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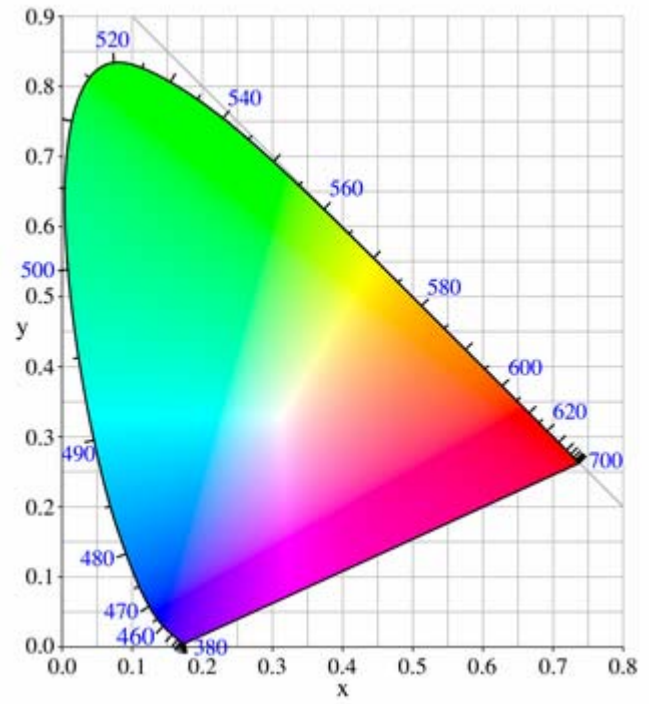
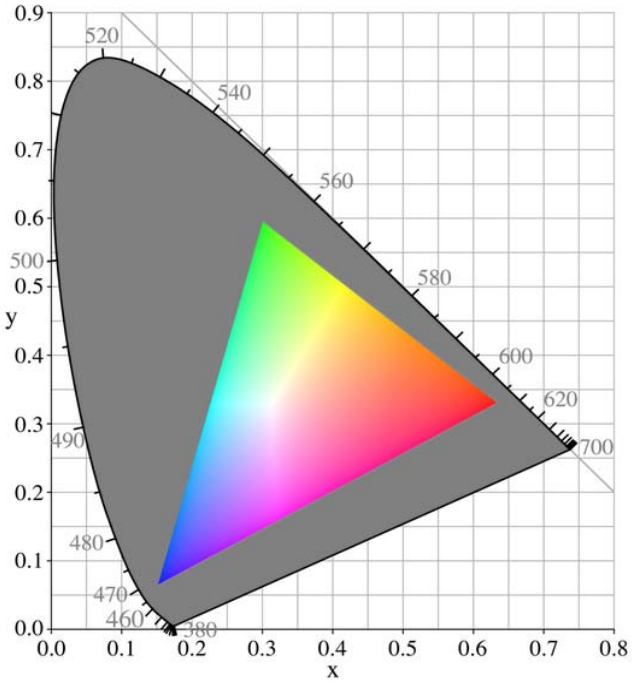
Color Models

Defining color using mathematical representations is a problem that predates the development of computer graphics. In the early 1930s, researchers conducted experiments to try to determine the extent of human color perception. Their studies resulted in the CIE XYZ (or CIE 1931) color space.

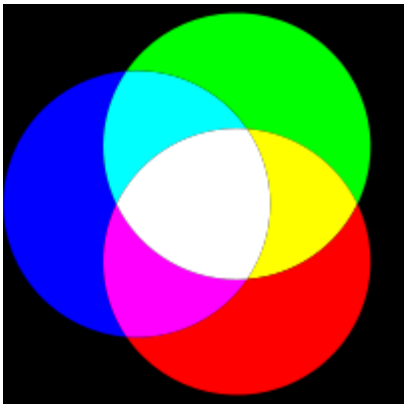
The CIE XYZ color model is intended to represent the range of color perception of human vision. This range of perception (or capability to display) is called the gamut. Thus, the CIE XYZ color model is intended to represent the gamut of human vision (but is limited by the gamut of the display that is showing the image). Some interesting notes about this model are that by picking two points in the color area, the line segment between those two points represent all of the colors that can be made by mixing the colors at those two points. The same is true by selecting any three points, where the triangle formed would be the range of colors able to be represented by mixing the colors at the three points. Another interesting note about the color space is that no three points can be selected that contain all of the perceivable colors. Therefore, all of the more simple color models that use three components are not absolute color models. Their gamut is smaller than the gamut of perceivable



The CIE XYZ Color Model

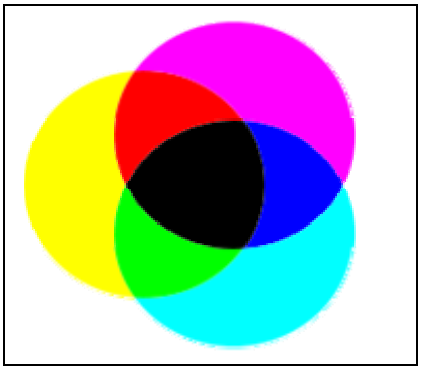


Gamut of a Typical CRT Display

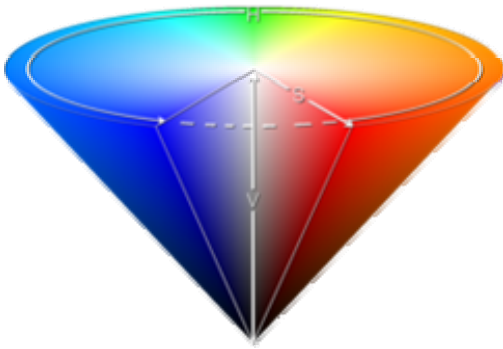


The RGB color model is the most prolific in computer graphics. It uses different values of Red, Green, and Blue components to determine the final color representation. Each component is represented by a number from the range zero to one. Additive color models like RGB start with black and add different values of the three color components to achieve a final color. Full values of RGB (1.0, 1.0,

1.0) will produce the color white. The color (1.0, 0.0, 0.0) will lead to the color red, and so forth. Almost all television and computer displays use this model for screen displays.



The CMYK color model, on the other hand, uses a subtractive color model in order to achieve the desired results. CMYK stands for Cyan, Magenta, Yellow, and Key (black) and the color model is used in printing. In order to achieve the desired color, the color model uses inks of the various colors to act as filters for the primary colors of light. Cyan will act as a filter that absorbs the color Red, Magenta will absorb Green, and Yellow will absorb Blue. Therefore, the final result will be the full amount of white light, minus the filtered amounts from the Cyan, Magenta, and Yellow inks. The Key (black) ink is added to save costs on printing by using pure black instead of trying to mix equal portions of CMY. Color printers use this scheme for printing, as the color ink cartridge will contain CMY inks and the black cartridge will be used to save the color cartridge ink, create black colors without having to mix three times the ink, and create better defined grayscales. The CMYK is rarely used in computer applications except when preparing documents digitally for print, such as in digital layout operations.



While RGB and CMYK are good color models for the applications they are used, many people find that trying to add individual color components is not the most intuitive method for modeling color, and other color models have been developed to provide a more intuitive representation. One such model is the HSV (or HSB) color space. The values stand for Hue, Saturation, and Value (or Brightness). The Hue represents the color type, such as red, blue, or yellow. Saturation is related to the “vibrancy” of the color. A low saturation value will produce a color that is faded and has more grayness. The Value is how light or dark a color is. The cone to the right represents the HSV color space. The Hue is represented by a degree value around the circle that forms the base of the cone. The Saturation increases from the center of the cone outwards, and the Value increases from the point of the cone to the center of the base. The cone helps visualize some factors of the HSV color space. An interesting point to note is that with a Saturation value of 0.0, the Hue is irrelevant and the Value can be manipulated to achieve grayscale.

Many other color models exist, but the color models mentioned are the most prolific because of their simple but fairly complete representations relative to other color models. The gamut of display devices is such that creating more complete color models is impractical because the bottleneck is in how the colors are displayed, not at what is being displayed. Perhaps in the future, when displays are more reliable and capable of displaying more unique colors, these color models will be replaced by more robust models capable of representing the entire spectrum of perceivable colors.

Sources

http://en.wikipedia.org/wiki/Color_theory

http://en.wikipedia.org/wiki/Color_model

http://en.wikipedia.org/wiki/Gamut

http://en.wikipedia.org/wiki/RGB

http://en.wikipedia.org/wiki/CMYK

http://en.wikipedia.org/wiki/HSV_color_space