CogSci109 Lecture 7

Fri, Oct. 12, 2007

Low-pass filtering, High-pass filtering continued, Color theory, Basic Visualization-beyond plots

Outline for today

- Announcements
- Causal filters
  - **Recursive low-pass filter**
  - **Recursive high-pass filter**
  - **Characteristics and examples**
- Visualizing data - to plotting, and beyond!
  - **Plots - what to include, what to leave out**
  - **Histograms, charts, pcolor, meshes, surfaces**
  - **Color theory**
    - Perception, representations
    - False-color representation
    - CIE chromaticity
    - Contrast tables

Announcements

- Reading is up
  - **Practice filling out readings - if you don’t understand, find an additional source and fill out understanding**
- Homework up tonight
  - **Description**
- About broken links
- Example codes

Last time we discussed non-causal filtering

- One main disadvantage is that your filtered data will react non-causally to events
- Another large disadvantage is that you must have ALL data in memory to run the filter
  - **Not an ‘online’ filtering method**
  - **Slow on large datasets**

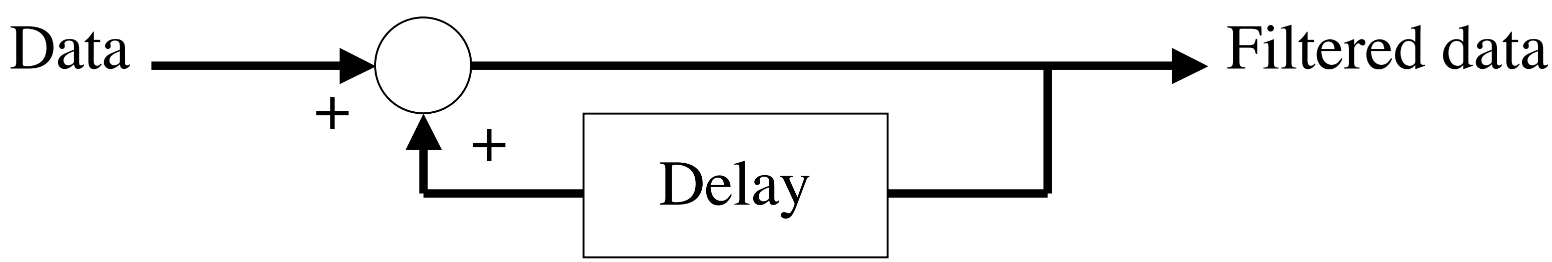
Recursive filtering

- ***Recursive algorithms*** are algorithms that often do not require keeping the entire dataset in memory. Instead these algorithms need keep a minimal number of data points in memory, plus a memory of the associated filter parameters and the last filtered point
  - **We will use a *first order* recursive filter, because it only has one filter parameter, and needs only remember the last filtered data point**
  - **Please be aware that there are MANY types of recursive filters, this is an introduction, and also a basic filter which is easy to implement, even on embedded microprocessors, and works well**

Here's how our recursive filter will work

$$x_f(i) = a * x(i) + (1-a) * x_f(i-1) \qquad 0 < a < 1$$

- The strength of the filter is determined by the parameter *'a,'* which determines the weight of the new measurement vs. the previous filtered data point
- Effectively this uses a delay, which delays output by one sample:



About the first order recursive low pass filter

- Easy to implement
- Smaller a means stronger filtering, and vice-versa

We can also use this to make a high pass filter

- Same as with moving average filter

$$x_{HP}(i) = x(i) - x_{LP}(i)$$

- Use a strong filter to remove high frequency components, then subtract from the raw data to get a high pass filter

Example

- EEG data which needs to be high-pass filtered so it can be amplified…
- To matlab

A note of caution

- Fourier transforms are only one of many methods of estimating frequency components of a signal
  - **Assumes the underlying system is**
    - Linear - defined previously
    - Stationary - signal's frequency composition is fairly constant through the dataset
- We're constructing our own filters, so we can make any filter system we want (our filters can be linear and stationary even if the system they filter is not)
- NO METHOD IS PERFECT AND GENERALLY APPLICABLE TO EVERY SITUATION

A note of caution (continued)

- Wavelet analysis and others
- Takehome message
  - **use any analysis technique with caution and awareness of its limitations**
  - **Use as much insight into the underlying process as possible**
    - Us the appropriate method for the situation - nothing is perfect but is a particular method appropriate

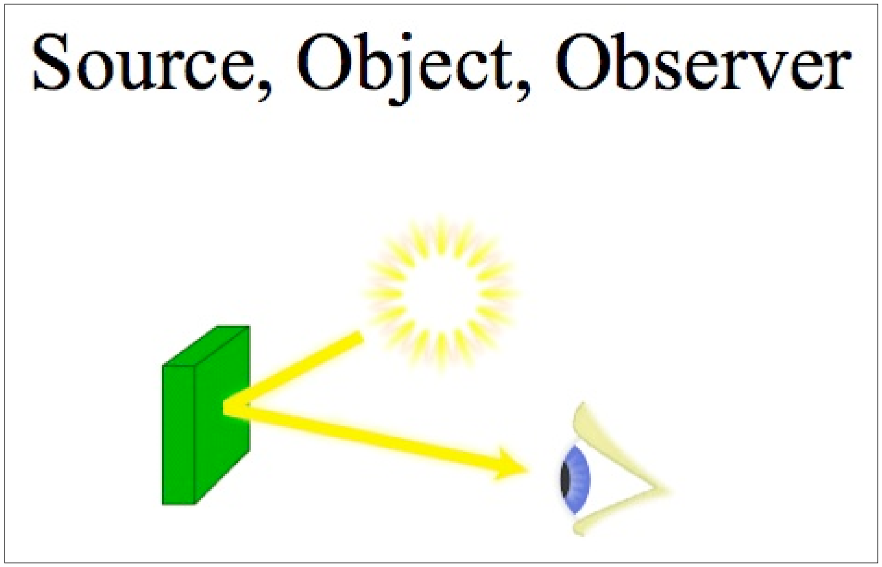
Now a change of gears

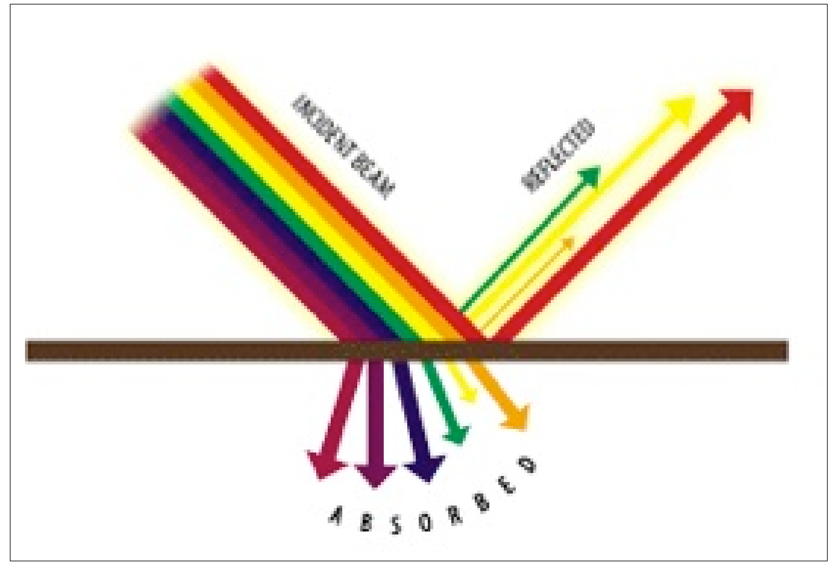
- We want to represent our data in order to ‘look’ at it’s contents in a basic way
  - **Basic Visualization**
    - Plots, charts, histograms, pcolor matrix colortables, surfaces and 3d plots
  - **Color theory and perception**
    - Color theory
    - Color constancy
    - Proper communication of basic visualizations

Visualization

- Can communicate information without words, by encoding motion as part of the information
- http://svs.gsfc.nasa.gov/

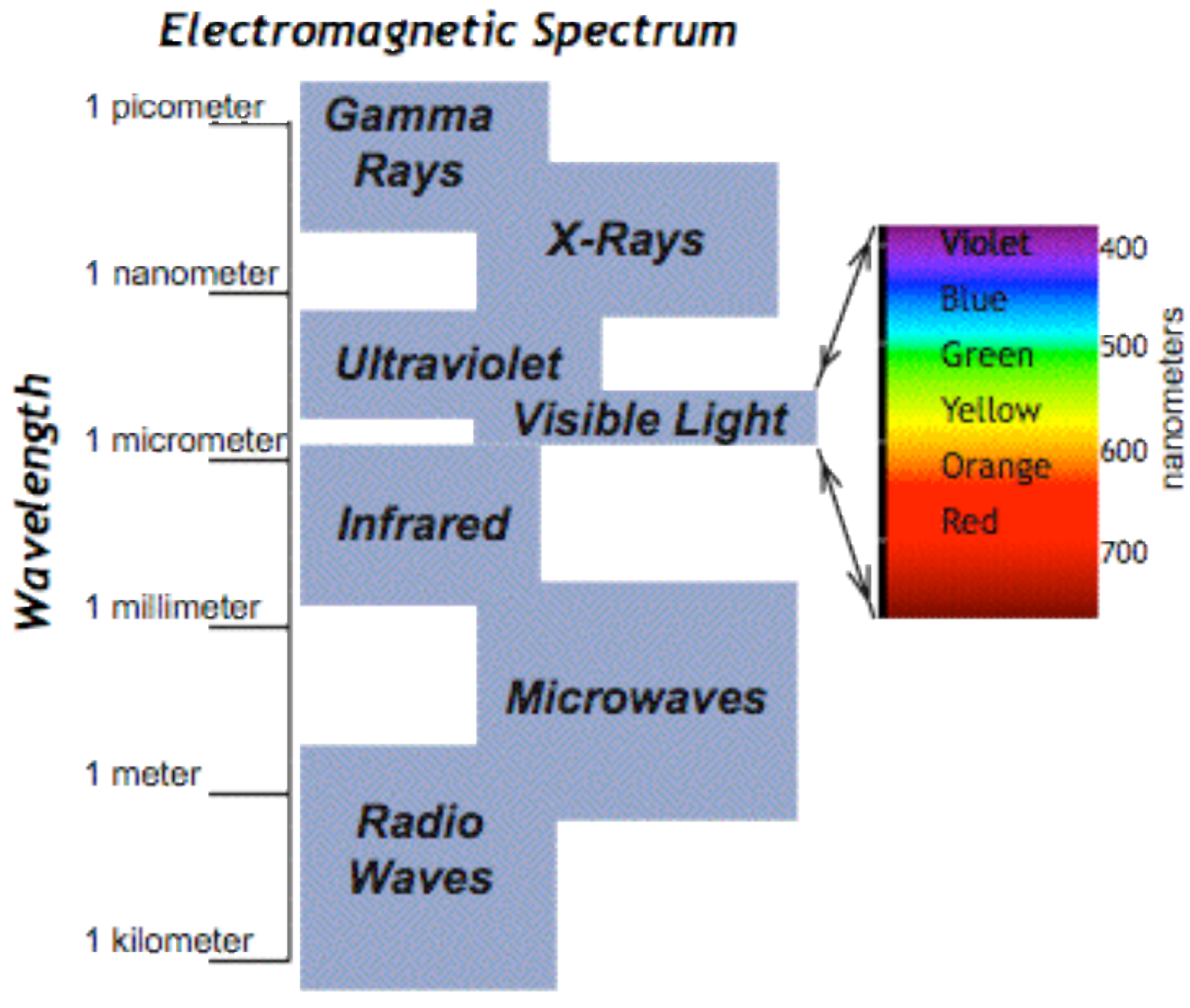
What is color?



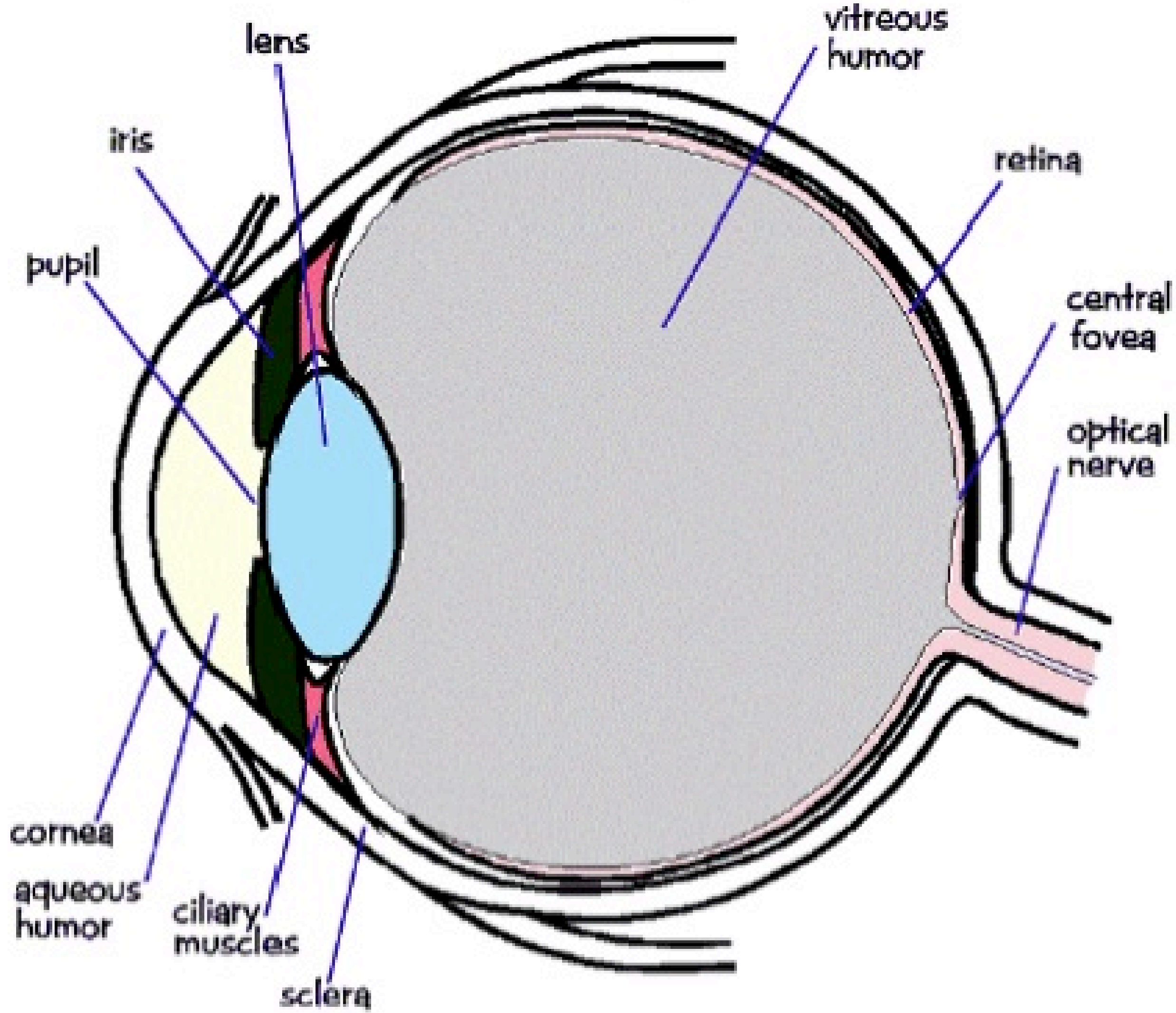


- Reflected light = color of object
- Color is the set of wavelengths of light reflected from an object
- A light source can be a light bulb, the sun, etc or another object

Electromagnetic Spectrum



The Eye

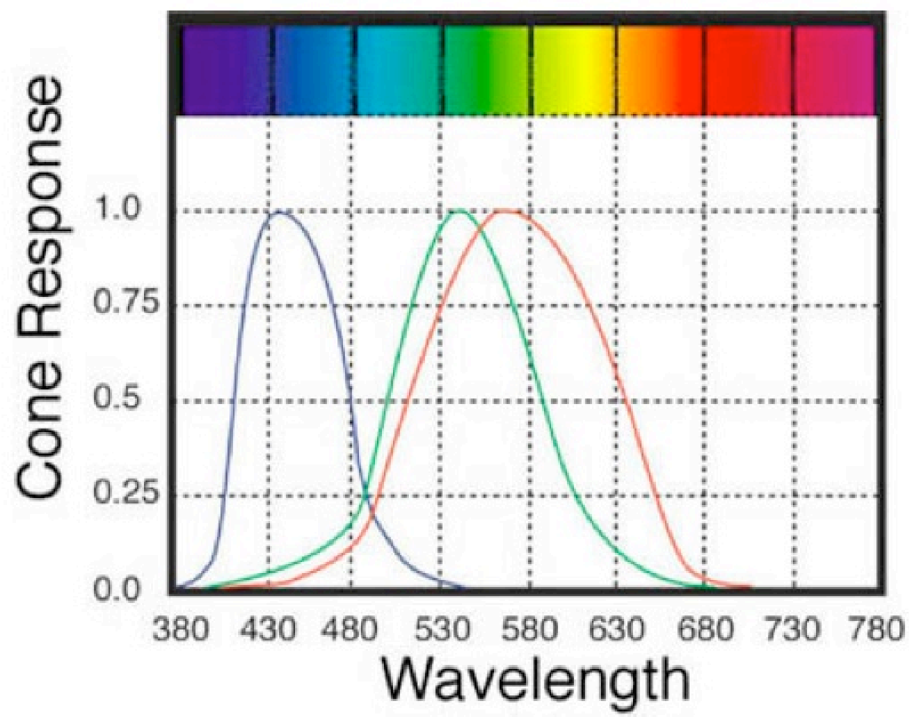

lens
vitreous humor
iris
retina
pupil
central fovea
optical nerve
cornea
aqueous humor
ciliary muscles
sclera

Human perception of color

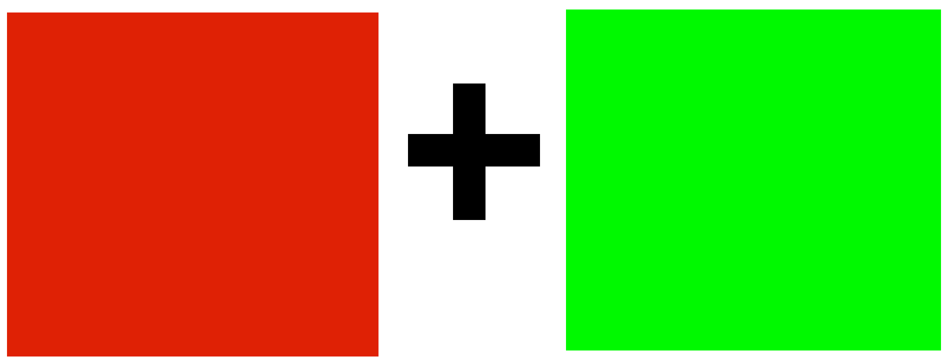
- Color constancy - our visual perception is constantly adjusting to compensate for changing surroundings
- Human color perception is context dependent
  - **Ever try to perceive the difference between two colors of clothing in low light?**
  - **Movie example - Abyss Yellow/green light source, "Cut the blue wire with the white stripe, NOT the black wire with the yellow strip"**
    - Side note- how to fix this as the designer of the device? Use one wire with dashes instead of a stripe - "Cut the wire with the dashes." Person cutting: "Easy. It's done!"

Rods and Cones

- **Rods** - sensitive to intensity (black and white sensitivity in low light conditions)
- **Cones** - three types, S, M and L corresponding to short, medium and long wavelength light sensitivities



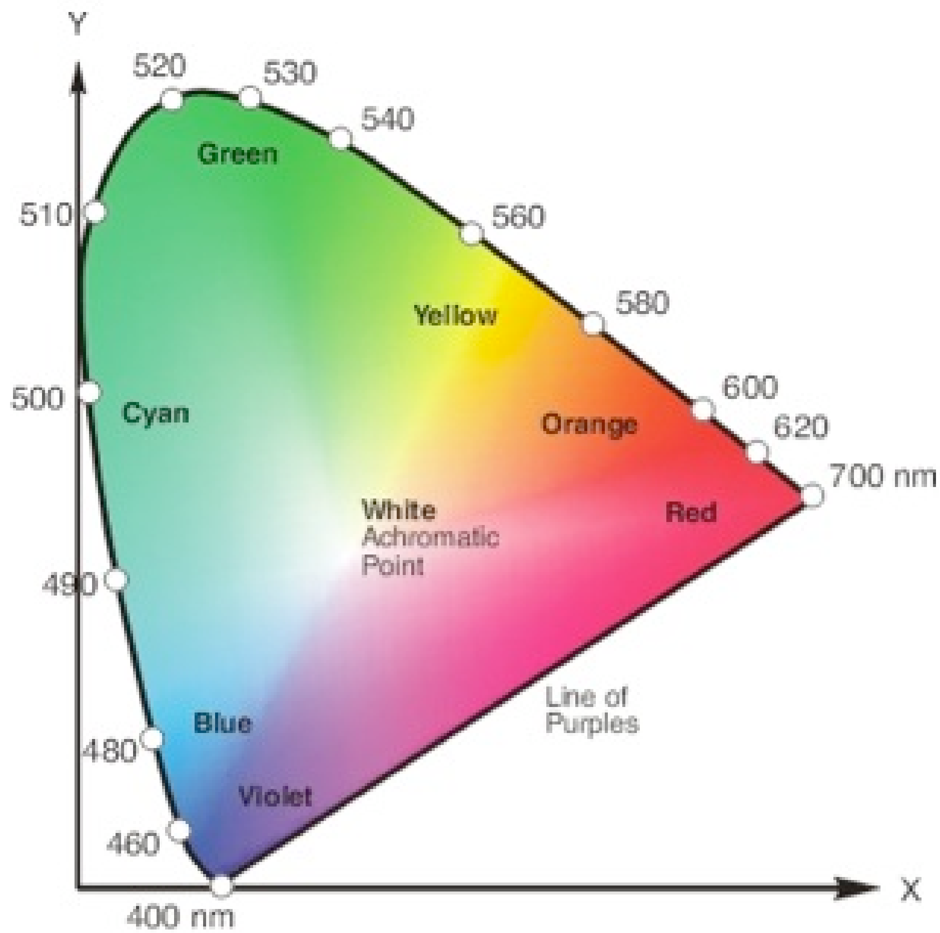
Perceptual example: Afterimages



Perceptual example :

Afterimages

CIE Color chromaticity chart

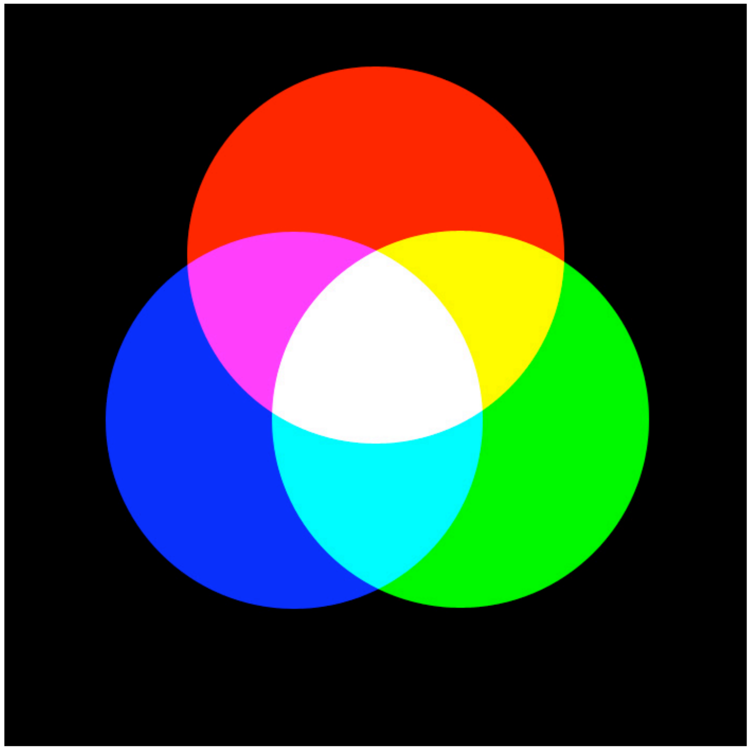


Color spaces

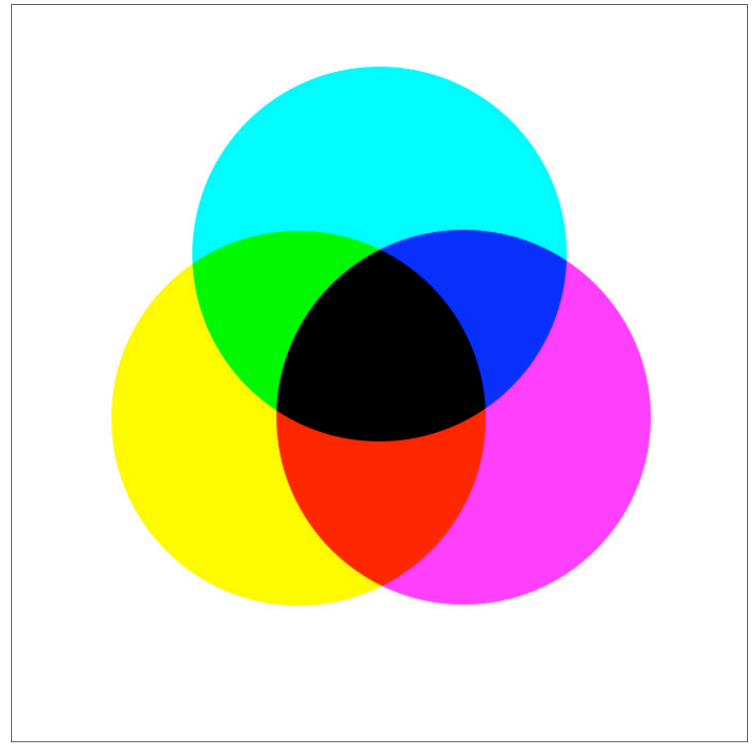
- Now that we have a sense of how we perceive light and color, we can define several *MODELS* of color
- Each color is assigned a coordinate which has three components relative to some color *space model (*ie RGB)
- Some of these color spaces are additive, some are subtractive

Additive vs. subtractive color

Additive (RGB)



Subtractive (CMY)



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

Color models

- RGB
  - **red-green-blue**
  - **Additive scheme**
- CMY
  - **Cyan-magenta-yellow**
  - **Subtractive scheme**
  - **Black (CMYK) is typically added to inkjet printers**
    - Difficult to make exact black by mixing CMY, requires precision
    - Typically one uses black the most so it makes sense to have a separate ink cartridge for black
- HSV
  - **Hue-saturation-value**
  - **Many feel this is a more natural way to describe color for humans**

Example: Bad color matching

- Eeeghh!
- The red and blue are on opposite ends of the visual color spectrum, so we have trouble focusing on both colors simultaneously
- I could have made this worse by adding all equations, but last time too many people passed out!
- AVOID REDS ON BLUES OR BLUES ON REDS

Example: Good color matching

- Ahhh…
- This is much more comfortable for the eyes.
- Choose colors which are based on luminance differences
- generally avoid two fully saturated colors as foreground and background
- Increase contrast by reducing the perceived intensity of either the foreground or background

Bad Contrast

Bad Contrast
Bad Contrast

- The most important thing you need to know to get the most out of your education is that you should value the learning and try to make it your own
- The most important thing in this paper is that we did not really find anything important

Good Contrast

- Use the luminance equation (or an intuitive understanding of it) to suggest good contrast combinations, also can use the precomputed luminance and contrast tables

Luminance equation

$$Y = .30 * Red + .59 * Green + .11 * Blue$$

- Perceived intensity due to a color
  - **Different contributions of red/green/blue components**
  - **Empirically determined**