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Analysis on Image Color Model

Haneet Kour

M.Tech student, 3rd Sem, Department of Computer Science & IT, University of Jammu, J & K

Abstract: Color models play an important role in real world applications such as computer graphics, image processing, television broadcasting, etc. Each color model has its own significance and applicable in different application domains. One of the interesting areas of digital image processing is to improve the image information for better processing image information for machine representation. Use of the color spectrum in image processing helps in objects recognition and extraction from the scene. In this paper, various (image) color models are studied to analyse their constituent components, application areas along with their merits and demerits.

Keywords: Color Model, Hue, Saturation, RGB, CMY, HIS.

I. INTRODUCTION

We are living in the era where a lot of research is going on in the field of digital image processing which has a significant impact on real life applications whether it is object motion tracking for security purposes, satellite image processing for weather prediction, biomedical image processing for diagnosis of diseases etc. In each area of digital image processing, input is given in the form of digital colored images. Hence it is important for researchers (doing research in digital image processing) to have knowledge about the components of color and how the components are used to represent these images so that they can simplify their work in image processing. [1][2]

A. Color model

Color model is a method for specifying colors in a standard way and the color model is represented by three dimensional coordinate system in which each color is represented by a single point within three dimensional systems. In case of human visual system, rods cells (in the eye) are sensitive to low intensity light waves recognizing binary images whereas cones cells are sensitive to red, green and blue light waves , thus, recognizing colored images. Thus red, green and blue colors are called as primary colors whereas cyan, yellow and magenta are known as secondary colors because these secondary colors are obtained by mixing two primary colors (combining green and blue results in cyan). On the basis of type of data, color models are of two types:

- Image Color models: These model focus on the representation of images only and mainly concentrates on quality of image data. E.g. RGB, CMY , HSI etc
- Video Color models: These are meant for representation of Video that focuses more on band width reduction to transfer video signals instead of its quality. E.g. YIQ ,YUV ,YCbCr etc. [1][3]

II. AIMS AND OBJECTIVES

Main objective of this paper is to analyse image Color models along with details of each and every aspect of these models. This paper aims to study various components, merits and demerits of these models. An analysis is done to understand how these models affect the appearance and histogram of the images.

III. IMAGE COLOR MODEL

A. RGB color model

It is an additive Color model represented with three primary colors, in which Red, Green and Blue light waves are added together to reproduce a broad array of colors. RGB is device dependent and quality of the white color depends on the nature of primary light sources. Its Color Components are red, blue and green each has value in the range [0-255].

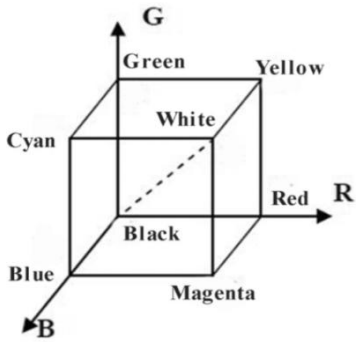

Figure1: RGB Color space

Fundamental Colors Representation [R, G, B]

Color	Red	Green	Blue
Red	255	0	0
Green	0	255	0
Blue	0	0	255
White	255	255	255
Black	0	0	0

B. CMY color model

It is subtractive and device dependent color model in which when Cyan, Magenta and Yellow inks are applied to a white surface, it subtracts some color from white surface create final color. Its Color Components are cyan, magenta and yellow, each has value in the range [0-255].

Color	Cyan	Magenta	Yellow
Cyan	255	0	0
Magenta	0	255	0
Yellow	0	0	255
Black	255	255	255
White	0	0	0

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Conversion from RGB to CMY

Cyan = 1- Red
Magenta = 1- Green
Yellow = 1-Blue

In case of CMY model, black color is obtained by mixing Cyan, Magenta and Yellow inks but it does not generate pure black; so CMY is modified to CMYK. CMYK is an acronym for Cyan, Magenta and Yellow along with Black (K). It is also subtractive model and its merit is pure black color can be printed due to use of Black color ink as separate component. Color Components - (C, M, Y) each varies in the range [0-255] and (k)[0 or 1].

Color	Cyan	Magenta	Yellow	Black
Cyan	255	0	0	0
Magenta	0	255	0	0
Yellow	0	0	255	0
Black	0	0	0	1
White	0	0	0	0

Conversion from CMY to CMYK

K=min{C,M,Y}
If K is equal to 1, then
C=M=Y=0
If K is not equal to 1, then
C = (255 - R) - K
M = (255 - G) - K
Y = (255 - B) – K

It has been found that RGB & CMY models are suitable for hardware implementation, but these are not suitable to describe colors in terms that are practical for human interpretation. When we refer to the color of any object , we don't consider the composition of each primary color. When we view a colored object, we specify it in terms of hue, saturation and brightness. RGB is not very efficient when dealing with real-world images as the three components require equal bandwidth to generate arbitrary colors within the RGB color cube. Also, processing an image in the RGB color space is usually not the most efficient method. Hence, we can say that RGB is suitable for image generation but not for color description. [3][4]

C. HSI color model

HSI model is an improvement over RGB model as it is user oriented. Its main components are hue, saturation and brightness. Hue(H) defines color itself. Values for Hue axis vary from 0 to 360 degree. Saturation(S) represents the amount by which the color is diluted with white light. It is based on the idea of human visual system. Hue and saturation represents chromaticity and this model separates the luminance component from chrominance component, this chrominance component depends on how human perceive this color spectrum. The S varies from 0 to 1. Intensity (I) varies from 0 (Black) to 1(White). [5][6]

Conversion from RGB to HSI

$$\mathbf{I} = (R+G+B)/3$$
$$\mathbf{S} = 1 - \min(R,G,B)/I$$
$$\mathbf{H} = \theta \text{ if } B <= G \textbf{ or } 360 - \theta \text{ if } B>G$$

where

$$\theta=\cos^{-1}[(0.5*(R-G)+(R-B))/((R-G)^2+(R-B)(G-B))^{0.5}]$$

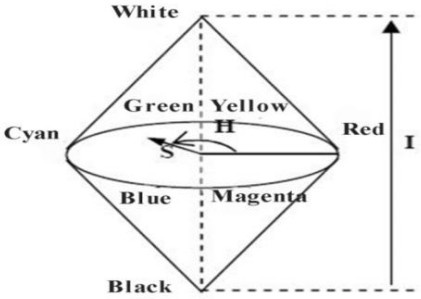

Figure 2: HSI color space

IV. ANALYSIS

After analyzing these image color models, it has been found that the RGB color model is the standard model used for design of display systems but not ideal for all of its applications. It directly reflects the physical properties of true color display. The red, green, and blue color components are highly correlated. The main merit of HSI model is that Chrominance (H, S) and luminance (I) components are decoupled. Hue and saturation is intimately related to the way the human visual system perceives color. Table 1 summarizes the overall analysis done in this paper.

Table1. Analysed image color model

Color Model	**Use**	**Merit**	**Demerit**
RGB	Used in digital cameras and scanners	Can specify color in the CSS2 standard	RGB requires the use ofCRTs, since it is hardware oriented system.
CMY, CMY(K)	Printing	Commonly used for printing production.	Since it is a subtractive model, components are pigments, not colors.
HSI	Human visual perception, Human Vision	Provide better intuition for humans. HSI color space is more precise in describing color	Undefined achromatic hue points are sensitive to value deviations of RGB and instability of hue,

These image color models are analysed (in matlab) by representing the same image in various models (RGB, HSI and CMY) and their respective histograms are also studied. The results of both image representation in various color models and respective histogram are shown in figure 3.

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V. CONCLUSION

It has been concluded that each color model is used in different applications depending upon its components and its purpose is to facilitate the specification of colors in some standard generally accepted way. These models used various components of an image to display on specific hardware platform. Researcher can simplify his work by choosing appropriate color model which is the basic for Color image representation.

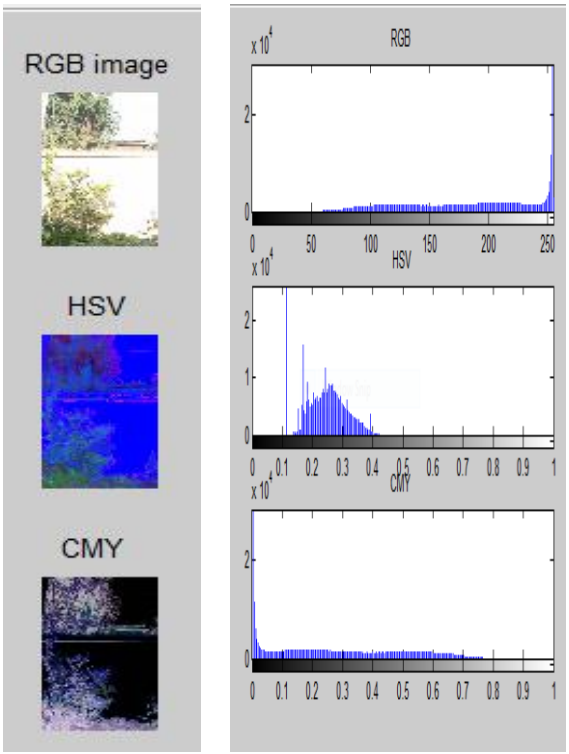

Figure3: (a) Image represented in different color models (b) Histogram of image represented in different color models

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