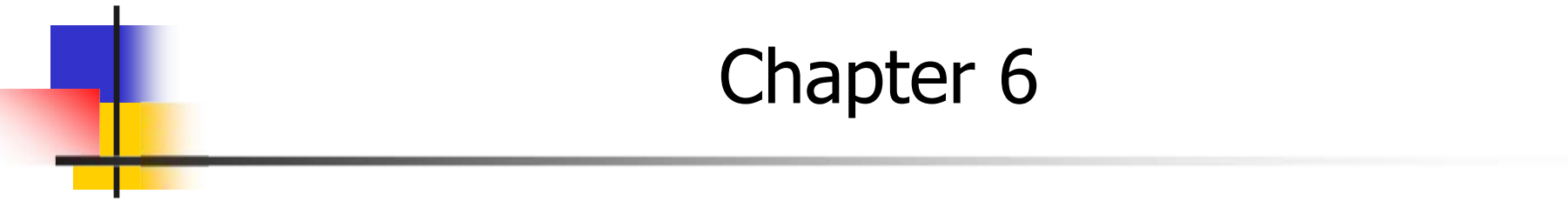
Color



Chapter 6

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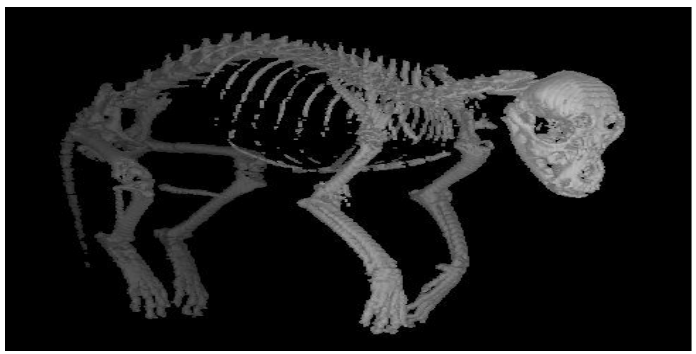
Color

- Very important in human perception
- Same shapes with different color coding may look different

Cat on a rug?

Tiger in a jungle!

Color



- Used heavily in human vision
- Color is a pixel property, making some recognition problems easy
- Visible spectrum for humans is 400nm (blue) to 700 nm (red)
- Machines can "see" much more; ex. X-rays, infrared, radio waves

Colors

$$\text{Intensity } I = \frac{R + G + B}{3}$$

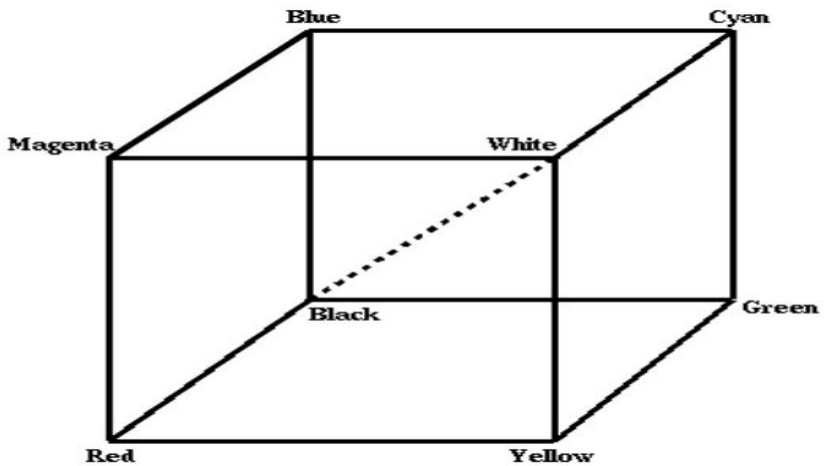
$$\text{Normalized Red } r = \frac{R}{R + G + B}$$

$$\text{Normalized } \textit{Blue } b = \frac{B}{R + G + B}$$

$$\text{Normalized G}\textit{reen } g = \frac{G}{R + G + B}$$

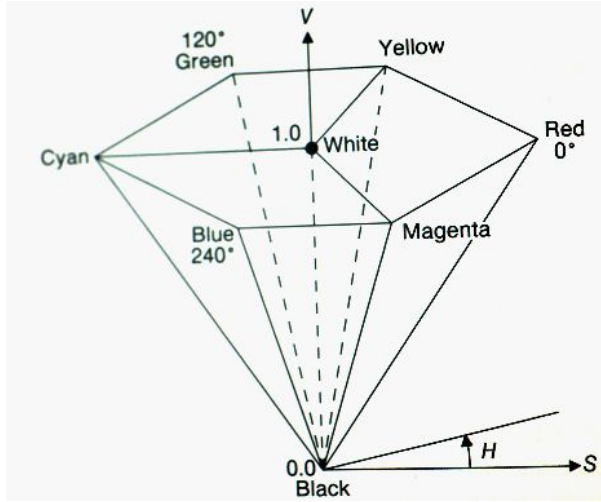
RGB Color model

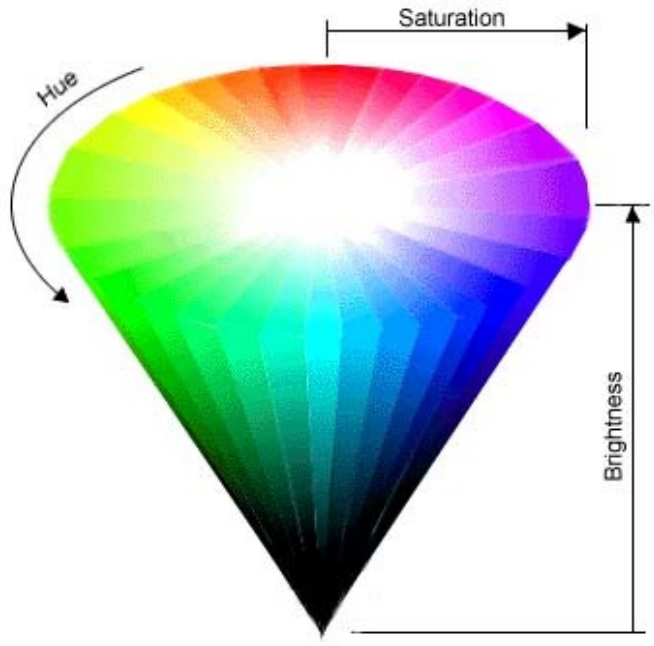
- The RGB color space or typical color image consists of the 3 additive primaries: red, green and blue.
- Spectral components of these color combine additively to produce a resultant color.



Color Model (HSI)

- HSI (=HSB)
  - Hue, Saturation, Value (=Brightness)
  - **HUE**: the actual color.
    - measured in angular degrees around the cone
    - Ex) red = 0 or 360 (so yellow = 60, green = 120, etc.)
  - **SATURATION**: the purity of the color
    - measured in percent from the center of the cone (0) to the surface (100).
    - At 0% saturation, hue is meaningless.
  - **BRIGHTNESS/INTENSITY**
    - measured in percent from black (0) to white (100).
    - At 0% brightness, both hue and saturation are meaningless.





Color Image Processing

RGB to HSI Conversion

$$I = \frac{1}{3}(R+G+B), \quad \text{where } 0 \le I, R, G, B \le 1$$

$$H = \cos^{-1}\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{\sqrt{(R-G)^2+(R-B)(G-B)}}\right\}, \quad \text{if } g_0 > b_0$$

$$H = 360^{\circ} - H, \quad \text{if } g_0 < b_0 \qquad \text{where } g_0 = G/I, \;\; b_0 = B/I$$

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

Color Image Processing

HSI to RGB Conversion

$$B = \frac{1}{3}(1 - S)$$

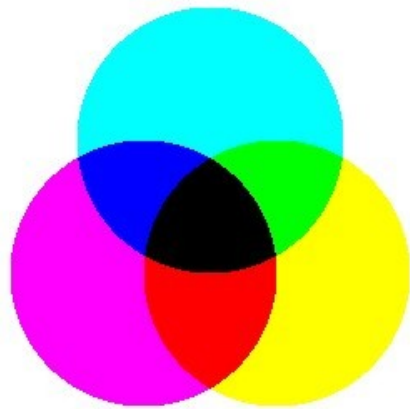
$$R = \frac{1}{3}\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

$$G = 1 - R - B$$

assume $0^\circ \le H \le 120^\circ$

CMY Color System

- Models printing on white paper
- Subtracts from white instead of adding to black
- C : Cyan : absorbs red
- M : Magenta : absorbs green
- Y : Yellow : absorbs Blue



Color Image Processing

CMY Model

Color Printer, Color Copier

RGB data CMY

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

Color Space – CMYK

Used for: printer printing

Use the subtractive color mixing

Axes:

- Cyan
- Magenta
- Yellow
- K: black

Color Space – CMYK

Conversion from RGB:

- C = 255 -Y - 1.4021(Cr-128)
- M = 255 - Y + 0.3441(Cb-128) + 0.7142(Cr-128)
- Y = 255 - Y - 1.7718(Cb -128)
- K = min (C, M, Y)

YCbCr Color Conversion

- The RGB image is converted into the YCbCr image as the RGB image is more sensitive to illumination

- RGB is more **sensitive** to illumination variation
- YCbCr color space is a **linear** luminance color space

Y = Luminance

Cb = Chromaticity of **Blue**

Cr = Chromaticity of **Red**

RGB to YCbCr conversion formula

$$Y = 16 + (65.481 * R + 128.553 * G + 24.966 * B) \quad (1)$$

$$Cb = 128 + (-37.797 * R - 74.203 * G + 112 * B) \quad (2)$$

$$Cr = 128 + (112 * R + 93.786 * G + 18.214 * B) \quad (3)$$

Information Range

Y = 16 to 235

Cb = 16 to 240

Cr= 16 to 240