IMAGE ENHANCEMENT

GRADIENT IMAGE

- For a function f(x,y), gradient of f at coordinates (x,y) is defined as two dimensional column vector

$$\nabla f = \text{grad}(f) = \begin{bmatrix} g_x \\ g_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}$$ ----------(1) • Important property of this vector is it points in the direction of greatest rate of change of f at location (x,y). • Magnitude(length) of vector is denoted as M(x,y) where

$$M(x, y) = \text{mag}(\nabla f) = \sqrt{g_x^2 + g_y^2}$$ ----------(2) is the value at (x,y) of rate of change in the direction of gradient vector.

- In some implementations, it is more suitable to approximate the squares and square root operations by absolute values

$M(x,y) \approx |g_x| + |g_y|$----------(3) • Gradient

direction is given by:-

$$\theta = \tan^{-1}\left(\frac{\partial f}{\partial y} / \frac{\partial f}{\partial x}\right)$$

GRADIENT OPERATORS

- Roberts Operator •

Prewitt Operator •

Sobel Operator •

Laplacian Operator

ROBERTS

OPERATOR

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

3×3 region of an image

−1	0	0	−1
0	1	1	0

Roberts Cross Gradient Operators

- Consider the center point to be z_5.

$g_x = (z_9 - z_5)$ and $g_y = (z_8 - z_6)$----------(4)

- Substituting eq 4 in eq 2

$M(x,y) = [(z_9 - z_5)^2 + (z_8 - z_6)^2]^{1/2}$----------(5)

- Substituting eq 4 in eq 3

$M(x,y) \approx | z_9 - z_5 | + | z_8 - z_6 |$----------(6)

- Masks of size 2×2 are awkward to implement because they do not have a clear center. So we make use of mask of size 3×3(smallest mask).

PREWITT OPERATOR

- It detects two types of edges

  Horizontal edges

  Vertical Edges

- All the masks that are used for edge detection are also known as derivative masks and has following properties:-

  Opposite sign should be present in the mask.

  Sum of mask should be equal to zero.

  More weight means more edge detection.

- Prewitt operator provides us two masks one for

detecting edges in horizontal direction and another for detecting edges in an vertical direction.

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

3×3 region of an image

-1	-1	-1
0	0	0
1	1	1

-1	0	1
-1	0	1
-1	0	1

Masks in horizontal and vertical direction

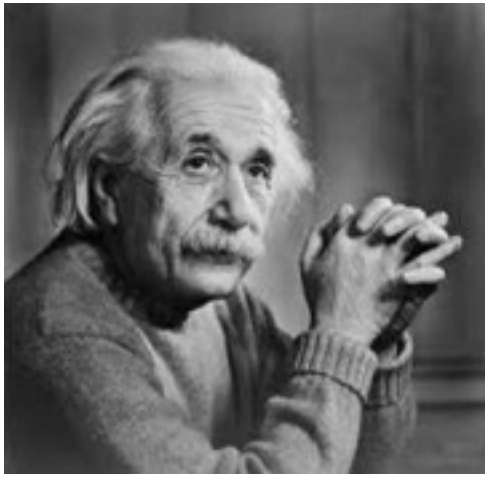
- Here the mask size is 3×3.

$g_x = (z_7+z_8+z_9) - (z_1+z_2+z_3)$

and

$g_y = (z_3+z_6+z_9) - (z_1+z_4+z_7)$

- Vertical Direction mask will find the edges in vertical direction. When you will convolve this mask on an image, it will give you the vertical edges in an image.
- Similarly, horizontal Direction mask will find the edges in horizontal direction. When you will convolve this mask on an image, it will give you the horizontal edges in an image.



Input Image


Vertical Mask Result Horizontal Mask Result

SOBEL OPERATOR

- The sobel operator is very similar to Prewitt operator

and is used for edge detection. It is also used to detect two kinds of edges in an image:

- Vertical direction
- Horizontal direction

−1	−2	−1
0	0	0
1	2	1

−1	0	1
−2	0	2
−1	0	1

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

3×3 region of an image

Masks in horizontal and vertical direction

- Vertical Direction mask will find the edges in Vertical direction. When you will convolve this

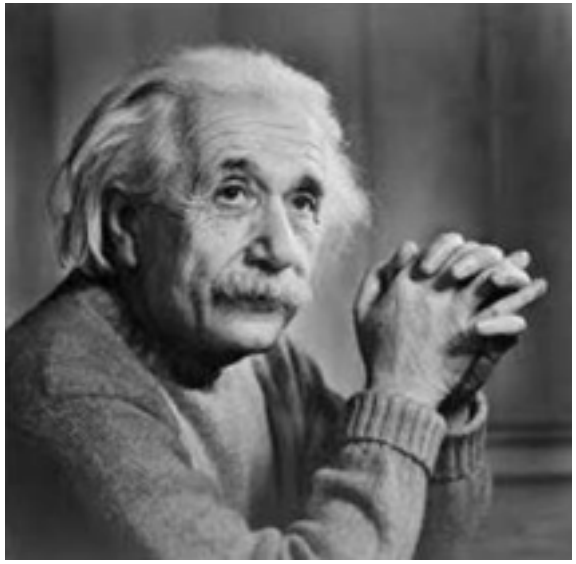
mask on an image, it will give you the Vertical edges in an image. It uses 2 and -2 as a center element of first and third column.

- Horizontal Direction mask will find the edges in horizontal direction. When you will convolve this mask on an image, it will give you the horizontal edges in an image. It uses 2 and -2 as a center element of first and third row.

- Here the mask size is 3×3.

$$g_x = (z_7 + 2z_8 + z_9) - (z_1 + 2z_2 + z_3)$$

$$g_y = (z_3 + 2z_6 + z_9) - (z_1 + 2z_4 + z_7)$$



Input Image

Vertical Mask Result Horizontal Mask Result

LAPLACIAN OPERATOR

- Laplacian Operator is also used to find edges in an image.

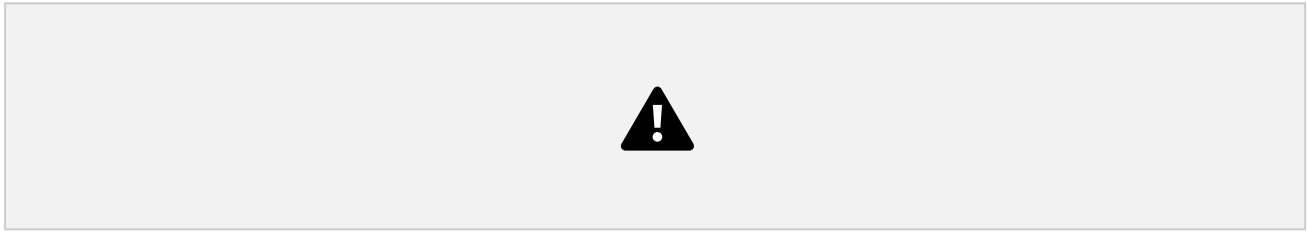
- Major difference between Laplacian and other operators is that these all are first order derivative masks but Laplacian is a second order derivative mask.

- Laplacian operator is classified as
  - Positive Laplacian Operator
  - Negative Laplacian Operator

- Laplacian operator takes out edges either as
  - Inward Edges
  - Outward Edges

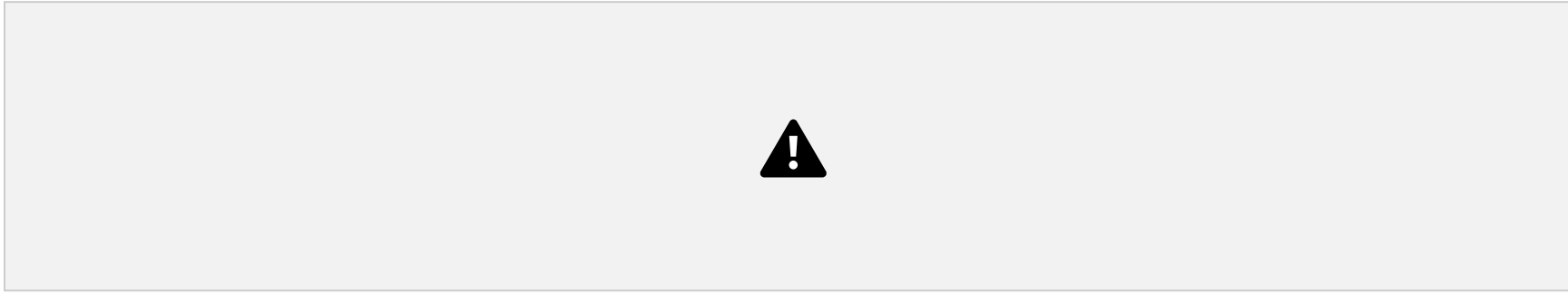
❑ Positive Laplacian Operator

- In Positive Laplacian we have standard mask in which center element of the mask should be negative and corner elements of mask should be zero.
- It is used to take out outward edges in an image.



❑ Negative Laplacian Operator

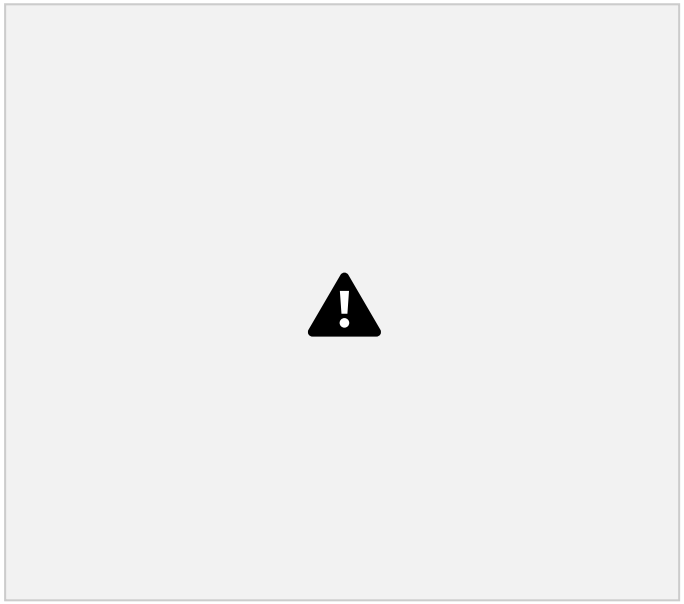
- In negative Laplacian operator we also have a standard mask, in which center element should be positive. All the elements in the corner should be zero and rest of all the elements in the mask should be -1.
- Negative Laplacian operator is use to take out inward edges in an image.



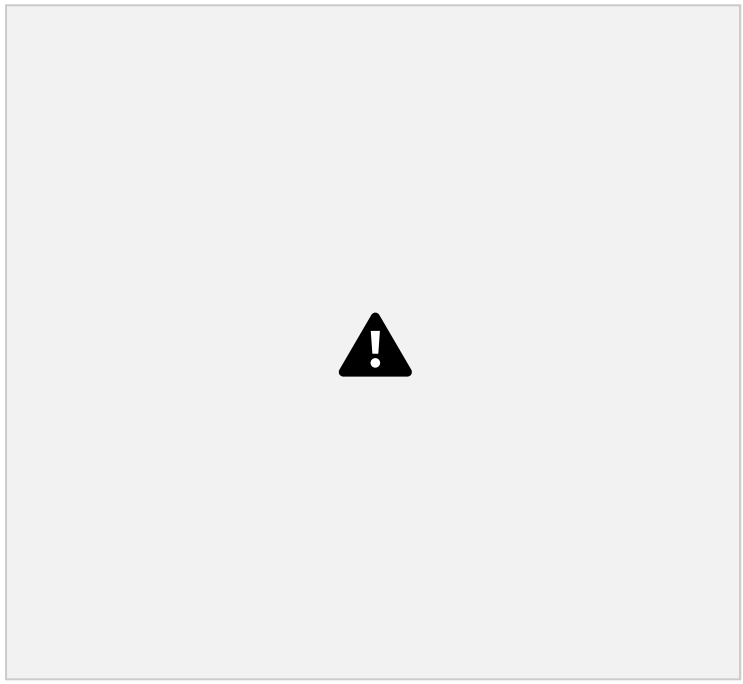
- The important thing is how to apply these filters onto

image.

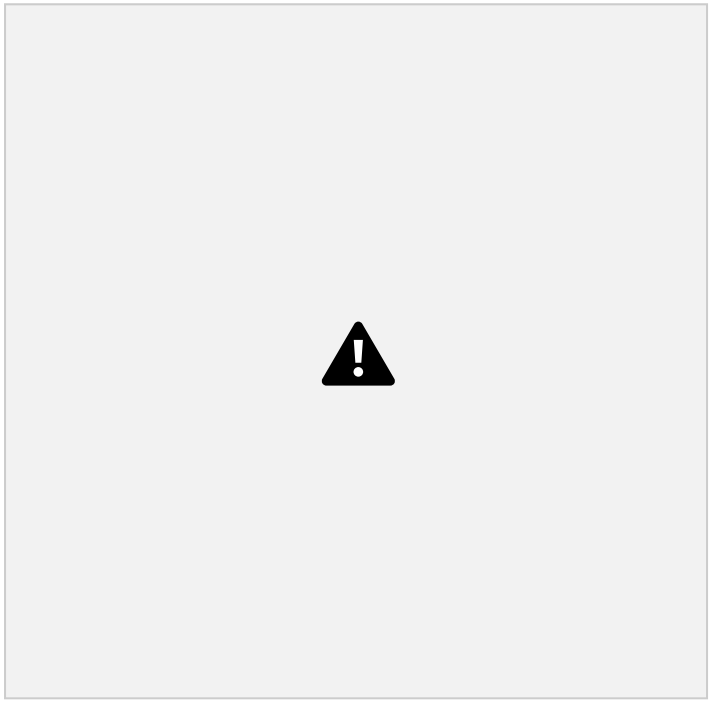
- We cannot apply both the positive and negative Laplacian operator on the same image. We have to apply just one.
- If we apply positive Laplacian operator on the image then we subtract the resultant image from the original image to get the sharpened image. Similarly if we apply negative Laplacian operator then we have to add the resultant image onto original image to get the sharpened image.



Original Image



After applying Positive Laplacian Operator



After applying Negative Laplacian Operator