Image Processing and Computer Vision

Prof. (Dr.) Deepali S. Jadhav
Dept. of Information Technology,VIT,Pune

COLOUR IMAGE PROCESSING

- Mainly there are two areas-

- Full colour Processing -It is used for full colour analysis. Images acquired with full colour sensor.

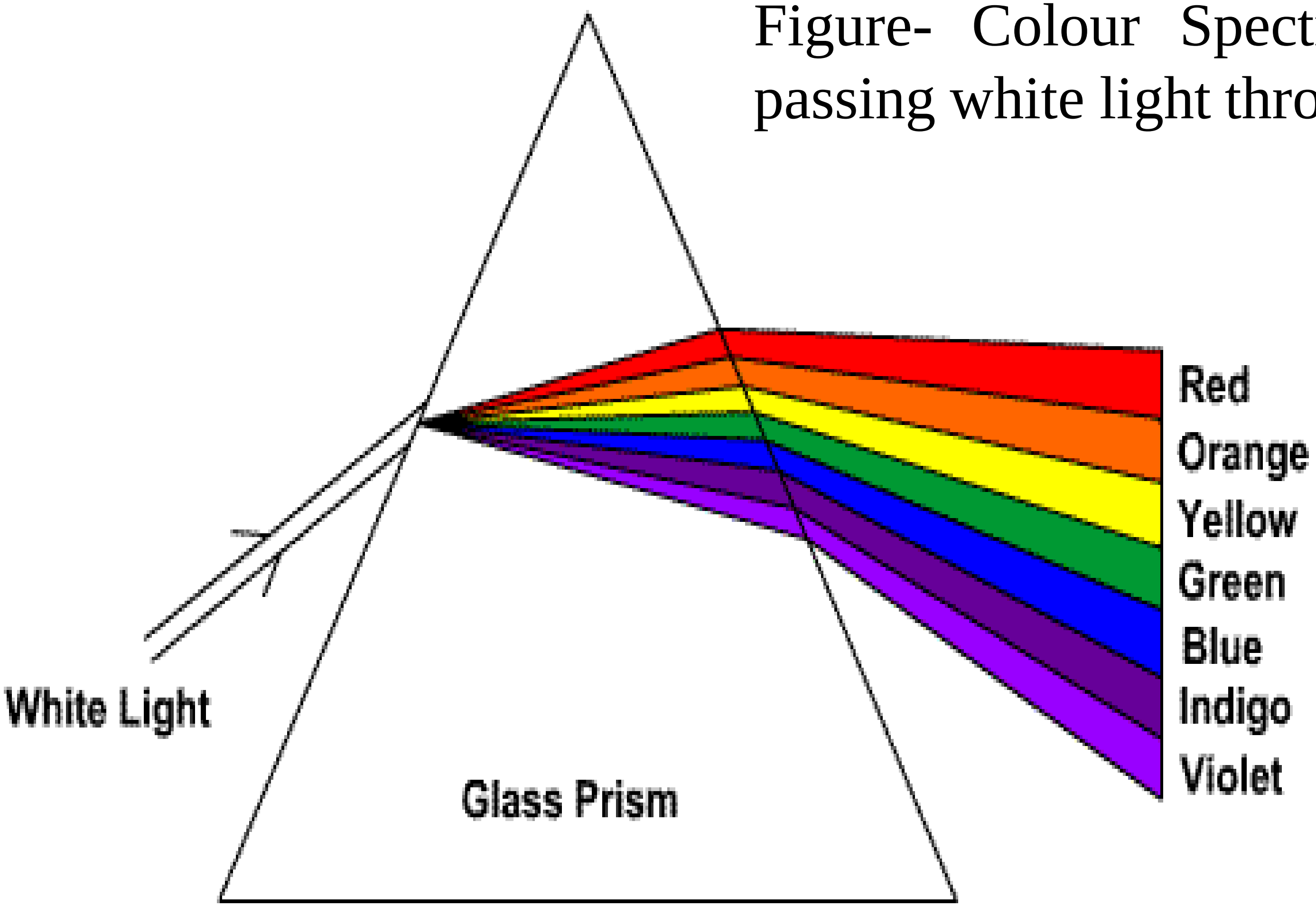
- Pseudo colour Processing- The process of adding colour to a gray scale image is called pseudo colour or false colour.

It is used for Human Interpretation purpose.

Prof. (Dr.) Deepali S. Jadhav
Dept. of Information Technology,VIT,Pune

COLOUR SPECTRUM

Figure- Colour Spectrum seen by passing white light through a Prism



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Dept. of Information Technology,VIT,Pune

ELECTROMAGNETIC SPECTRUM

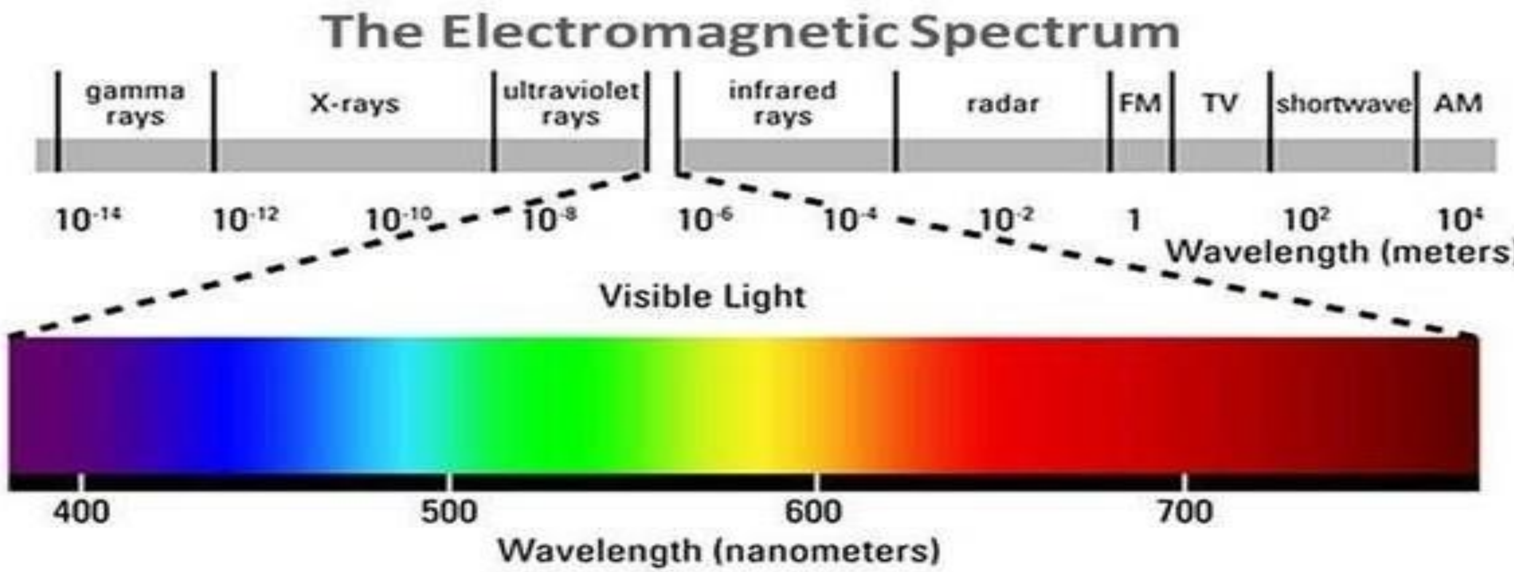

Figure -Wavelength comprising the visible range of the electromagnetic Spectrum

QUALITY OF COLOUR

- Radiance- It is the total amount of energy i.e. come out from light source. It is measured in unit of watts.
- Luminance- It is amount of an energy perceived by an observer. It is measured in Lumens.
- Brightness – Perceived luminance of the surrounding.
- **Contrast -Contrast** is the difference in luminance and/or colour that makes an object (or its representation in an image or display) distinguishable.

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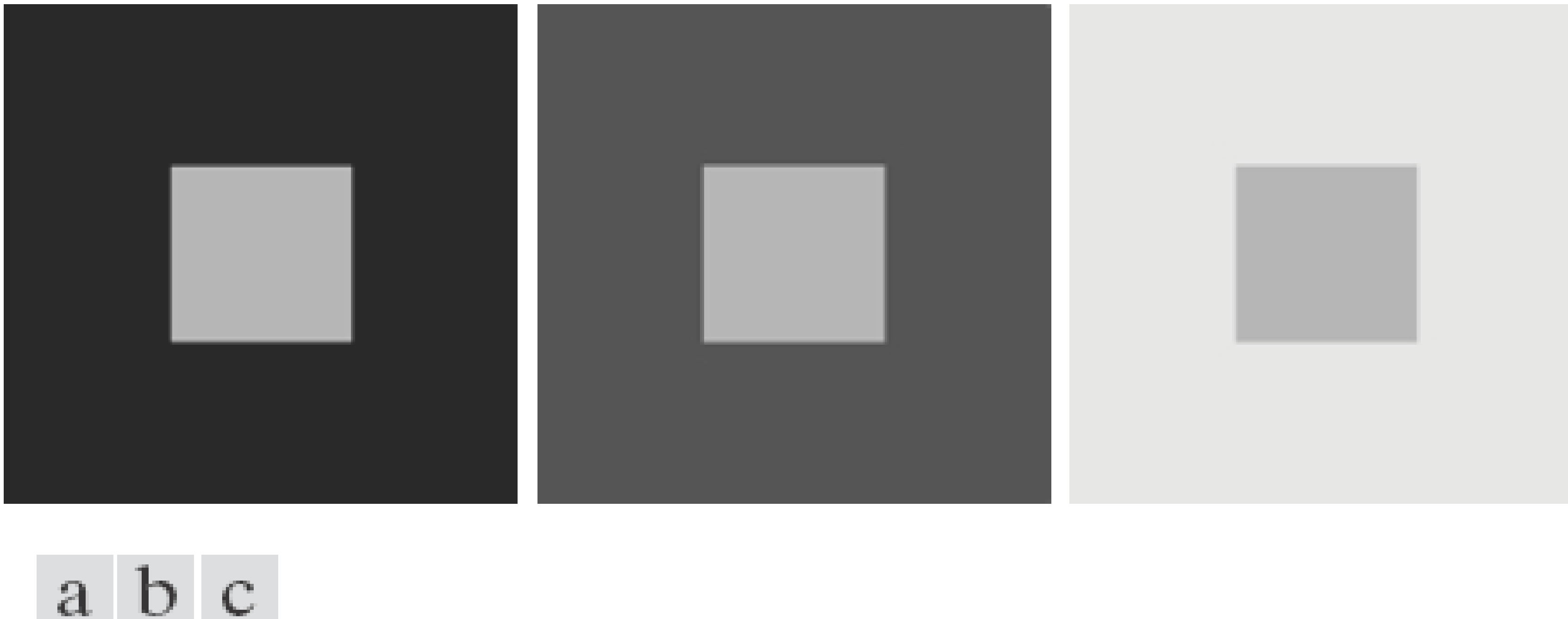
Dept. of Information Technology,VIT,Pune

QUALITY OF COLOUR

- **Contrast Example**



- Examples of simultaneous contrast. All the inner squares have the same intensity, but they appear progressively darker as the background becomes lighter.

PRIMARY COLOURS

- There are three primary colours-Red, Green Blue
- Cones-More sensitive to colour components. 6 to 7 Millions.

- 65%-Red colour
- 33%-Green Colour
- 2%-Blue Colour

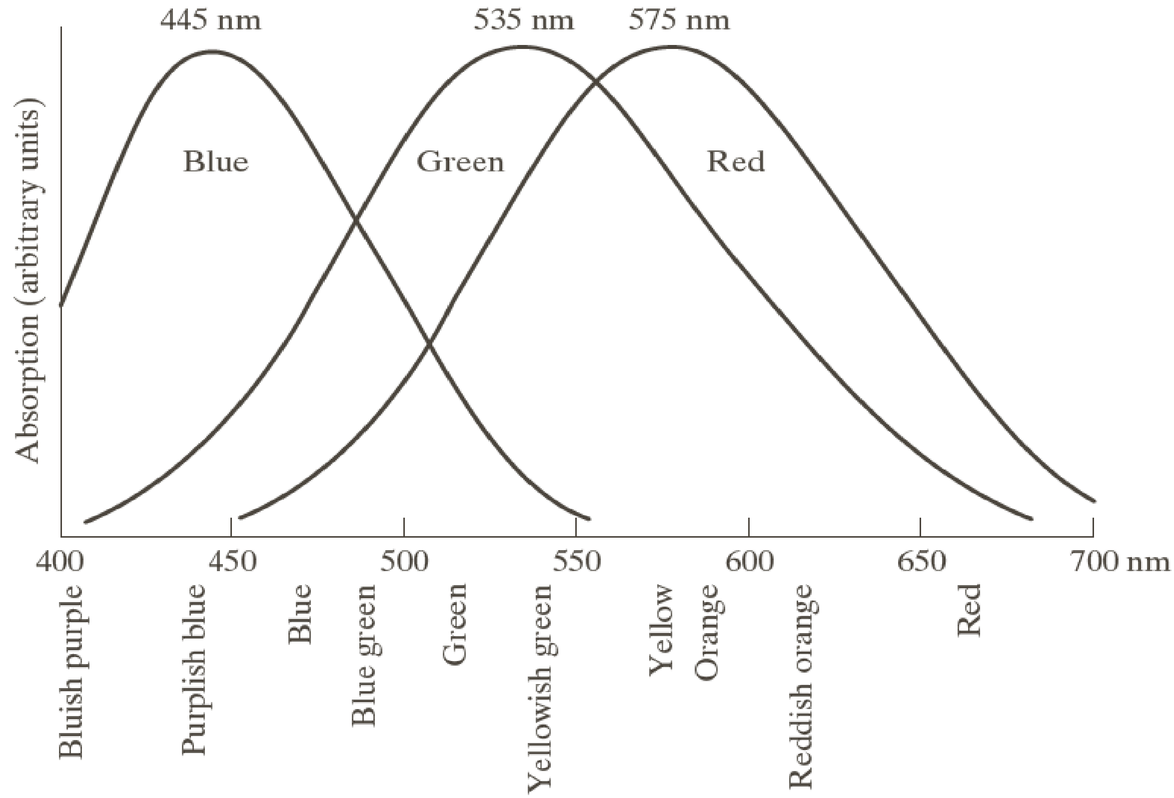
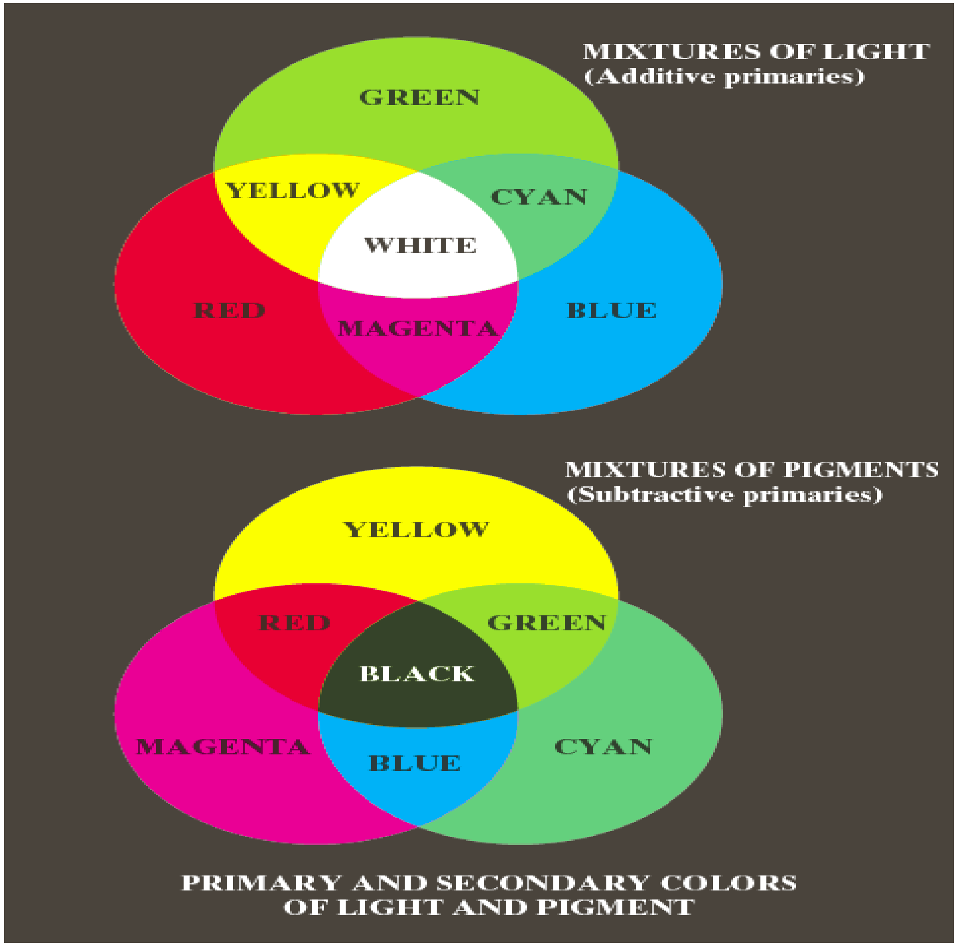


Figure- Absorption of light by the Red Green and Blue cones in the human eye as a Function of wavelength.

PRIMARY AND SECONDARY COLORS



Primary and Secondary Colours of light and Pigments

Subtractive Primaries-
Example:-Cyan=White-Red

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Dept. of Information Technology,VIT,Pune

PIGMENT

- A pigment is a material that changes the colour of reflected or transmitted light as the result of the wavelength selective absorption.
- Many materials selectively absorbs certain wavelength of light.
- A pigment must have a high tinting strength relative to the materials it colors.
- Pigments are used for coloring paints, ink, plastic, fabric, food, cosmetic and other materials.

PRIMARY AND SECONDARY COLOURS- PIGMENTS

Red + Blue → Magenta

Green + Blue → Cyan

Red + Green → Yellow

Pigments

Red

Green

Blue

Secondary Colours for Pigments

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Dept. of Information Technology,VIT,Pune

COLOR PERCEPTION

There are two types of photoreceptors

- Rods
- Cones

Rods are responsible to recognize intensity/luminance of object.

Cones are responsible to recognize colour of object.

Sensitivity of the Human eye is greatest for green light

COLOUR CHARACTERISTIC

Colour has three characteristics to specify visual information-

- Luminance-Intensity.
- Brightness-It is the perceived luminance of the surrounding.
- Hue-It is a colour attributes that describes a pure colour. It represents dominant colour as perceived by an observer.
- Saturation-It gives a measure of the degree to which a pure colour is diluted by white light. The degree of saturation is inversely proportional to the amount of white light added.

Example-Pink(white + red), Lavender (violet + white)

Prof. (Dr.) Deepali S. Jadhav
Dept. of Information Technology,VIT,Pune

COLOUR MODELS

- **RGB -Monitor**
- **CMY –Colour Printer**
- **CMYK –Colour Printer**
- These are Hardware Oriented colour model.

- **HSI-Hue Saturation and Intensity Colour model**
- It is application oriented/perception oriented.
- I- Gray scale information
- H & S- Chromatic information.

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Dept. of Information Technology,VIT,Pune

TRICHROMATIC COEFFICIENTS

- Hue and Saturation taken together are called Chromaticity (colour components).
- The amount of Red, Green, and Blue needed to form any particular colour called as-Tristimulus values(X,Y, Z).
- Its Tri-Chromatic coefficients are

$$x = X/(X+Y+Z)$$

$$y = Y/(X+Y+Z)$$

$$z = Z/(X+Y+Z)$$

It is also denoted as

$$x+y+z=1 \text{(normalize form)}$$

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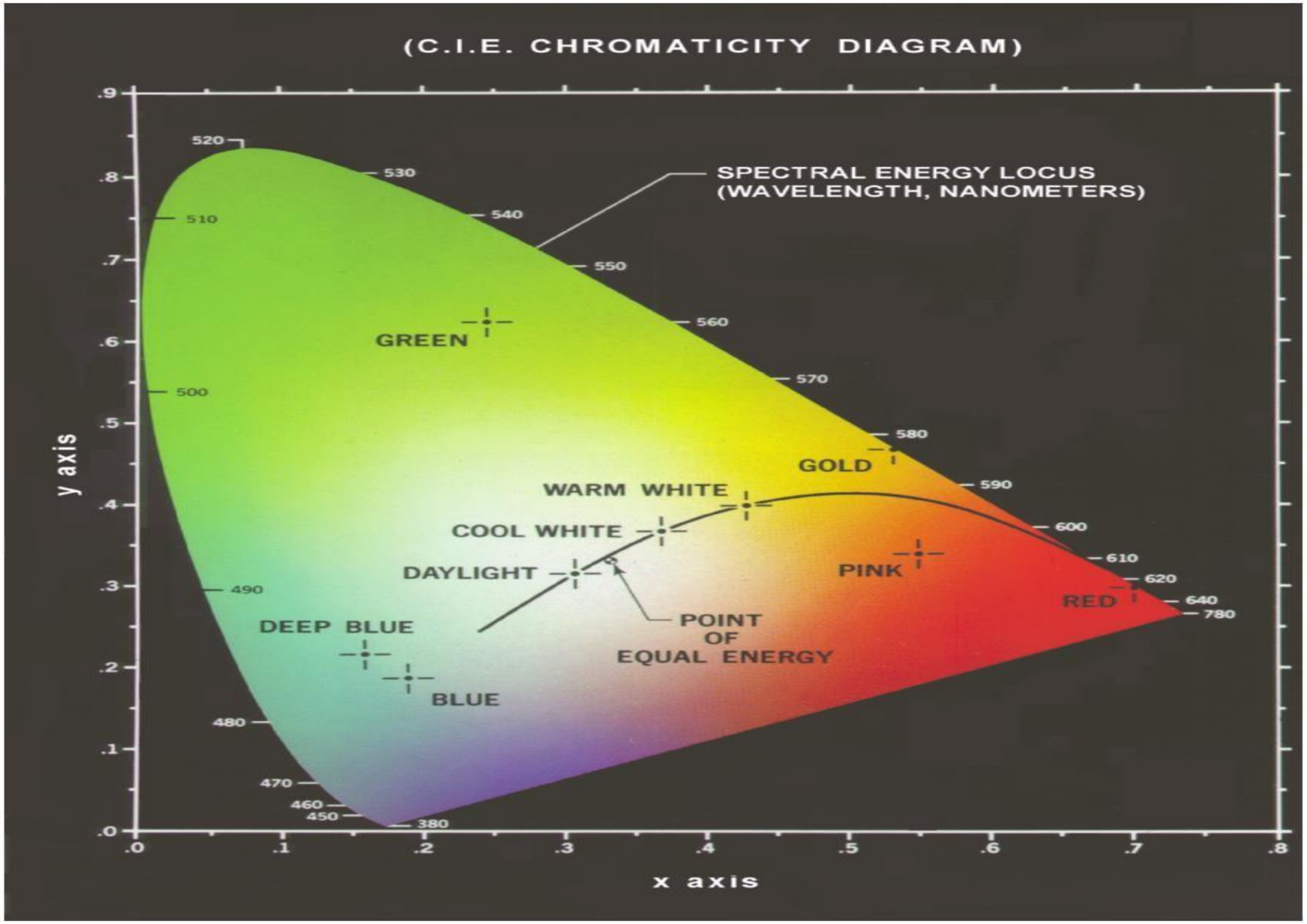
Dept. of Information Technology,VIT,Pune

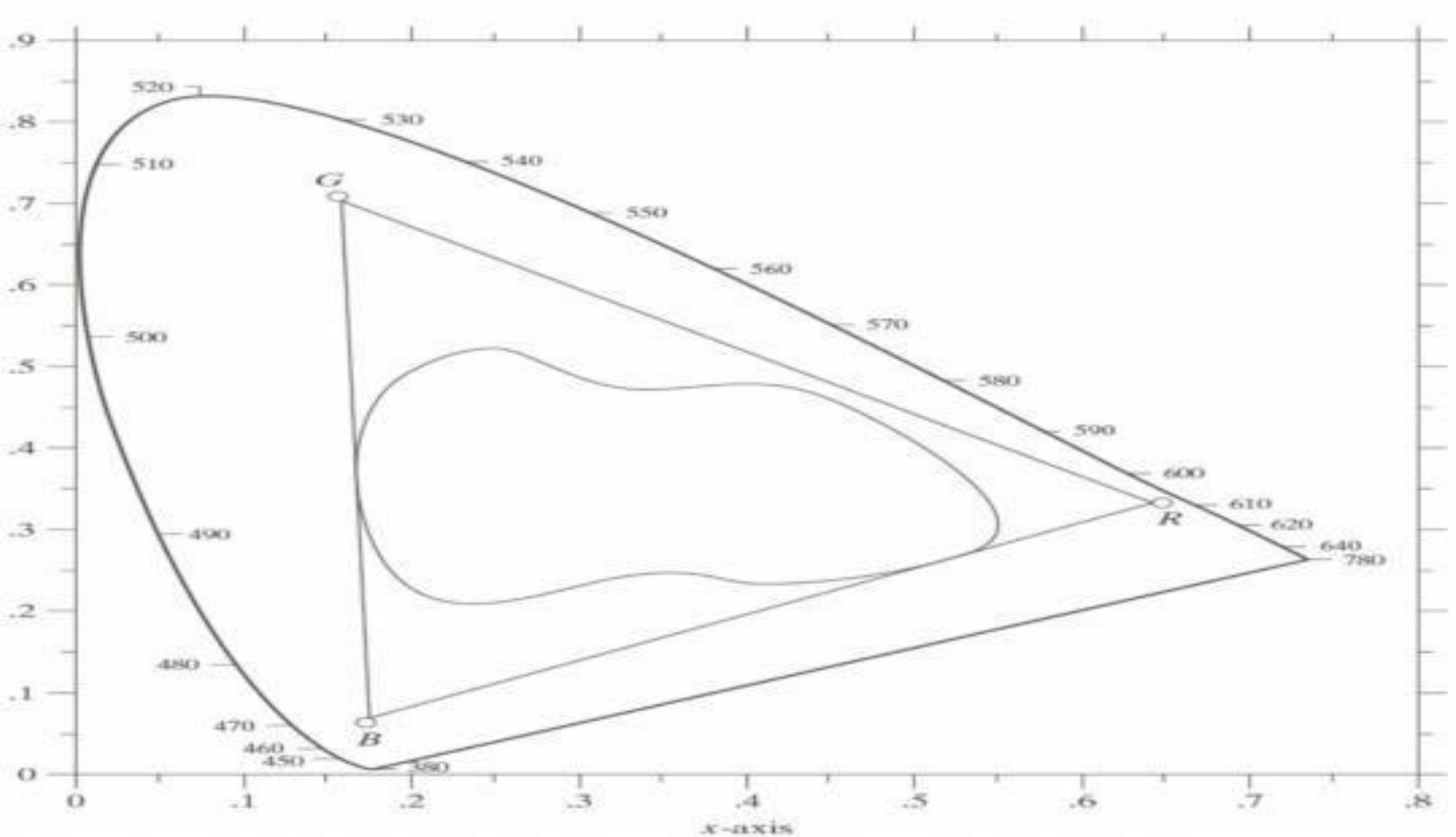
CHROMATICITY DIAGRAM- COLOUR MIXING



$Z=1-(x+y)$

C.I.E-International Commission on Illumination

CHROMATICITY DIAGRAM



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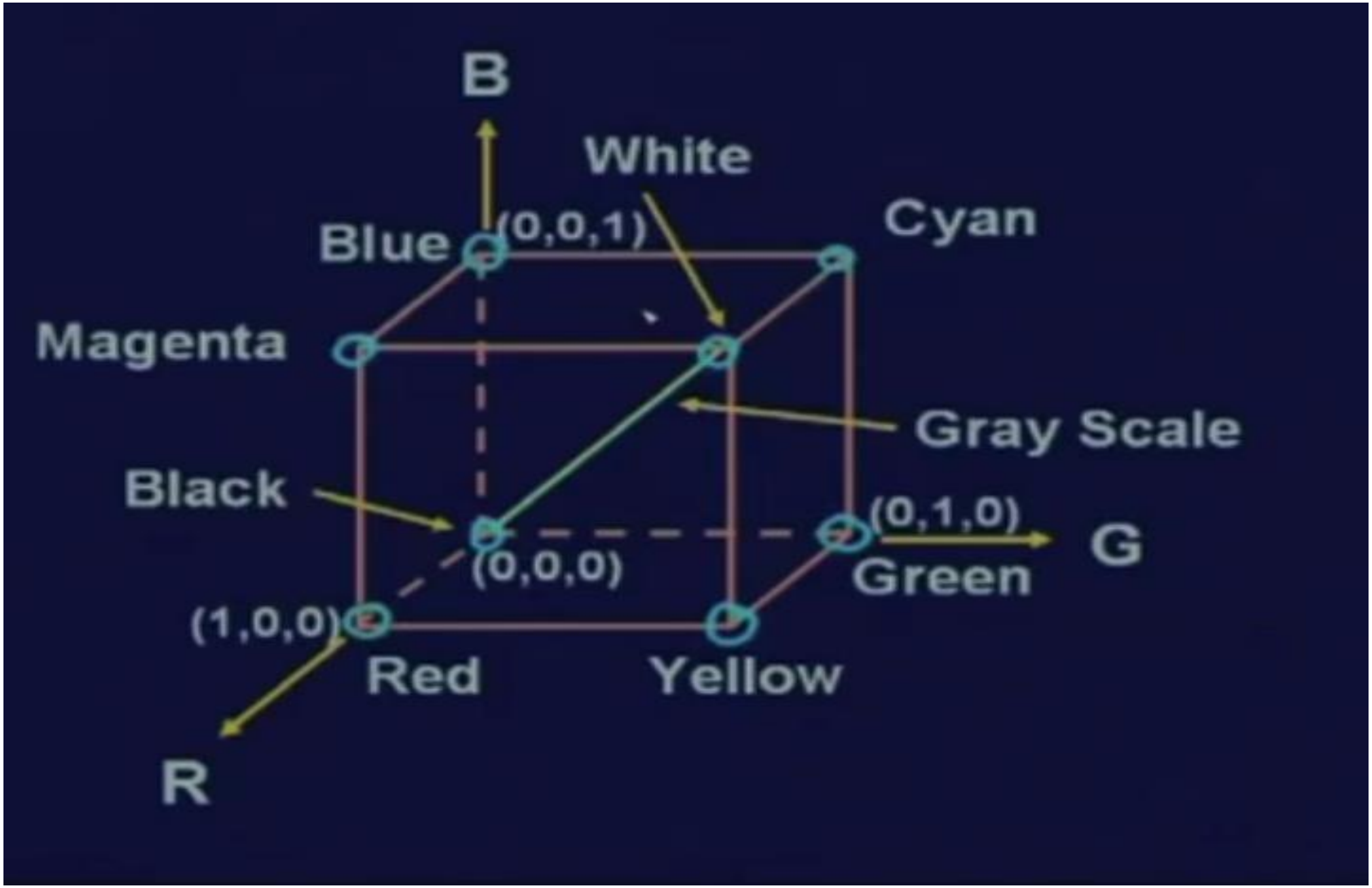
RGB COLOR CUBE-UNIT CUBE



Color model is a specification of 3D- coordinates system.

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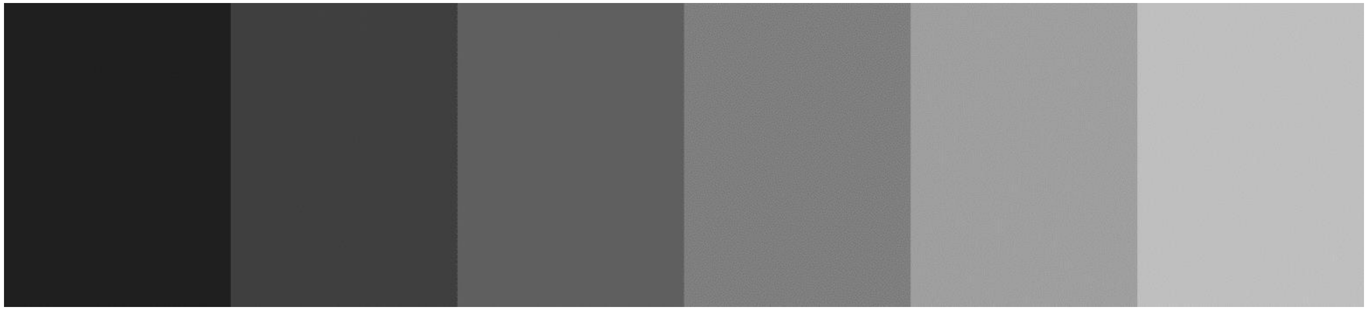
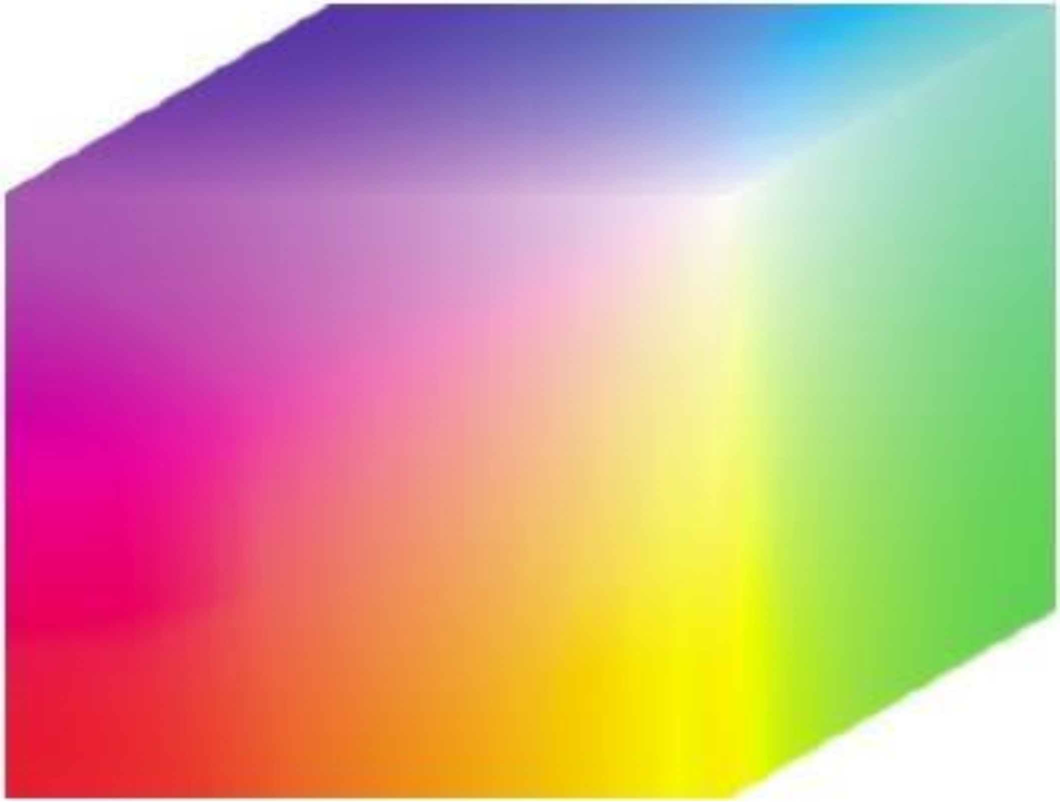
GRAY LEVEL BAND EXAMPLE



RGB COLOR CUBE



RGB 24-bit color cube.

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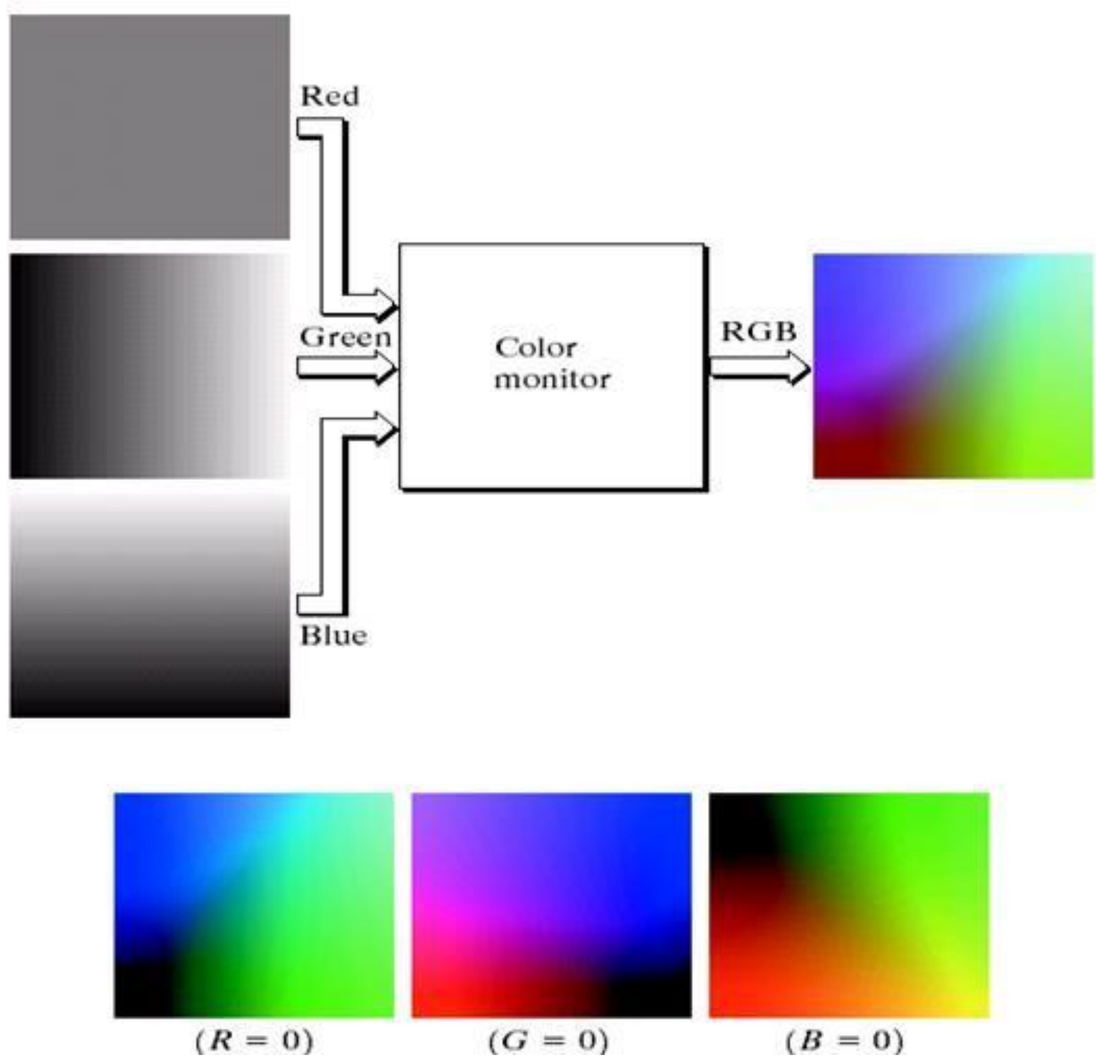
RGB COLOR GENERATION

a
b

FIGURE 6.9
(a) Generating the RGB image of the cross-sectional color plane $(127, G, B)$.
(b) The three hidden surface planes in the color cube of Fig. 6.8.



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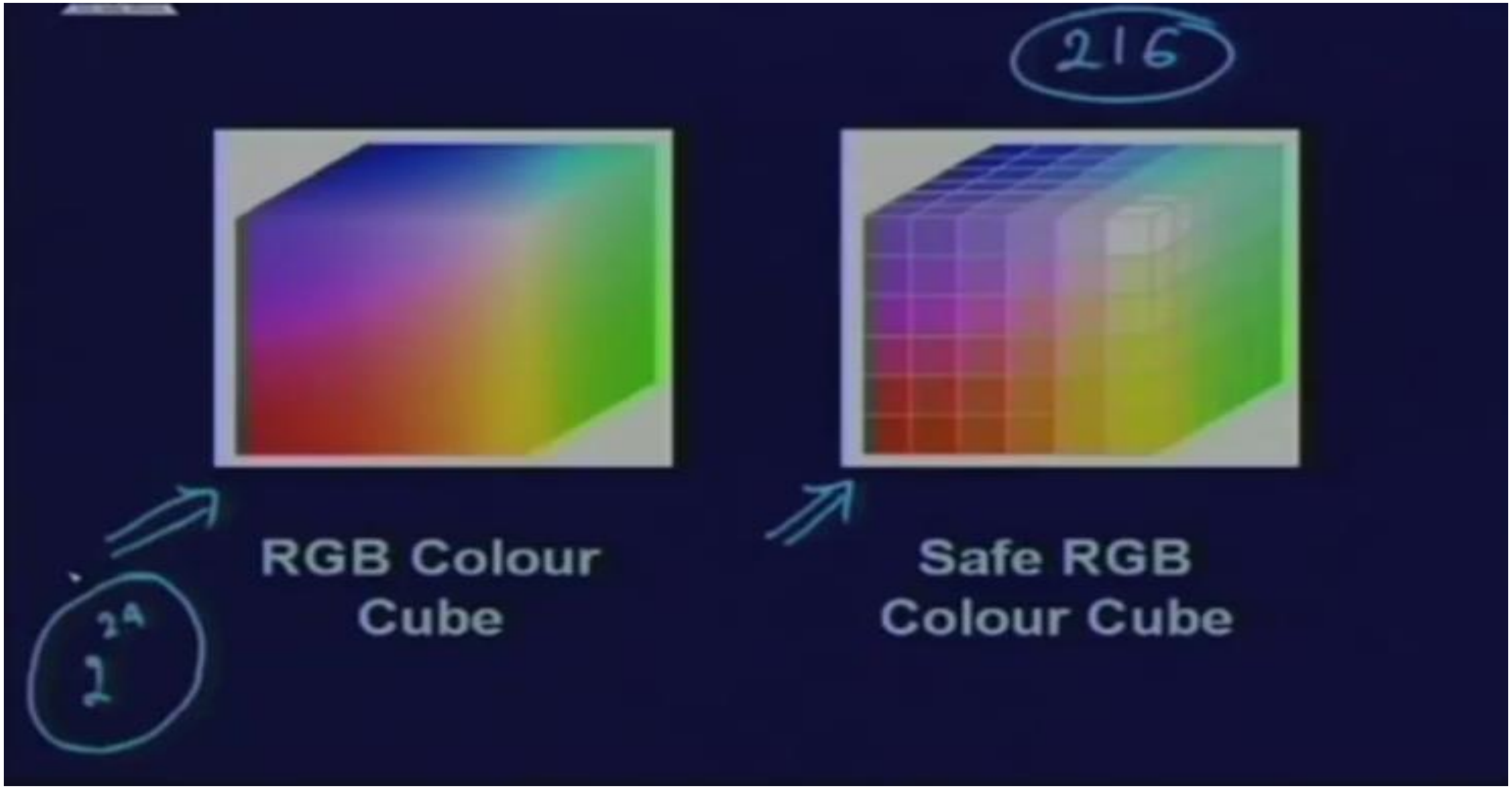
RGB COLOR CUBE AND RGB SAFE COLOR CUBE



RGB safe color cube-6*6*6=216

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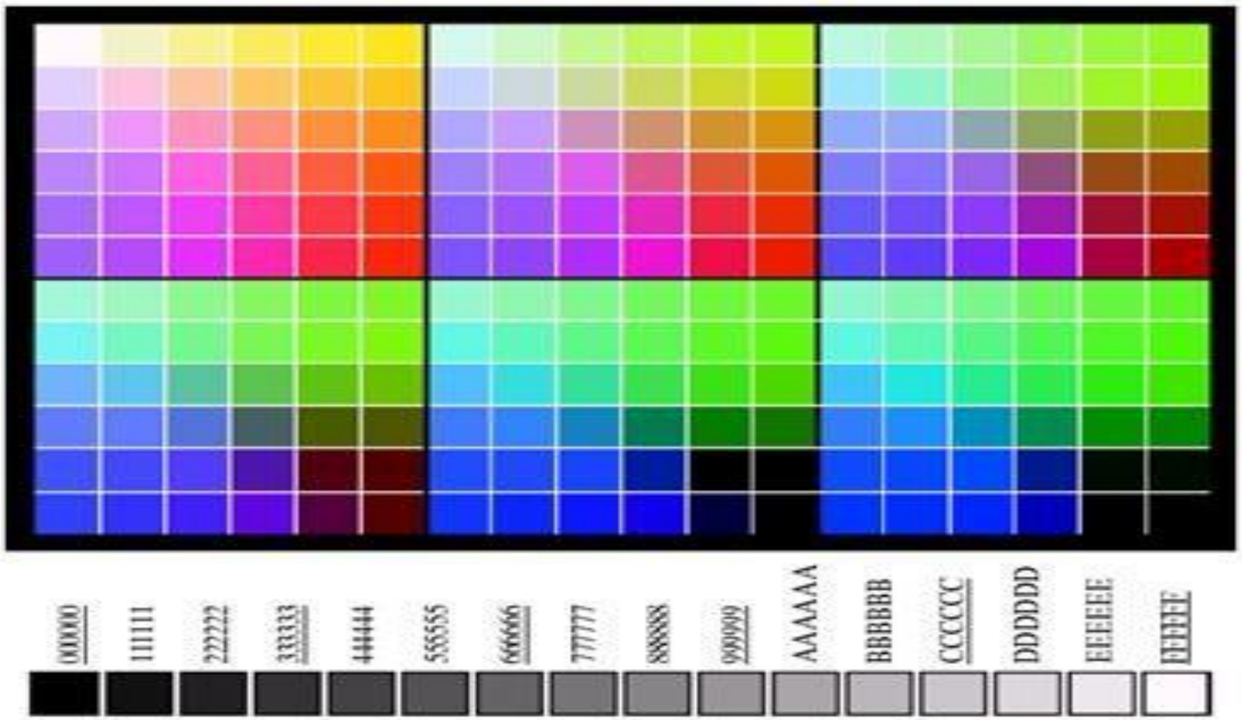
RGB SAFE COLOURS

Number System	Color Equivalents					
Hex	00	33	66	99	CC	FF
Decimal	0	51	102	153	204	255

TABLE 6.1
Valid values of each RGB component in a safe color.



a
b

FIGURE 6.10 (a) The 216 safe RGB colors. (b) All the grays in the 256-color RGB system (grays that are part of the safe color group are shown underlined).

RGB

Red, Green & Blue are Primary colors.

Red, Green and Blue components of colour image

Luminance $Y=0.3R + 0.59G+ 0.11B$

THE HSI COLOR MODEL

- Hue—the color
- Saturation—the amount of white that is mixed with the hue
- Intensity—expresses the brightness or luminance of the chromaticity (=hue and saturation)

CONVERTING FROM RGB TO HSI

$$H = \begin{cases} \theta, & \text{if } B \le G \\ 360 - \theta, & \text{if } B > G \end{cases}$$

$$\theta = \cos^{-1}\left(\frac{(R-G)+(R-B)}{2\sqrt{(R-G)^2 + (R-B)(G-B)}} \right)$$

$$S = 1 - \frac{3\min(R, G, B)}{(R+G+B)}$$

$$I = \frac{(R+G+B)}{3}$$

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Dept. of Information Technology,VIT,Pune

YC_BC_R

The Human visual system is less sensitive to colour than to Luminance.

Luminance $Y = K_r R + K_g G + K_b B$

Where K are weighting factors

The color information can be represented as colour difference components

$$Cb = B - Y$$

$$Cr = R - Y$$

$$Cg = G - Y$$

YCBCR

Cr, Cg and Cb components

However Cb + Cr + Cg is constant. So only two components need to be stored or transmitted

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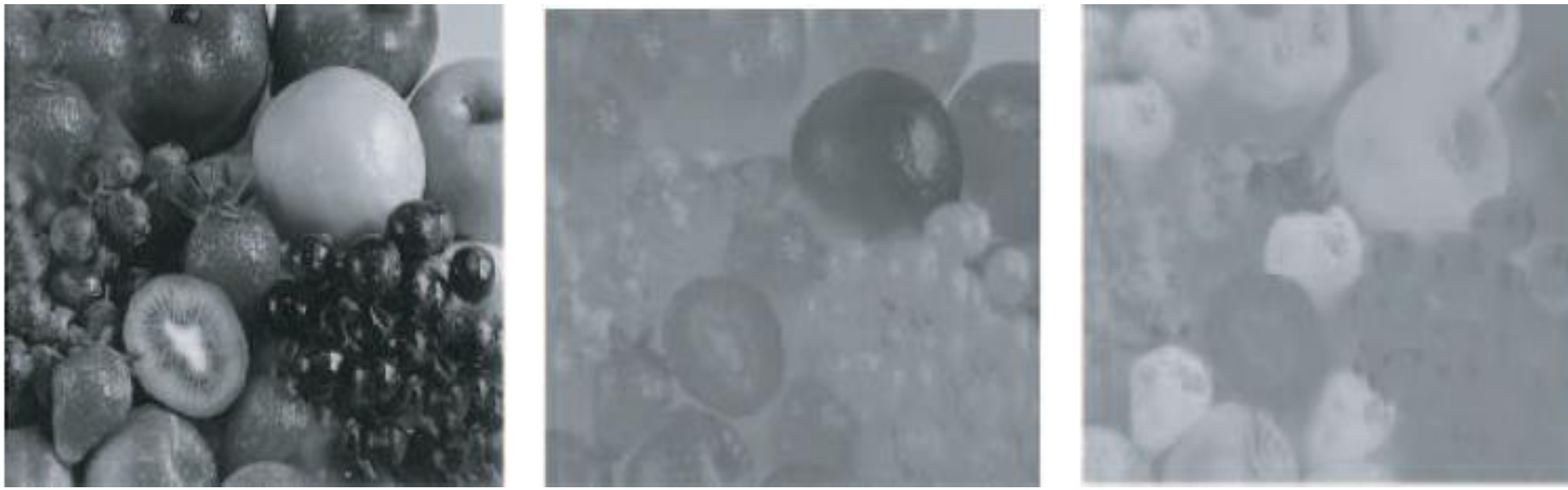
Dept. of Information Technology,VIT,Pune

YCbCr



(A) (B) (C)

(A) Luminance (Y), (B) blue-yellow (Cb), (C) red-green (Cr) components.

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Dept. of Information Technology,VIT,Pune

YCbCr Sampling Formats

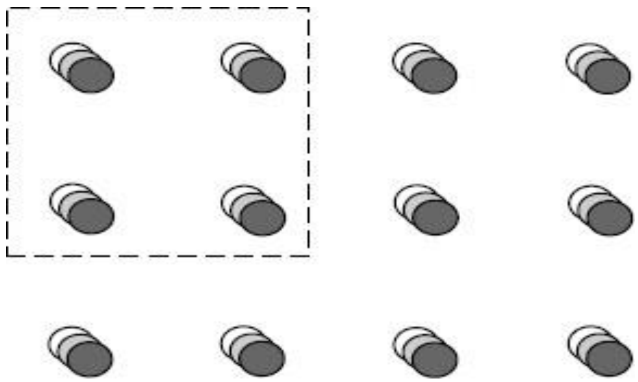
There are three sampling formats

4:4:4 - Y, Cb & Cr have same resolution.

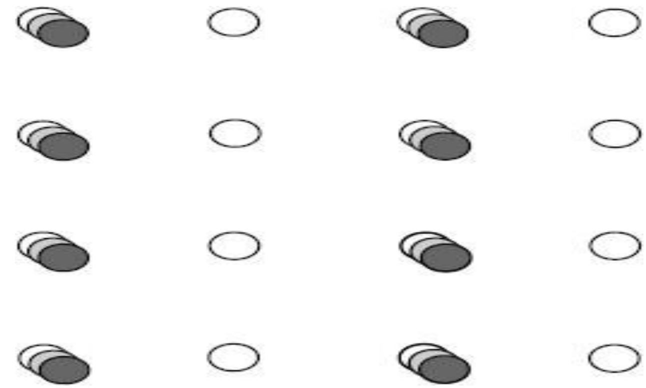
4:2:2 - Cb, Cr have same vertical resolution as the luma but half the horizontal resolution.

4:2:0 - Cb, Cr each have half the horizontal and vertical resolution of Y.

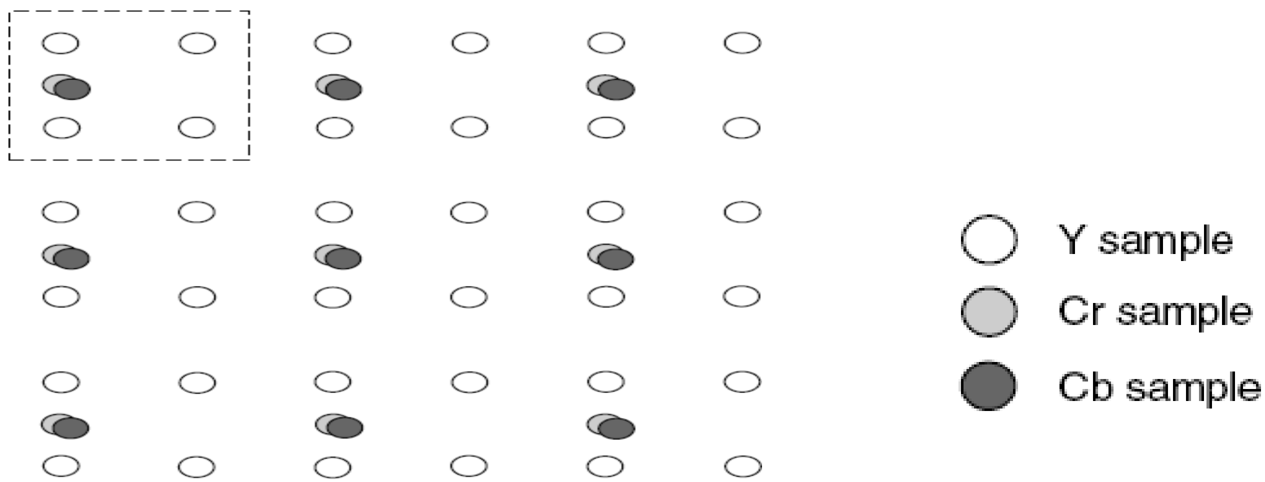
YCbCr Sampling Patterns



4:4:4 sampling -12 samples

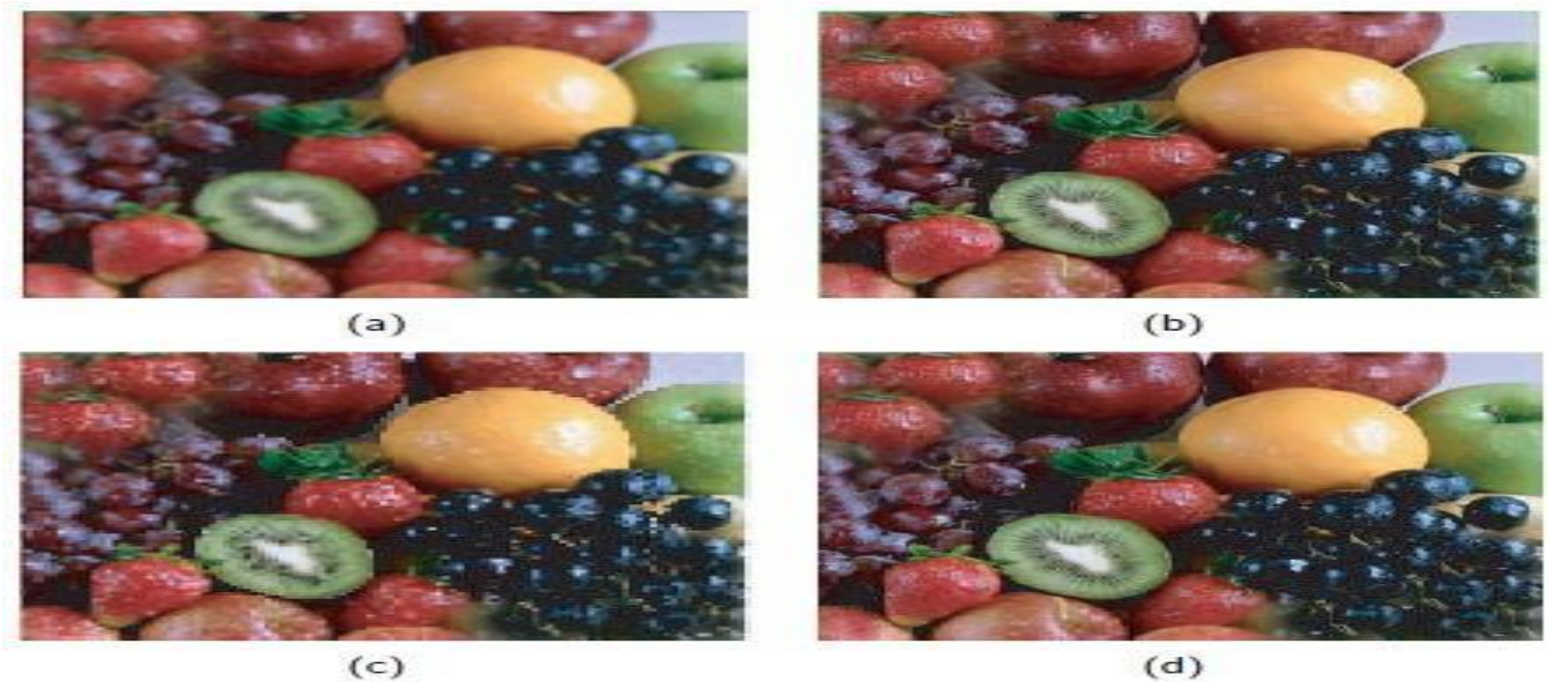


4:2:2 sampling – 8 samples



4:2:0 sampling – 6 samples

Images obtained by modifying luminance and chrominance channels.



(a) The luminance channel is blurred and the chrominance channel is left unmodified; (b) The chrominance channel is blurred and the luminance channel is left unmodified; (c) The luminance channel is down sample and the chrominance channel is left unmodified; (d) the chrominance channel is down sample and the luminance channel is left unmodified.

CMY MODEL

- Relationship between colors from the CMY and RGB models:

  C=1-R M=1-G Y=1-B
- Problem in the CMY model is inability to reproduce large number of colors.
- It is difficult to reproduce fluorescent and similar colors and the most importantly the black!!!
- Approximately just about 1 million of colors is possible to reproduce with good quality.
- The main problem is black since it is very important for human (important for image recognition, edges of shapes, etc).
- Reason: mix cyan, magenta and yellow and you will get dark but not black color (or you will use huge amount of color what is not economical).

CMY MODEL

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

Black Colour-Muddy Black colour.

CMYK- Colour model

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Dept. of Information Technology,VIT,Pune

CMYK MODEL

- Printing machines usually print images in the CMYK model (4-channel model). K means blacK since B is reserved for Blue.
- Relationship between CMY and CMYK models:

$K=\min(C,M,Y)$

$C'=C-K$

$M'=M-K$

$Y'=Y-K$

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Dept. of Information Technology,VIT,Pune

CMY & CMYK MODEL –COMPARISON

CMYK image

CMY image

Prof. (Dr.) Deepali S. Jadhav
Dept. of Information Technology,VIT,Pune