Chapter 6: Colour image processing (page 416)

Motivation:
- Powerful descriptor → Object identification
- Humans discern thousands of colour shades, intensities (only two dozen shades of gray)

Colour IP:
- Full-colour processing
  - ○ Colour TV camera, scanner ○ Recent development
- Pseudo-colour processing
  - ○ Assign colour to monochrome intensity ○ Used in the past

Some gray-scale methods directly applicable to colour images, others require reformulation...

6.1 Colour fundamentals

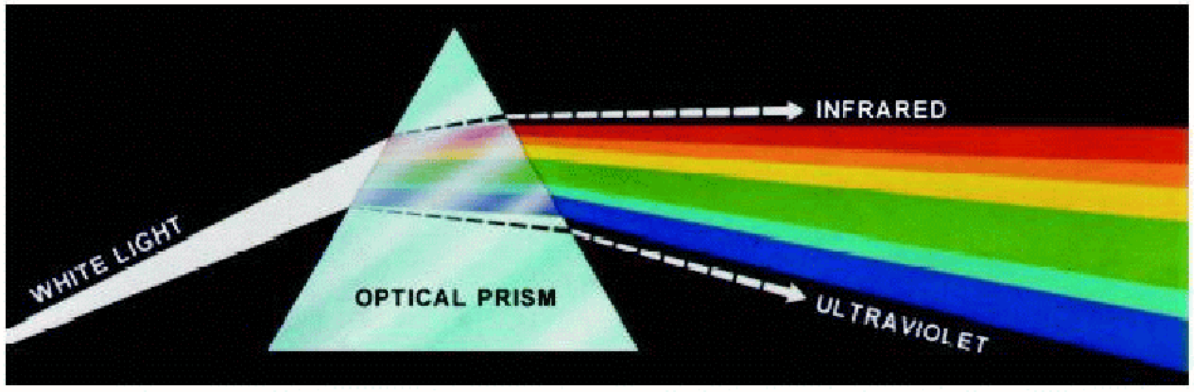


FIGURE 6.1 Color spectrum seen by passing white light through a prism. (Courtesy of the General Electric Co., Lamp Business Division.)

Perceived colour determined by light reflected by object
For example, green objects reflect light with wavelengths primarily in the 500 to 570 nm range, while absorbing most of the energy at other wavelengths

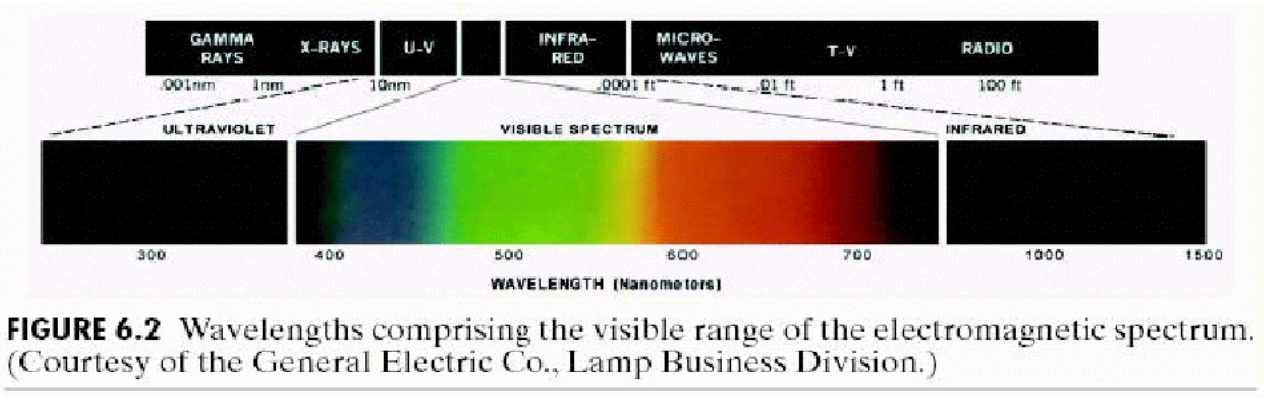


FIGURE 6.2 Wavelengths comprising the visible range of the electromagnetic spectrum. (Courtesy of the General Electric Co., Lamp Business Division.)

Achromatic light:
- **1 attribute, intensity $\rightarrow$ gray level**

Chromatic light:
- **Radiance**
  - **Total energy from light source** $\circ$ **Watts** (W)
- **Luminance**
  - **Amount of energy observer perceives** $\circ$ **Lumens** (lm)
- **Brightness**
  - **Subjective: "achromatic intensity"** $\circ$ **Can't measure**

Light emitted from source in far infrared region has significant energy (radiance), but luminance is almost zero

Sensors (cones) in human eye:
(R, G, and B: primary colours)

- **Red (R)** ○ **65 %**
- **Green (G)** ○ **33 %**
- **Blue (B)** ○ **2 %** ○ **Most sensitive**

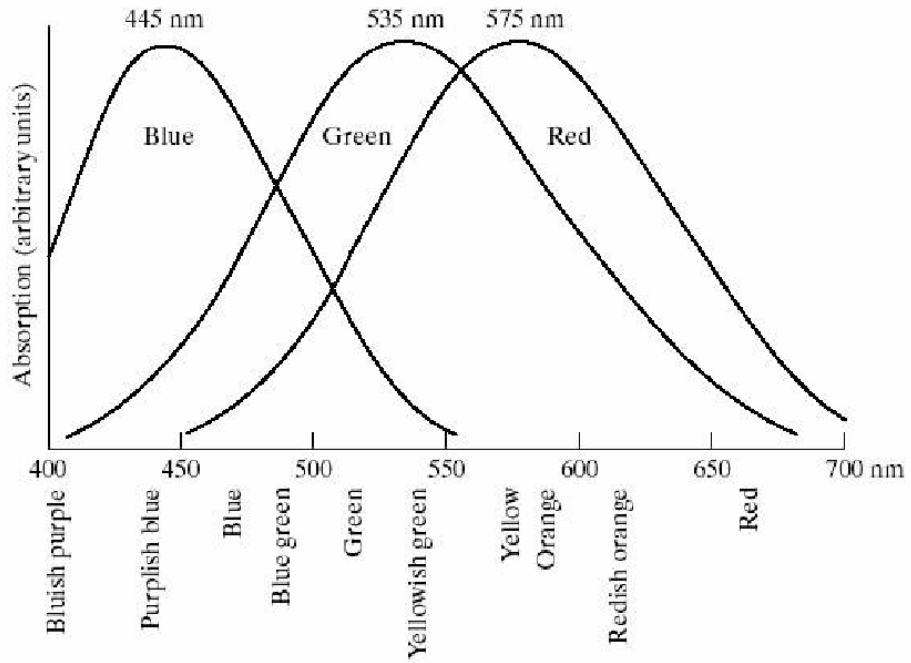


FIGURE 6.3 Absorption of light by the red, green, and blue cones in the human eye as a function of wavelength.

Note: No single colour may be called R, G, or B. When mixed in various intensity proportions, the three standard primaries can not produce all visible colours. The wavelength must also be allowed to vary.

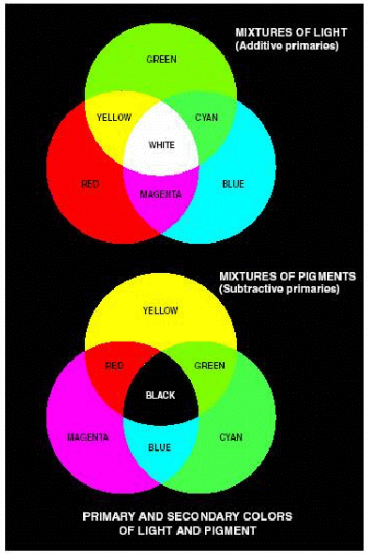
Primary colours of light

red + green + blue = white

Secondary colours of light

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

- Difference between primary colours of light and pigment
- Primary colour of pigment absorbs a primary colour of light and reflects the other two
- Primary colours of pigment: magenta, cyan and yellow
- Secondary colours of pigment: red, green and blue



a
b

FIGURE 6.4 Primary and secondary colors of light and pigments. (Courtesy of the General Electric Co., Lamp Business Division.)

Additive nature of light colours: colour TV reception

Characteristics used to distinguish colours:

- **Brightness**
  - **Chromatic notion of intensity**
- **Hue**
  - **Dominant wavelength**
  - **Dominant perceived colour**
- **Saturation**
  - **Relative purity**
  - **Pink is less saturated**
  - **$\downarrow$ Saturation $\Rightarrow$ $\uparrow$ White light**

Hue & Saturation $\equiv$ Chromaticity

Tristimulus values: amount of R, G and B needed to form a particular colour and is denoted by X, Y and Z, respectively

Trichromatic coefficients:

$$x = \frac{X}{X+Y+Z},\ y = \frac{Y}{X+Y+Z},\ z = \frac{Z}{X+Y+Z},\ \boxed{x+y+z=1}$$

For a specified wavelength, the tristimulus values can be obtained from curves or tables (complied from experiments)

Another approach: CIE chromaticity diagram...

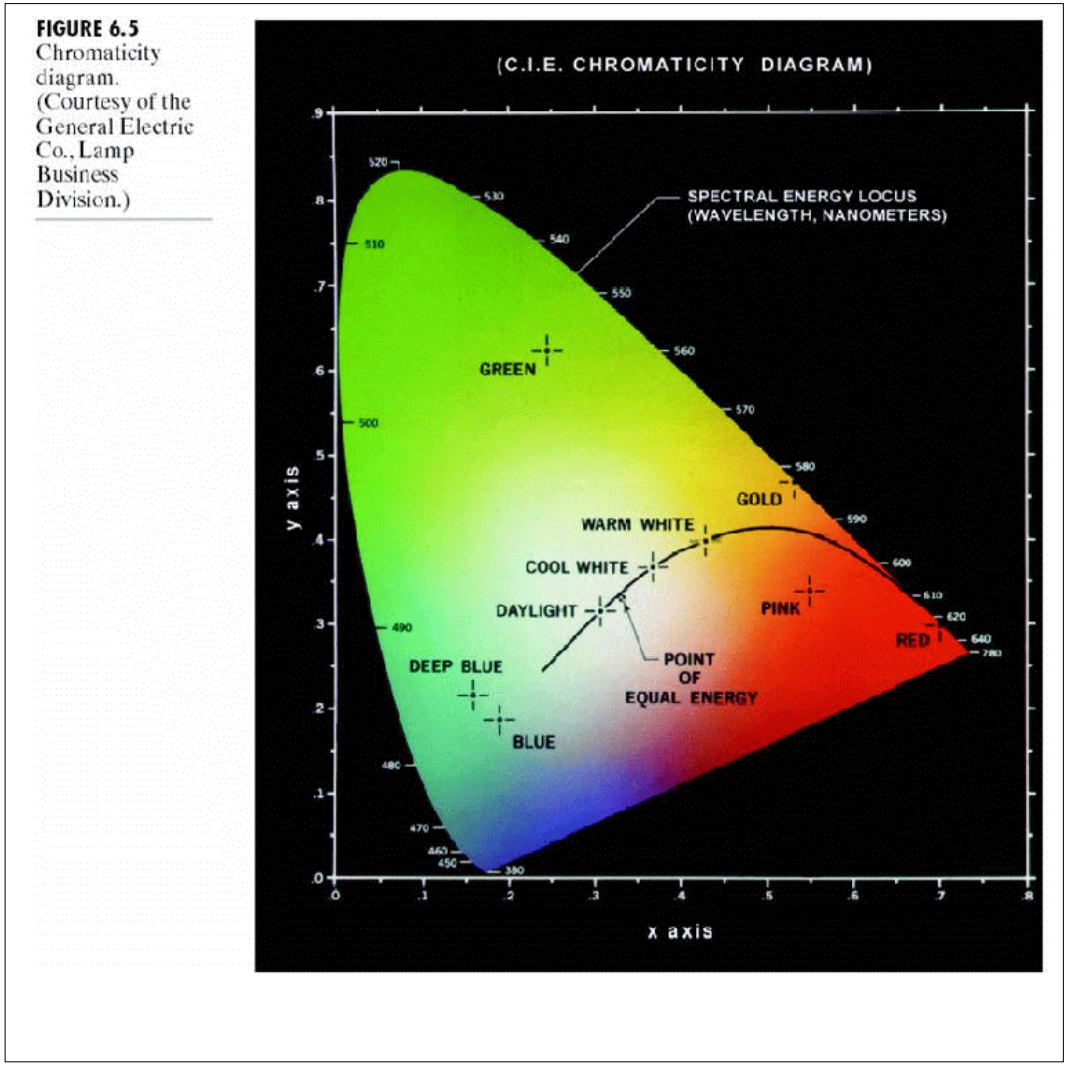


FIGURE 6.5 Chromaticity diagram. (Courtesy of the General Electric Co., Lamp Business Division.)

• **Colour composition is func of x (red) and y (green) • Blue: $z = 1 - (x + y)$**

For example, point marked green: 62% G, 25% R, and 13% B

Pure colours (fully saturated) are on boundary of tongue-shaped region: spectrum of fig 6.2

Points within diagram represent mixture of colours (white light is added, less saturated)

Point of equal energy, $(1/3, 1/3)$, is CIE standard for white light (saturation is zero)

Straight-line segment joining two points in diagram defines all the different colour variations by adding these colours

Three colours $\rightarrow$ triangle: colours inside triangle obtained by various combinations

Again note: not all colours can be obtained with three single, fixed primaries

Figure 6.6:

Triangle:	**range of colours produced by RGB monitors (colour gamut)**
Irregular region:	**colour gamut for current high quality printing devices – irregularity due to combination of additive and subtractive colour mixing**

Fig 6.6: Typical colour gamut of colour monitors (triangle) and colour printing devices (irregular region)

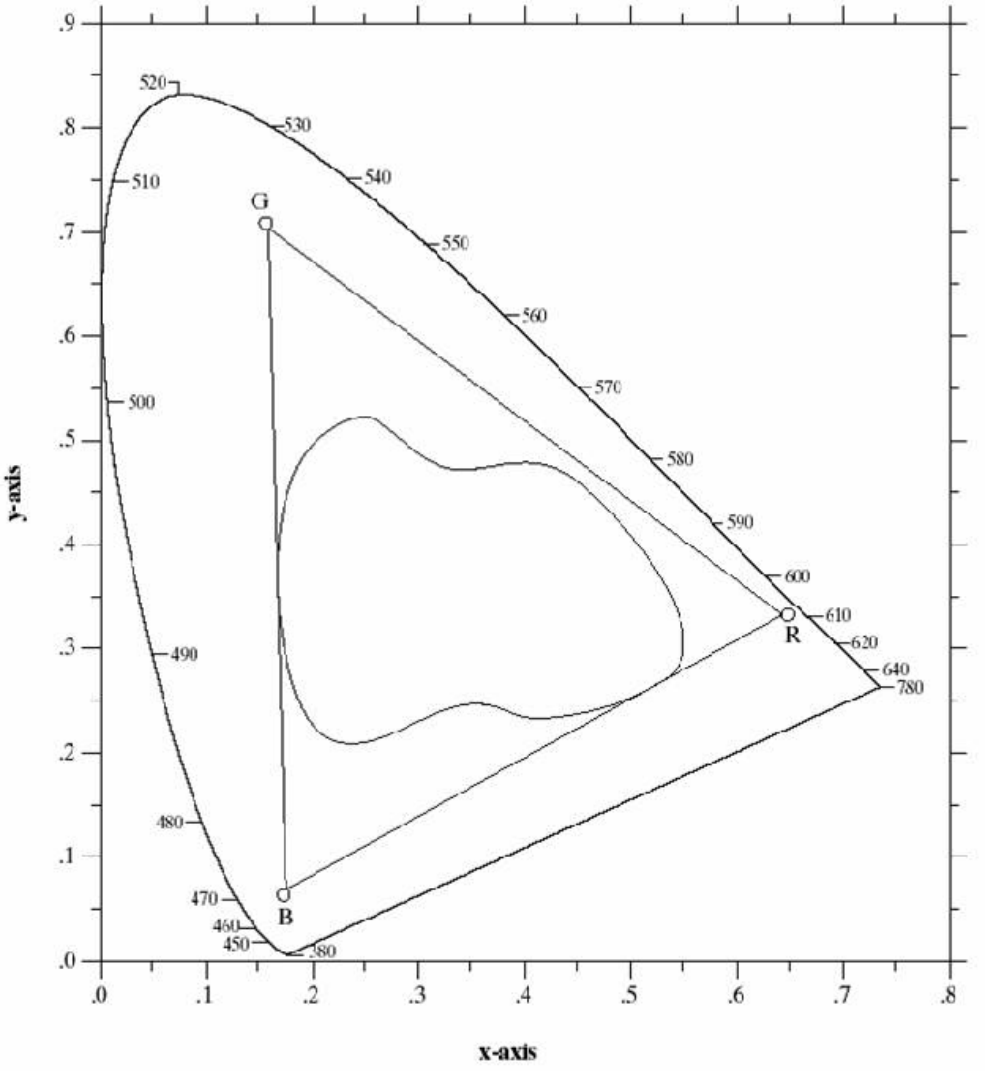


FIGURE 6.6 Typical color gamut of color monitors (triangle) and color printing devices (irregular region).