ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 3, March 2014

Investigative Analysis on Color Models

Mr I. Bala Venkateswarlu

Associate Professor, Department of Computer Science and Engineering, St.Ann's College of Engineering and Technology, Chirala, India

Abstract: Broad range of research is going on in the filed of Image Processing. Most of the researchers are attracted by Image Processing due to its variety of applications in various areas including Digital image processing, Medical image processing, Object motion tracking, Thumb or Face recognition for security, Satellite image processing for weather prediction etc. Digital color images are used as input for all of these applications. In order to represent color image it is mandatory to know components of color and how component are used to describe colors for the images. Image Processing researchers are more familiar with Image Processing algorithms. But, Knowing details of Color models will help the researcher to simplify their application processing. Main objective of this paper is to present investigative analysis on Color models along with details of each and every aspect of color models. This analysis report will help Image Processing researchers to consider best suitable color model based on their application to get ligiblely improved results.

Keywords: Color image, Color models, Image Processing, Investigative analysis, Details of Color models

I. FUNDAMENTALS OF COLOR IMAGE REPRESENTATION

Now a days world became Image centric because it is one of the most essential thing in our daily life. Consider the history of photography. In the mid 1820s, Joseph Nicephore Niepce[4] succeeded in capturing camera Images. Later various needs motivated researcher to introduce the field of Image Processing. With in the span of few years, plenty of versatile developments are taken place in the field of Image Processing. This paper focuses mainly the representation of Digital Color Image representation because it is essential for all other Image Processing techniques. Digital Color Image is a digital image that includes color information for each pixel in two dimensional grid. Main objective of this paper is emphasize more on Color image representation and Color model along with tabulation of Color models. We worked a lot to produce compiled result on Color models, which is helpful for Image Processing researchers. In this chapter we discussed about how a Color image will be formed and can be represented.

A. Human and Camera vision system

Human vision system[1] is also known as Eye-Brain system because Eyes and Brain are the major parts. In this system, Eye is responsible to capture Image from environment while Brain processes and memorizes the captured image. Out of these two, eyes will plays major role with few inner components of eye which are useful to sense image. Eyes will perceive images which are determined by light rays emitted or reflected from scene. Healthy eye will react to these light rays if they are in visible electro-magnetic spectrum. It will send electric signal to Brain through optic nerves. Light rays reflected from an object will incident on Lens available behind iris on front side of the eye. These reflective light rays coming from the lens are focused on Retina which is available on back side of eye. Image projected on this Retina will be upside down as shown in Fig 1.1. Retina is equipped with two types of nerves: Rods and Cones where Rods are used to sense low intensity light rays useful for recognizing Black and White images at dark lights and Cones are used to sense high intensity light rays useful for recognizing Color images in day lights.

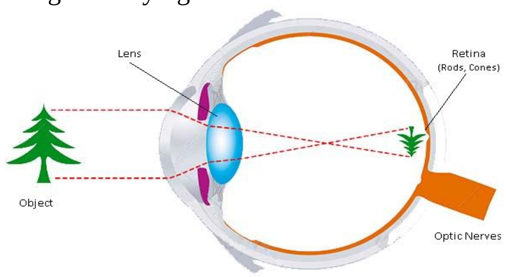

Fig 1.1: Human Vision system

Human vision system is the source for implementing Camera vision system which contains Lens and Film. An optical Lens is fixed in front of camera to pass reflected light rays coming from the object. These light rays are focused on a Film to preserve the image information. Camera system will also work as Human vision system as shown in Fig 1.2. One important distinction between these two systems is that Camera system requires a special Film development process to take print out of preserved image information of the film.

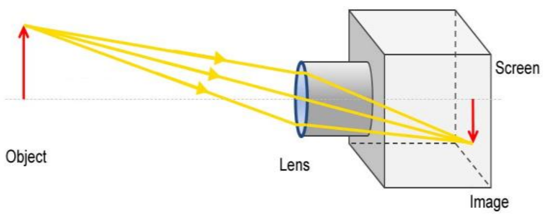

Fig 1.2: Camera Vision system

B. Color Image capturing

Vision systems that are discussed above uses simple analog image formation systems. Either human eye or camera will capture image information in the form of analog light waves. From the basics of light, Visible Light[4] is an electromagnetic radiation that is responsible

ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 3, March 2014

for sense of sight and will be in visible spectrum that ranges from 380nm to 750nm. Light exhibits particle as well as wave nature and hence it can be understood by two different equations:

Velocity of light wave(v)= $\lambda.f$
Energy of light wave(E)= $h.f$

Where λ is wave length, f is frequency of light wave, h is Planck's constant(6.62x10-34 J-sec). First equation exhibits particle nature and second shows wave nature of light. Wave length of various colors in visible spectrum is difficult to measure accurately. But general wave length ranges of standard colors can be considered in nm as below.

Violet	Blue	Green	Yellow	Orange	Red
380-450	*450-495*	*495-570*	*570-590*	*590-620*	*620-750*

In order to know formation of image it is mandatory to know types of objects based on reaction with light waves. They can be classified into two type as follows:
1. Self luminous objects
2. Non self luminous objects

Self luminous object emits light waves and is referred as Light source. Characteristics of light source can be represented with Spectral Power Distribution(SPD) curve denoted as E(λ). Similarly Non self luminous object is unable to emit light waves, but has capability of reflecting light waves that are incident on it. Reflectance ability of non self luminous object is measured with surface reflectance equation S(λ). Consider Energy dissipated by any light source as SPD E(λ). When light wave incident on non self luminous object having surface reflectance S(λ), then light will be reflected by the surface of the object. Finally this reflected wave is perceived by human eye or camera as Color function C(λ) with cone function q(λ). According to human vision system this color function is visualized by three color components Red, Green and Blue with the help of three types of cones attached to Retina. These three color components are represented as follows:

$$C_R(\lambda) = \int E(\lambda).S(\lambda).q_R(\lambda).d\lambda$$

$$C_G(\lambda) = \int E(\lambda).S(\lambda).q_G(\lambda).d\lambda$$

$$C_B(\lambda) = \int E(\lambda).S(\lambda).q_B(\lambda).d\lambda$$

Where E(λ) is SPD of light source, S(λ) is reflectance of object and q(λ)=$[qR(\lambda),qG(\lambda),qB(\lambda)]^T$ is cone function of human eye. In human vision system C(λ)=$[CR(\lambda),CG(\lambda),CB(\lambda)]^T$ is perceived by cones and these analog signals are sent to Brain for processing.

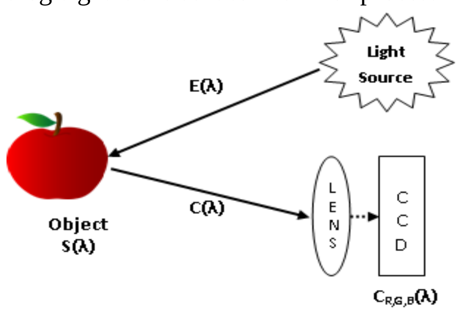

Fig 1.3: Color image capturing process

Similarly, in case of Camera system this color information C(λ) will be captured by conventional Charge Coupled Device (CCD) or CMOS sensor. Color is given by putting filter in front of sensor with particular pattern of Red, Green and Blue filters one for each sensor pixel known as Bayer Filter. Entire process of color image capturing can be seen in Fig 1.3.

C. Analog and Digital Image representation

CCD sensor receives color information of each and every pixel as two dimensional array. This sensor is an analog device which produce analog values of pixel. The signals captured from this CCD sensor will be focused directly on a transparent plastic film coated with light sensitive gelatin emulsion in case of old cameras. Later the plastic film will be developed to take print out of the photo graph or image captured from camera. Such cameras are also known as Analog camera and this process is known as Analog image representation.

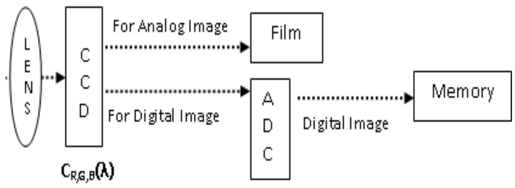

Fig 1.4: Analog and Digital image storage

Upper portion of Fig 1.4 shows process for storing Analog image directly on Film coated with light sensitive emulsion. Digital image representation requires one more steps after capturing Color image information from CCD sensor as shown in lower portion of Fig 1.4. Analog to Digital Converter(ADC) attached to CCD sensor is used to convert Analog image to Digital image. Finally this digital image can be stored in memory.

II. COLOR MODELS

Color model[1,4] is abstract mathematical model describing the way colors can be represented as tuple of numbers. It is specification of three dimensional coordinate system and subspace within that system where each color is represented by single point. Consider there are three types of Cones in Human vision system to recognize Red, Green and Blue colors respectively. That's why these three colors are known as Primary colors. Similarly, Cyan, Magenta and Yellow colors are known as Secondary color model because these colors are formed by mixing any two primary colors. Combining Red and Green gives Yellow, Green and Blue gives Cyan and Blue and Red gives Magenta. When we combine all the three primary colors gives White and opposite to this is Black color. These two colors can be considered as basic colors of light. Color co-ordinate values can be represented in different ways. But, a standard and normalized representation uses Black color with value 0 which is minimum intensity level and White color with value 1 which is maximum intensity level. The values between 0 to 1 gives millions of colors. Similarly, when we want to represent a color co-ordinate with 8-bit values then minimum intensity value is 0 and maximum intensity

ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 3, March 2014

value is 2^8-1=255. Color models can be classified into two types depending on type of data as follows:

1. **Image Color models**: These color models are intended for representation of Images only. Image representation mainly concentrates on quality of image data.
2. **Video Color models**: These color models are intended for representation of Video. Video representation considers more on minimization of band width for transfer of video signals instead of quality. This reason made to use special category of video color models instead of Image color models.

III. IMAGE COLOR MODELS

A. RGB color model

RGB color model is represented with three primary colors and is considered as Primary color model even though there are several color models. RGB Color model [1,2,3] is an additive Color model in which Red, Green and Blue light are added together to reproduce a broad array of colors. RGB is device dependent color model with color representation as shown in Fig 3.1.

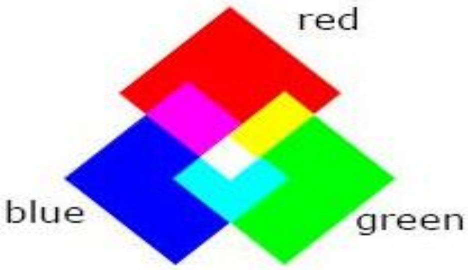

Fig 3.1: RGB color model

In order to form a color with RGB, three color light beams of Red, Green and Blue must be superimposed. Summary of RGB color model is as follows:

Color Components

Red (R) [0 to 255]
Green (G) [0 to 255]
Blue (B) [0 to 255]

Fundamental Colors Representation [R,G,B]

Color	R	G	B
Black	0	0	0
White	255	255	255
Red	255	0	0
Green	0	255	0
Blue	0	0	255
Cyan	0	255	255
Magenta	255	0	255
Yellow	255	255	0

Zero intensity for each channel gives the darkest color i.e. No light which is considered as Black color. Similarly, maximum intensity of each color channel gives White color. Quality of this White color depends on the nature of primary light sources. When intensity of all channels is same, then resulting color becomes shades of Gray. Darkness or Lightness of Gray depends on the intensity of color channels. When intensity of channels is different, then result is colorized depending on levels of intensities of primary colors employed. RGB color model is the basic representation for various other color models, because it is derived from human eye system. Depending on requirements of the applications there are several types of color models can be considered. Each of these color models can be obtained from RGB color model using simple matrix transformations.

There are some other RGB color spaces are available which includes:

- **Standard RGB(sRGB)**: It is created by Hewlett Packard(HP) and Microsoft Corporation for use on Internet. It is intended as common color space for creation of images for viewing Internet and World Wide Web.
- **Adobe RGB**: It is created by Adobe System in 1998. It was designed to encompass most of colors achievable on CMYK color printers, but by using RGB primary colors on device.
- **Adobe Wide Gamut RGB**: It is also developed by Adobe System as an alternative to sRGB. It is able to store wide range of color values than sRGB which is an extended version of Adobe RGB.

B. CMY and CMYK color model

CMY color model[1,2,3] is subtractive color model means that when Cyan, Magenta an Yellow inks are applied to a white surface to subtract some color from white surface to create final color.

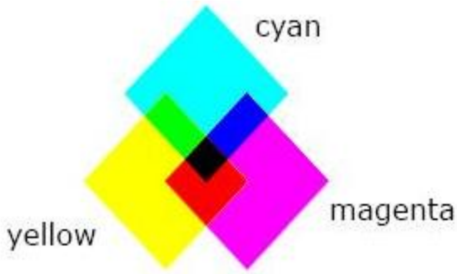

Fig 3.2: CMY color model

CMY also device dependent color model with color representation shown in Fig 3.2. Color co-ordinate values in CMY color model is opposite to the RGB color can obtain by simple subtraction of RGB value from Maximum value of Color co-ordinate. Summary of CMY color model is as follows:

Color Components

Cyan (C) [0 to 255]
Magenta (M) [0 to 255]
Yellow (Y) [0 to 255]

Fundamental Colors Representation [C,M,Y]

Color	C	M	Y
Black	255	255	255
White	0	0	0
Red	0	255	255
Green	255	0	255
Blue	255	255	0
Cyan	255	0	0

ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 3, March 2014

Magenta	0	255	0
Yellow	0	0	255

RGB to CMY Transformation

C = 1 - (R / 255)
M = 1 - (G / 255)
Y = 1 - (B / 255)

CMYK color model [1,2,3] is a subset of RGB model and is primarily used in color print production. CMYK is an acronym for Cyan, Magenta and Yellow along with Black (noted as K). CMYK color model is subtractive model as CMY. Black color generated by mixing commercially practical Cyan, Magenta and Yellow inks is unsatisfactory, so four-color printing uses black ink in addition to the subtractive primaries. Advantage of CMYK is pure black color can be printed due to use of Black color ink as separate component. Summary of CMYK color model is as follows:

Color Components

Cyan (C) [0 to 255]
Magenta (M) [0 to 255]
Yellow (Y) [0 to 255]
Key or Black (K) [0 or 1]

Fundamental Colors Representation [C,M,Y,K]

Color	C	M	Y	K
Black	0	0	0	1
White	0	0	0	0
Red	0	255	255	0
Green	255	0	255	0
Blue	255	255	0	0
Cyan	255	0	0	0
Magenta	0	255	0	0
Yellow	0	0	255	0

RGB to CMYK Transformation

K=min{C,M,Y}
Case 1: If K is equal to 1
C=M=Y=0
Case 2: If K is not equal to 1
C = (255 - R) - K
M = (255 - G) - K
Y = (255 - B) – K

C. CIE XYZ and CIE RGB color model

CIE XYZ [1,2,3] is one of the first mathematically defined color spaces created by International Commission on Illumination in 1931. XYZ color space is an international standard developed by CIE (Commission Internationale del'Eclairage). CIE color matching function $\bar{x}(\lambda)$, $\bar{y}(\lambda)$ and $\bar{z}(\lambda)$ are the numerical description of chromatic response of observer. For general Spectral Power Distribution E(λ), the essential colorimetric information required to characterize color is set of tri-stimulus values X, Y and Z defined as follows:

$$X = \int E(\lambda).\bar{x}(\lambda).d\lambda$$
$$Y = \int E(\lambda).\bar{y}(\lambda).d\lambda$$
$$Z = \int E(\lambda).\bar{z}(\lambda).d\lambda$$

CIE XYZ primaries are hypothetical because they do not correspond to any real light wavelengths. The Y primary is intentionally defined to match closely to Brightness or luminance, while X and Z primaries give Color information or Chromaticity. Since the human eye has three types of color sensors that respond to different ranges of wavelengths, full plot of all visible colors is three dimensional diagram known as CIE chromaticity diagram as shown in Fig 3.2.

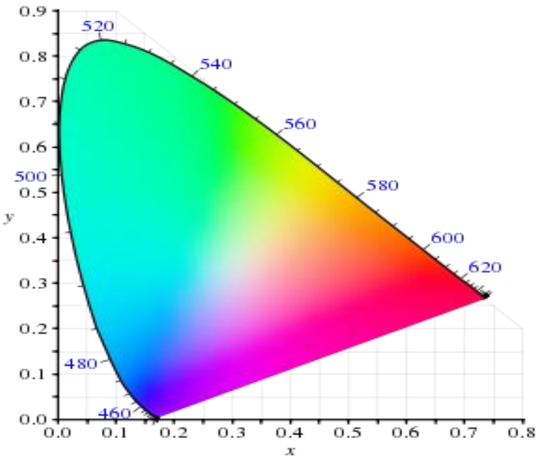

Fig 3.2: CIE chromaticity diagram

CIE XYZ model uses gamma corrected RGB for transformation. Photoshop uses CIE XYZ when it converts from RGB color mode to the CMYK color mode. Gamma corrected RGB values R',G',B' are used for CIE XYZ transformation. CIE XYZ is device independent model and summary is as follows:

Color Components

Luminance (Y) [0 to 100]
Chrominance (X and Z) [0 to 255]

Fundamental Colors Representation [X,Y,Z]

Color	X	Y	Z
Black	0	0	0
White	95.05	100	108.89999
Red	41.24	21.26	1.93000
Green	35.76	71.52	11.92
Blue	16.05	7.22	95.05
Cyan	53.81	78.74	106.97
Magenta	59.29	26.48	96.98
Yellow	77.00	92.78	13.85

RGB to XYZ Transformation

X = 0.4124*R' + 0.3576*G' + 0.1805*B'
Y = 0.2126*R' + 0.7152*G' + 0.0722*B'
Z = 0.0193*R' + 0.1192*G' + 0.9505*B'

D. CIE LUV and CIE LAB color model

CIE LUV and CIE LAB color model [3,5,6] are considered to be perceptually uniform and are referred to uniform color models. Both are uniform derivations from standard CIE XYZ space. Perceptually uniform means that two colors that are equally distant in color space are equally distant perceptually.

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 3, March 2014

ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940

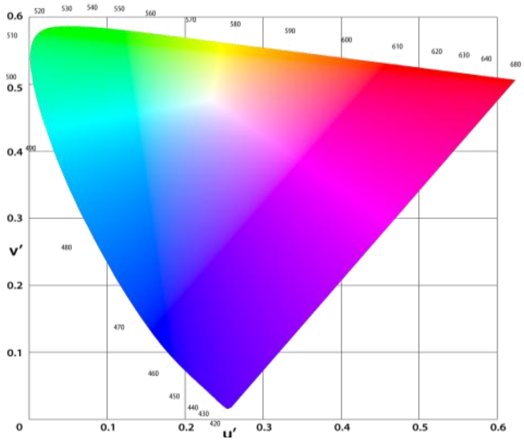

Fig 3.3: CIE LUV color model

Common consideration for both LUV and LAB:
X_n=95.047, Y_n=100, Z_n=108.883
Summary of CIE LUV color modes is as follows:

Color Components
Luminance (L) [0 to 100]
Chrominance (U and V) [0 to 255]

Fundamental Colors Representation [L,U,V]

Color	L	U	V
Black	0	0	0
White	100	0.00089	-0.01710
Red	53.23286	175.05303	37.75050
Green	87.73703	-83.07975	107.40136
Blue	32.30258	-9.39986	-130.35840
Cyan	91.11652	-70.47243	-15.21697
Magenta	60.31993	84.07466	-106.71158
Yellow	97.13824	7.70296	106.78912

CIE XYZ to CIE LUV Transformation

$$L = 116 * \left(\frac{Y}{Yn}\right)^{(1/3)} - 16$$

$$U = 13 * L * \left[\left(\frac{4*X}{(X+15*Y+3*Z)}\right) - \left(\frac{4*X_n}{(X_n+15*Y_n+3*Z_n)}\right)\right]$$

$$V = 13 * L * \left[\left(\frac{9*Y}{(X+15*Y+3*Z)}\right) - \left(\frac{9*Y_n}{(X_n+15*Y_n+3*Z_n)}\right)\right]$$

In CIE LAB, value of Luminance (L) range from 0 to 100. It is solid at each L brightness level and more washed out colors nearer the central achromatic axis. Range of A values is –A to +A which correspond from Green and Red. Similarly, range of B values is –B to +B which correspond from Blue to Yellow. CIE LAB model is shown in Fig 3.4.

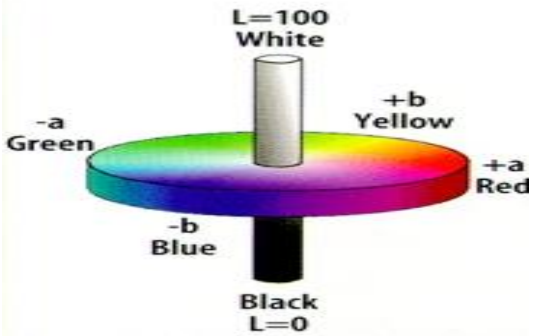

Fig 3.4: CIE LAB color model

Summary of CIE LAB color modes is as follows:
Color Components
Luminance (L) [0 to 100]
Chrominance (A and B) [-128 to +128]

Fundamental Colors Representation [L,A,B]

Color	L	A	B
Black	0	0	0
White	100	0.00526	-0.0104
Red	53.23288	80.10930	67.22006
Green	87.73703	-86.18463	83.18116
Blue	32.30258	79.19666	-107.86368
Cyan	91.11652	-48.07961	-14.13812
Magenta	60.31993	96.25421	-60.84298
Yellow	97.13824	-21.55590	94.48248

CIE XYZ to CIE LAB Transformation

$$\left[L = 116 * \left(\frac{Y}{Y_n}\right)^{(1/3)} - 16\right]$$

$$A = 500 * \left[\left(\frac{X}{X_n}\right)^{(1/3)} - \left(\frac{Y}{Y_n}\right)^{(1/3)}\right]$$

$$B = 200 * \left[\left(\frac{Y}{Y_n}\right)^{(1/3)} - \left(\frac{Z}{Z_n}\right)^{(1/3)}\right]$$

Photoshop uses CIE LAB as a reference color space when it converts from one RGB profile to another RGB color space.

It is possible to use the CIELAB color space for image editing in Photoshop, although few choose it for that purpose since it is not as easy to understand as the other color models.

E. HSV and HSL color model

HSV and HSL color models [3,5,6] were developed to be more intuitive in manipulating with color and to approximate way humans perceive and interpret color.

Hue(H) defines color if self. Values for Hue axis vary from 0 to 360 beginning and ending with Red and Running through Green , Blue and all intermediary colors.

Saturation(S) indicates degree to which Hue differs from neutral Gray. The values run from 0(Color saturation) to 1(Fullest saturation). It is also referred as Chroma.

Intensity components: Value(V) in case of HSV and Lightness(L) in case of HSL indicates illumination level. Both varies from 0 (Black or no light) to 1(White or full illumination).

HSV is essentially cylinder but usually it is represented as Cone or Hexagonal Cone as shown in Fig 3.5. Value(V) is vertical axis, radius of cone represents Chroma or Saturation(S) and Circular angle represents Hue(H).

ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 3, March 2014

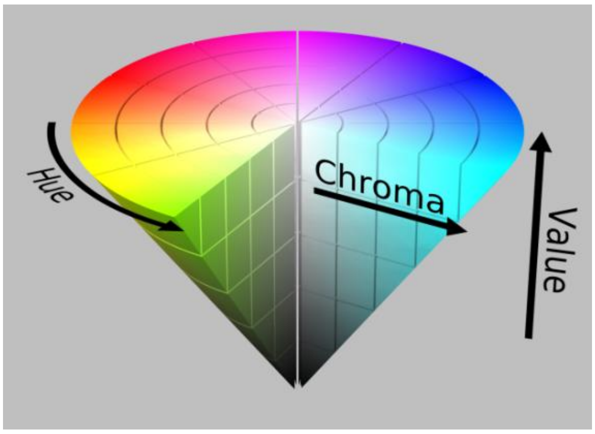

Fig 3.5: HSV color model

Common considerations for both HSV and HSL:

C_{Min}=min{R, G, B}

C_{Max}=max{R, G, B}

C=C_{Max}-C_{Min}

Where $D_R = \dfrac{\left(\frac{C_{Max}-R}{6}\right)+\left(\frac{C}{2}\right)}{C}$, $D_G = \dfrac{\left(\frac{C_{Max}-G}{6}\right)+\left(\frac{C}{2}\right)}{C}$, $D_B = \dfrac{\left(\frac{C_{Max}-B}{6}\right)+\left(\frac{C}{2}\right)}{C}$

Summary of HSV model is as follows:

Color Components

Hue(H) [0° to 360°]

Saturation(S) [0 to 100]

Value(V) [0 to 100]

Fundamental Colors Representation [H,S,V]

Color	H	S	V
Black	0	0	0
White	0	0	1
Red	0	1	1
Green	120	1	1
Blue	240	1	1
Cyan	180	1	1
Magenta	300	1	1
Yellow	60	1	1

RGB to HSV Transformation

Case 1: If C_{Max} is equal to 0

H=S=0

V=C_{Max}

Case 2: If C_{Max} is not equal to 0

$$H=\begin{cases} D_B - D_G & If \quad C_{Max}=R \\ \frac{1}{3}+D_R - D_B & If \quad C_{Max}=G \\ \frac{2}{3}+D_G - D_R & If \quad C_{Max}=B \end{cases}$$

$$S=\frac{C}{C_{Max}}$$

V= C_{Max}

HSL is double hexagonal cone as shown in Fig 3.6. In this color model Vertical axis represents Lightness(L), Radius of the cone denotes Chroma or Saturation (S) and Circular anlage gives Hue (H).

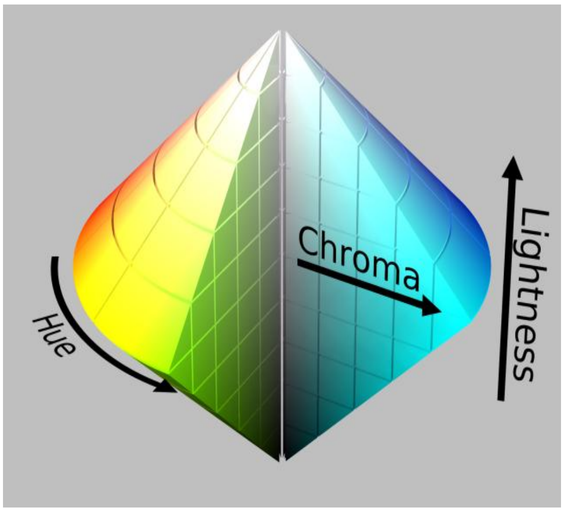

Fig 3.6: HSL color model

Summary of HSL color model is as follows:

Color Components

Hue(H) [0° to 360°]

Saturation(S) [0 to 100]

Lightness(L) [0 to 100]

Fundamental Colors Representation [H,S,L]

Color	H	S	L
Black	0	0	0
White	0	0	100
Red	0	100	50
Green	120	100	50
Blue	240	100	50
Cyan	180	100	50
Magenta	300	100	50
Yellow	60	100	50

RGB to HSV Transformation

Case 1: If C_{Max} is equal to 0

H=S=0

$$L=\frac{C_{Max}+C_{Min}}{2}$$

Case 2: If C_{Max} is not equal to 0

$$H=\begin{cases} D_B - D_G & If \quad C_{Max}=R \\ \frac{1}{3}+D_R - D_B & If \quad C_{Max}=G \\ \frac{2}{3}+D_G - D_R & If \quad C_{Max}=B \end{cases}$$

ISSN (Online) : 2278-1021
ISSN (Print) : 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 3, Issue 3, March 2014

$$S=\begin{cases}\dfrac{C}{C_{Max}} & If \quad L<0.5\\[2ex] \dfrac{C}{2-C_{Max}-C_{Min}} & Otherwise\end{cases}$$

$$L=\frac{C_{Max}+C_{Min}}{2}$$

IV. VIDEO COLOR MODELS

A. YUV color model

YUV color model[1,5] is the basic color model used in analog color TV broadcasting. Initially YUV is the re-coding of RGB for transmission with minimum bandwidth and for downward compatibility with Black and White television.

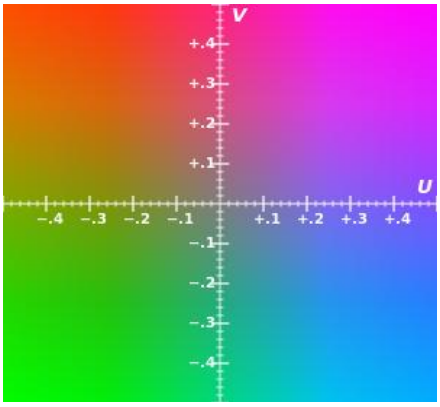

Fig 4.1: UV plane for Y' value as 0.5

It is derived from the RGB which comprises the Luminance (Y) and two Color difference U and V components. Luminance(Y) can be computed as a weighted sum of Red, Green and Blue components ranges from 0 to 1. Similarly, UV representation of chrominance was chosen over straight R and B signals because U and V are color difference signals ranges from -1 to +1. UV plane for given Y' value of 1 is shown in Fig 4.1.

Advantage of YUV model in image processing is decoupling of luminance and color information. The importance of this decoupling is that the luminance component of an image can be processed without affecting its color component. YUV color space can be obtained from gamma corrected RGB. Summary of YUV color model is shown below:

Color Components

Luminance (Y) [0 to 1]
Chrominance (U and V) [-0.5 to 0.5]

Fundamental Colors Representation [Y,U,V]

Color	Y	U	V
Black	0	0	0
White	1	0.001	0
Red	0.299	-0.147	0.615
Green	0.587	-0.289	-0.515
Blue	0.114	0.437	-0.100
Cyan	0.701	0.148	-0.615
Magenta	0.413	0.290	0.515
Yellow	0.886	-0.436	0.100

RGB to YUV Transformation

Y = 0.299*R + 0.587*G + 0.114*B
U = -0.14713*R - 0.28886*G + 0.436*B
V = 0.615*R - 0.51499*G - 0.10001*B

B. YIQ color model

YIQ color model [1,5] is used by NTSC color TV system employed mainly in North and Central America and Japan. In this model Y stands for Luminance and is only component used by Black and White television receivers. I and Q represents chrominance information where I stands for In-phase while Q stands for Quadrature referring to components used in Quadrature amplitude modulation. It is intended to take advantage of human color response characteristics. Eye is more sensitive to changes in Orange-Blue(I) range than Purple-Green(Q) range. Therefore less band width is required for Q than I

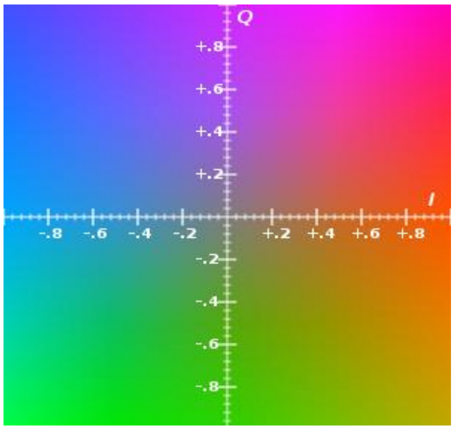

Fig 4.2: IQ plane for Y' value as 0.5

YIQ color space can be obtained from gamma corrected RGB. Summary of YIQ models is as shown below:

Color Components

Luminance (Y) [0 to 1]
Chrominance (I) [-0.523 to 0.523]
Chrominance (Q) [-0.596 to 0.596]

Fundamental Colors Representation [Y,I,Q]

Color	Y	I	Q
Black	0	0	0
White	1	0	0
Red	0.299	0.596	0.212
Green	0.587	-0.274	-0.523
Blue	0.114	0.437	-0.100
Cyan	0.701	-0.596	-0.212
Magenta	0.413	0.274	0.523
Yellow	0.886	0.322	-0.311

RGB to YIQ Transformation

Y = 0.3*R+0.59*G+ 0.11*B
I = 0.6*R- 0.28*G- 0.32*B
Q = 0.21*R- 0.52*G+ 0.31*B

C. YCbCr or YPbPr color model

YCbCr color model [1,5] is used for component digital video and was developed as part of ITU-R BT.601 recommendation. It is scaled and offset version of YUV color space. It is not an absolute color space, rather it is way of encoding RGB information. The actual color displayed depends on actual RGB primaries used to display signal. CbCr plane for the given Y' value as 0.5 is shown in Fig 4.3.

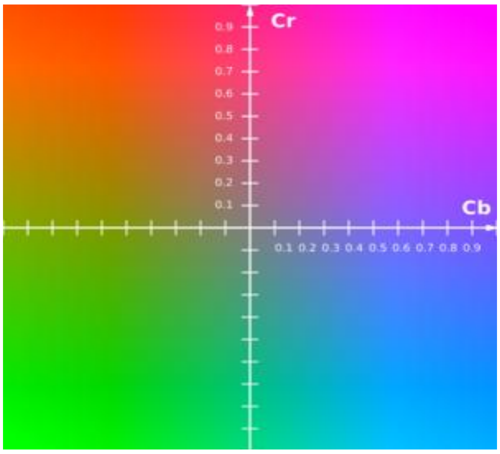

Fig 4.3: CbCr plane for Y' value as 0.5

Y'CbCr was defined for Standard Definition Television(SDTV) for use with digital component video is derived from corresponding RGB space as follows:
K_B=0.114, K_R=0.299

From the above constants, Analog YPbPr from analog R'G'B' are derived as follows:
Y'= 0.299*R'+ 0.587*G'+ 0.114*B'
Pb=-0.168736*R'-0.331264*G'+ 0.5*B'
Pr= 0.5*R'-0.418688*G'-0.081312*B'

Similarly, Digital YCbCr are derived from analog R'G'B' as follows for 8 bits per sample:
Y'= 16+(65.481*R'+128.553*G'+24.966*B')
Cb=128+(-37.797*R'- 74.203*G'+ 112.0*B')
Cr= 128+(112.0*R'- 93.786*G'- 18.214*B')
Summary of YCbCr model is as follows:

Color Components
Luminance (Y) [0 to 255]
Chrominance (Cb and Cr) [0 to 255]

Fundamental Colors Representation [Y,Cb,Cr]

Color	Y	Cb	Cr
Black	16	128	128
White	235	128	128
Red	82	90	240
Green	145	54	34
Blue	41	240	110
Cyan	170	166	16
Magenta	107	202	222
Yellow	210	16	146

Other version of YCbCr are as follows:

- **Photo YCC**: Kodak Photo YCC was developed for encoding Photo CD image data. It is based on both ITUR recommendations 601 and 709 using Luminance-Chrominance representation of color. It comprises Luminance(Y) and two Color difference or Chrominance (C1, C2). It is optimized for color photographic material and provides color gamut that is greater than one that can currently be displayed.
- **YCoCg**: It was developed to increase effectiveness of image compression. It compromises luminance(Y) an two color difference components: Offset orange(Co), Offset green(Cg).

V. CONCLUSION

Digital color image is the only source for many Image Processing applications. Image processing researchers usually change algorithms to improve results of processing. But, they must know the representation of color models to make processing easy. Considering the best suitable color models will simplify their work of processing because Color models are the basic for Color image representation. This paper focused on this to produce analytical review on Color models. This will the starting step to get Legible difference in processing of images and can able to predict the results.

REFERENCES

[1] Ze-Nian Li and Mark S. Drew, "Fundamentals of Multimedia", Pearson Edition
[2] Mete, M.; Topaloglu, U., "Statistical comparison of color model-classifier pairs in hematoxylin and eosin stained histological images", Computational Intelligence in Bioinformatics and Computational Biology, 2009. CIBCB '09. IEEE Symposium on , vol., no., pp.284,291, March 30 2009-April 2 2009
[3] http://software.intel.com/sites/products/documentation/hpc/ipp/ippi/ippi_ch6/ch6_color_models.html
[4] http://en.wikipedia.org/wiki/
[5] http://www.easyrgb.com/index.php
[6] http://www.picturetopeople.org/color_converter.html

BIOGRAPHY

Bala Venkateswarlu Isunuri received M. Tech. degree from Jawaharlal Nehru Technological University, India and B. Tech. degree from Acharya Nagarjuna University. Now he is working as Associate Professor in St. Ann's College of Engineering and Technology, Chirala. He has 8 years of teaching experience. His research work focuses in Computer Vision and Image Data Mining.