INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Department of Electronics & Electrical Communication Engineering

M Tech First year

Vision and Intelligence Systems (VIS)

EC69211 – Image and video Processing Laboratory

Experiment Number: 4

Spatial Filtering

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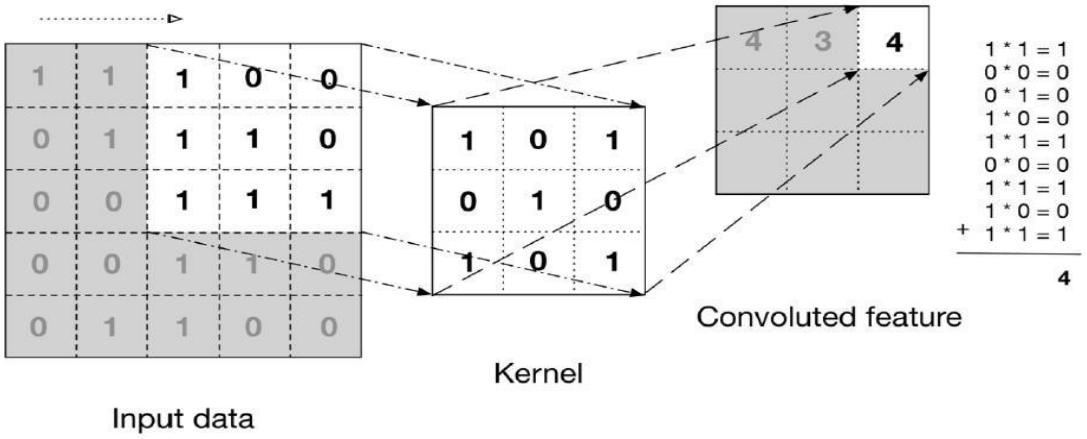
INTRODUCTION

. In this experiment we are performing spatial filtering, by convolving different mask of different filters with that of the image pixels in the spatial domain. Convolving is done by placing the mask (kernel) over the image pixels and doing a multiplication between the respective pixel with that of respective kernel value and then finally performing the summation and assigning that value to a single pixel. This is done for each and every pixel in order to get the final spatially filtered image.



There are many types of filtering, and it has to be used depending upon the application.

Mean filter, takes the average of the pixels which are multiplied with the individual elements of the mask and assigns it to a respective pixel. This operation can also be called as the smoothening operation, wherein the high frequency components like noises are removed.

Median filter is used to remove salt and pepper type of noises present in the image. In this type of filter, the pixel values are arranged in the ascending order and the middle value is taken and assigned to the respective pixel.

Prewitt and Sobel filters are also called as first order derivative filters, and they are used for the image edge detection purposes. They have two masks; one is for horizontal and the other one is for vertical. The magnitude of both of them should be taken together and has to be assigned for the respective pixels. The difference between Sobel and Prewitt is that Sobel operator mask coefficients can be changed, but we need to make sure we don’t violate any property of derivative mask.

Laplacian filter is a second order derivative filter. This filter is also used for Edge detection purpose only. But unlike first order derivative where horizontal and vertical mask were separate, here they are together and there is a single. Diagonal included mask can also be used for edge detection.

Gaussian blur filter is used to remove noise from an image which has gaussian noise distribution in it. The gaussian function is given by

$$G(x, y) = (1 / 2\pi\sigma 2) \exp(- (x2 + y2) / 2\sigma 2)$$

Laplacian of the gaussian is done because if we apply Laplacian first on a noisy image, it will have a strong response for those high frequency components and we wouldn't be able to do a proper edge detection. Therefore, we first perform the Gaussian blurring and then the Laplacian is performed over it.

KERNALS

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

Mean filter

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

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

Prewitt filter (Horizontal and Vertical)

-1	0	1
-2	0	2
-1	0	1

-1	-2	-1
0	0	0
1	2	1

0	1	2
-1	0	1
-2	-1	0

-2	-1	0
-1	0	1
0	1	2

Sobel filter (Horizontal, Vertical and Diagonal)

0	1	0
1	- 4	1
0	1	0

Laplacian filter

3.2e-15	9.39e-7	8.45e-5	9.39e-7	3.2e-15
9.39e-7	0.034	0.153	0.034	9.39e-7
8.45e-5	0.153	0.252	0.153	8.45e-5
9.39e-7	0.034	0.153	0.034	9.39e-7
3.2e-15	9.39e-7	8.45e-5	9.39e-7	3.2e-15

Gaussian filter

ALGORITHM FOR SPATIAL FILTERING

1. OpenCV is used for both image reading as well as image writing purpose
2. Perform the convolution operation of different masks with that of the image matrix, and assign the new values to each and every pixel respectively
3. For median filter where there is no mask as such, sort the pixels neighbouring pixel values and take the middle value in the sorted array and assign it the centre pixel
4. For gaussian 5X5 mask is created using the G(x,y) formula mentioned above. The centre of the mask is taken as x = 0, y = 0. And the standard deviation is taken as one

ALGORITHM FOR ITERATIVE GAUSSIAN UNBLUR

1. A blurred image should be given as an input to this program
2. Let the original image inputted be I_0 and the unblurred image be I_k at the k^{th} iteration. The maximum limit for k has been taken as 30
3. Compute $A_k = I_k * G_\sigma$ (convolution).
4. Set, $B_k = I_0 / A_k$ (pixel by pixel division).
5. Compute $C_k = Bk * G_\sigma$ (convolution).
6. Set, $I_k + 1 = I_k \times C_k$ (pixel by pixel multiplication).
7. Run steps, 8, 9, 10 until the image converges.

Input and Output Images

Input image

Output image for mean filter

Input image

Output image for median filter

Input image

Output image for Prewitt filter

Input image

Output image for Sobel filter

Horizontal edge detection

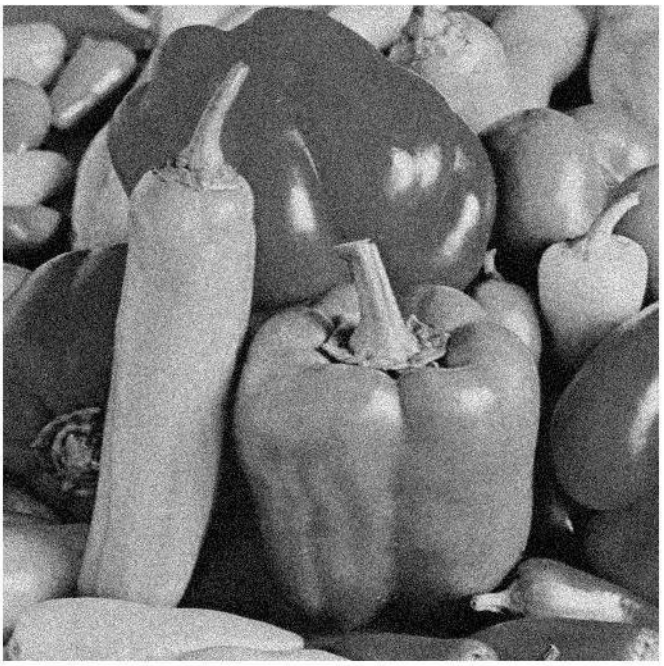
Vertical edge detection

Input image

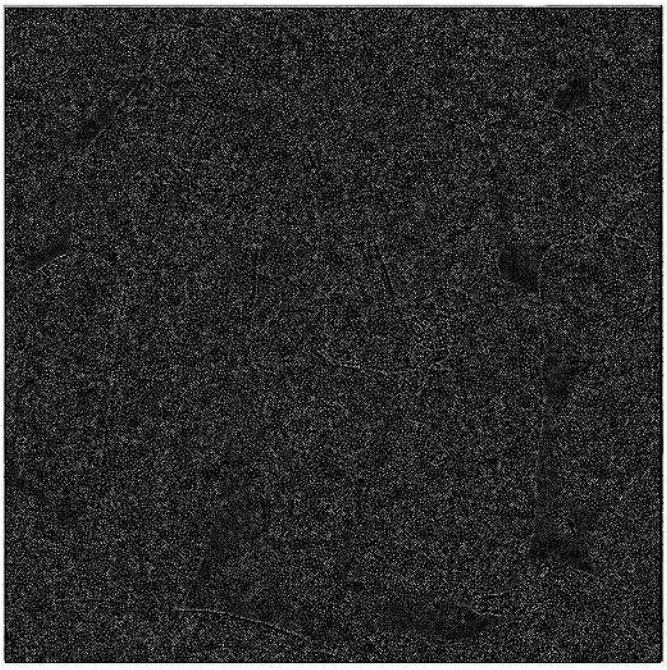
Output image for Laplacian filter

Input image

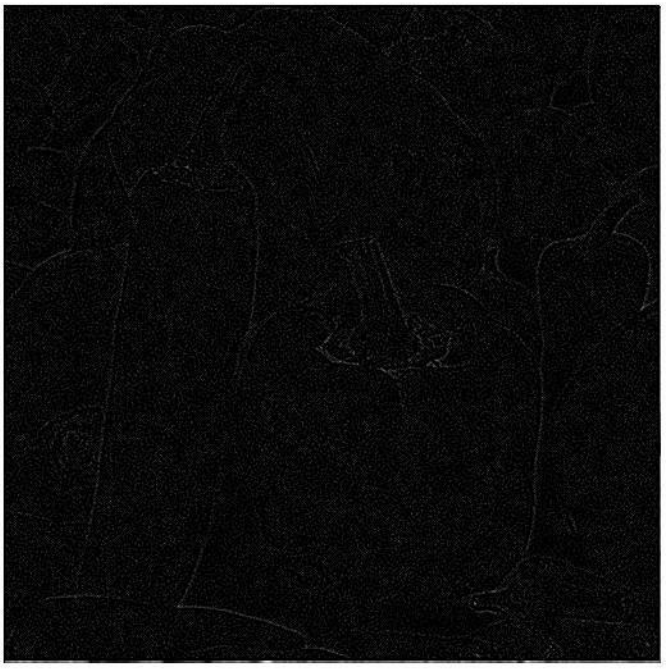
Output image for Gaussian filter



Input image



Noisy image Laplacian filter



Gaussian filered image Laplacian filter

Input image

Gaussian blurred image

Unblurred image

DISCUSSION

Averaging filter acts like a low-pass filter. It helps in reduction of irrelevant details in the image. It creates a smoothing effect but is also blur the edges. The Median filter uses statistical properties of the image. It is very effective in removing impulse noise like salt and pepper noise. It also preserves the edges in the image and thus preserves the details while reducing the noise. The Prewitt operator detects the edges in the image. It uses a first-order derivative and thus at the edges, it produces thick lines as the value goes from zero to negative to zero again at the edges. Laplacian operator uses second-order derivative and thus provides stronger response to thin lines and isolated points. This way it also becomes susceptible to noise. Sobel operator is a weighted first-order derivative. It differentiates in one direction and smoothes edges in other direction. The edge-detected output will be smoothed in this case.

SOURCES

[1] https://en.wikipedia.org/wiki/Median filter

[2] https://en.wikipedia.org/wiki/Image gradient

[3] NPTEL course on Image Processing

[4] https://homepages.inf.ed.ac.uk/rbf/HIPR2/log.htm

[5] Digital Image Processing –Gonzalez Woods