FBSP: Colors

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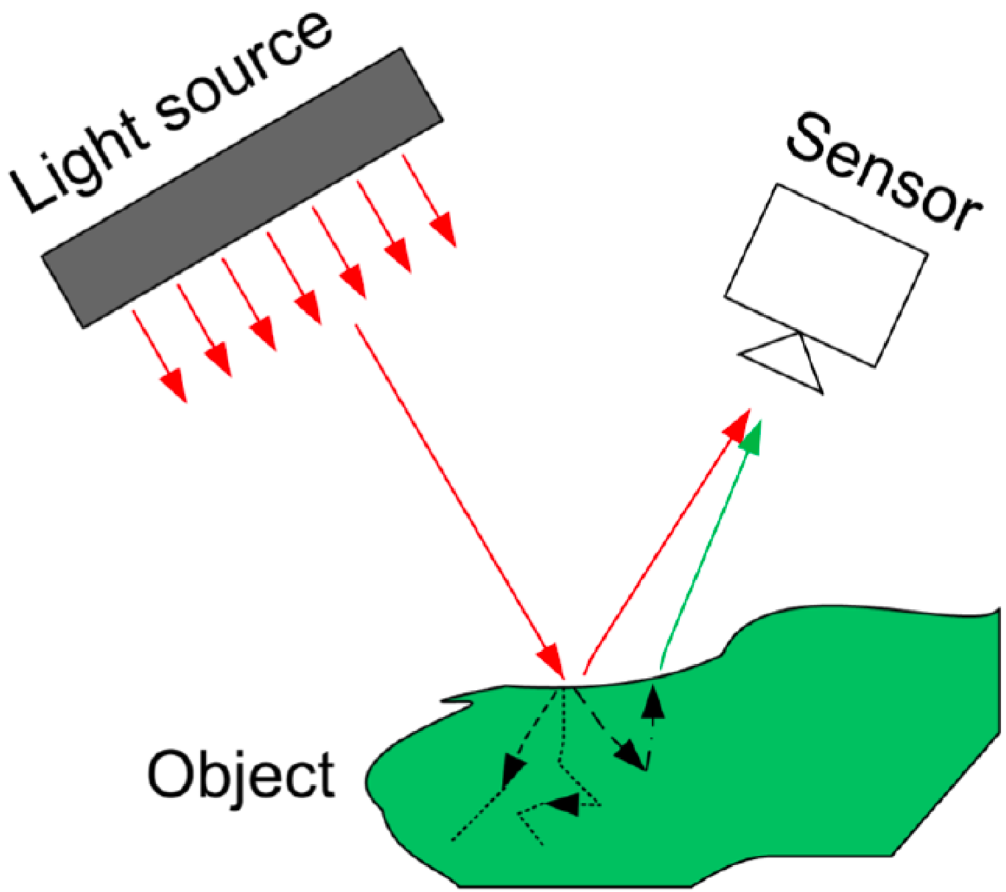
What are colors?



- The colors that humans and cameras perceive are determined by the nature of the light reflected from an object
- Green objects reflect “green” light

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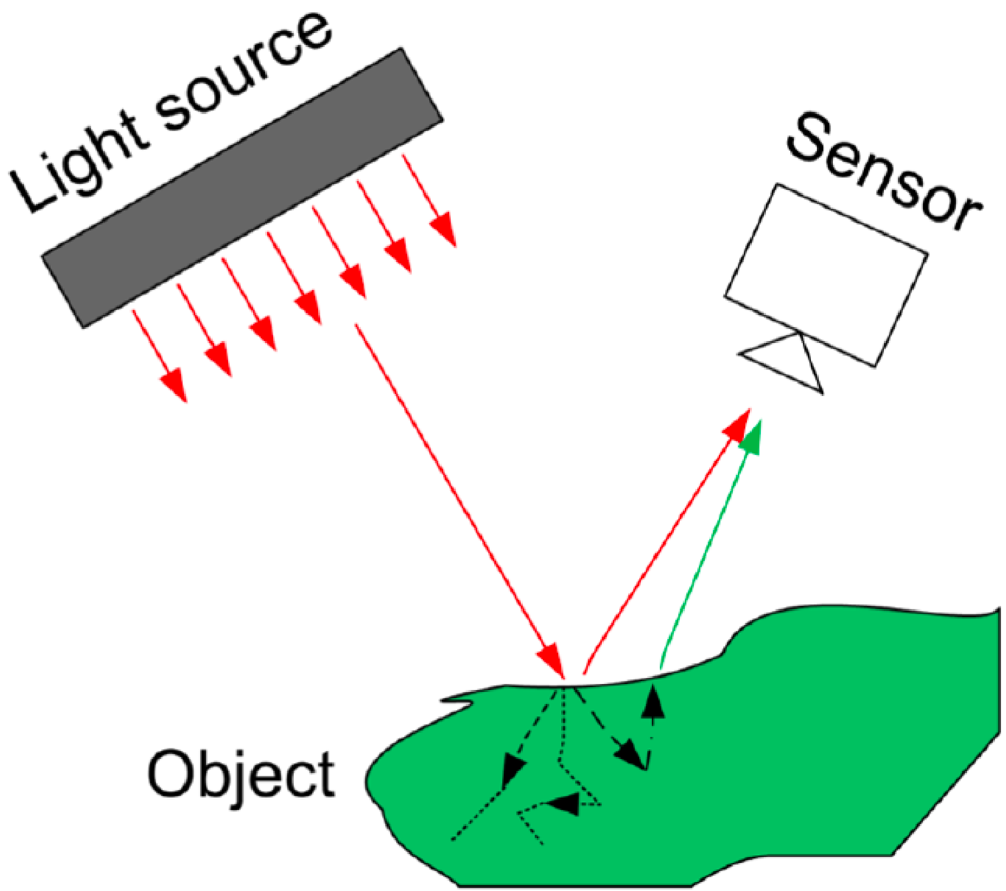

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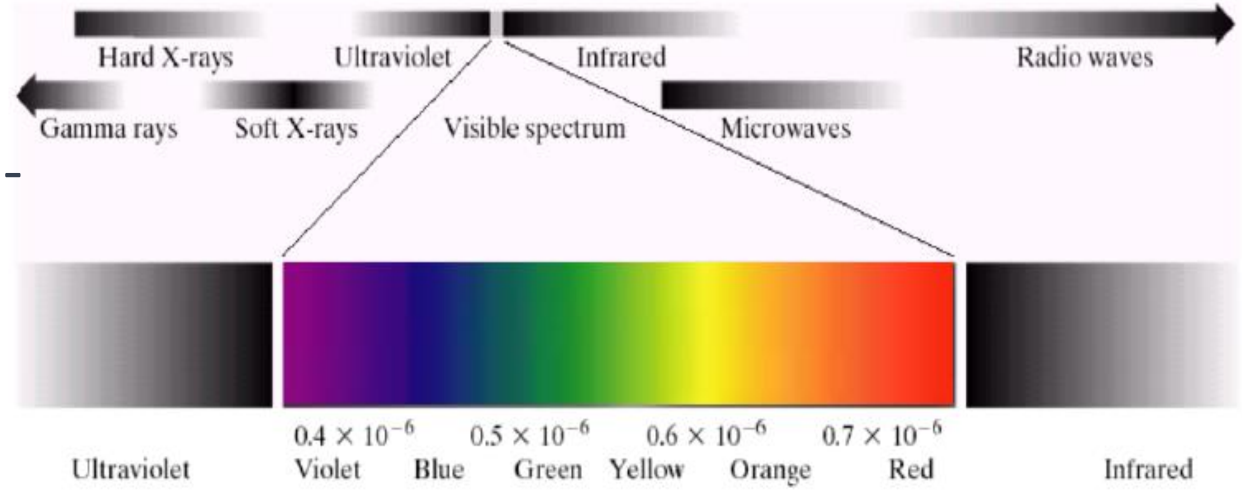
What are colors?

- Achromatic: Only intensities (amount of light)
  - Gray levels as seen in a black and white TV monitor
  - Ranges from black and white

- Chromatic: Light waves: Visual range 400nm-700nm



What are colors?

- The eye contains three types of cones, each sensitive to different wavelength ranges. The human brain interprets the output from these different cones as different colors
- So, a color is defined by a certain wavelength in the electromagnetic spectrum. Due to the three different types of cones we have the notion of the *primary colors* being **red**, **green**, and **blue**.

Photoreceptor cell	Wavelength in nanometers (nm)	Peak response in nanometer (nm)	Interpretation by the human brain
Cones (type L)	[400–680]	564	Red
Cones (type M)	[400–650]	534	Green
Cones (type S)	[370–530]	420	Blue
Rods	[400–600]	498	Shade of gray

What are colors?

- When all wavelengths (all colors) are present at the same time, the eye perceives this as a shade of gray, hence no color is seen!

Fig. 8.1 The relationship between colors and wavelengths

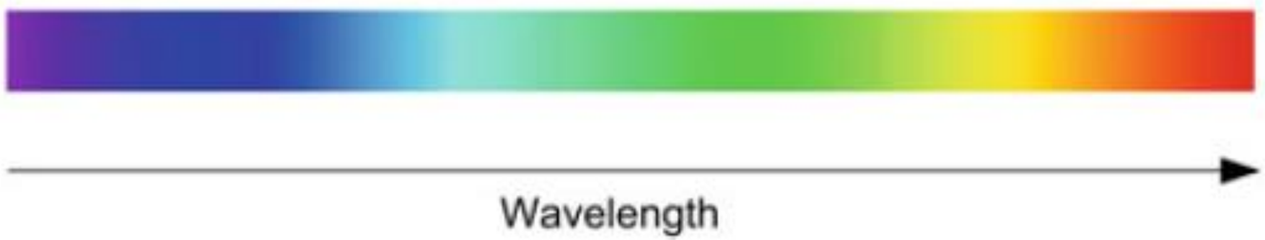
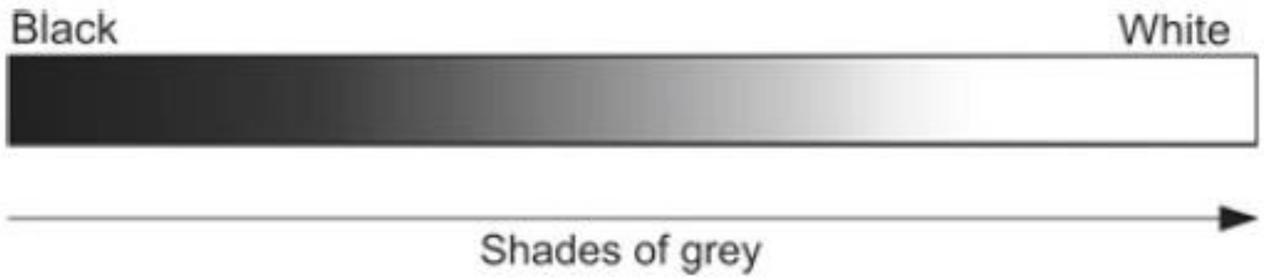


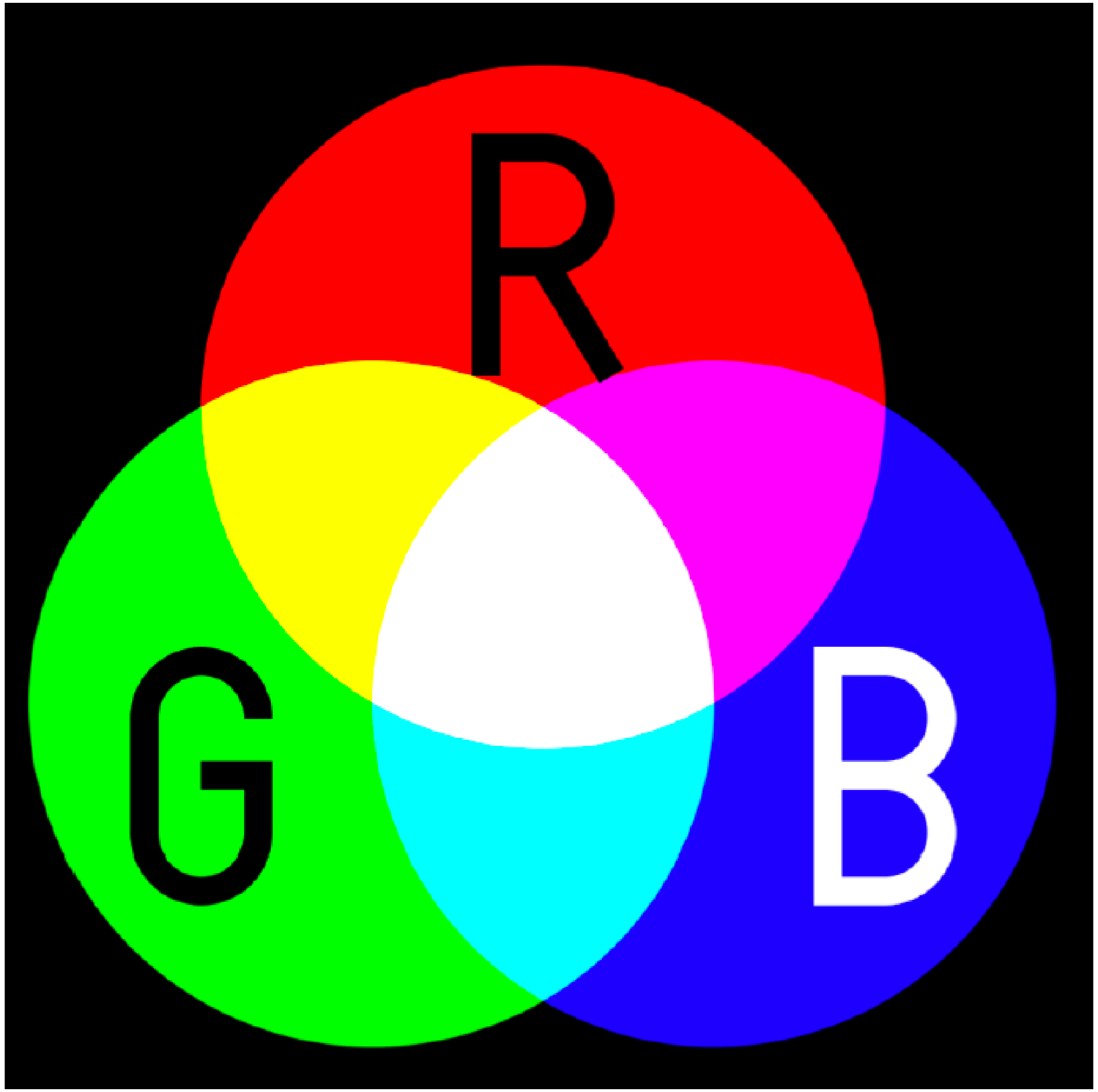
Fig. 8.2 Achromatic colors



- In case of images. We got three sensors: each sensor measures one of the three colors (red, green and blue).

Colors: Summary

- Red, green, blue are called Primary Colors
- R,G,B were chosen due to the structure of the human eye
- R,G,B are used in cameras as they got three sensors



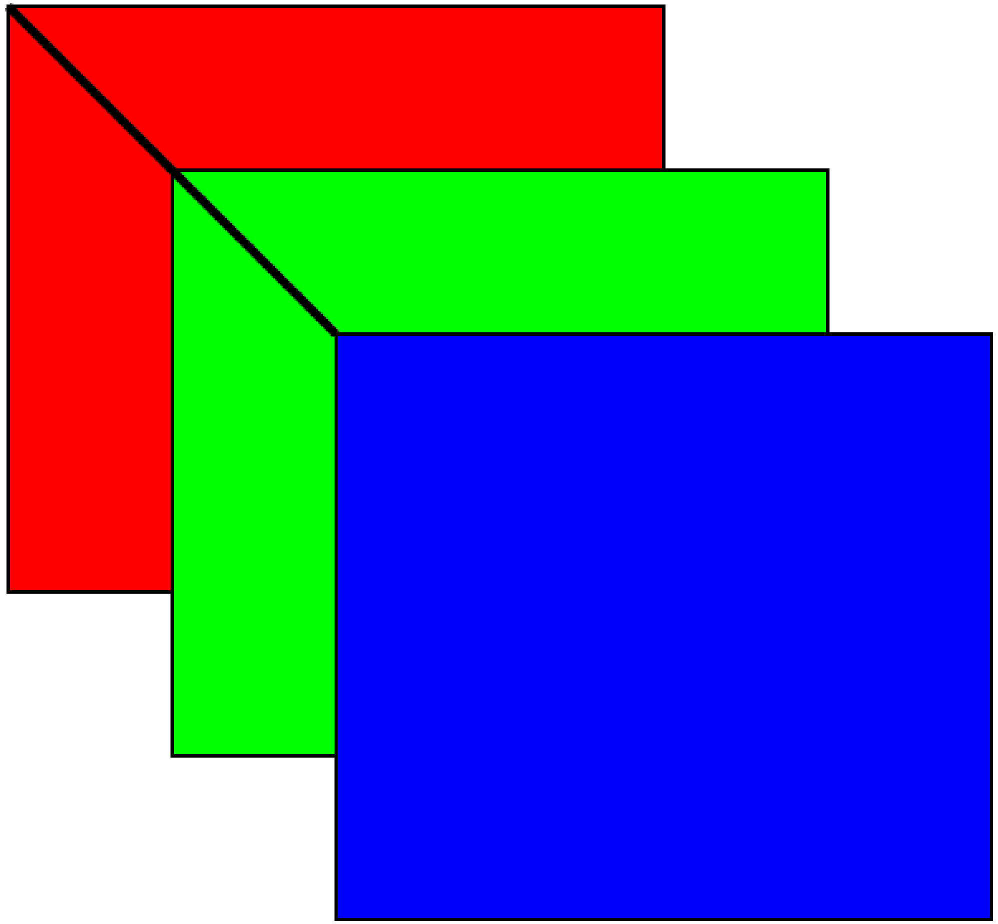
RGB Pixels

- Like I said before, each sensor measures one of the three colors (**red**, **green** and **blue**)
- In a color image, each pixel therefore consists of three values: **red**, **green**, and **blue**.

Color pixel = [Red, Green, Blue] = [R, G, B]

- Typically each color value is represented by an 8-bit (one byte) value meaning that 256 different shades of each color can be measured.

RGB Pixels



A pixel consists of three components: [0,255]

Each pixel is a vector

Pixel vector in the computer memory

Final pixel image

Question

Combining different values of the three colors:

- How many different colors can each pixel actually represent?

RGB Examples

- The actual representation might be three images—one for each color, but it can also be a three-dimensional vector for each pixel, hence an image of vectors.

RGB Pixels - Examples

Original Image

R-Component

G-Component

B-Component

RGB color space

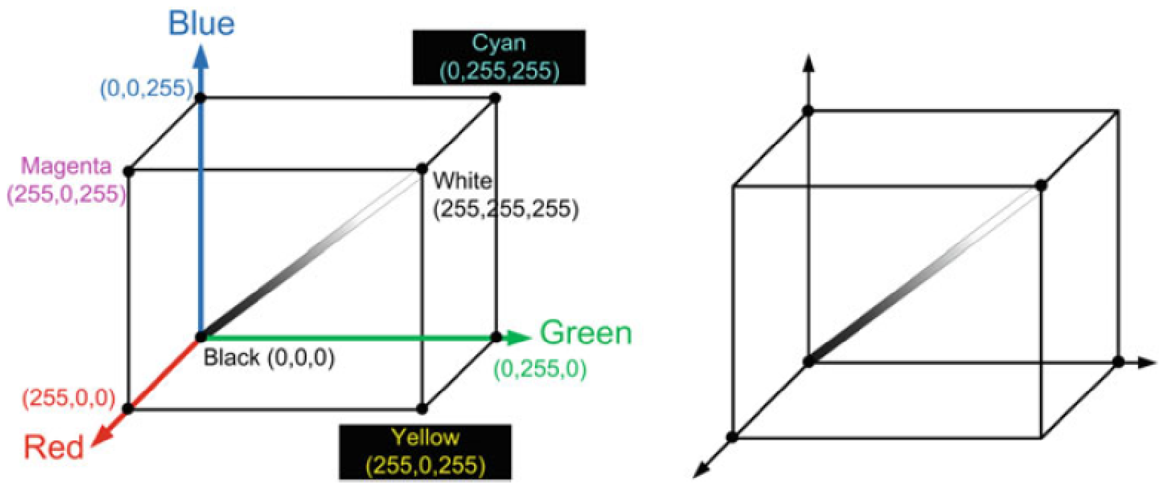
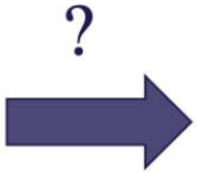


Fig. 8.5 Left: The RGB color cube. Right: The gray-vector in the RGB color cube

Table 8.2 The colors of the different corners in the RGB color cube

Corner	Color	
(0,0,0)	Black	
(255,0,0)	Red	
(0,255,0)	Green	
(0,0,255)	Blue	
(255,255,0)	Yellow	
(255,0,255)	Magenta	
(0,255,255)	Cyan	
(255,255,255)	White	

Converting color to grayscale



- $I = (R+G+B) / 3$

where I is the **intensity**

WR + WG + WB = 1 are **weight factors** for **R**, **G**, and **B**

As default the three colors are equally important, hence
WR = WG = WB = 1/3

(

+

+

) / 3 =

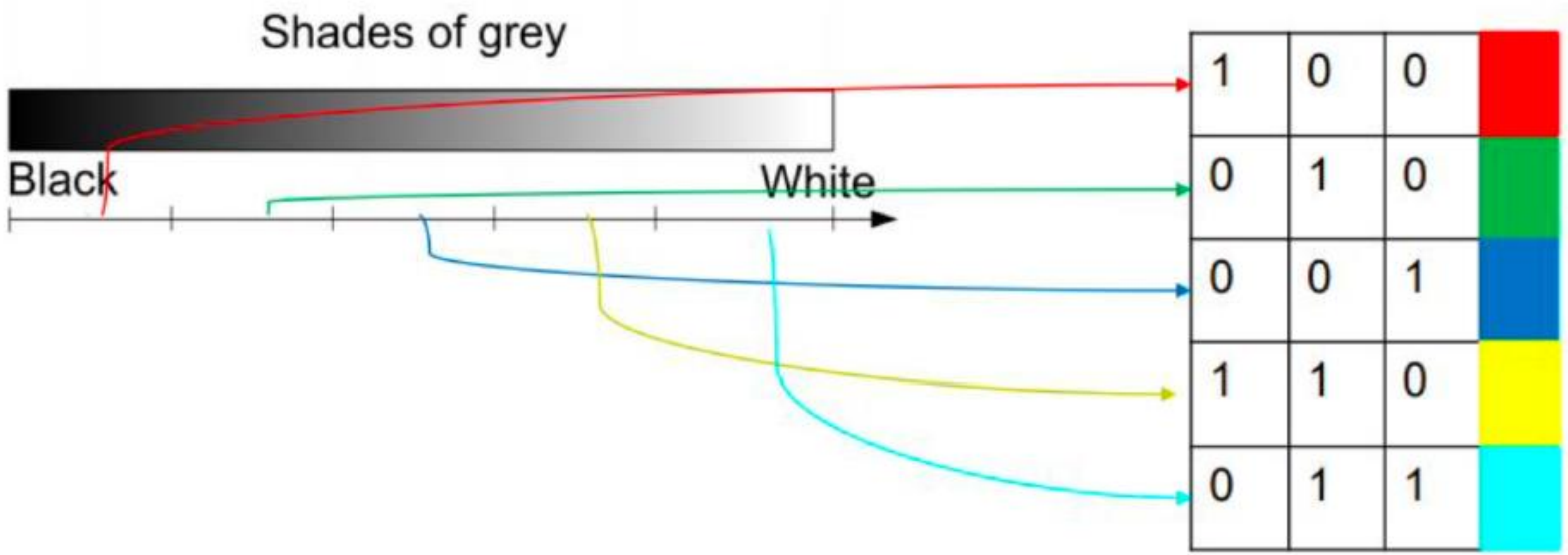
- $I = W_R \times R + W_G \times G + W_B \times B$, $W_R + W_G + W_B = 1$

Converting color to grayscale

- Optimal weight vary based on the task:
- For example, when processing images of vegetation the **green** color typically contains the most information $W_R = 0.299 \quad W_G = 0.587 \quad W_B = 0.114$


Slicing the image into levels

- A method for colorizing grayscale images
- Convert grayscale images to indexed images using thresholding
- Slices the image into N levels using an equal step thresholding process
- Example: Create five slices, which maps to a custom colormap



Custom colormap

- A colormap is a M by 3 matrix, with values in **double format** in the range [0, 1].
- 1st column is red value, 2nd column is green value, and 3rd column is blue value

Example:

```
mymap = [0.2 0.1 0.5;
         0.1 0.5 0.8;
         0.2 0.7 0.6;
         0.8 0.7 0.3;
         0.9 1 0];
```

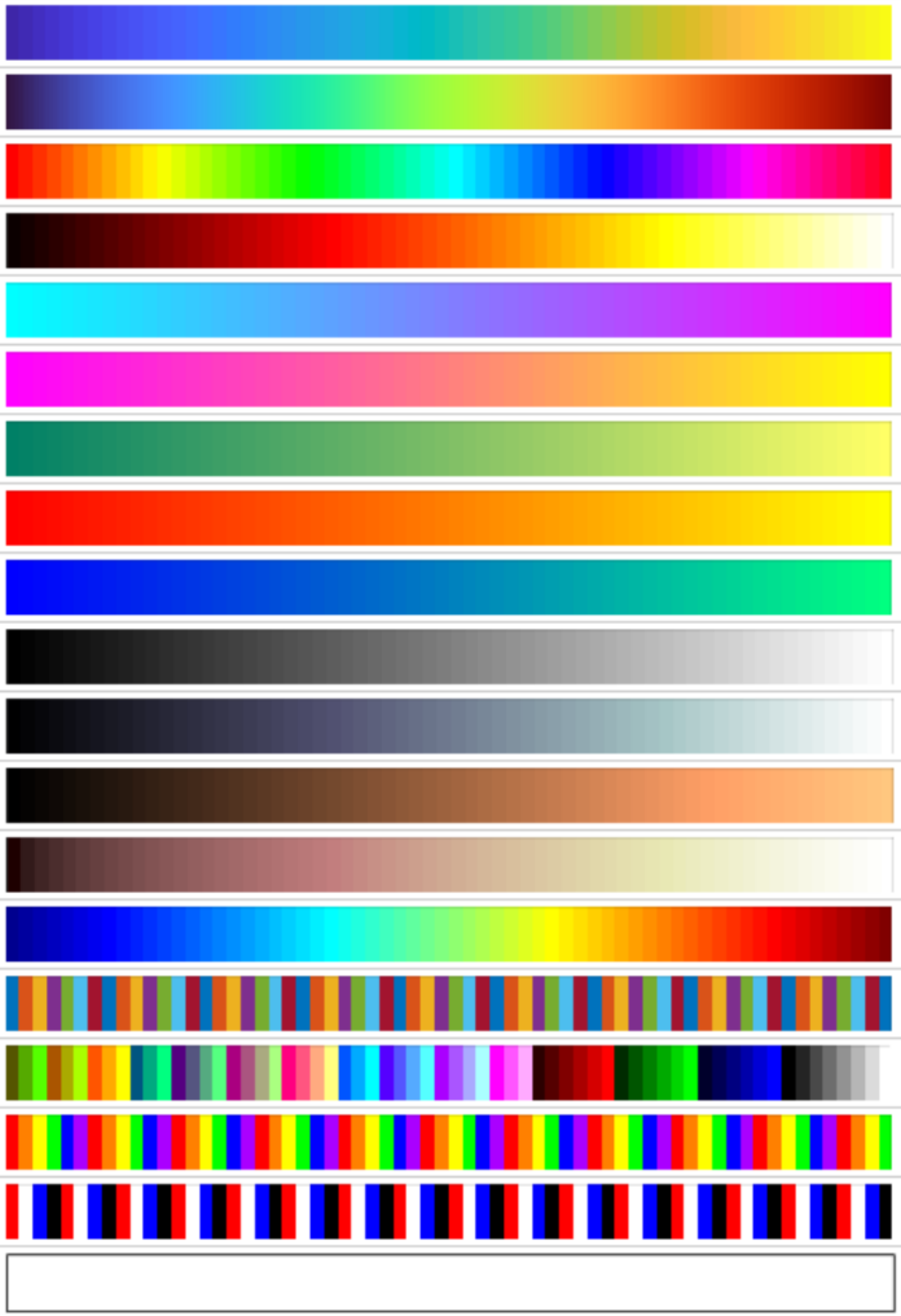
Common colors:

Color	RGB Triplet
yellow	[1 1 0]
magenta	[1 0 1]
cyan	[0 1 1]
red	[1 0 0]
green	[0 1 0]
blue	[0 0 1]
white	[1 1 1]
black	[0 0 0]

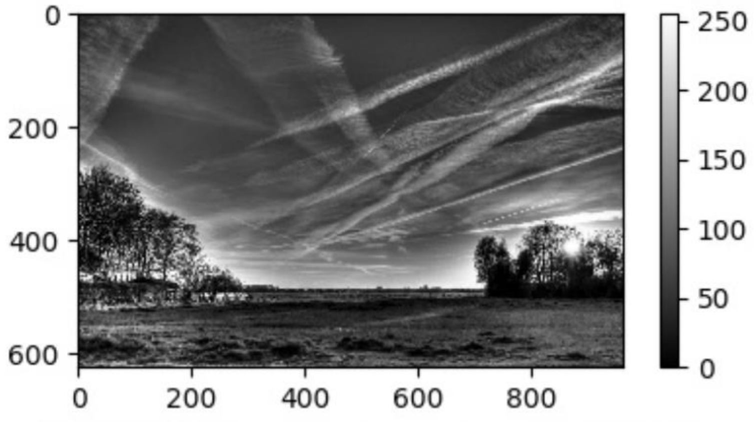
Color maps

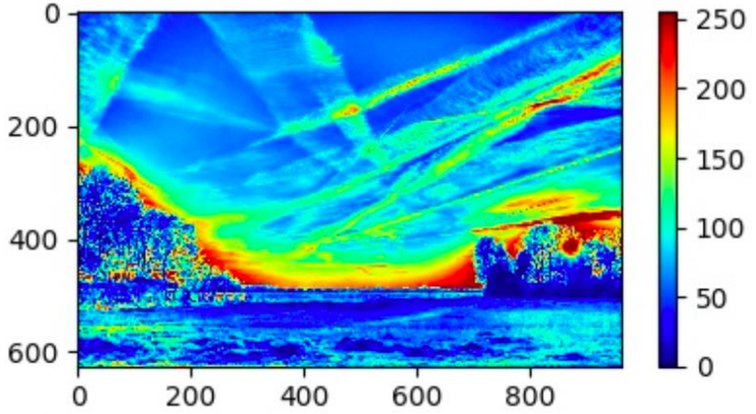
A color map (called a color table or a palette) is an array of colors used to map pixel data (represented as indexes into the color table) to the actual color values.

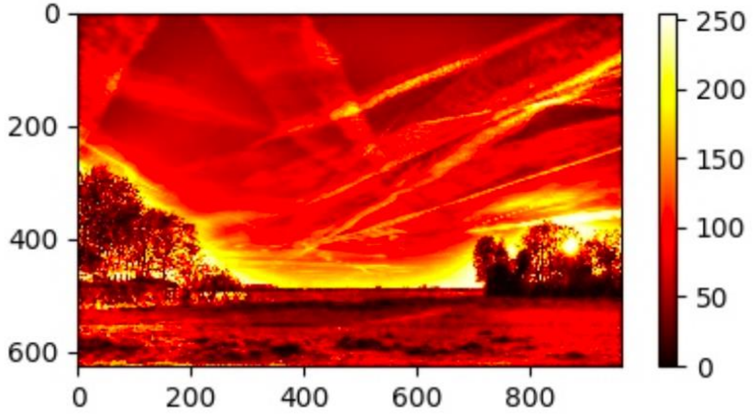
Colormap Name	Color Scale
parula	
turbo	
hsv	
hot	
cool	
spring	
summer	
autumn	
winter	
gray	
bone	
copper	
pink	
jet	
lines	
colorcube	
prism	
flag	
white	



Slicing the image into levels







Choosing Colormaps in Matplotlib

- Matplotlib has a number of built-in colormaps accessible via matplotlib.colormaps

- There are also external libraries that have many extra colormaps

- For help, see: https://matplotlib.org/stable/tutorials/colors/ colormaps.html