Machine Vision.

C.V	Embedded vision	Machine Vision.
In a computer. with a CPU	In an embedded machine where ~~CPU~~ traditional CPU is not possible (eg) cars).	→ In a fixed env, whereas in CV the background environment may change

→ Machine vision camera
  → Higher FPS.
  → Ability to capture fast moving objects
  → shutter → Rolling, → 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.

Date
Page

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

Basic components of Machine Vision System:-

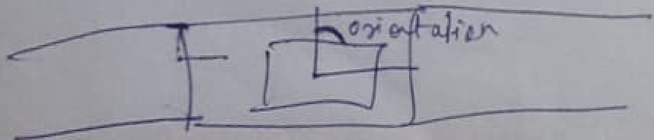
1. Image Aquisition System (camera + lens + light).
2. Processing Software
3. Machine & Automation (eg - conveyer belt, laser sensors, etc.)

Four kinds of Applications :- | Inspections

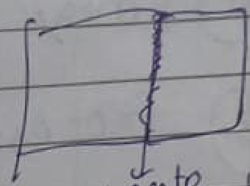
1. Locate
2. Inspect
3. Measure
4. Identify.

(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 ~~op~~ 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 Locator



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 (Optical character recognition), OCV (Optical character verification), etc.
where labels are involved.

Chap-2

→ About Sampling and quantization.

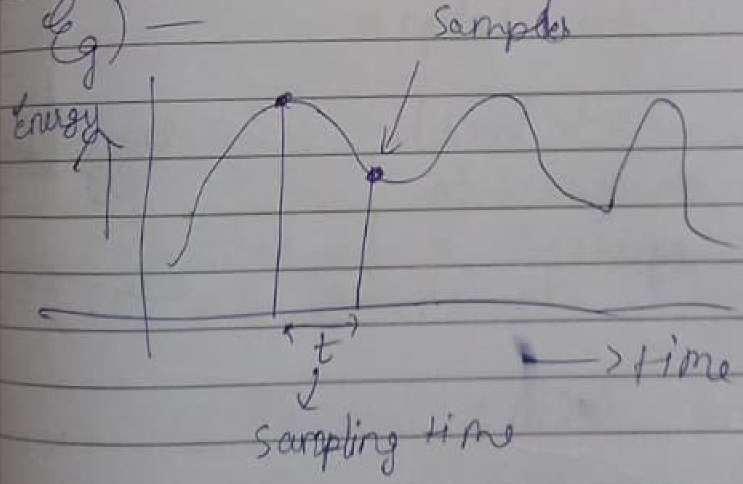
Image formation:-

→ 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:-

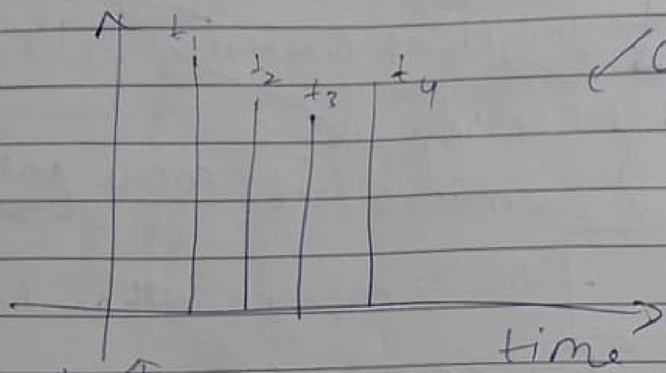
Sampling ⇒ Discretization

Eg) —

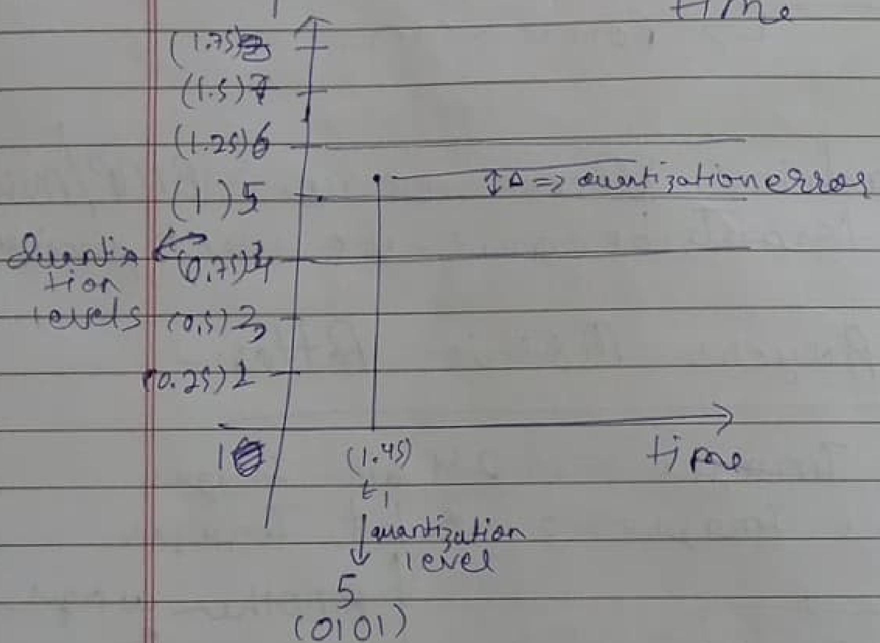


Quantization → Digitize.

Eg) → $t_1 = 1\cancel{0}.45$ V
$t_2 = 1\cancel{0}.36$ V
$t_3 = 1\cancel{0}.35$ V
$t_4 = 1\cancel{0}.40$ V



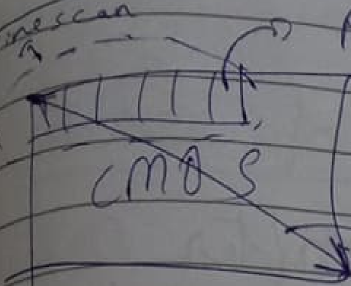
← after sampling



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

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

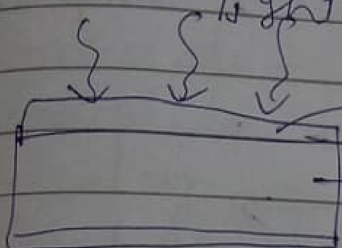
Sensors:-



→ Photosites (µms in size)

→ Area scan

→ length of diagonal → 1, 1/3, 2/3, etc. → used to represent size of sensor.



→ micro lens (focus energy on base material)

→ Si or any other base material

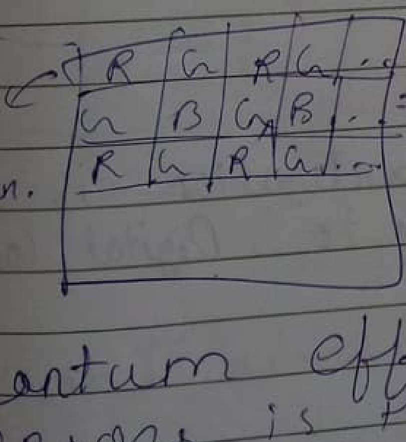
↳ Point scan.

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

CFA / Bayers Mosaic Patter:-

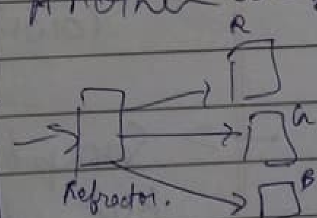
RGB → Images ⇒ 24 bit Images.
Monochrome Images ⇒ 8 bit Images.

50% green.



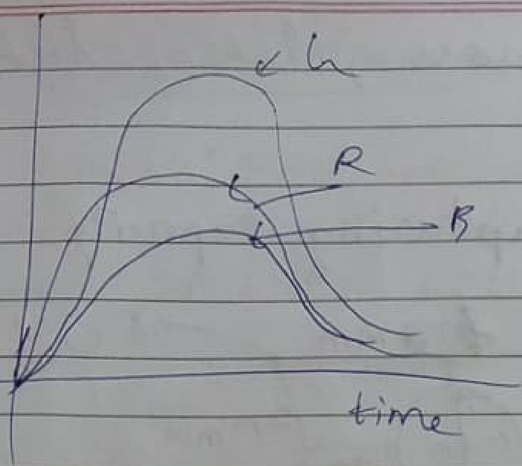
→ Sensor.

~~Another ways.~~



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

Q.E



→ Rate of conversion of electrons to required energy levels.

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

↓

Use interpolation.

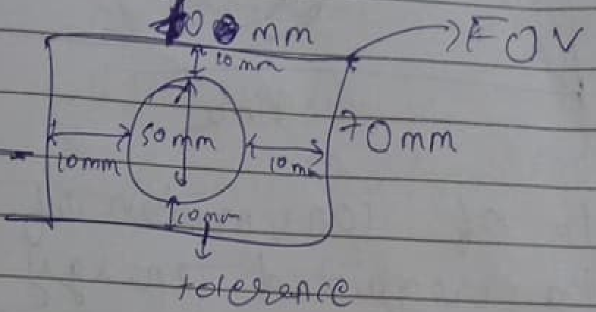
↓

should be invariate to edges & other object's 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.

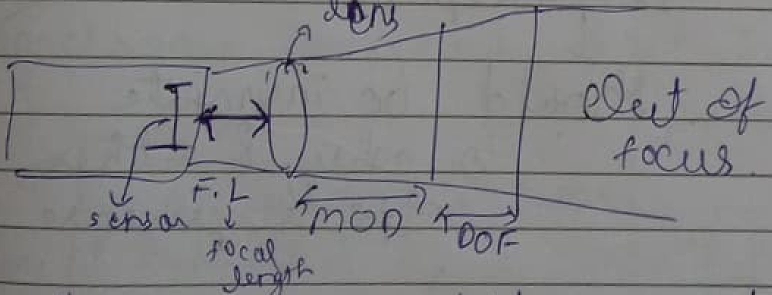
FOV:- Capturing capacity.



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. Distance btw Top surface of object & camera.

Object Resolution:-

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

& we choose
1600x1200 resolution
then.

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

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

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

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

$= 500$ p/mm

if FOV is 70 mm.

then, we would need.

500×70 resolution.

35000 pixels for height.

If ratio is 3:4, then

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

$$\begin{array}{r} 35 \\ \times 47 \\ \hline 245 \\ 1400 \\ \hline 1645 \end{array}$$

Hence camera resolution is.

46668×35000 pixels.

$\simeq 47000 \times 35000$ pixels.

$= \underline{1645 \quad MP}$

very high $\Rightarrow$ 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 $\Rightarrow$ a sharp image

long " " $\Rightarrow$ 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, $\frac{2}{3} \rightarrow ?$ $\Rightarrow ? = \frac{50.8}{3}$ mm. = sensorsize

$1 \rightarrow 25.4$

so, if ~~sensor~~ FOV is 40mm.
then lets take,

$WD = 150$ mm

&

sensor size $= \frac{2}{3} \times 25.4$ mm.

Also, lenses are available with the following focal lengths:-

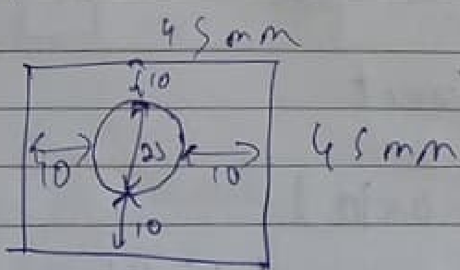
5, 6, 8, 12, 14, 16, 25, 35, 50, (65, 75, 110) + tele lenses

⇒ Indirect lighting works well for glossy surface.

Q. Find out company logo on a plastic cap.

Issues :-
1) Logo presence/absence
2) Off centered.
3) improper print.

The ~~ra~~ diameter of the cap is 25 mm.



If we want 10 p/mm, object resolution
then, resolution of a side becomes,

$45 \times 10 = 450$ pixels.

So, we can use some 640×480 (0.3 MP) resolution.

Lets take ~~FOV~~ sensor size as $\frac{2}{3} \times 25.4$

FOV = 45 mm

WD = 50 mm Or 90 mm

taking this.

$\therefore FL = \frac{\frac{2}{3} \times 25.4 \times 50}{45}$

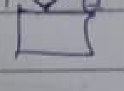
$\simeq 18.7$ mm.

Now, 16 mm F/camera is the nearest so we can select that for our application.

~~Now, types of light are:-~~

Light is bombarded in 2 ways:-

1) Direct



→ Bright field 6)

Dark field 5)

2) Indirect

3) Co-axial

4) Backfield light.

→ Bar Direct light can be used in bright & dark field light both.

⇒ Spot light is used in bright field & Direct illumination.

Bar light

Diffused
→ Light producing element is not visible.

Non diffused

⇒ Flat back light.

⇒ Co-axial light

→ Ring light. 

⇒ Dome light. → Indirect.

Now since we are using plastic which is not shiny we can go with bar light.

→ The color of light used depends on the color of bottle cap.

→ Software can be C, C++, Python, Matlab, NI Labview

Processing required by Software:-

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

→ There is a software called Halcon ~~Foo~~ 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.

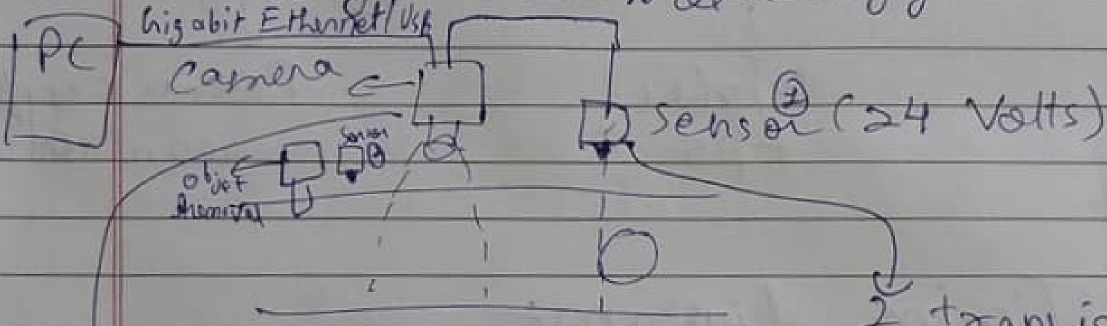
Smart cameras:-
1) Banner
2) Baumer
3) Matrix Vision
4) Sick
5) Panasonic
6) Omron
7) B&R
8) Keyence
9) Hikrobot
10) Cognex
11) P&F

⇒ 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.



2 transistor

NPN (24 V → 0 V)

PNP (0 → 24 V)

when beam is cut.

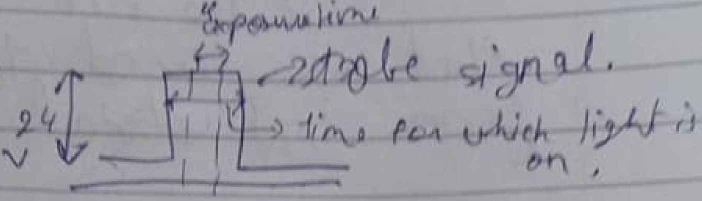
Trigger O/P → 24 V pnp

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.

→ Camera upon receiving 24V strobes the light.



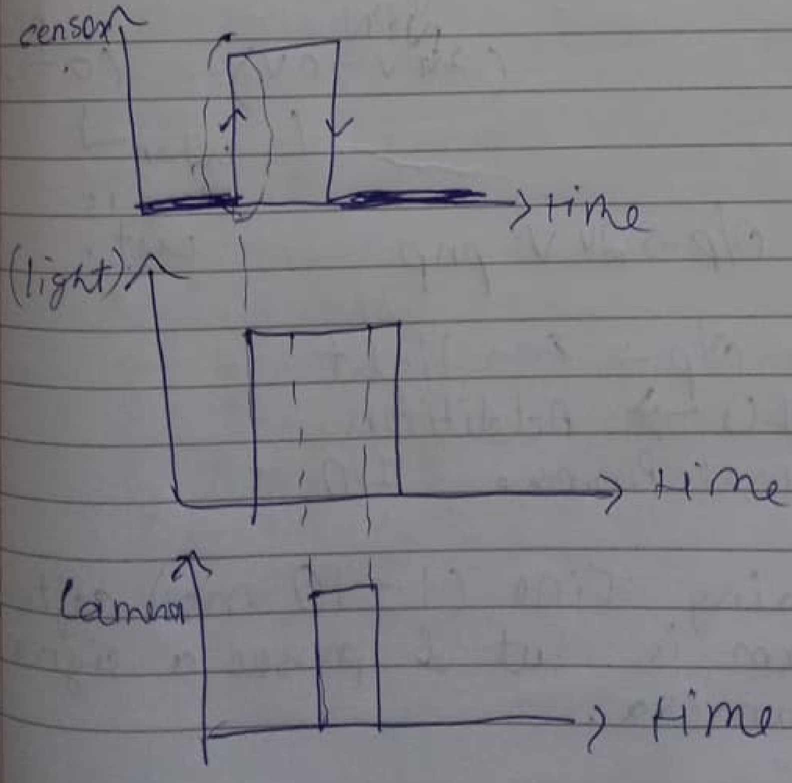
The time for which light is on must be greater than the exposure time of camera.

The connection of wire with PC is USB or GigE

USB ↓ higher fps

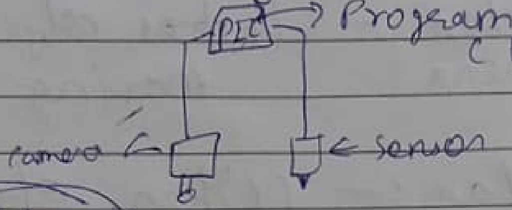
GigE ↓ Power supply required.

Timing diagram:



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

PLC → Programmable logic controller (used to add trigger delay)



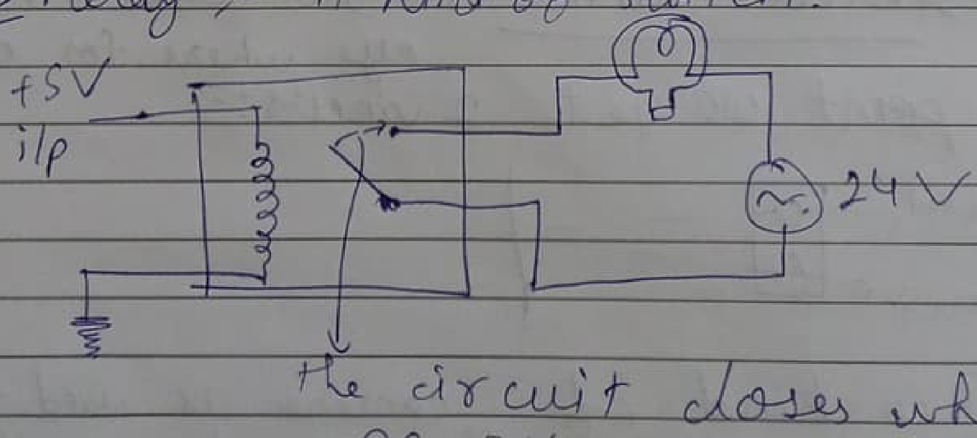
Buffer

	Sensor (1)	Camera	Sensor (2)	Rejection
triggered	1			
in buffer	2			
	3	captured ← 1		
	4	when 3rd object 2		
	5	is triggered 3	→ 1	→ 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.

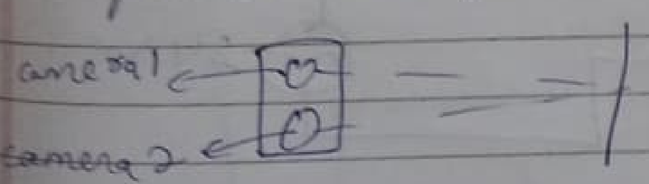
→ Global shutter camera :- When object is moving fast

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

3D Machine Vision:-

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

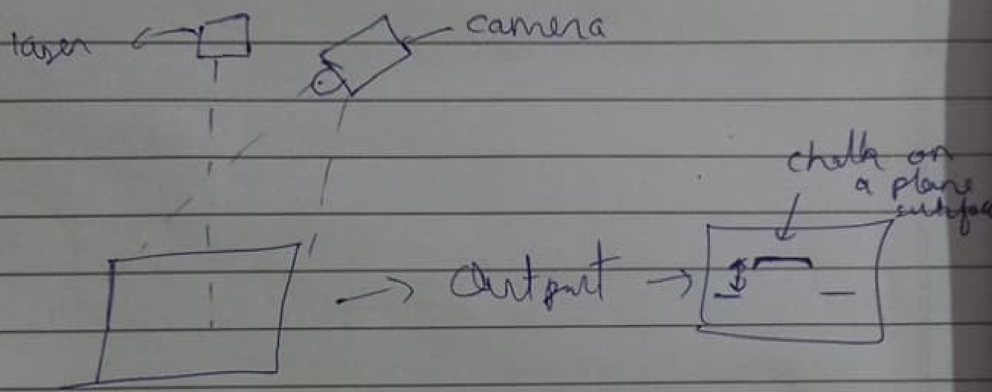
① Stereo Camera:- Just like a human eye where for one point we get 2 views:-



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.