MANU2480

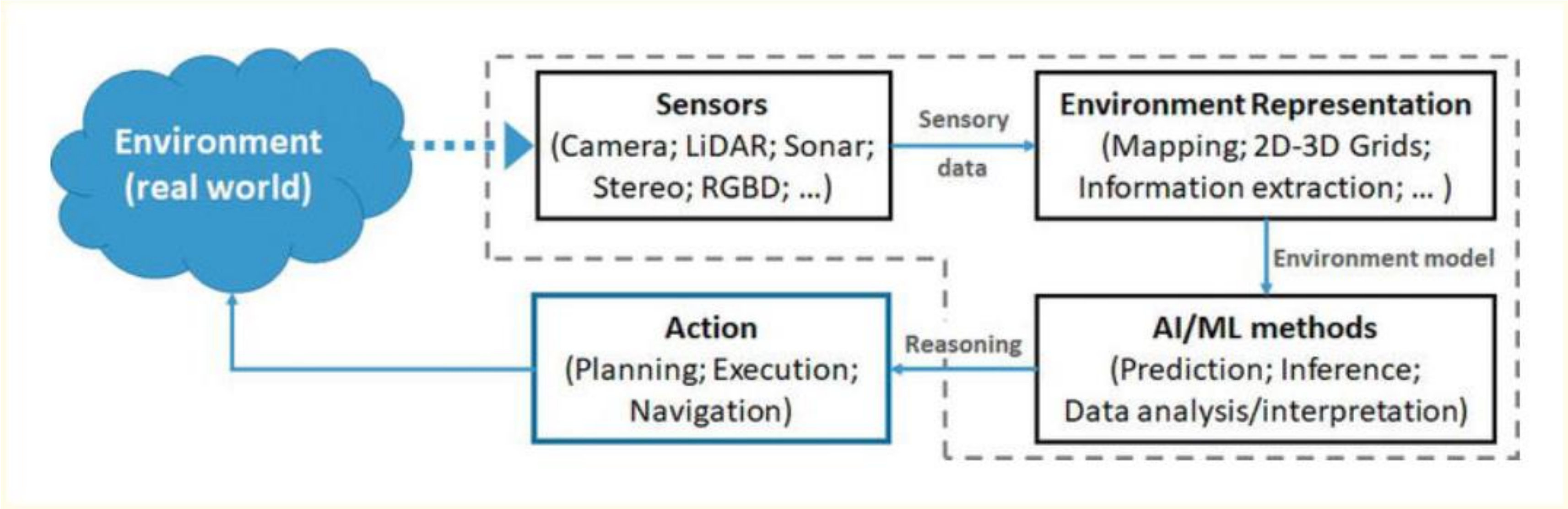
AUTONOMOUS SYSTEM

ROBOTIC PERCEPTION – Part 1

School of Science, Engineering and Technology, RMIT Vietnam

Problem Statement

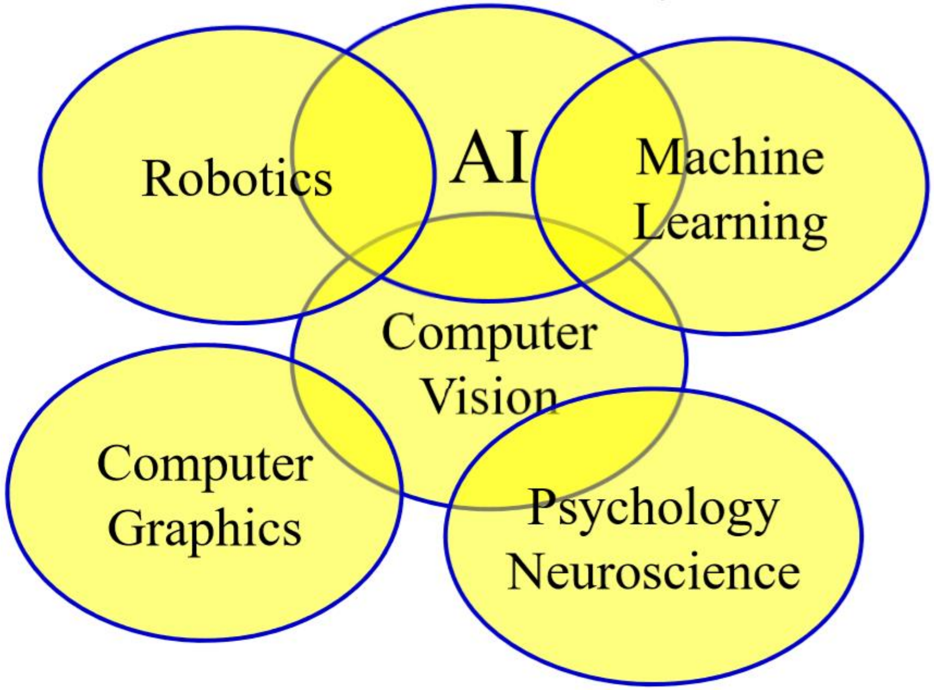
Robotic Perception with Computer Vision



Source: https://www.intechopen.com/chapters/62978

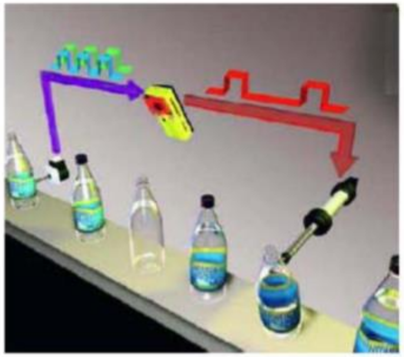
Computer Vision

Providing machines with sensors that mimic the capabilities of the human vision system.



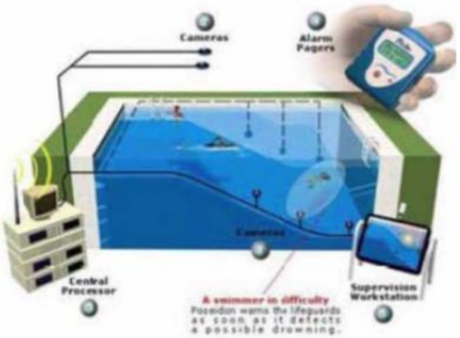
Computer graphics is a sub-field of computer science which studies methods for digitally synthesizing and manipulating visual content (Images, Videos, etc.)

Application of Computer Vision



Factory inspection

Reading license plates, checks, ZIP codes



Monitoring for safety (Poseidon)

Surveillance

Autonomous driving, robot navigation

Driver assistance (collision warning, lane departure warning, rear object detection)

Application of Computer Vision

Assistive technologies

Entertainment
(Sony EyeToy)

Movie special effects

Digital cameras (face detection for setting focus, exposure)

Visual search
http://www.kooaba.com/

Problem Statement

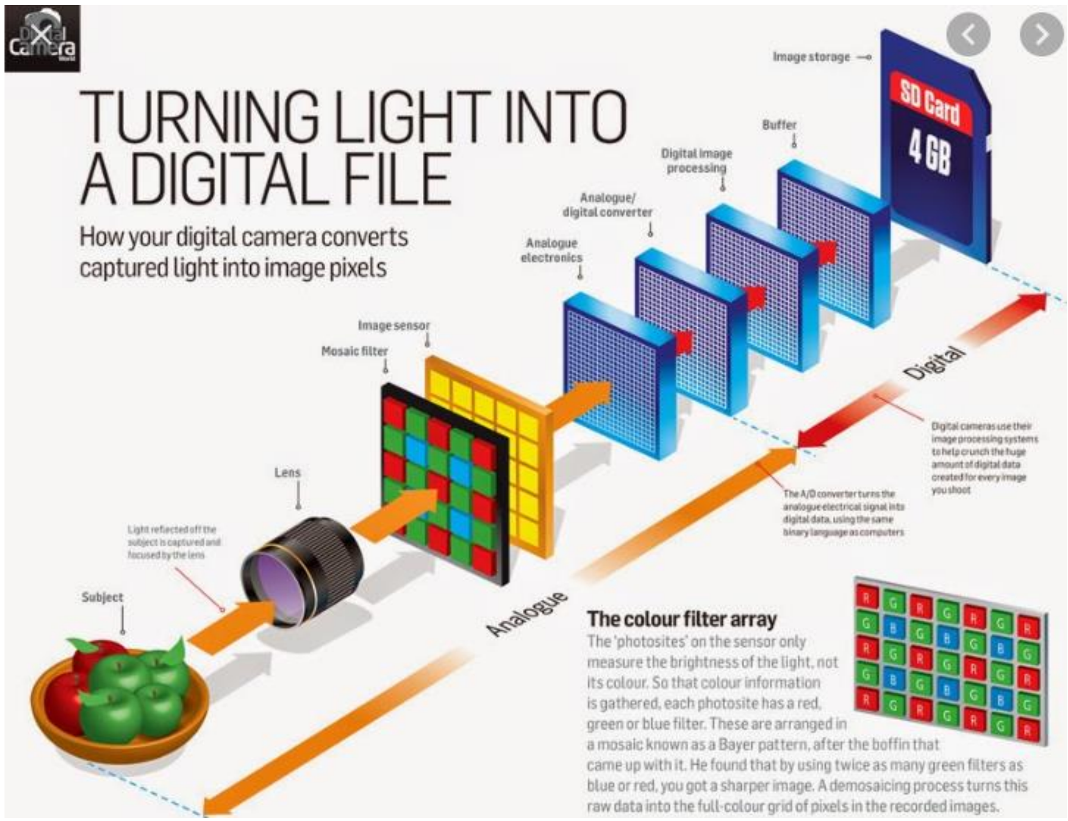
How is a digital image captured and processed?

Digital Camera

- Several nice properties of the **camera**, computational capabilities of modern **computers**, and advances in the development of **algorithms** make the use of a camera an extremely appealing sensor for solving problems in robotics.
- A camera can be used to **detect**, **identify**, and **track** observed objects in the camera's field of view, since images are projections of the 3D objects in the environment.

Digital Camera

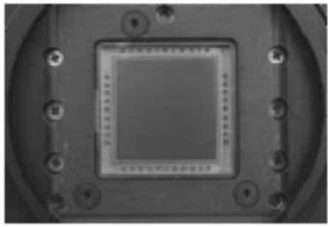
The pathway that a reflected light from an object becomes a digital image file.



http://timberwolfphotolounge.blogspot.com/2015/04/camera-sensors.html

Digital Camera – CCD Chip

- CCD = Charged Coupled Device
- The most popular basic ingredient of robotic vision systems today.



- The CCD chip:
  - an array of light-sensitive picture elements
  - each element = one pixel,
  - usually with between 20,000 and several million pixels total
  - each pixel = a light-sensitive capacitor
  - First, the capacitors of all pixels are fully charged.
  - Image is captured → The relative charges of all pixels is proportional to the light photons it receives.

Digital Image

- The **digital image** is a 2D discrete signal that is represented with a matrix of quantized numbers that represent either the presence or absence of light, light intensity, color, or some other quantity.
- In digital imaging, a pixel, or picture element is a physical point in an image and it is the smallest controllable element of a picture represented on the screen.

Digital Image – Colour Image

- **Color in a digital image** is normally represented with three color components: red, green, and blue; this is known as the RGB color model, [Red Value, Green Value, Blue Value].
- The **values from the RGB color space** usually given in the range (0, 255) or (0, 2^8). Red is [255,0,0], Green is [0,255,0], Blue is [0,0,255].
- https://www.rapidtables.com/web/color/RGB_Color.html
- Two other color spaces that are seldom used in machine vision are **HSL** (hue-saturation-lightness) and **HSV** (hue-saturation-value).

Digital Image – Colour Image

49	55	56	57	52	53
58	60	60	58	55	57
58	58	54	53	55	56
83	78	72	69	68	69
88	91	91	84	83	82
69	76	83	78	76	75
61	69	73	78	76	76

Red

64	76	82	79	78	78
93	93	91	91	86	86
88	82	88	90	88	89
125	119	113	108	111	110
137	136	132	128	126	120
105	108	114	114	118	113
96	103	112	108	111	107

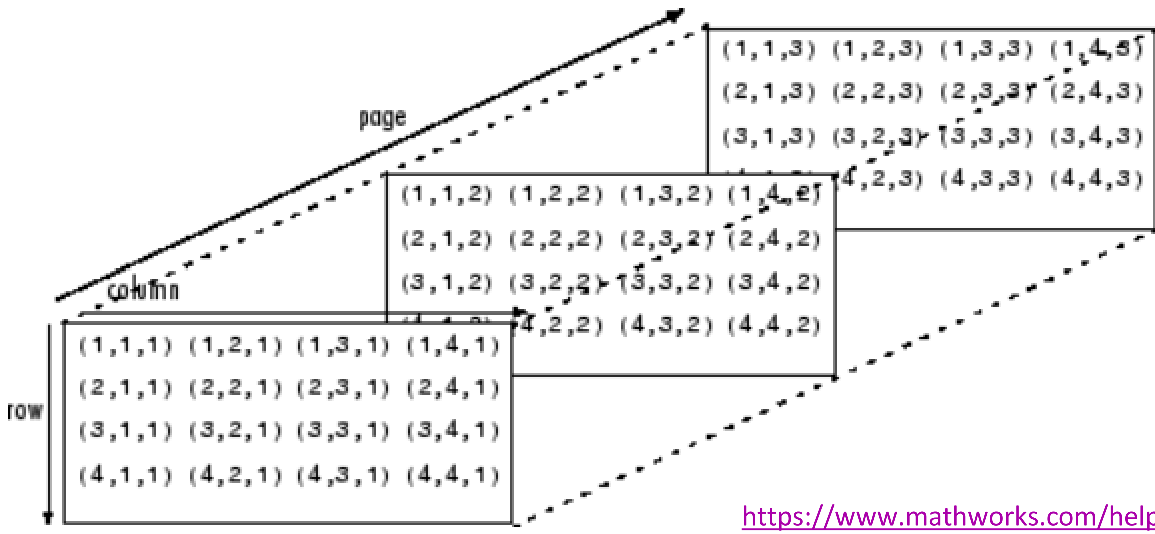
Green

66	80	77	80	87	77
81	93	96	99	86	85
83	83	91	94	92	88
135	128	126	112	107	106
141	129	129	117	115	101
95	99	109	108	112	109
84	93	107	101	105	102

Blue

Digital Image – Colour Image

The numerical values of the pixels are presented in a matrix of 3 array.

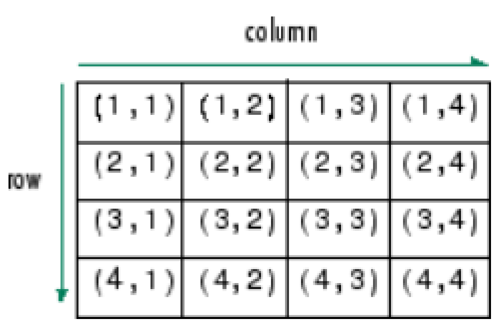


https://www.mathworks.com/help/matlab/math/multidimensional-arrays.html

```
>> M= [ 1 2 3; 4 5 6; 7 8 9]

M =

     1     2     3
     4     5     6
     7     8     9
```



Digital Image – Colour Image

- Origin of the coordinates frame = pixel location (1,1) = the pixel on the top-left corner.
- Note the meaning of X and Y coordinates: X is horizontal and Y is vertical.
- Each RGB colour record is an uint8 (meaning 256 levels of Red, 256 levels of Green and 256 levels blue).
- Total number of colours: 256^3= 16,777,216 colours!!

Digital Image – RGB Colour Image

- Let us consider a colour image.

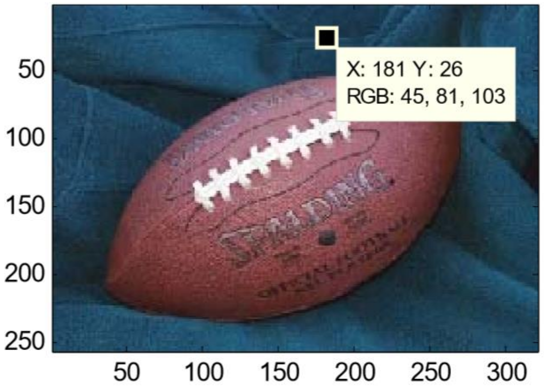
- Imagine an image saved in an array called **I**. For example:

I(2,4,1) = show the RED value of the pixel which has location (column 2 and row 4).

I(2,4,2) = show the GREEN value of the pixel which has location (column 2 and row 4).

I(2,4,3) = show the BLUE value of the pixel which has location (column 2 and row 4).

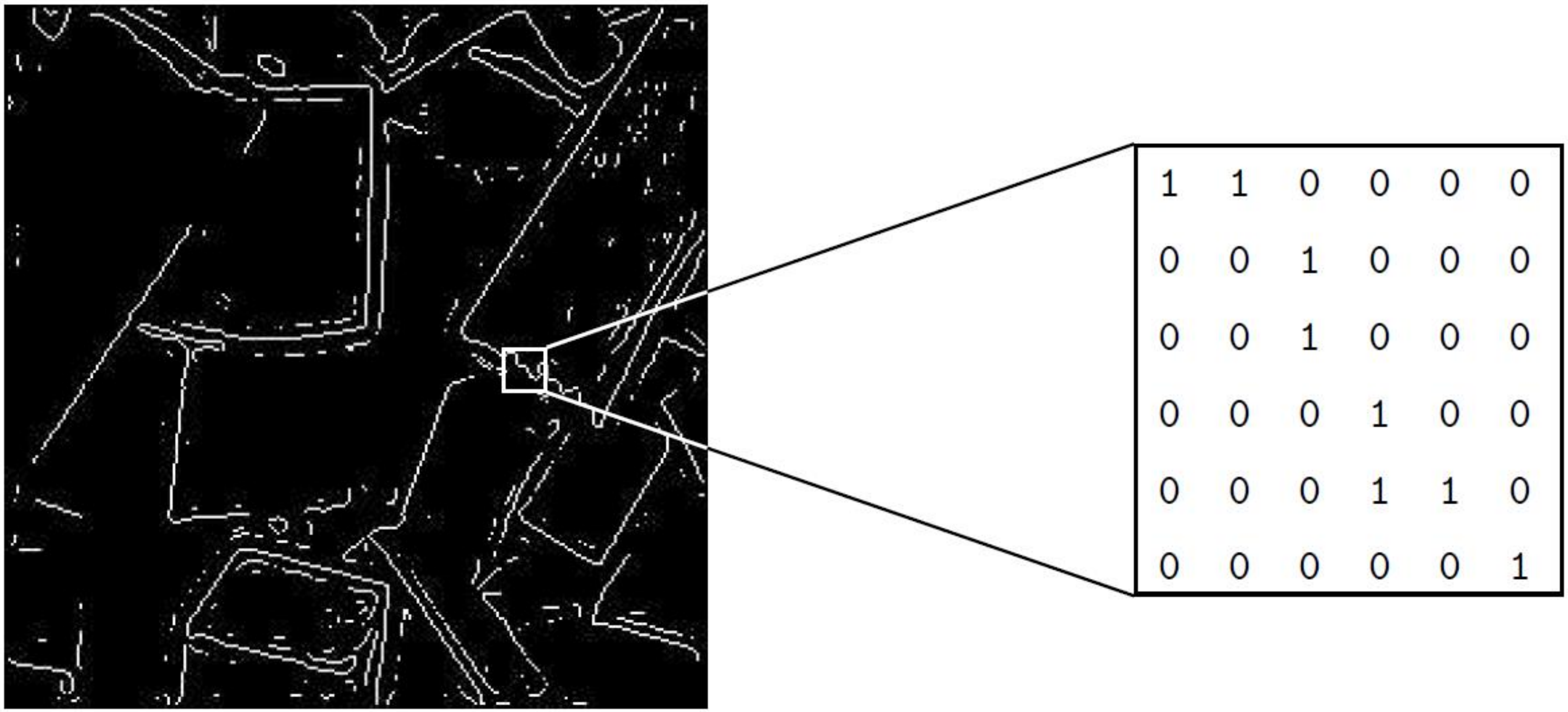
I(:,:,1) = a matrix containing the RED parts of the pixel colour.




```
>> Im(26,181,1)
ans =
45
>> Im(26,181,2)
ans =
81
```

```
>> Im(26,181,3)
ans =
103
```

Digital Image – Binary Image



Digital Image – Greyscale Image

230	229	232	234	235	232	148
237	236	236	234	233	234	152
255	255	255	251	230	236	161
99	90	67	37	94	247	130
222	152	255	129	129	246	132
154	199	255	150	189	241	147
216	132	162	163	170	239	122

Digital Image – Greyscale Image

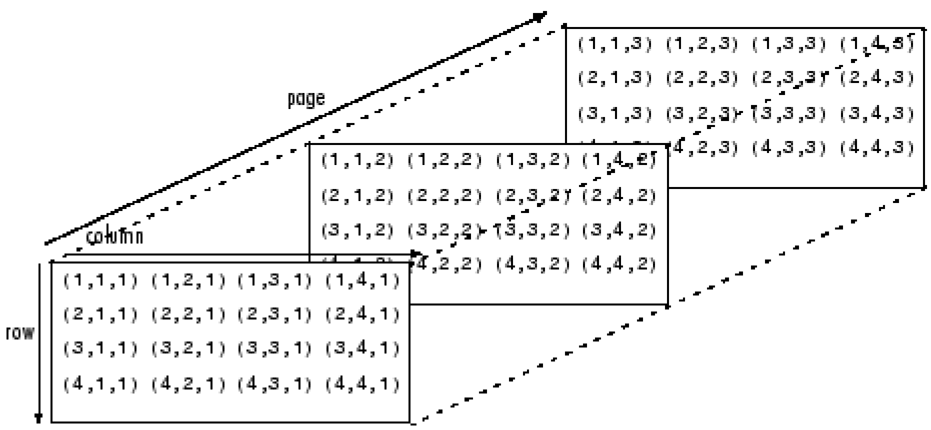
- In digital photography, a grayscale is one in which the value of each pixel is a single sample representing only an amount of light.
- A digital image in Grayscale represented by a 1 – array matrix.
- A Grayscale image is not a black-white image.

Digital Image – Greyscale Image

- The value of a pixel in a (x,y) location is calculated as:

$$Y = a \times R + b \times G + c \times B$$

$$Y = 0.2126 \times R + 0.7152 \times G + 0.0722 \times B$$

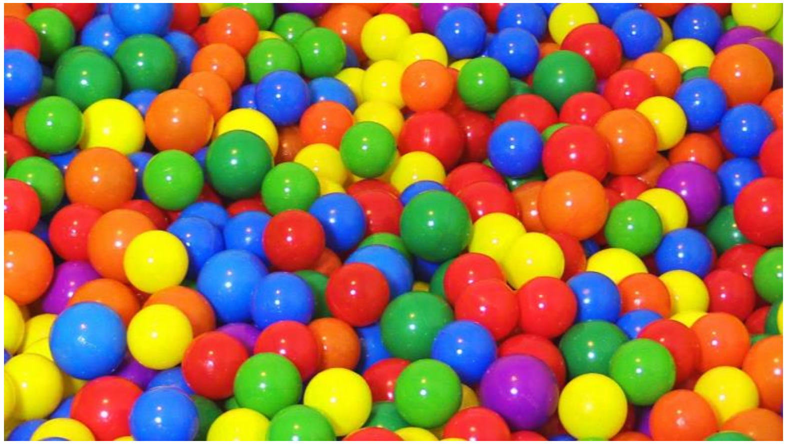


column

row				
	(1,1)	(1,2)	(1,3)	(1,4)
	(2,1)	(2,2)	(2,3)	(2,4)
	(3,1)	(3,2)	(3,3)	(3,4)
	(4,1)	(4,2)	(4,3)	(4,4)

Problem Statement

How could we detect a specific colour in a digital image?



Approach

- We need to estimate the range of RGB values that representing the colour we need to identify in the image.
- These ranges could be defined as: [Rmin Rmax], [Gmin Gmax], [Bmin Bmax].
- We then test the RGB value of each pixel in the way that:

  - Red level <= Rmax **and** Red level>=Rmin **and**
  - Green level <= Gmax **and** Green level>=Gmin **and**
  - Blue level <= Bmax **and** Blue level>=Bmin.

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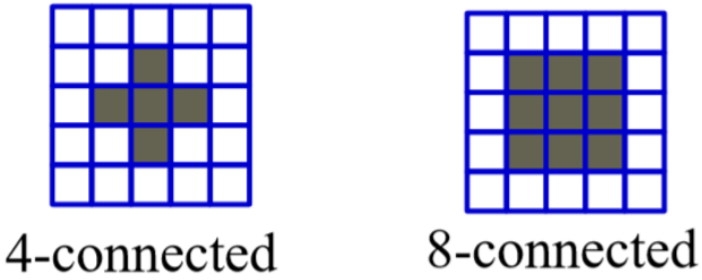
Approach

- The outcome will be a binary image, a matrix of 1's and 0's.
- We then integrate this matrix with the matrix representing the original colour image, we finally identify that expected colour.
- **Extra Work**: We could also perform the Segmentation technique to connect to true value pixel in the binary image to form a continuous region. There are 2 common types of connection as:



MATLAB DEMONSTRATION

- Open **Color Thresholder App** and Import one sample image.
- Select the RGB.
- Change the range of Red, Green, and Blue values as needed.
- Export the function.
- Apply the function with other images.

Reference

- *MATHWORKS official tutorial.*
- *Lecture slides from RMIT Melbourne Autonomous System course, delivered by Prof Reza Hoseinnezhad.*
- *Wheeled Mobile Robotics. From Fundamentals Towards Autonomous Systems.*
- *Alasdair McAndrew, An introduction to Image Processing with MATLAB.*

Thank you for your attendance :D

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