Machine Vision.

C.V	Embeddedvision	Machine Vision.
In a computer with a CPU	In an embedded machine where traditional CPU is not possible (Eg) cars).	→ In a fixed env, whereas in C V the background environment may chang

→ Machine vision camera
→ Higher FPS.
→ Ability to capture fast moving objects → Rolling
→ shutter → Global
→ Faster data transmission to processing unit.

* Shutter :- like a window to capture image.

→ Rolling shutter :- Captures one or two rows of the image is required at once.

→ Global shutter :- All the rows are exposed to the sensor at once.

Basic components of Machine Vision System:-

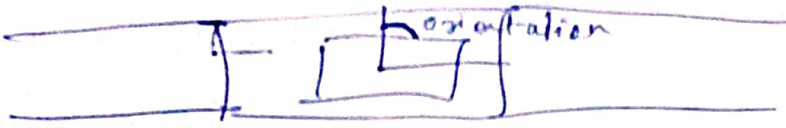
1. Image Aquisition system (camera, lens, light).
2. Processing Software
3. Machine & Automation (Eg - conveyer belt, laser sensors, etc.)

Four kinds of Application (Inspections) :-

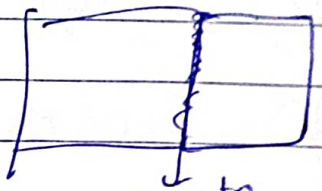
1. Locate
2. Inspect
3. Measure
4. Identify.

1. Locate:-

Consider an app. to pick up a box from a fast moving conveyer belt & put it into a container. Since, the orientations of different boxes on the belt may vary.



We need to get that orientation with the help of a camera placed at top and then pass that orientation to the robot to pick it up properly & put it in the box.
This is an example of locate or location identification.
Another example is weld seam Locaton



(2) Inspect:- All the applications which are finding the defects in products. Eg)- defect in apples, bottle necks, etc.

(3) Measure:- Used to measure size of various products, Eg) radius of a bearing, length of sides of boxes, etc.

(4) Identify:- 1D/2D barcodes, OCR/OCV, etc.
↓ where labels are involved.
↓ Optical character verification.
Optical charact. or cognition

★ Search for InGaAs.

★ key words:-

Basics of M.V
Four problems.
History.
Applications.
Need of M.V

Chap-2

About sampling and quantization.

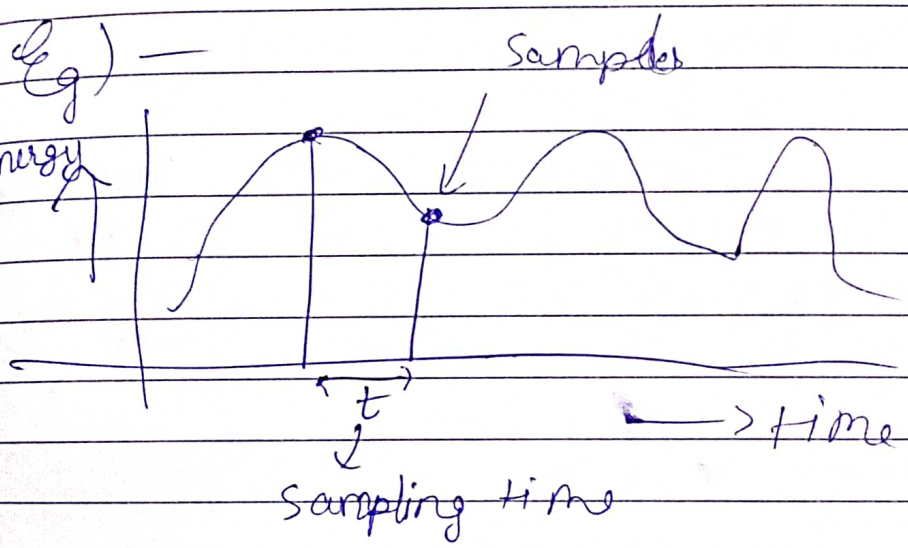
Image formation:-

- EM spectrum → 300-700 nm
- sensors → CMOS / CCD
- Principle → convert light → electrical energy
- Sampling and quantization
- Analog ~~vs~~ \ Digital circuit
- On board processing
- Store and communicate.

Sampling and Quantization:-

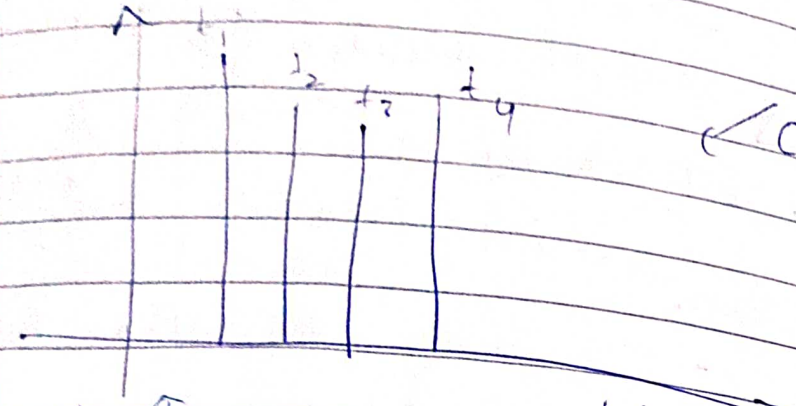
Sampling => Discretization

Eg) —

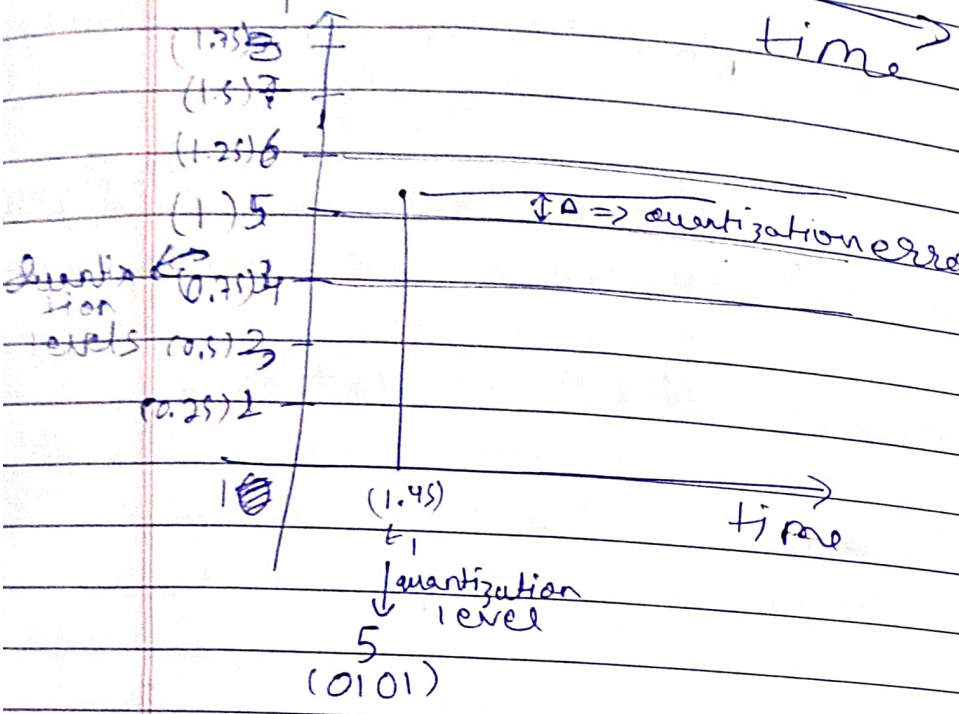


Quantization → Digitize.

(Eg) → $t_1 = 10.45$ V
$t_2 = 10.36$ V
$t_3 = 10.35$ V
$t_4 = 10.40$ V



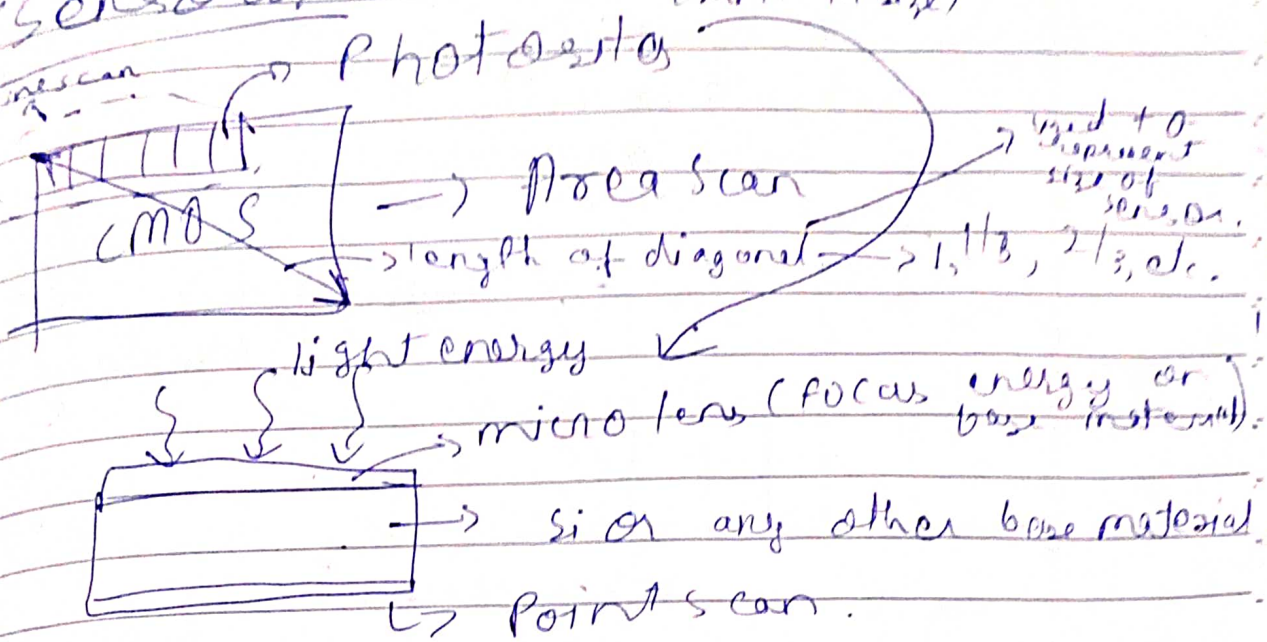
↙ after sampling



Range = 0-2 V
⇒ step size of quantization = $\frac{2-0}{8}$ = 0.25 V

→ Sampling & Quantization is done by ADC → Analog to Digital Converter.

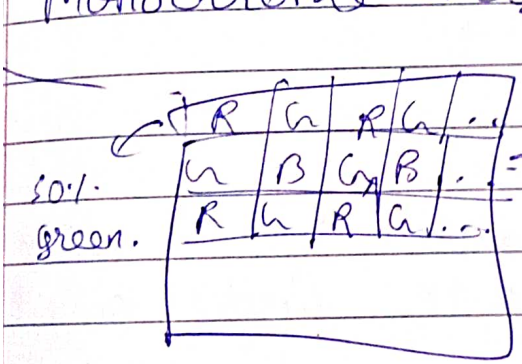
Sensors:



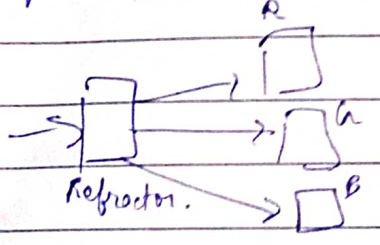
⇒ In Machine Vision we use BMP/PNG Image formats because we want precision.

CFA / Bayers Mosaic Patter:-

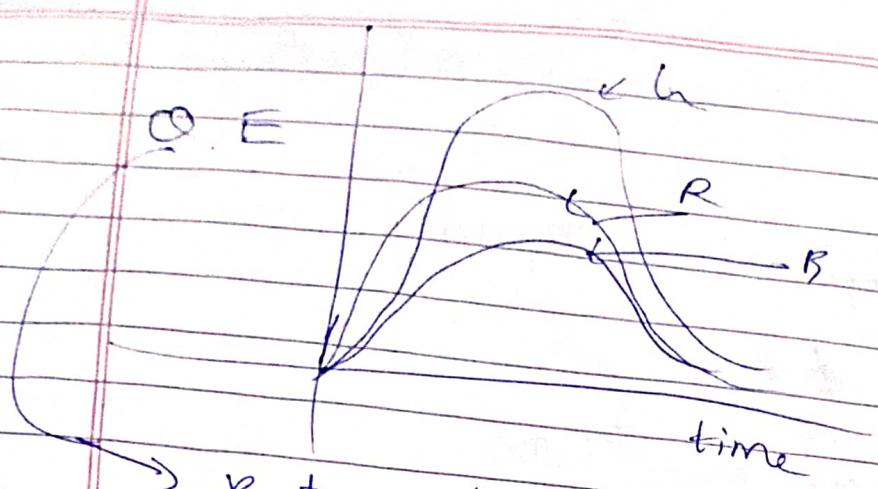
RGB → Images ⇒ 24 bit Images.
Monochrome Images ⇒ 8 bit Images.



Another ways.



Quantum efficiency (QE) for image sensors is the highest.
Humans also are most sensitive to Green color.



→ Rate of conversion of electrons to required energy levels.

How to generate 2/3 of unknown color values at photosites?

↓

Use interpolation.

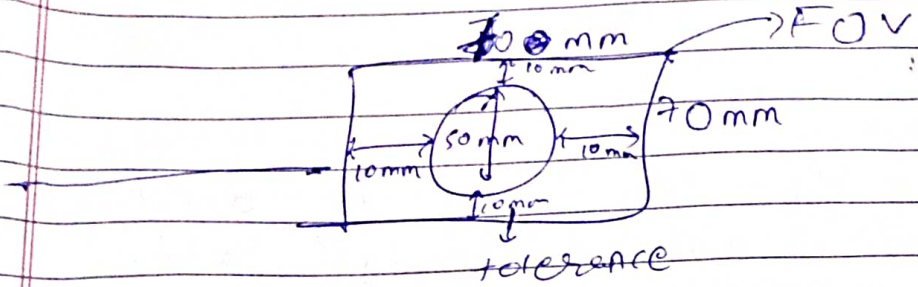
↓

should be invariate to edges & other objects presense

CCD	CMOS
(1) Difference in full-form.	→
(2) Earlier	→ Advanced chip tech
(3) Common circuitry → More interference ⇒ interference is for all so img. is generally better.	→ local circuitry ~~Less interference~~
(4)	→ less power consumption

☆ Image sensors, lens, lights.

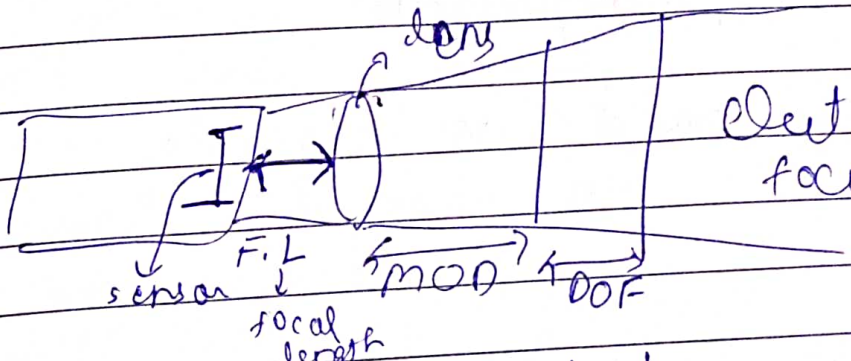
☆ FOV:- Capturing capacity.



FOV is generally rectangular.
FOV is generally defined in terms of millimeters or centimeters.

☆ DOF:- Depth of Field.

MOD:- Minimum Object distance.



Smaller focus → Wide angle

☆ Working distance (WD):- Where to keep camera for proper aquisition of. Distance btw Top surface of object & camera

Object Resolution:-

We need to set height settings & width will automatically be calculated based on the selected height.

& we choose
1600 x 1200 resolution
then.

$\therefore$ Object resolution $= \frac{1200}{70} \approx 17$ pixels/mm

→ For detection of minimum features of an object in machine vision we atleast need an object resolution of atleast 10 pixels/mm.

Eg) We want 5 pixels/10 um. then what is camera resolution.

$\frac{5}{210 \times 10^{-3}}$ p/mm → Object resolution

$= 500$ p/mm

if FOV is 70 mm.
then, we would need.
500 x 70 resolution.
35000 pixels for height.

If ratio is 3:4, then

$\frac{3}{4} = \frac{35000}{?} \Rightarrow ? = 46668$ pi

35
×47
245
1400
1645

Hence camera resolution is.

46668×35000 pixels.

$\simeq 47000 \times 35000$ pixels.

$= 1645$ MP

very high. => not possible

need to increase object resolution.

Exposure:- Amount of time for which we allow the light to fall on the sensor.

Exposure time is also called as shutter time.

short exposure time => a sharp image

long " " => a blur "

$$F.L = \frac{\text{sensor size} \times WD}{FOV}$$

Generally we assume WD to be approx. 2 times the FOV.

Now, 1 inch = 25.4 mm.

we can take $\frac{2}{3}$ inch sensor.

size.

So, $\frac{2}{3} \rightarrow ?$ => $? = \frac{50.8}{3}$ mm.

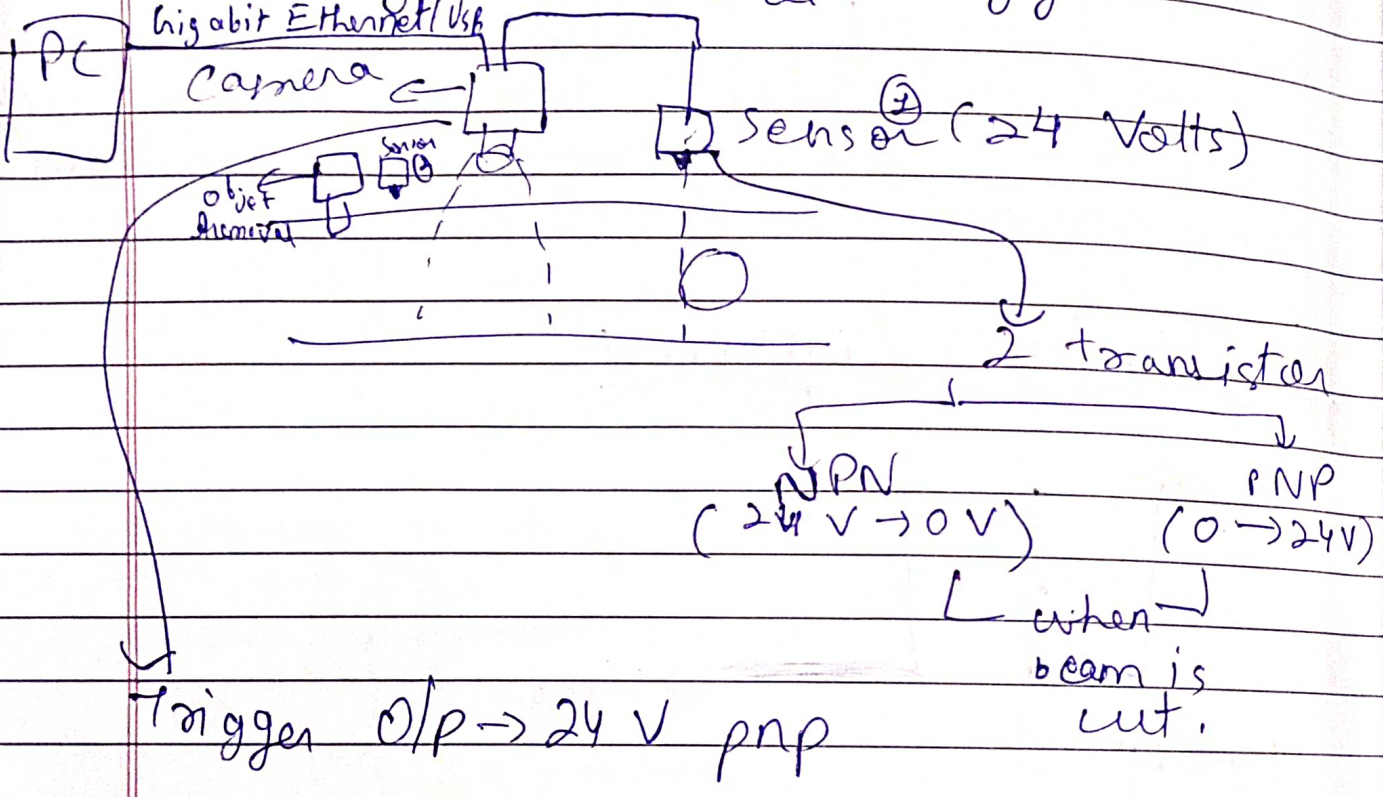
$1 \rightarrow 25.4$ = sensor size

⇒ Hardware Trigger / Software Trigger / Free run are 3 types that are used to acquire images from industrial camera.

→ Free run captures images until it is stopped.

⇒ Software trigger captures the given number of images when command is given to it.

→ Hardware Trigger is the most widely used methodology.



Strobe O/p → For light

GPIO → Addition General Purpose I/O.

→ Sensing Time (1 - 10 ms) after a beam is cut & passes a signal to camera.

Processing required by Software:-

1) Image Aquisition.
2) Processing
3) Result
4) UI.

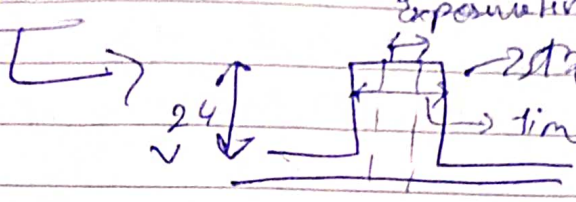
→ There is a software called Halcon too that is used for mv made by a german company MVTech.

→ There is also adaptive vision studio by Zebra company.
→ There is Matrox design studio.
→ Cognex Insight
→ Euresys.
→ Open evision.

Smart cameras:-

1) Banner
2) Baumer
3) Matrix Vision
4) Sick
5) Panasonic
6) Omron
7) B & R
8) Keyence
9) Hikrobot
10) Cognex
11) P&F

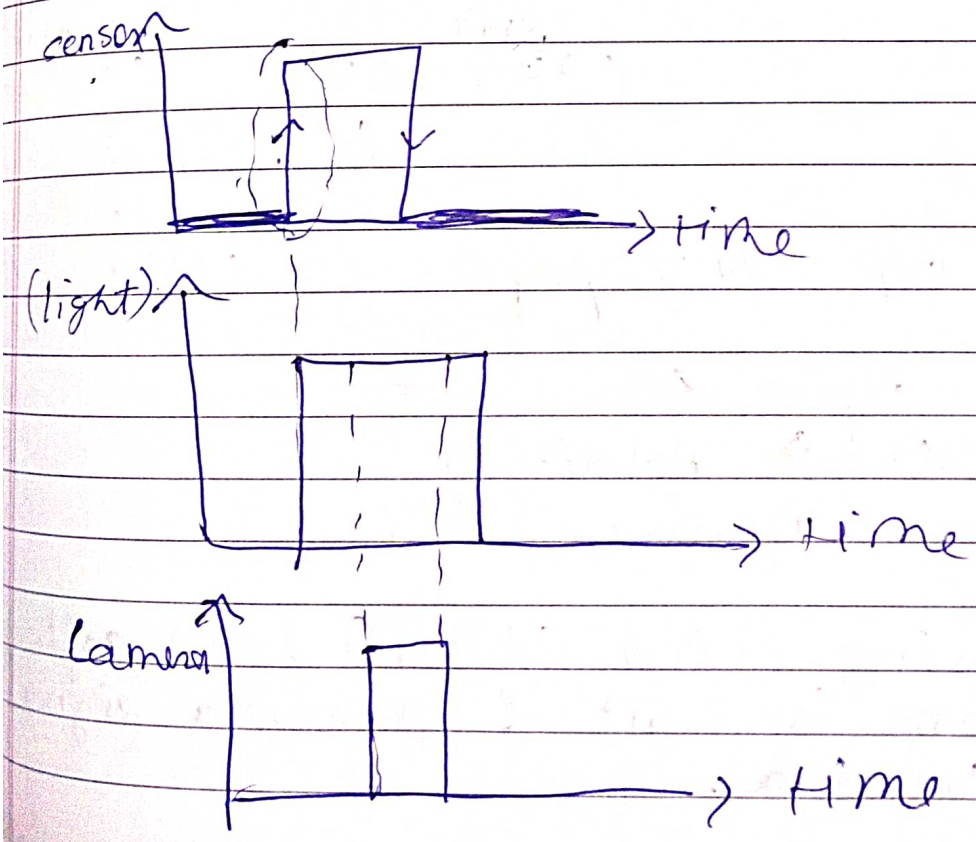
→ Camera upon receiving 24V strobes the light.



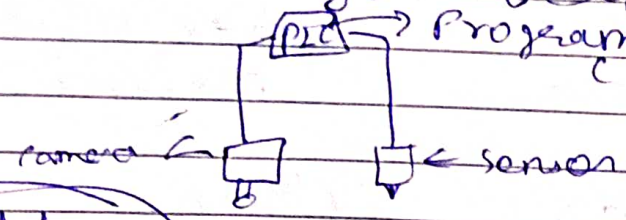
The time for which light is on must be greater than the exposure time of camera.

The connection of wire with PC is USB or GigE
- USB → higher fps
- GigE → Power supply required.

Timing diagram:



⇒ Sometimes cameras have a trigger delay that delays the start of expose of camera to object depending upon the speed of the conveyer belt.



Buffer

Sensor ① Camera Sensor ② Rejection

trigger 1
2
3
4
5

if buffer

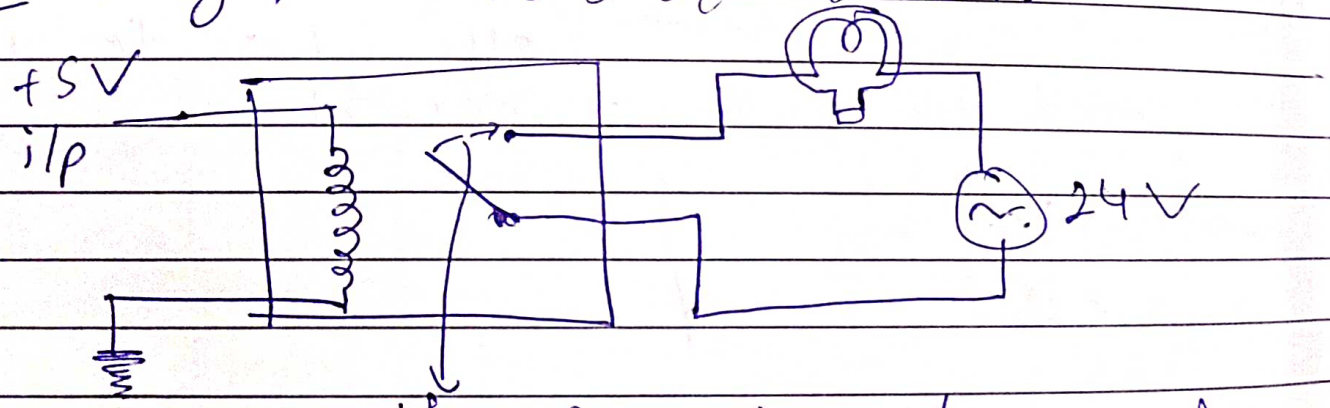
captured ← 7
when 3rd object 2
is triggered 3

→ 7 → 1

⇓

This sequencing is to be remembered by PLC.

⇒ Relay :- A kind of switch.



the circuit closes when DC 5V runs through coil & magnetic field is created which pushes the switch to close. When we stop DC 5V

again switch opens. This is called relay. This way the light would get started. Here 5V DC can be given by camera strobe signal.

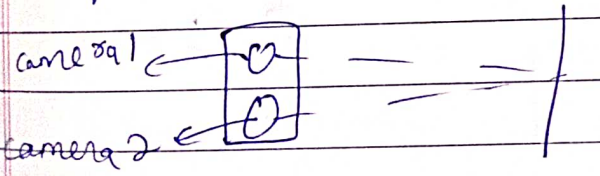
→ Global shutter :- When object is camera moving fast

→ Rolling shutter :- When object is a bit slow.

3D Machine Vision :-

Eg)- If we want to identify the company of a car type where the name is in black as well as the background is black we need 3D to get details of depth.

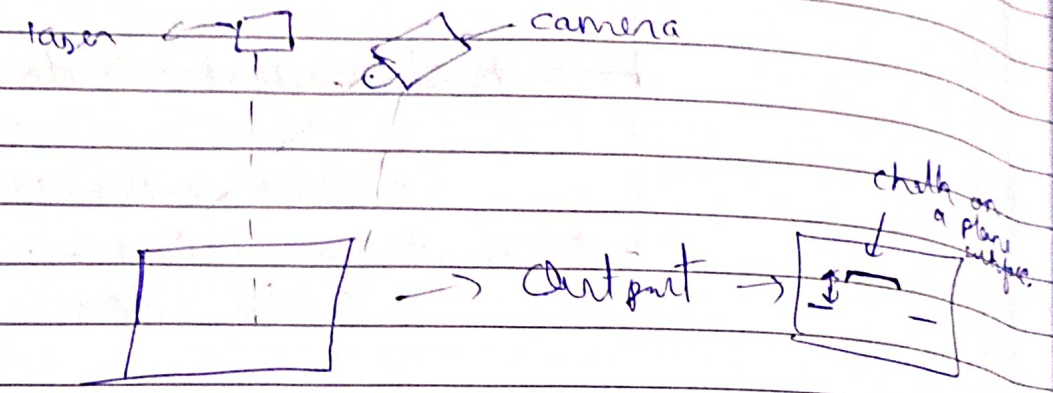
① Stereo Camera :- Just like a human eye where for one point we get 2 views :-



This kind of camera is used to create the depth map where farther the image is it is green whereas the nearer is red.

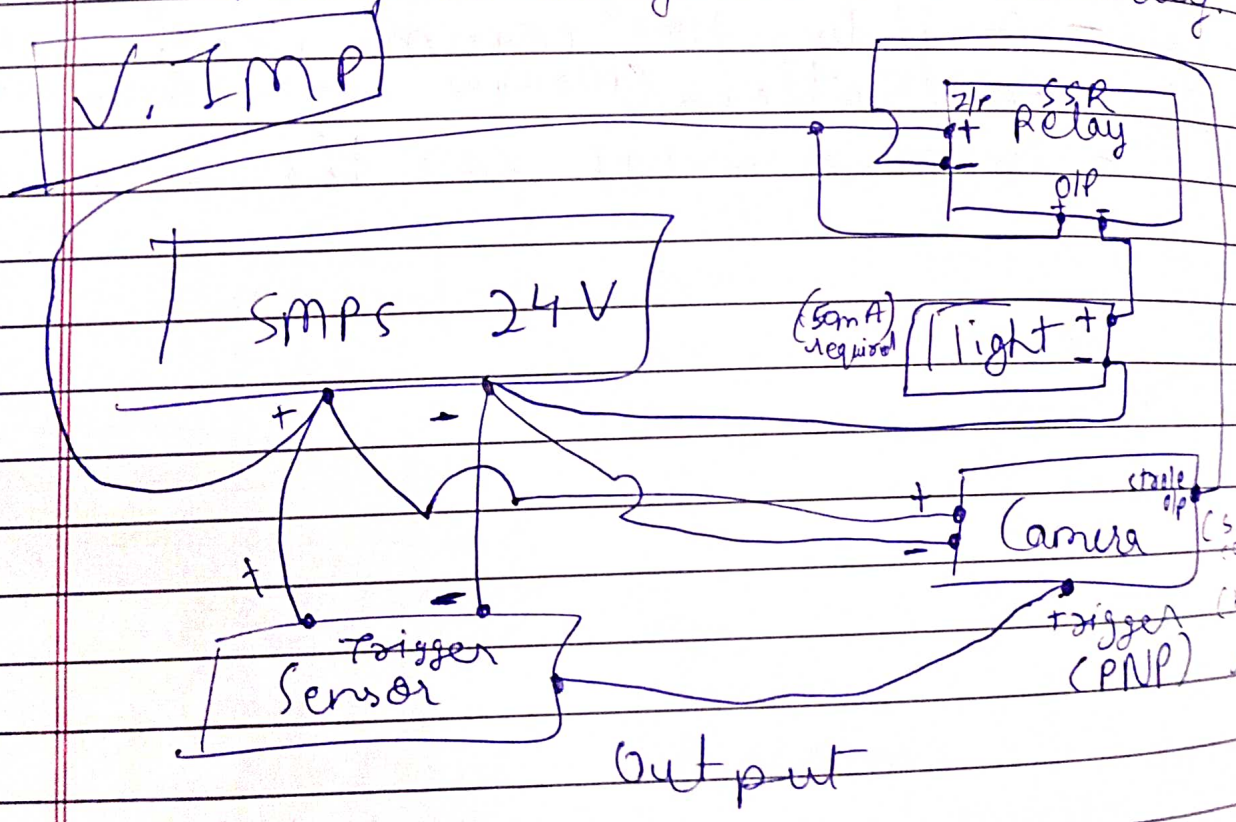
Computer Vision :- Intel Real Sense Camera
Machine Vision :- Cognex, etc. Camera

(2) 3D ~~laser~~ Triangulation:



→ Stereo Camera is not used for measurement where as in 3D laser triangulation gives um accuracy.

V. IMP



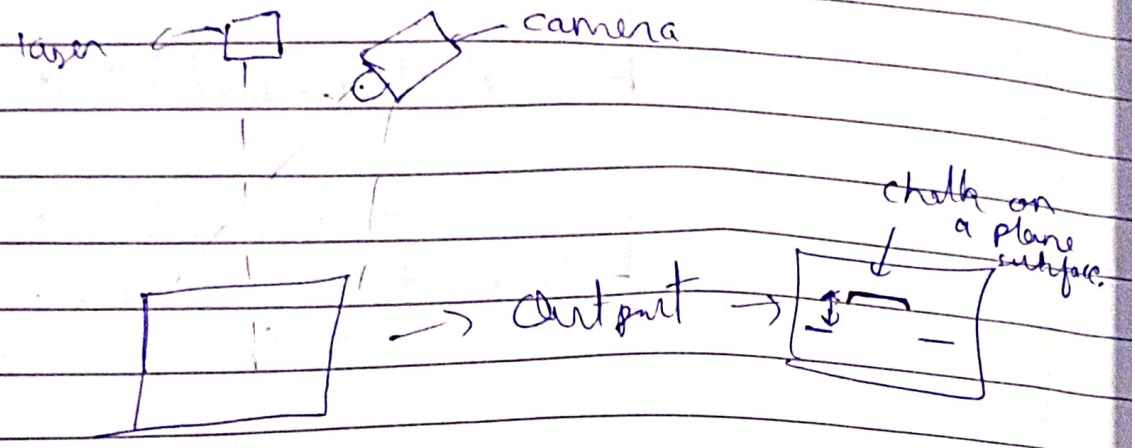
Sensor outputs → 2 types:

1) PNP
- 24V when object present
- 0V when object absent

2) NPN
- 24V object absent
- 0V object present

Computer Vision :- Intel Real Sense Camera
Machine Vision :- Cognex, etc. Camera.

(2) 3D ~~laser~~ Triangulation :-



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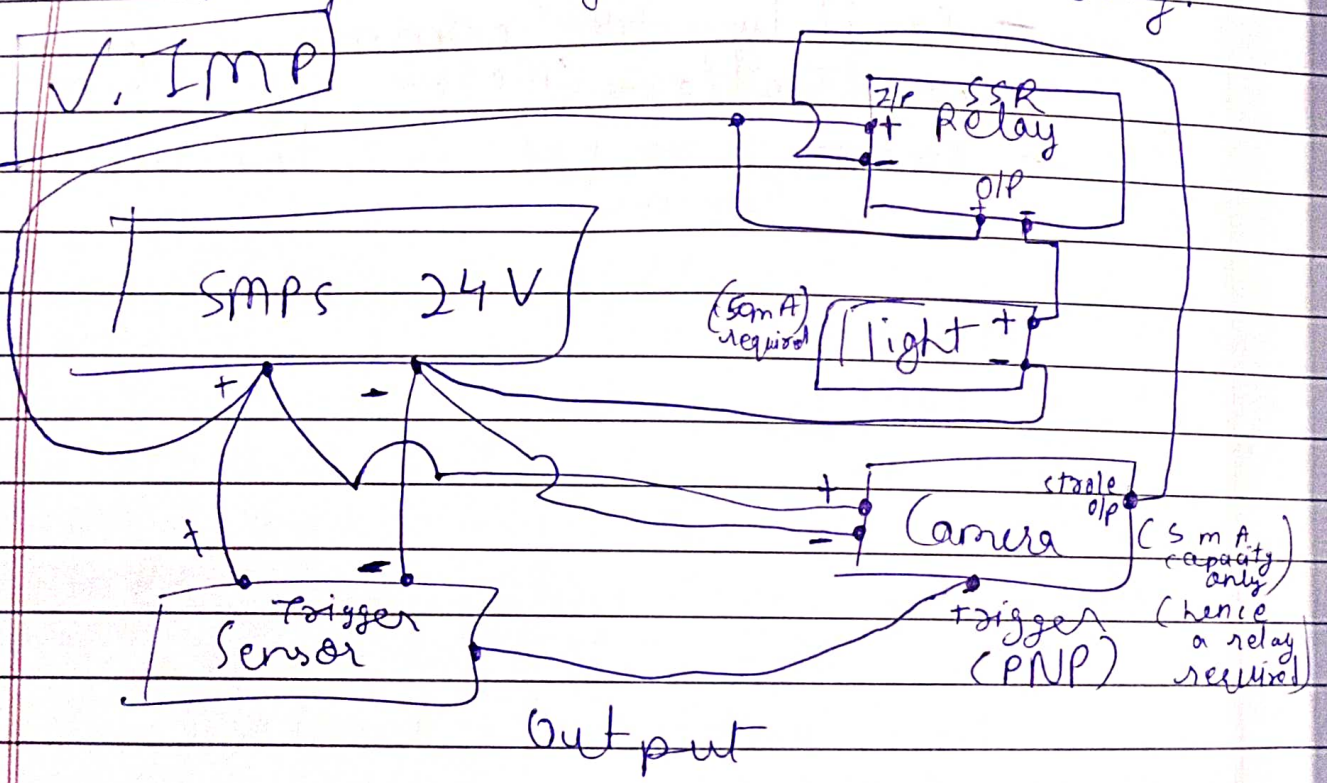
V. IMP



Sensor outputs → 2 types :-

1) PNP
- 24V when object present
- 0V when object absent

2) NPN
- 24V object absent
- 0V object present

Industrial

camera
- HikRobot → 1.6 MP - Global Shutter
  - Monochrome
  - Gig E
  - 1440 × 1080
  - 65 mm F.L
- Webcam
- Basler-dart → daA 2500
  - 25 fps
  - 5 MP, color, USB 3.0, Rolling
- matrix vision - -
  - 5 MP, color, USB 3.0, Rolling

Software should :-
- Support all types of camera.
- Processing the images
- facility to communicate with controllers (Modbus over Ethernet / TCP IP)
- Prepare a UI for the same.

Image Processing Algorithms:

- → Pre-processing
- → Segmentation
- → Edge Detection
- → Hough transform
- → Pattern Matching
- → line fitting
- → Circle fitting

(1) Pre processing:-

May include:-

(i) Conversion:- RGB → GRAYSCALE

(Color space conversion:-

a) RGB
b) HSI
c) CMYK
d) YCbCr
e) CIE Color lab.

$gray(i,j) = \alpha R(i,j) + \beta G(i,j) + \gamma B(i,j)$
where $\alpha + \beta + \gamma = 1$

(ii) Resize / Rescaling - via Interpolation.

(iii) Cropping

(iv) Contrast Enhancing
- ↳ Histogram equalization
- ↳ various filter.

(v) ROI (fixed / adaptive via matching certain pattern).

Special Assignment. (80% related to M.V)

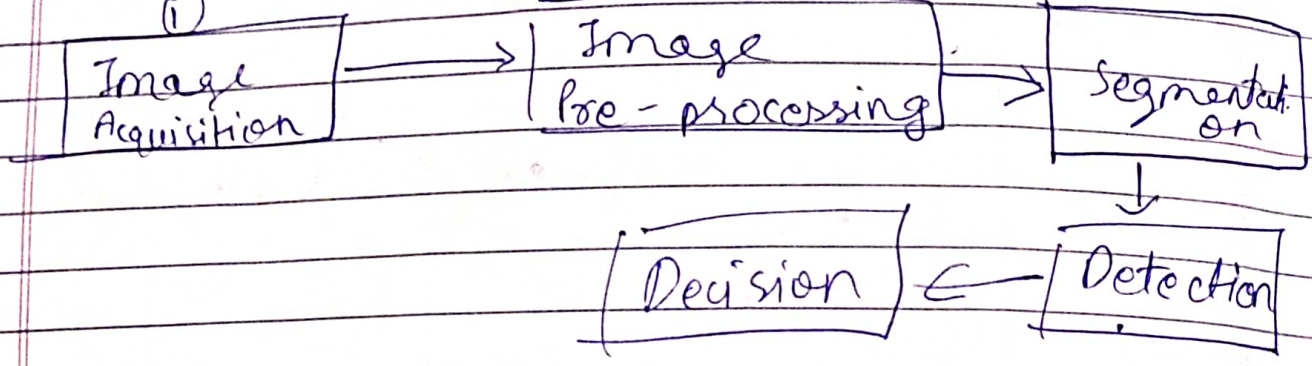
(1) Research Papers
↳ find good papers for an application.
→ form report & presentation.

(2) Case Study
Eg:- Zomatonbots
&
Apple defects → sorting
→ Report & Presentation

(3) Simulation.
→ Application
→ Should work on atleast 15/20 images
→ Report / Demo.

Company	Application
Zentron labs	Apple defects.

Flow of Algorithm:-



Intensity Operations:-

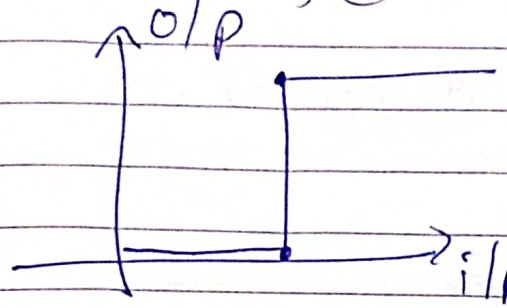
1) Linear mapping.
   - Inverse
   - log
   - Power law
2) Intensity slicing.
   - Contrast streching.
   - Bit plane slicing
   - Windowing.
   - Thresholding.

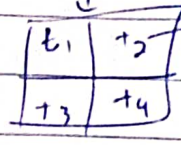
- Thresholding :-

[t] → single threshold.

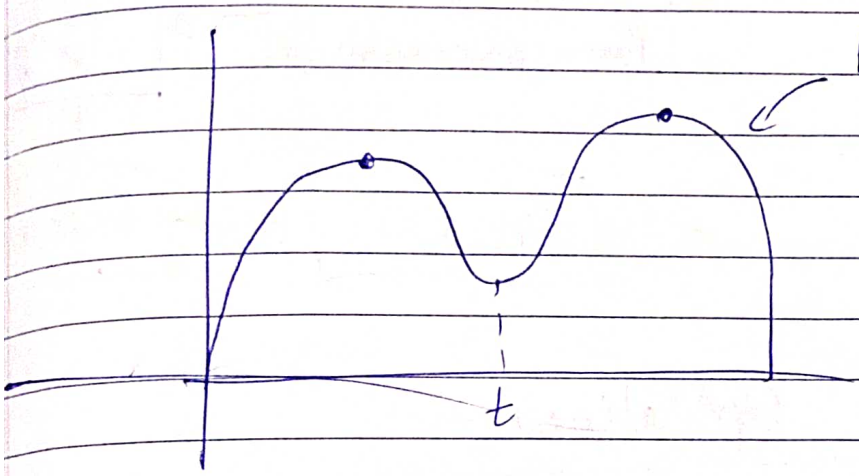
(1) Manual
(2) Automatic, (3) Global, (4) Local (only auto)

(Eg)-





→ variable threshold for local area



→ We need to find the optimal value of 't' (threshold)

local → Auto → black
→ Background correction.

Global → manual
→ Auto → Otsu
→ Clustering
→ Entropy
→ Metrics
→ Moments.

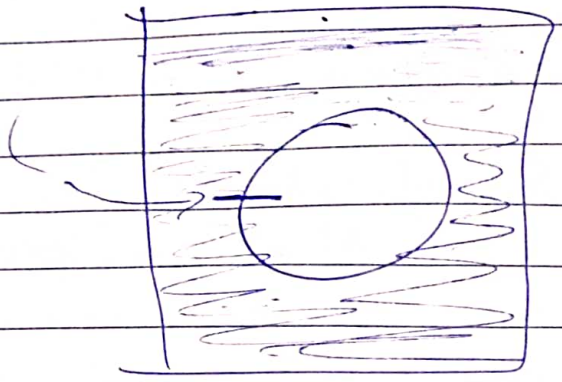
(can be applied with local as well.)

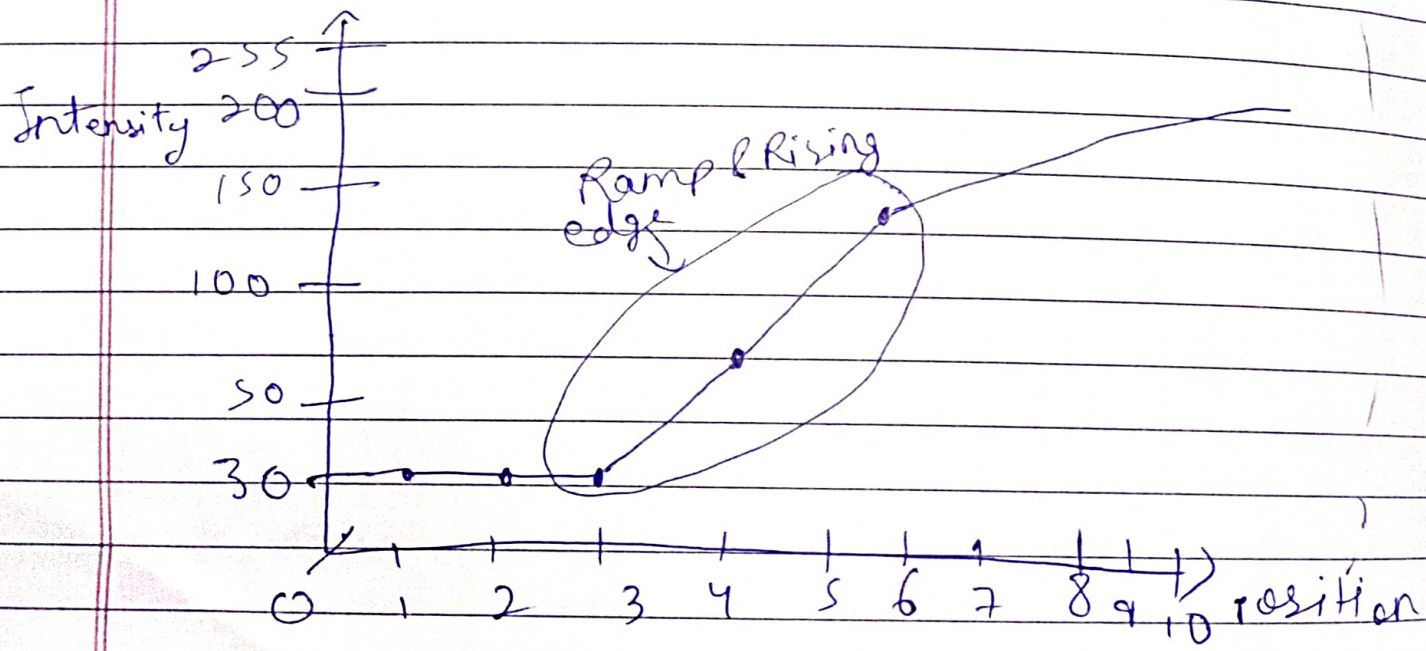
Image segmentation.

→ Global thresholding is used when there is uniform illumination in the image otherwise local thresholding is used.

Filters:- (spatial filters) (local processing)

(1) smoothing (Increase Ramp (⌐ → /))
(2) Sharpening (Decrease Ramp (/ → ⌐))

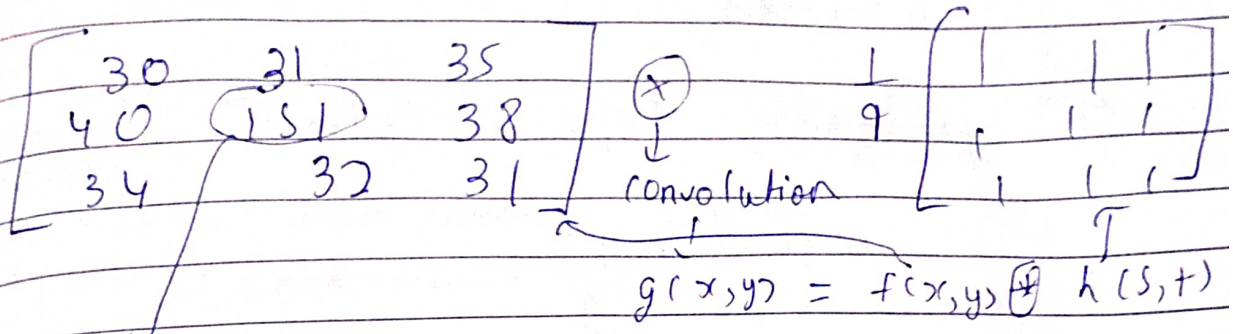




→ Raster images are taken by a camera
→ Vector images are generated by softwares.

Smoothing:-

① Avg filter.



value = 50

② Histogram operations :-

2 types :-

① Histogram Equalisation

② " Matching/Specification.