Image Processing Techniques :-

(1) Image Enhancement :- Image ki quality improve krna. Is k undr hum contrast ko bhtr krty hain, noise reduce krty hain aur details ko highlight krty hain.

① → Histogram Equalization (Contrast to improve krta hy).

- ye image ki pixel intensity values ko redistribute krta ha, issy contrast improve ho jata h.
- low contrast images kafi unclear hoti hain to unhain clear bnany k lie hum Histogram Equalization use krty hain.

Code :-

```
I = imread('low_contrast.jpg');   → imag load
I_gray = rgb2gray(I);             → convert in gray scale
I_eq = histeq(I_gray);            → Histeq equalization apply
subplot(1,2,1), imshow(I_gray), title('original');
subplot(1,2,1), imshow(I_eq), title('Equalized image');
```

1st graph

total

Area of figure

show both original & histogram equalized Image.

② → Smoothing (Bluring) / Noise Reduction :-

- Noise ko reduce kiah aur image ko smooth bnata h.
- hr image k undr thora noise hota h aur smooth krny sy image clear ho jati ha.

Code :-

```
I = imread('example.jpg');
I_blur = imgaussfilt(I, 2);   → Gaussian filter apply kiah
imshow(I_blur), title('Blur Imag');
```

Sigma = 2 k sath.

③ → Sharpening

- Edges aur details ko highlight krta h.
- jb image k undr details clear na hon to sharpening unhain ziada prominent bnati ha.

Code :-

```
I = imread('example.jpg');
I_sharp = imsharpen(I);
imshow(I_sharp), title('Sharpened Image');
```

(2) Edge Detection :-

- image ki boundaries ko detect krna
- edges ya boundaries ko identify krna
- isko ziada object detection m use krty hain.

(1) → Sobel operator :- Horizontal aur vertical edges detect krta h.

Code :-

```
I = imread('image.jpg');
I_gray = rgb2gray(I);
edges_sobel = edge(I_gray, 'Sobel');
imshow(edges_sobel), title('Sobel edge detection');
```

(2) → Canny Edge detection :- Accurate aur noise free edge detection krta h.

Code :-

```
I = imread('image.jpg');
I_gray = rgb2gray(I);
edges_canny = edge(I_gray, 'Canny');
imshow(edges_canny), title('Canny edge detection');
```

(3) Morphological operations :-

- applied on binary images
- noise remove kila h.
- shape ko refine kila h.

(1) → Erosion and Dilation :-

Erosion → Small object hata/dela h.

Dilation → Gaps fill kila h.

Code :-

```
I = imread('image.jpg');
se = strel('disk', 5);   → Disk shape ka structuring element bnaya.
I_eroded = imerode(I, se);   → erosion
I_dilated = imdilate(I, se);   → dilation
subplot(1,2,1), imshow(I_eroded), title('erosion');
subplot(1,2,2), imshow(I_dilated), title('dilation');
```

(4) Thresholding :- (Grayscale sy binary image bnana).

Grayscale image ko binary image m convert krna.

① → Simple Thresholding :-

- Is k under hum fixed Threshold value rkhty hain
- Agr pixel intensity Threshold sy ziada ho to usy white (1) bna dety hain. aur kam ho to black (0)

code :-

```
I = imread('image.jpg');
I_gray = rgb2gray(I);
I_bin = imbinarize(I_gray, 0.5);
imshow(I_bin), title(' ');
```

I → Threshold = 0.5

② → Adaptive / local Thresholding :- 128/255

- hr region ka alag Threshold collect krna h.
- under use hota h jin images m lighting uneven hoti ha.
- hr region ka Threshold w region ki pixel intensity pr depend krta h.

e.g Aik image jis mein shadow ha, us k under Simple Thresholding fail kamega lekin adaptive hr region ka alag Threshold laga kr better result dy ga.

Code:-

```
I = imread('image.jpg');
I_gray = rgb2gray(I);
I_adaptive = adaptthresh(I_gray, 0.5);
I_bin_adaptive = imbinarize(I_gray, I_adaptive);
imshow(I_bin_adaptive), title(' ');
```

→ Adaptive threshold

adaptive threshold ko use kr k image ko binary mein convert kia ha.

(5) Image Segmentation:-

- Image ko regions m divide krna
- divide krna regions m image ko la k analysis kia ja saky.

(i) → K-means clustering :-

pixels ko cluster mein group krlah.

Code:-

```
I = imread('example.jpg');
I_reshape = reshape(I, [], 3);
[idx, C] = kmeans(double(I_reshape), 3);
I_clustered = reshape(idx, size(I,1), size(I,2));
imshow(label2rgb(I_clustered)), title(' ');
```

→ img ko 2D array mein convert kia.

→ 3 cluster bnay

(6) color processing :-

(1) → RGB to HSV Conversion

Code :-
```
I = imread('image.jpg');
I_hsv = rgb2hsv(I);
imshow(I_hsv), title(' ');
```

(7) image Transformation :-

image ko ak domain sy dusri domain mein convert krna ya uski shape, position ya intensity change krna. Iska use image analysis, compression, filtering aur feature extraction mein hota ha.

(1) → spatial domain pixel values p directly apply hota h e.g include scaling, rotation, Translation and flipping.

rotation → kisi angle pr rotate krta h image ko

```
I = imread('image.jpg');
I_rotated = imrotate(I, 45);
imshow(I_rotated), title(' ');
```

Translation → image ko ak position sy dusri position p move krna

```
I = imread('image.jpg');
tform = affine2d([1 0 0; 0 1 0; 50 30 1]);
I_translated = imwrap(I, tform);
imshow(I_translated), title(' ');
```

scaling → image ka size change krta ha.

```
I = imread('img.jpg');
I_scaled = imresize(I, 0.5);
imshow(I_scaled), title
```

(2) → Frequency domain Transformation:-

Image ko spatial domain sy frequency domain mein convert kia jata h.

→ Fourier Transform (Frequency Analysis)

- Image ke frequency components ko extract kiya ha.
- low frequency components image k smooth areas represent krte hain.
- High frequency components edges aur sharp details represent krty hain.

Code:-

```
I = imread('image.jpg');
I_gray = rgb2gray(I);
F = fft2(double(I_gray));  → apply fourier Transform
F_shift = fftshift(F);  → freq components ko center m shift kiah.
magnitude = log(1+abs(F_shift));  → calculate magnitude
imshow(magnitude, []), title(' ');
```

→ inverse fourier transform:- Frequency domain mein modification krty hain, to is sy hum original image wapis la skty.

Code:-

```
I_reconstructed = ifft2(F);  → Inverse of Fourier Transform
imshow(uint8(abs(I_reconstructed))), title(' ');
```

(8) Image Restoration:- Kharab image ko jitna ho skta h utna original image k form mein lana

- blurred, noisy aur distorted image thek krny k lie hota ha.
- restoratim k undr hum mathematical model ka use krty hain jidr hum image ki degradation ko model krty hain.

(1) → Deblurring:- blur image ko thek krna
- is k lie hum deconvolution ko use krty

Wienner Filter:- degraded image aur noise ka model bnata hai aur best estimate return krta h.

```
I = imread('image.jpg');
PSF = fspecial('motion', 21, 11);   → motion blur kernel model bnata h.
I_deblurred = deconvwnr(I, PSF, 0.01);   → wienner deconvation.
imshow(I_deblurred);
```

blurred image sharp hojati ha.

(2) → Inpainting:- image k missing ya damaged parts ko intelligently fill krna taky wo natural lagy

code:-

```
I = imread('image.jpg');
mask = imread('mask_image.jpg');
I_inpainted = regionfill(I, mask);
imshow(I_inpainted);
```

mask jahan missing area h. (white = missing)

regionfill damaged region ko surrounding pixels ki basis pr fill krta ha.

regionfill filling method lagaya h.

(3) → Denoising :- unwanted noise ko remove krna taky image ziada clear aur smooth lagy.

Ehniques:- (1) Pseudo-color Processing false coloring

used to enhance greyscale image by maping pixel intensities to specific color range. make patterns & details more distinguishable.

→ (1) intensity based colour mapping
(2) Lookup Table (LUT) application
(3) Thermal imaging & fake colour satellite images

(2) Edge enhancement:-

→ (1) High pass filtering
(2) Sobel, Prewitt, laplacian edge detection
(3) unsharp masking
(4) canny edge detection.

(3) Image Restoration:-

(1) winer filtering
(2) Inverse filtering
(3) Blind deconvulation
(4) Noise reduction

(4) Geometric Transformation:-

(1) Affine Transformation
(2) Persective transformations
(3) Image registeration

lec#1

what is a digital Image processing?

digital Image processing ka mtlb ha digital image ko process krna taky unka bhtareen istemal kiya ja sky like we improve the quality of image, data ko extract krna ya kisi system k lie visualize krna.

what is digital image?

Digital Image is 2 dimensional representation which is collection of small pixels.

- hr pixel aik specific colour aur brigness value rakhta ha.
- ~~ka~~ digital image k kuch formats
  - → Grayscale image
  - → RGB image
  - → RGBA image (RGB k sath transparency ya opacity ka channel).

2 main Importance of Digital Image Processing?

1- Human Interpretation :- is ka mtlb ha k insano k lie image ko smjhna aur bhtr banana. DIP ka maqsad hota image ki quality improve krna taky insan us k undr mojud tamam malomat ko smjh saky.

2 Machine Perception :- computer ya AI system k lie images ko aise format main process krna jo woh samajh saky. Ye concept AI aur computer vision ka ahem hissa ha. Jismein digital Image ko analyze krkey automated decision making ki jati ha.

Continuum :- Jb hum image processing sy Computer vision ki taraf jaty hain to aik Continuum hota h.

This can be broken into

low, mid and high-level processes.

Gradual transition aik chz sy dusri chz tk smoothly shift hona bina kisi achanak jump k.

DIP aur computer vision k drmian bhi aik continuum hota h.

e.g aik old black and white damage image ko low level processing sy uska noise remove kr skte hain aur sharpness improve kr skty hain.

(1) Low-level processing ↑ ye sbsy basic aur fundamental stage hoti ha, isme sirf pixel-based operations perform ki jati hain. → Is k andr input aur output dono image hoti hain. → objective (maqsad) ◦ image ki quality improve krna ◦ Noise remove krna. ◦ Sharpness aur contrast adjust krna.

(2) Mid-level processing ye thodi advanced processing hoti ha jismy input aik image hoti ha aur output aik structured form hoti ha (e.g detected objects

shapes ya attributes).

→ objective :- • image ko analyze krna
• Segmentation aur object detection karna
• Image ka structure ya content smjhna.

→ Example :- Agr aik CCTV road ki footage record kr raha ha, to mid level processing cars ya logon ko identify krny k lie segmentation aur object detection use karegi. (object detecting segmentator).

③ High-level processing :- ye sbsy ziada advanced stage hoti ha jisme machine image ko samajhne aur decision making tk pohnchny lagti ha. Input structured attributes hote hain aur output understanding ya decision-making hoti ha.

→ objective :- • Scene understand krna.
• Automated decision making krna • AI aur deep learning models ko use krna

→ Example :- Ek self-driving car sirf objects detect nahi krti, balky un objects ko smjh kr apni driving adjust krti ha (agr road pr kuch ha to brake lagana h).

→ Facial recognition.

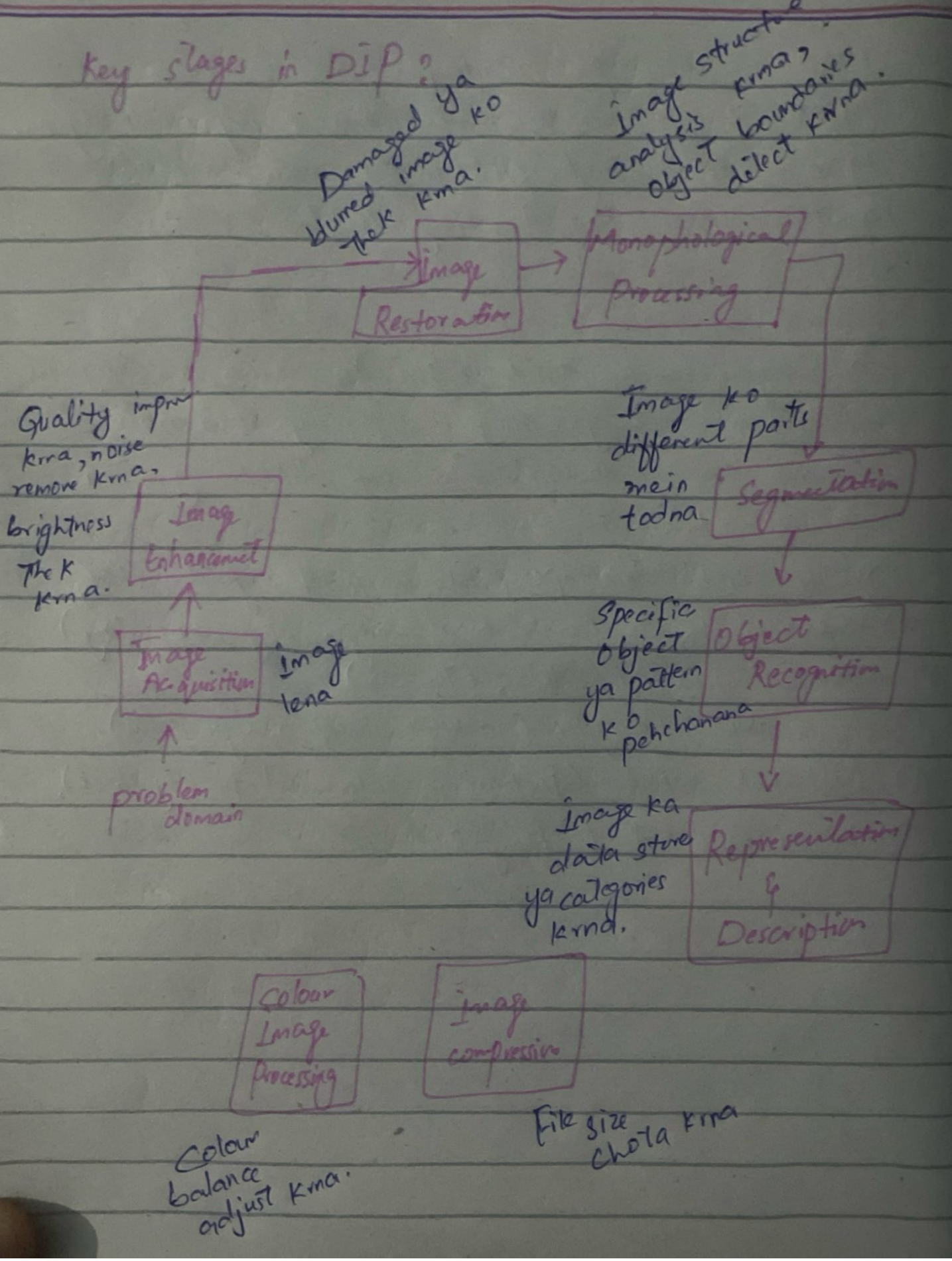
History of DIP :-

1920 → newspaper industry mein.
1960 → Space mission mein image improve krny m.
1970 → medical field m CT scan & MRI
1980 - onward → In every field

Examples of DIP :-

(1) image Enhancement (~~Als~~ Blur kam krna aur brightness theek krna jese ~~lungs~~ Chest image m cy sara noise remove karun g to sari ribs saf dikain g warna sb dark.)
(2) The Hubble Telescope (Take image of very distant objects)
(3) Artistic Effects (make image more visually appealing)
(4) Medical image (MRI, CT scan)
(5) Geographic info system (satellite image analyze krna).
(6) Industrial Inspection (factories m automated quality check).
(7) law Enforcement (Fingerprints

Key stages in DIP:



Human visual system:- Insan k dekhny ka tareeka. aik best natural model hai jo hme digital Image processing aur computer vision ko smjhny m madad deta h. Agr hum smjh jain k insani ankh aur dimagh kis trhan image ko process krty hain to hum better digital image algorithms bna sakain g.

Structure of Human eye:-

- Ankh ka lens light ko focus krta h aur usy retina pr project krta h. • Retina aik layer ha jo light ko detect krti ha aur brain ko signal bhejti ha. • Retina k under 2 kism k light receptors hoty hain.
  - Cones ye colour receptors Aoty.
  - Rods ye low light vision k lie hoty.

Blind spot experiment:- Ankh ka aik blind spot hota h jidr koi bhi image nahi dekhi ja skti. ye experiment prove krta k hmari ankh bina brain k process kie kam nahi kr sakti.

Experiment → aik paper p aik cross aur dot bnain with distance of 6 inch [• x] apni right ankh bnd karain aur bs cross p focus karain aur ahista sy paper ko ankh k kareb karain dot gaib ho jay ga.

Image Formation in Eye:- Ankh k muscles lens ki shape change krty hain ta ky focus adjust hosaky. jb hum dur ki chz pr focus krty han to lens thin ho jata h aur nazdek k lie thick. jb light retina p girti ha to rods aur cone excited ho jati ha aur signal brain tk bhejty hain. aur image ko decode hmara brain kr leta h.

Brightness Adaptation & discrimination:- human visual system 10 billion tk different light intensities dkh skta h lekin aik wkt mein limited brightness levels ko hi differentiate kr skta h.

Brightness Adaptation:- hum andhere aur roshni k drmiyan adjust ho skty hain jb hum andhere sy roshni m jaty hain to hmari aankh adjust hony mein kuch time leti ha.

→ kisi bhi object ka brightness uski aspas k objects p depend krta h.

Light and Electromagnetic spectrum:-

Light electromagnetic spectrum ka aik hissa ha jo hmari ankh detect kr sakti ha.

→ Visible Light range 400nm (violet) sy 700nm (red)

→ black objects sari light absorb kr lete hain

→ white object sb colors ko reflect krta h.

→ Green object white light m sb green show kry ga aur baki sb absorb ho jati ha.

Image Acquisition:- Kisi bhi scene ka digital image m conversion honey ko Image Acquisition khty hain, o sensors light ko absorb krty hain aur voltage signal generate krty hain.

Types :-

1. X-ray Images (Andr k tissues dkhny k lie)
2. Ultrasound Images (unborn Baby ya body scan k lie)
3. Microscopic Images (Bohl choti cheain dkhny k li

Image Sensing:- energy sensor material pr prti ha aur voltage signal generate hoty hain aur sensors k kafi collection hum arrange krty ta k image capture ki jay.

Image Sampling:- EK continous Image ko discrete pixels mein todna. → Higher Sampling Rate Better img quality → low sampling Rate Image blurry aur pixelated ho jati h.

→ taky usy digitally store aur process kia ja sky

Example:- Agr aik HD quality image 1920 x 1080 pixels ho, aur hum usy compress karain aur 32x32 ka kar dain to usky pixels kharab ho jain g ing blurr aur unclear ho jay g.

Quantisation:- Hr pixel ko aik finite intensity value dena. • Continous analogue signal ko digital representation mein Convert krna.

• Analogue Images ko digital format mein store krny k lie hota h. • Convert krny k lie hmain usky colours aur brightness ko limited values mein represent krna pta h.

Image Representation:- Digital Image aik matrix ki trhan hoti ha jis me hr pixel aik value store krta h. Grayscale Image 0-255 value rkhta h. RGB Image mein hr pixel k lie 3 values hoti hain Red, Green, blue.

Spatial Resolution:- it is determined by how sampling was carried out

Vision spacialist says → pixel size

Graphic designers → dots per inch (DPI)

High resolution → Sharp Image

low resolution → Blurr Image

Intensity level Resolution:- no. of intensity levels used to represent the image. is ka matlb ha k aik pixel k lie kitny shades of grey ya colors available hain.

8-bit image → 256 shades (256)
1-bit image → black & white only. (2)
2-bit → (4)
4-bit → (16)

256 grey levels = 8-bit per pixel.

Saturation and Noise:-

Saturation → Jb aik color itna ziada ho jay k uski details ko na dikhain

Noise → image mein unwanted distortions ya random dots ana.

Noise removal Techniques

- Median filter
  - ye aik non-linear filter ha jo image sy "salt and pepper noise" ko remove kny k lie use hota ha. is ka kam hr pixel ki value us ky aspas k pixel ki value k sy median sy replace krna hota h.
- Gaussian Blur
  - ye aik linear filter ha jo image ko smooth aur blur kny k lie use hota h. ye noise reduce krta h aur image ka soft-focus effect create krta h. Bluring effect aksr image processing aur object detection k lie use hota h.

Resolution – How Much is enough?

Resolution ka best level depend krta ha kis purpose k lie image use ho rahi ha.

high resolution → ziada details.
low resolution → chotifile size but less details.

→ agr size cars count krna ho to low res
→ agr no. plate b dekhni ha to high.

lecture #3

Grey level values:- digital images mein grey level values ka range hota h [0, 255].

0 → black 255 → white
200 → light grey 50 → dark grey

Image Enhancement:- image ko visually bhtr bnana aur useful banana. • ziada important details highlight krna • Noise removal krna.

dull blurry image → improve Contrast to make better.
dark CCTV foiage → ~~eg~~ add brightness & sharpness.

Spatial and Frequency domain:-

2 broad categories of image enhancement techniques.

- Spatial domain technique:- is main direct image pixels modify kie jaty hain. hr pixel ki value kisi mathematical function k zariye change ki jati ha taky image ki quality improve ho. Brightness, contrast adjustment, bluring, sharpening & edge detection ye task spatial m krty hain.

→ Limitation:- Complex imag analysis k lie effective nahi ha. Eg

$$g(x,y) = T[f(x,y)]$$

- $g(x,y)$: Processed Image
- T: Transformation function
- $f(x,y)$: Input Image.

- contrast stretching
- histogram equalization.
- filtering Techniques.

- Frequency Domain Technique:- Image ko Fourier Transform ya wavelet Transform ke zariye process kiya jata h.

→ low pass & high pass filtering.

MRI images ko Fourier sy process krna.

Image Histograms:- ye ek graph ha jo image ke grey level ka distribution dikhata ha.

X-axis ⟶ Grey level values (0-255)

Y-axis ⟶ Pixels ki Frequency

Example:- dark image histogram mostly left side (0-100) pe concentrated hoga.

bright image ka mostly right side (150-255) pe hoga.

Histogram:- • high contrast image ka histogram evenly spread hota h.

• low contrast image ka histogram condensed hota h.

Contrast stretching:- Agr image ka contrast weak ho, to contrast stretching use kiya jata h.

• faded old black & white image ko contrast stretching sy behtr banaya ja skta h.

Histogram Equalization:- • Dark aur washed out images improve krna. • contrast ko evenly spread krna.

$$S_k = T(r_k) = \sum_{j=0}^{k} P(r_j)$$

S_k — output processed intensity level

$T(r_k)$ — Transformation Function. (r_k — input intensity level)

$P(r_j)$ — Probability Distribution of Intensity levels.

$$P(r_j) = \frac{n_j}{n}$$

n_j — Frequency of intensity j

n — Total pixels

Equalisation Transformation Function:-

lecture # 4

Point Processing:- aik simple spatial domain operation jo hr pixel ko individually process krta h.

$$s = T(r)$$

r → original pixel value

s → Processed pixel value

T → Transformation function

Negative images:-

$$s = \text{intensity}_{max} - r$$

image ka hr pixel invert kr deti ha

$$s = 1.0 - r$$

→ X-ray aur medical images ko enhance krny k lie.

→ dark regions mein chupi hui details highlight krny k lie.

Threshhold:-

$$s = \begin{cases} 1.0 & r > \text{Threshold} \\ 0.0 & r \leq \text{threshold} \end{cases}$$

- object aur background ko separate krny k lie
- Fingerprint recognition aur license plate detection jese tasks mein useful.

Basic Grey level Transformations:-

3 common Transformations

1. Linear Transformation (-ve)
2. Logarithmic Transformation
3. Power law Transformation (Gamma Correction).

Logarithmic Transformations:- low intensity values ko zyada spread kia h take dark images zyada bright ho sakain.

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

we usually set c to 1

Grey level must be in range [0.0, 1.0]

Power law Transformations (Gamma correction):-

image ko light ya dark krny k lie use hoti ha.

$s = cr^{\gamma}$ → Gamma.

→ $\gamma > 1$ → Image dark ho jati ha

→ $\gamma < 1$ → Image bright ho jati ha.

$c = 1$

Gamma Correction in Monitors:- display devices do not respond linearly to different intensities

Piecewise Linear Transformation functions:-

Image Sensing kam kese krti ha?

jb bhi koi digital device image ko capture krti ha to is process m light sensors ka kam hota h.

2 types of image sensors.

(1) CCD sensors.

High quality image capture krty aur low noise wali images produce krty hain

(2) CMOS Sensors.

image ko jaldi capture krty hain.

Imag acquisitim Process?

(1) illuminatim :- ye tb ho sakti ha jb Light source available ho.

jb light ziada h to image bright aur clear hog.
Agr light kam h to image dark aur noisy hog.
X-ray imaging m light ki different types ka use hota h.

(2) Image capture :- image capture hony k bd usy digital fomat m convert krna imp hota h.

Types :-

(1) Active Image Acquisitim. :- Light source dia jata h X-ray imaging, X ray machines. e.t.c.

(2) Passive Image Acquisitim. :- use natural light or existing light source like normal Cameras, Mobile cameras e.t.c.

Image sampling and Quantization:- Jb hum kisi image ko ~~2 basic steps m~~ digital fomat m convert kty hain to 2 basic steps hoty.

1- Sampling → image ko discrete pixel m todty hain.
2- Quantization → Hr pixel ko specific intensity value assign krna.

Image sampling? is ka mtlb ha k image k pixels ka selection. Kisi bhi analog image ko tod kr choti choti pixels m divide krna. jitna ziada sampling rate hoga tou image ziada bhtr ho g. aur sampling rate jitna low ho ga image blurry aur pixelated ho g.

Image quantization? is ka mtlb ha k pixels k intensity levels ko limited values tk restrict krna High quantization levels (256 or more than 256) image smooth aur detailed ho gi. (256 levels) low quantization levels (16, 8 or less) image k andr color banding ya distortion ho ga. (16 levels)

Image enhancement in spatial domain:-

Image enhancement ka matlb ha image ko bhtr banana taky jaky uski sari details clear ho jain

Spatial domain k undr enhancement ka matlb hota h directly image k pixels modify krna taky uska contrast, brightness ya sharpness improve ho sky. is m image ki pixel values ko different mathematical transformations sy change kia jata h. ye transformation mostly histogramprocessing, filtering aur pixel-wise transformations pr based hoti hain.

lets Assume Grey scale image:-

pixel value range from 0-255

$$f = \begin{bmatrix} 50 & 100 & 150 \\ 200 & 250 & 100 \\ 50 & 150 & 200 \end{bmatrix}$$

(1) Brightness adjustment:-

$$g(x,y) = f(x,y) + 50$$

$$\begin{bmatrix} 50+50 & 100+50 & 150+50 \\ 200+50 & 250+50 & 100+50 \\ 50+50 & 150+50 & 200+50 \end{bmatrix}$$

$$\begin{bmatrix} 100 & 150 & 200 \\ 250 & 300 & 150 \\ 100 & 200 & 250 \end{bmatrix}$$

so pixel value cannot be greater than 255 so we restrict the value

$$\begin{bmatrix} 100 & 150 & 200 \\ 250 & 255 & 150 \\ 200 & 200 & 250 \end{bmatrix}$$ → The image brightness increased.

Negative Transformation Also known as pixel inversion

$$g(x,y) = 255 - f(x,y)$$

$$\begin{bmatrix} 255-50 & 255-100 & 255-150 \\ 255-200 & 255-250 & 255-100 \\ 255-50 & 255-150 & 255-200 \end{bmatrix}$$

$$\begin{bmatrix} 205 & 155 & 105 \\ 55 & 5 & 155 \\ 205 & 105 & 55 \end{bmatrix}$$

log Transformation. Dark image ko bright aur bright image ko compress krnlah

$$T[f(x,y)] = c \log(1 + f(x,y))$$

$$c = \frac{255}{\log(1 + \max(f))}$$

Since max (f) = 250 from image pixels.

$$c = \frac{255}{\log(1+250)} = \frac{255}{\log(251} = \frac{255}{5.52} = 46.2$$

Now apply log Transformation

$$\begin{bmatrix} 46.2\log(1+50) & 46.2\log(1+100) & 46.2\log(1+150) \\ 46.2\log(1+200) & 46.2\log(1+250) & 46.2\log(1+100) \\ 46.2\log(1+50) & 46.2\log(1+150) & 46.2\log(1+200) \end{bmatrix}$$

$$\begin{bmatrix} 46.2 \times 3.93 & 4.61 \times 46.2 & 46.2 \times 5.02 \\ 46.2 \times 5.30 & 5.52 \times 46.2 & 46.2 \times 46.1 \\ 46.2 \times 3.93 & 5.02 \times 46.2 & 46.2 \times 5.30 \end{bmatrix}$$

$$\begin{bmatrix} 181 & 212 & 232 \\ 244 & 255 & 212 \\ 181 & 232 & 244 \end{bmatrix}$$

Gamma Correction:- Brightness aur contrast adjust krta h

$$g(x,y) = cf(x,y)^{\gamma}$$

where

$$c = \frac{255}{(255)^{\gamma}}$$

lets assume $\gamma = 2.2$

$$c = \frac{255}{255^{2.2}} = \frac{255}{196964} = 0.001295$$

$$\begin{bmatrix} 0.001295 \times 50^{2.2} & 0.001295 \times 100^{2.2} & 0.001295 \times 150^{2.2} \\ 0.001295 \times 200^{2.2} & 0.001295 \times 250^{2.2} & 0.001295 \times 100^{2.2} \\ 0.001295 \times 50^{2.2} & 0.001295 \times 150^{2.2} & 0.001295 \times 200^{2.2} \end{bmatrix}$$

$$\begin{bmatrix} \\ \\ \\ \end{bmatrix}$$

$S = c \cdot R^{\gamma}$

Gamma Correction :- Brightness aur contrast adjust krta h
Power law — Non-linear brightness adjustment

$$g(x,y) = cf(x,y)^{\gamma}$$

where
$\gamma > 1$ Image dark hogi
$\gamma < 1$ Image bright hogi

$$c = \frac{255}{(255)^{\gamma}}$$

lets assume $\gamma = 2.2$

$$c = \frac{255}{255^{2.2}} = \frac{255}{196964} = 0.001295$$

$$\begin{bmatrix} 0.001295 \times 50^{2.2} & 0.001295 \times 100^{2.2} & 0.001295 \times 150^{2.2} \\ 0.001295 \times 200^{2.2} & 0.001295 \times 250^{2.2} & 0.001295 \times 100^{2.2} \\ 0.001295 \times 50^{2.2} & 0.001295 \times 150^{2.2} & 0.001295 \times 200^{2.2} \end{bmatrix}$$

$$\begin{bmatrix} 7 & 32 & 79 \\ 149 & 244 & 32 \\ 7 & 79 & 149 \end{bmatrix}$$

Point processing:- ye aik basic image processing technique ha is m hr pixel ki transformation alag hoti ha. hr pixel pr koi function apply kia jata h bgair neighbouring pixel ka effect lie.

$$g(x,y) = T[f(x,y)]$$

- T → Transformation function.
- $g(x,y)$ → Transform output image
- $f(x,y)$ → input image
- ye aik pixel pr jata h is lie fast hota hai.

Types :-
1. logarithmic Transformation.
2. Negative image (Inversion)
3. Power law Transformation (Gamma correction)
4. Contrast stretching (Linear Transformation) → enhance low contrast image.
5. Thresholding (Binary Image) → Image ko sirf black & white m convert krta h.

Threshold sy uper waly 255 white neche waly black 0

Linear Transformation :- use to adjust brightness & contrast.

Contrail stretching :-

$$g(x,y) = \frac{(f(x,y) - f_{min}) \times (L-1)}{f_{max} - f_{min}}$$

(L = max intensity level.)

$$\begin{bmatrix} 50 & 100 & 150 \\ 200 & 250 & 100 \\ 80 & 150 & 200 \end{bmatrix}$$

$f_{max} = 250$

$f_{min} = 50$

$$g(x,y) = \frac{(f(x,y) - 50) \times 255}{250 - 50}$$

Assume $f(x,y) = 100$

$$= \frac{(100 - 50) \times 255}{200} = \frac{12750}{200} = 64$$

Assume $f(x,y) = 150$

$$= \frac{(150 - 50) \times 255}{200} = 128$$

Assume all.

Original	Contrast
100	64
150	128
200	192
50	0
250	255

Brightness adjustment:-

$$g(x,y) = f(x,y) + C$$

C → +50 ho to bright hog image
−50 ho to dark hojayge.

$$\begin{bmatrix} 50+50 & 100+5 & 150+50 \\ 200+50 & 250+50 & 100+50 \\ 50+50 & 150+50 & 200+50 \end{bmatrix}$$

300 clip hokr 255

Thresholding:- lets assume Threshold of 65
to 65 sy uper waly sary white (0)
neche waly black (255)

$$\begin{bmatrix} 0 & 255 & 255 \\ 255 & 255 & 255 \\ 0 & 255 & 255 \end{bmatrix}$$ → Thresholding image.

```
I_gray = rgb2gray(I);
I_bin = imbinarize(I_gray, 0.5);
```
→ Threshold.

Histogram Equalization :- is ka main purpose low contrast image ko improve krna h.
ye aik contrast enhancement technique ha jo imag ki brightness aur contrast ko uniformly distribute krny k lie use hoti hy.

4 steps to solve

(1) compute Histogram (ye aik graph hota h jo k image m pixel intensities ka distribution show krta h.

Take of pixel of Grey scale image.

$$\begin{bmatrix} 52 & 55 & 61 & 66 \\ 70 & 61 & 64 & 73 \\ 63 & 59 & 55 & 90 \\ 85 & 63 & 72 & 83 \end{bmatrix}$$

52	1	70	1
55	2	72	1
59	1	73	1
61	2	83	1
63	2	85	1
64	1	90	1
66	1		

Jitni br hogi repeat hogi.

I-eq = histeq(I-gray);

(2) compute pdf

$$P(i) = \frac{\text{Count of } i}{16}$$

$$P(52) = \frac{1}{16} = 0.0625$$

$$P(55) = 2/16 = 0.125$$

$$P(61), P(63) = \frac{2}{16} = 0.125$$

all other $= \frac{1}{16} = 0.0625$

(3) compute cdf

$CDF(52) = pdf(52) = 0.0625$

$CDF(55) = CDF(52) + P(55) = 0.1875$

$CDF(59) = CDF(55) + P(59) = 0.1875 + 0.0625 = 0.25$

$CDF(61) = CDF(59) + P(61) = 0.25 + 0.125 = 0.375$

$CDF(63) = CDF(61) + P(63) = 0.375 + 0.125 = 0.5$

$CDF(64) = CDF(63) + P(64) = 0.5 + 0.0625 = 0.5625$

for all next same process.

(4) Normalize CDF

$$I'(i) = \text{round}\left(\frac{CDF(i) - \min(CDF)}{1 - \min(CDF)} \times 255\right)$$

$$I'(52) = \text{round}\left(\frac{0.0625 - 0.0625}{1 - 0.0625} \times 255\right) = 0$$

$$I'(55) = \text{round}\left(\frac{0.1875 - 0.0625}{1 - 0.0625} \times 255\right)$$

$$\frac{0.125}{0.9375} = 34$$

repeat for other

(5) Replace pixel values.

52 → 0
55 → 34
61 → 94
66 → 122
70 → 150

Histogram equalization.

grayscale image $\begin{bmatrix} 10 & 20 & 30 \\ 40 & 50 & 60 \\ 10 & 20 & 30 \end{bmatrix}$

Step 1 :- Compile Histogram

10	2
20	2
30	2
40	1
50	1
60	1

Step 2 :- Compile pdf

$$p(i) = \frac{\text{Count of } i}{16}$$

$$p(10) = \frac{2}{16} = 0.125$$

$$p(20) = 2/16 = 0.125$$

$$p(30) = 2/16 = 0.125$$

$$p(40) = 1/16 = 0.0625$$

$$p(50) = 1/16 = 0.0625$$

$$p(60) = 1/16 = 0.0625$$

Step 3 :- Compute CDF

$C(10) = p(10) = 0.125$

$c(20) = c(10) + p(20) = 0.125 + 0.125 = 0.25$

$C(30) = c(20) + p(30) = 0.25 + 0.125 = 0.375$

$C(40) = C(30) + p(40) = 0.375 + 0.0625 = 0.4375$

$c(50) = c(40) + p(50) = 0.4375 + 0.0625 = 0.5$

$c(60) = c(50) + p(60) = 0.5 + 0.0625 = 0.5625$

Step 4 :- Normalize CDF

$$I'(i) = \text{round}\left(\frac{cdf(i) - \min(cdf)}{1 - \min(cdf)} \times 255\right)$$

$$10 = \left(\frac{0.125 - 0.125}{1 - 0.125} \times 255\right) = 0$$

$$20 = \left(\frac{0.25 - 0.125}{0.875} \times 255\right) = 36$$

$$30 = \frac{0.375 - 0.125}{0.875} \times 255 = 73$$

$$40 = \frac{0.4375 - 0.125}{0.875} \times 255 = 91$$

$$50 = \frac{0.5 - 0.125}{0.875} \times 255 = 182$$

$$60 = \frac{0.5625 - 0.125}{0.875} \times 255 = 128$$

$$\begin{bmatrix} 0 & 36 & 73 \\ 91 & 182 & 128 \\ 0 & 36 & 73 \end{bmatrix}$$ ✓

Bit plane slicing:- image procersing technique ha ye image ko multiple binary images m break kr dete ha bit positions ki base pr.