The purpose of a color model is to allow convenient specification of colors within some color gamut.

Three hardware-oriented color models are RGB (CRT monitors), YIQ (broadcast TV color system), and CMY (color-printing devices).

To related directly to intuitive color notions of hue, saturation, and brightness, another class of models (HSV, HLS, HVC, etc) are developed with ease of use as a goal.
The RGB color model (color CRT monitors)

- the RGB primaries are additive primaries

**Color: (R,G,B)**

- $(0,0,1) =$ Blue
- $(0,1,1) =$ Cyan
- $(1,0,1) =$ Magenta
- $(1,1,1) =$ White
- $(0,0,0) =$ Black
- $(0,1,0) =$ Green
- $(1,0,0) =$ Red
- $(1,1,0) =$ Yellow

- Diagonal of the cube, with equal amounts of each primary, represents the gray levels from black $(0,0,0)$ to $(1,1,1)$.
- The color gamut covered by the RGB model is defined by the chromaticities of a CRT’s phosphors.
- Two CRTs with different phosphors will cover different gamuts.
The CMY color model (ink-jet plotters)

- **CMY are the complements of RGB.** When used as filters to subtract color from white light, they are called **subtractive primaries.**

- Colors are specified by what is removed or subtracted from white light, rather than by what is added to blackness.

- Cyan = RGB - R
- Magenta = RGB - G
- Yellow = GRB - B

- From white (paper) by adding CMY, we can generate all different colors.

- Use CMYK K=black instead of just CMY.
The YIQ color model (US color TV broadcasting)

• a recording of RGB for transmission efficiency and for downward compatibility with black and white television.

• Here Y=luminance, the same as the CIE Y primary. Only the Y component of a color TV signal is shown on black-and-white TVs.

\[
\begin{bmatrix}
Y \\
I \\
Q
\end{bmatrix}
=egin{bmatrix}
0.229 & 0.587 & 0.114 \\
0.596 & -0.275 & -0.321 \\
0.212 & -0.523 & 0.311
\end{bmatrix}
\begin{bmatrix}
R \\
G \\
B
\end{bmatrix}
\]

• More bits of bandwidth are used to represent Y than to represent I and Q, because our eye is more sensitive to changes in luminance.
The HSV color model

- RGB, CMY, and YIQ models are hardware-oriented.

- HSV (hue, saturation, value) or HSB (brightness) model is user-oriented.

  Black $V=0$; White $V=1$

- Intermediate values of $V$ for $S=0$ are the grays.
The HLS Color Model

- HLS (hue, lightness, saturation) is HSV pulled up.
Interactive Specification of Color

• Many application programs allow the user to specify colors of areas, lines, text, and so on.
• Interactive selection:

• Perception of color is affected by surrounding colors and the sizes of colored areas
Interpolating in Color Space

• Gouraud shading, antialiasing, and blending two images

• A straight line in one color model corresponds to a straight line in another color model: RGB, CMY, YIQ, CIE

• A straight line in RGB does not in general transform into a straight line in HSV or HLS.

• The model used for interpolation depends on the objectives: hue, saturation, or intensity
4 REPRODUCING COLOR

• color images are reproduced in print in a process called undercolor removal
• black ink replaces equal amount of primaries, and hastens drying by decreasing the amounts of CMY.
• The monochrome dithering techniques discussed can also be used with color to extend the number of available colors, again at the expense of resolution.
• Creating an accurate color reproduction is much more difficult than in approximating colors. Two display monitors can be calibrated to create the same tristimulus values.
5 USING COLOR IN COMPUTER GRAPHICS

• A conservative approach to color selection is to design first for a monochrome display, to ensure that color use is purely redundant.

• For aesthetic purposes: (certain rules)

Select colors by traversing a smooth path in a color model (by restricting the colors to planes of hexcones in a color space. This means using colors of constant brightness.)

Colors are best spaced at equal perceptual distances (Gouraud shading).

A random selection of different hues and saturations is usually quite garish.

If a chart contains just a few colors, the complement of one of the colors should be used as the background.
A neutral (gray) background should be used for an image containing many different colors.

If two adjoining colors are not particularly harmonious, a thin black border can be used to set them apart.

In general, it is good to use fewer number of colors.

• Physiological considerations: (certain rules)

  vary from the background not just in chromaticity, but in brightness (i.e. perceived intensity, which eye is more sensitive to)

  blue and black differ very little in brightness, yellow on white is relatively hard to distinguish.

  white on blue background provides a good contrast that is less harsh than white on black.
It is good to avoid reds and greens with low saturation and luminance, as these are the colors confused by those of us who are red-green color blind.

The eye cannot distinguish the color of very small objects.

The perceived color of a colored area is affected by the color of the surrounding area.

The color of an area can actually affect its perceived size. (red square is perceived as larger than green square of equal size)

Use of large areas of saturated colors is unwise (afterimage of the large area)

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