Multimedia Technology (IT-204-F)

Section B
Image compression & standards

LECTURE 5 COLOR MODELS REVISITED

COLOR SCHEME

Colour is a vital component of multimedia. Colour management is both a subjective and a technical exercise, because:

- Colour is a physical property of light, but
- Colour perception is a human physiological activity.
- Choosing a right colour or colour combination involves many trials and aesthetic judgement.
- Colour is the frequency/wave-length of a light wave within the narrow band of the electromagnetic spectrum (380 – 760nm) to which the human eye responds.

Wavelength	Intensity	Spectral Purity
Hue	Brightness	Saturation

Our sensations of colour are within us and colour connot exist unless there is an observer to perceive them. Colour does not exist even in the chain of events between the retinal receptors and the visual cortex, but only when the information is finally interpreted in the consciousness of the observer.

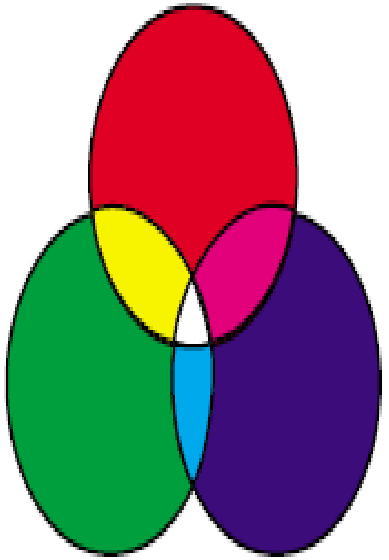
RGB Color Model

This is probably the most popular colour model used in computer graphics.

It is an *additive* system in which varying amount of the three primary colours, red, green and blue, are added to black to produce new colours.

You can imagine three light sources of the primary colours shine on a black surface. By varying the intensity of the lights, you will produce different colours.

R – Red
G – Green
B – Blue



CMY Color Model

This model is based on the light absorbing quality of inks printed on paper. Combining three primary colour pigments, Cyan, Magenta and Yellow, should absorb all light, thus resulting in black.

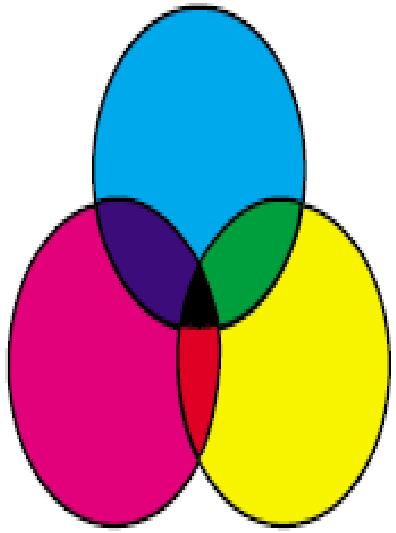
It is a *subtractive* model.

The value of each primary colour is assigned a percentage from the lightest (0%) to the darkest (100%).

Because all inks contain some impurities, three inks actually produce a muddy brown, a black colour is added in printing process, thus CMYK model.

Note: the primary colours in RGB and CMY models are complementary colours.

C – Cyan
M – Magenta
Y – Yellow



HSB Color Model

This model is based on the human perception of colour.

The three fundamental characteristics of colours are:

Hue — is the wavelength of the light. Hue is often identified by the name of the colour. It is measured as a location on the standard colour wheel as a degree between 0° to 360°.

Saturation — is the strength or purity of the colour. It represents the amount of gray in proportion to the hue and is measured as a percentage from 0%(gray) to 100%(fully saturated).

Brightness — is the relative lightness or darkness of the colour. It is measured as a percentage from 0%(black) to 100%(white).

YUV Color Model

This model is widely used in encoding colour for use in television and video.

The theory behind this model is that human perception is more sensitive to brightness than any chrominance information, so a more suitable coding distinguishes between luminance and chrominance. This also produces a system that is compatible with black-and-white TV systems.

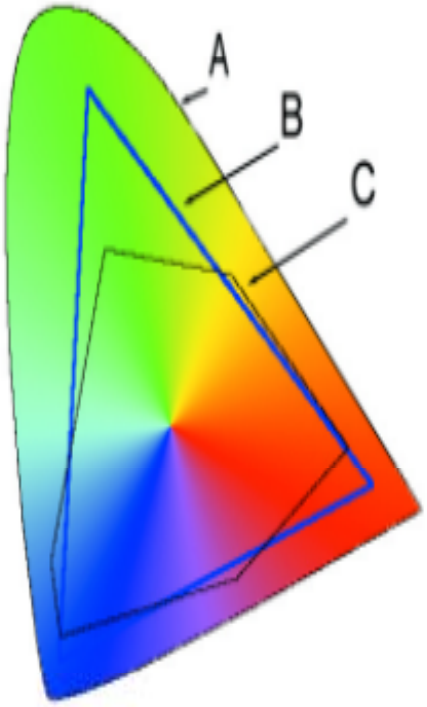
The Y-signal encodes the brightness information. Black-and-white television system will use this channel only.

The U and V channels encode the chromatic information. The resolution of the U and V channels is often less than the Y channel for the reason of reducing the size.

GAMUT

The *gamut* of a colour system is the range of colours that can be displayed or printed. The spectrum of colours that can be viewed by human eye is wider than any method of reproducing colour.

Different colour models have different gamut. The CMYK model is smaller than RGB model. On the right is a Chromaticity Diagram which illustrates gumat of RGB and CMYK colour systems.

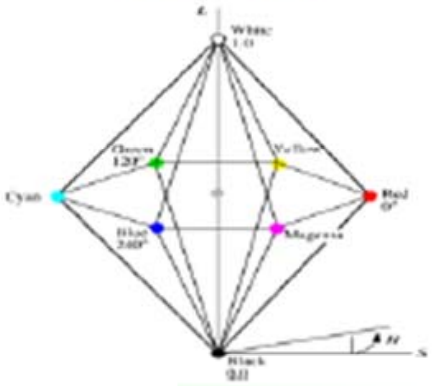


A Natural colour
B RGB gamut
C CMYK gamut

COLOR MODELS REVISITED

Color Models for Raster Graphics

- Hardware-oriented models: not intuitive – do not relate to concepts of hue, saturation, brightness
  - RGB, used with color CRT monitors
  - YIQ, broadcast TV color system
  - CMY (cyan, magenta, yellow) color printing
  - CMYK (cyan, magenta, yellow, black) color printing
  - IRODORI, six-primary-color projection system
- User-oriented models
  - HSV (hue, saturation, value)
  - also called HSB (B for brightness)
  - HLS (hue, lightness, saturation)
  - The Munsell system
  - CIE Lab

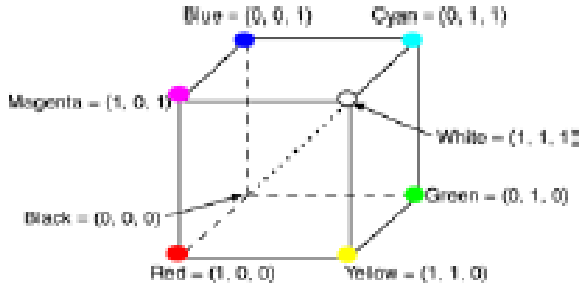


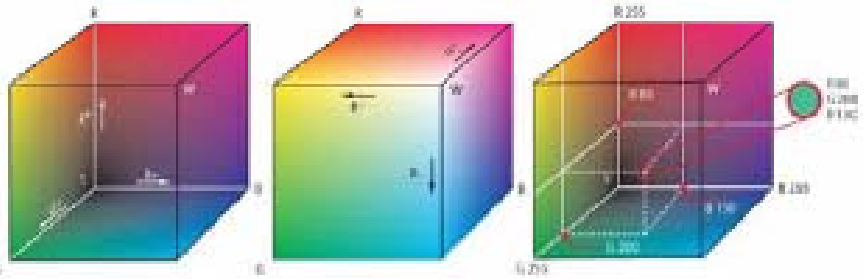
COLOR MODELS CONTD: 1

The RGB Color Model

- RGB primaries are *additive:*
- Main diagonal => gray levels
  - black is (0, 0, 0)
  - white is (1, 1, 1)
- Hue is defined by the one or two largest parameters
- Saturation can be controlled by varying the collective minimum value of R, G and B
- Luminance can be controlled by varying magnitudes while keeping ratios constant

The RGB cube (Grays on dotted main diagonal)

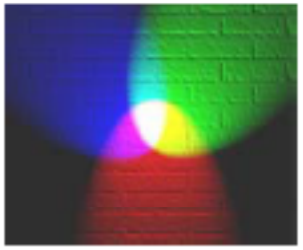


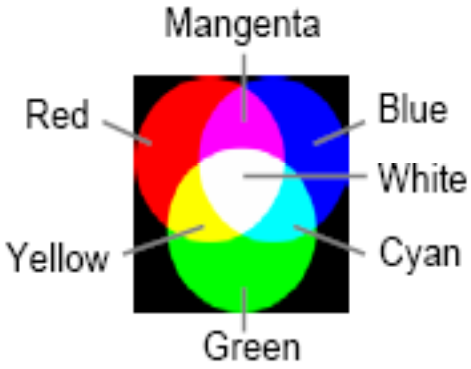


- RGB color gamut defined by display device chromaticities
  - differs form one display device to another

COLOR MODELS CONTD: 2

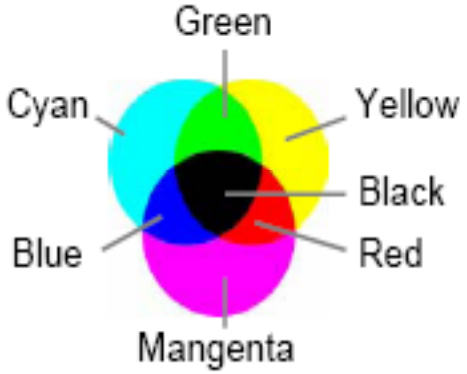
Additive vs. Subtractive Color Systems





RGB

- Print systems use subtractive color system:



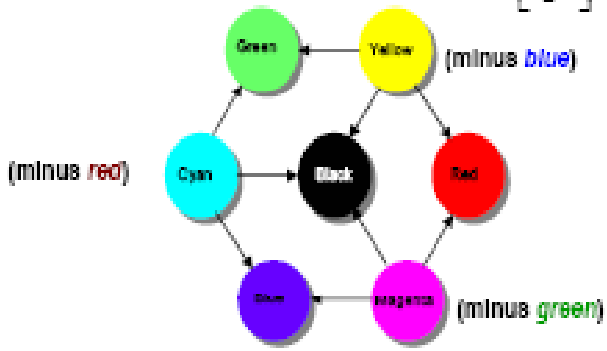
CMY

COLOR MODELS CONTD: 3

The CMY(K) Color Model

- Used in electrostatic/ink-jet plotters that deposit pigment on paper
- Cyan, magenta, and yellow are complements of red, green, and blue
- ***Subtractive primaries***: colors are specified by what is subtracted from white light, rather than by what is added to blackness
- Cartesian coordinate system
- Subset is unit cube
  - white is at origin, black at (1, 1, 1):

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



subtractive primaries (cyan, magenta, yellow) and their mixtures

COLOR MODELS CONTD: 4

The YIQ Color Model

- Recoded RGB for transmission efficiency, compatibility with B/W broadcast TV;
- used for NTSC (National Television Standards Committee (cynically, "Never The Same Color"))
- Y = CIE's Y (luminance); I and Q encode chromaticity
- Only Y = 0.3R + 0.59G + 0.11B shown on B/W monitors:

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.30 & 0.59 & 0.11 \\ 0.60 & -0.28 & -0.32 \\ 0.21 & -0.52 & 0.31 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

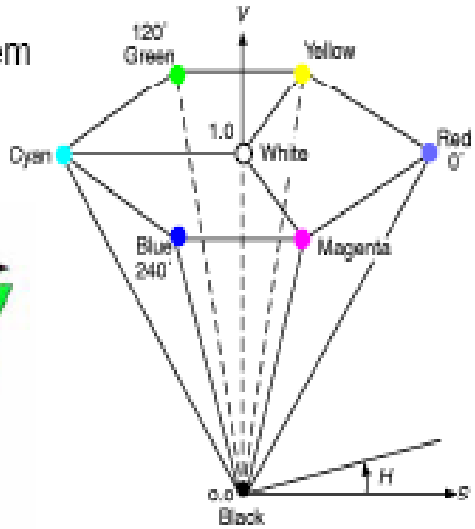
  - Weights: relative brightness of each primary
  - assumes white point is illuminant C:
    $x_W = 0.31$, $y_W = 0.316$, and $Y_W = 100.0$
- Preparing color material which may be seen on B/W broadcast TV, adjacent colors should have different *Y* values
- NTSC encoding of *YIQ*:

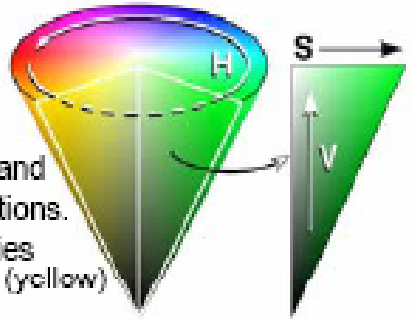
4 MHz	Y (eye most sensitive to △ luminance)
1.5 MHz	I (small images need 1 color dimension)
0.6 MHz	Q

COLOR MODELS CONTD: 5

The HSV Color Model

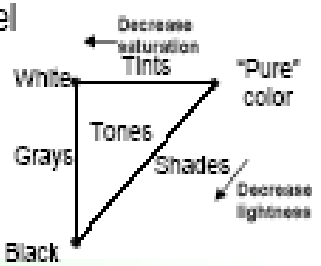
- Hue, saturation, value (brightness)
- Hexcone subset of cylindrical (polar) coordinate system
- Single hexcone HSV color model.
  (The V = 1 plane contains the RGB model's
  R = 1, G = 1, B = 1, in the regions shown):



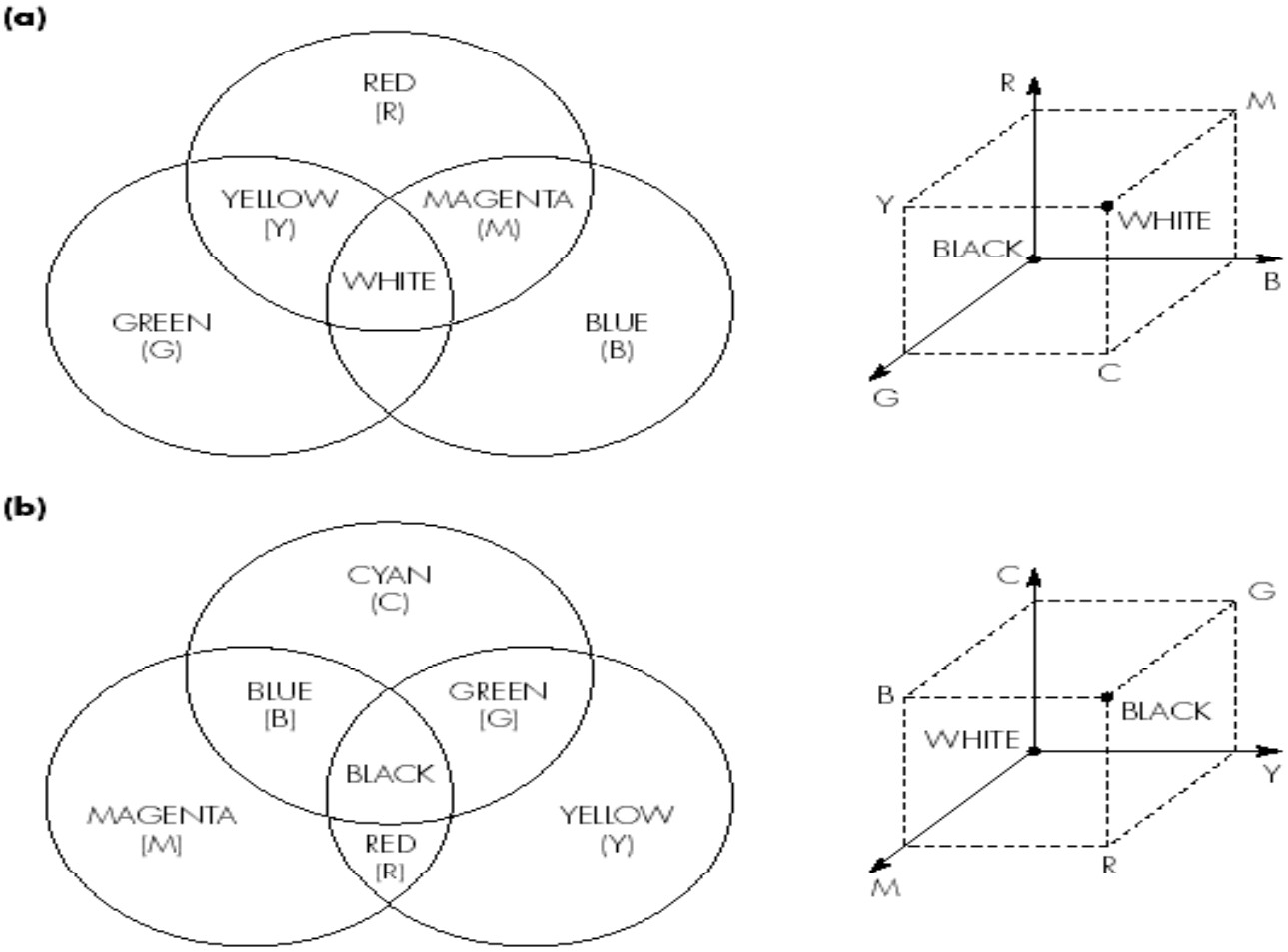


- The eye can see
  - about 128 different hues, and
  - about 130 different saturations.
  - The number of values varies between 16 (blue) and 23 (yellow)

- Has intuitive appeal of the artist's tint, shade, and tone model
  - pure red = **H** = 0, **S** = 1, **V** = 1; pure pigments are (I, 1, 1)
  - tints: adding white pigment ⇔ decreasing **S** at constant **V**
  - shades: adding black pigment ⇔ decreasing **V** at constant **S**
  - tones: decreasing **S** and **V**



COLOR MODEL: A. ADDITIVE COLOR MIXING; B. SUBTRACTIVE MIXING



Three main properties:

- ***Brightness:*** the amount of energy that stimulates the eye and varies on a gray scale from black to highest white. It is independent of the color of the source.
- ***Hue:*** actual color of the source, each color has a different frequency/wavelength and the eye determines the color from this.
- ***Saturation:*** the strength or vividness of the color (lowest has a pastel color. Also, a saturated color as red has no white light in it.
- *Luminance:* refers to the brightness.
- *Chrominance:* refers to the hue and saturation (color related).

APPLICATIONS

- Image Processing
- Image Enhancement
- Medical Imaging

SCOPE OF RESEARCH

- Statistical Color Models
- Multi Stage Color Models