.0, as compared to, for example, the $\frac{\sqrt{3}}{2}$ that we had to use for the S value for orange using HSV.

Once again, gray scales appear on the center line of symmetry, with $L = 0$ at the bottom and $L = 1$ at the top. In this model the line is twice as long as in HSV.

Pure colors have an *L* value of 0.5. So, for example, pure orange is at an HLS triple of (150°, 0.5, 1.0).

Overall HSV seems to be the preferred method for interactive selection of colors.

YIQ Color Model

YIQ is the system used for US TV broadcast (PAL is the most common system used in other countries). The primary goals of the system were to provide a signal that could be directly displayed by black and white TVs, while also providing easy coding and decoding of RGB signals.

The conversions from RGB to YIQ and back are given by the matrices:

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} .299 & .587 & .114 \\ .701 & -.587 & -.114 \\ -.299 & -.587 & .886 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

and

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 1.000 & .000 \\ 1.000 & -.509 & -.194 \\ 1.000 & .000 & 1.000 \end{bmatrix} \begin{bmatrix} Y \\ I \\ Q \end{bmatrix}$$

where obviously the two matrices are inverses.

The Y component, which is the same as the Y value in the CIE system, is the signal that is used directly by black and white TVs. Y is said to convey the luminance information and is transmitted on a separate carrier signal from the chromaticity components, I and Q.

This encoding is of far more importance for film & TV people than it is for computer graphics people.