7-9 Monday – 309-GD2

Xử lý ảnh
INT3404 1

Giảng viên: TS. Nguyễn Thị Ngọc Diệp

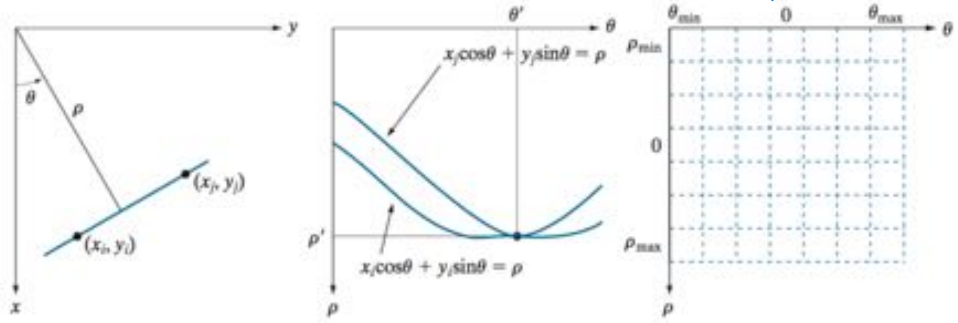
Email: ngocdiep@vnu.edu.vn

Slide & code: https://github.com/chupibk/INT3404_1

Week 8 recall: Hough transform

1. Using the polar parameterization

2. Create a Hough Accumulator Array (keeps the votes)

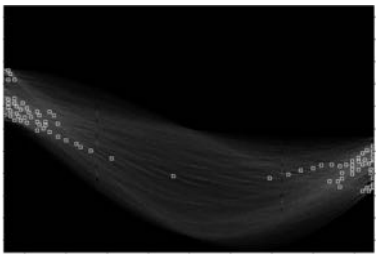


Week 8 recall: Line detection using Hough transform

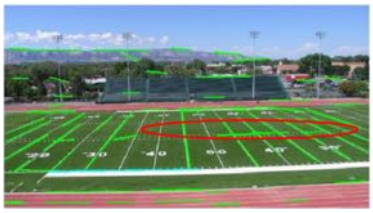
original

Canny edges

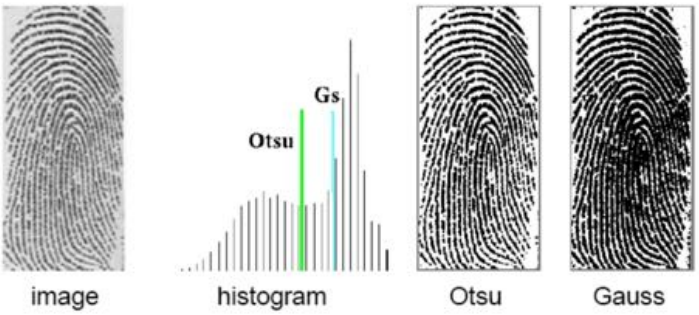
Vote space and top peaks



Longest segments found

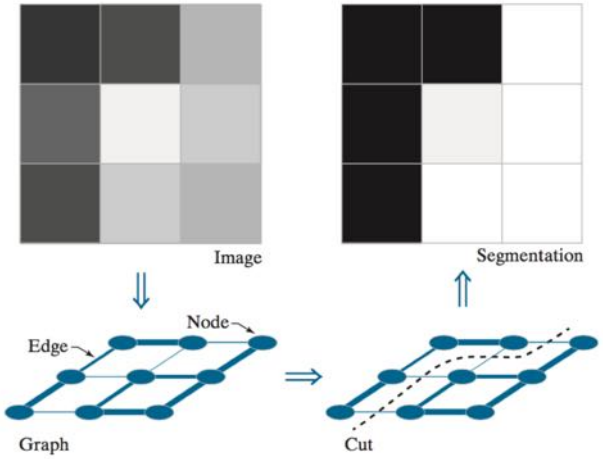


Week 8 recall: Threshold-based Segmentation



Week 8 recall: Graph-based Segmentation

- Graph cut
- Normalized graph cut



Final project registration

Registration form

- https://forms.gle/Qpp1hbX9QPG875gT8
- Speadsheet to edit:
  - https://docs.google.com/spreadsheets/d/1c13rgmfNdIpJEPD544qDY2sHxH-ZOxzobeW8fI1CI_w/edit#gid=82493842
  - → Edit with care!

Lịch trình

Tuần	Nội dung	Yêu cầu đối với sinh viên
1	Giới thiệu môn học Làm quen với OpenCV + Python	Cài đặt môi trường: Python 3, OpenCV 3, Numpy, Jupyter Notebook
2	Phép toán điểm (Point operations) – Điều chỉnh độ tương phản – Ghép ảnh	Làm bài tập 1: điều chỉnh gamma tìm contrast hợp lý
3	Histogram - Histogram equalization - Phân loại ảnh dùng so sánh histogram	Thực hành ở nhà
4	Phép lọc trong không gian điểm ảnh (linear processing filtering) - làm mịn, làm sắc ảnh	Thực hành ở nhà Tìm hiểu thêm các phép lọc
5	Tìm cạnh (edge detection)	Thực hành ở nhà
6	Các phép toán hình thái (Erosion, Dilation, Opening, Closing) - tìm biển số	Làm bài tập 2: tìm barcode
7	Chuyển đổi không gian - miền tần số (Fourier) - Hough transform	Thực hành ở nhà
8	Phân vùng (segmentation) - depth estimation - threshold-based - watershed/grabcut	Đăng ký thực hiện bài tập lớn
9	Mô hình màu Chuyển đổi giữa các mô hình màu	Làm bài tập 3: Chuyển đổi mô hình màu và thực hiện phân vùng
10	Mô hình nhiễu -Giảm nhiễu -Khôi phục ảnh -Giảm nhiễu chu kỳ - Ước lượng hàm Degration -Hàm lọc ngược, hàm lọc Wiener	Thực hành ở nhà
11	Template matching – Image Matching	Làm bài tập 4: puzzle
12	Nén ảnh	Thực hành ở nhà
13	Hướng dẫn thực hiện đồ án môn học	Trình bày đồ án môn học
14	Hướng dẫn thực hiện đồ án môn học	Trình bày đồ án môn học
15	Tổng kết cuối kỳ	Ôn tập

In this lecture

- Color basics
  - What is color
  - How human eyes perceive colors
- Color creation
  - How we present and create colors
- Color models
- Color image processing

Color basics

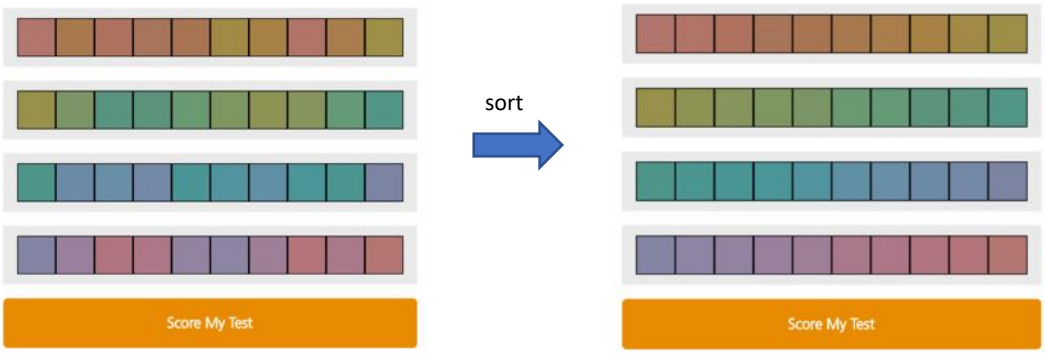
Colors

- Color exists only in light, but light itself seems colorless to the human eyes
- What is color and how we perceive colors?

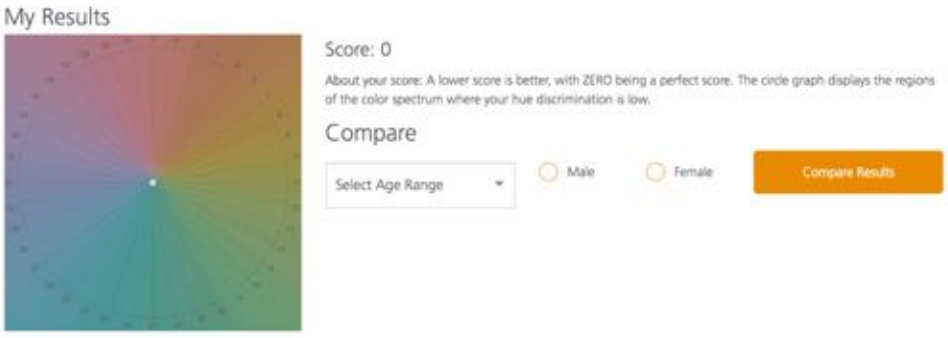
Color IQ: How well do you see color

- Do you know
  - 1 out of 255 women and 1 out of 12 men have some form of color vision deficiency?
- Color vision test:
  - Farnsworth Munsell 100 Hue Test (1949)
    - http://goo.gl/Nj6mBi
  - Farnsworth D15 arrangement test (1947)
    - http://goo.gl/OL1k6o

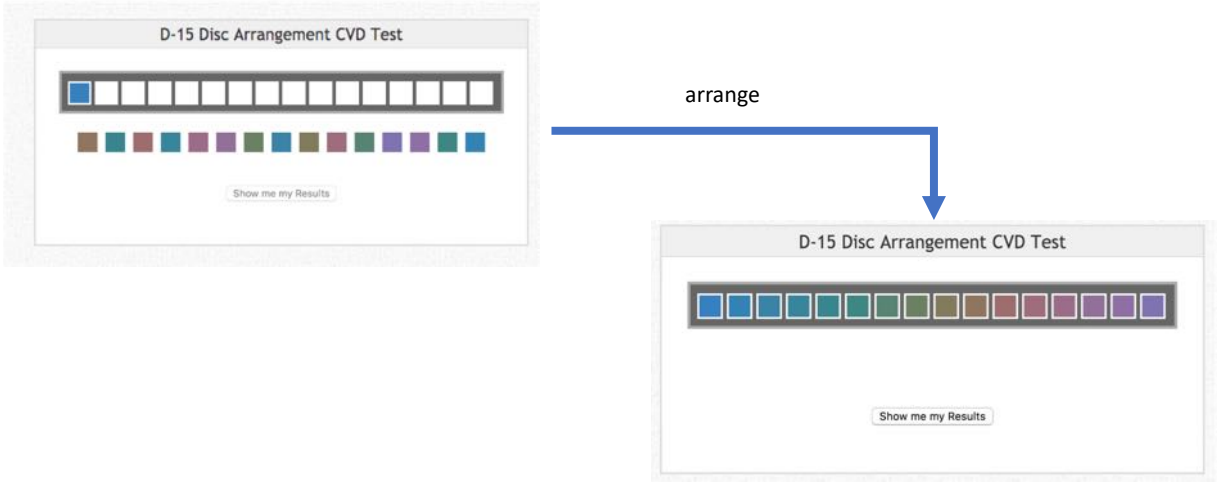
Farnsworth Munsell 100 Hue Test (1949)



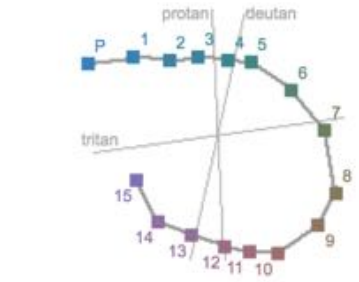
Farnsworth Munsell 100 Hue test result



Farnsworth D15 arrangement test (1947)



Farnsworth D15 arrangement results



The thick line describes your order of the test plates. People with normal color vision order them in a circle (P, 1, 2, ..., 15). Crossings indicate some form of color blindness. Paralleslism of crossings to a confusion line (protan, deutan, tritan) is a clue for the type of your color blindness.

Give me more detailed Results

Color IQ: it is not just for fun

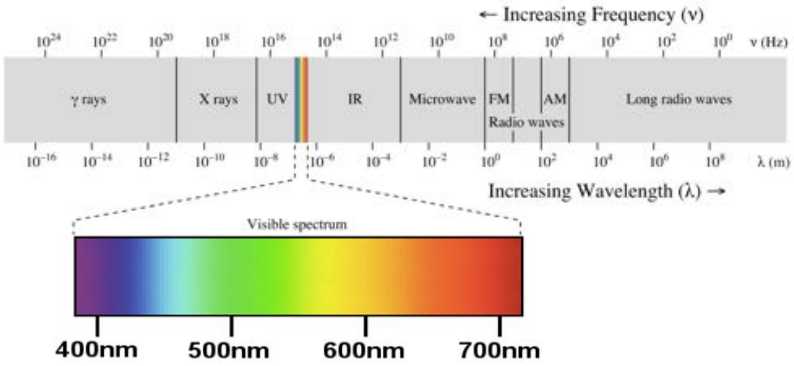
- Color vision can indicate certain medical conditions
- In industries, where color decisions are critical
  - E.g., Product sales, Design

What is color?

- Our world is just full of electromagnetic radiation of varied intensity and wavelengths
- Objectively, there is only the spectral power distribution of the light that meets the eye
- → Color originates in the mind of the observers

Electromagnetic spectrum

Electromagnetic spectrum is the range of all possible frequencies of electromagnetic radiation



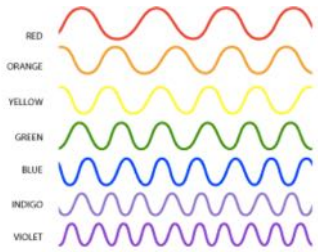
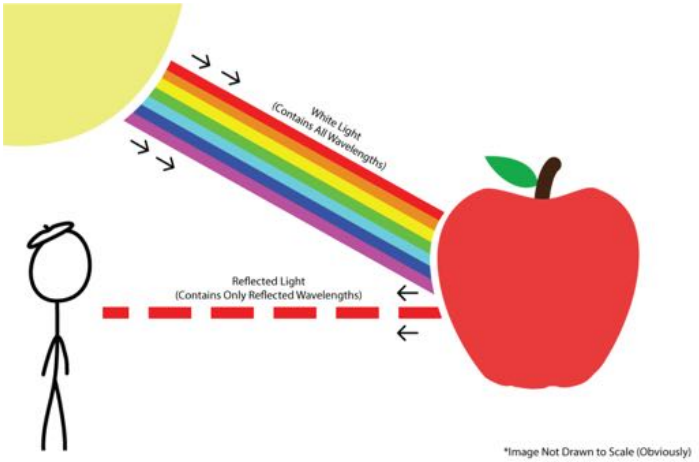
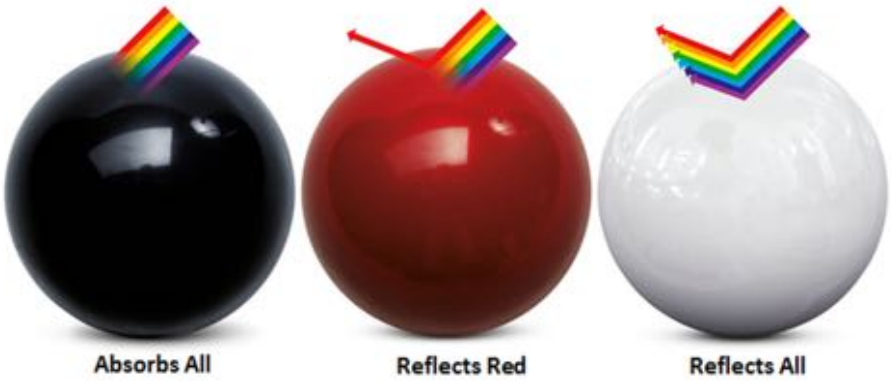
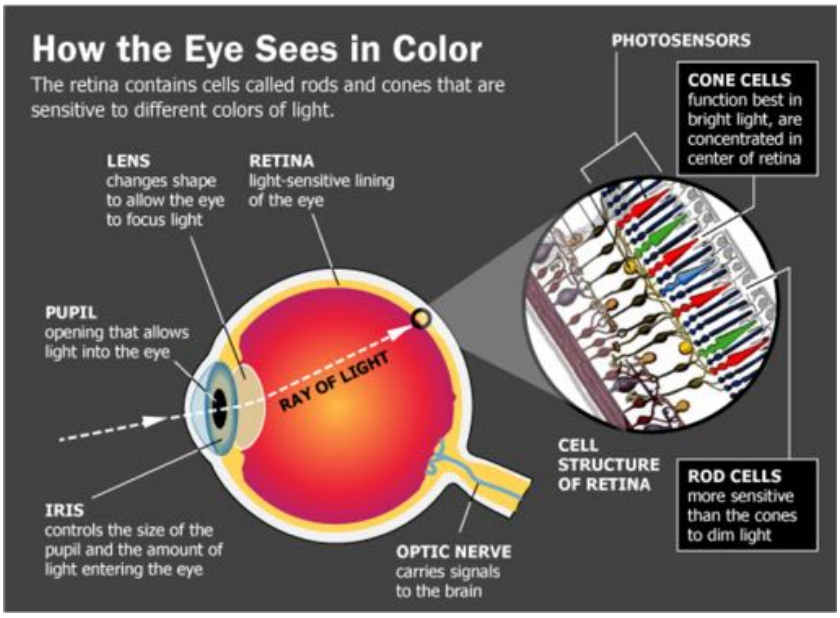


Image credit: wikipedia.org
nasa.gov

Seeing colors

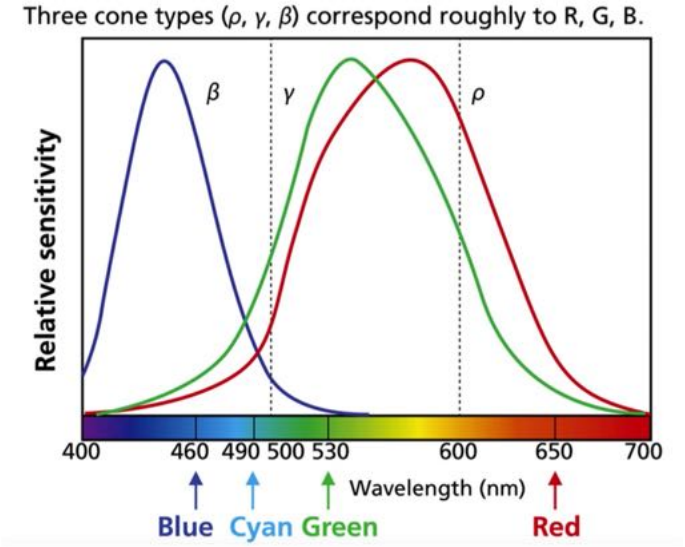






Source: National Library of Medicine, photos8.com

Human spectral sensitivity to color



Three types of cone cells:
(named after their sensitivity at wavelengths)

- Long (L)
- Medium (M)
- Short (S)

In principle, three parameters, corresponding to levels of stimulus to the three types of cone cells, can describe any color sensation

Color blindness

One or more cone types are defective

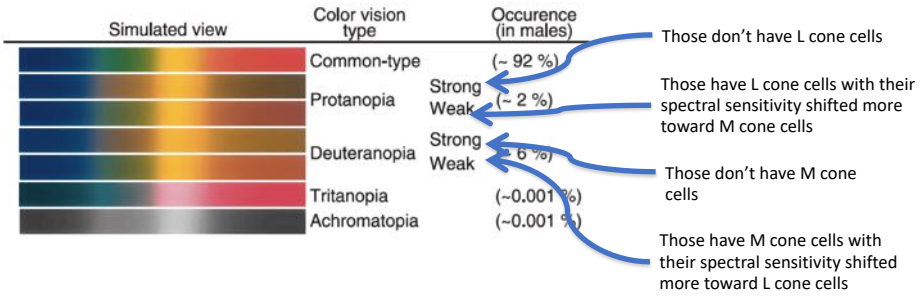


Image credit: www.cudo.jp

Example of color vision deficiency

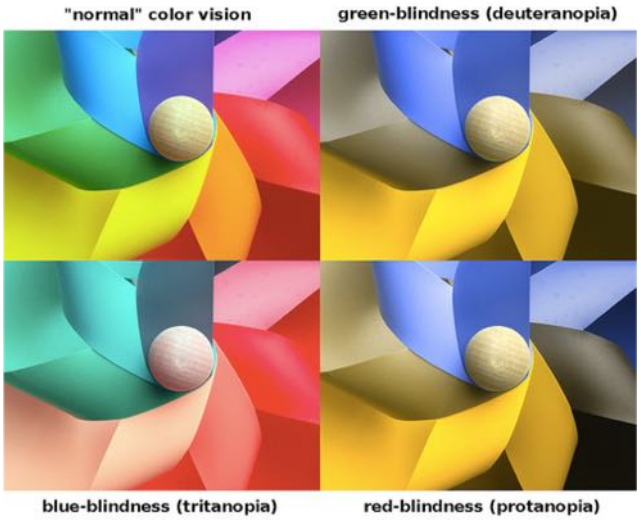
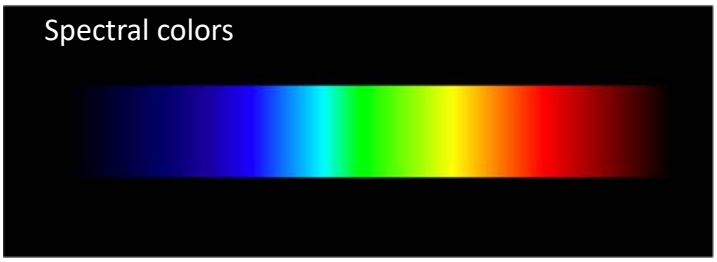


Image credit: flickr.com

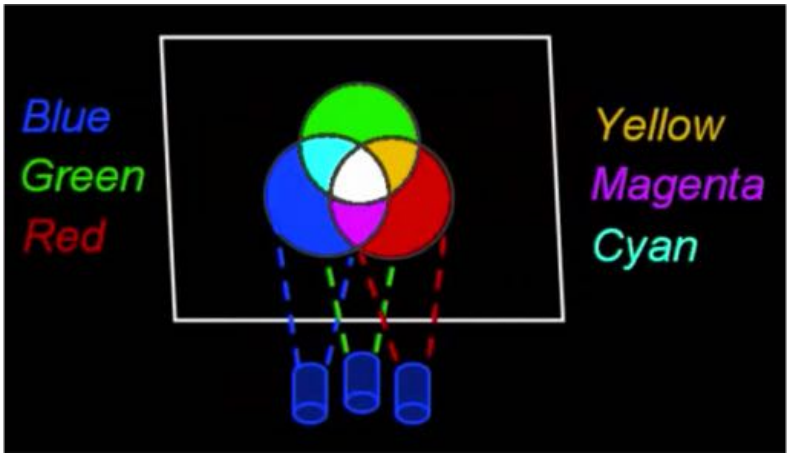
Color creation

Colors

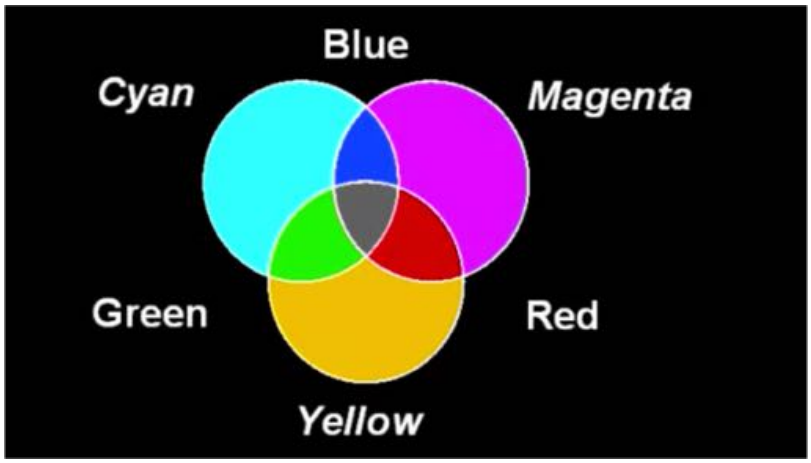
Newton 1666-72



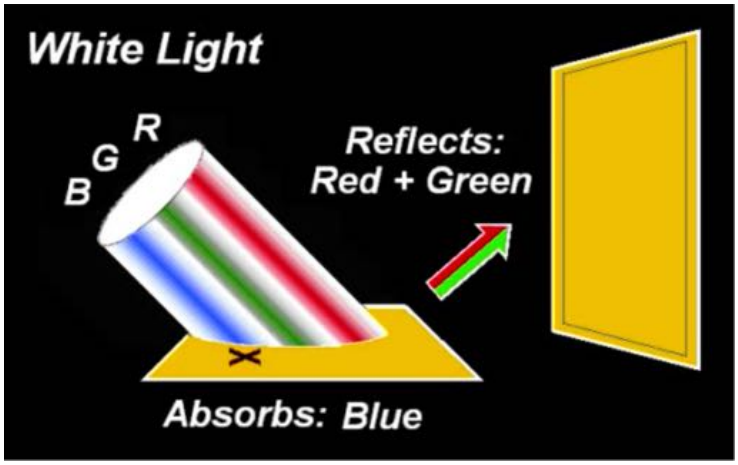
Additive color



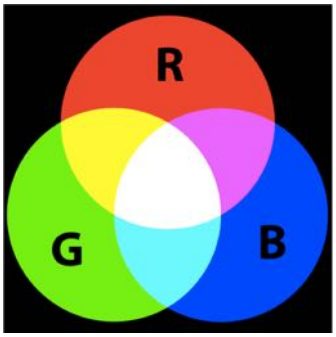
Subtractive color



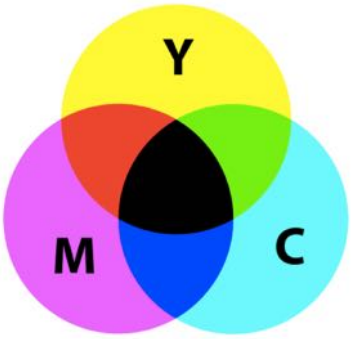
Subtractive color with filter



Additive vs Subtractive color creation

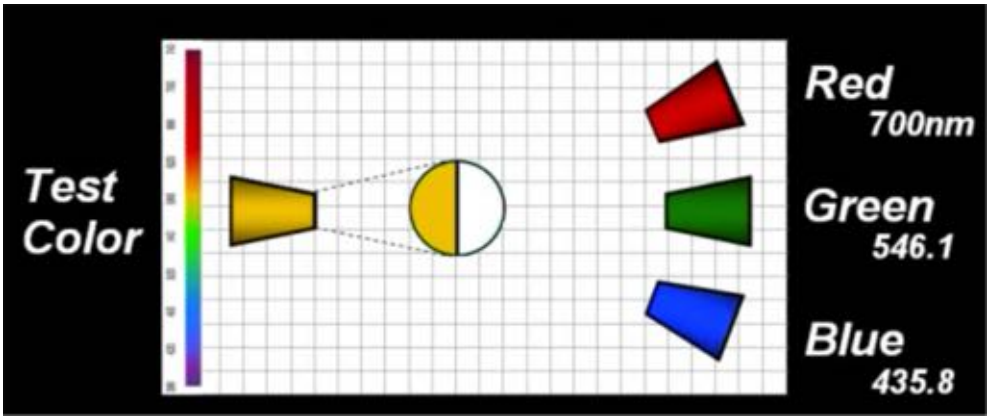


Your add light to make the color brighter



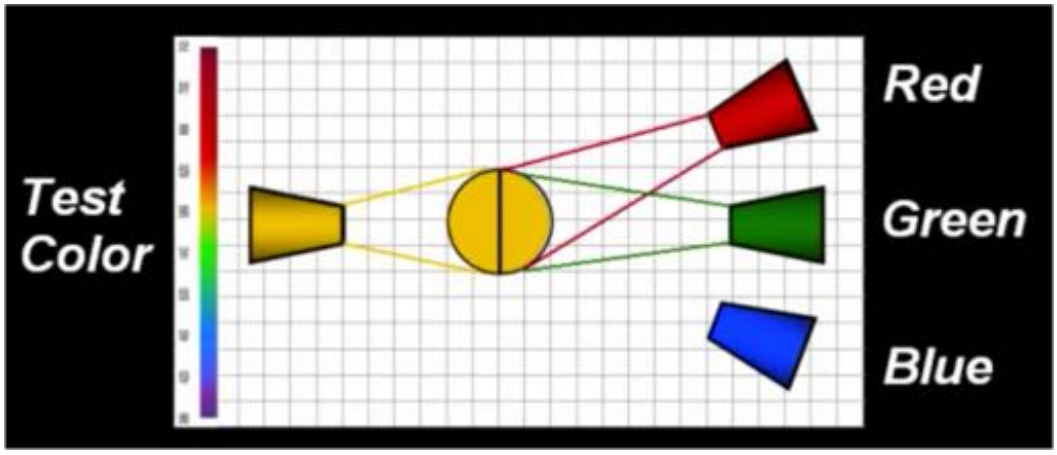
You subtract the light from the paper by adding more color

Color matching

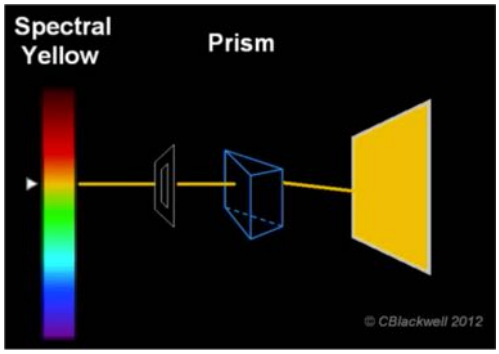


The amount of three colors: tristimulus values

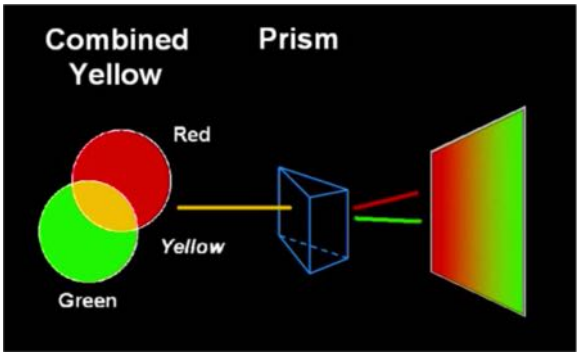
Color matching



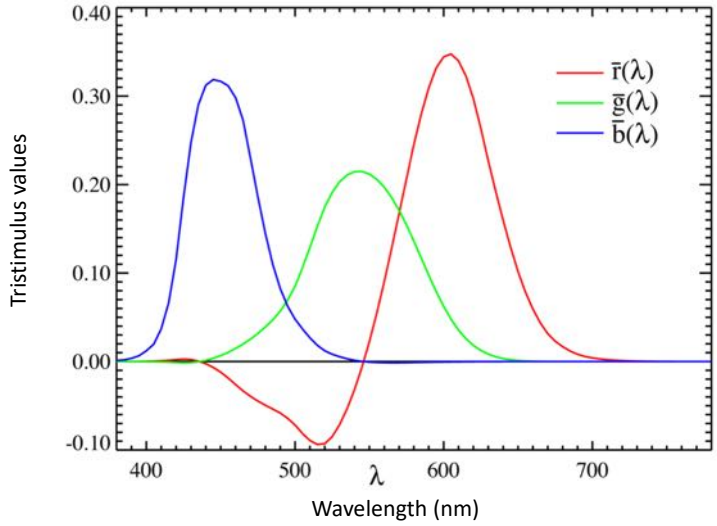
Note: color is in your mind



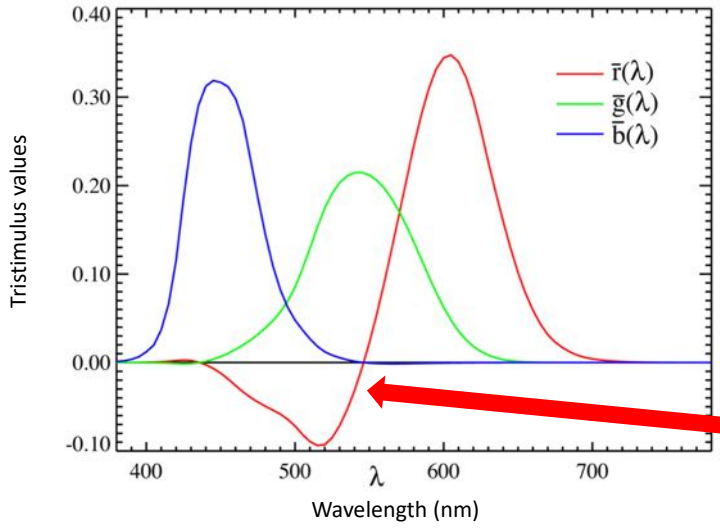
But...



Color matching RGB

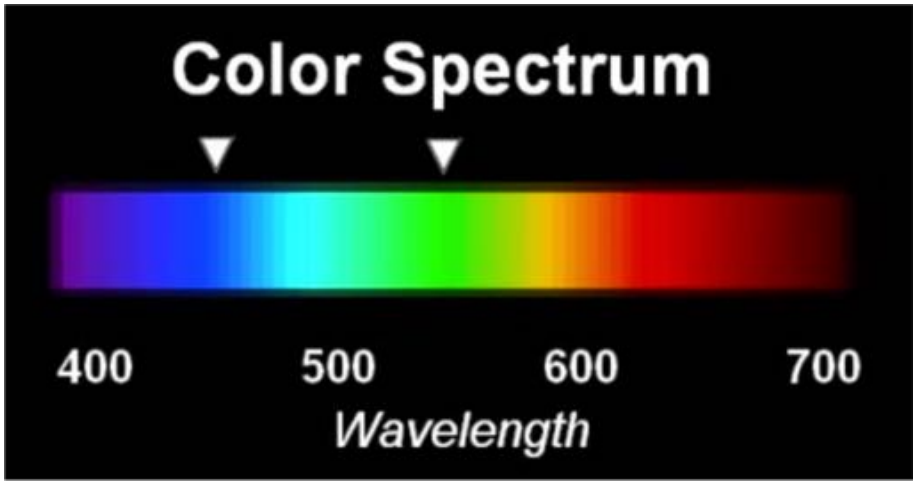


Color matching RGB

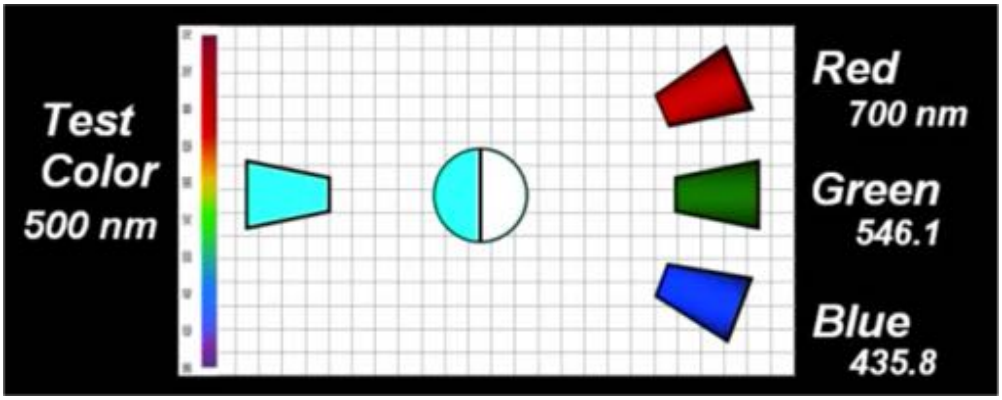


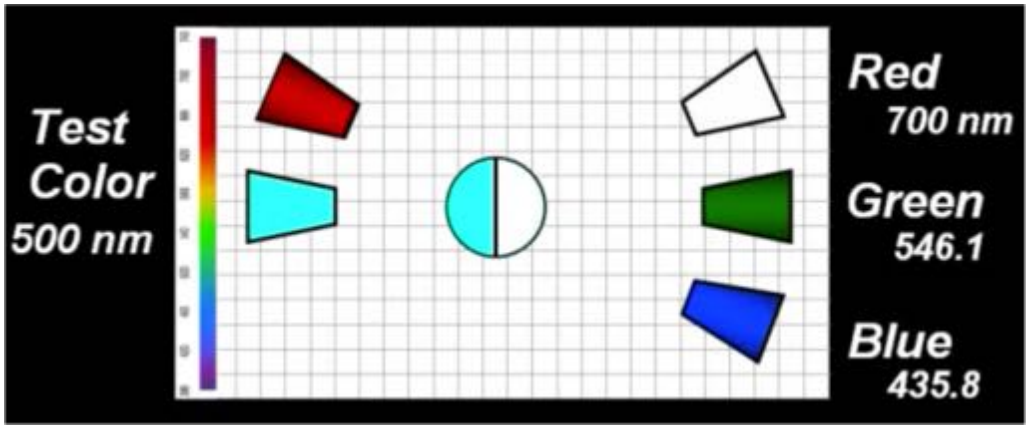
Negative amounts?

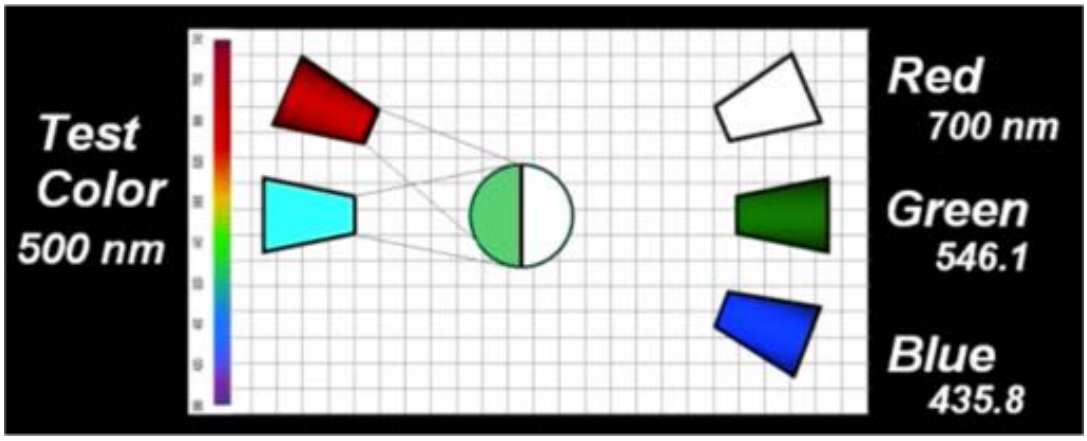
Unmatch-able examples using RGB

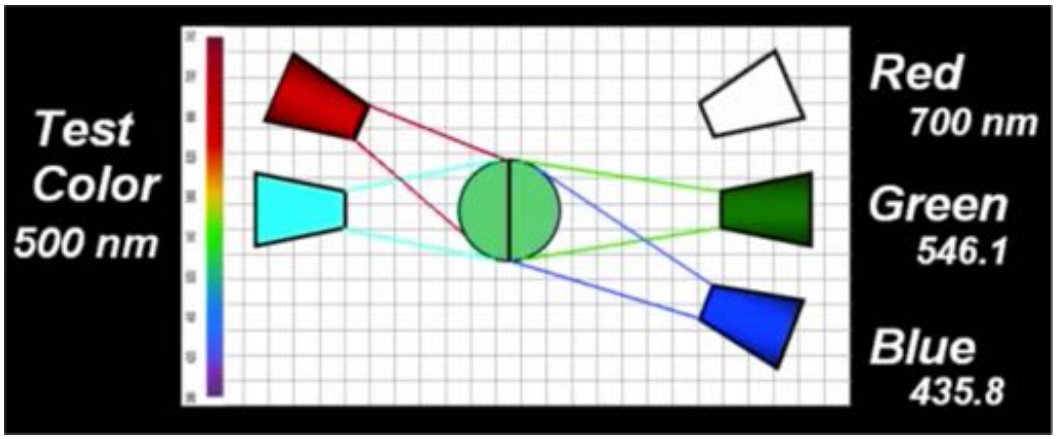


How is it matched?

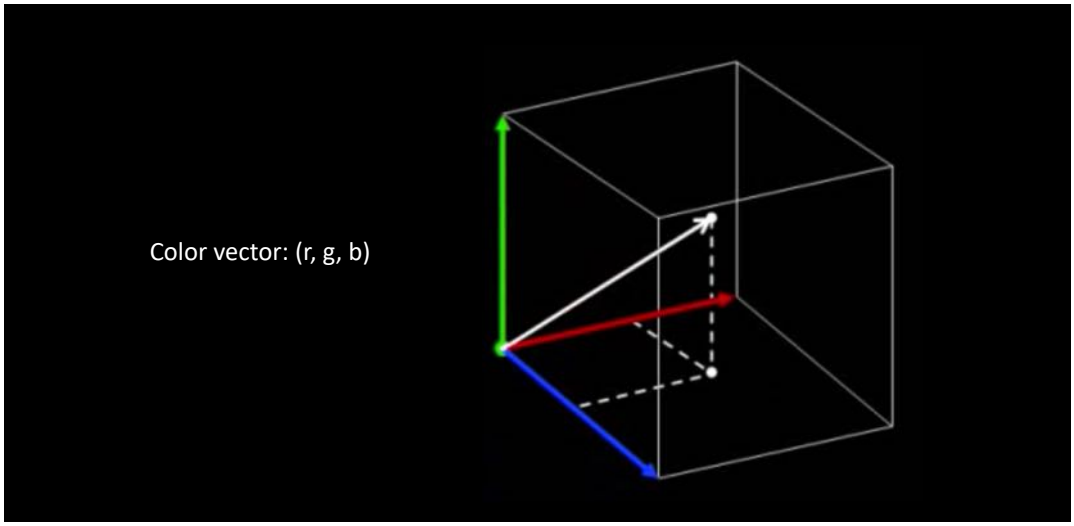



Test
Color
500 nm
Red
700 nm
Green
546.1
Blue
435.8

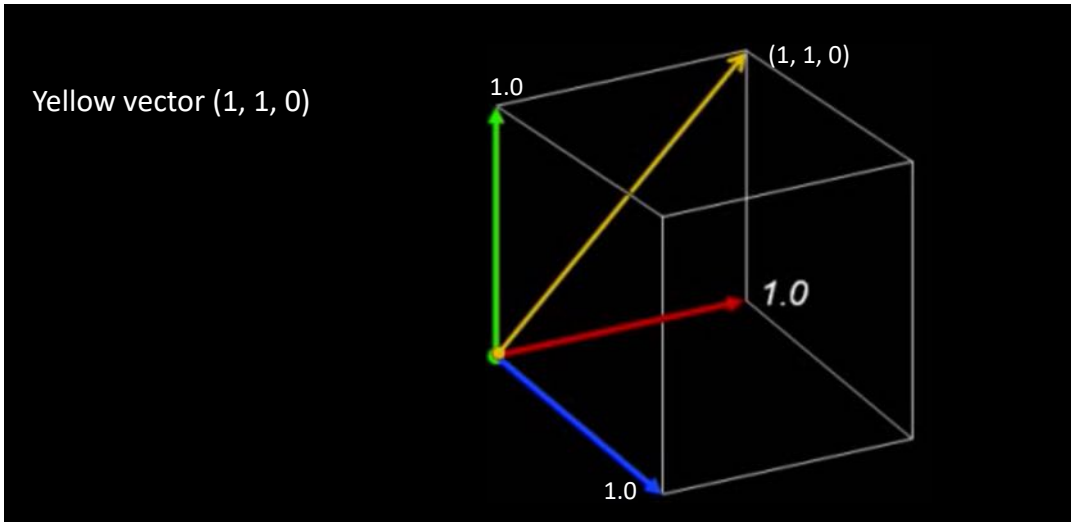

Test
Color
500 nm
Red
700 nm
Green
546.1
Blue
435.8



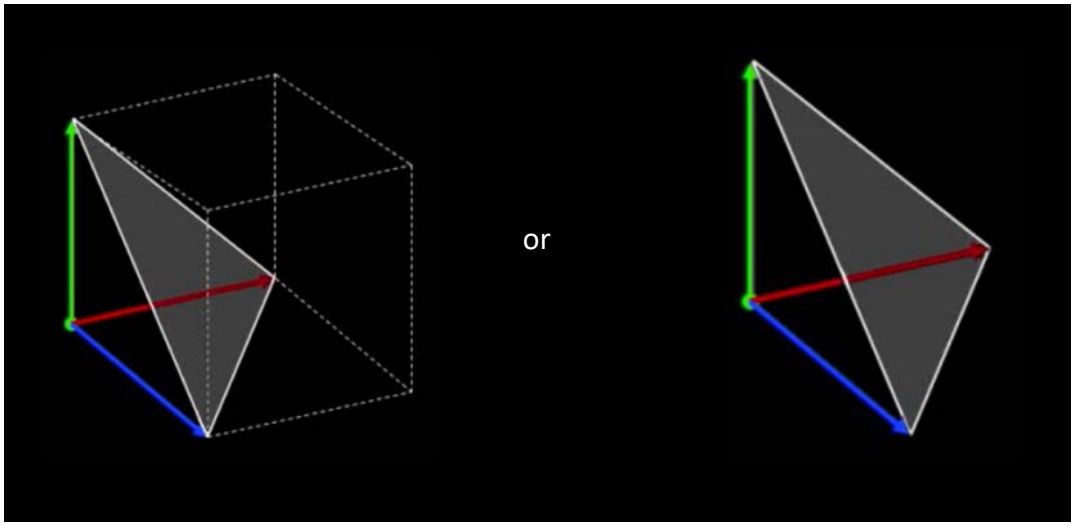
Color space: R-G-B



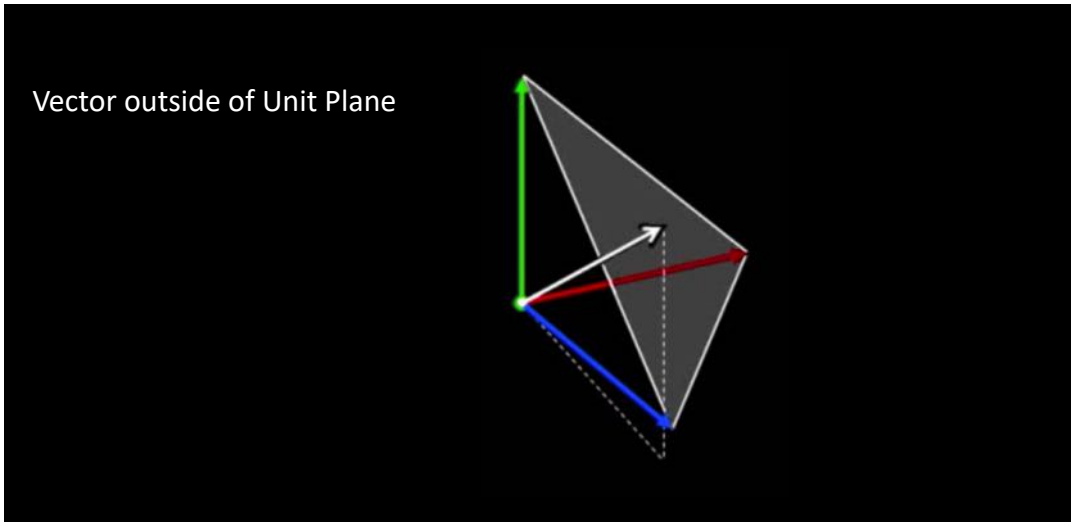
Color space RGB



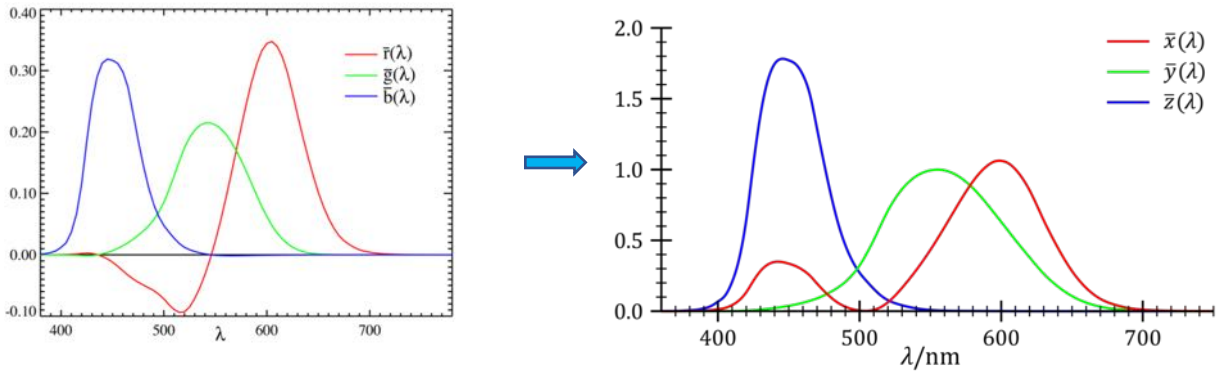
Unit plane



Negative red?

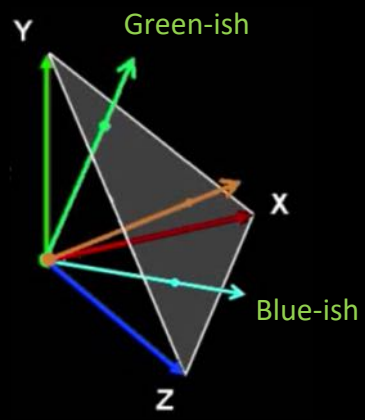


RGB to XYZ



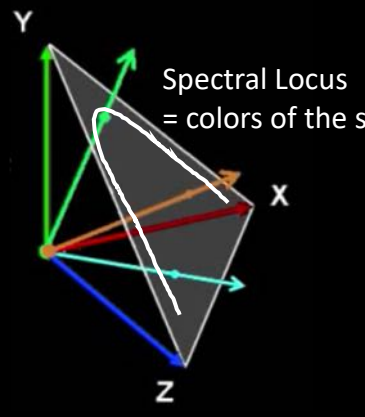
Color space X-Y-Z

Series of tristimulus vectors map out the chromaticity diagram

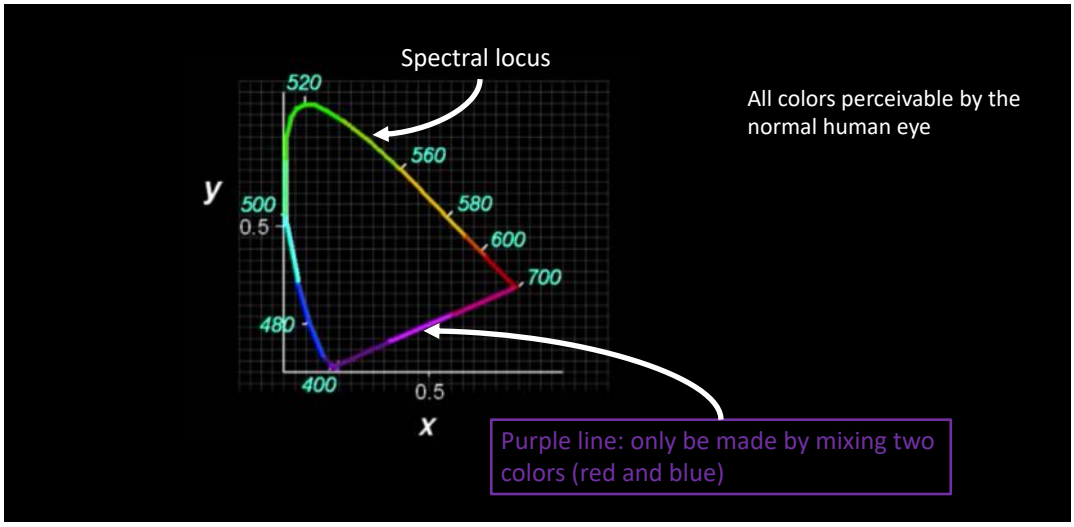


Color space X-Y-Z

Series of tristimulus vectors map out the chromaticity diagram



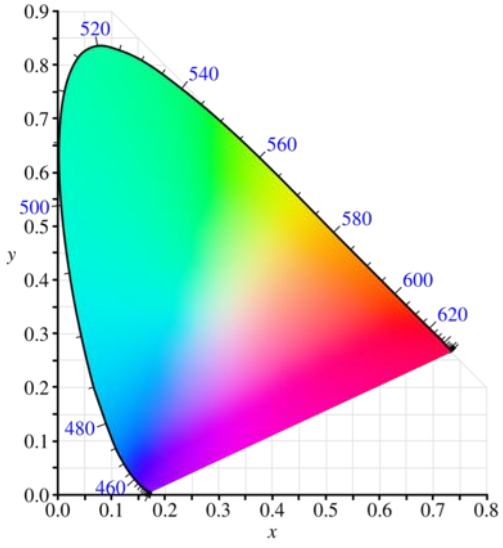
Chromaticity Diagram



CIE chromaticity diagram (1931)

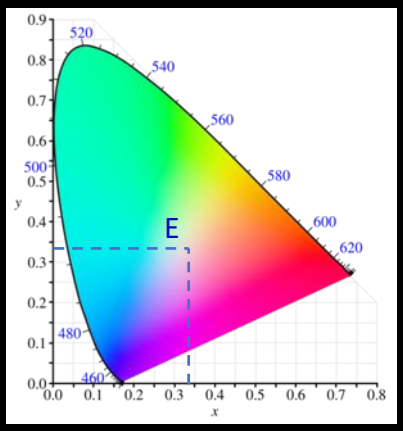
By the International Commission on Illumination

(French name: *"Commission internationale de l'éclairage"*)



White

Equal energy white
x = 0.33
y = 0.33



Traffic lights: green color

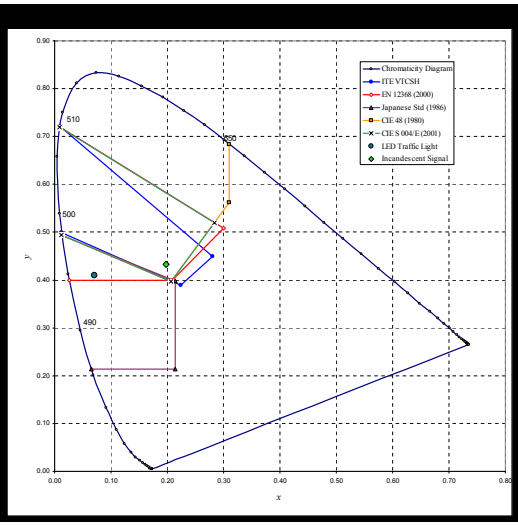
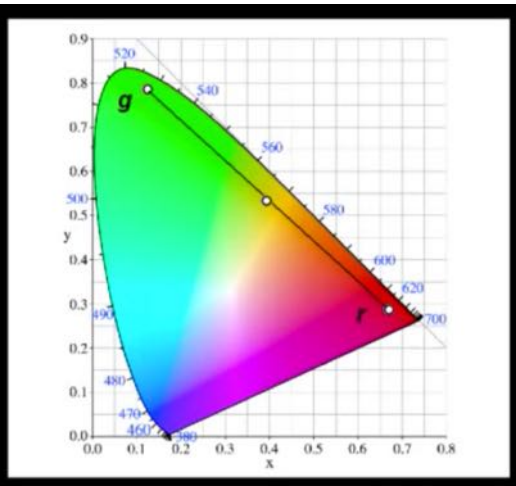


Figure 2c – Color Regions for Green Traffic Lights

CIE color mix

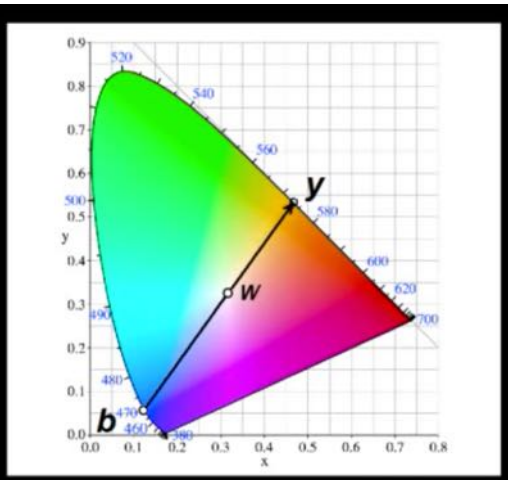
Midpoint: mixing of two colors



CIE color compliments

Opposite of “blue” via “White” is “yellow”

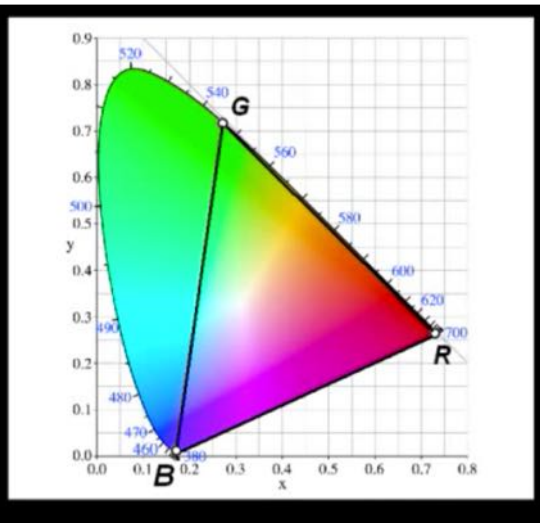
Or: adding “blue” and “yello” makes “white”



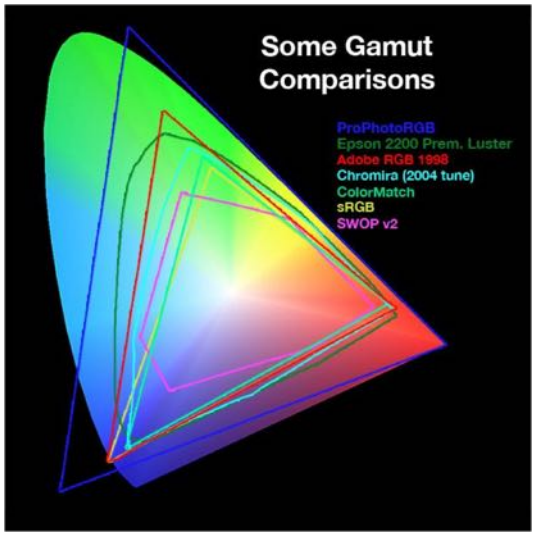
CIE color gamut

Red: 700.0 nm
Green: 546.1 nm
Blue: 435.8

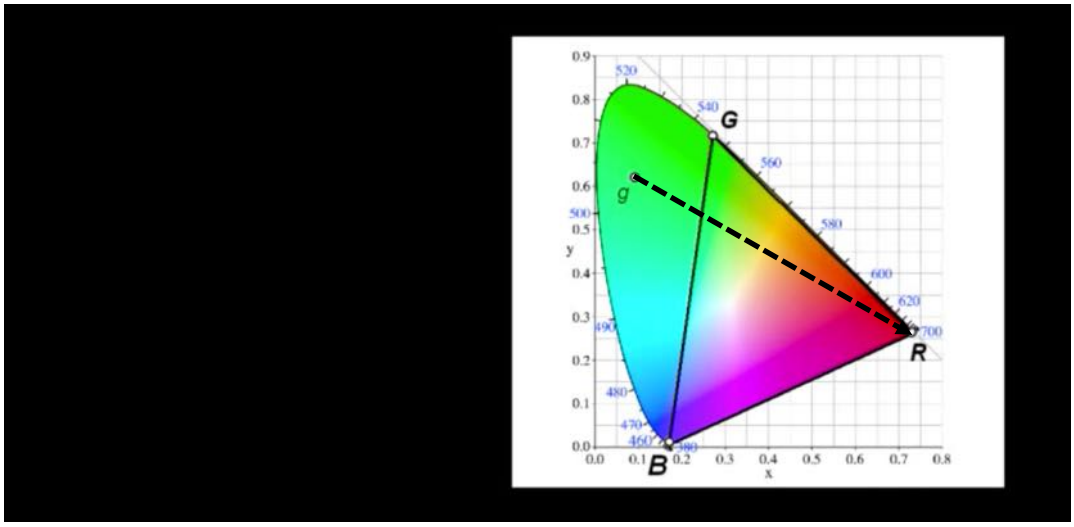
All colors can be made using those primary colors are in the triangle



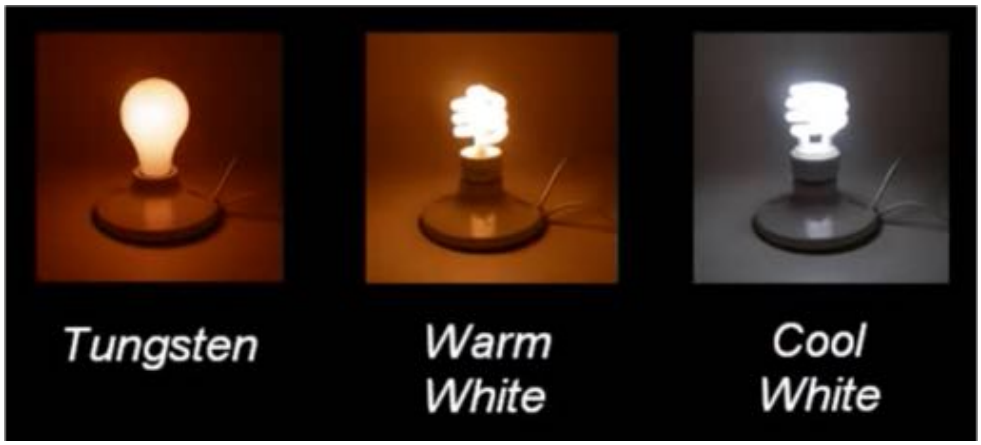
Some color gamuts



How to match color outside the triangle?

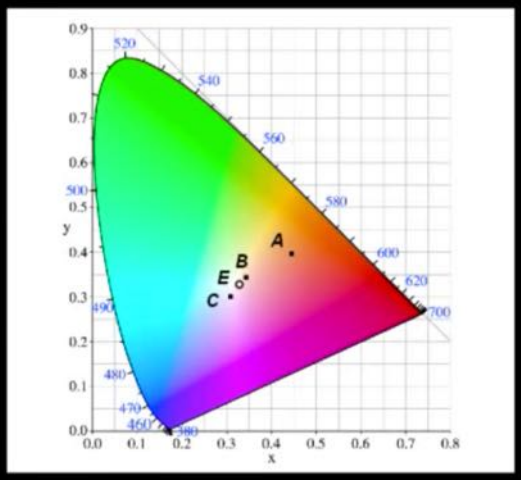


Many whites



CIE Standard Illuminants

A: Tungsten
B: Direct Sun
C: Average daylight

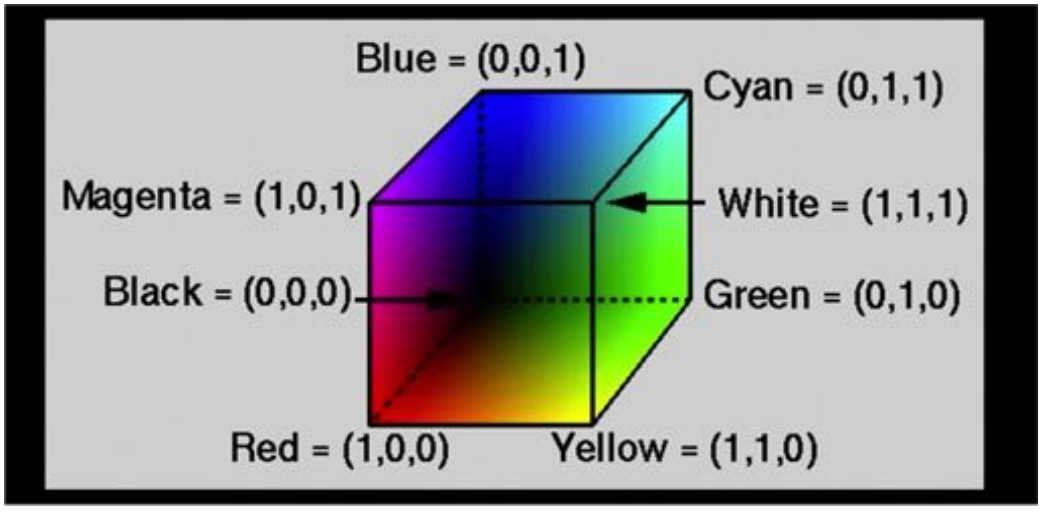


Color model

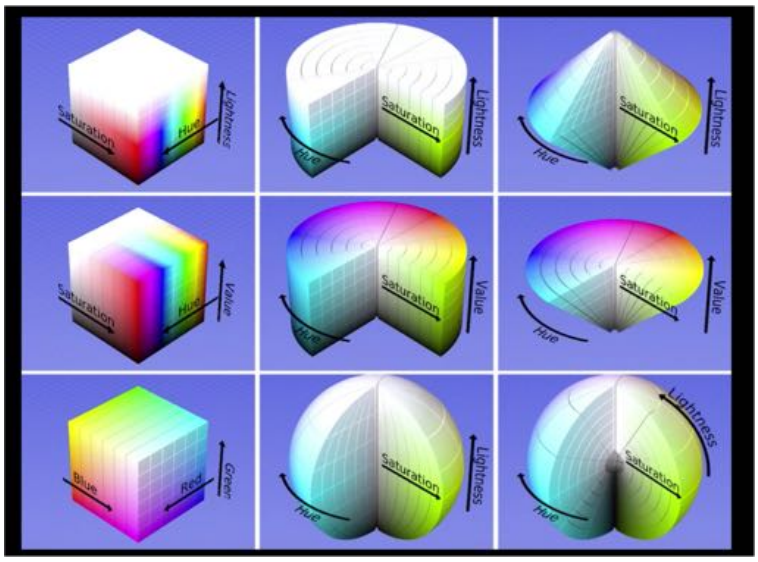
Color model

- A mathematical way to map wavelengths to certain colors
- A color model describes a coordinate system where each color is represented by a single point
- Each color model is used for different purpose
- For example:
  - RGB: computer graphics, image processing, image storage
  - HSV, HSL: human visual perception, human vision, computer vision
  - Y'CbCa: image compression
  - CMYK: printing
  - YIQ: television broadcasting systems and video systems

RGB color space

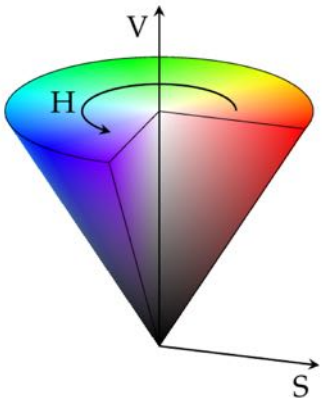


A lot of color spaces



HSV color model

- Hue: wavelength of color
  - Is presented by an angle from 0 to 360
- Value: value of brightness
  - Ranging in [0, 1]
  - V=0 → black
- Saturation: purity of color
  - Ranging in [0, 1]



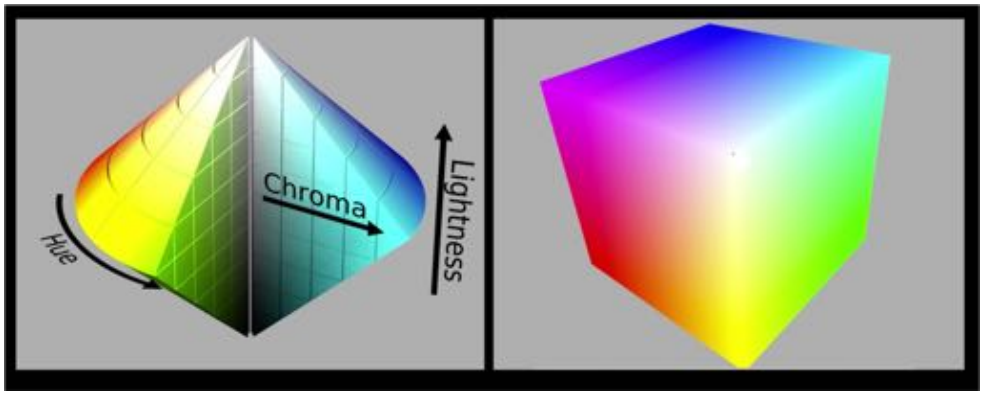
Quiz: Hue difference

If hue values range in [0, 360], what is the absolute difference between the following pairs of hues?

- 225 and 75
- 45 and 315

HCL color space

Like a squared double cone?



Color space conversion

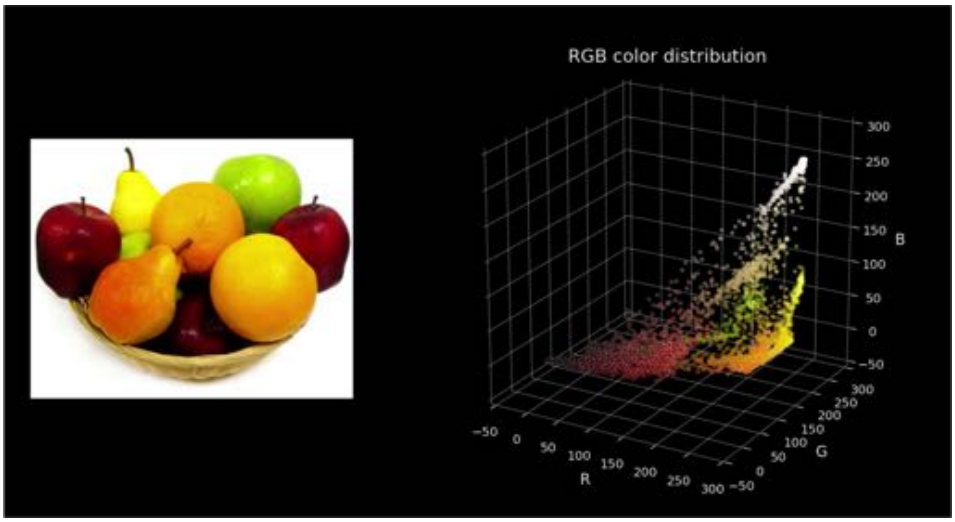
- Linear transformation
  - Transformation matrix
  - E.g.: XYZ <-> RGB

$$\begin{vmatrix} X \\ Y \\ Z \end{vmatrix} = \begin{vmatrix} X_r & X_g & X_b \\ Y_r & Y_g & Y_b \\ Z_r & Z_g & Z_b \end{vmatrix} * \begin{vmatrix} R \\ G \\ B \end{vmatrix} \qquad \begin{vmatrix} R \\ G \\ B \end{vmatrix} = \begin{vmatrix} X_r & X_g & X_b \\ Y_r & Y_g & Y_b \\ Z_r & Z_g & Z_b \end{vmatrix} (-1) * \begin{vmatrix} X \\ Y \\ Z \end{vmatrix}$$

- Non-linear transformation
  - RGB <-> CMYK
  - RGB <-> HSV
  - RGB <-> Munsell

Color image processing

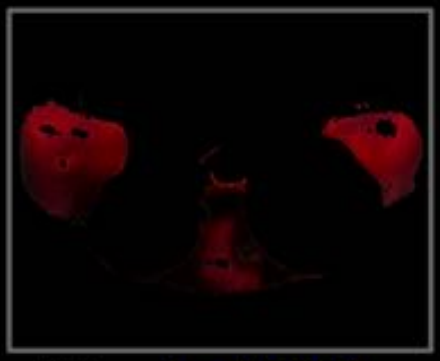
Color distribution



Example: Red filter

Filter: $R \in [0,255]$,
$G \in [0,100]$,
$B \in [0,100]$

Example: Red filter – more red!



Filter: $R \in [0,255]$,
$G \in [0,50]$,
$B \in [0,50]$

How intensity affects color values

(75, 87, 41)

(150, 173, 81)

(210, 220, 180)

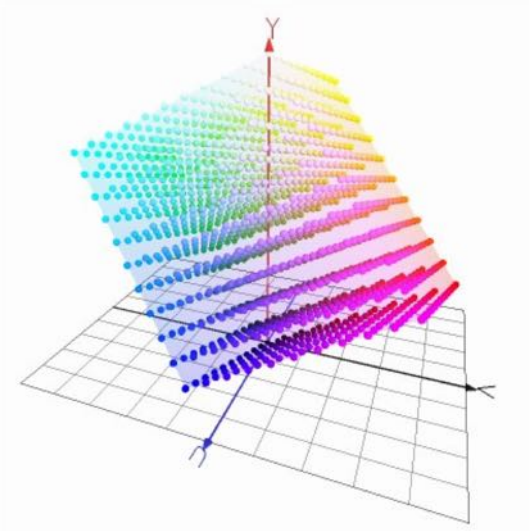
Darker

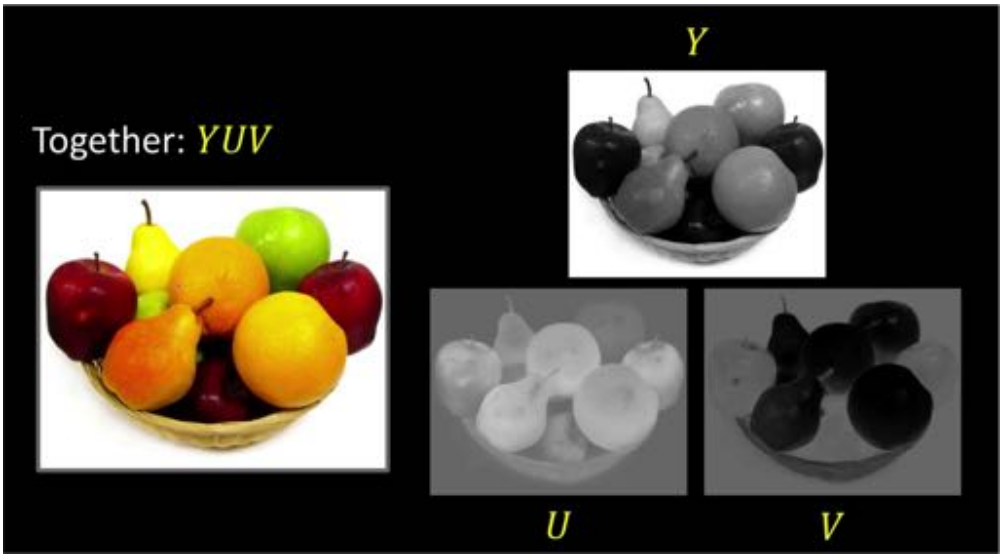
Lighter

Just different shades of green, but all 3 values change!

YUV color model

Y: luma component (the brightness)
U: blue projection
V: red projection





Quiz: UV filter

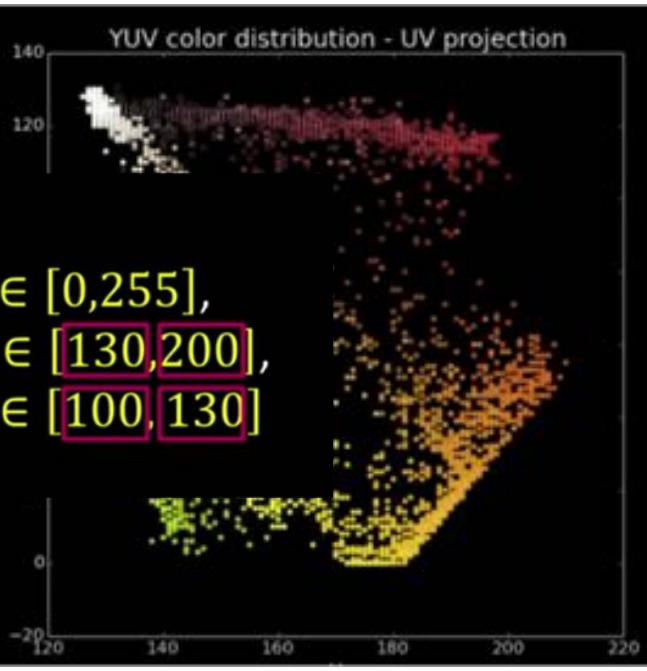
What UV limits should we use to extract red regio

Filter:

$Y \in [0,255]$,
$U \in [\ \ ,\ \ ]$,
$V \in [\ \ ,\ \ ]$

Filter:

$Y \in [0,255]$,
$U \in [130,200]$,
$V \in [100,130]$



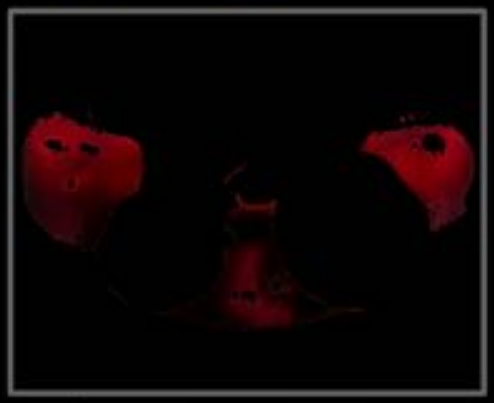
UV filter

Filter: $Y \in [0,255]$,
$U \in [130,200]$,
$V \in [100,130]$

YUV filter

Filter: $Y \in [0,150]$,
$U \in [130,200]$,
$V \in [100,130]$

Comparing RGB and YUV filters



Filter: $R \in [0,255]$,
$G \in [0,50]$,
$B \in [0,50]$

Filter: $Y \in [0,150]$,
$U \in [130,200]$,
$V \in [100,130]$

Intuition: Why YUV?

- Easier clustering of pixels
- Efficient encoding by *chroma subsampling*
  - Recall, human vision is more sensitive to intensity changes
  - Y channel can now use more bits
- E.g., YUV422 – to represent 2 image pixels, it uses 2 bytes for Y, and 1 byte each for U and V

References

- Youtube: Craig Blackwell channel
  - "Color vision" series
- Udacity: "Introduction to computer vision" course

Homework

Color segmentation

- Face segementation
- Submission link:
  - https://forms.gle/Ui4YZm6r81nDPzDTA
  - Deadline: Nov 6, 2019, 23:59 (Hanoi time)
- Useful OpenCV functions:
  - cv2.cvtColor()
  - cv2.inrange()