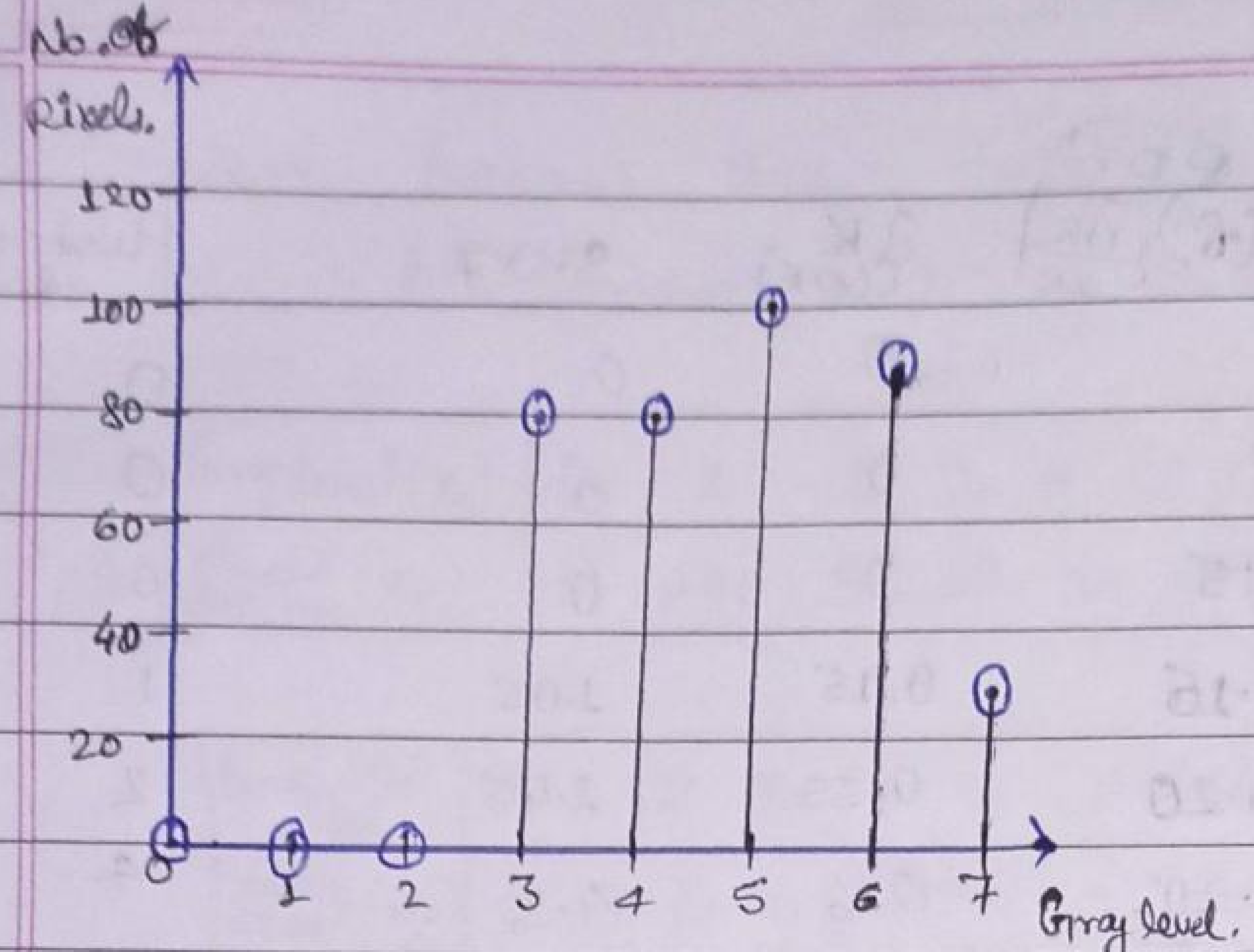
IP

4.

3 (4) Ans




[15-08-22]

▷ Spartial underlying filtering :-

(1) convolution (2) Co-Relation

Q).(1) Let $I = \{0,0,1,0,0\}$ be an image, using the (kernel) mask $K = \{3,2,8\}$, perform the convolution

S. (i) Zero padding process for convolution.

** In convolution process, we have to rotate the kernel by $180°$ (opposite)

Now,

K :- 8 2 3 8 2 3

I :- 0 0 0 0 1 0 0 0 0.

(0:- padded zero)

} Like this formate where image end again mask.

Convolution

Spartial Filter

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ii) Initial position.

Template
8 2 3
0 0 0 0 1 0 0 0 0

0

Output is 0 located at the center pixel.

∴ Have to multiply $(8\times0)+(2\times0)+(3\times0)$ & Answer will be at center bit.

iii) position after one shift

& K will shift one bit R.

Template is shifted by on zero.

8 2 3
0 0 0 0 1 0 0 0 0
0 0 ← same $(8\times0)+(2\times0)+(3\times0)=0$.

Output is zero.

iv) position after two shift :-

Template is shifted again

$(8\times0)+(2\times0)+(3\times1)=3$

8 2 3
0 0 0 0 1 0 0 0 0
0 0 3 : Output is 3 ;

v) Position after 3 shifts.

Template is shifted again :-

8 2 3

$(8\times0)+(2\times1)+(3\times0)=$ .

0 0 0 0 1 0 0 0 0
0 0 3 2
Output produced is 2

vi)

vi). Position after 4 shifts :-

Template is shifted again :-

8 2 3

0 0 0 0 1 0 0 0 0

0 0 3 2 8 [output is produced : 8]

again :- $(8\times1)+(2\times0)+(3\times0)$
$=8$.

vii) Position after 5 shifts :-

Template is shifted again

8 2 3

0 0 0 0 1 0 0 0 0

0 0 3 2 8 0

$(8\times0)+(2\times0)+(3\times0)$
$=0$

output produced is 0.

2). Co-Relation :-

Q.2) Let $I = \{0,0,1,0,0\}$ be an image Using the mask $K =$ ~~328~~ $\{3,2,8\}$, perform the co-relati

$\therefore$ $I = \{0\,0\,1\,0\,0\}$ $K = \{\cancel{8,2,3}\}$
3 2 8

Sol^n

i) Zero padding process for co-relation

3 2 8 3 2 8

0 0 0 0 1 0 0 0 0

0 :- padded zero

ii) Initial position :-

Template 3 2 8

0 0 0 0 1 0 0 0 0

0 is output

$(3\times0)+(2\times0)+(8\times$
$=0$

iii) Position after one shift

Template is shifted again

T:- 3 2 8

0 0 0 0 1 0 0 0 0

0 0

$(3\times0)+(2\times0)+(8\times0) = 0$

output produced is zero 0.

Position after 2nd shift.

iv) Temp. is shifted again

T:- 3 2 8

0 0 0 0 1 0 0 0 0

0 0 8

$(3\times0)+(2\times0)+(8\times1) = 8.$

Output is 8.

v). Position after 3rd shift

Temp. is shifted

3 2 8

0 0 0 0 1 0 0 0 0

0 0 8 2

$(3\times0)+(2\times1)+(8\times0) = 2.$

Output is produced '2'.

vi). Position after 4th shift

3 2 8

0 0 0 0 1 0 0 0 0

0 0 8 2 3

$(3\times1)+(2\times0)+(8\times0) = 3.$

output produced is '3'.

Final :-

3 2 8

0 0 0 0 1 0 0 0 0

[0 0 8 2 3 0 0]

so in the final position, the o/p co-relation, Ans. Produced is As

IP

# Co-Relation X Convolution.

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Q.* 2D, Let $I = \begin{pmatrix} 3 & 3 \\ 3 & 3 \end{pmatrix}$ be an image
and $K = \begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$ be a Kernel (mask)
Perform Convolution & Co-r

(i) Convolution :-

Solⁿ

* Rotate the kernel by 180°.

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix} \Rightarrow \begin{pmatrix} 3 & 4 \\ 1 & 2 \end{pmatrix} \Rightarrow \begin{pmatrix} 4 & 3 \\ 2 & 1 \end{pmatrix} = K'$$
New K'.

Solⁿ Convolution:-

a)

$$\begin{matrix} 0_4 & 0_3 & 0 & 0 \\ 0_2 & 3_1 & 3 & 0 \\ 0 & 3 & 3 & 0 \\ 0 & 0 & 0 & 0 \end{matrix} \Rightarrow \begin{matrix} \boxed{3} & 0 & 0 & 0 \\ 0 & 3 & 3 & 0 \\ 0 & 3 & 3 & 0 \\ 0 & 0 & 0 & 0 \end{matrix}$$

Screen.

$(4\times0)+(0\times3)+(3\times...)$
$= 3$
(will pl... at 1...

$$K' = \begin{pmatrix} 4 & 3 \\ 2 & 1 \end{pmatrix}$$

b)

$$\begin{matrix} 3 & 0_4 & 0_3 & 0 \\ 0 & 3_2 & 3_1 & 0 \\ 0 & 3 & 3 & 0 \\ 0 & 0 & 0 & 0 \end{matrix} \Rightarrow \begin{matrix} 3 & \boxed{9} & 0 & 0 \\ 0 & 3 & 3 & 0 \\ 0 & 3 & 3 & 0 \\ 0 & 0 & 0 & 0 \end{matrix}$$

$(4\times0)+(3\times0)+(2\times3)+(3\times1)$
$= 9$

c).

$$\begin{matrix} 3 & 9 & 0_4 & 0_3 \\ 0 & 3 & 3_2 & 0_1 \\ 0 & 3 & 3 & 0 \\ 0 & 0 & 0 & 0 \end{matrix} \Rightarrow \begin{matrix} 3 & 9 & \boxed{6} & 0 \\ 0 & 3 & 3 & 0 \\ 0 & 3 & 3 & 0 \\ 0 & 0 & 0 & 0 \end{matrix}$$

$(4\times0)+(3\times0)+(2\times3)+(0\times1)$
$= \boxed{6}$

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$$\begin{matrix} 3 & 9 & 6 & 0 \\ 0_4 & 3_3 & 3 & 0 \\ 0_2 & 3_1 & 3 & 0 \\ 0 & 0 & 0 & 0 \end{matrix} \Rightarrow \begin{matrix} 3 & 9 & 6 & 0 \\ \boxed{12} & 3 & 3 & 0 \\ 0 & 3 & 3 & 0 \\ 0 & 0 & 0 & 0 \end{matrix}$$

$(4\times 0)+(3\times 3)+(2\times 0)+(3\times 1)$
$= 12$

$$\begin{matrix} 3 & 9 & 6 & 0 \\ 12 & 3_4 & 3_3 & 0 \\ 0 & 3_2 & 3_1 & 0 \\ 0 & 0 & 0 & 0 \end{matrix} \Rightarrow \begin{matrix} 3 & 9 & 6 & 0 \\ 12 & \boxed{30} & 3 & 0 \\ 0 & 3 & 3 & 0 \\ 0 & 0 & 0 & 0 \end{matrix}$$

$(4\times 3)+(3\times 3)+(2\times 3)+(1\times 3)$
$= 30$

$$\begin{matrix} 3 & 9 & 6 & 0 \\ 12 & 30 & 3_4 & 0_3 \\ 0 & 3 & 3_2 & 0_1 \\ 0 & 0 & 0 & 0 \end{matrix} \Rightarrow \begin{matrix} 3 & 9 & 6 & 0 \\ 12 & 30 & \boxed{18} & 0 \\ 0 & 3 & 3 & 0 \\ 0 & 0 & 0 & 0 \end{matrix}$$

$(4\times 3)+(3\times 0)+(2\times 3)+(1\times 0)$
$= 18$

$$\begin{matrix} 3 & 9 & 6 & 0 \\ 12 & 30 & 18 & 0 \\ 0_4 & 3_3 & 3 & 0 \\ 0_2 & 0_1 & 0 & 0 \end{matrix} \Rightarrow \begin{matrix} 3 & 9 & 6 & 0 \\ 12 & 30 & 18 & 0 \\ 9 & 3 & 3 & 0 \\ 0 & 0 & 0 & 0 \end{matrix}$$

$(4\times 0)+(3\times 3)+(0\times 2)+(1\times 0)$
$= 9$

$$\begin{matrix} 3 & 9 & 6 & 0 \\ 12 & 30 & 18 & 0 \\ 9 & 3_4 & 3_3 & 0 \\ 0 & 0_2 & 0_1 & 0 \end{matrix} \Rightarrow \begin{matrix} 3 & 9 & 6 & 0 \\ 12 & 30 & 18 & 0 \\ 9 & \boxed{21} & 03 & 0 \\ 0 & 0 & 0 & 0 \end{matrix}$$

$(4\times 3)+(3\times 3)+(2\times 0)+(1\times 0)$
$= 21$

(I)

$$\boxed{\begin{matrix} 3 & 9 & 6 & 0 \\ 12 & 30 & 18 & 0 \\ 9 & 21 & \boxed{12} & 0 \\ 0 & 0 & 0 & 0 \end{matrix}}$$

Ans.

for – convolution answer is above.

## Smoothing Spatial filter



1) **Box filter** - all co-efficient are equal.

e.g.:-

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

2) **weighted average** :- give more (less) weight to pixel near (away from) the output location

$$\frac{1}{16} \times \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}_{3\times3} \rightarrow \text{mask.}$$

3) **Gaussian filter** the weights are samples of 2D Gaussian function :-

$\sigma$ (sigma) - (standard deviation)

$$G_\sigma(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{(x^2+y^2)}{2\sigma^2}} \quad \text{(2D Gaussian function)}$$

$$\frac{1}{16} \times \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}_{3\times3} \rightarrow \text{Mask}$$

⇒ Used to blur edges & reduce contrast.

⇒ Similar to median filter but faster.

Spartial Filter

* Non-linear (order-statistic) filters.

1). Median filter:- find the median value of all the pixel values.

2). Min filter :- find the minimum of all the pixels values.

3). Max filter :- Find the Maximum of all the pixel values

Q).1). Consider the image below and calculate the o/p of the pixel ~~(3,~~ (2,2) if Smoothing is done using 3X3 neighbourhood using all the filters below

a). Box / mean filter
b) weighted average filter
c). Median filter
d). Min filter
e). Max filter

| | | | | |
|---|---|---|---|---|
| 1 | 8 | 8 | 0 | 7 |
| 4 | 7 | 9 | 5 | 7 |
| 5 | 4 | 6 | 8 | 6 |
| 4 | 2 | 0 | 1 | 5 |
| 0 | 1 | 0 | 2 | 0 |

Sol:- a). Box filter :- Sum of original value (Because Box fit have '1').

Box filter :-

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

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

$$= \frac{1}{9} \times [42] = \boxed{4.66} \approx 5$$

b). weighted :- Multiply with ~~outp~~ original (given) value & sum:-

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

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

$$= \frac{1}{16} [81] = \boxed{5.0625}$$

c). Median filter :-
if value taken in ascending order.

$\cancel{0}$, $\cancel{1}$, $\cancel{2}$, 4, 5, 6, 7, 8, 9

Median = $\boxed{5}$ Ans

d). Min filter :-
= $\boxed{0}$

e). Max filter :-
= $\boxed{9}$ Ans

IT **

## Important Some Theory Questions

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Q). Why median filter is better than ~~t~~ mean filter?

Ans Median filter is normally used to reduce noise in an image, similar to the mean filter. However, it often does a better job than mean filter in preserving useful details in an image.

Median filter has 2 main Advantages.

1. The median is a more robust average than the 'mean' and so a single very un-representative pixel in a neighborhood will not affect the median value significantly.

2. Since the median value must actally be the value of one of the pixel in the neighborhood the median filter does not create new unrealistic pixel values when the filter straddles an edge. Therefore, it is much better at preserving 'sharp edges' than the mean filter.

# Note:- Mean filter is better at dealing with Gaussian noise than median filter.
- Median filter is better at dealing with salt and pepper noise than mean filters.

Q2 Write down a few approaches to deal with missing edge pixels.

** These are Missing edge pixel

eg:-

| | | | |
|---|---|---|---|
| 50 | 50 | 50 | 60 |
| 50 | 50 | 50 | 60 |
| 50 | 60 | 50 | 50 |
| 40 | 50 | 60 | 50 |

mask $\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$

Ans A few approaches to dealing with missing edge pixels are :-

1. Omit missing pixels.
   - only works with some filters.
   - Can add extra code and slow down processing.

2. Pad the image (eg: 0).
   - Typically with either all white or black pixels.

3. Replicate Border pixel :-
4. Truncate the image
5. Allow pixels used around the image
   - Can cause some strange image artifacts

Ex:- (2)

| | | | | |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 2 | 4 | 8 | 0 |
| 0 | 5 | 4 | 0 | 0 |
| 0 | 5 | 6 | 9 | 0 |
| 0 | 0 | 0 | 0 | |

(3)

| | | | | |
|---|---|---|---|---|
| 1 | 1 | 2 | 3 | |
| 1 | 1 | 2 | 3 | 3 |
| 4 | 4 | 5 | 6 | 6 |
| 7 | 7 | 8 | 6 | 6 |
| 7 | 7 | 8 | 6 | 6 |

ex:- replicate

* Wrapping of Pixels :-

eg:-

| | | | | |
|---|---|---|---|---|
| 9 | 7 | 8 | 9 | 7 |
| 3 | 1 | 2 | 3 | 1 |
| 6 | 4 | 5 | 6 | 4 |
| 9 | 7 | 8 | 9 | 7 |
| 3 | 1 | 2 | 3 | 1 |

2nd exam :-

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 1 | 2 |
| 4 | 9 | 8 | 4 | 9 |
| 6 | 7 | 8 | 6 | 7 |
| 1 | 2 | 3 | 1 | 2 |
| 4 | 9 | 8 | 4 | 9 |

Assumed image

# Sharpening Spartial filter

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⇒ The principal objective of sharpening is to highlight transitions in intensity.

* Blurring → Pixel averaging.
* Sharpening → Spartial differentiation

1. First-order derivative of a one-dimensional function $f(x)$:-

$$\frac{\partial f}{\partial x} = f(x+1) - f(x).$$

2. Second-order derivative of a one-dimensional functi. $f(x)$:-

$$\frac{\partial^2 f}{\partial x^2} = f(x+1) + f(x-1) - 2f(x)$$

* Laplacian filter

Q) ① Apply Laplacian filter on the given image on the center pixel.

$$\begin{bmatrix} 8 & 5 & 4 \\ 0 & 6 & 2 \\ 1 & 3 & 7 \end{bmatrix} * \begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

$= (8\times0) + (5\times1) + (4\times0) + (0\times1) + (6\times-4) + (2\times1) + (1\times0) + (3\times1) + (7\times0)$

$= 0+5+0+0-24+2+0+3+0$

$= 10-24 = \boxed{-14}$ will placed at 6 center.

* Enhanced laplacian Filter :-

We just increment with '1'.

$$\begin{matrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{matrix} \xrightarrow{\text{Enhanced}} \begin{matrix} 0 & 1 & 0 \\ 1 & -5 & 1 \\ 0 & 1 & 0 \end{matrix}$$

$$\begin{matrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{matrix} \xrightarrow{\text{Enhanced}} \begin{matrix} 1 & 1 & 1 \\ 1 & -9 & 1 \\ 1 & 1 & 1 \end{matrix}$$

Q) ② Apply enhanced Laplacian filter on the given image on the center pixel.

$$\begin{bmatrix} 8 & 5 & 4 \\ 0 & 6 & 2 \\ 1 & 3 & 7 \end{bmatrix} * \begin{bmatrix} 1 & 1 & 1 \\ 1 & -9 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

$= (8\times1) + (5\times1) + (4\times1) + (0\times1) + (6\times-9) + (2\times1) + (1\times1) + (3\times1) + (7\times1) =$

$= \cancel{30} \; 5 \quad 8+5+4+0 -54+2+1+3+7$

$= 30-54 = \boxed{-24}$ It will substitute of center value.

Q3 Apply Laplacian filter on the given image :-

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 50, | 50, | 50, | 50 | 100 | 100 | 100 | 100 |
| 50, | 50 -8 | 50, | 50 | 100, | 100 | 100 | 100 |
| 50, | 50, | 50, | 50 | 100 | 100 | 100 | 100 |
| 50 | 50 | 50 | 50 | 100 | 100 | 100 | 100 |
| 100 | 100 | 100 | 100 | 50 | 50 | 50 | 50 |
| 100 | 100 | 100 | 100 | 50 | 50 | 50 | 50 |
| 100 | 100 | 100 | 100 | 50 | 50 | 50 | 50 |
| 100 | 100 | 100 | 100 | 50 | 50 | 50 | 50 |

mask →

| | | |
|---|---|---|
| 1 | 1 | 1 |
| 1 | -8 | 1 |
| 1 | 1 | 1 |

Iteration :-

(1) $= 50 \times 8 - \cancel{80}\ 50 \times 8$

$= 0$

(3) $5 \times 5 + 100 \times 3 - 50 \times 8$

$= 450 + 300 - 400 = 150.$

(4) $50 \times 3 + 100 \times 5 - 400$

$= 150 + 500 - 400 = -150$

Final :-

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 150 | -150 | 0 | 0 |
| 0 | 0 | 150 | -150 | 0 | 0 |
| 150 | 150 | 200 | -200 | -150 | -150 |
| -150 | -150 | -200 | 200 | 150 | 150 |
| 0 | 0 | -150 | 150 | 0 | 0 |
| 0 | 0 | -150 | 150 | 0 | 0 |

Ans

# Un sharp Masking & High boost Filter

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* ## Un Sharp Masking :-

$$f_s(x,y) = f(x,y) - \bar{f}(x,y)$$

sharpened image = original image − blurred image.

* Subtracting a blurred version of an image from the original produces a sharpened image.

* ## High boost filtering :-

$$f_{hb}(x,y) = Af(x,y) - \bar{f}(x,y)$$
$$= Af(x,y) - [f(x,y) - f_s(x,y)]$$

$$\boxed{f_{hb}(x,y) = (A-1)\, f(x,y) - f_s(x,y).}$$

This is the generalized form of ~~to~~ Unsharp masking where $\boxed{A \geq 1}$, A specifies the amount of sharpening of the image.

⇒ If we use Laplacian filter to create the sharpened image $f_s(x,y)$ with addition of the original image :-

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$$f_s(x,y) = \begin{cases} f(x,y) - \nabla^2 f(x,y) \\ f(x,y) + \nabla^2 f(x,y) \end{cases}$$

$$f_{hb}(x,y) = \begin{cases} Af(x,y) - \nabla^2 f(x,y) \\ Af(x,y) + \nabla^2 f(x,y). \end{cases}$$

* Highboost Mask :-

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & A+4 & -1 \\ 0 & -1 & 0 \end{bmatrix} \quad \begin{bmatrix} -1 & -1 & -1 \\ -1 & A+8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

Imp Example

where $A \geq 1$

Q. Apply highboost filter on the image given below on the center pixel. use the Mask with $A = \boxed{1.7}$

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix} * \begin{bmatrix} -1 & -1 & -1 \\ -1 & A+8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

I/p image

$$= -1(1+2+3+4+6+7+8+9) + 5(1.7+8)$$

$$= -1(40) + 5(9.7)$$

$$(-40 + 48.5) = 8.5$$

This 8.5 will Replace to 5 that will be Answe

# First-Order Derivative Filter

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1. Robert operators (~~Gr~~ Cross-gradient)

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

* It used to ~~ero~~ cross diagonal diffrentiation.

$$\begin{bmatrix} 5 & 6 & 8 \\ 0 & 25 & 2 \\ 9 & 1 & 5 \end{bmatrix}$$ Ex.

▷ Problems with Robert Cross :-

1. 2x2 Mask are not easy to implement
2. No. of calculations are More
3. No. of neighboring pixels considered in one go are less.

⇒ To solve these Problems, we Make the following Changes:-
1). change in the size of the Mask
2). change in the No. of neighboring Pixels considered

* Sobel operators :-

$$\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \quad \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

* Prewitt operators :-

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

Q. Apply Roberts, Sobel and Prewitt operators on the pixel (1, 1) int the following image.

| | | | |
|---|---|---|---|
| 50 | 50 | 100 | 100 |
| 50 | 50 | 100 | 100 |
| 50 | 50 | 100 | 100 |
| 50 | 50 | 100 | 100 |

i/p Image

1). Roberts operators (any)

origin

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

$= 50 \times (-1) + 100 \times 1$

$= -50 + 100 = \boxed{50}$

2). Sobel operator.

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

$= 50(-1) + 50(-2) + 100(-1) + 50(1) + 50(2) + 100(1)$

$= \cancel{-50} \cancel{-100} \cancel{-100} \cancel{+50} \cancel{+100} \cancel{+100} = \boxed{0}$

3). Prewitt operator :-

$$\begin{bmatrix} 50 & 50 & 100 & 100 \\ 50 & 50 & 100 & 100 \\ 50 & 50 & 100 & 100 \\ 50 & 50 & 100 & 100 \end{bmatrix} * \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

I/p image

$= -1(50 + 50 + 100) + 1(50 + 50 + 100).$

$= \boxed{0}$ it will assigned at center 50 Answer.

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Q.1 Compute DFT of the sequence $f(x) = \{1, 0, 0, 1\}$
$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad 0\ 1\ 2\ 3$

$$F[k] = \sum_{x=0}^{N-1} f(x) e^{-j2\pi k x/N} \text{; where } k = 0, 1, 2 \dots N-1.$$

Here $x = 0$ ; $N = 4$

$$F[k] = \sum_{x=0}^{3} f(x) e^{-j2\pi k x/4}$$

$$= f(0) e^{0} + f(1) e^{-j2\pi k/4} + f(2) e^{-j\pi k} + f(3) e^{-j3\pi k/2}$$

$$= 1 + 0 + 0 + f(3) e^{-j3\pi k/2}$$

$$= \boxed{1 + e^{-j3\pi k/2}}$$

When $k = 0$

$$F[0] = 1 + e^{0} = 1 + 1 = \boxed{2}$$

When $k = 1$

$$F[1] = 1 + e^{\cancel{-j3\pi k/4}\ -j3\pi/2} = 1 + j$$

When $k = 2$

$$F[2] = 1 + e^{-j3\pi} = 1 - 1 = 0$$

When $k = 3$

$$F[3] = 1 + e^{-j9\pi/2} = 1 - j$$

* $F[K] = \{2, 1 + j, 0, 1 - j\}$ Final Answer.

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** Exam

We know, * Kernel of a 4-point DFT

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix} \rightarrow \text{Kernel}$$

* 1D DFT : $F[k] = \text{Kernel} \times f(x)$.

* 2D DFT : $F[k,l] = \text{Kernel} \times f(x,y) \times \text{Kernel}^T$ (Transpose)

Quest: Calculate 4-point DFT ~~in one~~ for the sequence $x(n) = \{0, 1, 2, 3\}$ using matrix Method.

Ans: The 4-Point DFT in one dimensional = Kernel × Input Sequence.

$$= \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix} \times \begin{bmatrix} 0 \\ 1 \\ 2 \\ 3 \end{bmatrix}$$

$$= \begin{bmatrix} 0 + 1 + 2 + 3 \\ 0 - j - 2 + 3j \\ 0 - 1 + 2 - 3 \\ 0 + j - 2 - 3j \end{bmatrix} = \begin{bmatrix} 6 \\ -2+2j \\ -2 \\ -2-2j \end{bmatrix}$$ Ans

IP ** Question/Answers

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Q). ③ Compute the 2D DFT of the gray scale image is given by.
$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix}$$

Ans $F(k,l) = \boxed{\text{Kernal} \times f(m,n) \times \text{Kernal}^T}$

Kernal for the 4-point DFT :-
$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix}$$

$$F[k,l] = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix} \times \underbrace{\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix}}_{\text{Given img}}$$

$$(\text{Kernal}^T) = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix}$$

$$F[k,l] = \begin{bmatrix} 4 & 4 & 4 & 4 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \times \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -j & -1 & j \\ 1 & -1 & 1 & -1 \\ 1 & j & -1 & -j \end{bmatrix}$$

$\begin{bmatrix} 4+4+4+4 & 4+4j+4+4j \end{bmatrix}$

$$F(k,l) = \begin{bmatrix} 16 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$ Ans

4+4+4+4, $4+(4 \cdot j) + 4 + 4j$
$= 0$.