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A Survey Of Color Model in Computer Graphics

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Abstract— Any person related to computer graphics is aware of the color model. Color model used at various places such as T.V., scanner, Plasma Screen , etc. In this paper "A Survey of Color Model" we gives the detailed description about the various color models and it also describe the relationships between them.

Keywords- Introduction, what does CIE color model mean?, XYZ color model, RGB model, YIQ model, CMYK model, HSV model.

I. INTRODUCTION

A color model is an abstract mathematical model describing the way colors can be represented as tuples of numbers, typically as three or four values or color components. When this model is associated with a precise description of how the components are to be interpreted (viewing conditions, etc.), the resulting set of colors is called color space. Color models provide a standard way to specify a particular color, by defining a 3D coordinate system, and a subspace that contains all constructible colors within a particular model. Any color that can be specified using a model will correspond to a single point within the subspace it defines. Each color model is oriented towards either specific hardware (RGB,CMY,YIQ), or image processing applications (HSI).The purpose of a color model is to facilitate the specification of colors in some standard generally accepted way. In essence, a color model is a specification of a 3-D coordinate system and a subspace within that system where each color is represented by a single point.

II. WHAT DOES CIE COLOR MODEL MEAN?

A Color model is a method for explaining the properties or behavior of color within some particular context, No single color model can explain all aspects of color, so we make use of different models to help describe the different perceived characteristics of color. The CIE color model is a color space model created by the International Commission Illumination known as the Commission Internationale de l'Elcairage(CIE). It is also known as the CIE XYZ color space or the CIE 1931 xyz color space. The CIE color model is mapping system that uses tristimulus (a combination of 3 color values that are close to Red/Green/Blue) values. Which are plotted on a 3D space. When these values are combined, they can reproduce any color that a human eye can perceive. The CIE specification is supposed to be able who accurately represent every single color the human eye can perceive.

III. CHROMATICITY DIAGRAM

In 1931, the Commission International de l'Eclairage(CIE) standardized a set of primaries and color matching functions that are the basis for most color measurement instruments used today. They transformed a set of color matching functions measured by Stiles and Burch to create a set of curves that were more convenient to use. This set is positive throughout the entire visible spectrum, and one of the curves can be used to compute the perceived brightness of the measured color. The CIE standard tristimulus values are notated X, Y and Z. They are often reduced to two dimensions by projecting them onto the X+Y+Z=1 plane, creating the CIE chromaticity diagram with its corresponding chromaticity coordinates, x and y.[2]

This diagram is useful for the following:-
-comparing color gamuts for different sets of primaries.
-Identifying complementary colors.
-Determining dominant wavelength and purity of a given color.

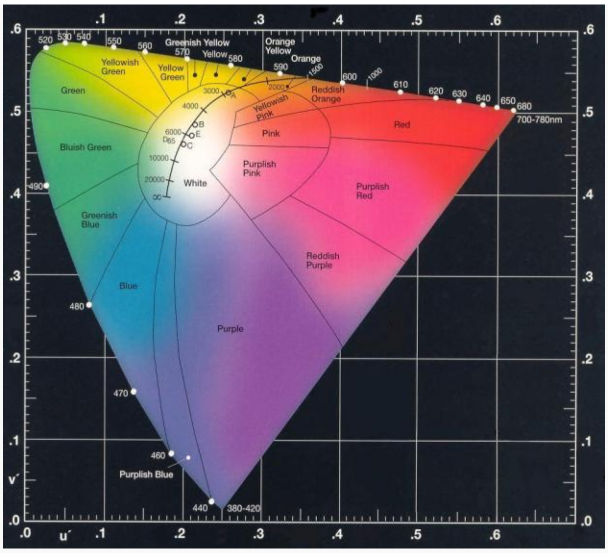


Figure 1.Chromaticity diagram [1]

IV. RGB COLOR MODEL

In the RGB model, each color appears as a combination of red, green, and blue. This model is called additive, and the colors are called primary colors. The primary colors can be added to produce the secondary colors of light (see Figure "Primary and Secondary Colors for RGB and CMYK Models") - magenta (red plus blue), cyan (green plus blue), and yellow (red plus green). The combination of red, green, and blue at full intensities makes white.
The RGB color model is additive in the sense that the three light beams are added together, and their light spectra add, wavelength for wavelength, to make the final color's spectrum.
The RGB model defines a color by giving the intensity level of red, green and blue light that mix together to create it on the display. With most of today's displays, the intensity of each color can vary from 0 to 255, which gives 16,777,216 different colors. (Older displays with less memory might only allow 256 colors, and really ancient displays might have only 16).

Color	**Red**	**Green**	**Blue**
Red	255	0	0
Green	0	255	0
Blue	0	0	255
Yellow	255	255	0
Cyan	0	255	255
Magenta	255	0	255
White	255	255	255

Black	0	0	0

Table 1. Primary and Secondary Colors for RGB and CMYK Models[1]

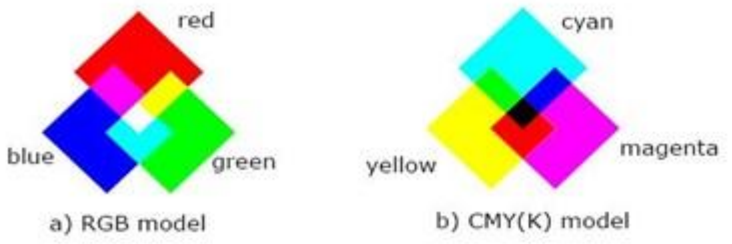


Figure 3. Primary and Secondary Colors for RGB and CMYK Models [1]

The color subspace of interest is a cube shown in Figure "RGB and CMY Color Models" (RGB values are normalized to 0..1), in which RGB values are at three corners; cyan, magenta, and yellow are the three other corners, black is at their origin; and white is at the corner farthest from the origin.

The importance of the RGB color model is that it relates very closely to the way that the human eye perceives color. RGB is a basic color model for computer graphics because color displays use red, green, and blue to create the desired color. Therefore, the choice of the RGB color space simplifies the architecture and design of the system. Besides, a system that is designed using the RGB color space can take advantage of a large number of existing software routines, because this color space has been around for a number of years.

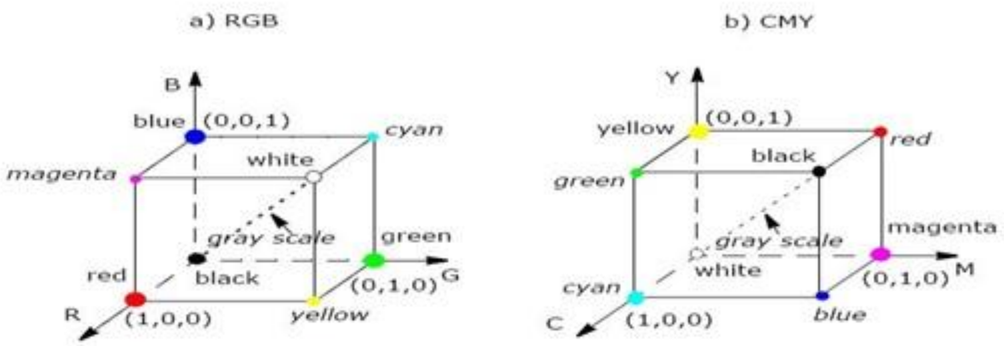


Figure 4. RGB and CMY Color Models[1]

However, RGB is not very efficient when dealing with real-world images. To generate any color within the RGB color cube, all three RGB components need to be of equal pixel depth and display resolution. Also, any modification of the image requires modification of all three planes.

Typical RGB input devices are color TV and video cameras, image scanners and digital cameras. Typical RGB output devices are TV sets of various technologies (CRT,LCD, plasma, etc).

V. YIQ COLOR MODEL

The YIQ (luminance-inphase-quadrature) model is a recording of RGB for color television, and is a very important model for color image processing. The conversion from RGB to YIQ is given by:

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} .299 & .587 & .144 \\ .586 & -.275 & -.321 \\ .212 & -.528 & .311 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} .30 & .60 & .21 \\ .59 & -.28 & -.52 \\ .11 & -.32 & .31 \end{bmatrix} \begin{bmatrix} Y \\ I \\ Q \end{bmatrix}$$

The luminance (Y) component contains all the information required for the black and white television, and captures our perception of relative brightness of particular colors. That we perceive green as much larger than red, and red lighter than blue, is indicated by their respective weights of .587, .299 and .144 in the first row of conversion matrix above. These weights should be used when converting a color image to grey scale If you want the perception of brightness to remain the same.

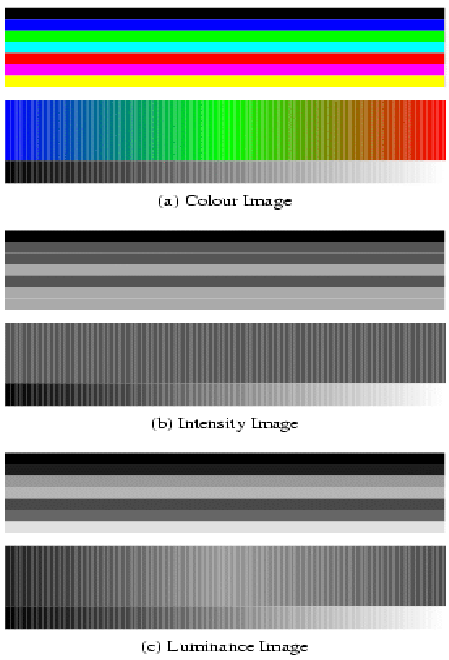


Figure 5. Colour, Intensity, Luminance Images of YIQ Color Model[1]

Figure 5 Image (a) shows a color test pattern, consisting of horizontal stripes of black, blue, green, cyan, red, magenta and yellow, a color ramp with constant intensity, maximal saturation, and hue changing linearly from red through green to blue, and a grayscale ramp from black to white. Image (b) shows the intensity for image (a). Note how much detail is lost. Image (c) shows the luminance. This third image accurately reflects the brightness variations perceived in the original image.

VI. CMYK COLOR MODEL

Color printing typically uses ink of four colors: cyan, magenta, yellow, and key(black). When CMY "primaries" are combined at full strength, the resulting "secondary" mixtures are red, green, blue.

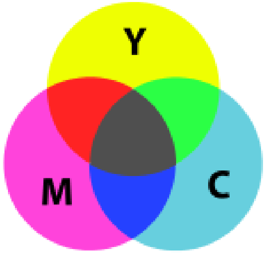


Figure 6. CMYK Color Model[1]

Mixing all three theoretically results in black, but imperfect ink formulations do not give true black, which is why the additional K component is needed.

The CMYK color model (process color, four color) is a subtractive color model, used in color printing, and is also used to describe the printing process itself. CMYK refers to the four inks used in some color printing: cyan, magenta, yellow, and key (black). Though it varies by print house, press operator, press manufacturer, and press run, ink is typically applied in the order of the abbreviation.

The CMYK model works by partially or entirely masking colors on a lighter, usually white, background. The ink reduces the light that would otherwise be reflected. Such a model is called subtractive because inks "subtract" brightness from white.

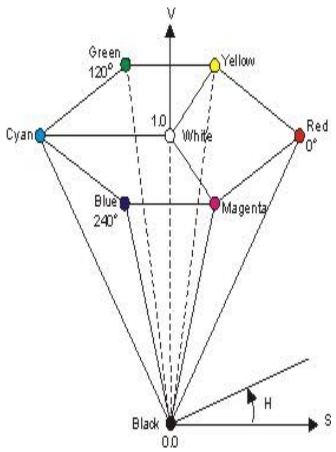
In additive color models such as RGB, white is the "additive" combination of all primary colored lights, while black is the absence of light. In the CMYK model, it is the opposite: white is the natural color of the paper or other background, while black results from a full combination of colored inks. To save money on ink, and to produce deeper black tones, unsaturated and dark colors are produced by using black ink instead of the combination of cyan, magenta and yellow.

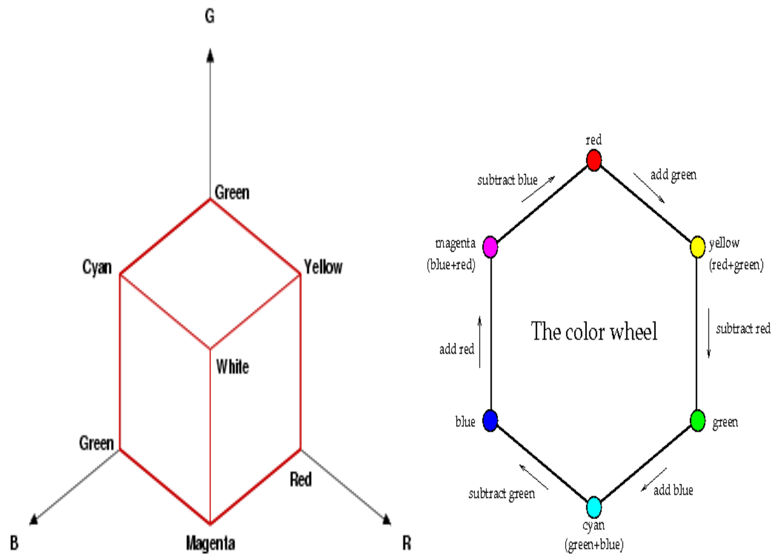
The cyan ink absorbs red light but transmits green and blue, the magenta ink absorbs green light but transmits red and blue, and the yellow ink absorbs blue light but transmits red and green. The white substrate reflects the transmitted light back to the viewer. Because in practice the CMY inks suitable for printing also reflect a little bit of color, making a deep and neutral black impossible, the K (black ink) component, usually printed last, is needed to compensate for their deficiencies. Use of a separate black ink is also economically driven when a lot of black content is expected, e.g. in text media, to reduce simultaneous use of the three colored inks. The dyes used in traditional color photographic prints and slides are much more perfectly transparent, so a K component is normally not needed or used in those media. When a surface coated with cyan pigment is illuminated by white light, no red light is reflected, and similarly for magenta and green, and yellow and blue. The relationship between the RGB and CMY models is given by:

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

VII. THE HSV COLOR MODEL

When artists began to use computers for graphic design, it was soon discovered that the RGB system is not a very intuitive way to represent colors. Alvy Ray Smith in 1978 was the first to describe colors using hue, saturation, and value (HSV model).Hue is a saturated color on the outer rim of the Wheel Saturation is the amount of white added to the color. 0% means that the color (at V=100%) is totally white; 100% means totally saturated with no white added (a fully saturated color is a pure hue on the outer rim of the HSV color wheel).Value is the brightness of the color. 0% means totally dark or black; 100% means full brightness, with the color is fully determined by the hue and saturation. Graphic artists like the HSV color model because it is an intuitive way to modify the colors in a region of an image. For example: Add more green to a region translates to "rotate the hue towards 120 degrees."Make the color more of a pastel color translates to "decrease the saturation."Make the colors in the image darker translates to "decrease the value."Try displaying colors in HSV color space using this Color Display Webpage.





(a) *(b)*

Figure 7. The HSV hexcone[1]

Figure 8. When the RGB color cube(a) is viewed along the diagonal from white to black, The color cube outline is a hexagon (b)[1]

The three dimensional representation of the HSV model is derived from the RGB cube if we imagine the cube along the diagonal from the white vertex to the origin (black), we see an outline of the cube that has the hexagon shape as shown in fig [8] and [9] . The boundary of the hexagon represents various hues , and it is used as the top of the HSV hexcone(fig [7]). In the hexcone , saturation is measured along a horizontal axis , and value is along a vertical axis through the center of hexcone.

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