Day: Friday :)

Date: 06/09/24

Image:

Can be described as:

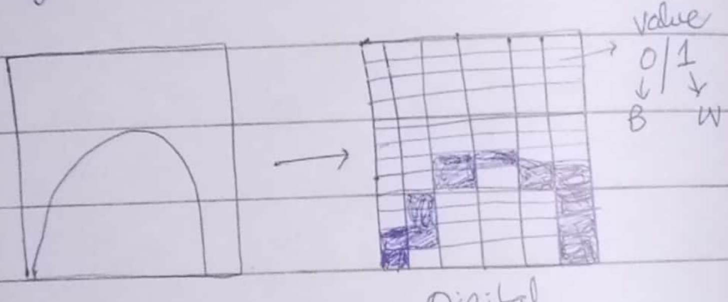
→ What objects are available in the image.

→ What are the properties of the object.

→ What are the relationships b/w the objects.

Image Acquisition:

→ main source to acquire any image is light



Continuous Digital Image

bits ⇒ only on & off

grey shade ⇒ 0 — 255 (intensity value)

0 → Black, between → shades of grey, 255 → White

→ Image is a function

$f(x, y)$ where x is row, y

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is column

amplitude of f at any point/pair of coordinates is intensity.

suppose: $f(x,y) = f(3,5) = 200$

Digital image:

→ When x, y and amplitude values of f are finite, discrete quantities

→ One cell of a grid is pixels.

→ Digital image is expressed as 2 dimensional matrix.

$$\begin{array}{cc} & \text{columns} \rightarrow \\ \text{rows} \downarrow & \begin{matrix} f(0,0) & \cdots & \cdot \\ \cdot & \cdots & \cdot \\ \cdot & \cdots & f(M-1,N-1) \end{matrix} \end{array}$$

Types of image:

Based on intensity value.

→ Gray Scale Image : IV (0-255)

→ Black & White : IV (0, 1)

→ Color Images : RGB

R(0-255), G(0-255), B(0-255)

Zero 0 means off (NO color)

(0,0,0) ..... (255, 255, 255)

Black White 256^3

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$$\begin{array}{c|l} 2 & 8 \\ \hline 2 & 4-0 \\ \hline 2 & 2-0 \\ \hline & 1-0 \end{array} \qquad \begin{array}{c|l} 2 & 12 \\ \hline 2 & 6-0 \\ \hline 2 & 3-0 \\ \hline & 1-1 \end{array}$$

$8 = (1000)_2$ $12 = (1100)_2$

$$\begin{array}{c|l} 2 & 16 \\ \hline 2 & 8-0 \\ \hline 2 & 4-0 \\ \hline 2 & 2-0 \\ \hline & 1-0 \end{array}$$

$16 = (10000)_2$

0, 1 ⇒ 1 bit

0–255 ⇒ 8 bits

Digital Image Processing:

DIP refers to process digital image by digital computer

Computer Vision:

→ Vision is about discovering what is present and where is present?

→ In CV, camera is attached to the computer.

* Computer Graphics ⇒ Models to Images
* Image Processing ⇒ Images to Images
* Computer Vision ⇒ Images to Models

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Human Vision Vs Computer Vision

→ Humans are better when no. of objects and properties are high.

→ Computers are better when recognition of objects & counting

→ Low level Process:

Input : Image

Output : Image

Examples : Noise Removal / Image Sharpening

→ Mid level Process:

Input : Image

Output : Attributes

Example : Object Recognition, Segmentation

objects ki location identify

→ High level Process:

Input : Image

Output : Understanding

Example : Making Sense of resembled objects

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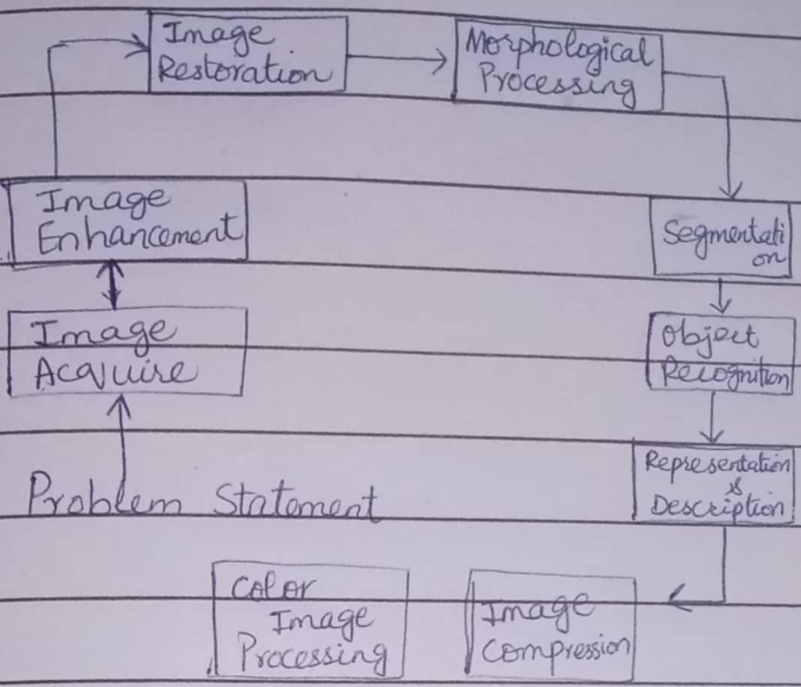
Stages of Image Processing



* Image Enhancement:

→ Edges sharp krna etc.

* Image Restoration:

→ Jis waja sy image kharab hoi he usy restore krna.

* Segmentation:

→ Sperration of objects based on their properties.

S t a g e s

↓ segment

S recognizes as S.

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Image Sampling and Quantization:

→ Human eye see objects in terms of analog signals

→ Computer see objects in terms of digital signal

Sampling:

digitization of coordinates values.

$F(x,y)$ = ampli/inten

Quantization:

digitization of amplitude values.

→ Image enhancement is to improve the quality of given image.

In Spatial domain,

an operation (linear/non-linear) is performed on pixels in the neighborhood of image $F(x,y)$ giving enhanced image $F'(x,y)$

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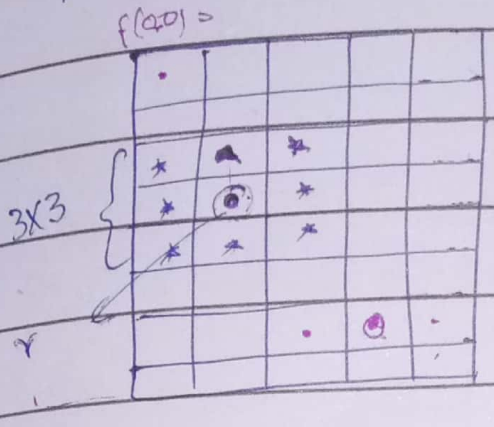
Grey Scale Manipulation



0 – 255

→ Simplest form of window (1X1)

→ $S = C(r)^n$

$r \Rightarrow$ intensity value of pixel

$c \Rightarrow$ constant

after calculating S replace r with 'S'.

Image.

Zooming:
Process of looking at the details of image by enlarging it.

Pixels:
Stores value proportional to the light intensity at that specific location.

Resolution: (height & width)
No. of rows X No. of columns

In Mega px = $\frac{\text{Row} \times \text{No. of Columns}}{10 \text{ Lac}}$

Example:

No. of rows = 2500

No. of columns = 3192

Pixels resolution = No. of rows X No. of columns

= 2500 * 3192

= 7980000 bytes

7980000/10Lac = 7.98 Mega pixels

Size = RXC X bpp - bits per pixels

bpp ⇒ how many ~~pix~~ bits are required to represent pixel.

→ having value of 2 bpp means 2 bits are required to represent pixel.

00 ⇒ 0

01 ⇒ 1

10 ⇒ 2

11 ⇒ 3

For RGB ⇒ bits (24 required)

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For Black n white $\Rightarrow$ 1 bit require

Grey image $\Rightarrow$ 8 bits

Aspect Ratio

→ Relation b/w height & width of an image.

Example:

Aspect Ratio = $6 : 2$ (6 = w, 2 = h)

pixel resolution = 480000

Bpp = 8

Calculate

i- dimension

ii- Size of an image

Width = colums, height = rows

As aspect ratio = $6:2$

$$w \times h = 6 : 2$$

$$w \times 2 = 6 \times h$$

$$w = \frac{6h}{2} \quad \text{--- (i)}$$

Also:

pixels resolution = $r \times c$ ($\because r = h$, $c = w$)

$$480000 = h \times w$$

$$h = \frac{480000}{w} \quad \text{--- (ii)}$$

... h in (i)

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$$W = \frac{6 \times 480000}{2W}$$

$$W^2 = 1440000$$

(No. of col) $W = 1200$

Now put this value in (ii)

$$h = \frac{4800\cancel{00}}{12\cancel{00}}$$

(No. of rows) $h = 400$

$\cancel{h \times} w \times h$

Dimensions $= \cancel{1200 \times 400 \text{ pixels}}$

400×1200

Size $= R \times C \times bpp$

$= 1200 \times 400 \times 8$

$= 3840000$ bits

$= 3840000/8$ bytes

$= 480000$ bytes

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

$= 468.75$ KB

Keep Smile :)

⇒ Spatial Resolution:

→ called pixel resolution

→ clarity cannot be determined by pixel resolution.

→ Smallest visible detail in an image, no. of independent pixels values per inch.

Types:

→ Pixel Size : Computer Vision

→ Dots per inch : (usually used in monitor)

→ Lines per inch : use in printer

→ Pixels per inch : Smart devices as tablets, Mobile phone etc.

⇒ Intensity Level Resolution:

→ NO of intensity levels used to represent image

→ Finer level details are obtained by more intensity level.

Bits	intensity level
1	2

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Low intensity level:
→ Low details
→ Less bits are required

High intensity level:
→ High details
→ More bits are required

How much resolution is Enough?
→ depends on the scope of problem we are solving
For inner details ⇒ More resolution
For outer ⇒ Less resolution

Image Enhancement

→ Process of improving the quality of an image.
→ To understand image and extract features.

Reasons:
→ Remove unwanted info, remove noise
→ Making images more visually appealing

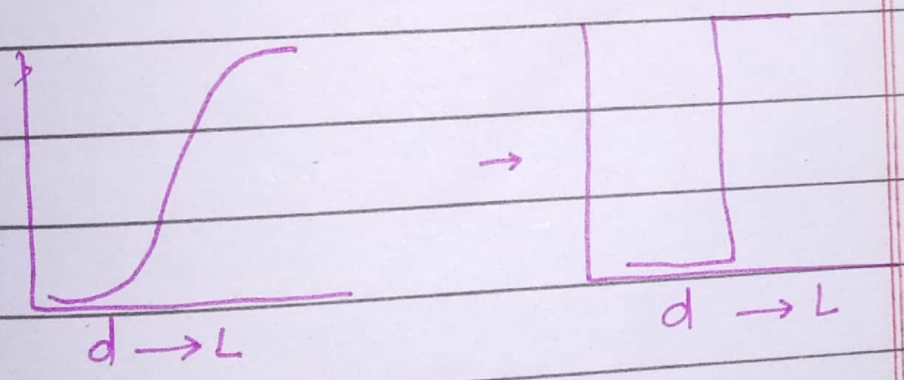
→ Highlighting interesting details in images i.e, sharpen the boundaries to differentiate

→ Categories of IET:

- Spatial Domain Technique
  direct manipulation of image pixel.
- Frequency Domain Technique
  manipulation of Fourier/ wavelet transform of an image

Spatial Domain:

Intensity Transformation:



Grey Scale Manipulation.

→ Simplest form of window (1X1)

Types (Intensity Transformation)

- Linear Transformation
- Log " (abrupt change na aaye)
- " (more color add hone)

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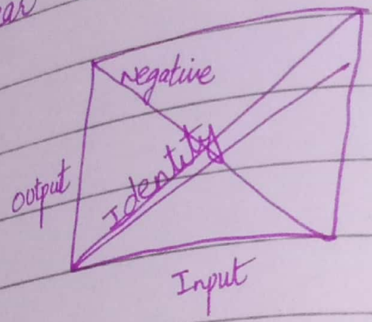
Linear : Identity , Negative



Negative Image ⇒ Black → White
White → Black

$$S = L - 1 - r$$

r = Input image ki grey Scale Value.

→ $r = 0$, $L = 256$

$S = 256 - 1 - 0 \Rightarrow 255$ = White

→ $r = 255$

$S = 256 - 1 - 255 \Rightarrow 0$ = Black

→ $r = 240$

Log Transformation

$$S = c \log(1 + r)$$

Contains abrupt high & abrupt low.

→ Useful when input grey level values may have extremely large

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Power law Transforma

$$S = cr^{\gamma}$$

$c, \gamma \Rightarrow$ positive

γ = Gamma

maps a nar

dark input valu

range of outp

PieceWise Linear T

→ Instead o

well defined m

on complete in

piecewise linea

→ Highlights

grey level.

→ Similar to

→ Other Le

Bit

→ Highlight the

of image by

isolati

Power Law Transformation:

$$S = cr^{\gamma}$$

$c, \gamma \Rightarrow$ positive constants

γ = Gamma Corrections

maps a narrow range of dark input values into a wi[de] range of output value or v[ice versa]

PieceWise Linear Transformation:

→ Instead of applying a well defined mathematical form[ula] on complete image, we use piecewise linear transformation.

→ Highlights a specific range grey level.

→ Similar to thresholding

→ Other levels can be supp[ressed]

Bit plan Slicing

→ Highlight the interesting aspects of image by

000 → least significan[t]

High

bits of the pixels values in an image.

→ Most significant bits contain High info.

→ Low significant bits contain low info.

Image Histogram (HT)

Practical Transformation Code (HA)

Ø1	1	4	5	1	5	6	7
2	2	4	Ø1	6	3	6	6
5	5	1	2	4	4	1	5
Ø1	5	5	5	5	Ø1	2	5
1	1	1	1	2	1	1	Ø1
Ø1	2	2	Ø1	4	2	2	2
5	3	4	4	5	5	4	4
4	4	5	4	1Ø	7	5	5

8X8

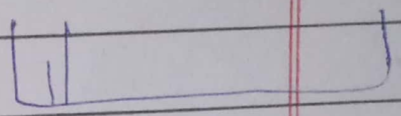


Image Histogram:

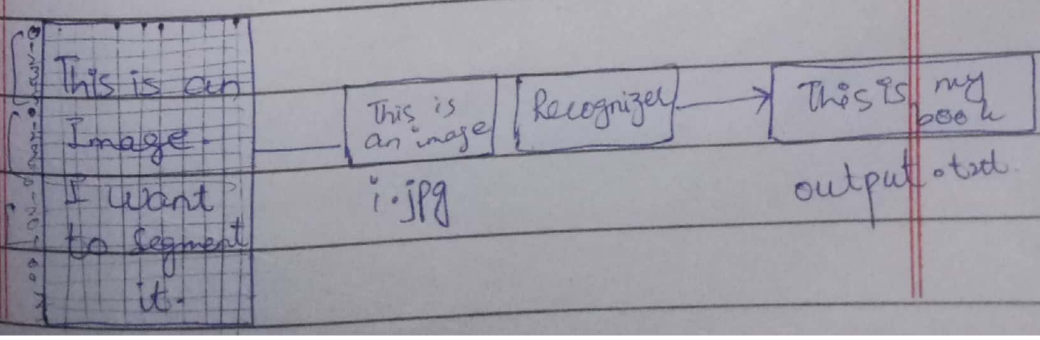
→ Plot of frequency of gray scale.

→ Shows the distribution of gray levels in the image.

→ Useful in segmentation

.txt ⇒ editable

.jpg ⇒ Non-editable



from one non-zero to other non-zero → Segment.

Image Histogram Equalization
→ Contrast stretching
→ Fix poor contrast images by applying a pretty simple contrast specification.

Frequency Table

Round off	L	New grey shade C×(L-1) C×(8-1)	F	f/N	Commulative	[illegible]
1	0	0.875	8	0.125	0.125	1
2	1	1.96875	10	0.15625	0.28125	2
3	2	3.0625	10	0.15625	0.4375	3
3	3	3.28125	2	0.03125	0.46875	3
5	4	4.59375	12	0.1875	0.65625	5
6	5	6.34375	16	0.25	0.90625	6
7	6	6.78125	4	0.0625	0.96875	7
7	7	7	2	0.03125	1	7

N=64

7 = 6 3 = 12
6 = 16 2 = 20
5 = 12 1 = 8

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Spatial Filtering

→ Neighborhood operations Simply operate on a larger neighborhood of pixels than point operations.

→ Average of all neighbors values.

1	1	2
2	?	1
1	1	1

→ mask, filter, window, kernal, template

→ Neighbors are rectangle around a central pixel.

→ Always odd number window. Size 3x3, 5x5, 9x9

→ 4- Connectivity (Vertical x horizontal)

→ 8- Connectivity (All neighbors) 3x3

Conventionally, used 3x3 window Size.

→ Sub-image is called filter mask, kernal template or window.

→ For linear spatial image filtering, the response is given by Sum of products of the filter co-efficients and corresponding image pixels in

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the area spaned by filter mask.

a 5	b 0	c 2
d 2	e 2	f 2
g 4	h 2	i 2

pixels values

$1/9^R$	$1/9^S$	$1/9^T$
$1/9^U$	$1/9^V$	$1/9^W$
$1/9^X$	$1/9^Y$	$1/9^Z$

mass Co-efficients

$$\text{New-values} = a \times R + b \times S + C \times T + d \times U + e \times V + f \times W + g \times X + h \times Y + i \times Z +$$

$$= \frac{1}{9}(5+0+2+2+2+2+4+2+2$$

$$= \frac{1}{9}(21)$$

$$= 2.33$$

Round off 2

→ Don't use update values use values from given/old images.

→ Mask should be in range

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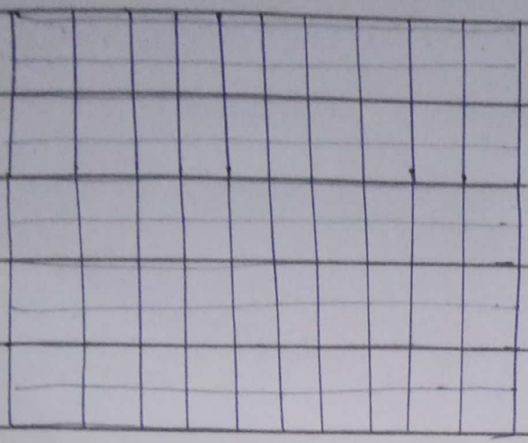
Sequence No. of window apply.



Temporary Image

→ For Window Size 3, Order of Temporary Image is 10 X 10

→ For original image, the order is 8X8 (2 rows & 2 columns are added additionly

→ Values of additional rows and columns can be 255, 0, or Copied first, last rows of original values.

Wrap Around: ⇒ Boundary Repeat.

→ Code for temporary image

Smoothing Filter Process:

$\left(M+\frac{2}{2}, N+\frac{2}{2}\right)$

104	100	108
99	106	98
95	90	85

$(x+1, y+1)$

0	0	0
0	104	100
0	99	106

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

$= 104 \times \frac{1}{9} + 100 \times \frac{1}{9} + 99 \times \frac{1}{9} + 106 \times \frac{1}{9}$

$= \frac{1}{9}(104+100+99+106)$

$= 409/9$

$= \cancel{314.77}$

$a = 45$

$b = (104+100+108+99+106+98)/9$

$b = 68$

$c = (100+108+106+98)/9$

$= 412/9$

$= 46$

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$d = (104+100+99+106+95+90)/9$

$= 594/9 = 66$

$e = (104+100+108+99+106+98+95+90+85)/9$

$= 885/9 = 98$

$f = (100+108+106+98+90+85)/9$

$= 587/9$

$= 65$

$g = (99+106+95+90)/9 \Rightarrow 390/9$

$= 43$

$h = (99+106+98+95+90+85)/9$

$= 573/9 = 64$

$i = (106+98+90+85)/9$

$=$

$= 42$

$$\text{resultant} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 45 & 68 & 46 & 0 \\ 0 & 66 & 98 & 65 & 0 \\ 0 & 43 & 64 & 42 & 0 \end{bmatrix}$$