Digital Image fundamental

Image is the 2D function $f(x, y)$

$x, y \rightarrow$ spatial Coordinate

→ Amplitude of f is intensity or gray level.

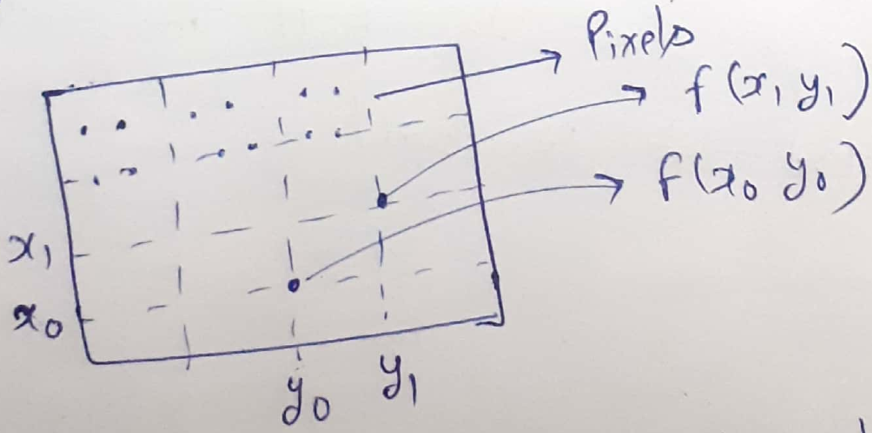
→ x, y & amplitude of f → finite & discrete value of the Digital Image

Digital Image Processing

Processing of Digital Image using digital Computer

→ finite number of element in the particular location and values.

↳ Image elements, Picture Element, Pixels.



→ vision → advance senses → limited to "visual band" EM spectrum.

visual band → IR, microwave and radio bands

Image machine is used for overcoming the disadvantage
→ Cover Entire Em's spectrum.

→ DIP covers wide and varied field of application.

Types of DIP

(i) Low level Process

Image → $\boxed{\text{DIP}}$ → Image
(noise image) (clear image)

(ii) middle level Process

Image → $\boxed{\text{DIP}}$ → attributes

for segment the image or extracting the value
it provides value of image

(iii) High level Process

attributes → $\boxed{\text{DIP}}$ → making sense

if the image given to ball and identify the image that it is ball

What is Digital Image

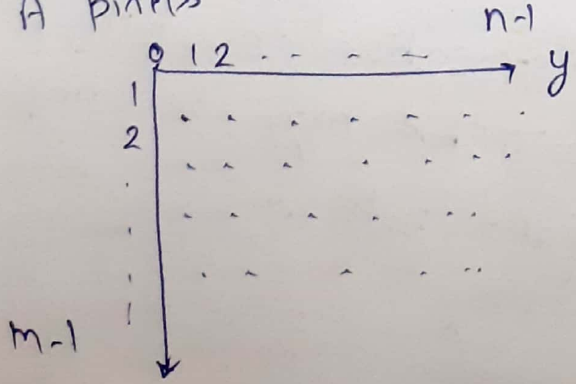
When (x, y) and $f(x, y)$ are all finite, discreate quantities we call the image as Digital image.

- Digital image is composed of a finite number of element each of which has a particular location and value. These referred as
  - → Picture Element
  - → Image Element
  - → Pels
  - → Pixels
- Pixels is the most widely used.

→ Digital image of M rows and N column

→ Each pixels, each represented by k bits

→ A pixels can have 2^k diffrent value



$k = 8$

2^8 possible value.

$= 256$ (levels exists).

0 → black level   255 → white ~~grey~~ level.

0 - 255 → various shade of grey.

→ ~~it~~ is suitable for computer processing.
~~it must~~ be digizidezed both spatially and in amplitude

→ Digitization ~~of~~ (x, y) is called image sampling

→ Amplitude digitization is called grey level quantization.

Digitization implies ~~that~~ a digital image is an approximation ~~of the~~ real scene.

Image Processing

→ method ~~of~~ converting image into digital form. ~~to~~ enhanced image and perform operation on it from it or ~~extract~~ some useful information from it

→ It is a ~~type~~ of dispensation in which input is image, and ~~output~~ may be image or characteristic associated with it

→ Rapidly growing technologies, various application in business, and core research area in computer Science discipline also

Steps of Image Processing

→ Importing the image by image acquisition tool.

→ Analyse and manipulate the image

→ output is the last stage for altering the image

Purpose of Image Processing

1. Visualization → observe the object that are not visible
2. Image Sharpening and Restoration: To create better image
3. Image Retrieval Seek the Image of interest
4. measurement of Pattern measure various object in image
5. Image Recognition Distinguish the object of an image

Method used for Image Processing

1. **Analog Image Processing** :— The image are manipulated by electrical means by varying the electrical signal.

2. **Digital Image Processing** — It help to change the image by using computer. The three general phase of manipulation

→ Pre Processing

→ Enhancement and display

→ Information Extraction

Ex — ~~hot~~ T ~~Represent~~ white and 0 represent black

$$T \xrightarrow{\text{Digitize}} \begin{matrix} 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 \end{matrix}$$

56	56	57	58
56	56	57	56
57	57	57	59
58	58	58	60

(1,1) — intensity is 56

(2,2) — intensity is 56

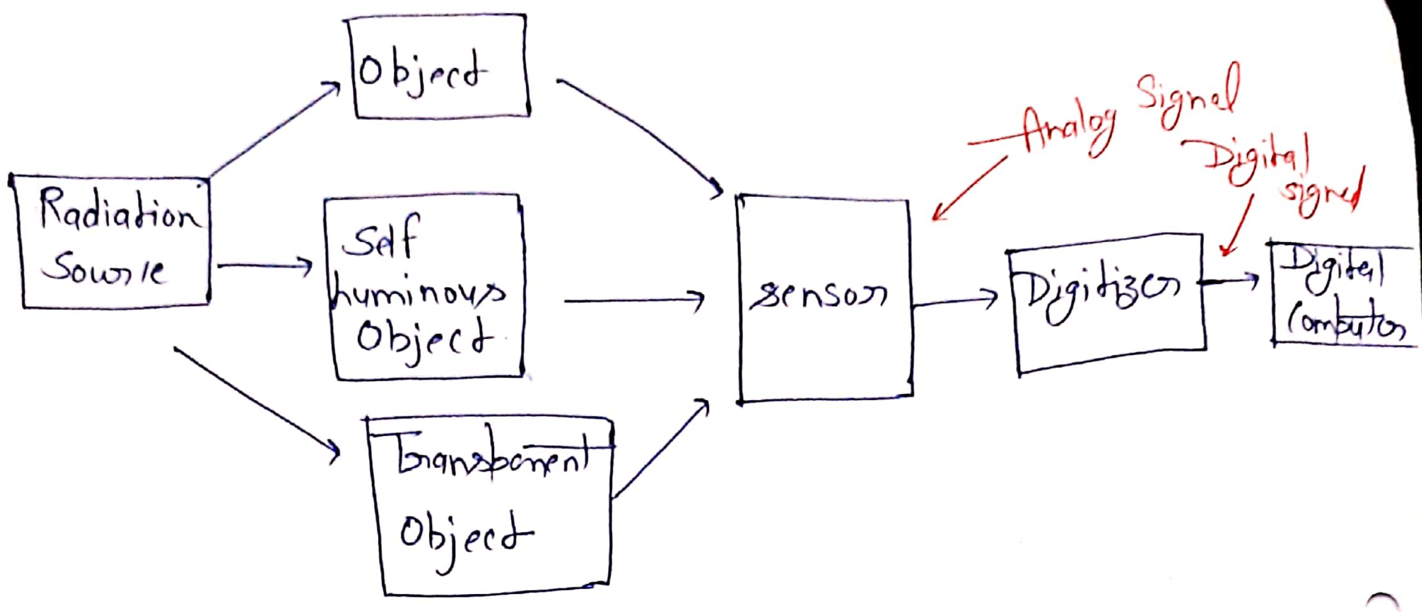
Scanned by CamScanner

Nature of Image Processing

Sources of Image.

→ Paintings
→ Photograph in magazine
→ Journal
→ Image gallery
→ Digital Libraries
→ Newspapers
→ Advertisement board.
→ Television and internet.

→ image are intimation of images.
→ the term image is used to denote the image data that is sampled, quantized, are readily available in form suitable for further processing by digital computer



Radiation Source → Sun, light.

Object → Person, building, ~~structure~~ (2D, 3D)

Sensor → sense the energy Radiated by the object wish to detect object

light energy → electrical energy.

Digitizer → ~~output of~~ physical form into electrical signal.

Digital Computer → Any PC or laptop.

Image Processing and related field

→ Optics
→ Statistics
→ Video
→ Digital Image Processing
→ Graphics
→ machine Vision

Image Processing and Computer Graphics

- it deals with raster data or bitmaps.
- it deals with the vector data

Image Processing and Signal Processing

It deals with the processing of one dimensional signal with the visual information. that is provided into one and two form.

Image Processing and machine vision

It interpret the image and to extract its physical, geometric or topological properties.

Fundamental steps in Digital image Processing

Not necessary to apply all the image process in the particular image.

(i) Image Acquistion : The main aim to obtain digital image of the object.

2. Image Enhancement The ~~steps~~ improve ~~the~~ quality ~~of the~~ ~~of the~~ image so ~~that the~~ analysis image is reliable

3. Image Segmentation ~~it~~ divide the image into many sub regions and ~~extract~~ ~~the~~ region ~~it~~ used for further analysis.

4. ~~feature~~ ~~extraction~~ and ~~object~~ Description ~~it~~ use many routine for ~~extraction~~ ~~of~~ image feature so ~~it~~ is used for recognition.

5. Pattern Recognition
It is used for identifying and recognizing ~~the~~ object is present in the image.

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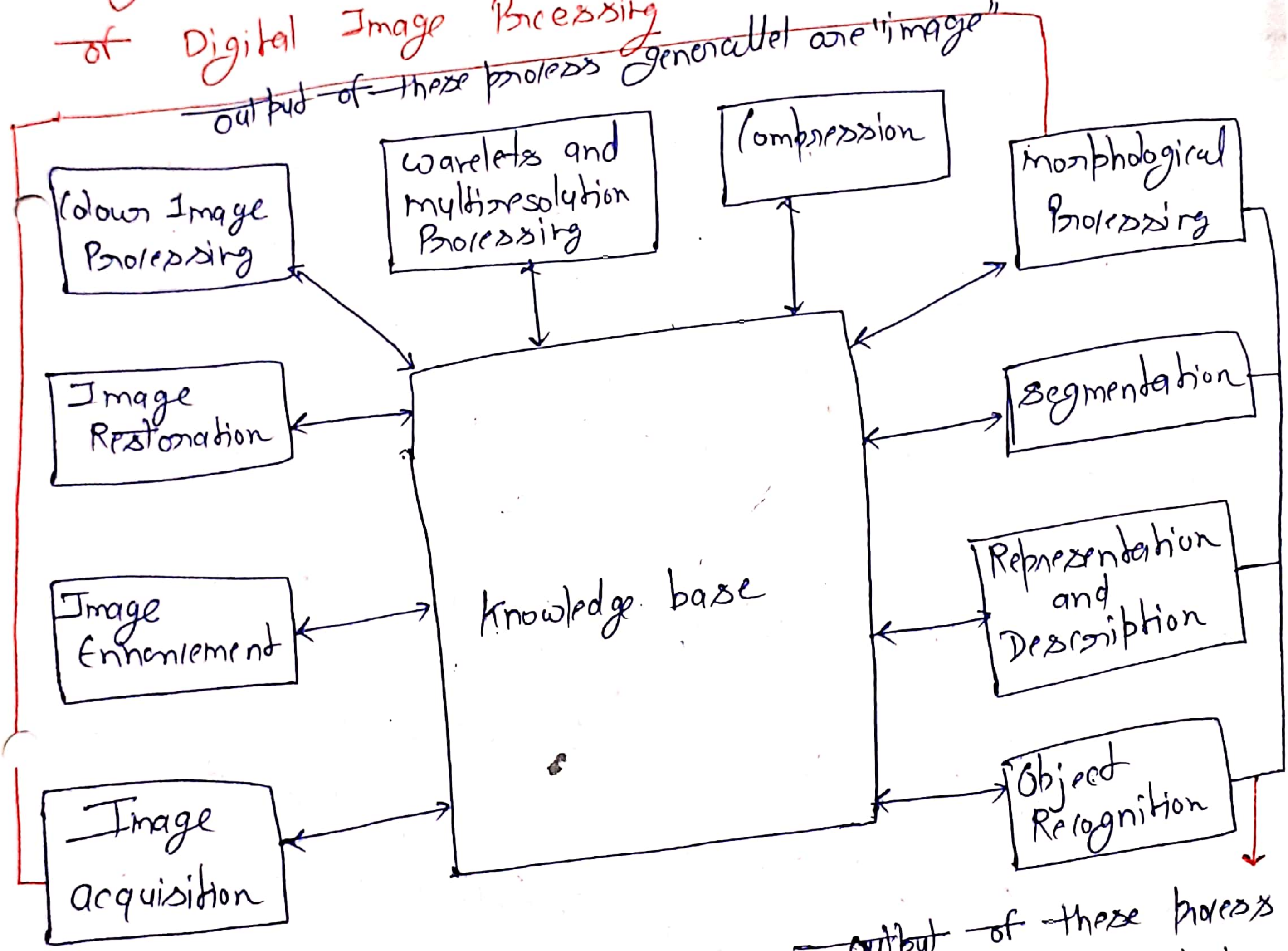
Origin of Digital Image Processing / Fundamental steps of Digital Image Processing



output of these process generally are attributes.

steps of D.I.P.

The important steps of images processing is as follows:

1. **Image Enhancement:** It is the most important class of algorithm. The image is not so good due to noise, poor brightness, contrast and blur. Noise is any unwanted signal. Blur is a disturbance that makes the image difficult to interpret. Artefacts are feature that are not true. These are observational error, including dust and scratch on the image surface. The dark image is enhanced by an image to increase the brightness of the image.

2. **Image Restoration**

   It is the objective way for improving the quality of the image. Image Restoration is different, because it deals with degradation such as sensor system, poor lighting connection. it include technique where problem are solved mathematically. the inverse filtering for storing the image is the negative process. and remove the degradation.

3. Image Compression

multimedia object cover lot of space. it can be transmitted in the imaging application such as telemedicine. Image storation and compression is the very big task. So Reduction is needed to describe the object.

Two classes of image compression algorithm.

(i) lossless Compression - it preserve the information that is very critical and used in medical domain

(ii) Lossy Compression - It is used where loss of image data cannot be perceived by the human observer or loss of information is acceptable.

4. Image Analysis - it include measurement of shape, size, texture and colour of the object. it take image as input and produce numerical and graphical information based on

characteristics of data. it classified the object and performe statistical task and provide extraction and description of the scene.

Plotting the histogram is the important task for the image analysis.

it define the grey level of an image in the form of table or graph. The darkness of the image is applied in the histogram.

Image Analysis involve finding measurement of the object such as mean and variance.

4. Image Synthesis

It deals with creation of image from other image or non image data. It is used to create image that are not available physically and cannot be used by any other imaging process.

Sampling and Quantization

CCD sensors or scanner use the digitization process for converting analog signal into digital signal.

Sampling ~~it~~ Involves two ~~steps~~, sampling and ~~intensity~~ quantization. The sampling process convert analog signal ~~into~~ discreate signal. ~~convert~~

For sampling a signal should be frozen. ~~it~~ ~~cannot~~ be moving. If the signal is frozen for T time. T is called the sampling Period. or measure in second. The sampling frequency is the reciprocal ~~of the~~ sampling rate.

It find by multiplying a continuos signal by a sailing function $s(t)$

$$\boxed{f(n) = f(t) \times s(t)}$$

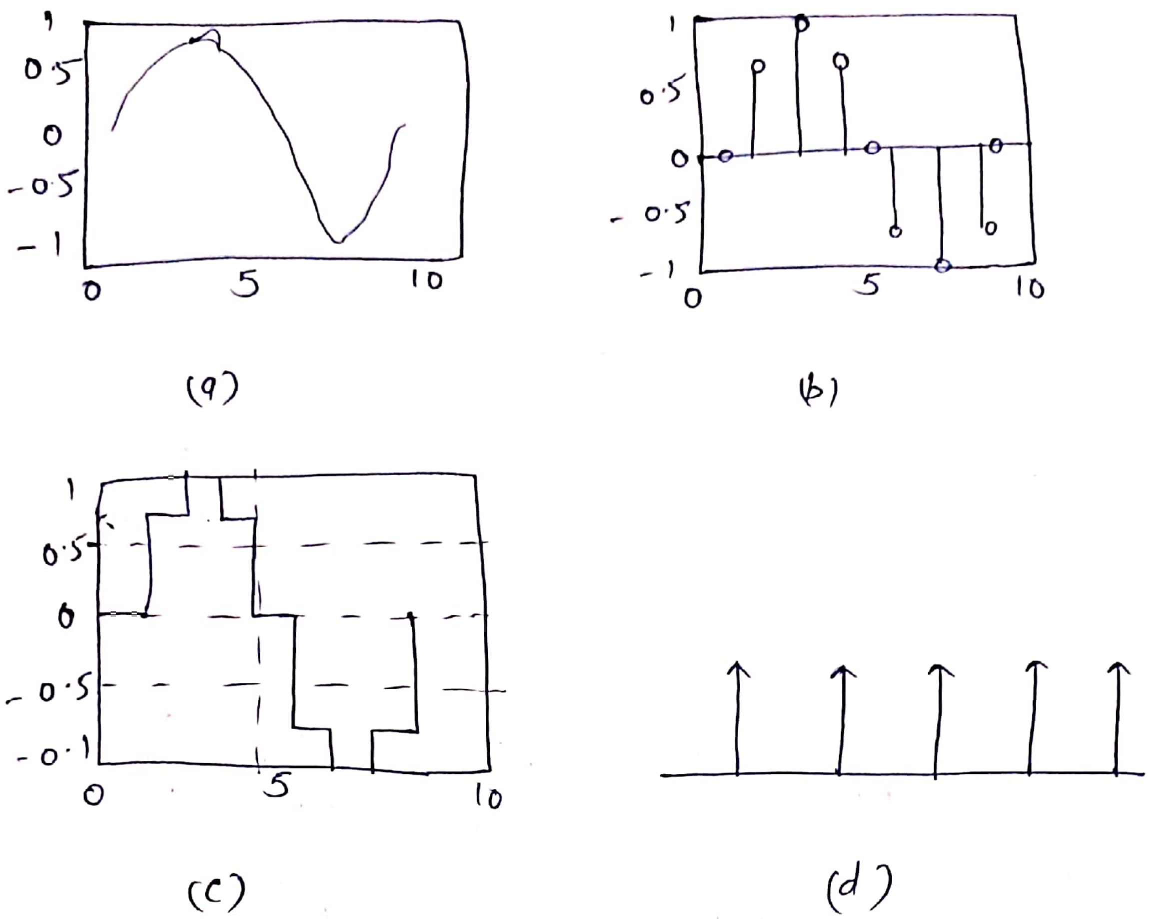
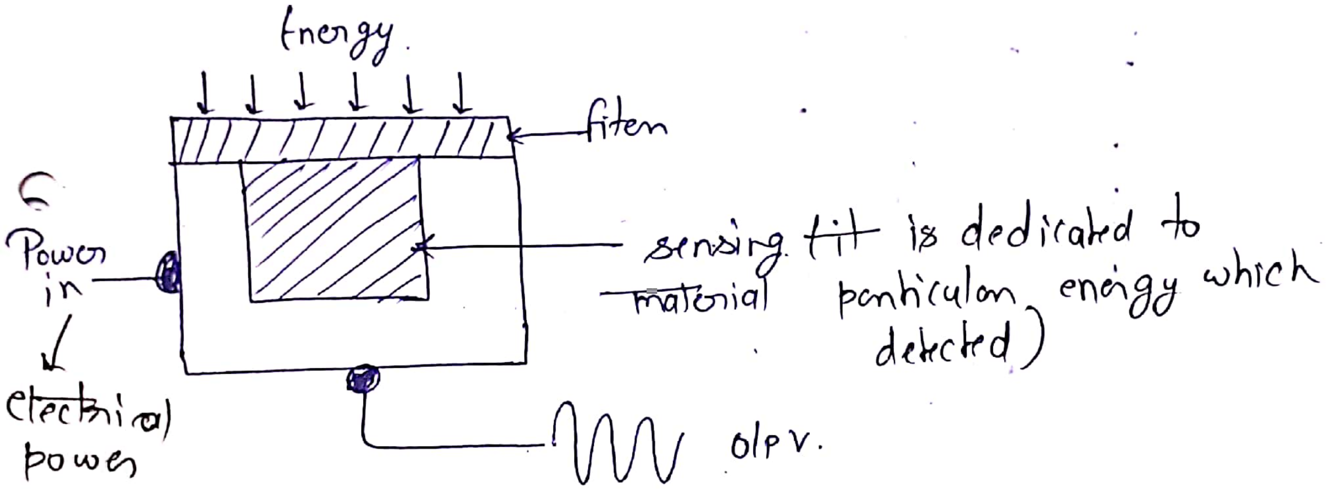


fig Sampling Process
(a) Original Image (b) sampled image $f(n) = f(t) \times x(t)$
(c) Reconstructed image (d) Train of impulse image

Sampling is the reversible process. It reconstruct the original signal from the sampled signal by loss pass circuit and ~~extracting~~ the base band component over the $\pm f_s$ infinite spectrum of samples signal. f_s is the sampling frequency as per shanon theoram.

Sampling frequency decide the distance between samples. This distance provides the linear pixel size

Image Sensing and acquisition

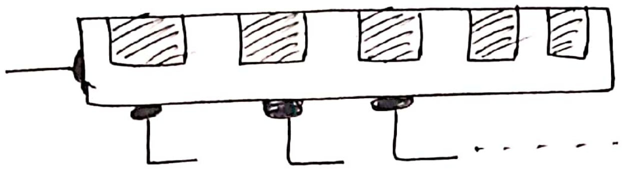


(a) Single image Sensor

Images are generated from combination of the illusion source and reflection and observation of the energy that are reflected from the image that the sense between the image was reflected

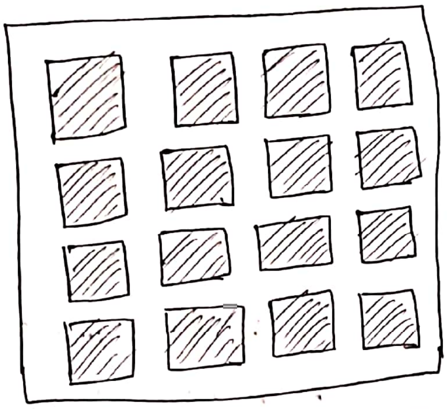
Illumination can be generated from source of em energy such as radar, x-ray or infrared sensor. The illumination can also be ultrasound or computer generated illumination pattern.

The illumination energy can be reflected and transmitted through object.



array in the form of line

(b) Line Sensor



sensor arranged in the array form.

(c) Array of Sensor

Image acquistion using sensor:

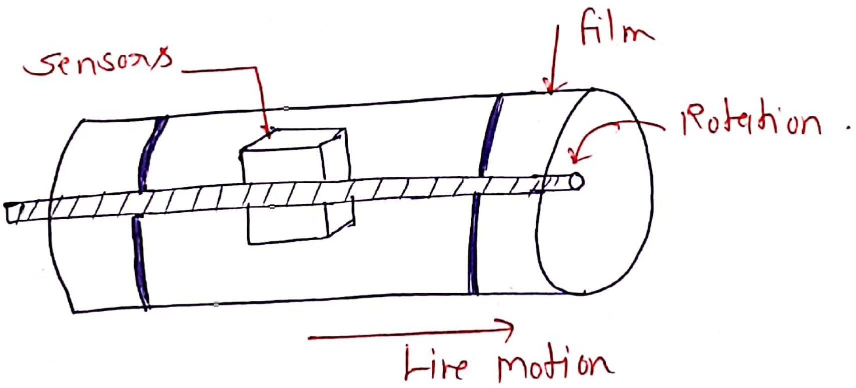
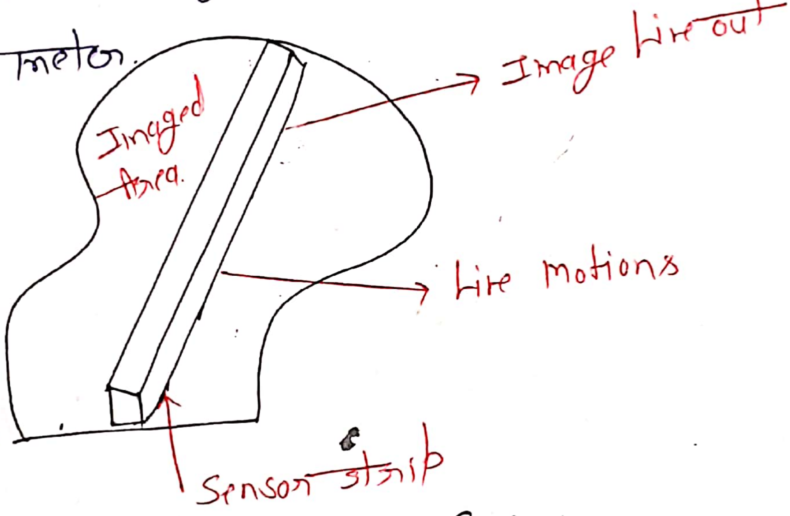


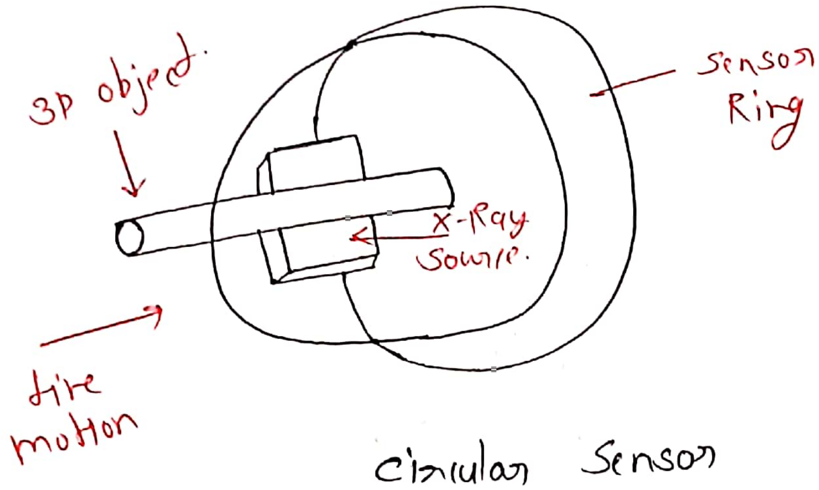
Image aquisition using single sensor

for 2D image consideration the sensor should be marked in the x direction and Y direction. The figure shows the high precision of the scanning The negative film is mounted on the drum. mechanical rotation is provided by ~~the rotation of~~ 1-D direction. Sensors is placed by the lend screw, that provides motion in the perpendicular direction. The ~~method~~ is very expensive ~~but it~~ provides high resolution. The mechanical system used is known as micro densor ~~meter~~.



Line Sensor or Linear Sensor.

The ~~strip~~ is provide the image in the particular direction. Sensor one used is ~~most~~ flat beded scanner. More than 4000 sensors are used for the In lining bond. It also used in airbore system. 1-D sensor ~~strip~~ respond towards the electro magnetic band mounted ~~at~~ the pendicular to the direction of the flight. The strip gives 1 line image at the particular time. motion of the strip can used by the other dimension of the strip



Circular Sensor

used in medical and industrial application image of for acknowledging the cross sectional the 3D object. X-Ray is the source that provide illumination

for Array sensor, the example of the array is the digital camera. The sensors are also known as CCD Array structure known as change coupled device array. motion of the sensors are not required for the array sensors.

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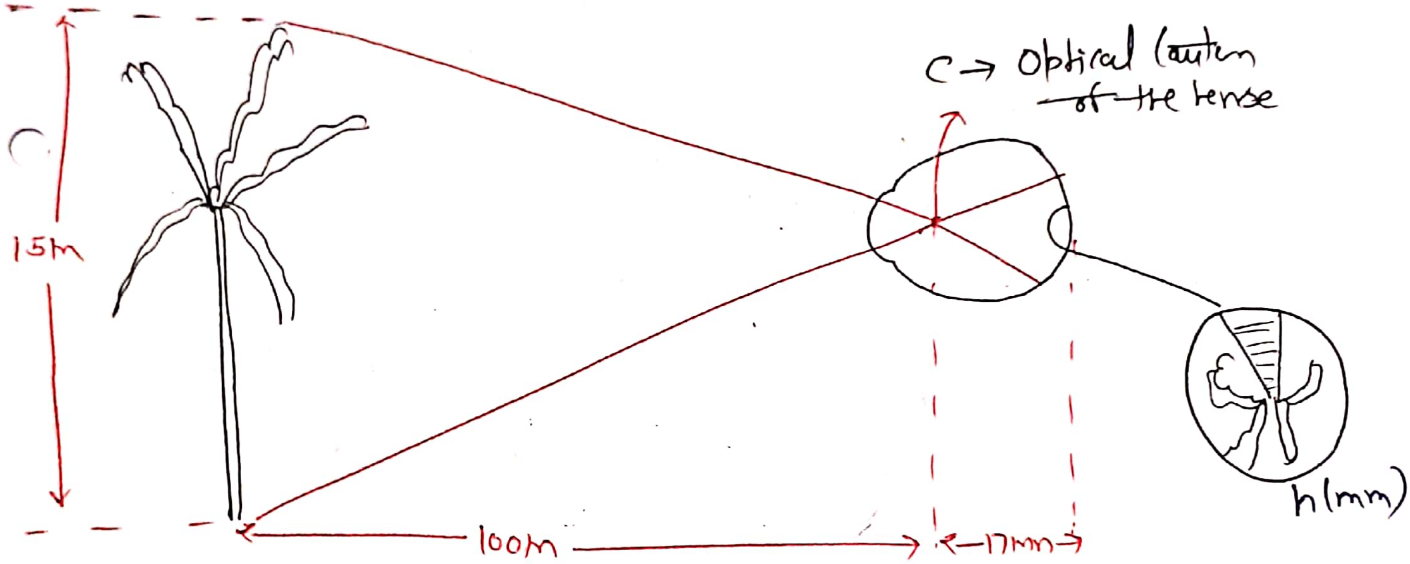
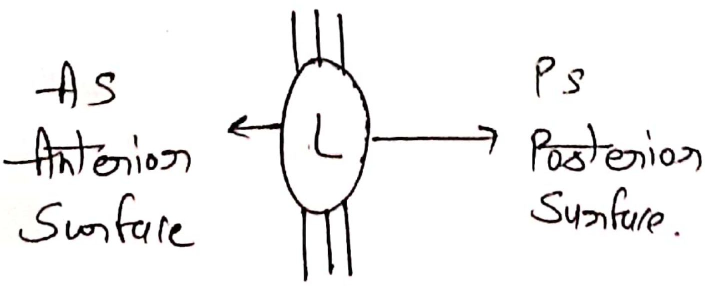
Image formation in an Eye



If eye is properly focus on the object The object is appear on the retina. If the lens is suspended through the fibers



AS > PS

Scanned by CamScanner

for focusing the object the lense define the surface to be flatenend. This muscle allow the lens become thick to observe the object of the distance. If the object is neares than the focus will be reduced by the lense of the observer.

The distance between c and retina is called the focal length. It vary from 14mm to 17mm.

The variation is happen when reflective power increases from maximum to minimum.

If the object is far away the lense will reflect the less objective power or lowest reflective power.

$$\frac{15}{100} = \frac{h}{17}$$

$$\Rightarrow \boxed{h = 2.55mm.}$$

The retinal image reflected in the internal portion of the phobia.

Scanned by CamScanner

Colour Image Processing

It is very important and motivated by two principal factor

→ Easily identify the object of the colour image

→ Human Eye can identify thousand of colour image

it divided into two major factor

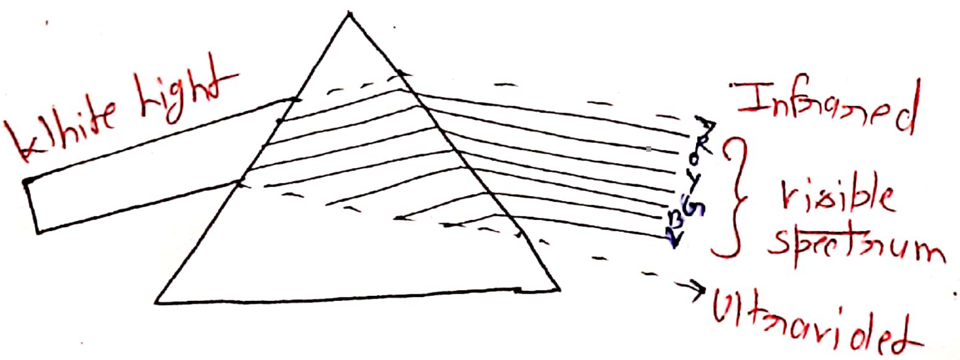
(a) full color Processing

(b) Pseado Color Processing

In full colour the image are determined by the full colour sensor such as t.v., camera, color scanner

but in the Pseado color is assign to the particular colour or intensity of the colour. or Range of the intensity

Colour fundamental



When beam is pass from the prism it represents as the range of continuos color spectrum violet at the one end and infra red to the other hand it divided into six region, violet, blue, green yellow and orange

A colour is the nature of the light reflected from the object.

⇒ A body that reflects light that is ~~visible~~ balanced in all visible wavelength is showed as white

⇒ The light reflected in limited range of visible spectrum it shows some shade of colour

Green object reflect the light 500 to 570nm range

⇒

Achromatic light Viewers can see black and white television set. It attributes is intensity or grey level.

Chromatic light. spends the electromagnetic spectrum. The range of ray is 400-700nm

it use in radiance, luminance and brightness.

Radiance Total energy flows from light source

Luminance measure the amount of energy and observer able to find out

Brightness it depending on the intensity of light

Q1 An image is 2400 pixel wide and 2400 pixels high. The image was scanned 300dpi. What is the physical size of image?

Ans Physical Size =

$$\frac{\text{No of pixels in width}}{\text{Resolution}} \times \frac{\text{no of pixels in height}}{\text{Resolution}}$$

$$= \frac{2400}{300} \times \frac{2400}{300} = 8\text{inch} \times 8\text{inch}$$

Q2 A Scenic image whose physical dimension is 2.5 inch x 2 inch on paper is scanned at 150dpi. How many pixels would be there in the scanned image?

Ans No of pixels = Physical Dimension x Resolution

$$(2.5 \times 150) \times (2 \times 150)$$

$$375 \times 300 = 112500 \text{ pixels}$$

Q2 Given a grey scale image of size 5 inch by 6 inch scanned at the rate of 300 dpi, Answer the following

1. How many bits are required to represent the image
2. How much time is required to transmit the image if the modem is 28kbps
3. Repeat the aforementioned if it were a binary image.

Ans (i) No of bits required to represent grey scale.

$5 \times 300 \times 6 \times 300 \times 8 = 21600000$ bit.

($\because$ Grey scale required 8 bit)

(ii) Total time taken to transmit image

$$= \frac{\text{Total no of bits in image}}{\text{Transmission Speed}}$$

$$= \frac{21600000}{28000} = 771.43 \text{ sec.}$$

(iii) if it is binary image then the no of bit required to represent binary image

$= 5 \times 300 \times 6 \times 300 \times 1 = 2700000$ bit.

Total Transmission time.

$$= \frac{\text{Total no of bits}}{\text{Transmission Speed}} = \frac{2700000}{28000} = 96.429 \text{ sec.}$$

~~it~~ 1D idea can also be used for 2D images. 2D function is known as comb. function. It is arranged by ~~rectangular~~ pulse seperated by Δx and Δy. 2D sampling can be viewed as the multiplication ~~of~~ ~~the~~ sailing function and continous function ~~to~~ give discreate sample.

The value ~~of~~ Δx and Δy will be same for the horizontal and vertical ~~point~~ so ~~the~~. pixel is always in a square shape pixel. It is called pixel aspect ratio. The size of pixel is important for image quality. If ~~the~~ size is large, there will be lesser no. of pixel. Hence ~~the~~ details become less, which make ~~the~~ image blurred and meaningless.

It is called pixelization error

The ideal size is given by Shannon Nyquist theorem. So ~~the~~ sampling freqtion. should be greater ~~than~~ or equal ~~to~~ $2 \times f_{max}$, when ~~fmax~~ is ~~the~~ highest frequenty present in image.

(distance) $d \leq \frac{1}{2 f_{max}}$

The other frequency used for sampling is the Nyquist frequency. The Nyquist frequency (f_N) is $\frac{1}{2}$ x sampling frequency. So it should be greater than or equal to the fmax.

If the sampled image has frequencies higher than the Nyquist frequency the result is called alising.

Resampling

In scaling, the number of pixels should be increased for retaining the image quality. It can be done by resampling and downsampling

1. Downsampling the image is scaled down half by reducing the sampling rate. It is done by choosing the alternating sample. It is also known as image reduction. It is performed by replacement of group of pixels by arbitrary chosen pixel value.

f =

3	3	3	3
9	9	9	9
3	3	3	3
9	9	9	9

Subsampling can be done by choosing an upper left pixel and replacing the neighbourhood with a chosen pixel value.

$$f = \begin{bmatrix} 3 & 3 \\ 3 & 3 \end{bmatrix}$$

It is called single pixel selection.

$$f = \begin{bmatrix} \frac{3+3+9+9}{4} & \frac{3+3+9+9}{4} \\ \frac{3+3+9+9}{4} & \frac{3+3+9+9}{4} \end{bmatrix} = \begin{pmatrix} 6 & 6 \\ 6 & 6 \end{pmatrix}$$

Replication is called a zero hold order process when each pixel along the scan line is repeated once.

for example $f = \begin{pmatrix} 2 & 1 \\ 1 & 3 \end{pmatrix}$ is replicated as follows:

2	0	1	0
0	0	0	0
1	0	3	0
0	0	0	0

H =

it is called zero hold process. once the zero one uploaded it can be upload by row and column.

2	2	1	1
2	2	1	1
1	1	3	3
1	1	3	3

Image Quantization

A natural image has continuosly varying shade and colour it is known as continuos image. It is necessary to convert tore image to the disrcreate image where grey tone or brightness are used.

Image quantization is the process of converting sampled analog pixel intensity into a discreate valued integer. It has a continuos value x into the discreate value x'.

The process of quantization involves partioning of input value into equally spaced interval. The end point of image are called decision boundaries.

$B = \{b_0, b_1 \dots b_m\}$

The length of image input range is from $-X_{max}$ to $+X_{max}$.

The length of the interval between succesive decision boundaries is called the step size

DETAILED LECTURE NOTES

~~The step size~~ is given by $(2 \times X_{max}) / m$

The midpoint between successive decision and boundaries is called ~~the output~~ or reconstruction level.

~~The two types of~~ quantizer is used midrise and midtread.

Midtread is used when ~~the~~ image ~~of output~~ levels are even, midrise is associated with an odd number ~~of~~ levels. Midtread also produces 0 as an ~~output~~ if necessary.

When $\Delta = 1$

Quantizer = midrise (x): $[x] - 0.5$

Quantizer - midtread $(x) = [x + 0.5]$

The difference between the actual value and quantized reconstructed value is called quantization error. The quantization is in the range $(-\Delta/2$ to $\Delta/2)$. The number of bit is necessary to encode the o/p level is given by $R = \log_2 m$

If the number of bit is reduced, the quality of image decrease and false contouring effect occur.

~~output~~ sensor → continuos r & g
~~it~~ convert continused sensed data in the digital form.

Image → Continuos → x & y amplitude
↳ Amplitude.

Digital form → Sample → x & y
↳ Amplitude

Digitizing co ordinate value
⇓
'Sampling'

{ digitized x/y codinates of the continuos time signal

Digitizing Amplitude values
⇓
'Quantization'

{ digitized the amplitude of the continuos time signal known as quantization

Image Enhancement

There are two types of image enhancement

These are

→ Qualitative Enhancement

→ Quantitative Enhancement

⇒ Qualitative Enhancement refer to modification of image to make it more appealing to human for applying different type of filter on instagram to make the photos look better is qualitative enhancement.

⇒ Quantitative Enhancement refers to the modification of information that an images carries In edge detection process the edge is the necessary information

Some example. the image analysis of coin band.

The main purpose of image enhancement to see the clear visual information.

It depends on the information the user is expecting to extract from the image

→ The first condition of image enhancement that information must exist in the image

→ The second condition that image must not be swamped by noise, if information having noise than the information cannot be enhancement.

The main goal of image enhancement is to process image to make it suitable for a required task than the original one

Cones in ~~the~~ human high is responsible for the color vision. There are ~~for~~ ~~the~~ color 3 principal ~~categories~~ (6 to 7 million cones)

R G B → Primary color

R → 65%, G → 33%, B → 2%

$\underbrace{65\% \quad 33\% \quad 2\%}_{\text{Sensitive Ratio}}$

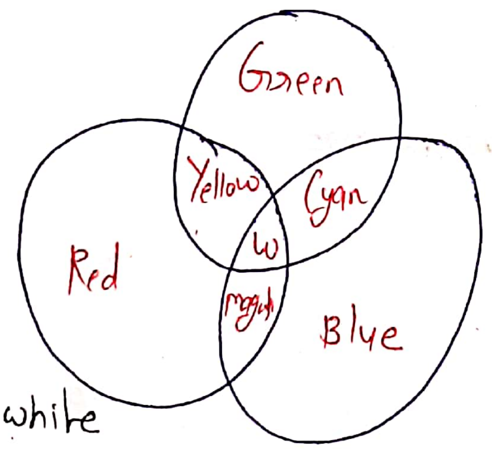
By mixing Primary color ~~the~~ secondary colour can be find.

→ magenta, Cyan & Yellow

magenta → R+B

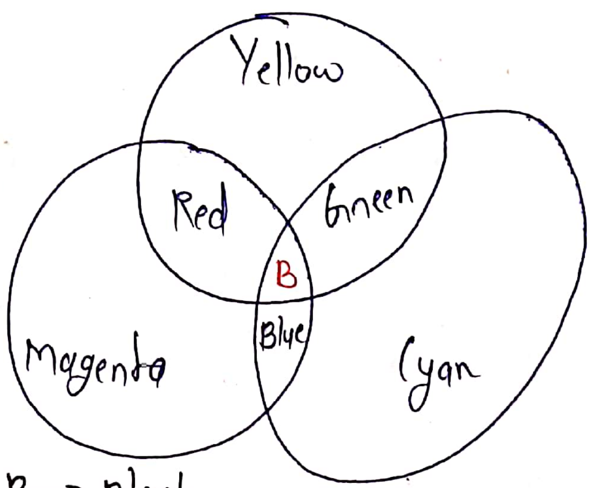
Cyan → G+B

Yellow → R+G



W = white

mixture of light



B → Black

mixture of Pigment

Characteristics of distinguish of different color.

→ Brightness (depend on the intensity of light)

→ Hue (Dominant color observed by observer)

→ Saturation (All color are fully saturated, some color are less saturated these are pink & lavender)

Types of Images

1. Binary Image — 0 & 1 → monochrome

   0 ↓ Black, 1 White

2. 8 bit color format

   $2^8 = 256$ colour

   0 ↓ Black color — 127 Grey color — 255 White color

3. 16 bit color

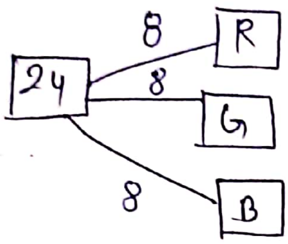
   $2^{16} = 65{,}536$ High color format

   16 → R — 5 bit
   16 → G (6) —
   16 → B 5

   1 bit assign to green color because it is very smoothing to eyes

4 24 bit color

True color



Black (0, 0, 0)
White (255, 255, 255)
Red (255, 0, 0)
Green (0, 255, 0)
Blue (0, 0, 255)
Grey (128, 128, 128)

5. Cmyk model

C – Cyan (0, 255, 255)

(255, 0, 255)

m → magenta

Y → Yellow (255, 255, 0)

k → black

used in printer two cartons

mix Black

Conversion

RGB to Hex

1. Take color (255, 255, 255) white.

$$\begin{array}{r|l} 16 & 255 \quad 15 - F \\ \hline & 16 \\ \hline & 95 \\ & 80 \\ \hline & 15 - F \end{array}$$

↓

(FF FF FF)

for all 255

Hex to RGB

1. take Hex no (FF FF FF)

↓

F → 1111 = 256

So the conversion (255, 255, 255)

RGB to Gray

Two method

1. Average method
2. Weighted method or luminosity method

1. Average method — Gray image = $\frac{R+G+B}{3}$

take the average because all these colours have diffrent wavelength

2. Weighted ~~method~~

→ Red colour has more wavelength to all three

→ Green have less wavelength ~~but~~ have very smoothing to our eyes.

Scanned by CamScanner

New grey image = $(.3 \times R) + (.59 G) + (.11 B)$

30% of Red
59% of Green
11% of Blue

Sampling and Quantization Relationship with Pixel

if we are doing only sampling the signal is not converted into digital format.
Quantization is also needed

if 5 row and 5 column.

Pixel (total no) = total no of Row x Total no of Column

$25 = 5 \times 5$

Total pixel = 25

Sampling → up sampling (over sampling & Zooming)
Sampling → Down Sampling

Q What is the difference between sampling and Zooming?

Sampling on signal
Zooming on digital image

Resolution : n x m

~~if~~ resolution high (↑) Quality of image (↑) high.

Mega Pixel

$m \times n$ / 1 milion

$$\boxed{\text{size of image} = \text{no of pixel} \times \text{bpp}}$$

Image Dimension 2500 x 3192

$$\text{Resolution} = \frac{2500 \times 3192}{1000000} = 7.98 \simeq 8 \text{MP}$$

Aspect Radio

~~Another~~ important concept with the pixel resolution is aspect Ratio

$$\text{aspect Ratio} = \frac{\text{width of image}}{\text{length of image}} = \frac{c}{r}$$

Example ~~Aspect~~ Ratio = 6 : 2

Pixel Resolution = 480000

Bits per pixel grayscale image = 8 bpp

Find no of Rows ?

no. of coloumn ?

= $AR = \frac{6}{2} = \frac{C}{R} \Rightarrow C = \frac{6R}{2}$ ... (1)

Pixel Resolution = $480000 = R \times C$

$C = \frac{480000}{R}$ ... (2)

using (1) and (2)

$$\frac{6R}{2} = \frac{480000}{R}$$

$$R^2 = \frac{480000 \times 2}{6}$$

$$R = 400$$

$$C = \frac{6}{2} \times R \Rightarrow \frac{6}{2} \times 400 = 1200$$

size of image

$= r \times c \times bpp$

$= 400 \times 1200 \times 8$ bits

$= \frac{480000 \times 8}{800000}$ bytes

$= \frac{480000}{1024}$ KB

$\simeq 48$ kb

Zooming Method

(i) Pixels Specification or nearest neighbour

(ii) Zero Order Hold method interpolation

(iii) Zooming k times.

(i) Pixel Specification

→ As name suggest just replicate the neighbouring pixels

→ Suppose we have image

1	2
3	4

$\xrightarrow{\text{Zoom in}}$ Row wise (2 times)

1	1	2	2
3	3	4	4

↓

(2×2)×2 times Zoom → (4×4)

1	1	2	2
1	1	2	2
3	3	4	4
3	3	4	4

(4×4)

Advantage :– Very Simple

Disadvantage :– Output image get blur and if zooming factor increased, the image got more and more blured

(ii) Zero Overhold

This known as zoom twice (i) Pick two adjacent element from the row respectively add them and divide the result by two of them. place the result in between two

Image (2x2)

1	2
3	4

Row wise Zooming :–

1	1	2
3	3	4

$(2+1) = 3/2 \Rightarrow 1.5 \simeq 1$

$(4+3) = 7/2 \Rightarrow 3.5 \simeq 3$

Coloum wise Zooming

1	2
2	6
3	4

$1+3 = 4/2 = 2$

$4+2 = \frac{6}{2} = 3$

Size of image :- [2 (no of row) -1] x
[2 (no. of column) -1)

$= (2 \times 2 - 1) \times (2 \times 2 - 1) = 3 \times 3$

Advantage : Does not create blurry image as compare to nearest neighbour Interpolation

Disadvantage: It only run on the power of 2. like we have image of 2x2 and want to zoom 6 time than

$(6 \times 2 - 1)(6 \times 2 - 1)$

11×11

(iii) K- times Zooming

One of the perfect zooming method.

Steps:- (i) Take two adjacent pixel and than subtract smaller from the greater one.

(ii) Divide the o/p with zooming factor. Now add result in the smaller value in b/w the adjacent pixel

(iii) Repeat ~~step~~ (ii) for place (k-1) values Add o/p in the current calculated value.

(iv) Repeat ~~steps~~ for all row and column.

(v) Get zoomed image.

Row Wise Zooming :-

15	30	15
30	15	30

Zoom three times

k = 3

(i) 15 30 = 30 - 15 = $\frac{15}{3}$ = 5 (o/p) same for column 2 and 3.

30 15 30 - 15 = $\frac{15}{3}$ = 5 o/p

(ii) now add 5 into 15 because 15 is the smaller value

15	20	25	30	20	25	15
30	20	25	15	20	25	30

Add ~~output~~ to the last value.

Add o/p to smaller value 15 + 5 = 20

(iv) Repeat same ~~steps~~ for last two pixel.

So Row wise zooming is present

15	20	25	30	20	25	15
30	20	25	15	20	25	30

After inserting the value ~~sort~~ the value sort in ascending order according to inserted value in ascending order smaller value.

So new table

15	20	25	30	25	20	15
30	25	20	15	20	25	30

Column Wise Zooming:-

(i) Calculate the difference b/w adjacent value pixels

(30-15) → 15/3 → 5
(25-20) → 5/3 → 1
(25-20) → 5/3 → 1
(30-15) → 15/3 → 5
(25-20) → 5/3 → 1
(25-20) → 5/3 → 1
(30-15) → 15/3 → 5

o/p

New Table.

15	20	25	30	25	20	15
20	21	21	25	21	21	20
25	22	22	20	22	22	25
30	25	20	15	20	25	30

New image size:—

old image size = 2×3

new Image size = 4×7

formula : (k(no of Row − 1) + 1) ×
[k(no of coloum − 1) + 1]

$= (3\times(2-1)+1) \times (3\times(3-1)+1)$

$= (3\times1+1) \times (3\times2+1)$

$= 4\times7$

Advantage :— it give improved Result and componize the power of two algorithm

Disadvantage: In the end sort the pixel value, which Inncrease the cost of computation.

POORNIMA
COLLEGE OF ENGINEERING
DETAILED LECTURE NOTES

Distance Measures

~~for~~ pixel p, q, and z with co-ordinate
(x, y) (s, t) ↳ (v, w)

distance function or ~~metric~~ c ~~if~~ following properties satisfy

(i) $D(p, q) \geq 0 \; (D(p,q) = 0 \text{ iff } p = q)$

(ii) $D(p, q) = D(q, p)$ and

(iii) $D(p, z) \leq D(p, q) + D(q, z)$

~~it~~ is called ~~the~~ property of ~~trigular~~ inequality.

① The Euclidean distance b/w p and q is defined

$$D_e(p, q) = [(x-s)^2 + (y-t)^2]^{1/2}$$

(2) D_4 distance or city block distance b/w p, q is $D_4(p, q) = |x-s| + |y-t|$

So the pixel having a D_4 distance from (x, y) less than or equal to some value r and form a diamond convented at (x, y)

D_4 distance ≤ 2 $\quad (x, y) \rightarrow$ Centerpoint

$$\begin{array}{ccccc}
 & & 2 & & \\
 & 2 & 1 & 2 & \\
2 & 1 & 0 & 1 & 2 \\
 & 2 & 1 & 2 & \\
 & & 2 & &
\end{array}$$

if $D_4 = 1 \rightarrow$ 4 neighbour of (x, y)

(3) D_8 distance (chess board distance) b/w p and q

$$D_8(p, q) = \max(|x-s|, |y-t|)$$

So the pixel with D_8 distance from (x, y) less than or equal to some value form a square centered at (x, y)

D_8 distance ≤ 2 $\quad (x, y)$ — Center point

2	2	2	2	2
2	1	1	1	2
2	1	0	1	2
2	1	1	1	2
2	2	2	2	2

if pixel $D_8 = 1$ are 8 neighbours of (x, y)

Example

p(2, 2)
q = (1, 1)

	1	2	3
1	q		
2		p	
3			

Euclidian Distance

$$\left((1-2)^2 + (1-2)^2 \right)^{1/2} = (1+1)^{1/2} = (2)^{1/2}$$

$D_4 = |1-2| + |1-2| = 2$

$D_8 = \max(|1-2|, |1-2|) = 1$

Example

use D_4 Distence

	1	2	3
1		d	
2	a	p	c
3		b	

a = (2, 1)
b = (3, 2)
c = (2, 3)
d = (1, 2)
p = (2, 2)

Pixel A : $|2-2| + |2-2| = 1$

Pixel B : $|3-2| + |2-2| = 1$

Pixel C : $|2-2| + |3-2| = 1$

Pixel D : $|1-2| + |2-2| = 1$

$D_0 - D_8$ (distance)

Distance Matrix

→ Dm distance is defined as the shortest m path b/w the point

→ In this case, the distance b/w two pixel will depend on the value of the pixel along the path, as well as the value of their neighbours

Ex: Consider the following arrangement of pixel Assume P_1 P_2 and P_4 have value 1 and P_1 and P_3 can have value 0 or 1

$V = \{1\}$

	P_3	P_4
P_1	P_2	
P		

Case 1:

if $P_1 = 0$ & $P_3 = 0$

The length of shortest path m path is

2 (P, P_2, P_4)

Case 2

if $P_1 = 1$ and $P_3 = 0$

```
  0 1
1 1
1
```

then length of the shortest path

3 (P, P_1, P_2, P_4)

Case 3

if $P_1 = 0$ & $P_3 = 1$

```
  1 1
0 1
1
```

same 3 (P, P_2, P_3, P_4)

Case 4:

if $P_1 = 1$ $P_3 = 1$

```
  1 1
1 1
1
```

length

4 (P, P_1, P_2, P_3, P_4)

Resampling

→ During the scaling of an image, the number of pixels should be increased to retain image quality.

→ Pixels are reduced for better compression.

→ Their increase and decrease of the no. of pixel is called resampling. It is in the two form.

(1) Downsampling (subsampling)

(2) Upsampling

→ spatial resolution techniques in which image is scaled down by half by reducing the sampling rate.

→ This is done by replacement of a group of pixels by an arbitrary chosen pixel value.

single pixel selection

$$f = \begin{array}{|c|c|c|c|} \hline 3 & 3 & 3 & 3 \\ \hline 9 & 9 & 9 & 9 \\ \hline 3 & 3 & 3 & 3 \\ \hline 9 & 9 & 9 & 9 \\ \hline \end{array} \Rightarrow \begin{bmatrix} 3 & 3 \\ 3 & 3 \end{bmatrix}$$

or $\frac{3+9+3+9}{4} = 6$ $\quad f = \begin{bmatrix} 6 & 6 \\ 6 & 6 \end{bmatrix}$

Scanned by CamScanner

Upsampling: ~~it~~ can be done using replication or interporation

Replication: Zero hold process, whereas each pixel along the same line is repeated once. ~~than~~ the scan line is repeated

Interpolation: Linear Interpolation is equalent to fitting a ~~straight~~ line by taking the average along the rows and colums.

$\Downarrow$

$$f = \begin{bmatrix} 2 & 1 \\ 1 & 3 \end{bmatrix} \Rightarrow \begin{bmatrix} 2 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & 0 & 3 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$\Downarrow$

$$\begin{bmatrix} 2 & 2 & 1 & 1 \\ 2 & 2 & 1 & 1 \\ 1 & 1 & 3 & 3 \\ 1 & 1 & 3 & 3 \end{bmatrix}$$

$$f = \begin{bmatrix} 2 & 1 \\ 1 & 3 \end{bmatrix} \Rightarrow \begin{bmatrix} 2 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & 0 & 3 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$\downarrow$ 2. Interpolation. (avg of column)

For Row

$$\begin{bmatrix} 2 & 1.5 & 1 & 0.5 \\ 1.5 & 1.75 & 2 & 1 \\ 1 & 2 & 3 & 1.5 \\ 0.5 & 1 & 1.5 & 0.75 \end{bmatrix} \leftarrow \begin{bmatrix} 2 & 1.5 & 1 & 0.5 \\ 0 & 0 & 0 & 0 \\ 1 & 2 & 3 & 1.5 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

(For Column)

Q. Assume 1-D image f= [23 45 60], perform upsampling using zero-hold interpolation and linear interpolation

Ans zero-hold = 23 0 45 0 60 0
[23 23 45 45 60 60]

Linear f = [23 24 45 53 60 30]

Q Apply linear interpolation

$$f = \begin{bmatrix} 0 & 7 \\ 3 & 15 \end{bmatrix}$$

Ans

$$\begin{bmatrix} 0 & 3.5 & 7 & 3.5 \\ 1.5 & 6.25 & 11 & 5.5 \\ 3 & 9 & 15 & 7.5 \\ 1.5 & 4.5 & 7.5 & 3.75 \end{bmatrix}$$

Q Let $V = \{0, 1\}$ compute D_e, D_4, D_8 and D_m distance b/w two pixel p and q.

$p(3, 0)$
$q\ (2, 3)$

$$\begin{array}{c|cccc} & 0 & 1 & 2 & 3 \\ \hline 0 & 0 & 1 & 1 & 1 \\ 1 & 1 & 0 & 0 & 1 \\ 2 & 1 & 1 & 1 & 1 \rightarrow q \\ 3 & 1 & 1 & 1 & 1 \end{array}$$

$\downarrow$ p

$D_e =$

$$\sqrt{(3-2)^2 + (0-3)^2}$$

$$\sqrt{1^2 + 9} = \sqrt{10}$$

$$D_4 = |3-2| + |0-3|$$

$$D_4 = 4$$

$$D_8 = \max(|3-2|, |0-3|)$$

$$D_8 = 3$$

D_m ~~If~~ $\quad V = \{1\}$

$$\begin{array}{cccc} 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ & & & \uparrow \\ 1 \rightarrow & 1 \rightarrow & 1 \rightarrow & 1 \end{array}$$

4 path length

$p = (0, 0)$
$q = (4, 4)$

Q Compute D_4 . D_8 D_m

(i) $V = [2, 3]$

(2) $V = [2, 6]$

D_4, D_8 don't spend on V value

only D_m depend on V value

$D_4 = |4-0| + |4-0|$

$= 8$

$D_8 = \max(|4-0|, |4-0|)$

$= 4$

$D_m =$ ~~not~~ possible (no path)

$V(2,3)$

$$\begin{array}{c|ccccc} & 0 & 1 & 2 & 3 & 4 \\ \hline 0 & 2 & 3 & 2 & 6 & 1 \\ 1 & 6 & 2 & 3 & 6 & 2 \\ 2 & 5 & 3 & 2 & 3 & 5 \\ 3 & 2 & 4 & 3 & 5 & 2 \\ 4 & 4 & 5 & 2 & 3 & 6 \end{array}$$

p, q

Q $V = \{0, 1\}$ find $= \{1, 2\}$

q

$$\begin{bmatrix} 3 & 1 & 2 & 1 \\ 2 & 2 & 0 & 2 \\ 1 & 2 & 1 & 1 \\ 1 & 0 & 1 & 1 \end{bmatrix}$$

p

(i) 4 adjacent

~~not~~ possible

(ii) 8- adjacent

3	1	2	1
2	2	0	2
1	2	1	1
1	0	1	1

3) m- path

3	1	2	1
2	2	0	2
1	2	1	1
1	0	1	1

Neighbourhood of Pixels

Basic Relationship of the pixel

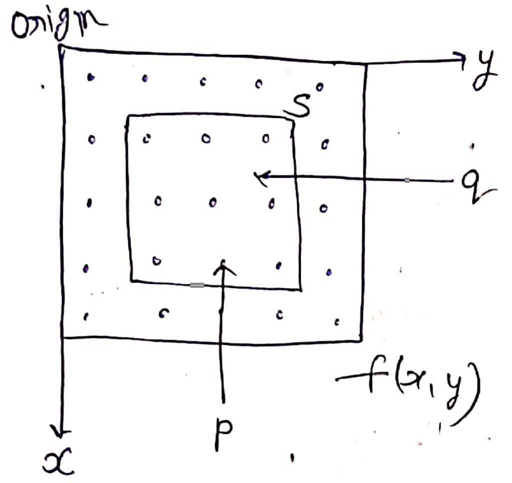
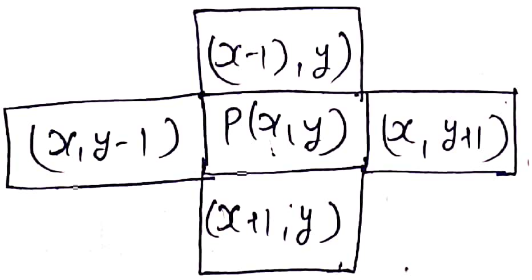


Image = $f(x, y)$

S = subset of pixels

q, P → Particular Pixels

4 Neighbours [$N_4(P)$]



2 Horizontal $(x, y-1)$ $(x, y+1)$

2 Vertical $(x-1, y)$ $(x+1, y)$

$N_4(P) = (x, y-1), (x, y+1), (x-1, y), (x+1, y)$

Diagonal Neighbours $[N_D(p)]$

$(x-1, y-1)$		$(x-1, y+1)$
	$P(x, y)$	
$(x+1, y-1)$		$(x+1, y+1)$

$N_D(p) = (x+1, y-1), (x-1, y-1), (x-1, y+1), (x+1, y+1)$

8 Neighbours $[N_8(p)]$

$(x-1, y-1)$	$(x-1, y)$	$(x-1, y+1)$
$(x, y-1)$	$P(x, y)$	$(x, y-1)$
$x-1, y+1$	$(x+1, y)$	$(x+1, y+1)$

Connectivity / Adjacent

1. 4 adjacency
2. 8- adjacency
3. m- adjacency. (mixed adjacency)

Binary Image $V = \{1\}$

$$\begin{matrix} 0 & 1 & 0 & 1 \\ 0 & 0 & \boxed{1} & 0 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \end{matrix}$$

8 adjacency

4 adjacency

Gray Scale Image

[0 - 255] $V = \{0, 1, 2, 3 \cdots 10\}$

54	10	100	5
81	150	$\boxed{2}$	34
201	200	3	45
7	70	147	56

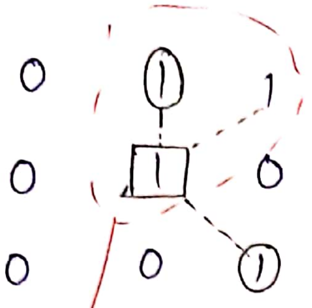
8 adjacency.

4 adjacency.

not connected

m-Adjacency (mixed adjacency)

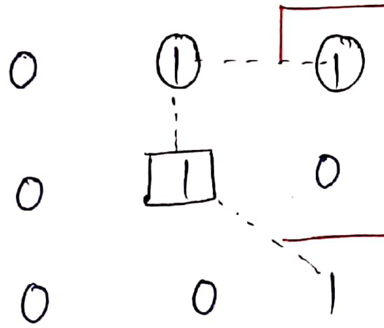
is equal to the 8 adjacency ~~but it~~ remove the ambiguity is arrive for in 8-adjacency.



$$\begin{matrix} 0 & 1 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix}$$

→ ambiguity that connected through which part

∵ if straight line connection is easily mentained than follow the given path. beside that the diagonal part.



N_4 adjacency.

Diagonal adjacency.