Lecture 2 - Image Fundamentals

This lecture will cover:

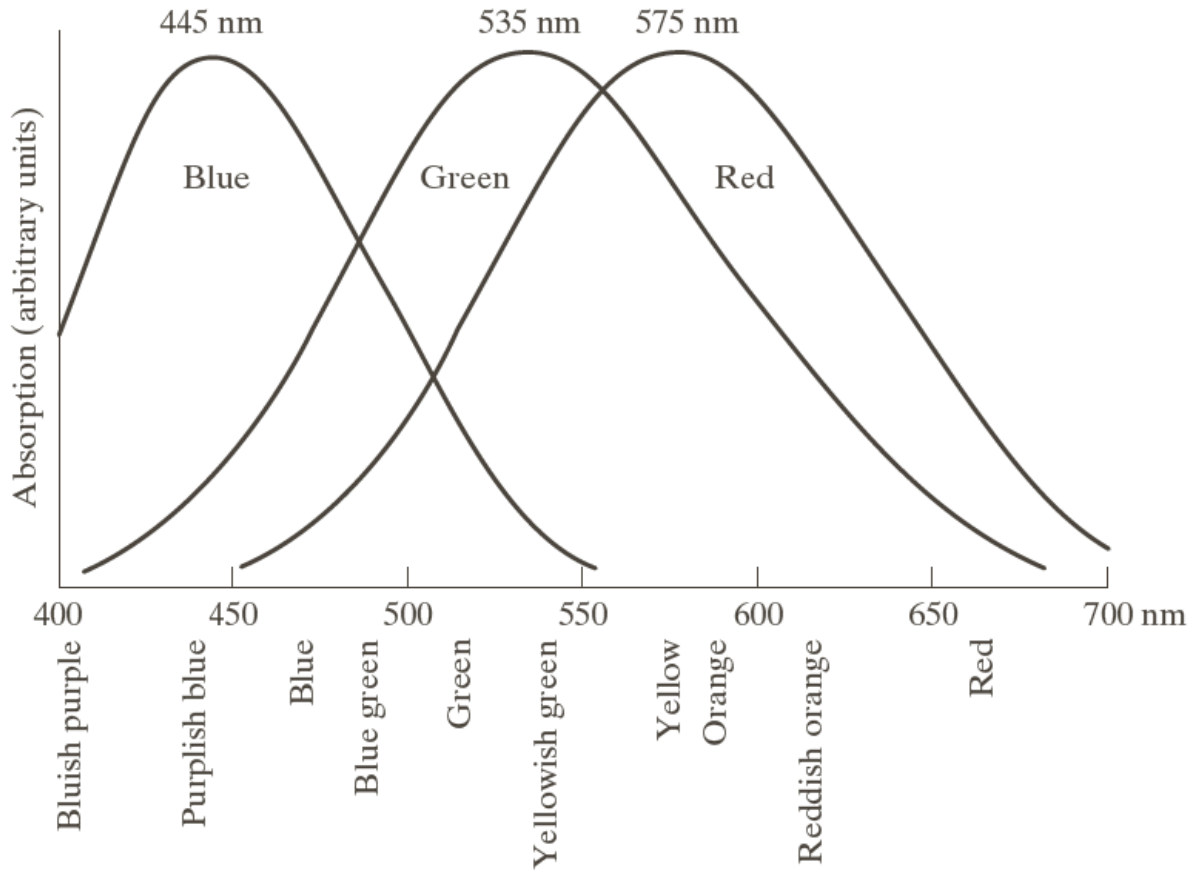
- Image acquisition
- Sampling and Quantization
- Pixels
- Image operation
- **Color space**

Color space

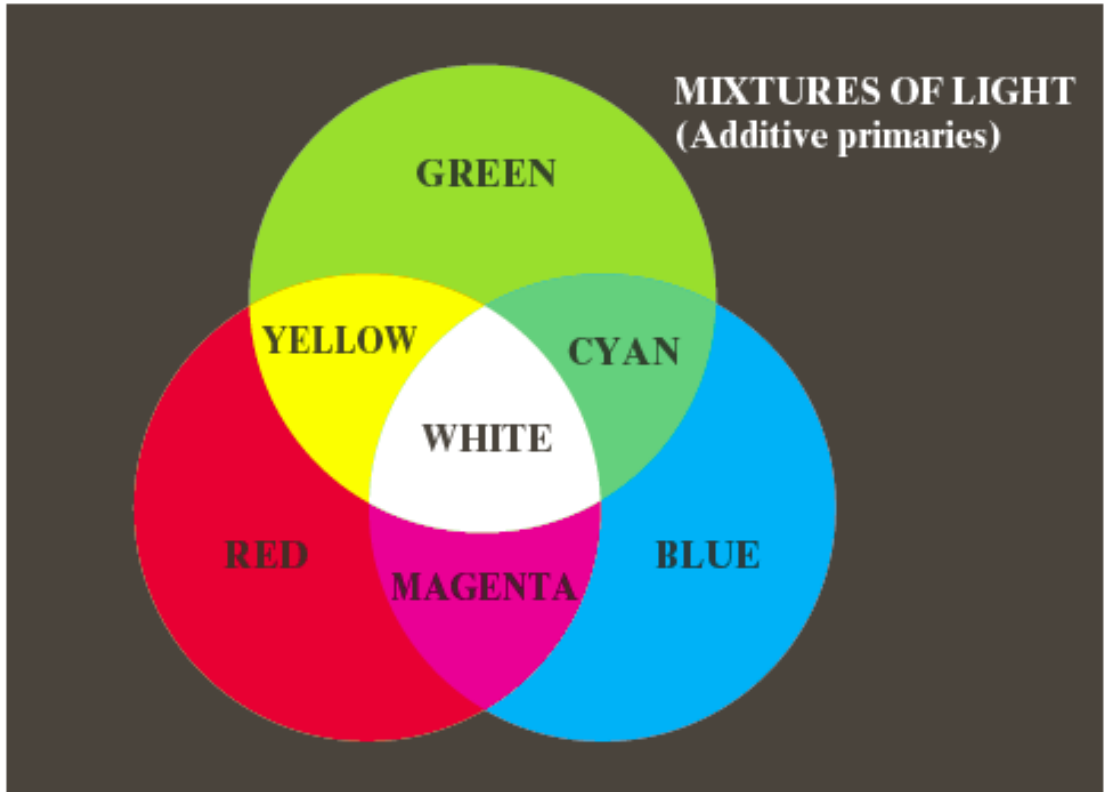
- **Color fundamentals**
  - Primary colors
  - Secondary colors
  - Color gamut
- **Color models**
  - RGB model
  - CMY and CMYK model
  - HSI model
- **Color transformation**

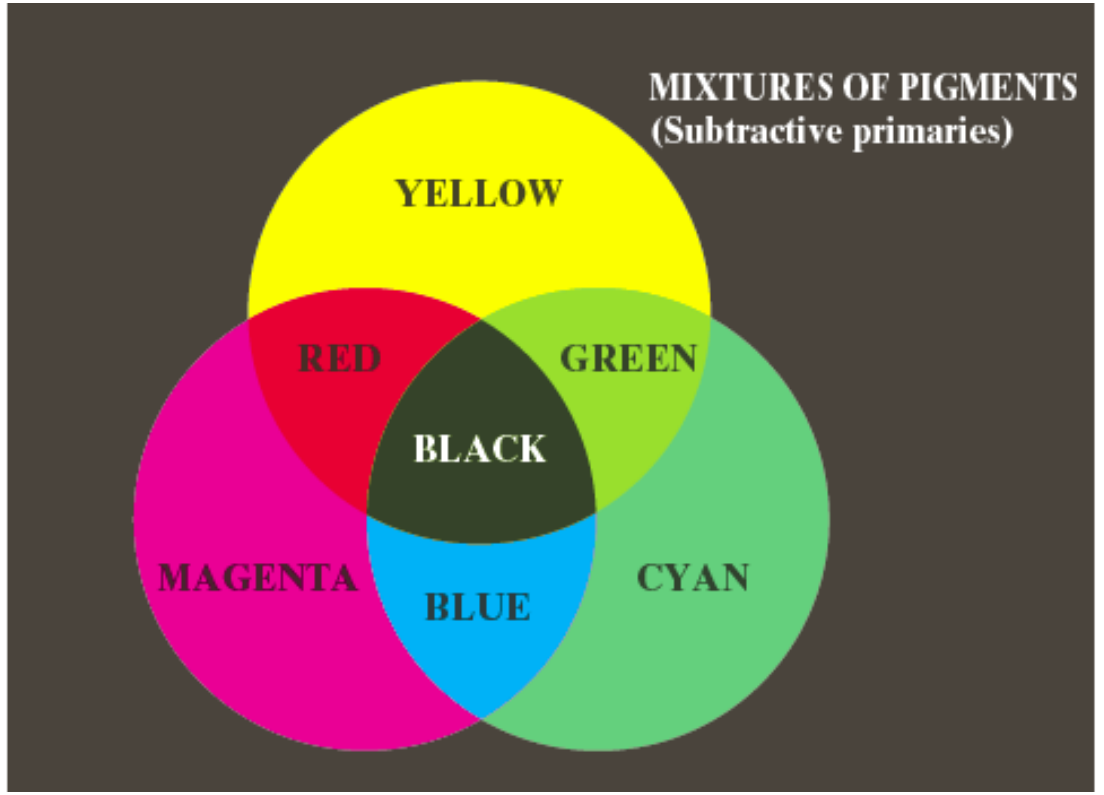
Primary colors

- **CIE RGB Standard**
  - Blue = 435.8 nm
  - Green = 546.1 nm
  - Red = 700 nm
- **CMY and CMYK color**
  - Cyan = White – Red
  - Magenta = White – Green
  - Yellow = White – Blue
  - Black = White – Red - Green - Blue

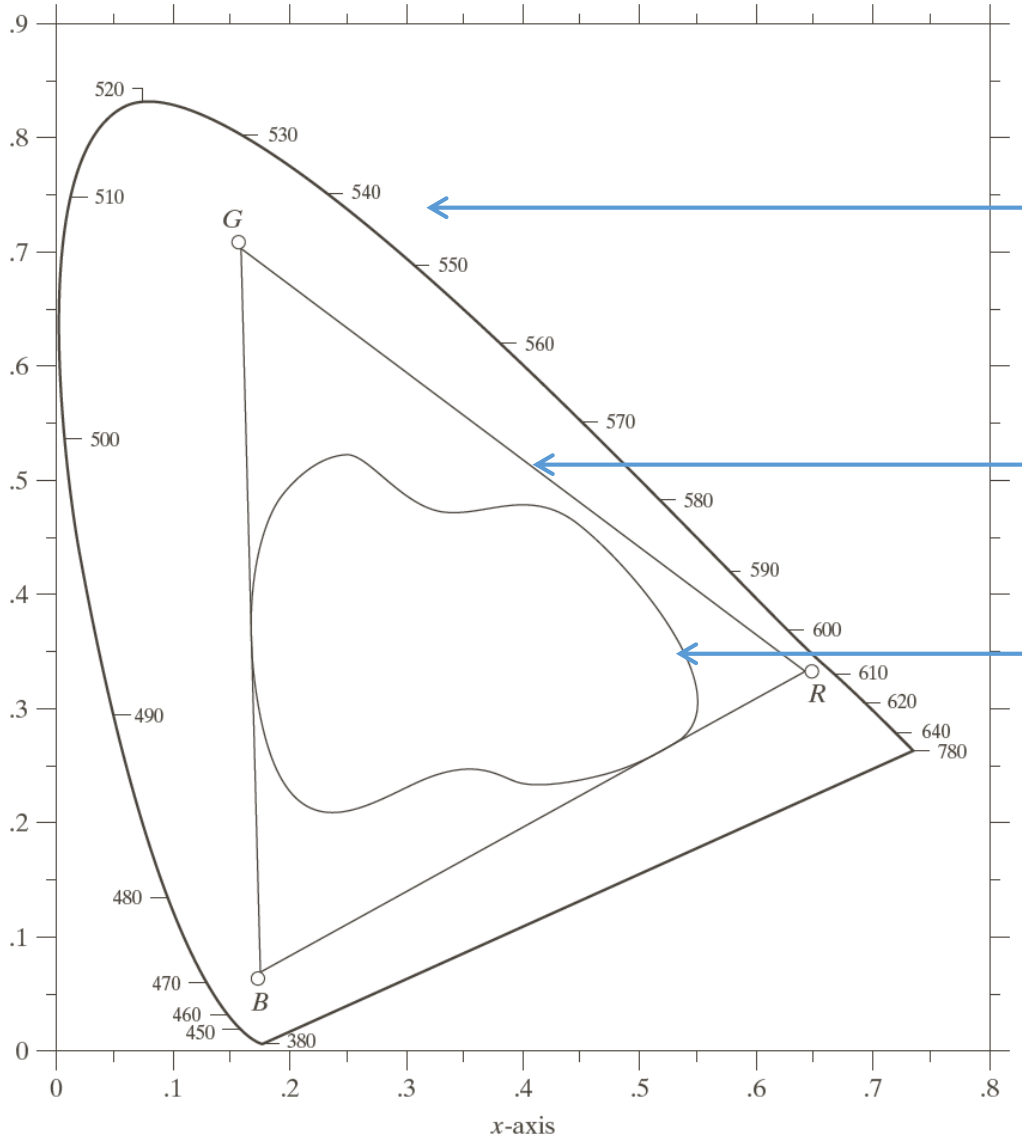


Secondary colors





Color Gamut

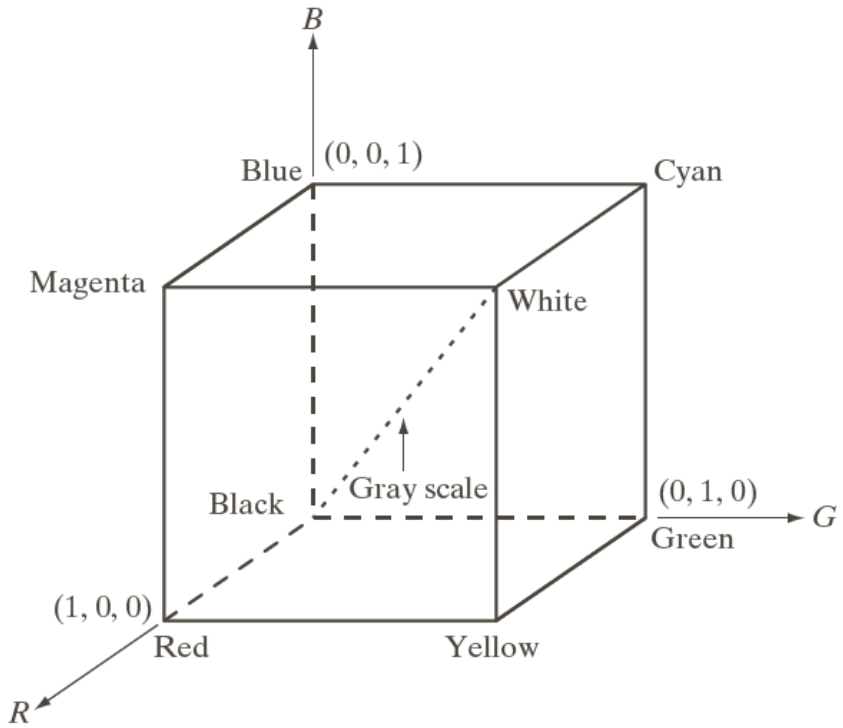


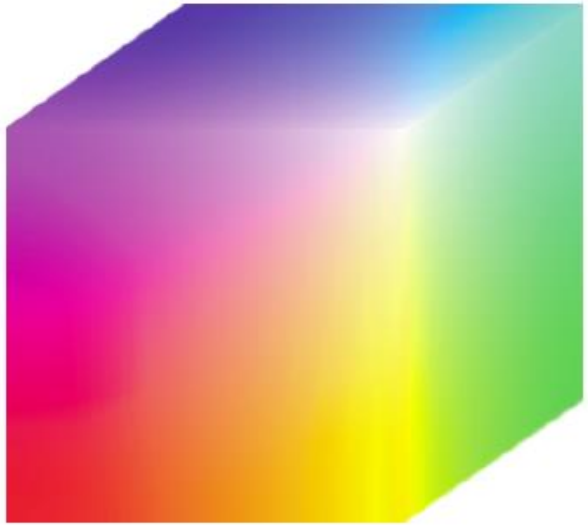
CIE Chromaticity diagram

Color gamut for monitor

Color gamut for printer

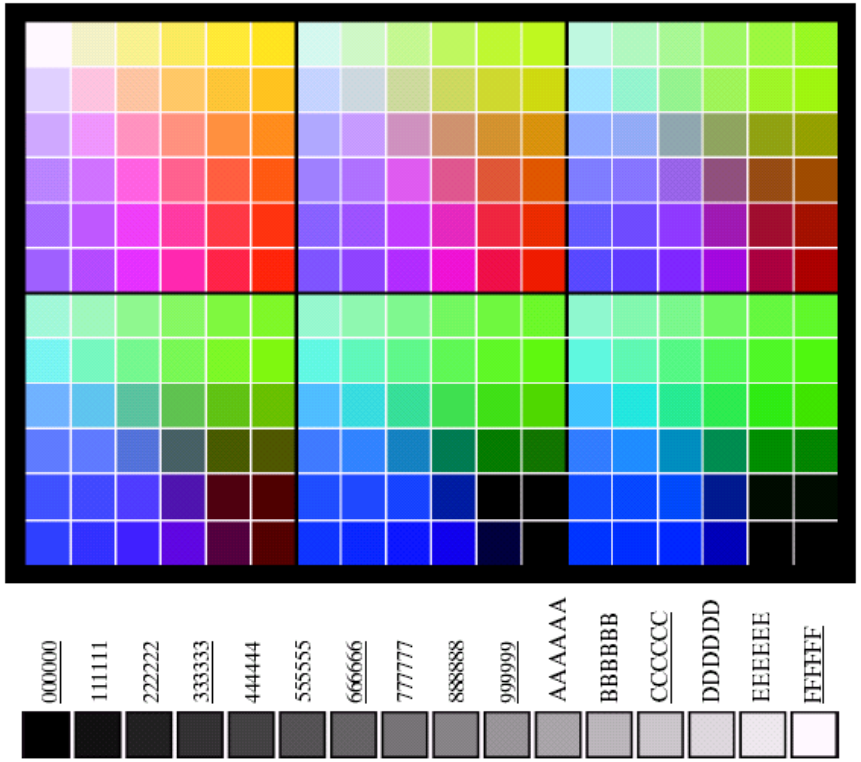
RGB Color Model

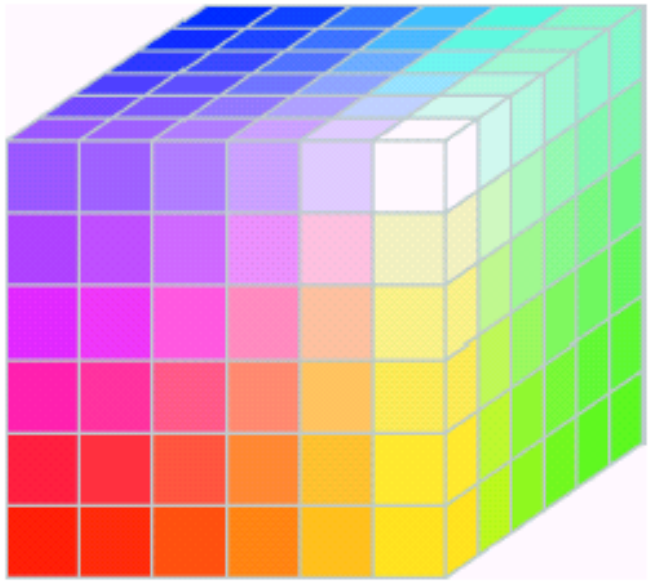




Safe RGB Color

Number System	Color Equivalents					
Hex	00	33	66	99	CC	FF
Decimal	0	51	102	153	204	255





CMY Color Model

- **RGB to CMY conversion**

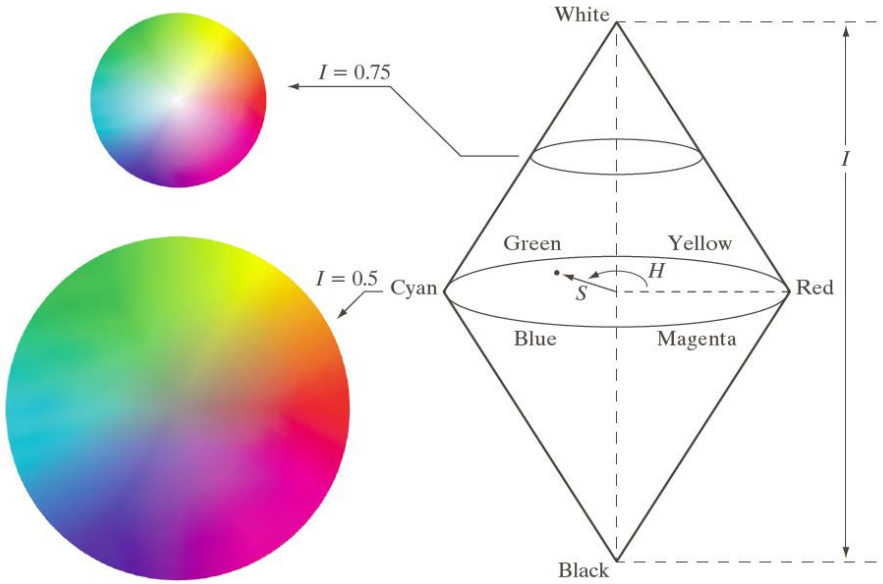
$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

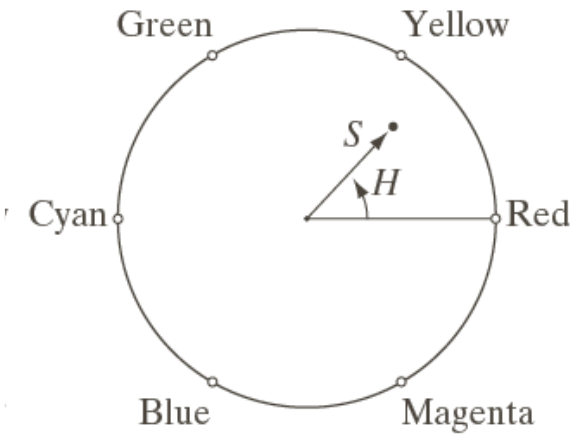
In order to produce true black in printing, a fourth color, black, is added into the CMYK color model

HSI Color Model

➢ HSI Color Model

- Hue: Dominant color associated with wavelength
- Saturation: relative purity, the amount of white light mixed with a hue
- Intensity





RGB to HSI

$$\theta = \arccos\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-G)(G-B)]^{\frac{1}{2}}}\right\}$$

$$H = \begin{cases}\theta, & G \geq B \\ 360-\theta, & G < B\end{cases}$$

$$S = 1 - \frac{3}{R+G+B}[\min(R,G,B)]$$

$$I = \frac{R+G+B}{3}$$

$$S = 0 \rightarrow H = 0\ , \quad I = 0 \rightarrow S = 0,\ H = 0$$

HSI to RGB

- $0° \leq H < 120°$

$$B = I(1 - S), \qquad R = I\left[1 + \frac{Scos(H)}{\cos(60° - H)}\right], \qquad G = 3I - (R + B)$$

- $120° \leq H < 240°$

$$R = I(1 - S), \qquad G = I\left[1 + \frac{Scos(H - 120°)}{\cos(180° - H)}\right], \qquad B = 3I - (R + G)$$

- $240° \leq H < 360°$

$$G = I(1 - S), \qquad B = I\left[1 + \frac{Scos(H - 240°)}{\cos(300° - H)}\right], \qquad R = 3I - (G + B)$$

Inverse Color Transformation

$$\begin{bmatrix} g_R(x,y) \\ g_G(x,y) \\ g_B(x,y) \end{bmatrix} = \begin{bmatrix} 255 - f_R(x,y) \\ 255 - f_G(x,y) \\ 255 - f_B(x,y) \end{bmatrix}$$

RGB to Gray scale

- **Maximum value:**

$$g_R(x,y) = g_G(x,y) = g_B(x,y) = \max[f_R(x,y), f_G(x,y), f_B(x,y)]$$

- **Average value**

$$g_R(x,y) = g_G(x,y) = g_B(x,y) = [f_R(x,y) + f_G(x,y) + f_B(x,y)]/3$$

- **Weighted value**

$$g_R(x,y) = g_G(x,y) = g_B(x,y) = 0.299 f_R(x,y) + 0.587 f_G(x,y) + 0.114 f_B(x,y)$$



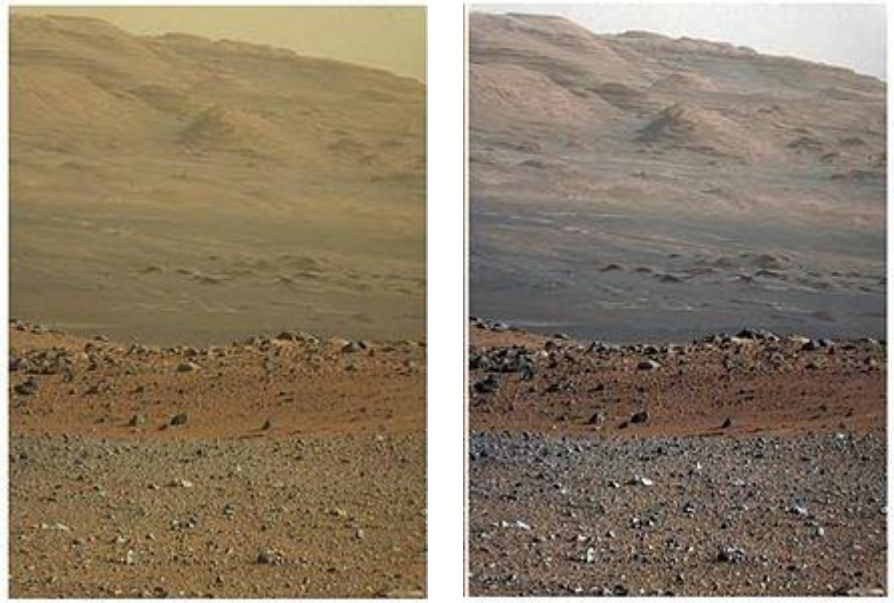

Color Balance

- **White balance:**

$$I(x,y) = 0.299f_R(x,y) + 0.587f_G(x,y) + 0.114f_B(x,y)$$

$$k_R = \frac{\bar{I}}{\bar{R}} \quad k_G = \frac{\bar{I}}{\bar{G}} \quad k_B = \frac{\bar{I}}{\bar{B}}$$

$$\begin{bmatrix} g_R(x,y) \\ g_G(x,y) \\ g_B(x,y) \end{bmatrix} = \begin{bmatrix} k_R & & \\ & k_G & \\ & & k_B \end{bmatrix} \begin{bmatrix} f_R(x,y) \\ f_G(x,y) \\ f_B(x,y) \end{bmatrix}$$



- **Maximum value balance**

$$S_{RGB} = \min[R_{max}, G_{max}, B_{max}]$$

$$k_R = \frac{S_{RGB}}{T_R} \quad k_G = \frac{S_{RGB}}{T_G} \quad k_B = \frac{S_{RGB}}{T_B}$$

$$\begin{bmatrix} g_R(x,y) \\ g_G(x,y) \\ g_B(x,y) \end{bmatrix} = \begin{bmatrix} k_R & & \\ & k_G & \\ & & k_B \end{bmatrix} \begin{bmatrix} f_R(x,y) \\ f_G(x,y) \\ f_B(x,y) \end{bmatrix}$$