Human vision systems & Image

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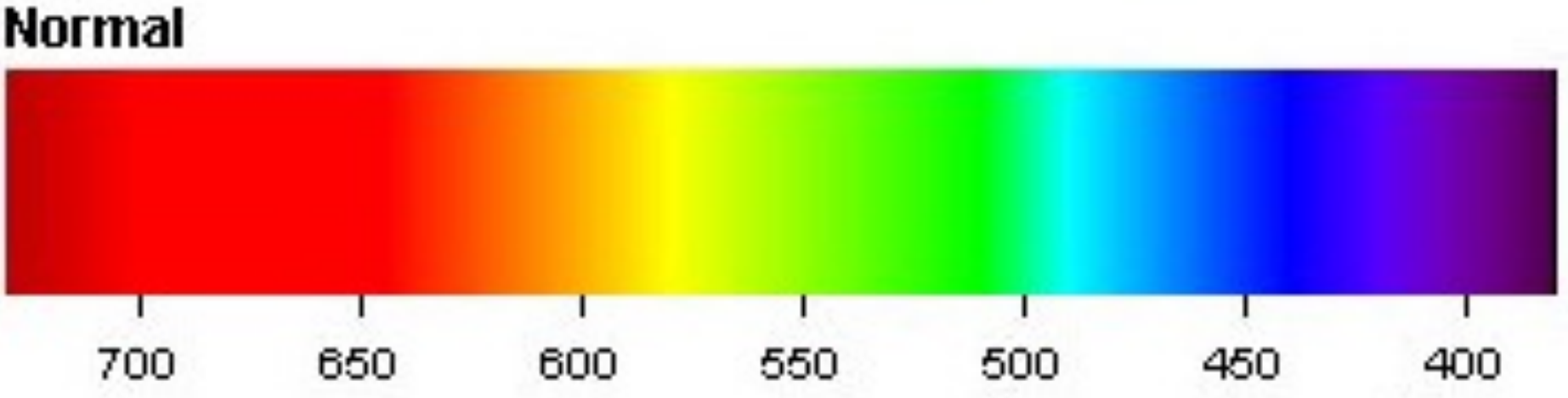
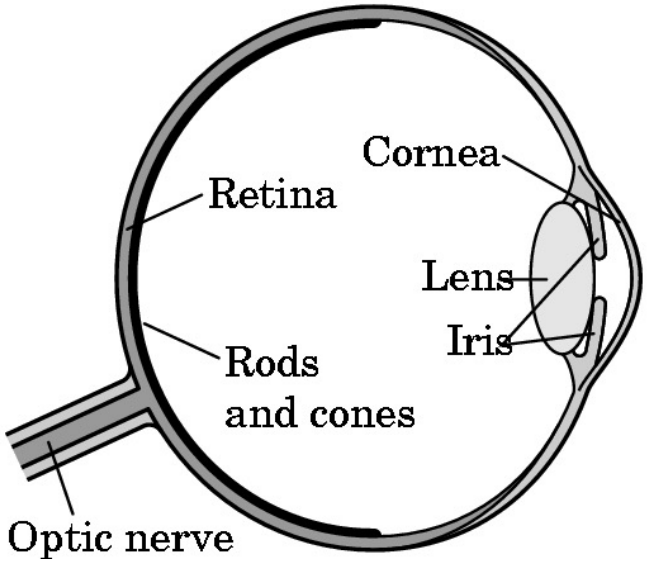
Light

- Light is the part of the electromagnetic spectrum that causes a reaction in our visual systems
- Generally, these are wavelengths in the range of about 350-750 nm (nanometers)
- Long wavelengths appear as reds and short wavelengths as blues

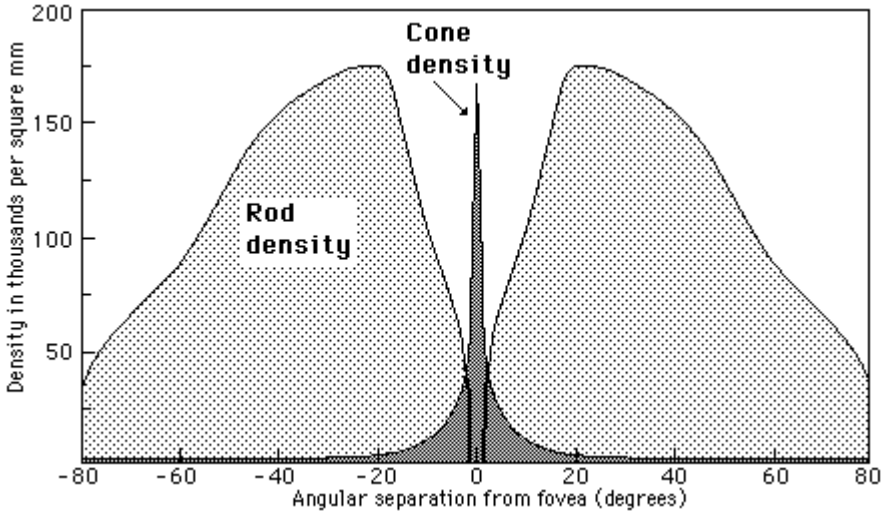


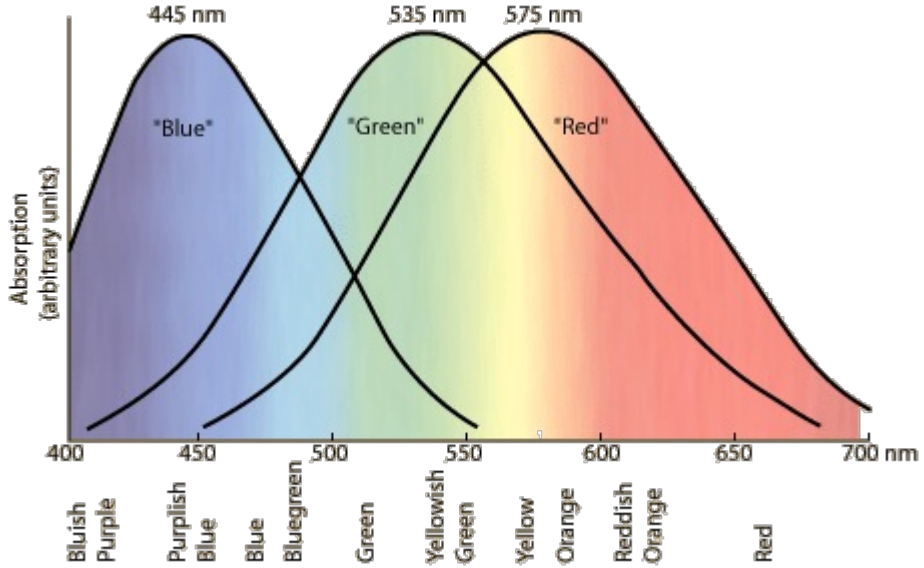
Three-Color Theory

- Human visual system has two types of sensors
  - Rods: monochromatic, night vision
    - Monochromatic: a single wavelength or frequency
    - About 120 million
  - Cones
    - About 7 million
    - Color sensitive
    - Three types of cones
    - Only three values (the tristimulus values) are sent to the brain



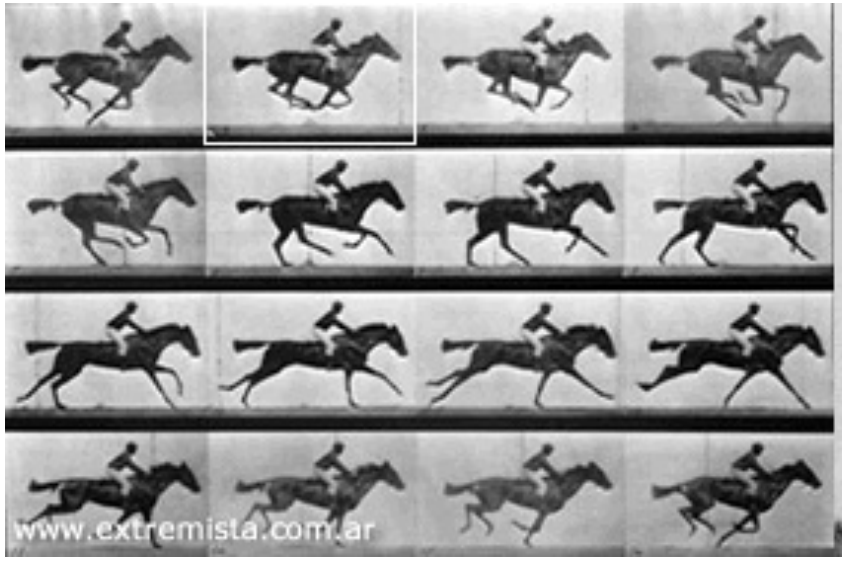
Color Sensitivity

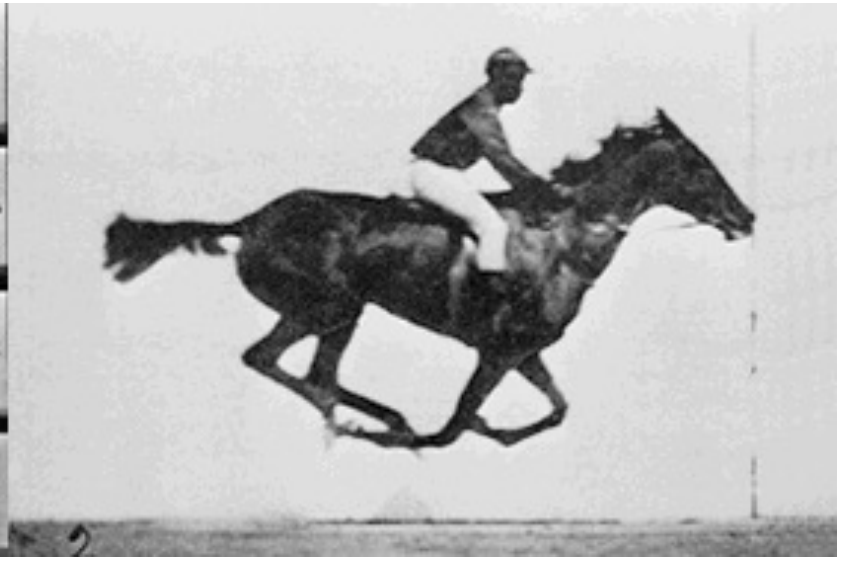




Persistence of vision

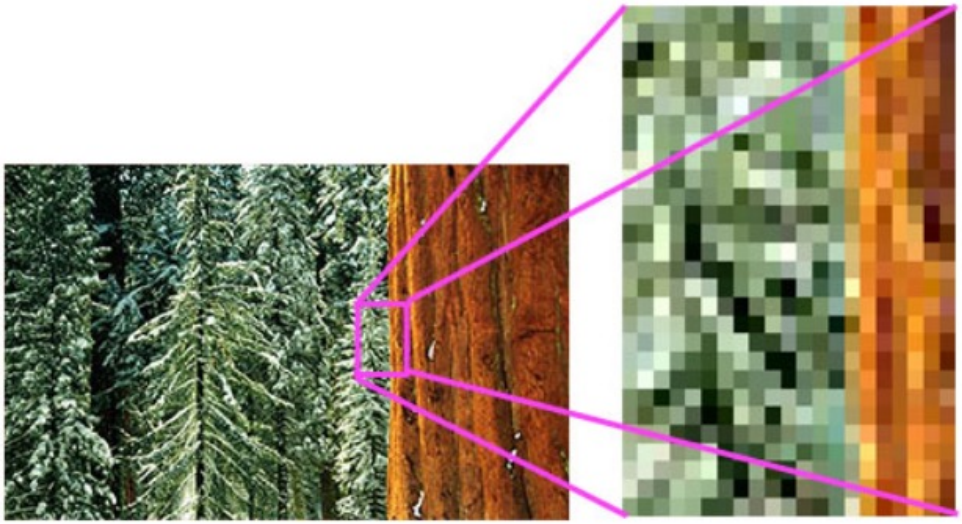
- The image of any object stays on the retina for about 1/10th of the second, even after the object is being removed from our eye sight.
- If there is any displacement of the object took place during this period our vision did not notice the displacement but perceive it as the object moved from one position to another position.



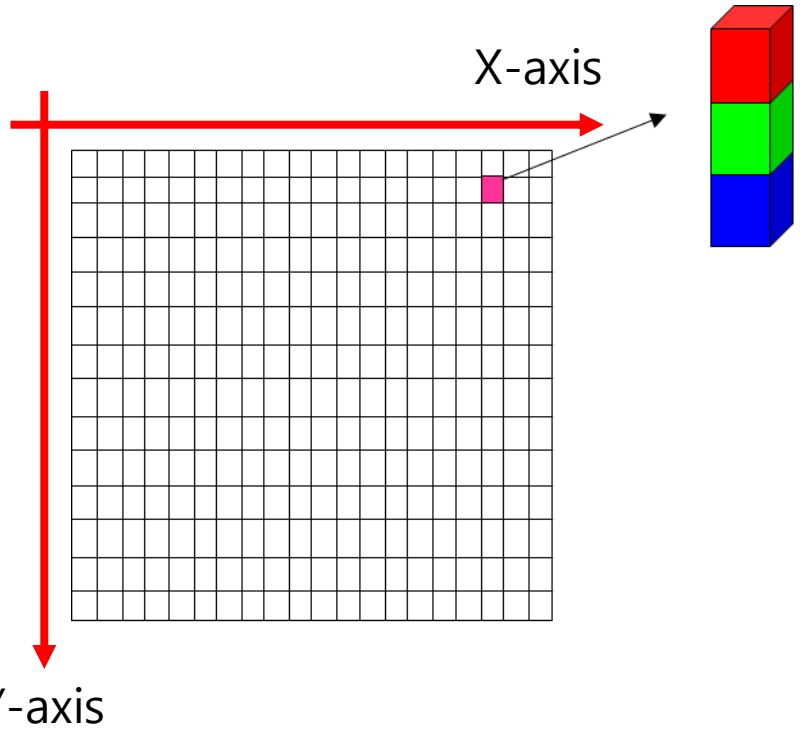


Basics of a Digital Image/Video

- Every digital image is made up of pixels
  - Pixel means picture element
  - Pixels are the smallest unit of information that make up a picture
  - Each pixel may have multiple values
  - The location of a pixel is represented by 2D coordinates



https://www.ultimate-photo-tips.com/what-is-a-pixel.html



Basics of a Digital Image/Video

- A digital video is made up of images
  - Images are taken with very short interval
    - Normally 33ms
  - Frame rate
    - The number of images(frames) of a video per second

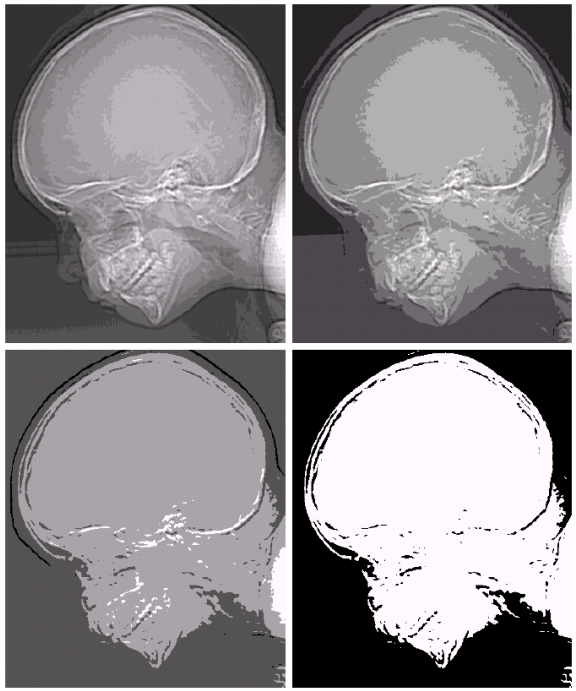
Low frame rate

High frame rate

https://www.mediacollege.com/video/frame-rate/

Basics of a Digital Image/Video

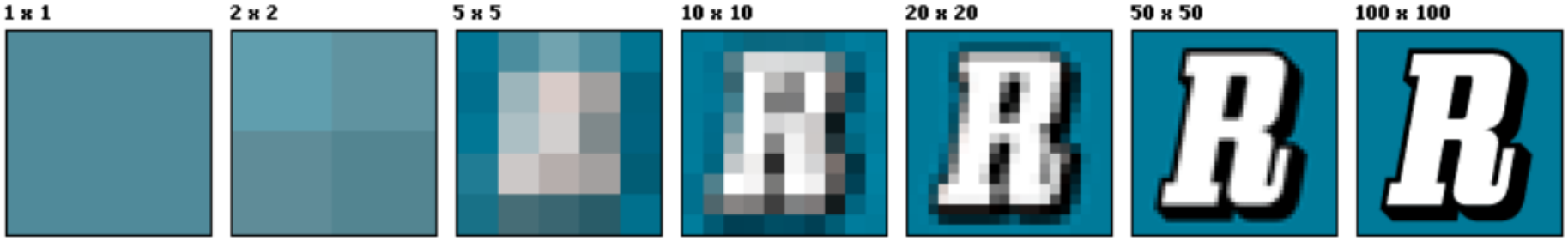
- Intensity level
  - Intensity level is typically an integer power of 2 ➔ $L = 2^k$
  - The continuous range of light intensity is quantized to L gray levels
  - Normally L=256



Images with different intensity levels(16,8,4,2)

Basics of a Digital Image/Video

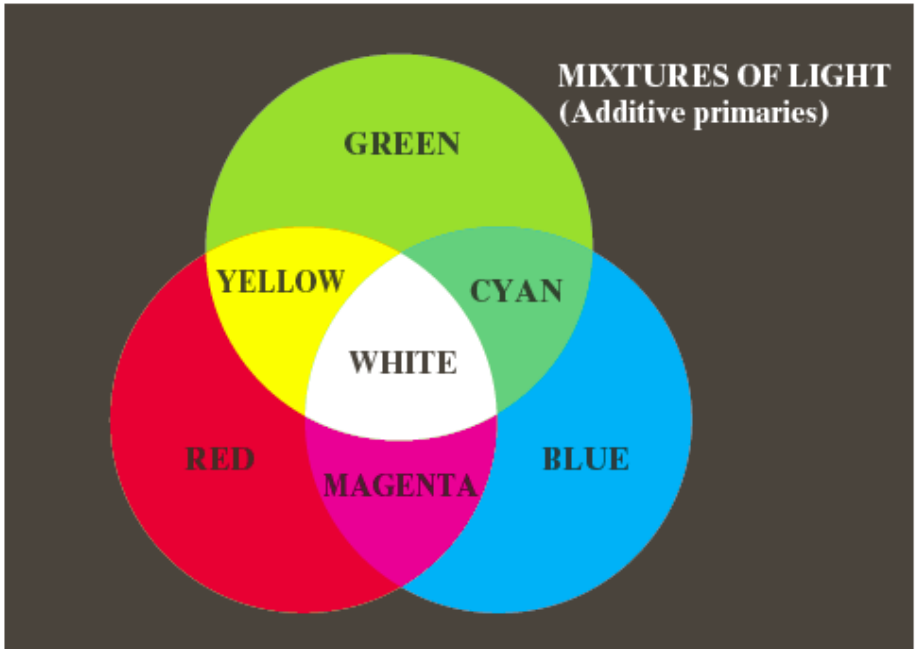
- Pixel resolution
  - The number of pixels in an image



VGA	640X480
HD	1280X720➔1k
FHD	1920X1080➔2k
QHD	2560X1440
UHD	3840X2160➔4k

Additive and Subtractive Color

- Additive color
  - Form a color by adding amounts of three primaries
    - CRTs, projection systems, positive film
  - Primaries are Red (R), Green (G), Blue (B)
- Subtractive color
  - Form a color by filtering white light with cyan (C), Magenta (M), and Yellow (Y) filters
    - Light-material interactions
    - Printing
    - Negative film



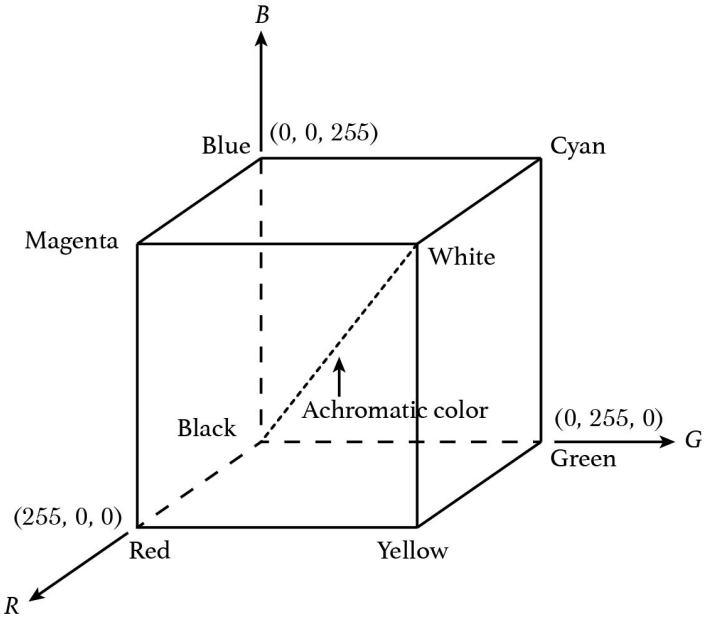
Luminance and Color Images

- Luminance Image
  - Monochromatic
  - Values are gray levels
  - Analogous to working with black and white film or television

- Color Image
  - Normally consists of R,G,B

Color Models

- RGB
  - Consists of R-channel, G-channel, B-channel
  - When intensity level of each channel is [0, 255]
    - Red = (255, 0, 0)
    - White = (255, 255, 255)
    - Black = (0, 0, 0)



Color Models

- HSI
  - Consists of Hue-channel, Saturation-channel, and Intensity-channel
  - Intensity(Brightness): achromatic notion of intensity
  - Hue: the dominant wavelength in a mixture of light waves
  - Saturation: the relative purity or the amount of white light mixed
  - HSI ≅ HSV
  - Large value of S ➔ clear color
  - Large value of I ➔ bright color

Color Models

- HSI