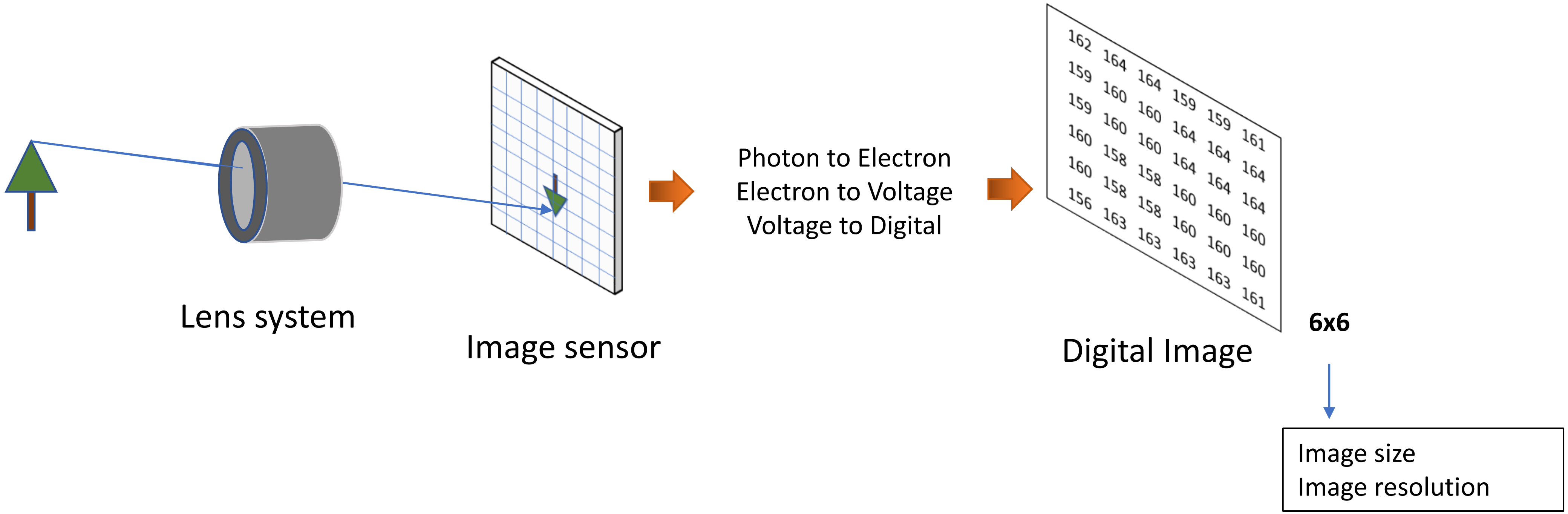
Image Understanding

Lecture 01: CS 472, CS 572

Digital Image

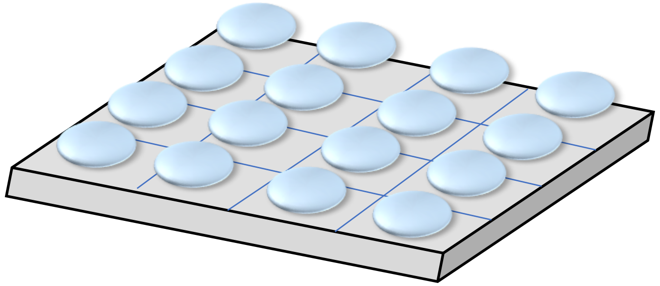


Modern days digital cameras use a lens system to project the light rays reflected from an object on the image sensor. The image sensor of a digital camera is a 2-dimensional (2D) array of tiny photosensitive sensors. Each of the tiny sensors is responsible to record the average light intensity in a small area on the image sensor known as a pixel value. A digital image is formed by a 2D array of pixel values. The process is shown in the above diagram.

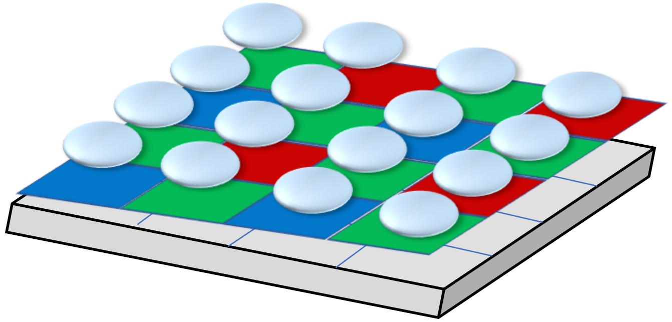
Digital Image

There are mainly two types of sensors that are widely used: CCD (Charged Coupled Device), CMOS (Complementary Metal Oxide Semiconductor).For both of the sensor types, the sensor is divided into many small regions call photosites. Each photosite is responsible to measure the value of a pixel. When light incidents on a photosite, it generates electron flow which is measured and converted to a digital pixel value.

For visible light sensing, there can be two types of sensors, mono and color. Mono sensors are not sensitive to color of light, and therefore can only record a grayscale value for each pixel. On the other hand, a color sensor uses 4 local photosites to record a pixel value. Two of the photosites are sensitive to Green light, one is sensitive to Red light, and one is sensitive to Blue light. Therefore, each pixel records three values R, G, and B. This helps to render color images.



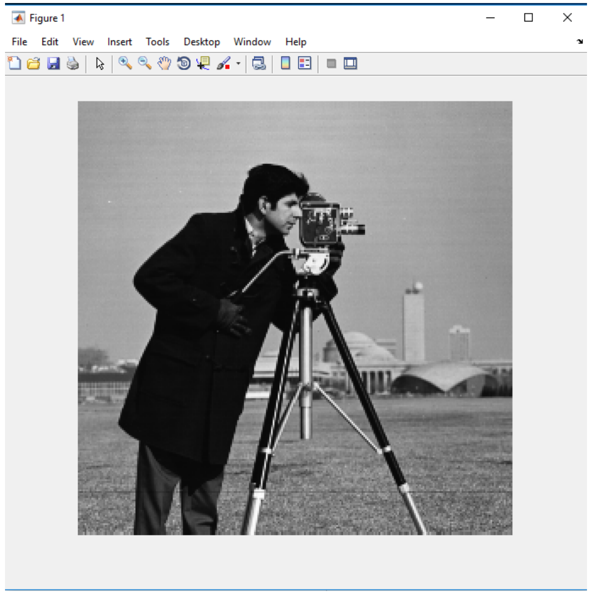
mono sensor



color sensor

Operations on Image

```
img = imread('cameraman.jpg');
figure(1), imshow(img);
```



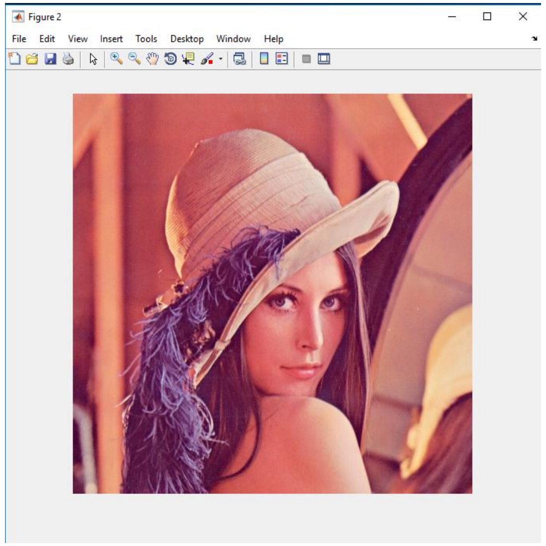

```
img(30:35, 30:35)
```

162	164	164	159	159	161
159	160	160	164	164	164
159	160	160	164	164	164
160	158	158	160	160	160
160	158	158	160	160	160
156	163	163	163	163	161

Operations on Image

Color image:

```
img = imread('lena_color.jpg');
figure(1), imshow(img);
```




```
img(30:35, 30:35, :)
```

162	164	164	159	159	161
				164	164
				164	164
				160	160
				160	160
				163	161

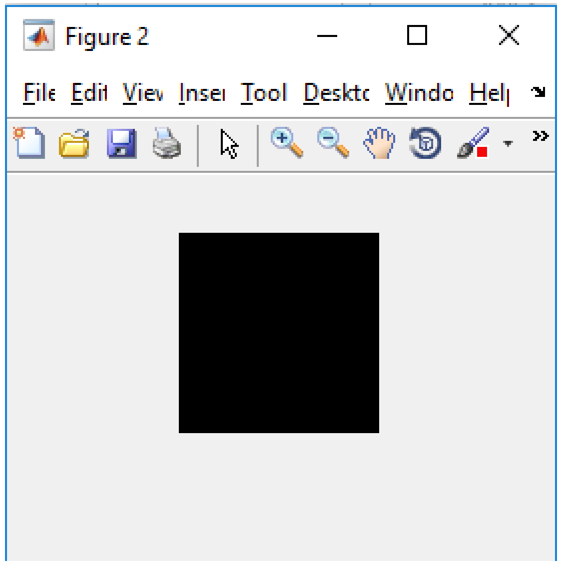
162	164	164	159	159	161
				164	164
				164	164
				160	160
				160	160
				163	161

162	164	164	159	159	161
159	160	160	164	164	164
159	160	160	164	164	164
160	158	158	160	160	160
160	158	158	160	160	160
156	163	163	163	163	161

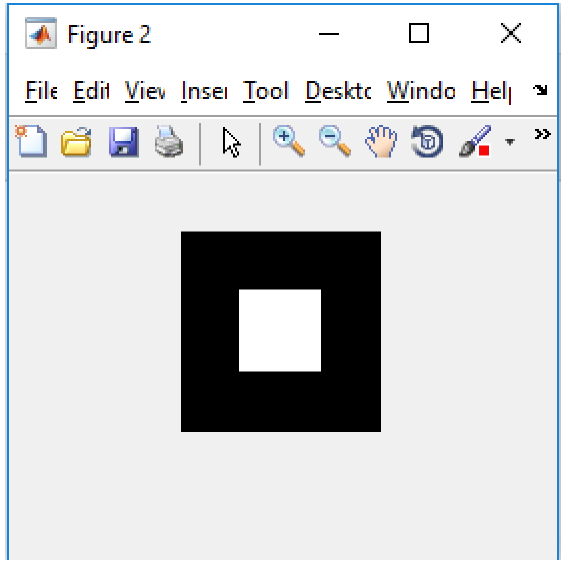
Operations on Image

My image:

```
myImg = zeros(100, 100);
figure(2), imshow(myImg);
```



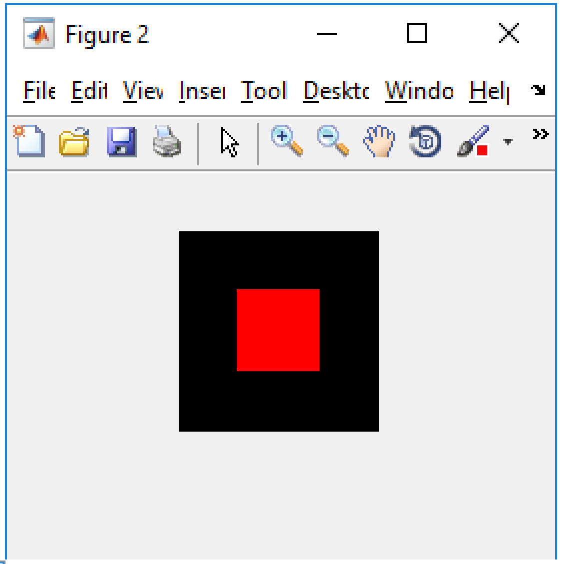

```
myImg(30:70, 30:70) = 255;
figure(2), imshow(myImg);
```



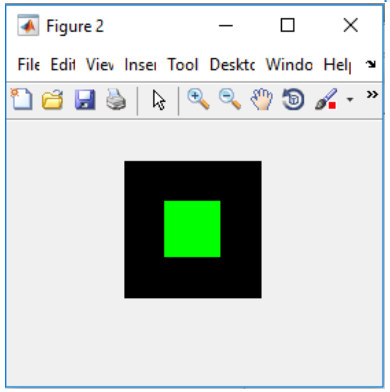
Operations on image

My color image:

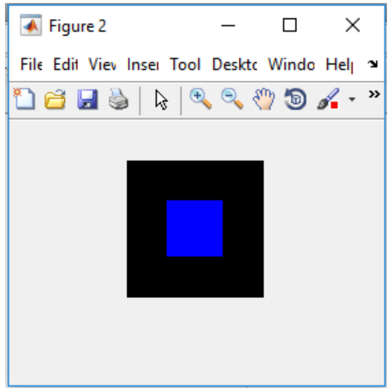
```
myImgColor = zeros(100, 100, 3);
myImgColor(30:70, 30:70, 1) = 255;
figure(2), imshow(myImgColor);
```



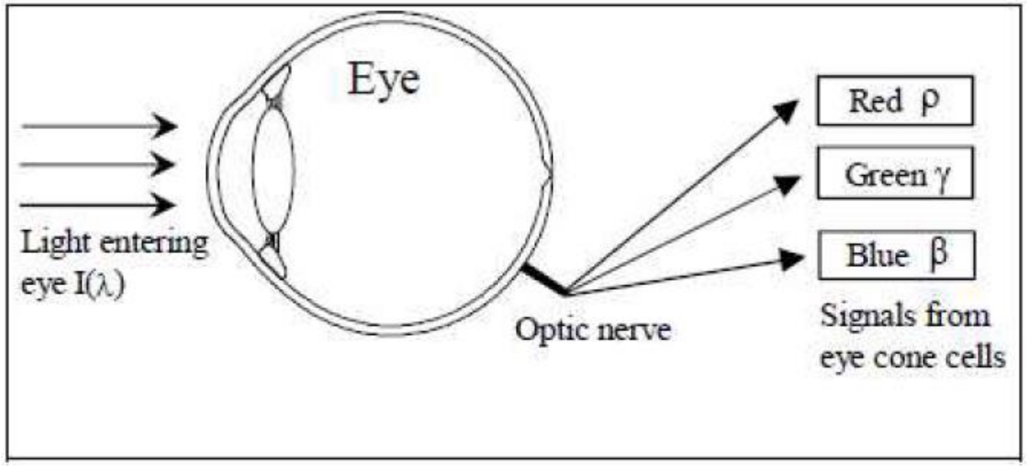

```
myImgColor = zeros(100, 100, 3);
myImgColor(30:70, 30:70, 2) = 255;
figure(2), imshow(myImgColor);
```

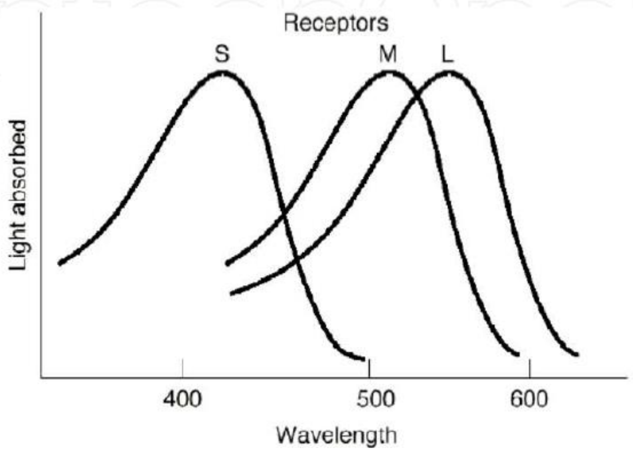



```
myImgColor = zeros(100, 100, 3);
myImgColor(30:70, 30:70, 3) = 255;
figure(2), imshow(myImgColor);
```



What is Color?





Human eyes have three different color receptors

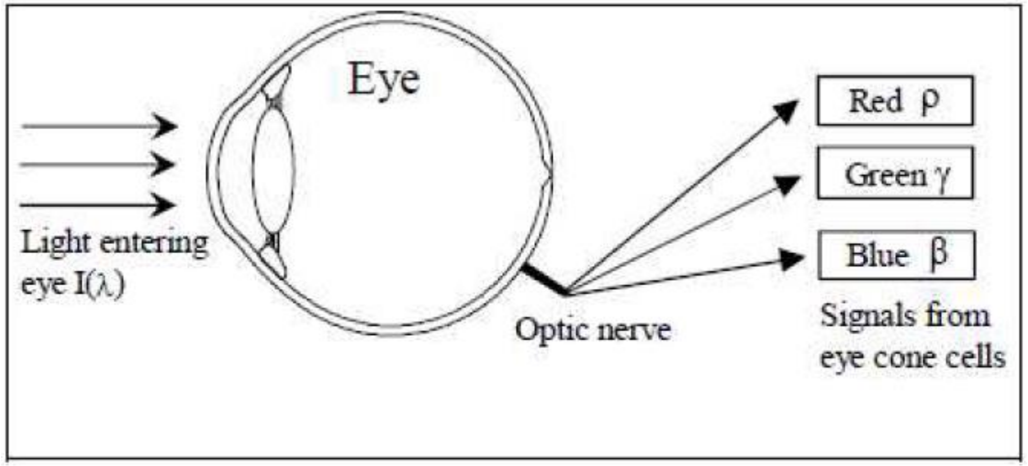
- S (Short): most receptive at 419nm: equivalent to **BLUE**
- M (Medium): most receptive at 531nm: equivalent to **GREEN**
- L (Long): most receptive at 558nm: : equivalent to **RED**

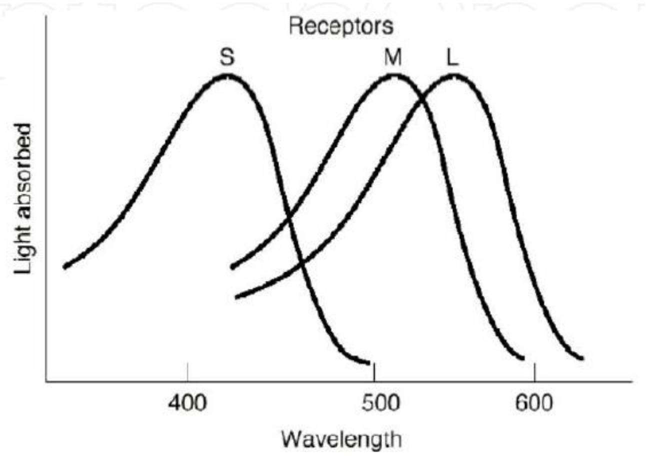
As shown in the plots in the right, each receptor has a different receptivity vs. light wavelength relationship. Each of them is most receptive at a particular wavelength and less receptive at other wavelengths.

When light from a source incident on an eye, each receptor generates a different signal. Color is the sensation created by the brain combining the signals generated by three different types of receptors.

“**Understanding Color Image Processing by Machine Vision for Biological Materials**”, Ayman H. Amer Eissa and Ayman A. Abdel Khalik

What is Color?





"Trichromatic theory" of color vision

- Human color perception can be formed by mixing blue, green and red light in different proportions

Trichromatic theory states that the magnitudes of three stimuli (from three types of receptors) determine the perception of color and not the detailed distribution of light energy across the visible spectrum. If these stimuli are the same for two different light distributions, then the color appearance of the lights will be the same, irrespective of their spectrum. Furthermore, all color sensations can be created by only Red, Green, and Blue lights with different combinations of intensity values.

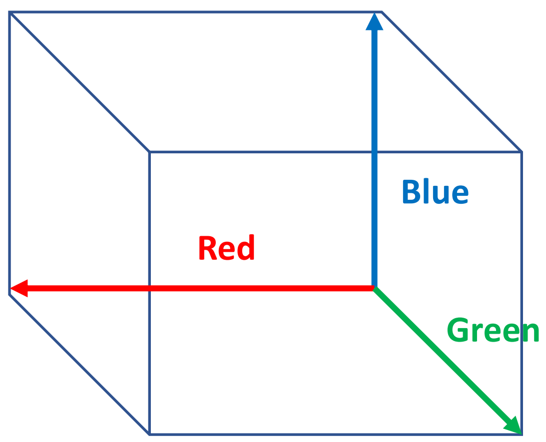
"**Understanding Color Image Processing by Machine Vision for Biological Materials**", Ayman H. Amer Eissa and Ayman A. Abdel Khalik

Color Space : R G B

A color model is a method to define each color value by a set of numbers that is easy for a computer to store, manipulate, and visualize.

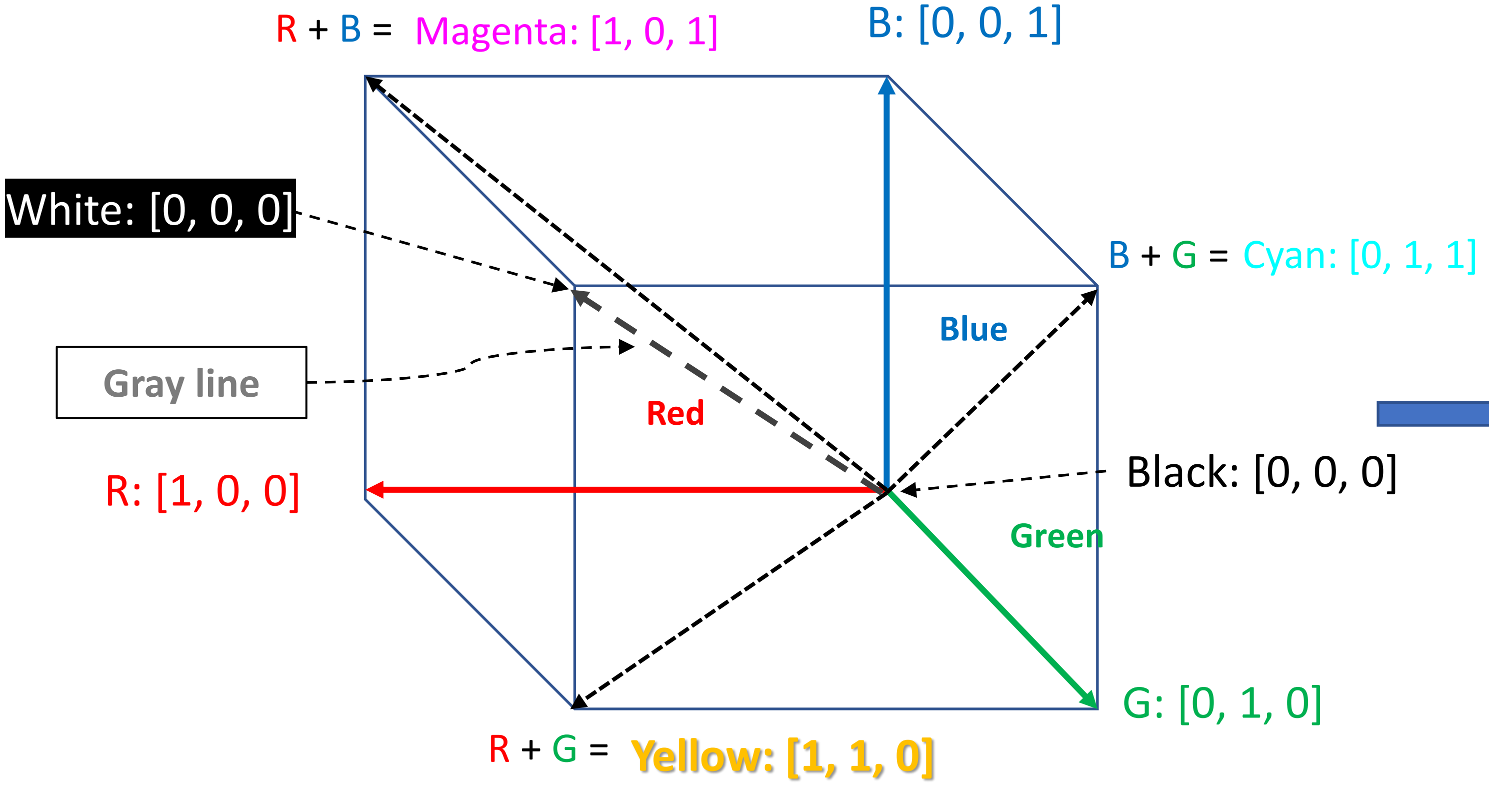
Inspired by trichromatic theory, RGB (‘Red’, ‘Green’, and ‘Blue’) color model defines color by a positive combination of Red, Green, and Blue values. These three colors are called primary colors that can be combined in appropriate proportions to create any color in the RGB space.

RGB color space can be imagined as a 3-dimensional Cartesian coordinate system. Each point in the space is defined by a different combination of Red, Green, and Blue values.

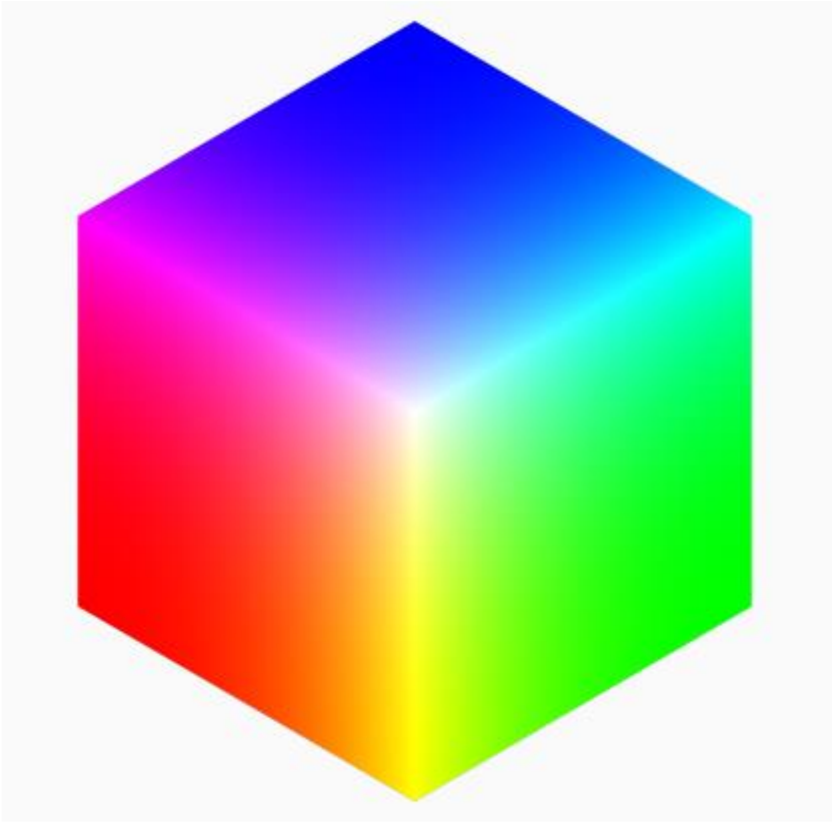


Color cube

Color Space : R G B



Color cube

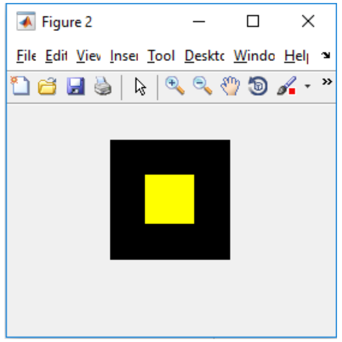


Some example color values are shown in the diagram on the left. The right color cube is showing how color varies on the surface of the color space.

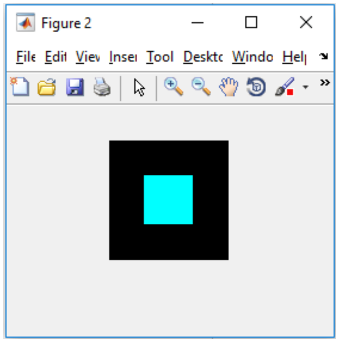
Color Space : R G B

RGB color space example:

```
myImgColor = zeros(100, 100, 3);
myImgColor(30:70, 30:70, 1:2) = 255;
figure(2), imshow(myImgColor);
```




```
myImgColor = zeros(100, 100, 3);
myImgColor(30:70, 30:70, 2:3) = 255;
figure(2), imshow(myImgColor);
```




```
myImgColor = zeros(100, 100, 3);
myImgColor(30:70, 30:70, 1) = 255;
myImgColor(30:70, 30:70, 3) = 255;
figure(2), imshow(myImgColor);
```