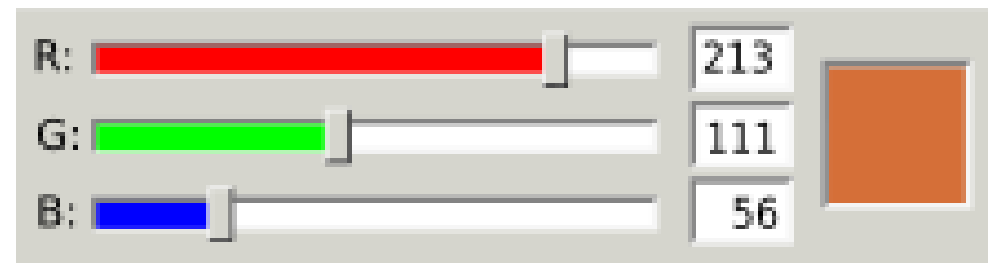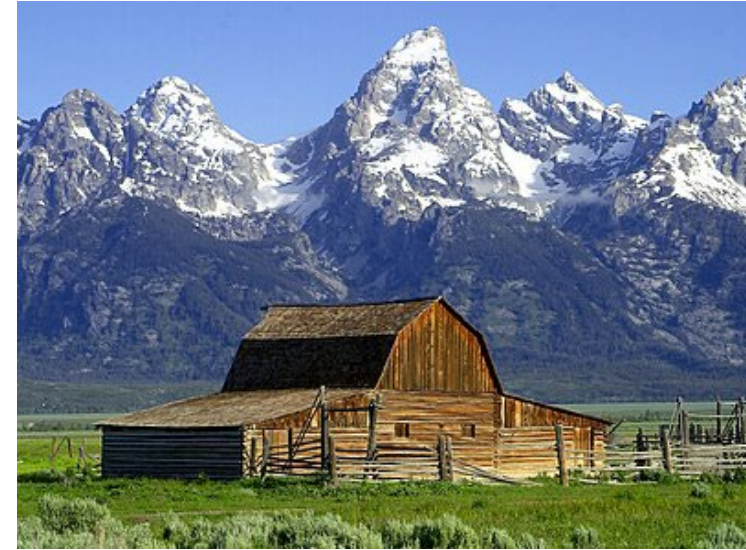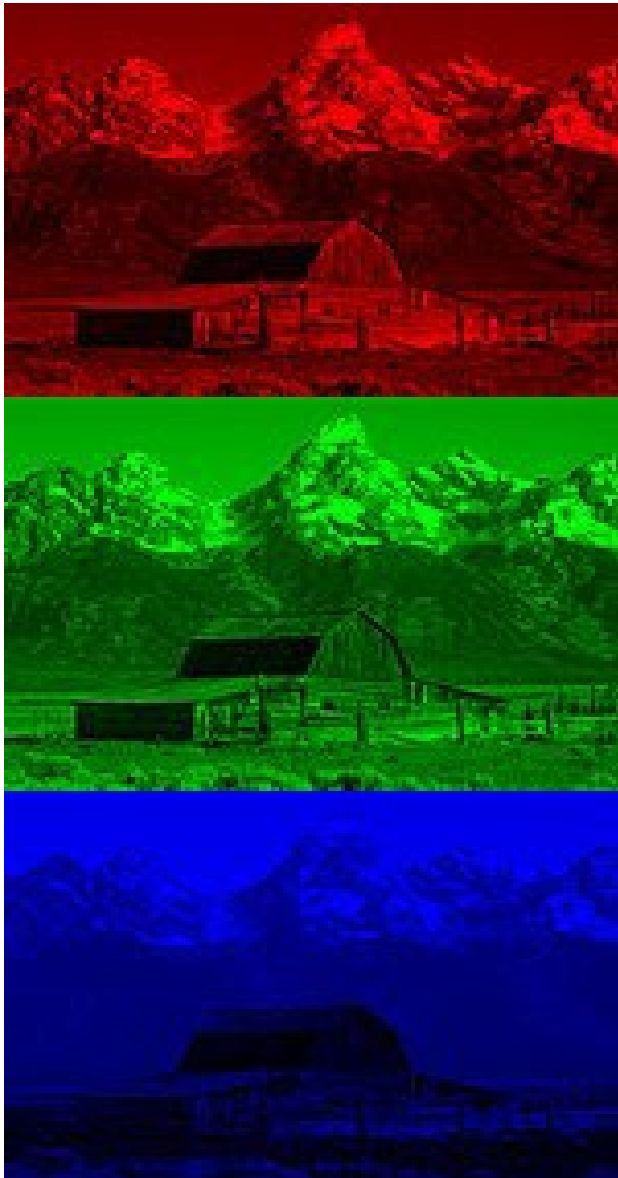# Lecture 3
Image Color-spaces & Statistics

ECE 1390/2390

Learning Objectives:

- Histograms
- Color schemes
- Gamma-correction
- Hue, saturation

RGB

CMY/CMYK

CMY/CMYK

Half toning

CMYK works well for half-toning. Colors are created from varied size/density of dots. The human eye blends these together to get a color.
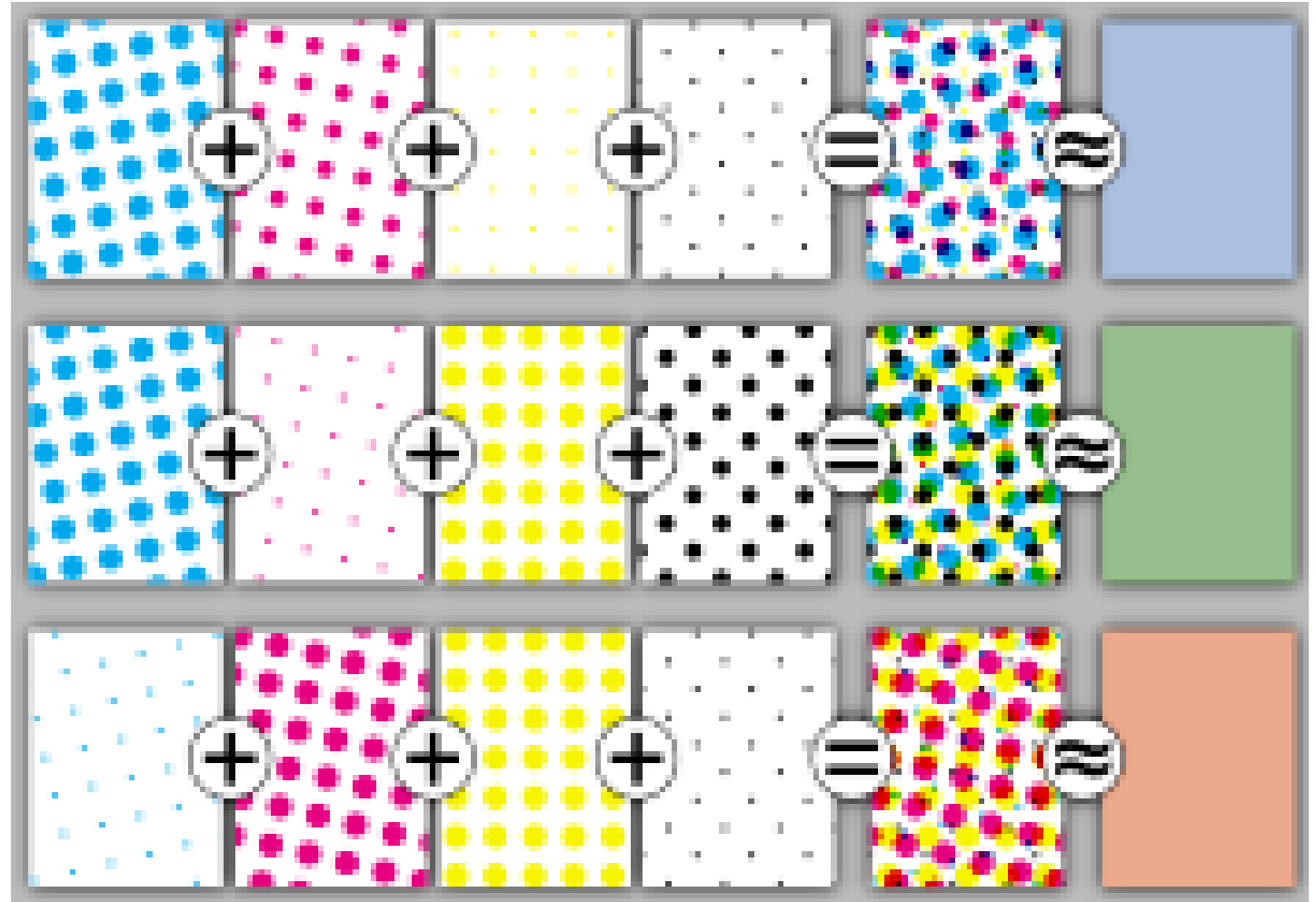
Saves ink in printing

Image from wikipedia

- **Brightness**: Mean of intensity over the power spectrum

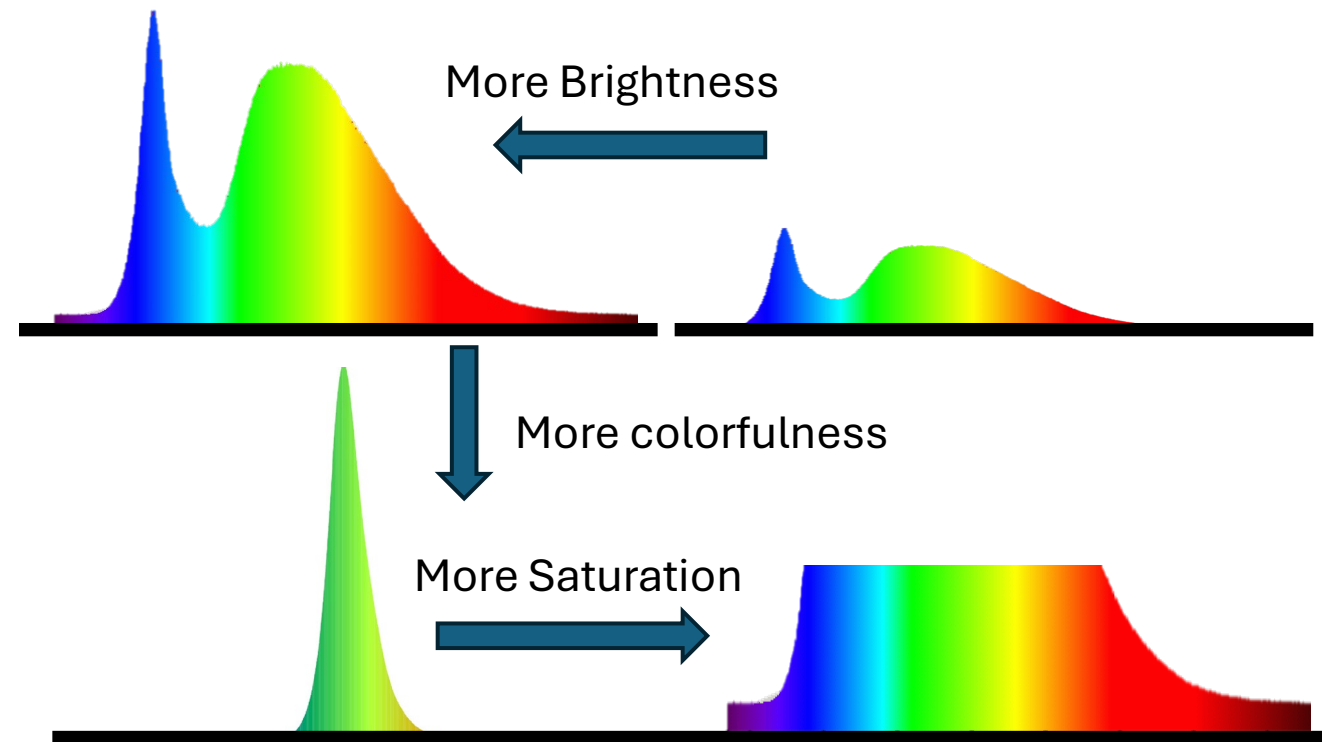- **Colorfulness**: inverse of "variance" of power spectrum

- **Saturation**: Brightness/Colorfulness

- **Radiance**. Light power through a solid angle

  Units: $W \cdot sr^{-1} \cdot m^{-2}$ [sr = steradian; $\theta = \phi = 1$ radian]
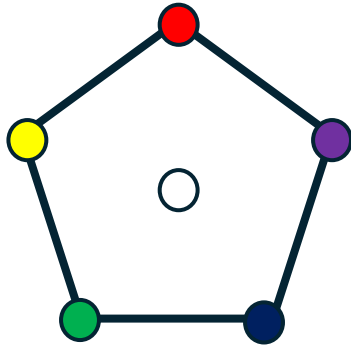
- **Luminance**. Radiance * sensitivity of human eye

  Units: $cd \cdot m^{-2}$ [cd = candela]

More Brightness

More colorfulness

More Saturation

HSV (Hue-Saturation-Value)

Hue. The "attribute of a visual sensation according to which an area appears to be similar to one of the perceived colors: red, yellow, green, and blue"

Red = 0°
Yellow = 60°
Green = 120°
Blue = 240°
Purple = 300°

Saturation. The "colorfulness of a stimulus relative to its own brightness"

Value. The "attribute of a visual sensation according to which a area appears to emit more or less light"
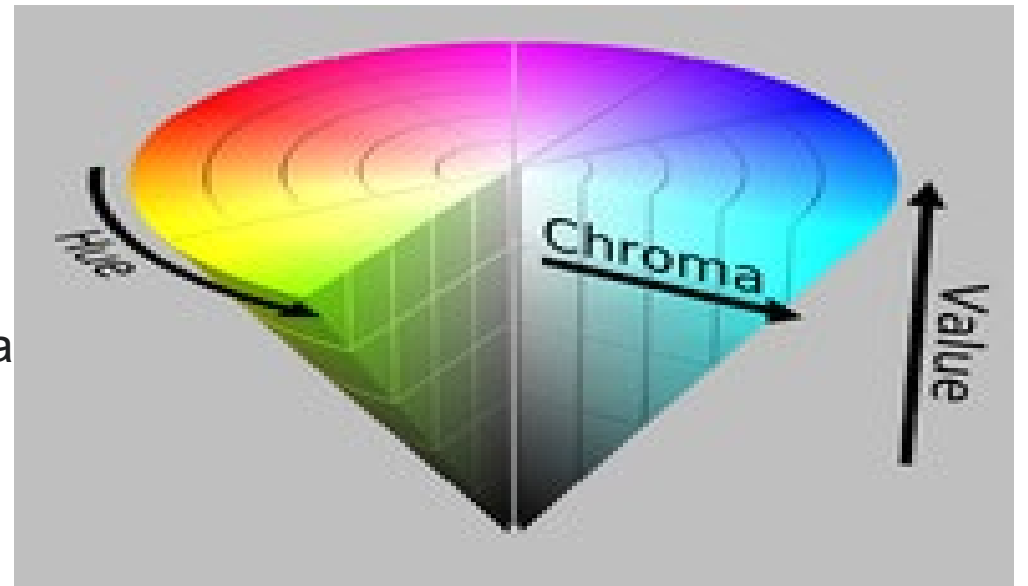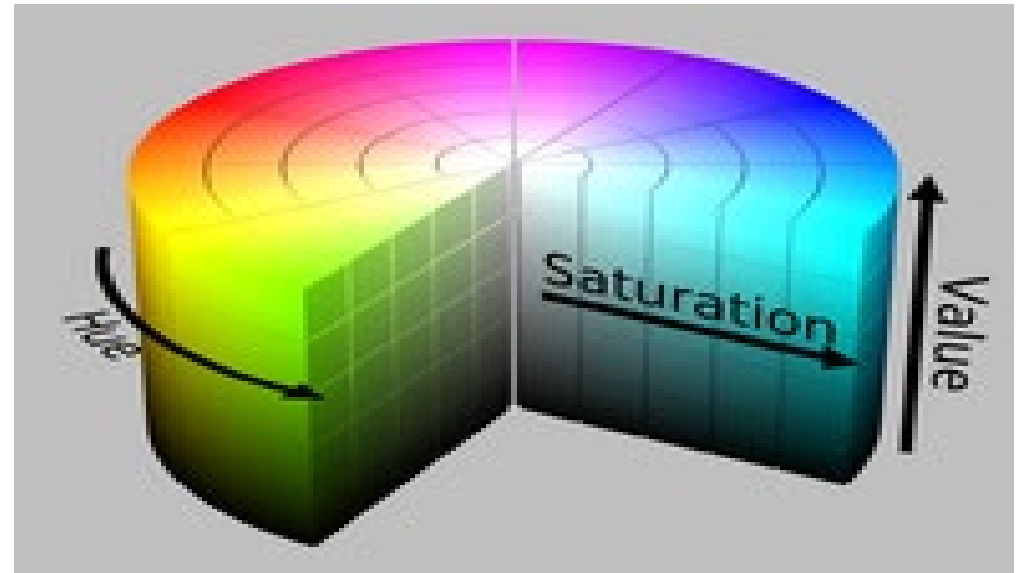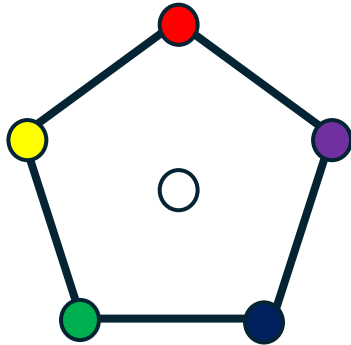
0 = Black
1 = Full color

Image from wikipedia

HSL (Hue-Saturation-Lightness)

Hue. The "attribute of a visual sensation according to which an area appears to be similar to one of the perceived colors: red, yellow, green, and blue"

Red   = 0º
Yellow = 60º
Green = 120º
Blue   = 240º
Purple = 300º

Saturation. The "colorfulness of a stimulus relative to its own brightness"

Lightness. The "brightness relative to the brightness of a similarly illuminated white"
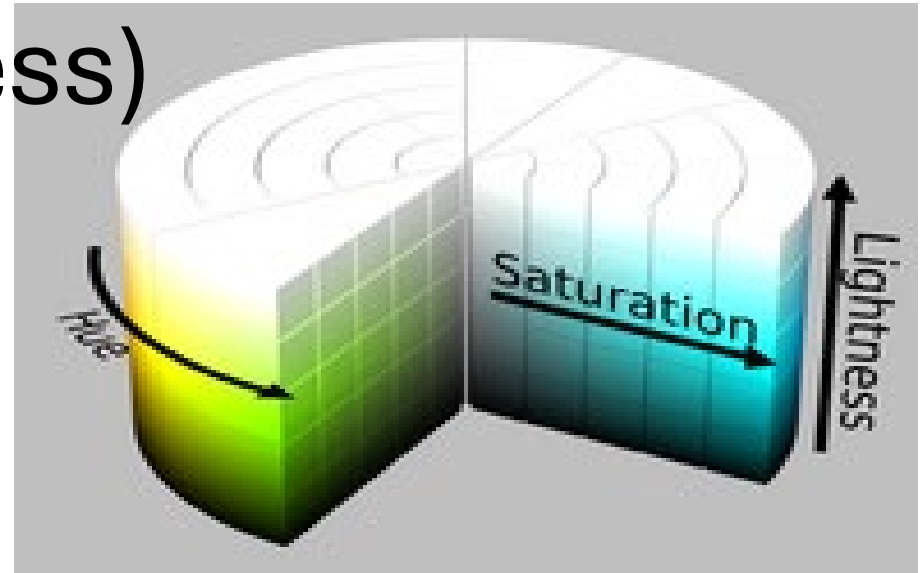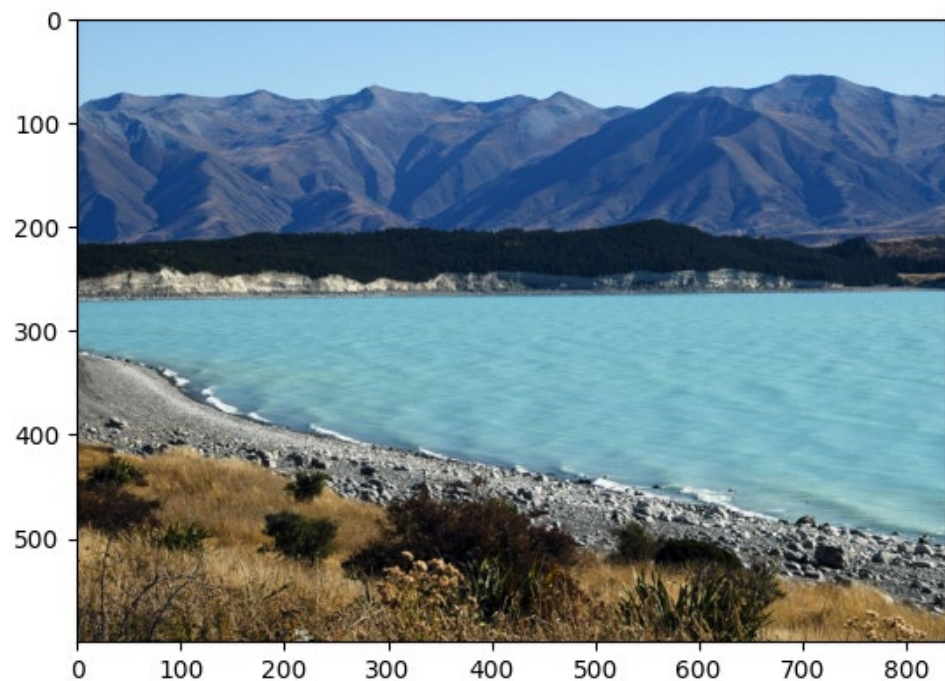
0 = Black
1 = White

Image from wikipedia
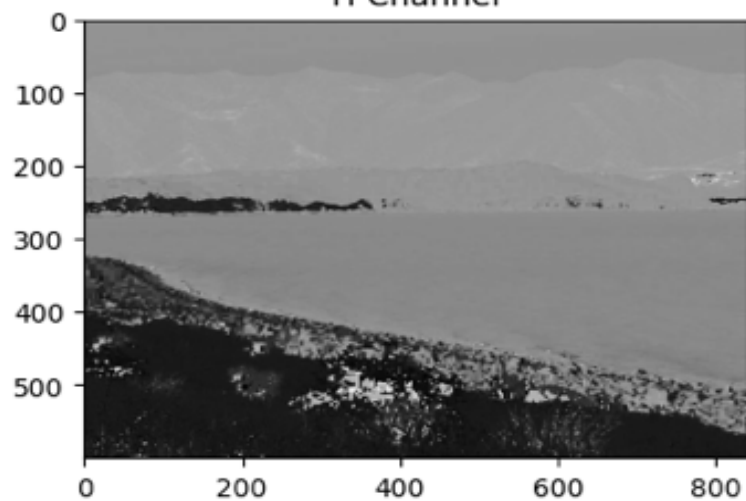
In 08_ColorSpaces.ipynb

convert to BGR to HSV
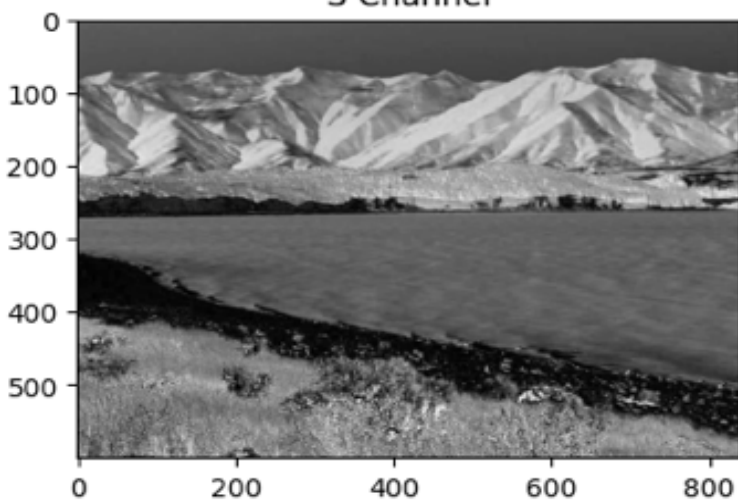lake_img_hsv = cv2.cvtColor(lake_img,cv2.COLOR_BGR2HSV)

Split the HSV (monochromatic images)
H,S,V = cv2.split(lake_img_hsv)

Image from opencv.org
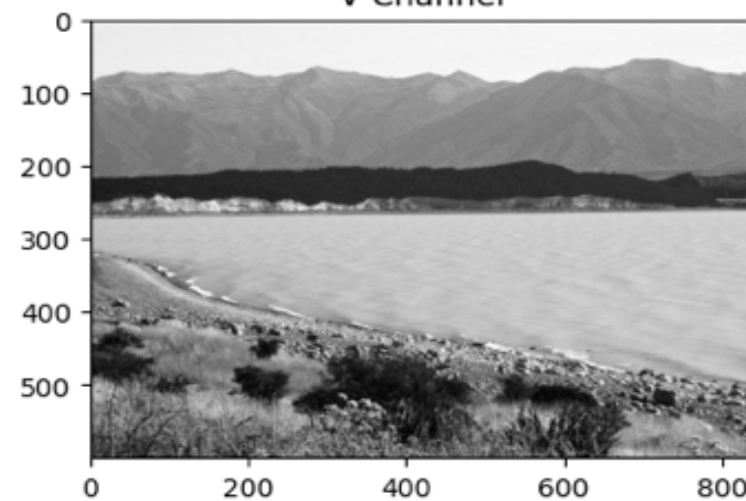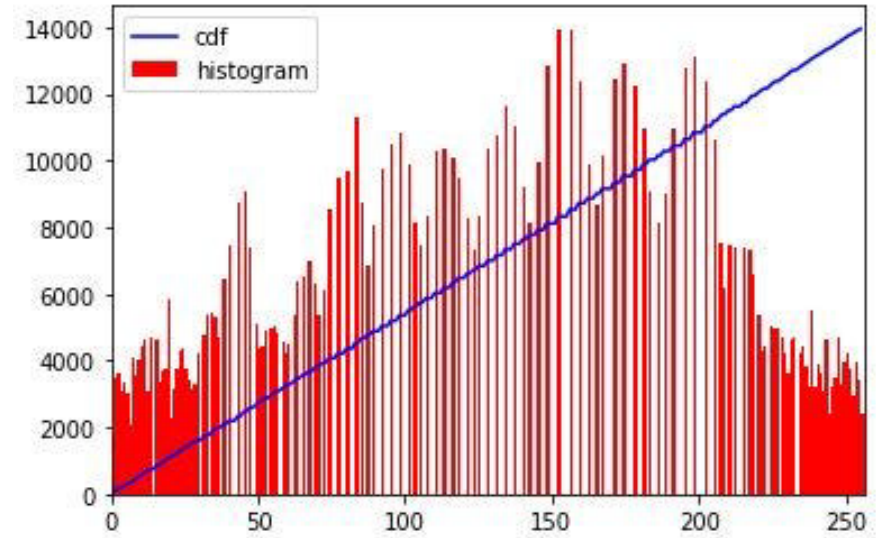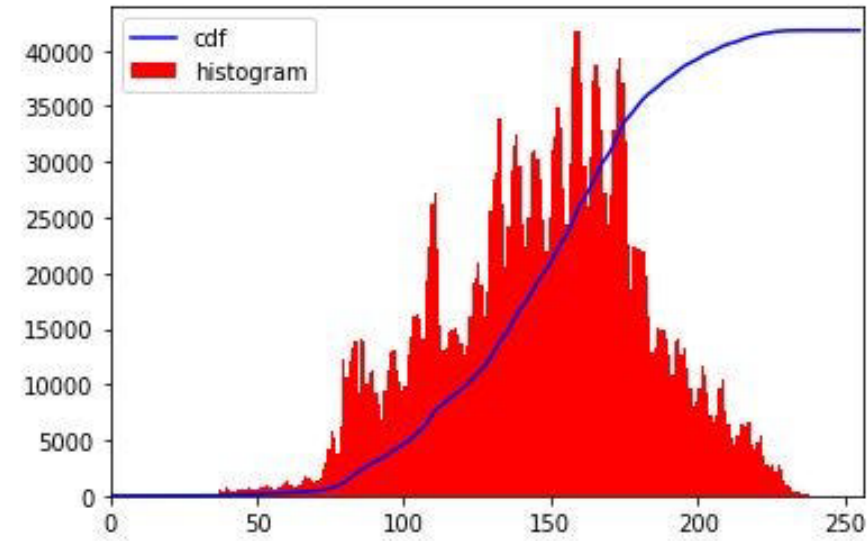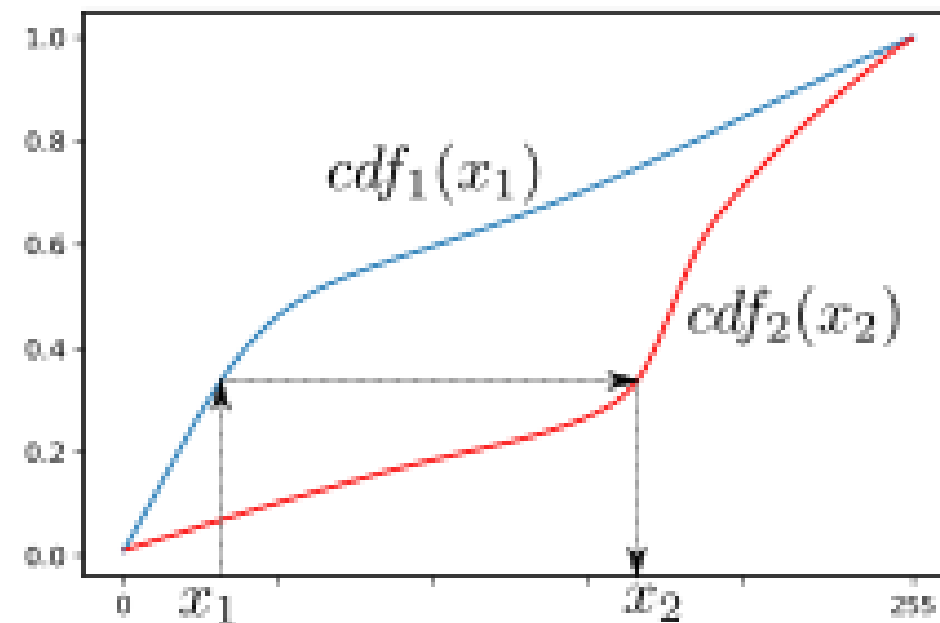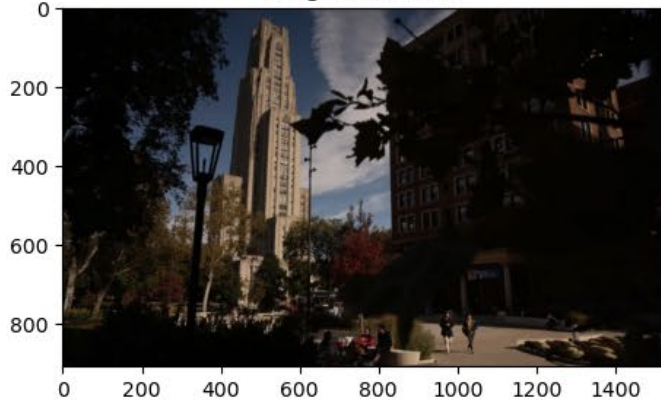
Equalization

$$h(v) = \text{round}\left(\frac{\text{cdf}(v) - \text{cdf}_{\min}}{(M \times N) - \text{cdf}_{\min}} \times (L - 1)\right)$$
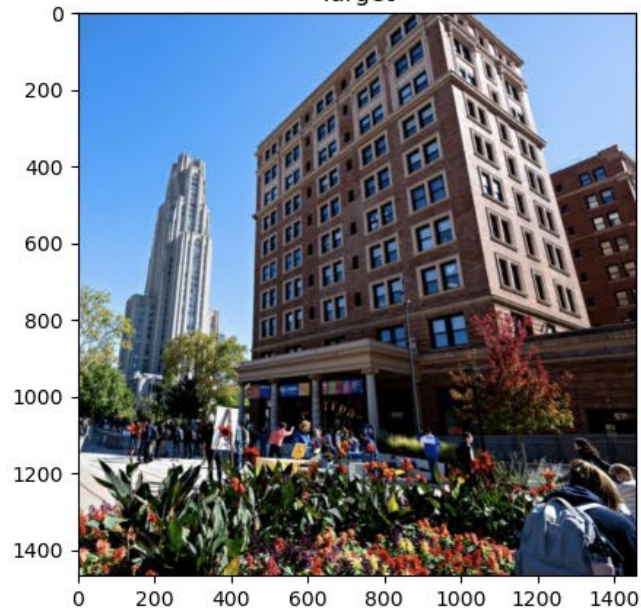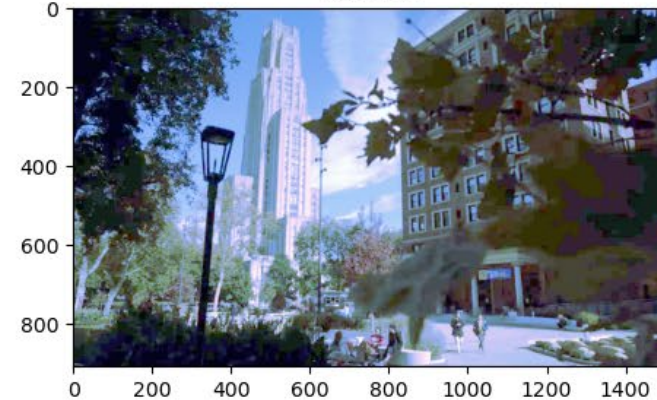
Histogram matching

$cdf_1(x_1)$

$cdf_2(x_2)$
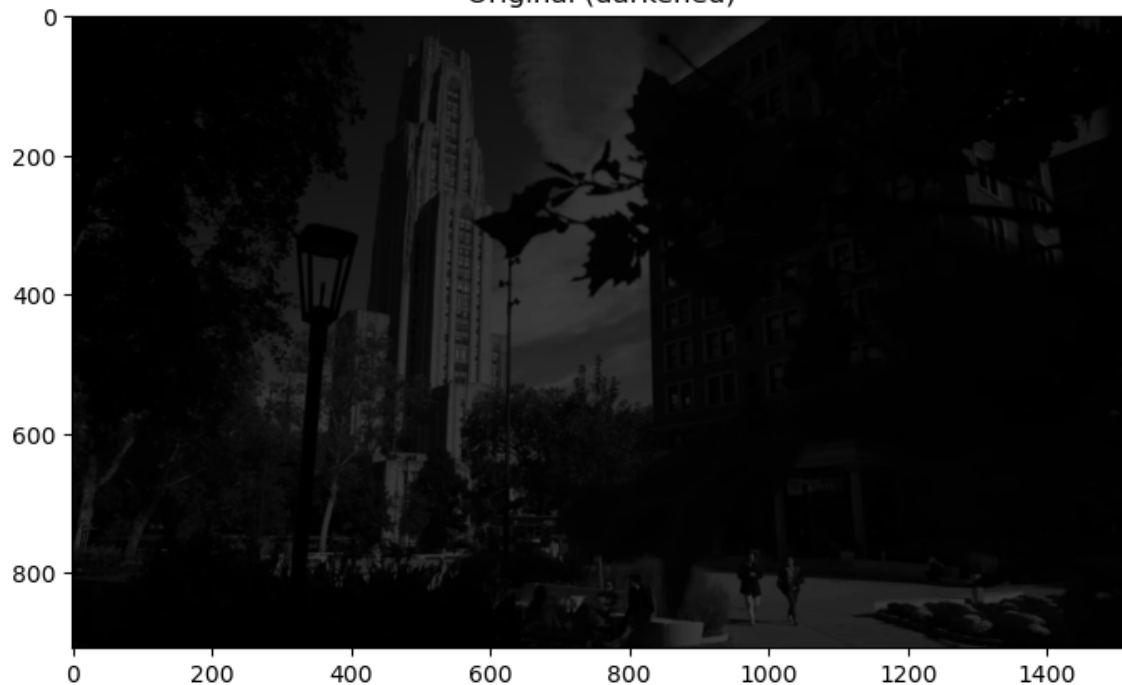
x_1 x_2
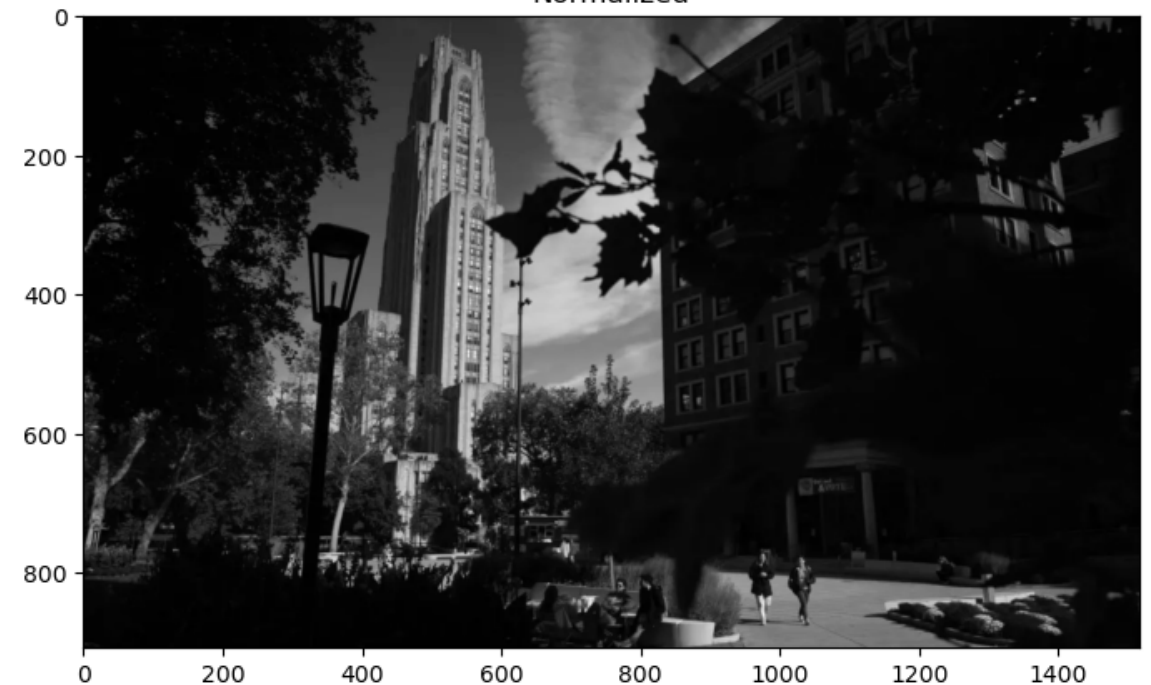
Target

Original Source

Matched

Normalization

Match the contrast level (range of intensities)

$$I_N = (I - \text{Min}) \frac{\text{newMax} - \text{newMin}}{\text{Max} - \text{Min}} + \text{newMin}$$
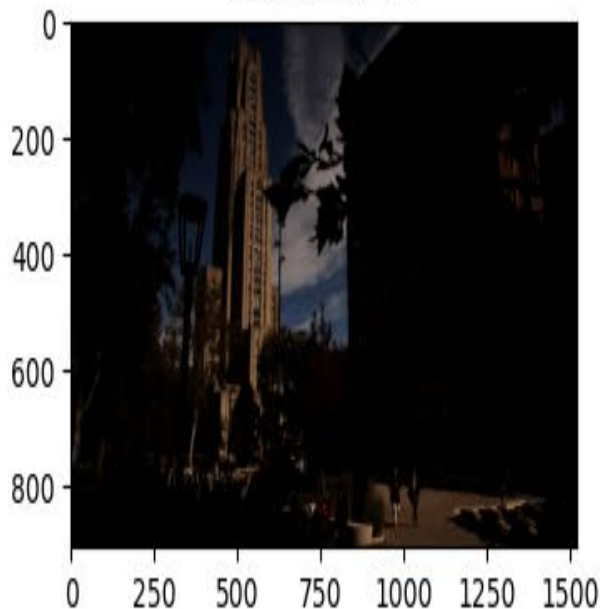

Original (darkened)

Normalized

Gamma correction

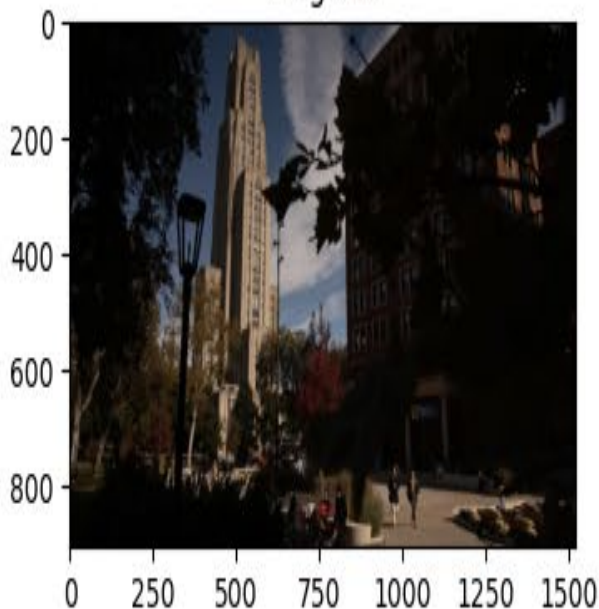*Your eye is not linear to intensity*

Linear encoding V_S = 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Linear intensity I = 0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
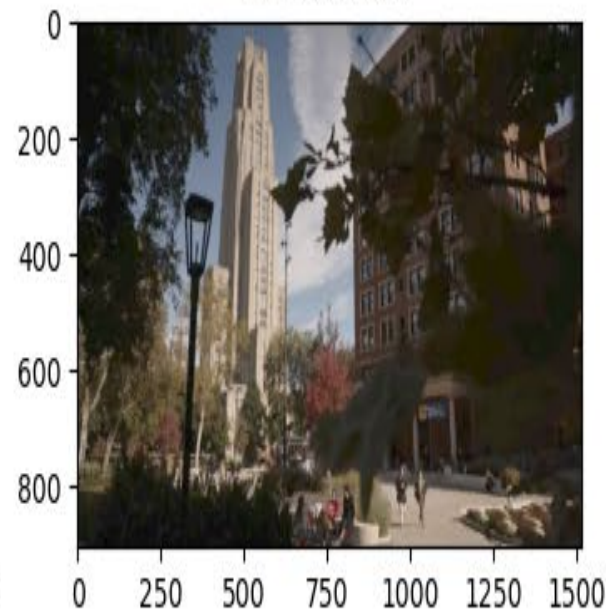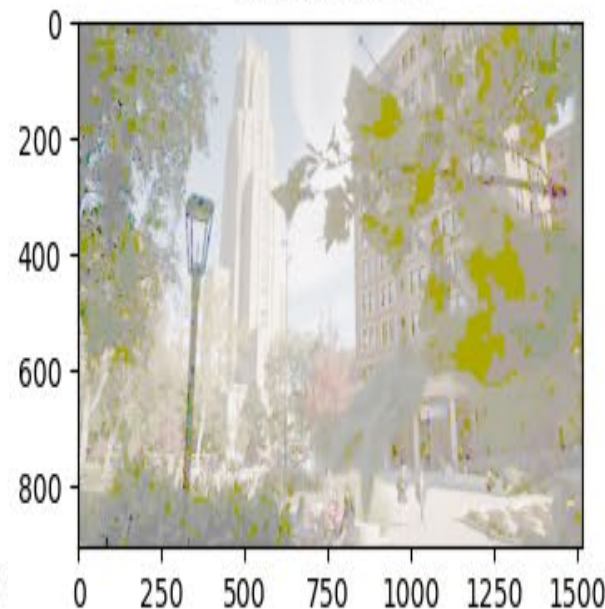
$$Out = I^{1/\gamma}$$

Alpha Blending

$$\alpha_o = \alpha_a + \alpha_b(1 - \alpha_a)$$

$$C_o = \frac{C_a \alpha_a + C_b \alpha_b (1 - \alpha_a)}{\alpha_o}$$