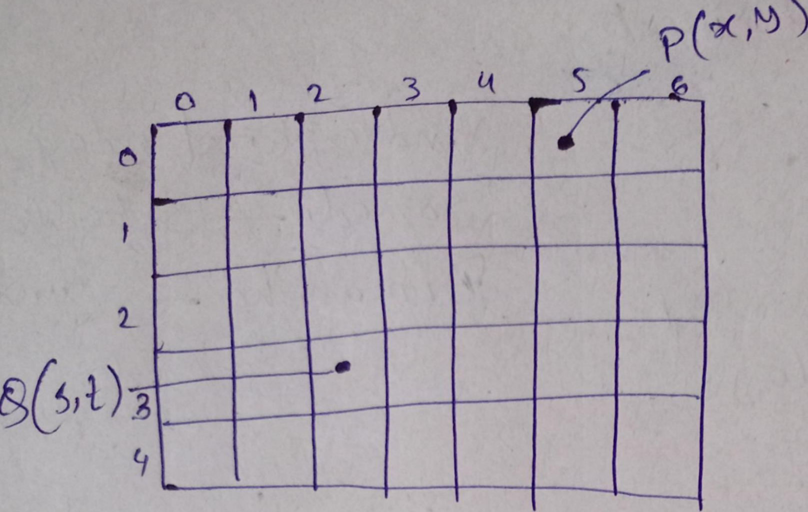
15/1/2025



$$D_e(P,Q) = \sqrt{(x-s)^2 + (y-t)^2}$$
$$= \sqrt{(0-3)^2 + (5-2)^2}$$
$$= \sqrt{9+9} = \sqrt{18} = 3\sqrt{2} \text{ unit (Ans)}$$

This is <u>eucledian distance.</u>

// <u>D_4 distance</u>

$$D_4(P,Q) = |x-s| + |y-t|$$
$$= |0-3| + |5-2|$$
$$= 3+3 = 6 \text{ unit (Ans)}$$

// <u>Chessboard distance</u>

$$D_8(P,Q) = \max(|x-s|, |y-t|)$$
$$= \max(3, 3) = 3 \text{ unit (Ans)}$$

Histogram Specification / or Histogram mapping

(10 marks)

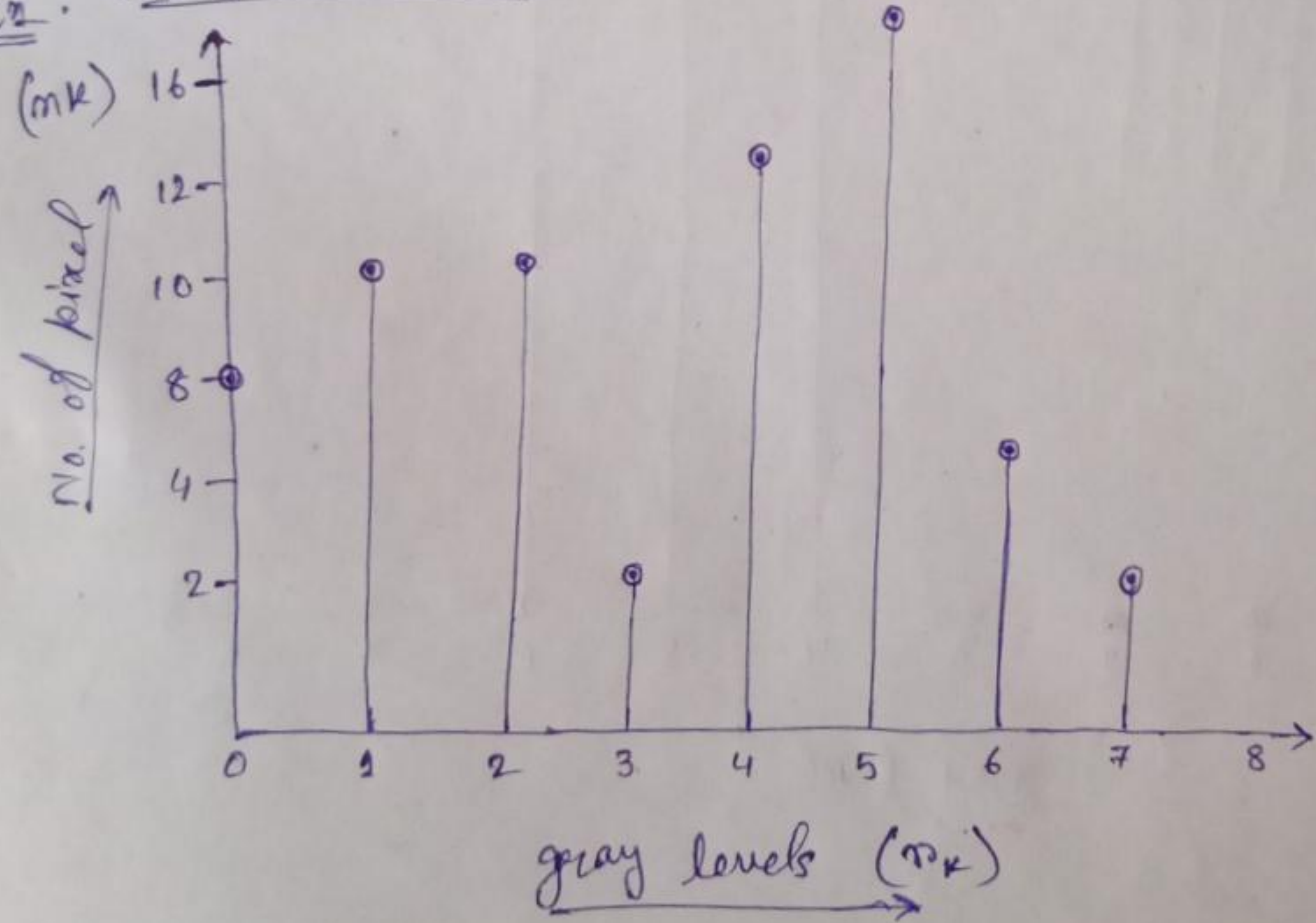
Original Image

gray level	0	1	2	3	4	5	6	7
No of pixel	8	10	10	2	12	16	4	2

Desired Image / Target Image

gray level	0	1	2	3	4	5	6	7
No of pixel	0	0	0	0	20	20	16	8

Soln: Original Image:

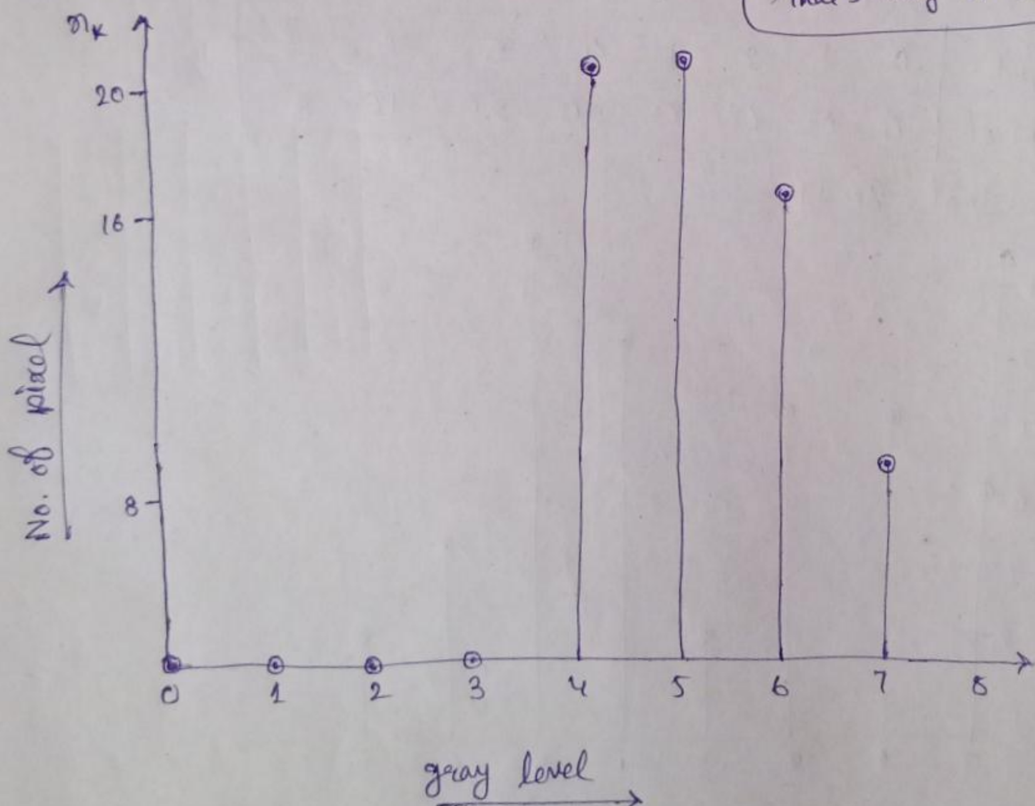


Histogram of original image —

gray levels r_k	No. of pixels n_k	$P(r_k) = n_k/n$ (PDF)	S_k CDF	$S_k \times 7$	Histogram equilized level
0	8	0.125	0.125	0.875	1
1	10	0.156	0.281	1.967	2
2	10	0.156	0.437	3.059	3
3	2	0.031	0.468	3.276	3
4	12	0.188	0.656	4.592	5
5	16	0.25	0.906	6.342	6
6	4	0.063	0.969	6.783	7
7	2	0.031	1	7	7
	$n = 64$				

Why $S_k \times 7$? → Here we are assuming 8 bits (0–7). 7 is 3 bits digits. $7 \rightarrow 111$. So, $2^3 = 8$. Let, $8 = L$. But in formula we have to use $(L-1)$. That's why it is $S_k \times (L-1)$

Desired Image



Histogram of desired image —

gray levels r_k	No. of pixels n_k	$P(r_k) = r_k/n$ (PDF)	S_k CDF	$S_k \times 7$	Histogram equilized level
0	0	0	0	0	0
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	20	0.313	0.313	2.191	2
5	20	0.313	0.626	4.403	4
6	16	0.25	0.876	6.132	6
7	8	0.125	1.001	7.007	7
	$n = 64$				

<u>Mapping</u>

Gray level	H(O)	H(D)	Mapping
0	2	0	4 ✓
1	2	0	4 ✓
2	3	0	5 ✓
3	3	0	5 ✓
4	5	2	6 ✓
5	6	4	6 ✓
6	7	6	7 ✓
7	7	7	7 ✓

<u>Modified Image:</u>

Gray level	0	1	2	3	4	5	6	7
No. of pixels	0	0	0	0	18	12	28	6

Gray level slicing

(1) With Background

$a \le r \le b$

where $a = 3$, $b = 6$ (given)

Ex. 1

pixel

	0	1	2	3	4
0	.	.	.	.	.
1	.	.	..	253	.
$f(x,y)$ 2	.	.	250	~~253~~	.
3		2			
4	0				

Ex. 2 $3 \le r \le 6 = 7$

~~otherwise~~ Otherwise r

1	4	2	7	5
3	2	4	5	2
2	6	5	7	0
4	6	6	5	1
0	2	3	2	1

⇓

1	7	2	7	7
7	2	7	7	2
2	7	7	7	0
7	7	7	7	1
0	2	7	2	1

(2) Without Background

$3 \le r \le 6 = 7$

otherwise 0

1	4	2	7	5
3	2	4	5	2
2	6	5	7	0
4	6	6	5	1
0	2	3	2	1

⇓

0	7	0	7	7
7	0	7	7	0
0	7	7	7	0
7	7	7	7	0
0	0	7	0	0

Bit plane Slicing:

167	133	111
144	140	135
159	154	148

Step 1: Binary format for above Image is —

10100111	10000101	01101111
10010000	10001100	10000111
10011111	10011010	10010100

For 1st digit: Binary format of 167

1	0	1	0	0	1	1	1
MSB	7th bit	6th bit	5th bit	4th bit	3rd bit	2nd bit	LSB

Step 2: Bit plane Slicing of above example.

1	1	0
1	1	1
1	1	1

8 bit (MSB bit) Plane

0	0	1
0	0	0
0	0	0

7 bit

1	0	1
0	0	0
0	0	0

6 bit

0	0	0
1	0	0
1	1	1

5 bit

0	0	1
0	1	0
1	1	0

4 bit

1	1	1
0	1	1
1	0	1

3 bit

1	0	1
0	0	1
1	1	0

2 bit

1	1	1
0	0	1
1	0	0

LSB Plane (1 bit)

24/01/2025

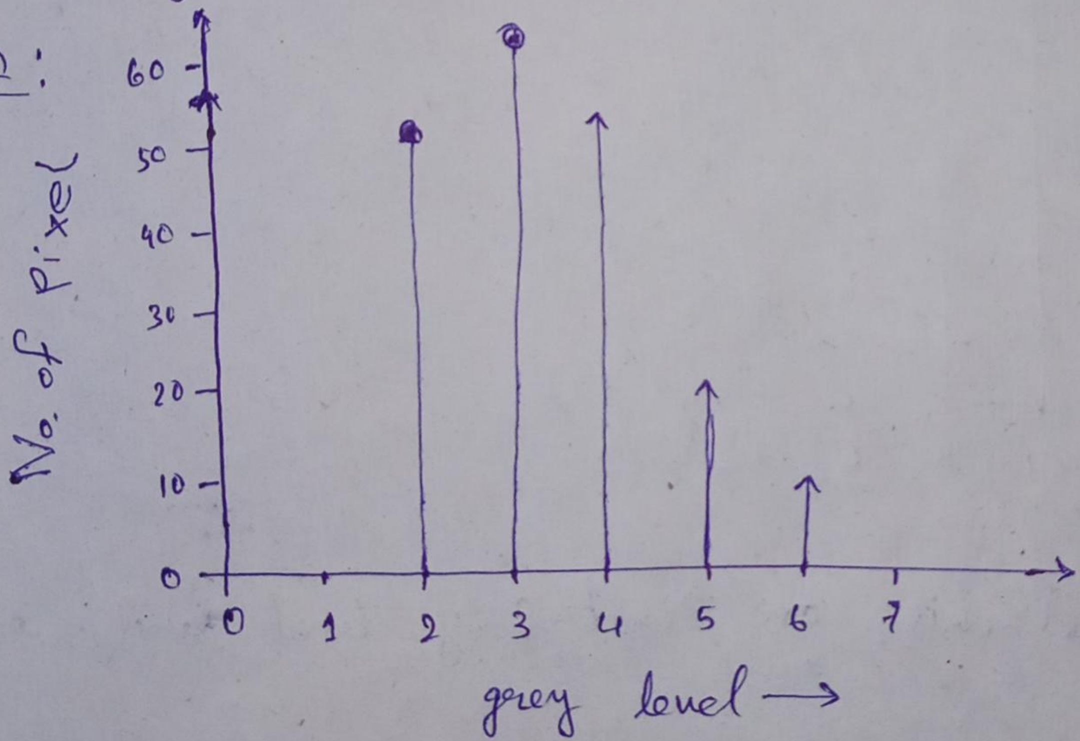
DIP

Histogram streching / Contrast streching

grey level	0	1	2	3	4	5	6	7
No. of pixels	0	0	50	60	50	20	10	0

Perform histogram streching such that the new image has dynamic range [0 → 7].

Soln:



$S_{min} = 0$

$S_{max} = 7$

$r_{min} = 2$

$r_{max} = 6$

$$\text{Slope, } s = \left(\frac{s_{max} - s_{min}}{r_{max} - r_{min}}\right) \times (r - r_{min}) + s_{min}$$

when, $r = 2$

$$s_2 = \left(\frac{7-0}{6-2}\right) \times (2-2) + 0 = \frac{7}{4} \times 0 + 0 = 0$$

when, $r = 3$

$$s_3 = \left(\frac{7-0}{6-2}\right) \times (3-2) + 0 = \frac{7}{4} \times 1 + 0 = 1.75 \approx 2$$

when, $r = 4$

$$s_4 = \left(\frac{7-0}{6-2}\right) \times (4-2) + 0 = \frac{7}{4} \times 2 + 0 = 3.5 \approx 4$$

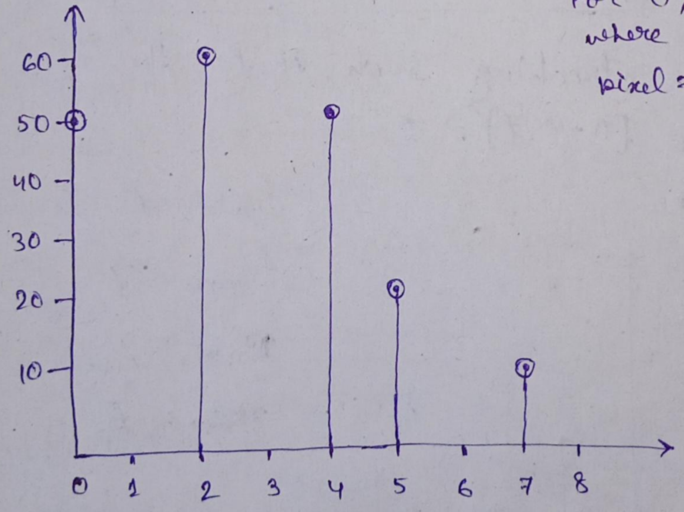
when, $r = 5$

$$s_5 = \left(\frac{7-0}{6-2}\right) \times (5-2) + 0 = \frac{7}{4} \times 3 = 5.25 \approx 5$$

when, $r = 6$

$$s_6 = \left(\frac{7-0}{6-2}\right) \times (6-2) + 0 = \frac{7}{4} \times 4 + 0 = 7$$

For 0, $r = 2$ and in graph where grey level $= 2$ there no. of pixel $= 50$.



Qn.) Apply contrast streching on 3-bit grey level image of size 4×4.

Soln:

$f(x, y)$

2	1	2	1
4	5	5	6
3	2	1	4
6	2	1	6

DIP

$f(x,y) =$

6	7	7	7	3
5	1	1	2	2
5	0	5	0	3
0	0	3	3	3
5	1	1	4	4

1) Apply grey scale slicing for the image where $3 \leq r \leq 5$
2) Construct Image Histogram Equilization
3) Find Image Negative
4) Distance from P to Q (CITY Block)

---

1) Apply Grey Scale Slicing

With Background

$a \leq r \leq b$ where, $a = 3$, $b = 5$.

6	7	7	7	3
5	1	1	2	2
5	0	5	0	3
0	0	3	3	3
5	1	1	4	4

$3 \leq r \leq 5 = 7$

otherwise r as it is

6	7	7	7	7
7	1	1	2	2
7	0	7	0	7
0	0	7	7	7
7	1	1	7	7

without Background

Range

$3 \leq r \leq 5 = 7$

without 0

0	0	0	0	7
7	0	0	0	0
7	0	7	0	7
0	0	7	7	7
7	0	0	7	7

3) Image Negative

Max Value = 7 → $(111)_2$

Formula - 1: $\boxed{S = (L-1) - r}$

$= (8-1) - r$

$= 7 - r$

No. of bit $L = 3$

Formula - I

$L = 2^n$

$= 2^3 = 8$

Negative

1	0	0	0	4
2	6	6	5	5
2	7	2	7	4
7	7	4	4	4
2	6	6	3	3

(4) (*)

Distance = / f(x,y) =	0	1	2	3	4
0	6	7	7	7	3
1	5	1	1	2	2
2	5	0	5	0	3
3	0	0	3	3	3
4	5	1	1	4	4

$P(x_1, y_1)$ (1, 3)

$Q(x_2, y_2)$

$d(P,Q) = |x_1 - x_2| + |y_1 - y_2|$

let $P(1,3)$, $Q(3,1)$

$d(P,Q) = |1-3| + |3-1|$

$= 2 + 2 = 4$

2)

Grey Level	0	1	2	3	4	5	6	7
No of Pixel	4	4	2	5	2	4	1	3

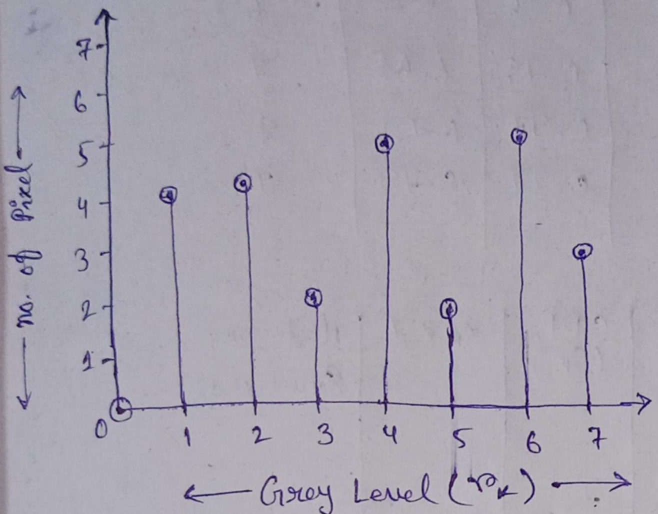
$n = 25$

Grey Level (r_k)	No of Pixel (n_k)	$P(r_k) = \frac{n_k}{n}$ (PDF)	S_k (CDF)	$S_k \times 7$	Histogram Equilized
0	4	0.16	0.16	1.12	1
1	4	0.16	0.32	2.24	2
2	2	0.08	0.4	2.8	3
3	5	0.2	0.6	4.2	4
4	2	0.08	0.68	4.76	5
5	4	0.16	0.84	5.88	6
6	1	0.04	0.88	6.16	6
7	3	0.12	1	7	7
	$n = 25$				

• New Image

6	7	7	7	4
6	2	2	3	3
6	1	6	1	4
1	1	4	4	4
6	2	2	5	5

Grey Level	0	1	2	3	4	5	6	7
No. of Pixel	0	4	4	2	5	2	5	3



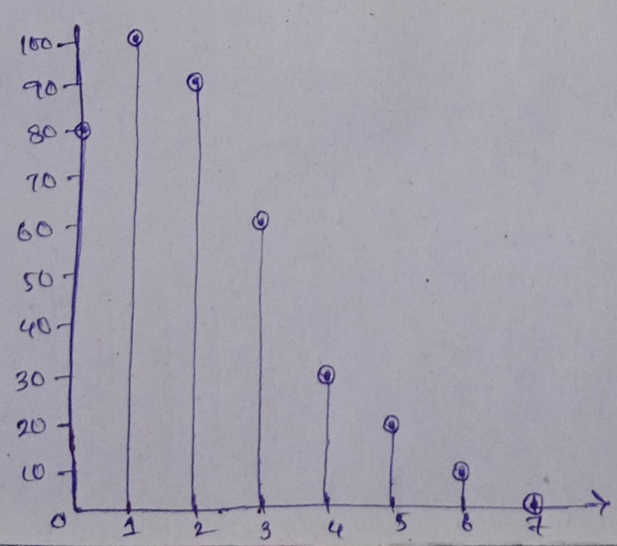
Qn) Input Image :-

Grey level	0	1	2	3	4	5	6	7
No of pixel	80	100	90	60	30	20	10	0

Target / Desired Image :-

Grey level	0	1	2	3	4	5	6	7
No of Pixel	0	0	0	60	80	100	80	70

Ans:



For Input Image

Grey level (r_k)	No. of Pixel (n_k)	PDF $p(r_k) = \frac{n_k}{n}$	CDF (S_k)	$S_k \times 7$	Histogram Equilized.
0	80	0.20	0.20	1.4	1
1	100	0.25	0.45	3.15	3
2	90	0.23	0.68	4.76	5
3	60	0.15	0.83	5.81	6
4	30	0.07	0.9	6.3	6
5	20	0.05	0.95	6.65	7
6	10	0.02	0.97	6.79	7
7	0	0	0.97	6.79	7
	$n = 390$				

For Desired Image

Grey level (r_k)	No of Pixel (n_k)	PDF $p(r_k) = \frac{n_k}{n}$	CDF (S_k)	$S_k \times 7$	Histogram Equilized
0	0	0			
1	0	0			
2	0	0			
3	60	0.15			
4	80	0.20			
5	100	0.25			
6	80				
7	70				
	$n = 390$				

Logical Operation

(1) AND operation:

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

$f(x,y)$

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

$f_1(x,y)$

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

$g(x,y)$

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

(2) OR operation:

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

$g(x,y)$

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

(3) NOT operation:

Y	Y
0	1
1	0

$\theta(x,y) \rightarrow of[f(x,y)]$

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

DIP

30/1/2025

Logical Image Arithmetic:

① **Detect Differences**: Image subtraction can be used to find difference between of the objects.

② **De-noise**: Adding successive image of the same scene can reduce random noise.

③ **Collection of Illumination**: Dividing two images can correct shadow and non-homogenious illumination.

④ **Adjust Brightness**: Multipling pixel values by number > 1. while dividing the factor > 1 can darken the image.

⑤ **Blend Images**: Varying the value ~~of~~ ~~α~~ between 0 & 1. Then it make Transition images.

MSE = Mean Square Error
SNR = Square to Noise Ratio
PSNR = Peak Square to Noise Ratio

These are used to measure the quality of images and sequence.

Qn What is MSE?

Ans:) MSE is a error measurement of original image and distorted image.

- PSNR → Ratio of the max. possible signal power to the power of the noise that effects the signal.
  Unit is DB (Decibal)
- Measure a quantity of contrast or reconstructed image. It indicates that higher PSR value indicates better quality.

- SNR → Measure quality of any signal.
- MSE → Avg. of the sequence errors between the original and distorted image. It compares the original image with distorted image. The lower ~~noise~~ MSE value indicates lesser.

Problems:

(1) $f(x, y) = \begin{bmatrix} 3 & 2 & 1 \\ 1 & 2 & 1 \\ 3 & 2 & 2 \end{bmatrix}$, $\hat{f}(x, y) = \begin{bmatrix} 3 & 2 & 2 \\ 1 & 1 & 2 \\ 1 & 1 & 1 \end{bmatrix}$

MSE Formula:

$$MSE = \frac{1}{MN} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} \left[f(x,y) - \hat{f}(x,y) \right]^2$$

Soln:

$$MSE = \frac{1}{9}\left[(3-3)^2+(2-2)^2+(1-2)^2+(1-1)^2+(2-1)^2+(1-2)^2+(3-1)^2+(2-1)^2+(2-1)^2\right]$$

$$= \frac{1}{9} \times 9 = 1$$

Problem (2):

$f(x,y) = \begin{bmatrix} 3 & 2 & 1 \\ 1 & 2 & 1 \\ 3 & 2 & 2 \end{bmatrix}$, $\hat{f}(x, y) = \begin{bmatrix} 3 & 2 & 2 \\ 1 & 1 & 2 \\ 1 & 1 & 1 \end{bmatrix}$

SNR Formula:

$$SNR = 20 \log_{10} \frac{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} \left[f(x,y) \right]^2}{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} \left[f(x,y) - \hat{f}(x,y) \right]^2}$$

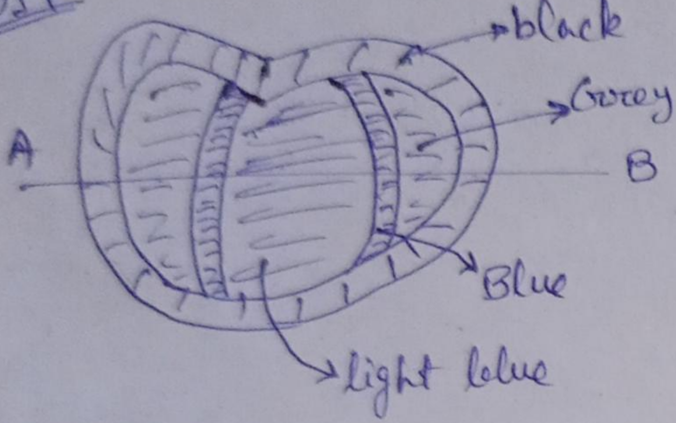
Soln:

$$SNR = 20 \log_{10} \frac{[9+4+1+1+4+1+9+4+4]}{9}$$

$$= 20 \log_{10} \frac{37}{9} = 12.27$$

DIP

31/1/2025

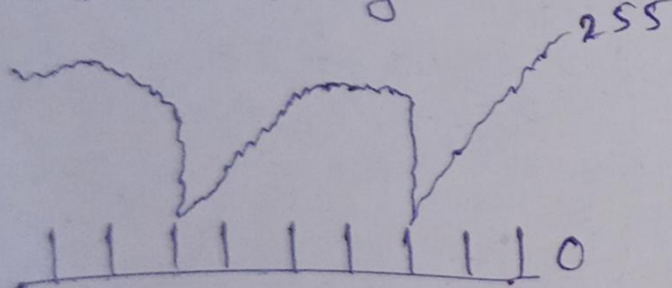


darker → 0

0 - black - low intensity
gray - slightly higher
blue - Medium Intensity
light blue - High Intensity
white - Very high intensity

Sampling & Quantization :

—— clear
~~~ noisy





## Image Negative & Thransholding :

### Image Negative :
~~~

12	68	64	32
8	12	15	32
8	10	16	28
36	40	52	65

Original

How much is $L = ?$

$68 = 1000100$

$L = 2^n = 2^7 = 128$

$S = (L-1) - r = 127 - r$

115	59	63	95
119	115	112	95
119	117	111	99
91	87	75	62

Negative Image

Problem ①:

Thresholding with $T = 4$.

4	3	5	2
3	6	4	6
2	2	6	5
7	6	4	7

$$S = \begin{cases} L-1 = 7; & r \geq 4 \\ 0; & r < 4 \end{cases}$$

$L = ?$

7 is max. number

$14 \rightarrow 3$ bit

$2^3 = 8 \quad \therefore L = 8, \ L-1 = 7$

$\boxed{S = (L-1) - r}$

If $r = 0, 1, 2, 3 \Rightarrow S = 0$

$r = 4, 5, 6, 7 \Rightarrow S = 7$

Ans:

7-4 =3	0	7-5 =2	0
0	7-6 =1	7-4 =3	
0	0		
7-7 =0	7-6 =1	7-4 =3	0

Zooming:

Zoom in

(Doubling Row & Column)

4	3
3	6

2×2

$\longrightarrow$

4	4	3	3
4	4	3	3
3	3	6	6
3	3	6	6

point operation.

Shrinking:

Sampling & Quantization :-

D - 31/1/25

These are the processes used to convert analog signal into digital signal.

1) What is sampling?

→ The process of collecting data from an analog source at regular intervals.

→ It determines the special resolution of an image.

→ Digitizing the cordinate value is called sampling.

2) What is quantization?

→ The process of converting a continuous set of values into a discreate set of values.

→ Also Digitizing the amplitude value is called quantization.

DIP

6/2/2025

Smoothing Special filters are used for blurring and noise reduction.

- **Bluring** is used in Pre-processing task such as removal of small details from an image prior to (large) object extraction.
- **Noise Reduction** can be accomplished by blurring with a linear as well as non-linear filter.

Smoothing Special filters

- Linear
  - Mean Filter/ Box Filter
  - Weighted Average Filter
  - Gauseon Filter
- Non-linear
  - Median Filter
  - Maximum Filter
  - Minimum Filter

Smoothing Linear Filters :— They are known as averaging or low-pass-filters as they are simply average of the pixels. Content in neighboorhood of the pixel.

The process in a result in an image with reduced sharp, transition in intensity which ultimately lends to noise reduction.

(A) **Mean Filter / Box Filter** :—

$$\left.\frac{1}{9}\times\begin{bmatrix}1&1&1\\1&1&1\\1&1&1\end{bmatrix}_{3\times3}\right\}\text{Mask}$$

(B) **Weighted Average Filter**

— Gives more (less) weight to pixel near (away from) the output location.

(iii) **Gausian Filter** :— Weights are samples of 2D gausian filter.

$$G_\delta(x,y) = \frac{1}{2\pi\delta^2}e^{-\frac{(x^2+y^2)}{2\delta^2}}$$

Blur Edge Reduce Contrast

- It is used to Blur image & reduce to contrast.

- <u>Non linear Filter / Order Statistical Filter :-</u>

There response is based on ordering (ranking). The pixels containing image area encompassed by the filter and then replacing value of the pixel by the value determined the ranking result

Median Filter :- Median of the pixel values

Maximum Filter :- To find the maximum of all pixel values

Minimum Filter :- To find the minimum of all pixel values

- <u>Median of the Pixel Values :-</u>

3	1	0
5	4	6
2	3	2

~~0~~, ~~1~~, ~~2~~, ~~2~~, 3, ~~3~~, ~~4~~, ~~5~~, ~~6~~

Median

DIP 7/2/2025

Smoothing Spatial Filter:

Smoothing Spatial Filters are used for blurring and noise reduction.

- **Blurring:** Blurring is used in preprocessing task, Such as removal of small details from an image prior to object extraction.
- **Noise reduction:** It can be done by blurring with both linear and non-linear filters.

Smoothing Spatial Filter
- Linear Filter
  - Mean or Box Filter
  - Weighted Average filter
  - Gaussian Filter
- Non-linear Filter
  - Median Filter
  - Max Filter
  - Min Filter

Mask:

(1) **Mean / Box filter**

$$\frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}_{3\times 3}$$

(2) **Weighted Avg. filter**

$$\frac{1}{16}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

(3) **Gaussian Filter**

$$G_\delta(x, y) = \frac{1}{2\pi\delta^2} e^{-(x^2+y^2)/2\delta^2}$$

For 2D,

$$\frac{1}{16}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

Qn: Consider the image and calculate the output of the pixel (2,2). If smoothing is done using (3×3) neighbourhood. Mean Filters have it is used.

$$
f(x,y)\;
\begin{array}{ccccccc}
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 8 & 8 & 0 & 7 & 0 \\
0 & 4 & 7 & 9 & 5 & 7 & 0 \\
0 & 5 & 4 & 6 & 8 & 6 & 0 \\
0 & 4 & 2 & 0 & 1 & 5 & 0 \\
0 & 0 & 1 & 0 & 2 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0
\end{array}
$$

→ index

→ 0 padding

$\frac{1}{9}[7\times1+9\times1+5\times1+4\times1+6\times1+8\times1+2\times1+0\times1+1\times1]$

$=\frac{1}{9}\times42 = 4.66 \simeq 5$

- **For weighted Avg.**

$\frac{1}{16}[7\times1+9\times2+5\times1+4\times2+6\times4+8\times2+2\times1+0\times2+1\times1]$

$=\frac{1}{16}\times 81 = 5.06 \simeq 5$

Non-Linear Filter:

(i) Median Filter, [Mask is empty]. | let, pos (4,1)

if n is odd
mid val
else
mid 2 avg

~~1~~, ~~4~~, ~~4~~, ~~5~~, 6, ~~7~~, ~~8~~, ~~8~~, ~~9~~

let, pos = (2,2)
Ans = 5

Max replace with max value

Min replace with min value

0 padding:

ex:

0	0	0	0	0
0	1	2	2	0
0	1	0	1	0
0	8	0	5	0
0	0	0	0	0

DIP

13/02/2025

(i) 0 padding
(ii) Pixel Examine
(iii) Convolution and Correlation

$I = \{0\ 0\ 1\ 0\ 0\}$ mask/ $K = \{3\ 2\ 8\}$

0 0 0 0 1 0 0 0 0

Step 1: Rotate the mask by 180 →

i) ~~Corr~~ Convolution

$8 \times 0 + 2 \times 0 + 3 \times 0$

ii)

8 2 3

0 0 0 0 1 0 0 0 0

$*$ (0 0 3 2 8 0 0)

Qn: Let $I = \begin{bmatrix} 3 & 3 \\ 3 & 3 \end{bmatrix}$ be an image and $K = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$ be the kernal /mask.

$\downarrow$

$\begin{bmatrix} 3 & 4 \\ 1 & 2 \end{bmatrix} \rightarrow \begin{bmatrix} 4 & 3 \\ 2 & 1 \end{bmatrix}$

0_4	0_3	0	0
0_2	3_1	3	0
0	3	3	0
0	0	0	0

$\Rightarrow$

3	9	6
12	30	18
9	21	12

(i) 0 padding —

0	0	0	0	0
0	3	2	1	0
0	6	4	2	0
0	3	1	5	0
0	0	0	0	0

→

0	2	0
2	3	1
0	2	0

(ii) Pixel Examine —

3	3	2	1	1
3	3	2	1	1
6	6	4	2	2
3	3	1	5	5
3	3	1	5	5

→

3	2	2
3	3	2
3	3	4