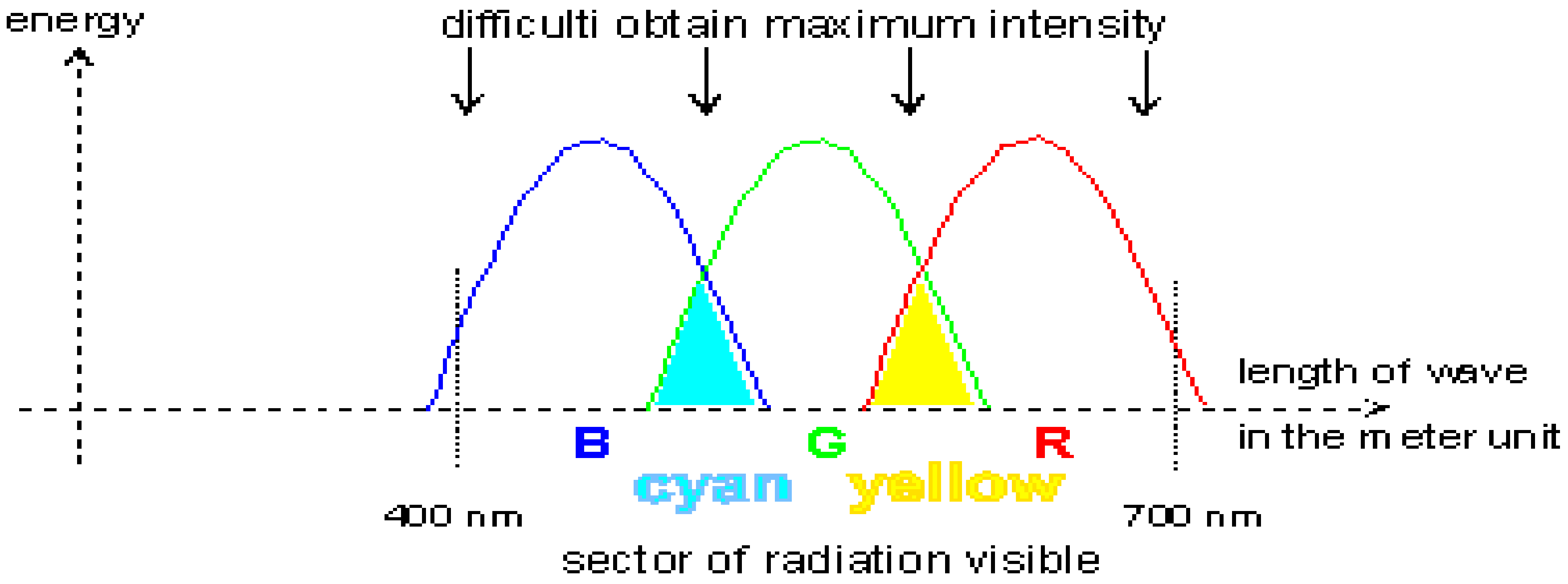
COLOR

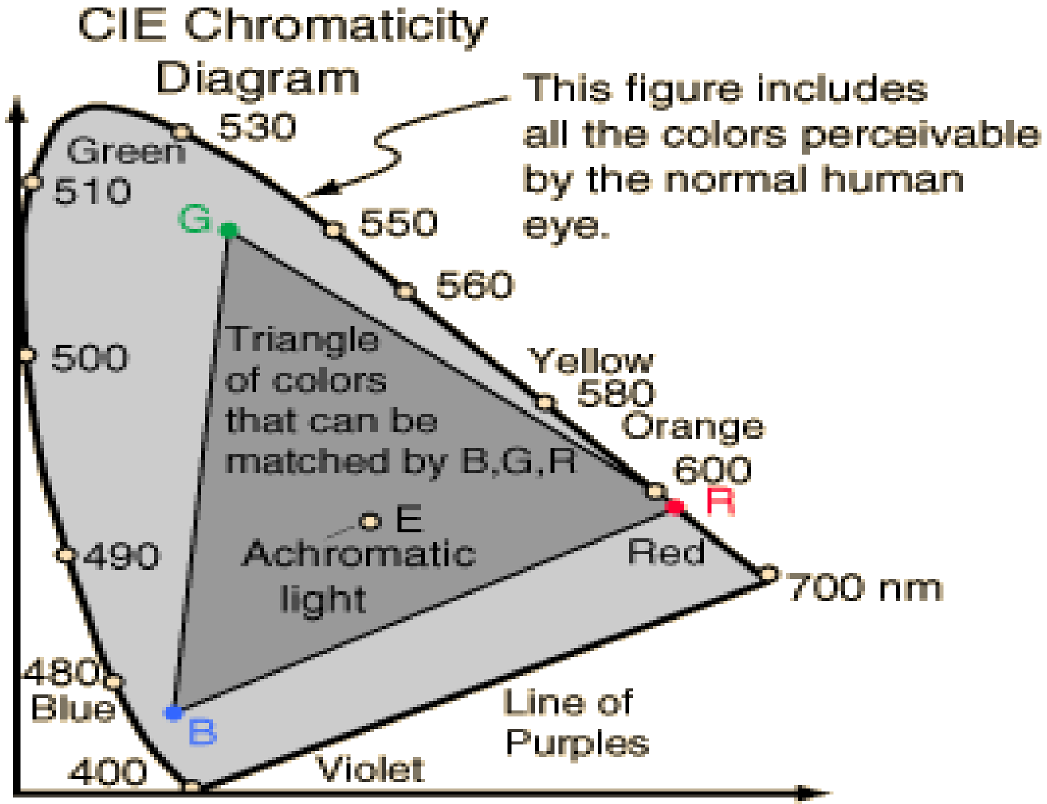
Duangpen jetpipattanapong

COLOR

- Electromagnetic radiation with wavelength in the length between about 400 and 700 nanometers stimulates human neurosensor and produce the sensation of color.

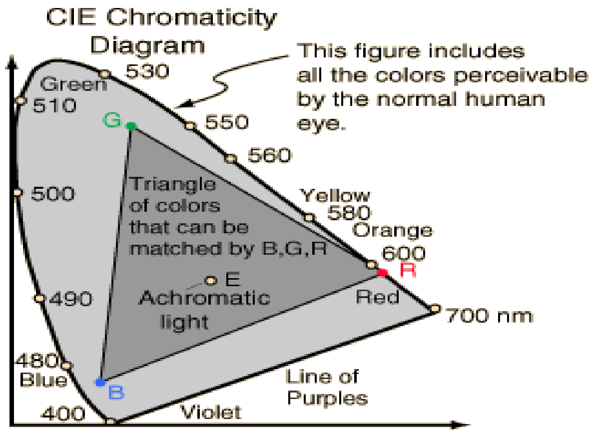


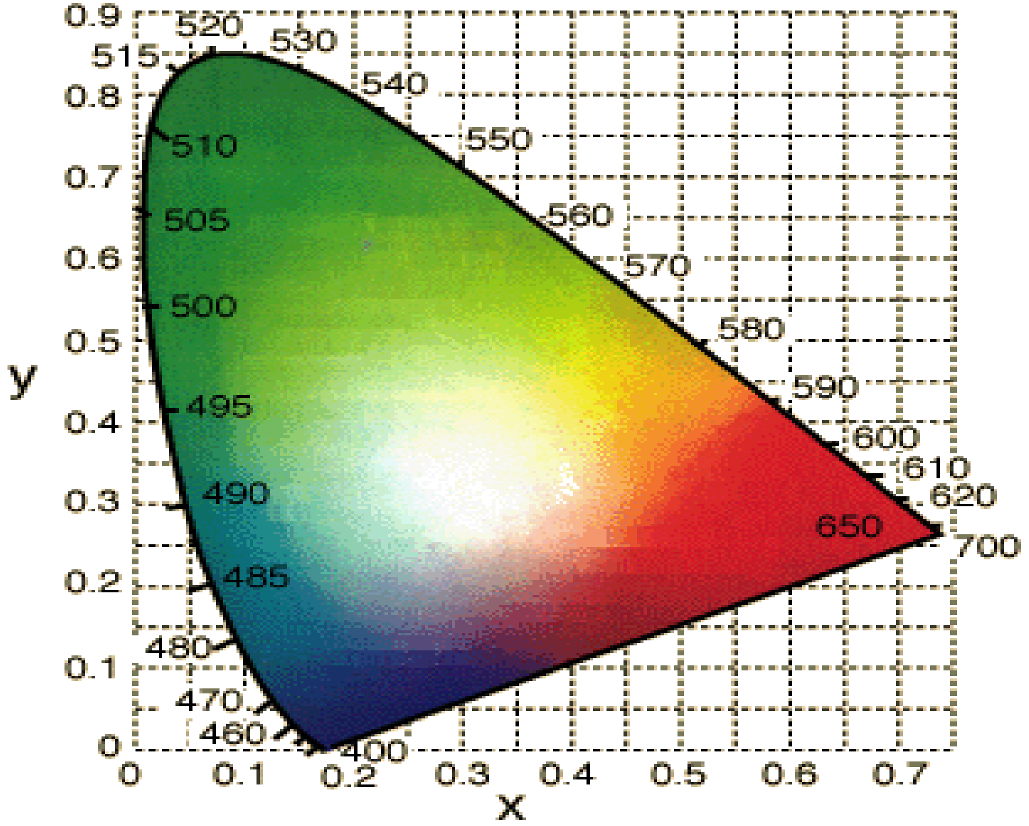
- The CIE (Commission Internationale de l'Eclairage – The international Commission on Illumination) proposed the spectral primary system RGB corresponding to monochromatic primary source

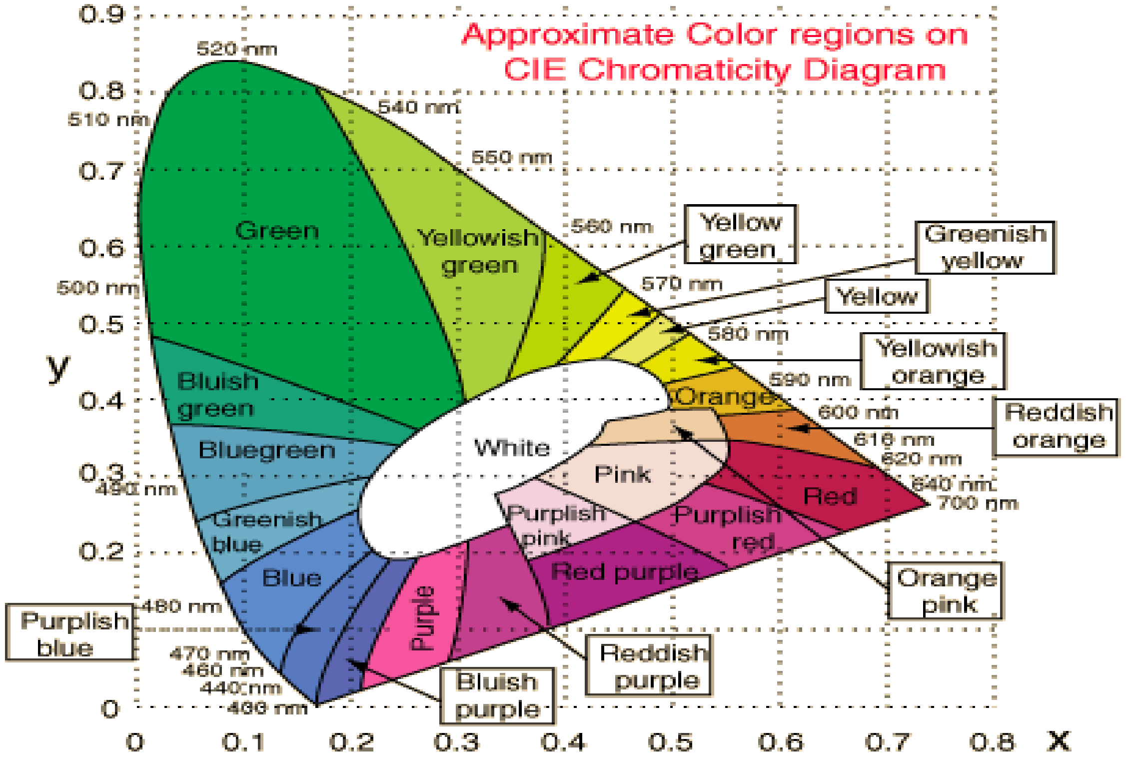


R_{CIE} = red 700 nm
G_{CIE} = green 546.1nm
B_{CIE} = blue 435.8nm

The CIE system characterizes colors by a luminance parameter Y and two color coordinates x and y which specify the point on the chromaticity diagram.


CIE Chromaticity
Diagram
This figure includes
all the colors perceivable
by the normal human
eye.
Green
530
510
G
550
560
500
Triangle
of colors
that can be
matched by B,G,R
Yellow
580
Orange
600
R
E
Achromatic
light
490
Red
700 nm
480
Blue
B
Line of
Purples
400
Violet


0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
y
520
530
515
540
510
550
505
560
570
500
580
590
495
600
610
490
620
650
700
485
480
470
460
400
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
x

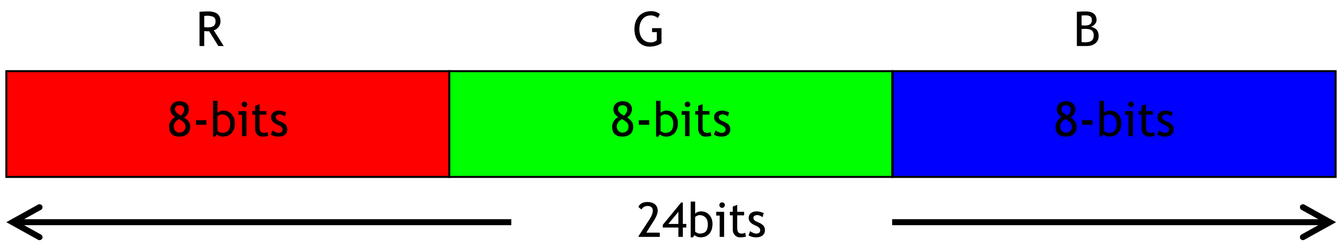

Approximate Color regions on
CIE Chromaticity Diagram
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
y
520 nm
540 nm
510 nm
550 nm
560 nm
Yellow
green
Greenish
yellow
Green
Yellowish
green
570 nm
500 nm
Yellow
580 nm
Yellowish
orange
590 nm
Orange
Bluish
green
600 nm
Reddish
orange
White
610 nm
620 nm
Bluegreen
Pink
640 nm
700 nm
490 nm
Red
Purplish
pink
Purplish
red
Greenish
blue
Blue
Red purple
Orange
pink
Purplish
blue
480 nm
Purple
Reddish
purple
470 nm
460 nm
440 nm
400 nm
Bluish
purple
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
x

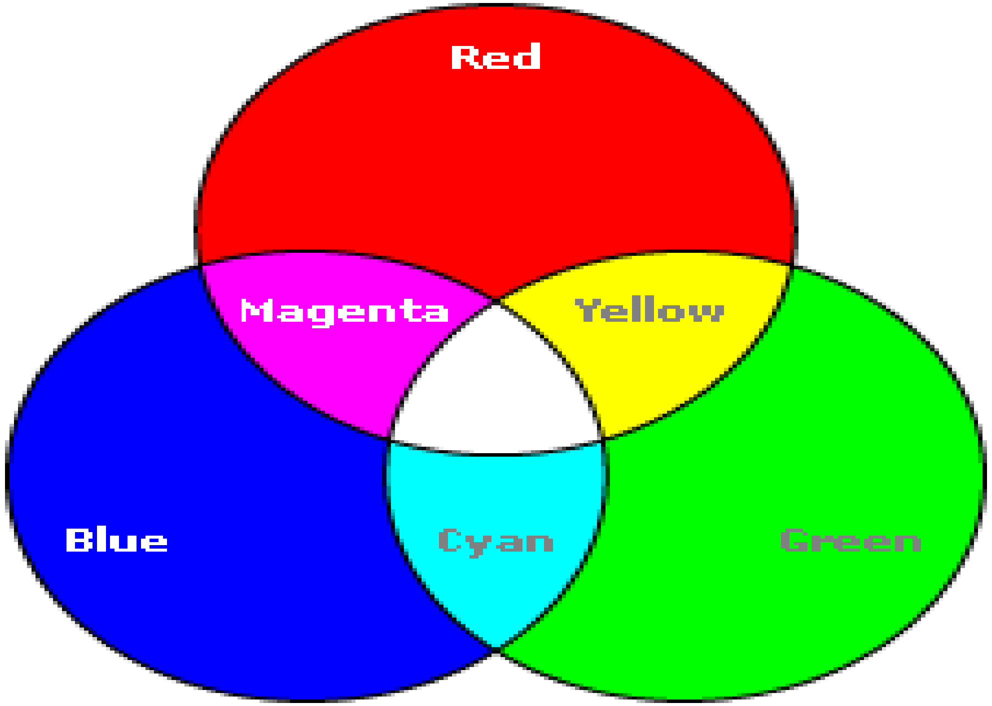
MODELS OF COLORS

- RGB
- CMY
- HSI
- YIQ / YUV

RGB

- The trichrommatic RGB (red-green-blue) encoding in graphics systems usually uses three bytes enabling 2^{24} or roughly 16 million distinct color code.
- Each 3-byte or 24-bit RGB pixel includes one byte for each red, green, blue.
- The order in which each appears in memory can vary.

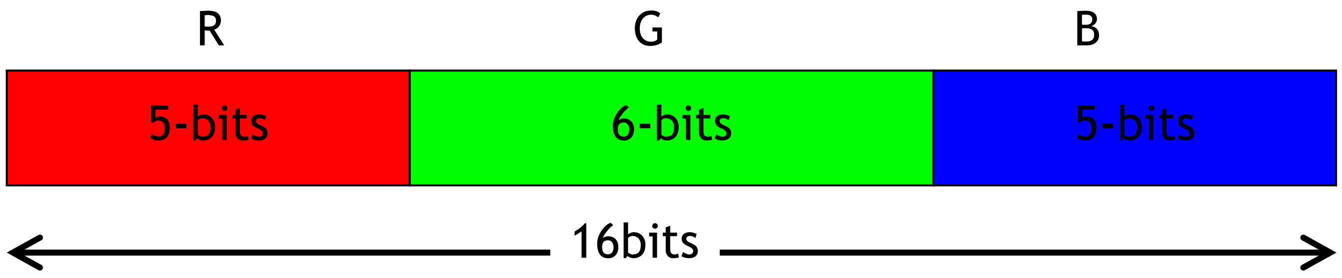




Red	= (255,0,0)
Green	= (0,255,0)
Blue	= (0,0,255)
Red+Green	= (255,255,0)
Red+blue	= (255,0,255)
Green+Blue	= (0,255,255)
White	= (255,255,255)
Black	= (0,0,0)
Gray	= (c,c,c) $0<c<255$

True color

- Display devices whose color resolution matches the human visible is called true color, At least 16 bits are need
- 16 bit – better model the relatively larger green sensitivity 6 bits

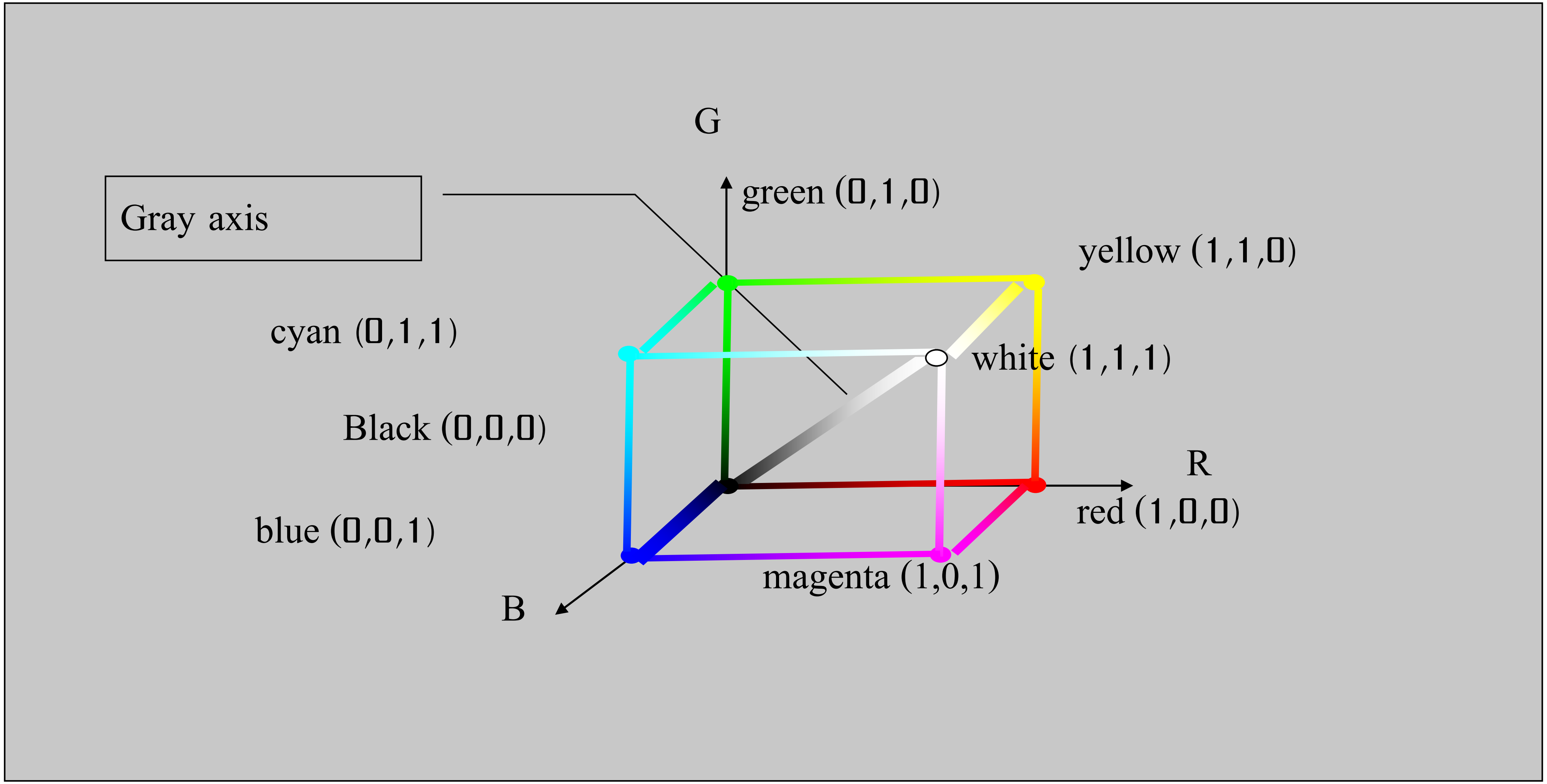


True Color

- The RGB system is an additive color system because colors are created by adding components to black (0,0,0)
- To normalize image data for interpretation by both computer programs and people and for transformation to other color systems.

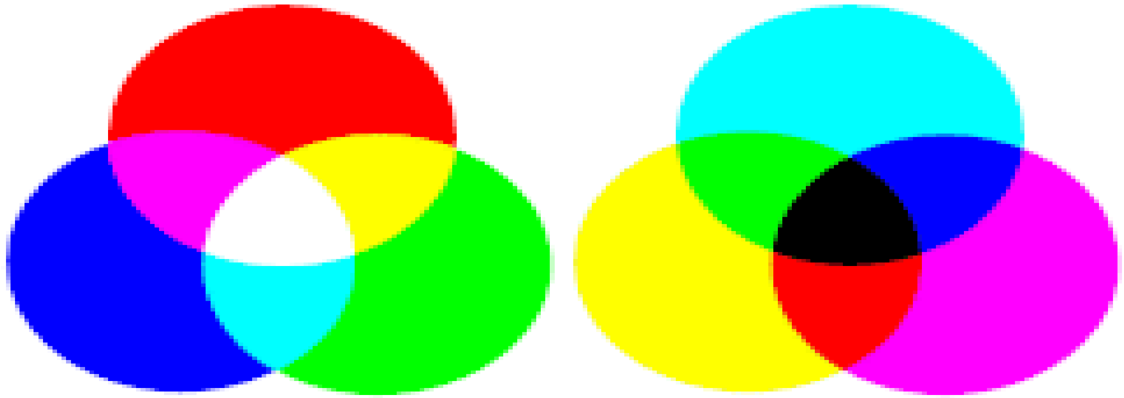
Intensity	$I = (R+G+B)/3$
Normalized red	$r = R/(R+G+B)$
Normalized green	$g = R/(R+G+B)$
Normalized blue	$b = R/(R+G+B)$

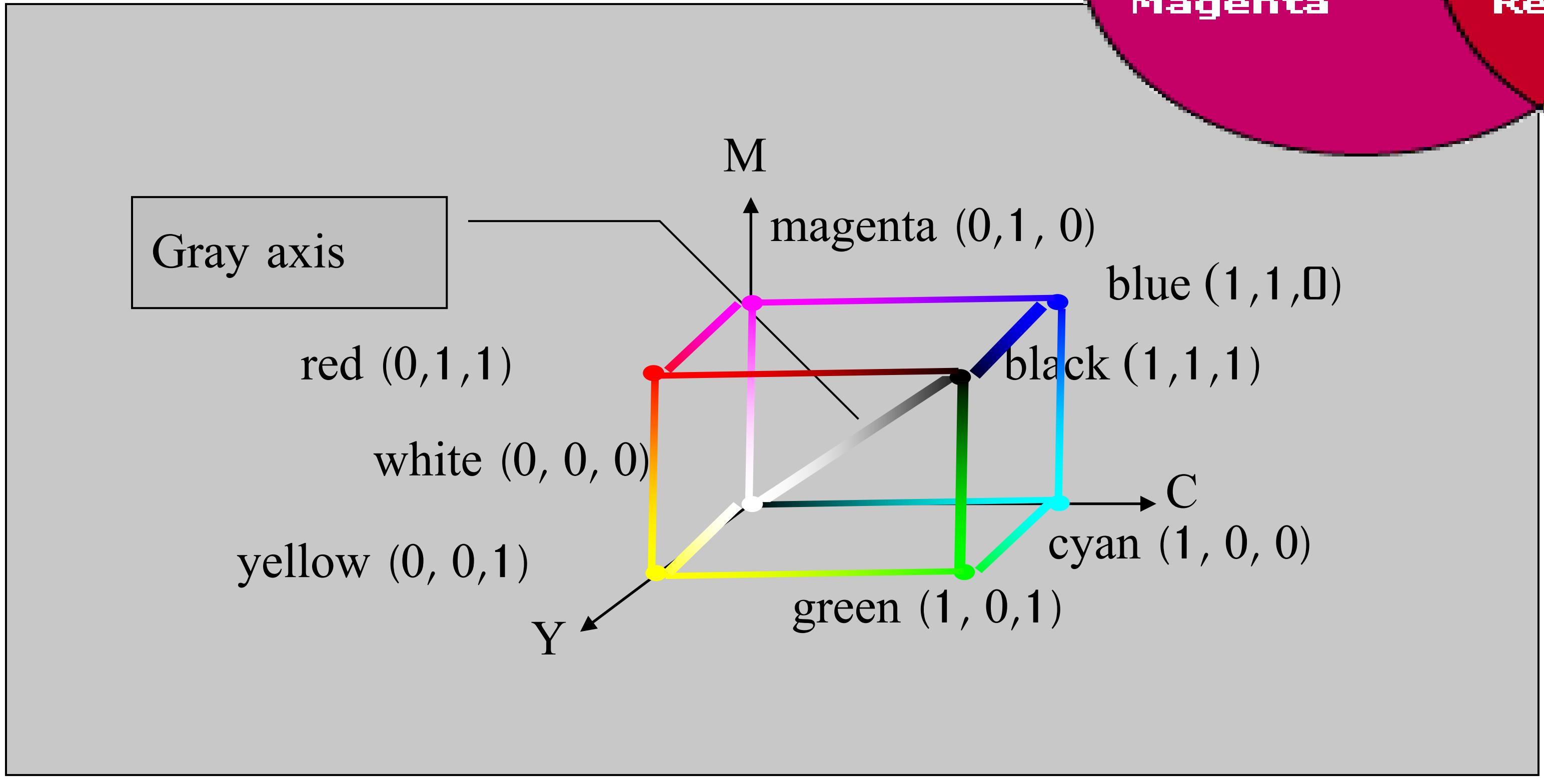
* The normalize values will always sum to 1

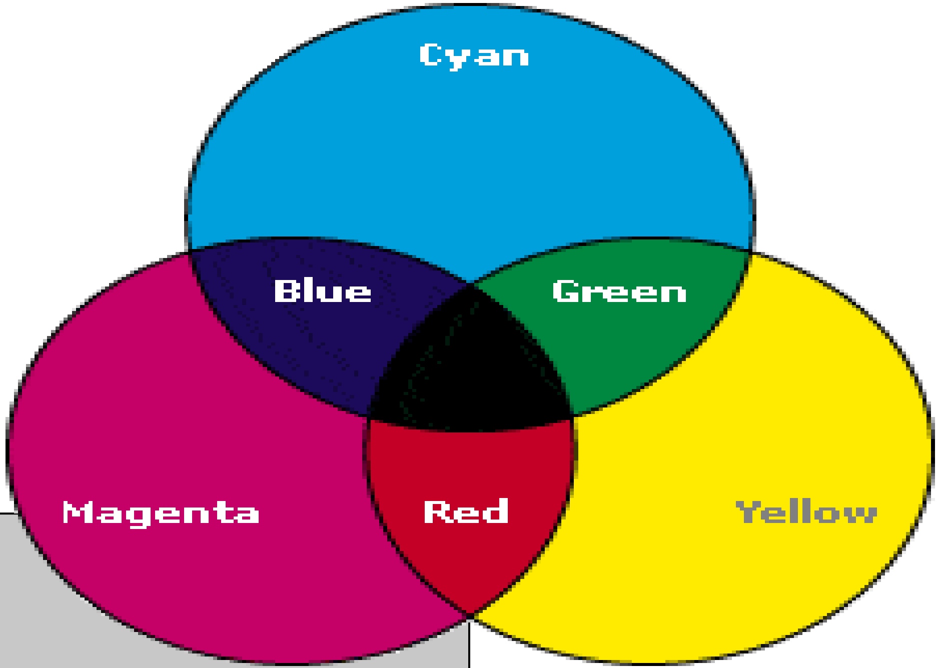

G
Gray axis
green (0,1,0)
yellow (1,1,0)
cyan (0,1,1)
white (1,1,1)
Black (0,0,0)
R
red (1,0,0)
blue (0,0,1)
magenta (1,0,1)
B

CMY

- CMY is an abbreviation of Cyan-Magenta-Yellow.
  - Cyan absorbs red illumination
  - Magenta absorbs green
  - Yellow absorbs blue
- CMY color system is subtractive color system
  - subtracts from white rather than adds to black as the RGB system does.

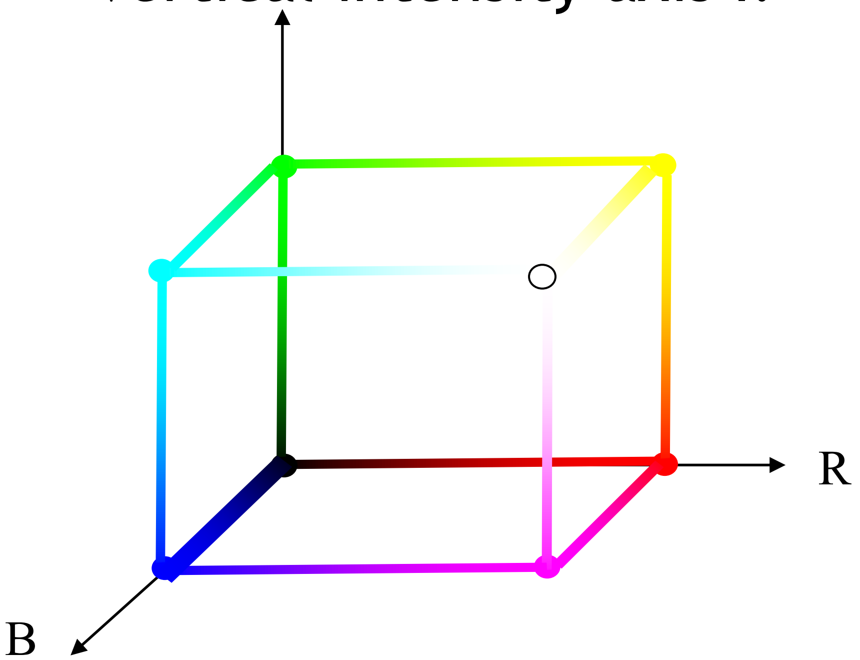


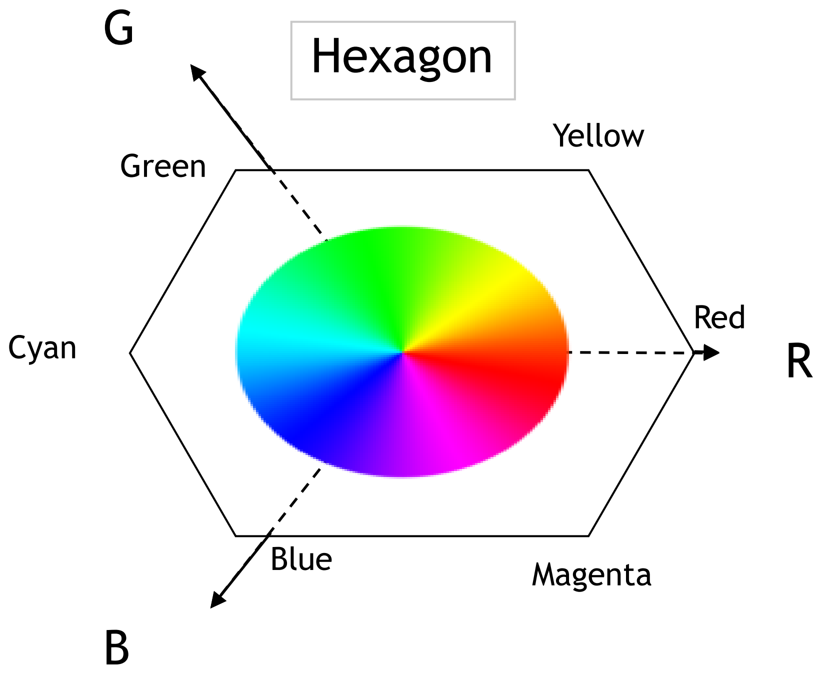

Gray axis
M
magenta (0,1, 0)
blue (1,1,0)
red (0,1,1)
black (1,1,1)
white (0, 0, 0)
C
cyan (1, 0, 0)
yellow (0, 0,1)
green (1, 0,1)
Y


Cyan
Blue
Green
Magenta
Red
Yellow

HSI

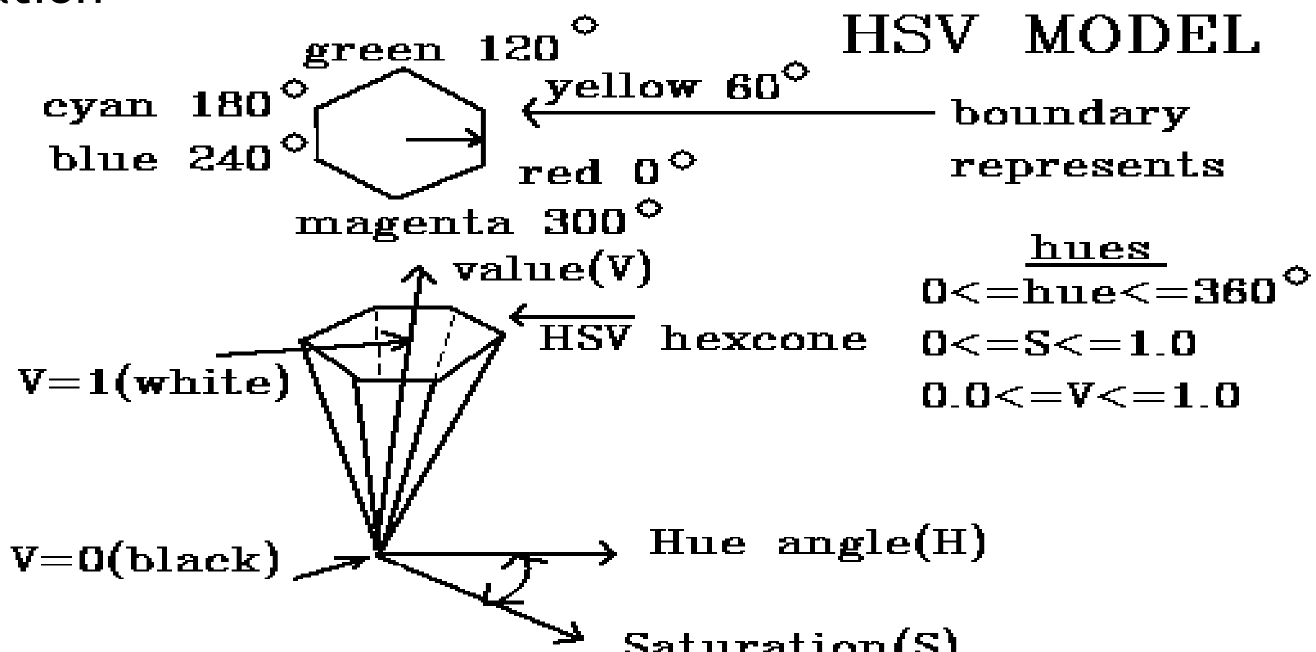
- HSI system encodes color information by separating out an overall intensity value I from two values encoding chromaticity hue H and saturation S.
- Hexagone allows us to visualize the former cube diagonal as a vertical intensity axis I.





HSI

- Hue H is defined by angle between 0 and 2pi relative to the red-axis.
- Saturation S is the 3rd coordinate value, number of the parity of the color hue range 0 – 1
  - 1 is completely pure color
  - 0 is completely unsaturation



Hexacone

I = max(R,G,B)

S = (I – min(R,G,B))/I

If point with in +/- 60 degrees of red axis (R=I)

$$H = \frac{\frac{\pi}{3}(G-B)}{I-\min(R,G,B)}$$

If point with in +/- 60 degrees of green axis (G=I)

$$H = \frac{2\pi}{3} + \frac{\frac{\pi}{3}(B-R)}{I-\min(R,G,B)}$$

If point with in +/- 60 degrees of blue axis (B=I)

$$H = \frac{4\pi}{3} + \frac{\frac{\pi}{3}(R-G)}{I-\min(R,G,B)}$$

Note

I is returned in the same range as input value.

S is not defined when intensity I=0

H is not defined when S=0

YIQ / YUV

- The NTSC television standard is an encoding that use one luminance value Y and two chromaticity values I and Q
- Only Y is used by black and white TV. While all three are used by color TVs.
- In practice, Y value is encoded using more bits than I, Q because human visual system is more sensitive to luminance than chromaticity values.

  - Luminance $Y = 0.3R+0.59G+0.11B$
  - R-Cyan $I = 0.6R - 0.28G - 0.32B$
  - Magenta-green $Q = 0.21R-0.52G+0.31B$

PROBLEMS

- Convert the normalize colors to RGB, CMY, HSI, and YIQ system
  - r =0.2 g=0.3 b=0.5 I=150
  - r =0.2 g=0.3 b=0.5 I=100
  - r =0.4 g=0.6 b=0 I=100

- Convert HSI to RGB
  - H =$5\pi/6$ S = 0.25 I = 200

COLOR HISTOGRAM

- Histogram for each color created by concatenate the higher order two bits of each RGB color code.
- The histogram will has 2^6=64 colors

Color = **01**011101**11**000101**01**100001

Color histogram = 011101

- We can compare the image histogram to model histogram by

Intersection – the sum of the minimum overall K

$$\text{Intersection}\left(h(I),h(M)\right) = \sum_{j=1}^{K} \min(h(I)[j],h(M)[j])$$

Match – measure of how much color model content is present in image

$$\text{match}\left(h(I),h(M)\right) = \frac{\sum_{j=1}^{K} \min(h(I)[j],h(M)[j])}{\sum_{j=1}^{K} h(M)[j]}$$

Intersection =

Match =

Color [k]	Histogram image I h(I)	Histogram model M h(M)	Min{h(I),h(M)}
0	15	15	
1	40	30	
2	65	80	
3	100	40	
4	30	15	
5	80	40	
6	0	40	
7	25	30	
8	100	60	
9	20	25	
Sum =	475	375	