CSE- 4105

Lecture- 11

Color Models

COLOR MODELS FOR RASTER GRAPHICS

- Three hardware-oriented color models are RGB (CRT monitors), YIQ (broadcase TV color system), and CMY (color-printing devices)

- To related directly to intuitive color notions of hue, saturation, and brightness, another class of models (HSV, HLS, HVC, etc) are developed with ease of use as a goal

Color Model

* What is the color?

- **Color** is a sensation produced by the human eye and nervous system.

- It is related to light, but an understanding of the properties of light is not sufficient to understand color, and is especially not sufficient to understand the art of color reproduction.

What is COLOR?

- It is an attribute of objects (like *texture, shape, smoothness,* etc.)
- It depends on:
  - 1) spectral characteristics of the *light source(s)* (e.g., sunlight) illuminating the objects (relative spectral power distribution(s) SPD)
  - 2) spectral properties of *objects* (*reflectance*)
  - 3) spectral characteristics of the *sensors* of the *imaging device* (e.g., the human eye or a digital camera)

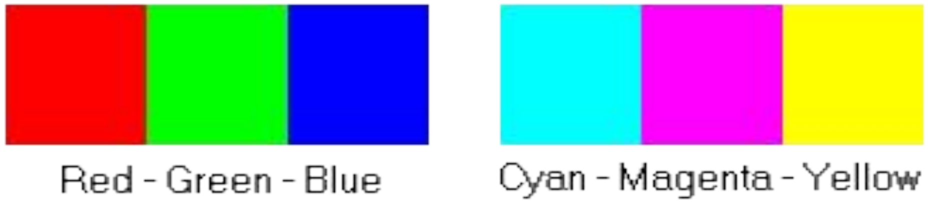
Primary and Secondary Color

- Due to the different absorption curves of the cones, colors are seen as variable combinations of the so-called primary colors: *red*, *green*, and *blue*
- Their wavelengths were standardized by the CIE in 1931: *red*=700 nm, *green*=546.1 nm, and *blue*=435.8 nm
- The primary colors can be added to produce the secondary colors of light, *magenta* (R+B), *cyan* (G+B), and *yellow* (R+G)

Color Model

- **It is useful to represent a color by a set of exactly three numbers.**

- In practice, the set of three numbers must be related to some actual color reproduction process. The numbers commonly specify portions of some set of primary colors such as:



Color Model

* Color model.

- **A color model** is an orderly system for creating a whole range of colors from a small set of primary colors.
- In color reproduction, including computer graphics and photography, the **gamut**, or **color gamut**, is a certain *complete subset* of colors. The most common usage refers to the subset of colors which can be accurately represented in a given circumstance, such as within a given color space or by a certain output device.
- Another sense, less frequently used but still correct, refers to the complete set of colors found within an image at a given time. In this context, digitizing a photograph, converting a digitized image to a different color space, or outputting it to a given medium using a certain output device generally alters its gamut, in the sense that some of the colors in the original are lost in the process.

Color Model

- A color model is an abstract mathematical model describing the way colors can be represented as tupples of numbers, typically as three or four values or color components.

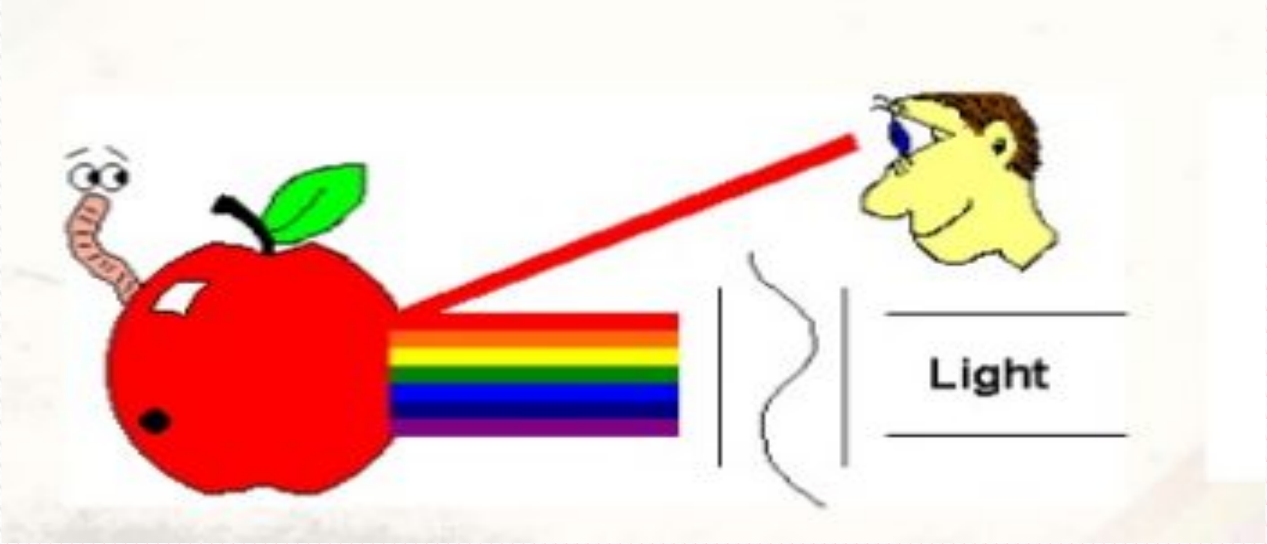
- Any method for explaining or behavior of color within some particular context is called a color model.

Different Color Models

- **Color Models**
  - **RGB (Red, Green, Blue)**
  - **CMY (Cyan, Magenta, Yellow)**
  - **HSI (Hue, Saturation, Intensity)**
  - **YIQ (Luminance, In phase, Quadrature)**
  - **YUV (Y' stands for the luma component (the brightness) and U and V are the chrominance (color) components)**

Properties of light

- When white light is incident on an opaque object, some frequencies are reflected and some are absorbed.
- The combination of frequencies present in the reflected light determines the color of the object that we see.



RGB Model

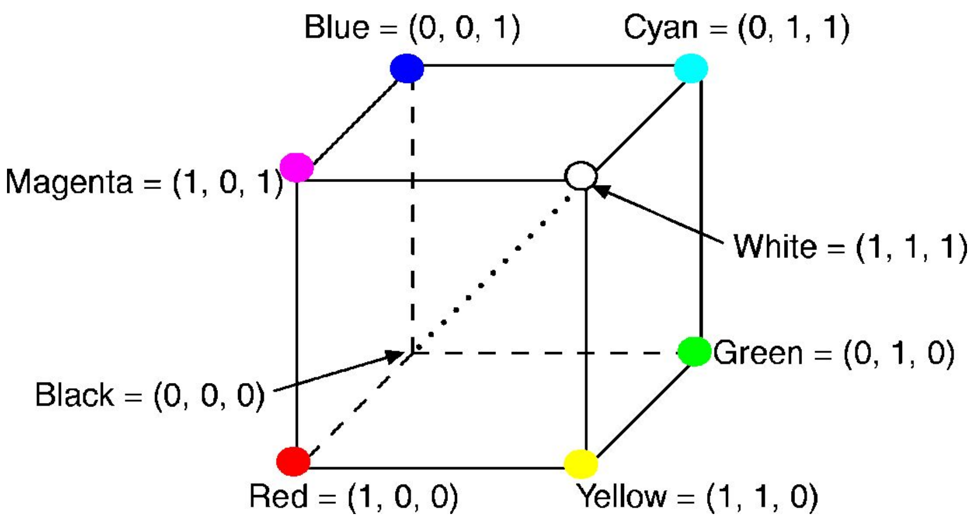
- In this model, the primary colors are red, green, and blue. It is an additive model, in which colors are produced by adding components, with white having all colors present and black being the absence of any color.

- This is the model used for active displays such as television and computer screens.

- The RGB model is usually represented by a unit cube with one corner located at the origin of a three-dimensional color coordinate system, the axes being labeled R, G, B, and having a range of values [0, 1]. The origin (0, 0, 0) is considered black and the diagonally opposite corner (1, 1, 1) is called white. The line joining black to white represents a gray scale and has equal components of R, G, B.

RGB Color Model

- The RGB primaries are additive primaries.
  - The individual contributions of each primary are added together to yield the result.



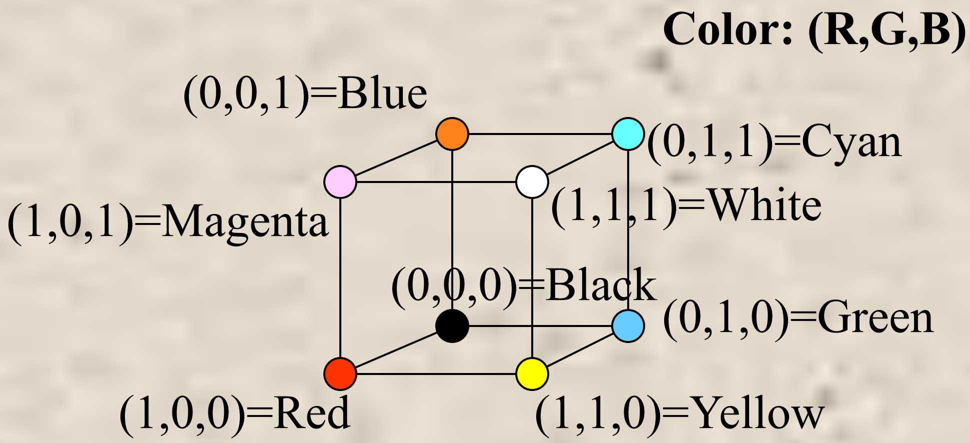
The RGB cube (Grays on dotted main diagonal)

Main diagonal => gray levels

- black is (0, 0, 0)
- white is (1, 1, 1)

The RGB color model (color CRT monitors)

- the RGB primaries are additive primaries



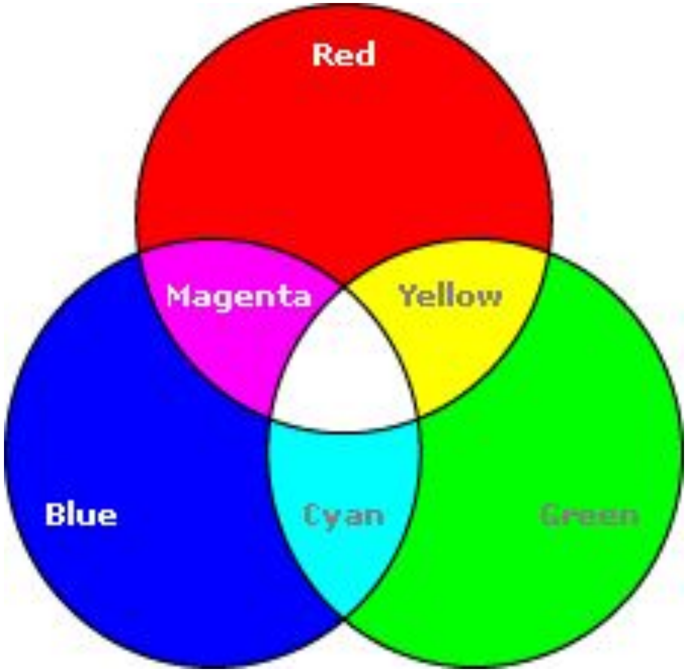
- **Diagonal of the cube, with equal amounts of each primary, represents the gray levels from black (0,0,0) to (1,1,1).**
- **The color gamut covered by the RGB model is defined by the chromaticities of a CRT's phosphors.**
- **Two CRTs with different phosphors will cover different gamuts.**

Color Model

* Types of Color model.

1) **RGB Color Model**:

* Additive color model.
* For computer displays.
* Uses light to display color.
* Colors result from transmitted light.
* Red + Green + Blue = White.



Importance of RGB color model

- The color model RGB is used in hardware applications like PC monitors, cameras and scanners.
- It is used for Web graphics, but it cannot be used for print production.
- It directly reflects the physical properties of "True-color" displays.

Importance of RGB color model

- It is used—
- For sensory representation.
- Display of text images in electronic system, For example- computer, TV, camera.

Why RGB is better

- RGB is really a better way to go for many reasons. Conversion from one color space to another can sometimes be problematic for companies that have a limited knowledge of color management. But in this time of automated color-managed workflows, the resistance to RGB makes little sense from a production point of view. And the pros of RGB generally are stronger than the cons.

Why RGB is better

- The most compelling reason to adopt an RGB workflow is to increase the print provider’s ability to "match the original"-the RGB color space simply allows for a wider range of colors. While it’s true that no output device can match the color range of a transparency or digital camera, modern wide-format devices offer a much wider color gamut than traditional offset presses. In many cases, it makes perfect sense for each print job to try to get the maximum color space your device is capable of reproducing. Clearly, the more data you input to the device, the more you can output.

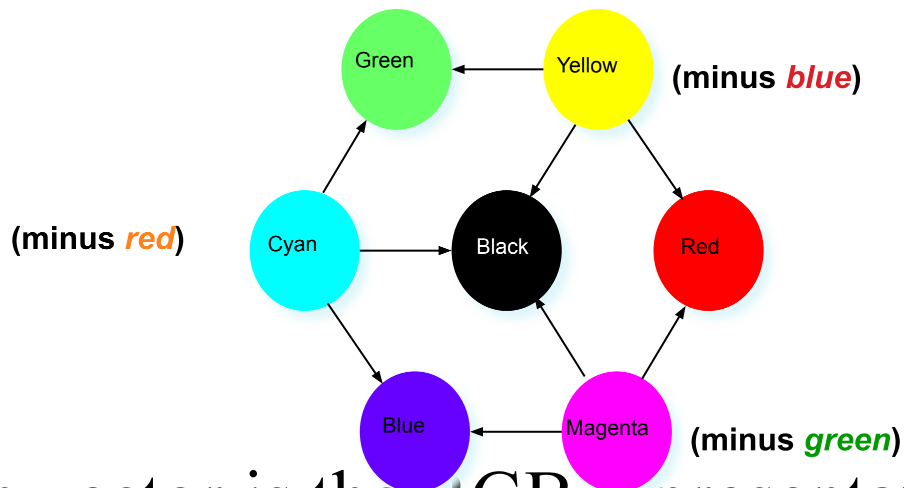
Why RGB is better

- CMYK conversion, by definition, reduces the data contained in the original RGB image. And data that is thrown away can never be reclaimed-it's gone for good. To retain as much data as possible, there is a growing trend toward performing color conversion only in the final rasterizetion process before printing. That way, all of the data in the image file is retained.

CMY Color Model

- Relations between RGB and CMY

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



- The unit column vector is the RGB representation for white and the CMY representation for black.

CMY Color Model

- Another color model, CMYK, uses black as a fourth color.
- Given a CMY specification, black is used in place of equal amounts of C, M, and Y, according to the relations:
  - K:=min(C,M,Y)
  - C:= C – K
  - M:= M – K
  - Y:= Y - K

The CMY color model (ink-jet plotters)

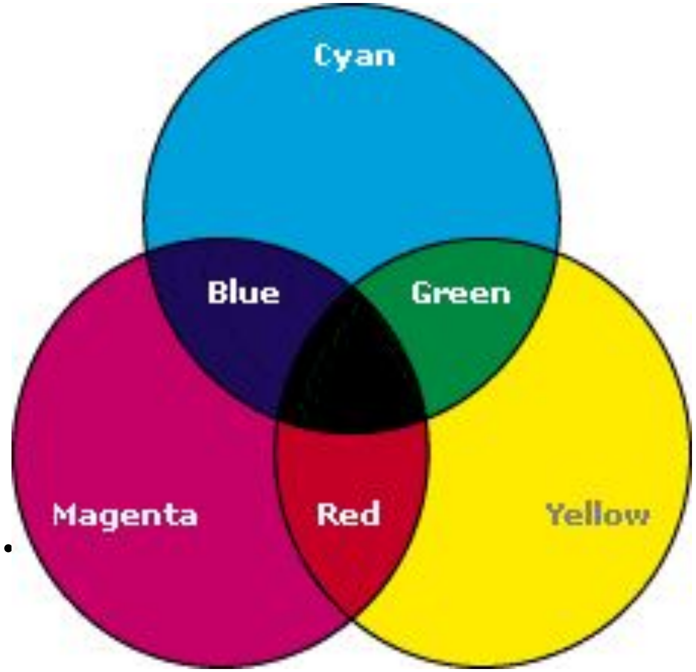
- CMY are the complements of RGB. When used as filters to subtract color from white light, they are called subtractive primaries.
- Colors are specified by what is removed or subtracted from white light, rather than by what is added to blackness.
- Cyan = RGB - R
- Magenta = RGB - G
- Yellow = GRB - B
- From white (paper) by adding CMY, we can generate all different colors.
- Use CMYK K=black instead of just CMY.

Color Model

* Types of Color model.

2) CMYK Color Model:

* Subtractive color model.
* For printed material.
* Uses ink to display color.
* Colors result from reflected light.
* Cyan + Magenta + Yellow = Black.



Color Model

- the color model RGB is used in hardware applications like PC monitors, cameras and scanners, the CMY color model is used in color printers,
- Each color can be a point in the RGB color model cube. Red, green and blue are known as the primary colors. These colors can be added to produce secondary colors which are:
- **magenta = red + blue**
- **cyan = green +blue**
- **yellow = red + green**
- Other possible combinations:
- **white = blue (primary) + yellow (secondary)**
- **white = green (primary) + magenta (secondary)**
- **white = red (primary) + cyan (secondary)**

Importance of cymk color model

- The CMY color model is used in color printers.
- It is created by the subtractive mode
- Used in most commercial color printing (Books, Magazines etc.).

Advantages of CMYK technique

- 1) Less color process / screen for print.
- 2) More productivity.
- 3) Cost minimizing.
- 4) Good hand feel because of using less color on ground.
- 5) CMYK color can be used for different item of print because of common color way.

The YIQ color model (US color TV broadcasting)

- a recording of RGB for transmission efficiency and for downward compatibility with black and white television.
- Here Y=luminance, the same as the CIE Y primary. Only the Y component of a color TV signal is shown on black-and-white TVs.

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.229 & 0.587 & 0.114 \\ 0.596 & -0.275 & -0.321 \\ 0.212 & -0.523 & 0.311 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

- More bits of bandwidth are used to represent Y than to represent I and Q, because our eye is more sensitive to changes in luminance