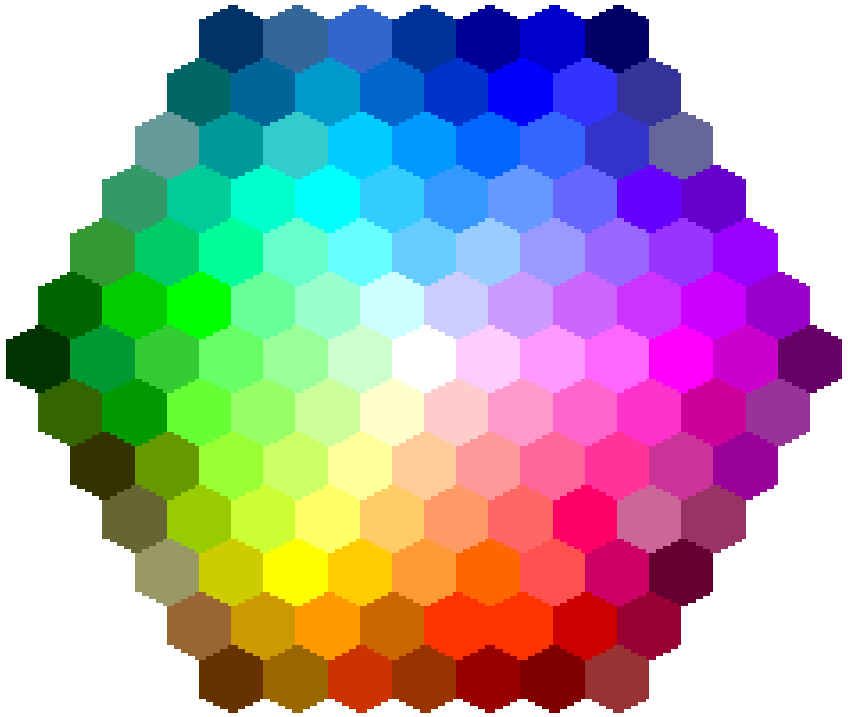
Lecture 3
Image Color-spaces & Statistics

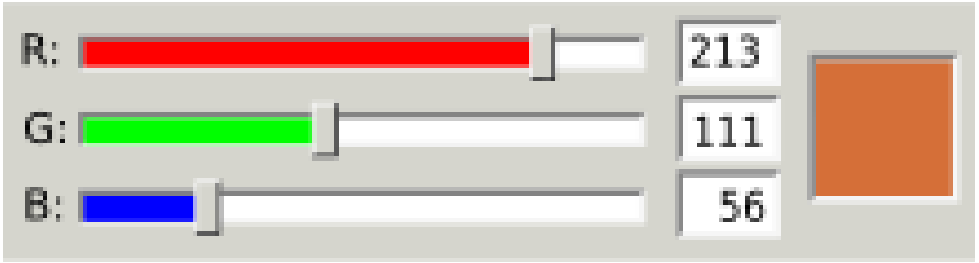
ECE 1390/2390

Learning Objectives:

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



RGB



CMY/CMYK

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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

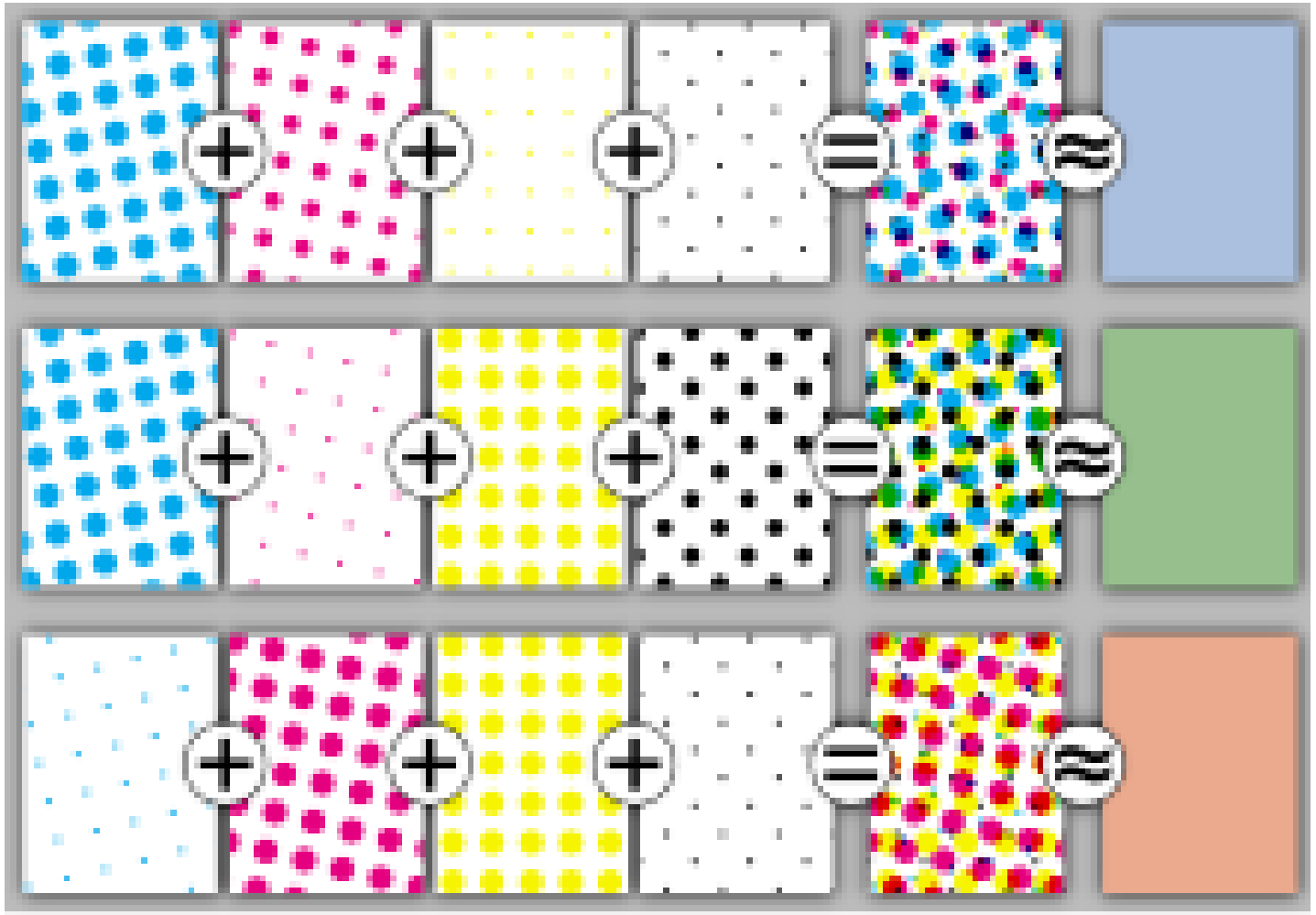
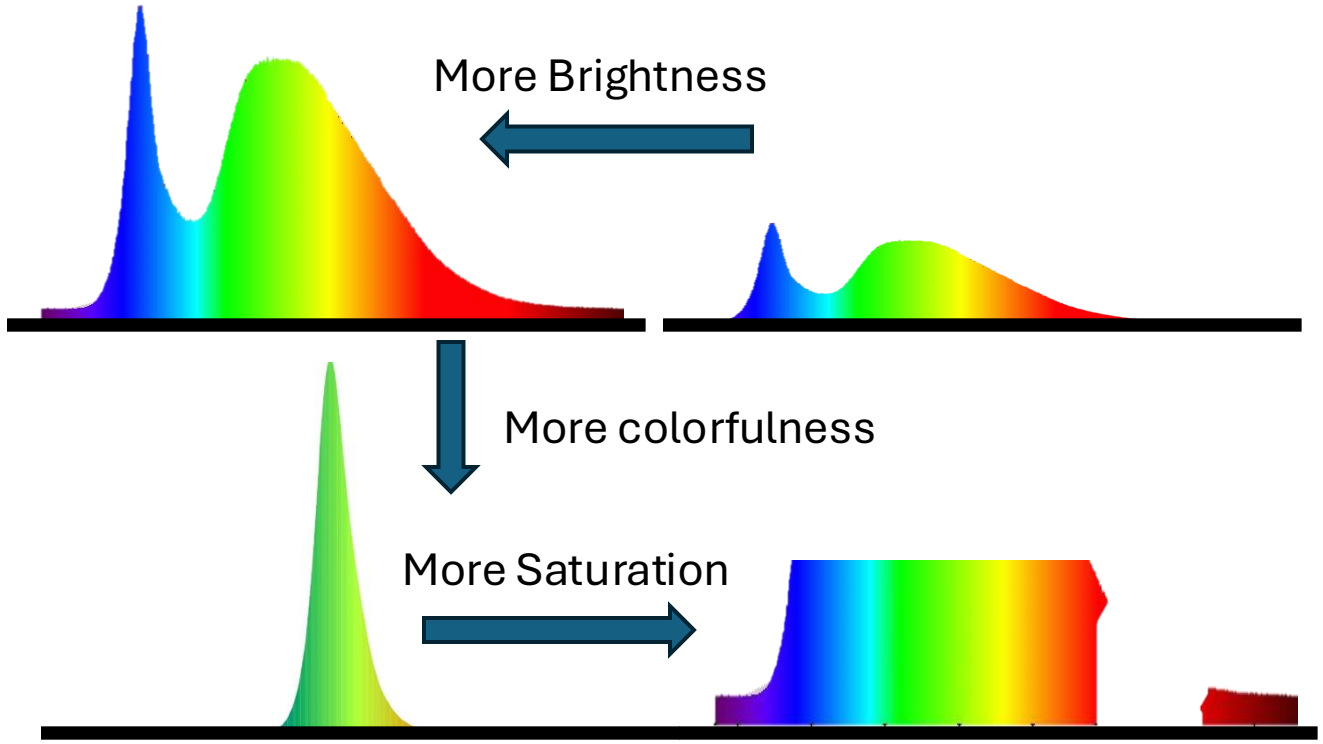


Image from wikipedia

- **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; θ=ϕ=1 radian]

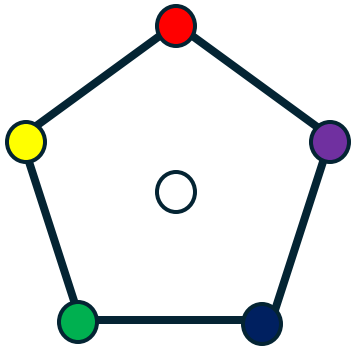
- **Luminance**. Radiance * sensitivity of human eye

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

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"

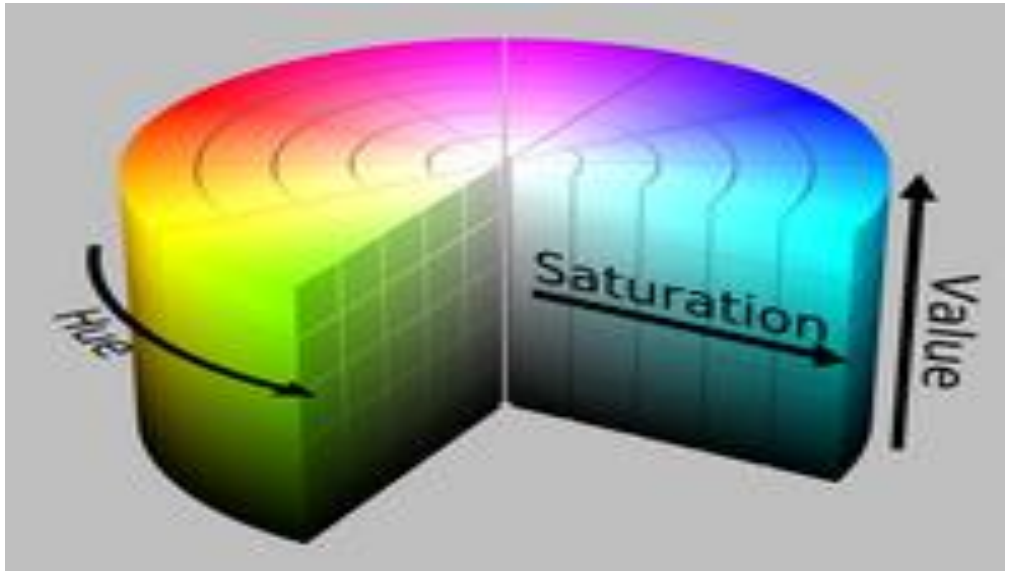
Red = 0°
Yellow = 60°
Green = 120°
Blue = 240°
Purple = 300°



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



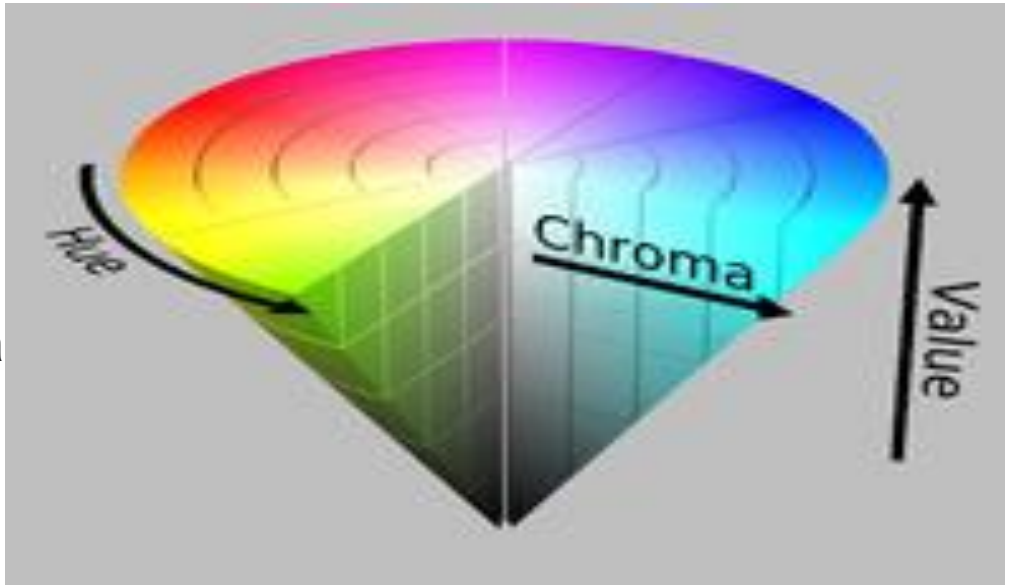
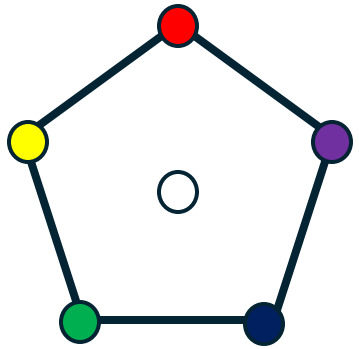


Image from wikipedia

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"

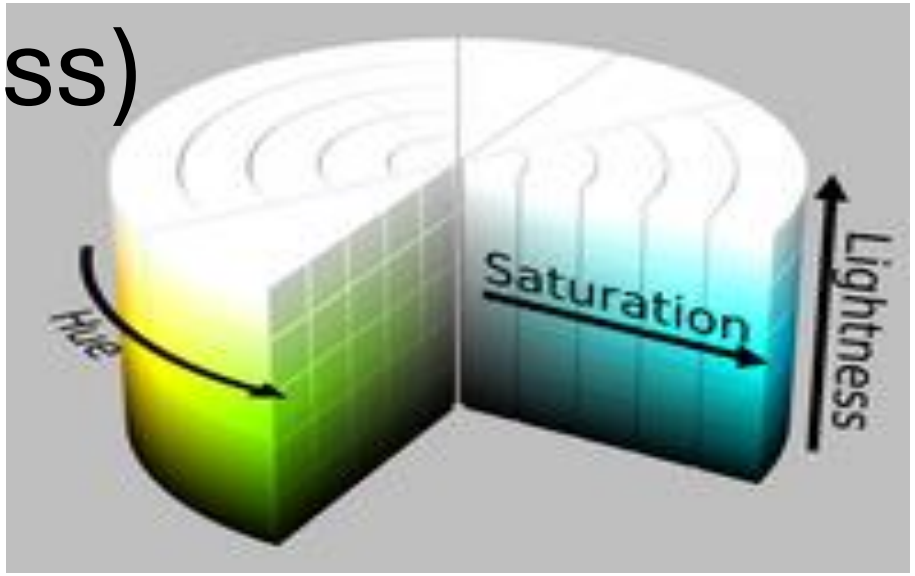
Red = 0°
Yellow = 60°
Green = 120°
Blue = 240°
Purple = 300°



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



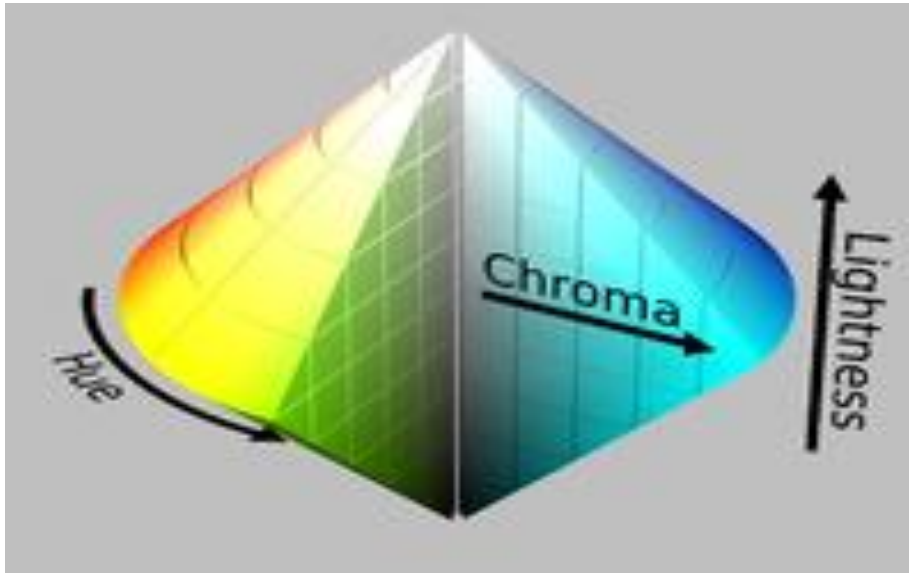
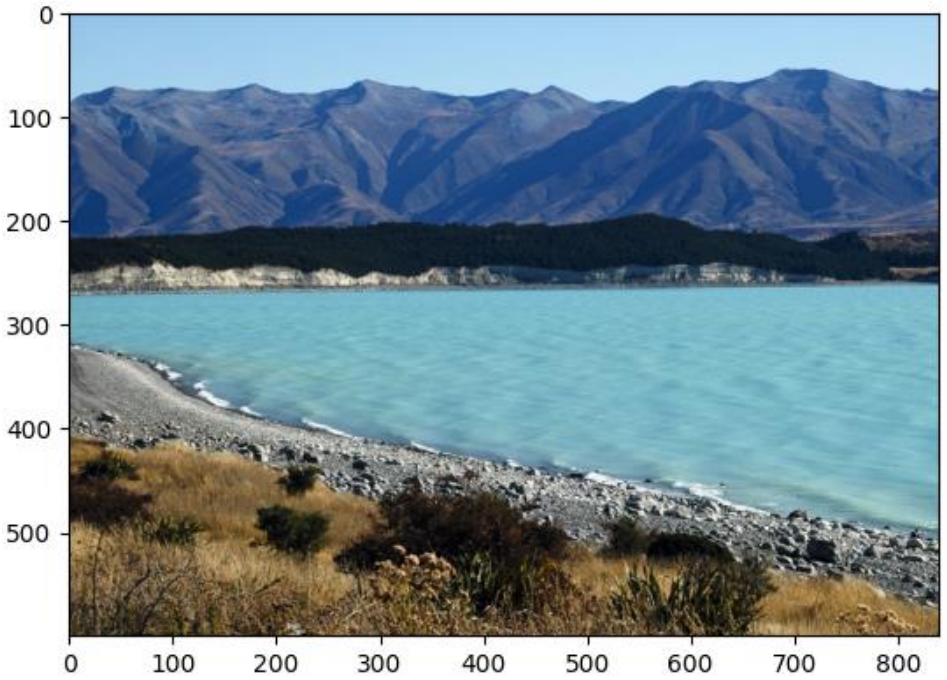


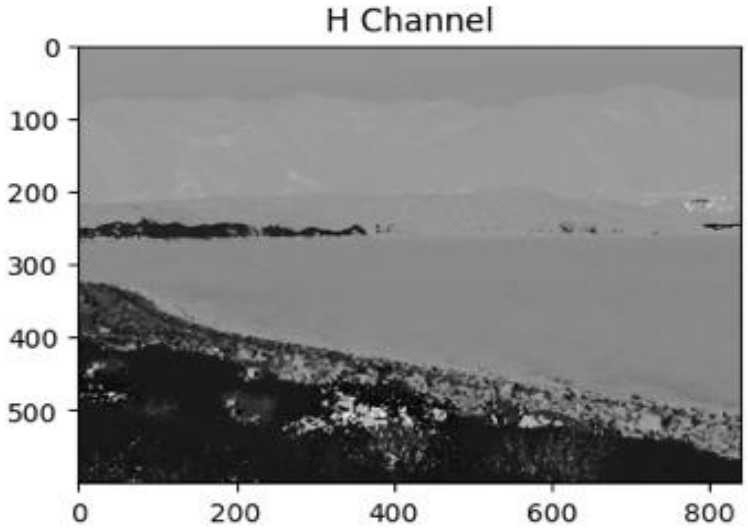
Image from wikipedia

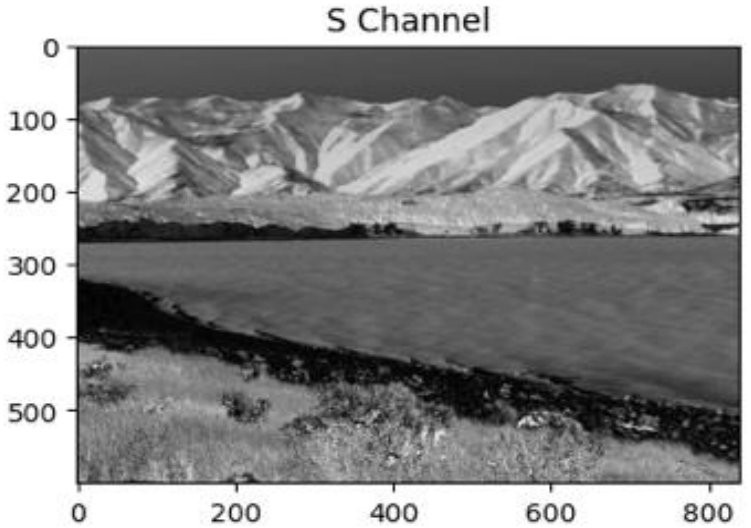


In 08_ColorSpaces.ipynb

```
# 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)
```





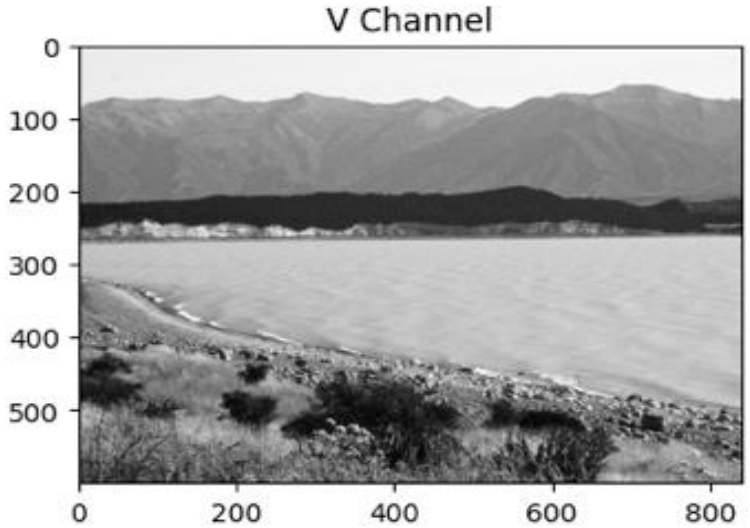
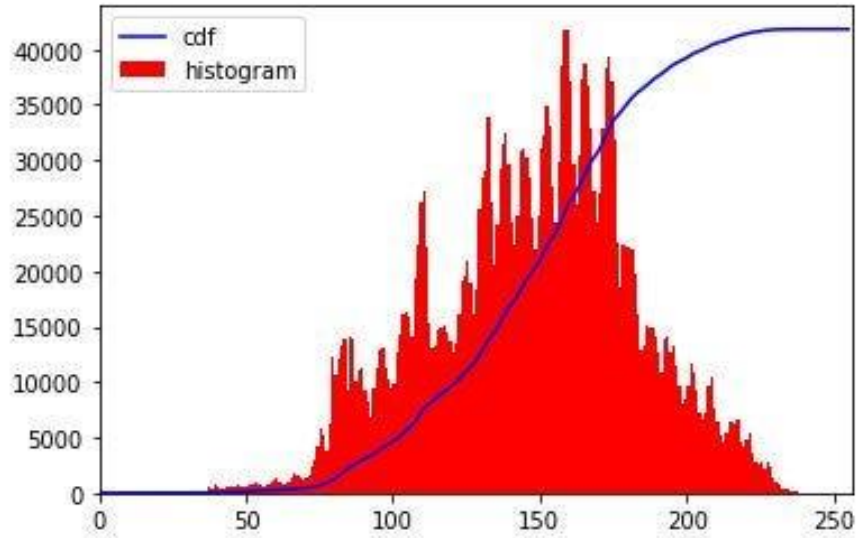
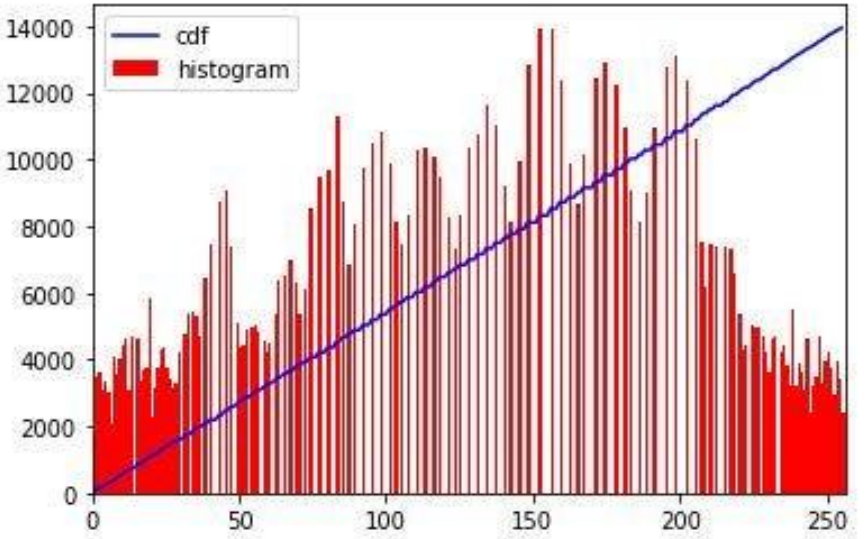


Image from opencv.org

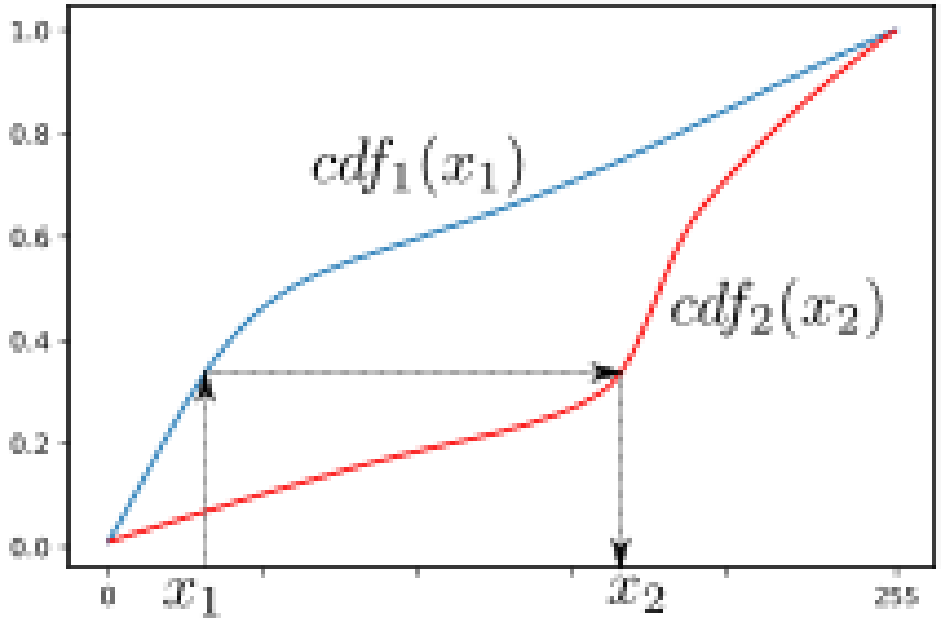
Equalization

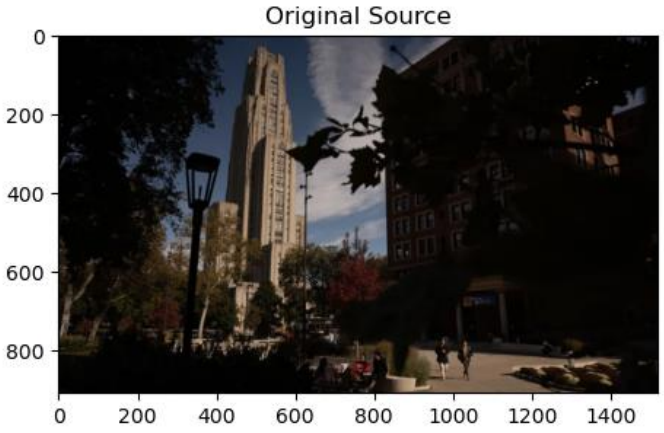
$$h(v) = \text{round}\left(\frac{\text{cdf}(v) - \text{cdf}_{\text{min}}}{(M \times N) - \text{cdf}_{\text{min}}} \times (L-1)\right)$$

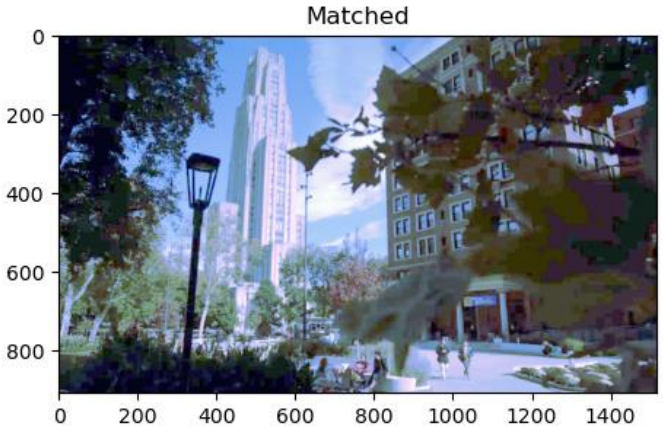




Histogram matching



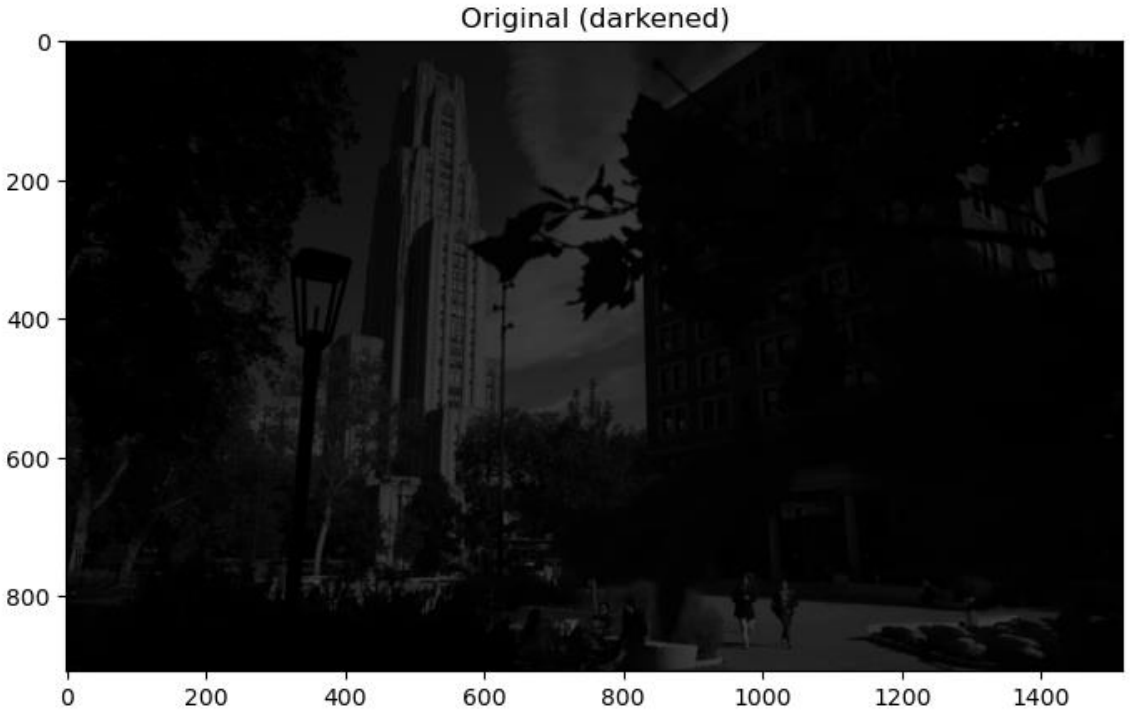


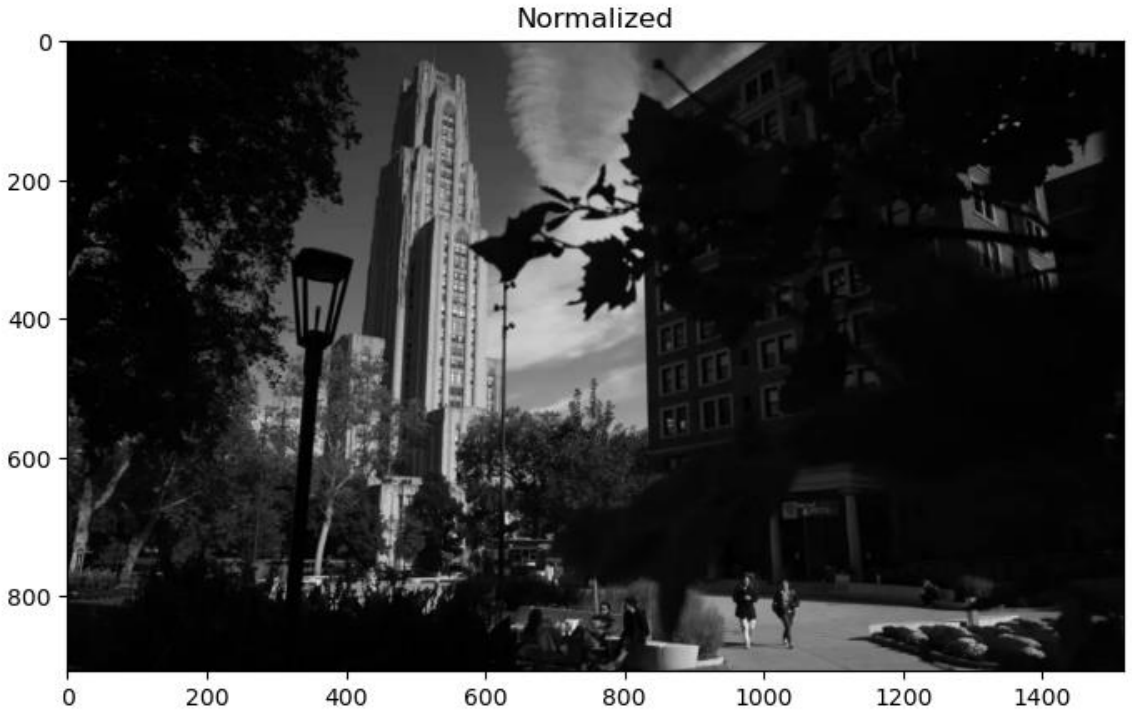


Normalization

Match the contrast level (range of intensities)

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



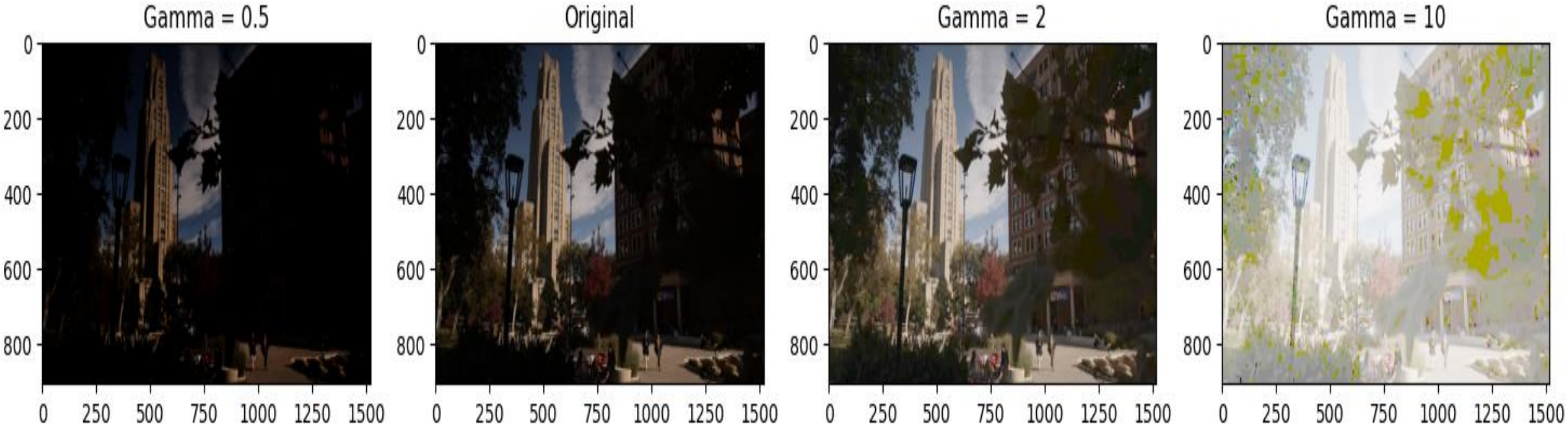


Gamma correction

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

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