0. Introduction

What is Computer vision?

- computer vision is the use of seen as a major input that control actions.
- computer vision is the science of using image processing to make it useful, extract data or learn something from image.

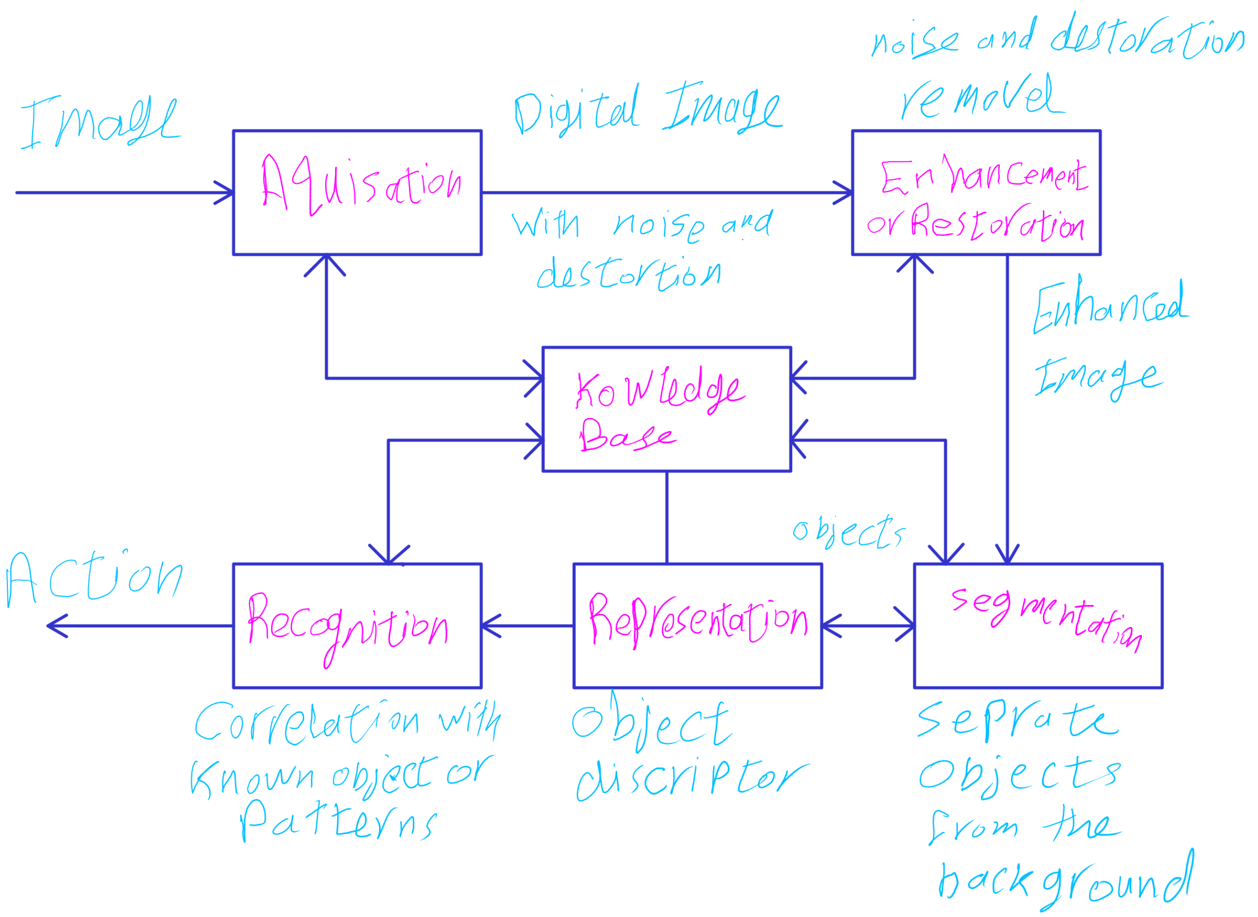
What is Image Processing?

- Image processing means to perform objective operations on the images, to extract data form it.

Sample Computer vision Systems:

- Smart bombs / Smart missiles
- Security systems (face recognition, finger prints)
- Material analysis
- Machine Control
- Medical (X-ray, Sonar, Radiation and analysis)
- Auto-Drive
- Robotics
- Motion Detection

Image processing-based system / computer vision system structure and stages



The Basic Elements of computer vision system

- Acquisition
- Enhancement
- Restoration
- Segmentation
- Description
- Feature extraction
- Detection
- Recognition
- Encoding/Decoding

Acquisition

is the process of converting a scene to a digital image through **Sampling** and **Quantization**

Sampling

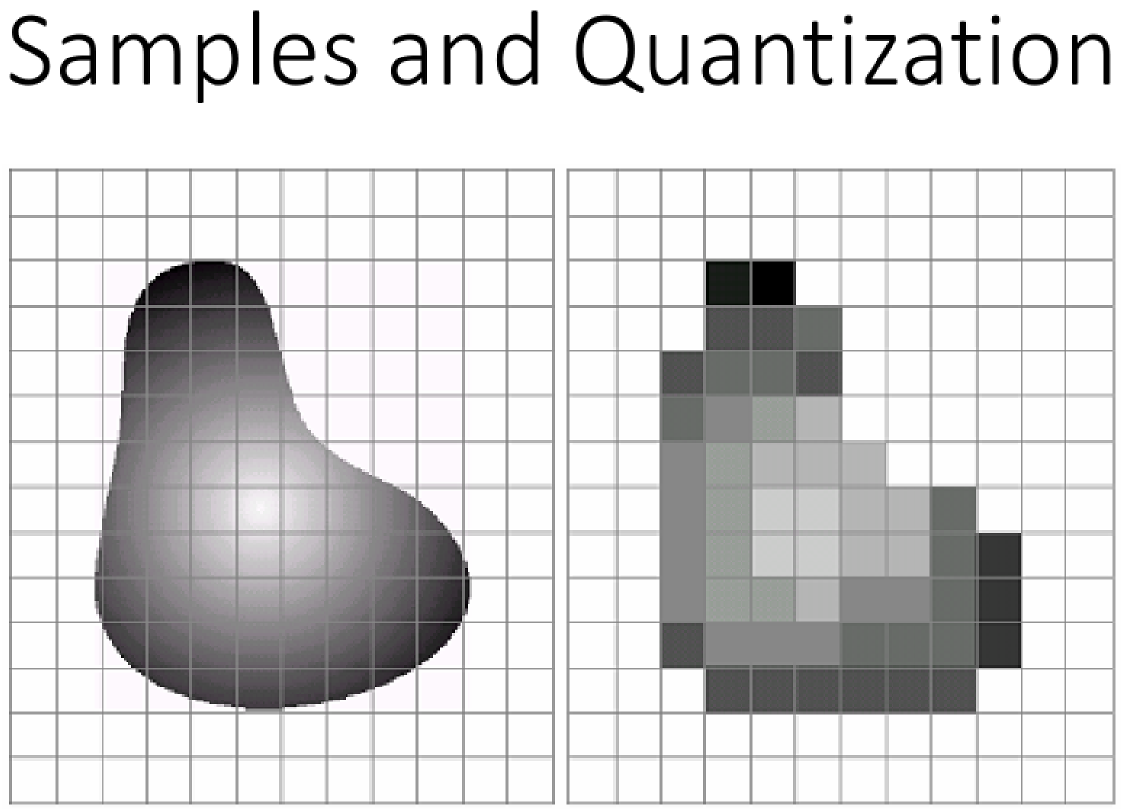
- is Dividing the image into samples `N in x` and `M in y` as result we will have `MxN` picture elements which is called pixels

Quantization

- is the process of converting analog image to digital image grouping a set of grays/colors into gray value or a specific color as result will have matrix at dimension `MxN`.
- Number of possible colors/grays are 2^q
- #note Image resolution is `MxNxq`

False contouring / Coarse sampling

- Insufficient number of intensity levels in smooth areas of digital image



Fine sampling	Coarse sampling
Good image	poor image
Precise description	false contouring
High memory requirements	low memory requirements
need a lot of processing power	low processing power
Transmit require high bandwidth	low bandwidth sufficient

Image resolution

- refers to the number of pixels in an image
- identified by the width and height of the image and number of colors in an image #note `R = MxNxq`

Digital image

- is an Image matrix which is finite matrix of integer values or 3 image matrices of color images

Image Matrix

if max gray level	130 --> Dark Image	255 --> no meaning	
if min gray level	170 --> bright	0 --> no meaning	
(max & min)	(100, 150) low contrast	(0, 255) no meaning	
Average	50 Dark	200 Bright	127 no meaning
stander deviation	big --> high contrast	low --> low contrast	

Histogram :

count the number of occurrences per gray/color/color component value within the image matrix/matrices.

Importance applications of histogram

- Analysis of image, image brightness
- using histogram to equalize an image

#Example Calculate the Following for the following Matrix: Find histogram

$$\begin{pmatrix} 5 & 5 & 4 & 5 \\ 10 & 20 & 5 & 4 \\ 10 & 20 & 5 & 10 \\ 20 & 4 & 5 & 100 \end{pmatrix}$$

#Answer

Grey Value	Count
4	3
5	6
10	3
20	3
100	1
Total count	16

Neighboring

Relation between pixels in some way.

Types of Neighboring :

- four neighboring

$$N_4(f(x,y)) = \{f(x-1,y), f(x+1,y), f(x,y-1), f(x,y+1)\}$$

	N_4	
N_4		N_4
	N_4	

- diagonal neighboring

$$N_D(f(x,y)) = \{f(x-1,y-1), f(x-1,y+1), f(x+1,y-1), f(x+1,y+1)\}$$

N_D		N_D
N_D		N_D

- Eight neighboring

$$N_8(f(x,y)) = \{N_D \cup N_4\}$$

N_8	N_8	N_8
N_8		N_8
N_8	N_8	N_8

Connectivity:

Pixels are considered connected if and only if

- They're neighbors
- $f(x_1,y_1), f(x_2,y_2) \in \xi$ ➔ Where ξ is the gray levels connectivity set $\xi = \{\ldots, \ldots, \ldots\}$

#Example : find connected pixels for $f(1,1)$ using N_4 and connectivity set $\xi = \{3,4,5,6,7,8,9,10\}$. Redo using N_D, N_8

2	4	7
6	5	100
13	120	9

#Answer

In case of, N_4 5 is connected with $f(1,0) = 4$ and $f(0,1) = 6$
In case of, N_D 5 is connected with $f(2,0) = 7$ and $f(2,2) = 9$
In case of, N_4 5 is connected with $f(1,0) = 4$, $f(0,1) = 6$, $f(2,0) = 7$ and $f(2,2) = 9$

Image Path

The Image path is a sequence of connected pixels starts at the first pixel $f(x_1, y_1)$ and ends at $f(x_n, y_n)$
#Example Find the Image Path Between $f(1,1)$ and $f(3,5)$

- Giving the connectivity set $\xi = \{3,4,5,6,7,8,9,10\}$

6	3	8	7	5	4	2
2	2	5	6	9	8	7
4	5	2	3	0	1	2
3	2	1	7	1	2	1
1	1	1	8	0	5	5
8	8	8	6	7	9	8
7	7	7	8	6	7	5

Connected Regions

A set of pixels of an image such that

- Between any two pixels inside there exist at lest on image path
- There exits no image path between any other pixel outside and an inside one
- #note An object within an image is a connected region
  Region: is the group of connected pixels.
  Labeling is a mean to find out the regions that exists within an image matrix
  #Example get the labels for the pixels satisfying the rule of $\xi = \{0 --> 20\}$ and neighbor N_8

100	100	100	110	120
110	90	5	7	100
5	100	6	110	120
7	100	100	120	10
110	5	70	110	8
111	110	7	10	120

finally, the found labels are $L1, L2$
$L1 = \{f(2,1), f(3,1), f(2,2)\}$
$L2 = \{f(0,2), f(0,3), f(1,4), f(2,5), f(3,5), f(4,3), f(f(4,4)\}$

Distance Metrics

1. Euclidian: $\Delta(f(x_1,y_1), f(x_2,y_2)) = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$
2. City Blocks: $\Delta(f(x_1,y_1), f(x_2,y_2)) = |x_1 - x_2| + |y_1 - y_2|$
3. Chess Board:$\Delta(f(x_1,y_1), f(x_2,y_2)) = \max(|x_1 - x_2|, |y_1 - y_2|)$