Digital Image Processing Lecture, parts

- Color
- Gonzales & Woods:
  - Chapter 6

Maria Magnusson, Computer Vision Lab., Dept. of Electrical Engineering, Linköping University

Color spectrum
Color wavelength

Which wavelength has magenta (cerise)?

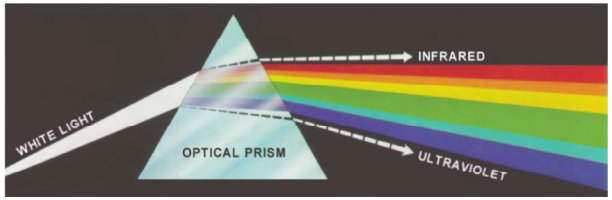


Fig. 6.1

In 1666, Newton discovered that sunlight (white light) passing through a glass prism split up into a color spectrum of wave lengths in the interval 400-700nm.

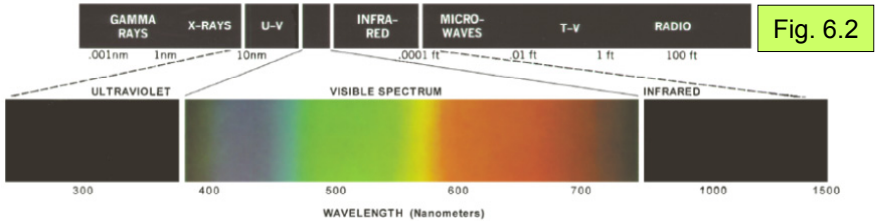


Fig. 6.2

Color of objects

An object that reflects light in all wave lengths appears white.

An object that reflects blue light and absorbs green-yellow-red light appears blue.

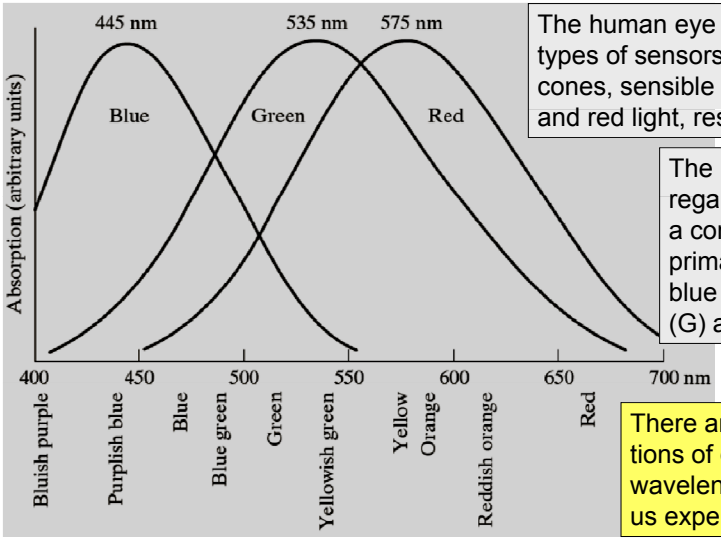
An object that reflects red light and absorbs blue-green-yellow light appears red.

Characteristics of a light source

- 1) Radiance
  - Total amount of energy that flows from the light source.
  - Measured in watts (W).
- 2) Luminance
  - A measure of the amount of energy the observer *perceives* from a light source.
  - Measured in lumens (lm).
  - Ex 1) Normally high Radiance corresponds to high Luminance.
  - Ex 2) High Radiance of infrared light correspond to low Luminance
- 3) Brightness
  - Embodies the achromatic notion of intensity
  - Impossible to measure
  - Ex) Which color is most intense - blue or red?

Absorption of light by the cones in the human eye

Fig. 6.3

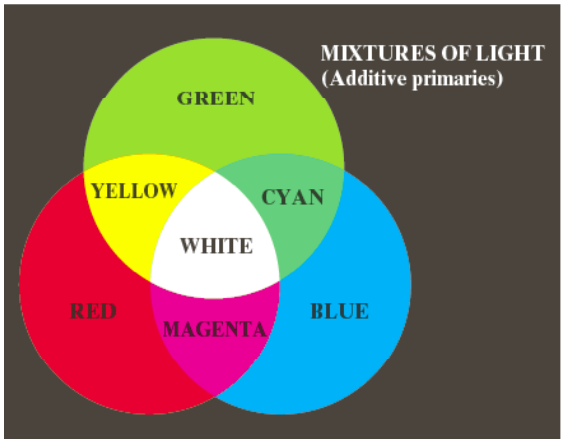


The human eye contains 3 types of sensors named cones, sensible to blue, green and red light, respectively.

The human eye regards a color as a combination of 3 primary colors blue (B), green (G) and red (R).

There are ∞ combinations of discrete wavelengths that let us experience yellow.

Primary and secondary colors of light. Additive color mixing.



Here, secondary colors are mixtures of two primary colors.

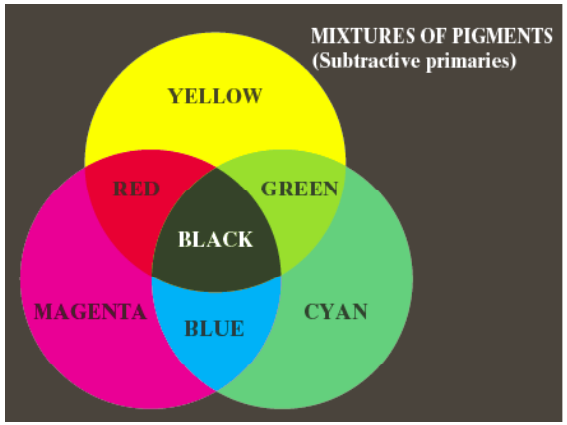
yellow = red + green
cyan = green + blue
magenta = red + blue

CRT
LCD
plasma

Answer to which wavelength magenta has.

Fig. 6.4

Primary and secondary colors of pigments. Subtractive color mixing.



A primary color of pigment absorbs 1 primary color of light and reflects the others.

red = yellow + magenta
green = cyan + yellow
blue = magenta + cyan

Painting colors
Clay

Color printing is a mixture of additive and subtractive color mixing

Fig. 6.4

Characteristics of a color

- 1) Brightness
  - Embodies the achromatic notion of intensity
  - Impossible to measure
- 2) Hue
  - Associated with the dominant wavelength in a mixture of light waves
  - Dominant color as perceived by an observer
- 3) Saturation
  - Refers to the relative purity or the amount of white light mixed with a hue
  - The pure spectrum colors are fully saturated
- Chromaticity
  - Hue and saturation taken together
  - A color may be characterized by its brightness and chromaticity
- Tristimulus
  - The amount of X ("red"), Y ("green") and Z ("blue") needed to form a particular color.
  - Do not exist in reality. Compiled from extensive experimental results with humans.

CIE Chroma-ticity diagram

Trichomatic coefficients:

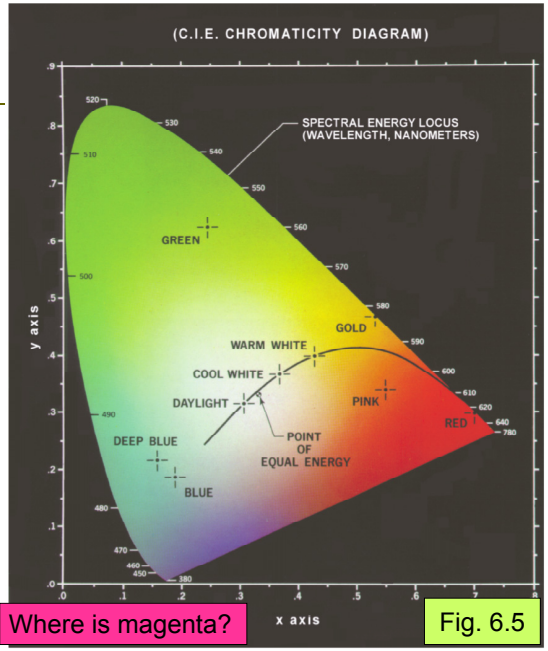
$$x = \frac{X}{X+Y+Z}$$

$$y = \frac{Y}{X+Y+Z}$$

$$z = \frac{Z}{X+Y+Z}$$

$$x + y + z = 1$$

Useful for mixing colors because a straight line between two colors gives the additive mixing result color.

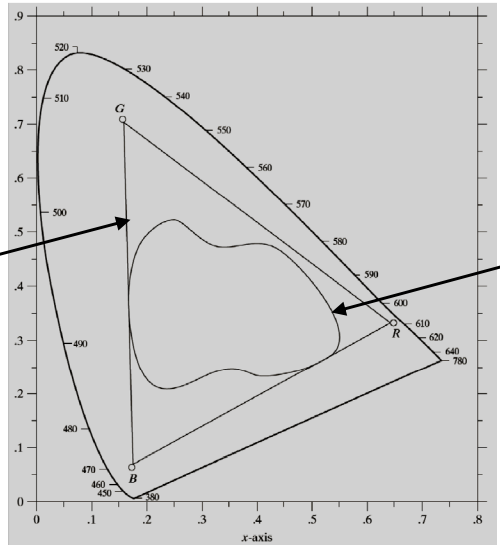


Where is magenta?

Fig. 6.5

Typical color gamut of color monitors and color printing devices

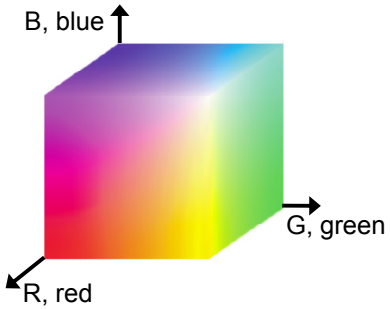
The colors inside this triangle can be composed by a typical RGB color monitor.

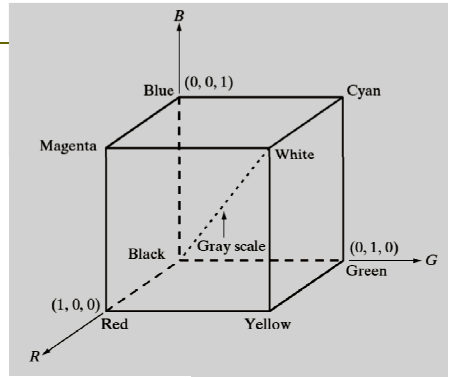


The colors inside this area can be composed by a high quality printing device.

Fig. 6.6

The RGB color model





Back-sides:

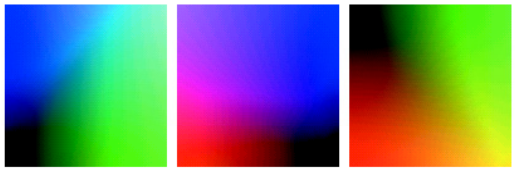


Fig. 6.7

Fig. 6.8

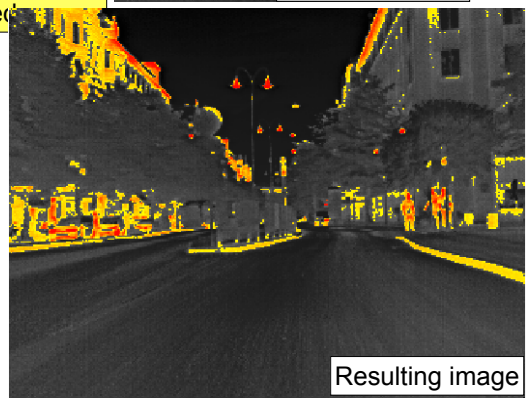
Fig. 6.9

Question:Intensity to color transformation

Construct a color transformation so that an IR-image is shown in gray scale up to 99. Then, the values are shown in a linear yellow-to-red scale from saturated yellow to saturated red

Input IR-image

Intensity	R	G	B
0:			
|			
98:			
99:			
100:			
|			
255:			



Resulting image

Basics of full-color image processing

- 1) We can process each color component individually and then form a composite processed color image from the individually processed components.
- 2) We can work with color pixels directly.

$$\mathbf{c}(x,y) = \begin{bmatrix} c_R(x,y) \\ c_G(x,y) \\ c_B(x,y) \end{bmatrix} = \begin{bmatrix} R(x,y) \\ G(x,y) \\ B(x,y) \end{bmatrix}$$

(6.4-2)

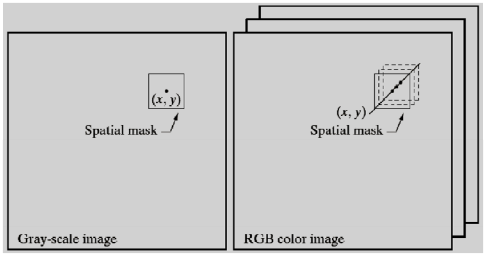
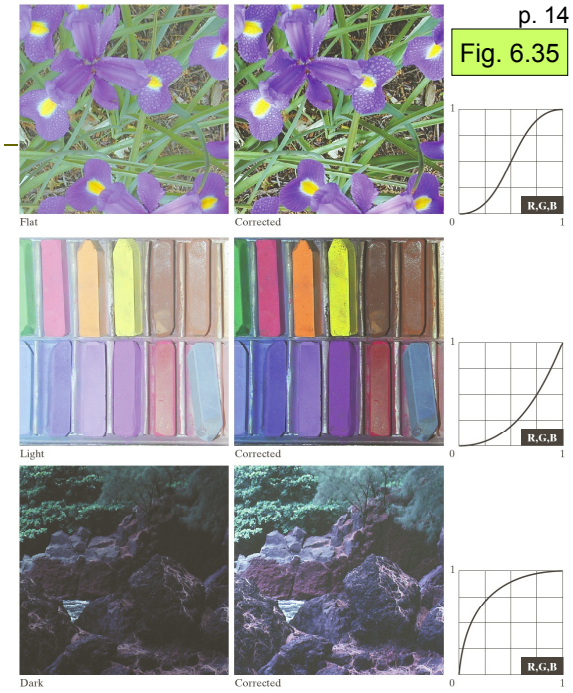


Fig. 6.29

Tone and color corrections

Fig. 6.35



The digital darkroom 1!

Conversion from color to gray scale in MATLAB

True color image

Gray scale image

$$\text{GrayV} = 0.2989 \cdot R + 0.5870 \cdot G + 0.1140 \cdot B \quad \text{(MatLab: rgb2gray)}$$

Answer: Intensity to color transformation

Construct a color transformation so that an IR-image is shown in gray scale up to 99. Then, the values are shown in a linear yellow-to-red scale from saturated yellow to saturated red.

Intensity	R	G	B
0:	0	0	0
|	|	|	|
98:	98	98	98
99:	99	99	99
100:	255	255	0
|	|	|	|
255:	255	0	0