A Comprehensive Study on Filters in Digital Image Processing

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Abstract: **To preserve the impression of depth, clarity and fine details, the image processor must have sharpen edges. Therefore we must detect edges correctly and reproduce them smoothly without over-sharpening. For that purpose we use a process known as filters in image processing for clear edge detection.**

Keywords: **filters, noise, low pass & high pass filters, sobel, canny, prewitt operators etc.**

I.INTRODUCTION

A. Noise:

Noise can come in variety of ways, in different areas like communication image processing etc .It is one of the most important concepts in image processing, noise leads to the disturbances in image. Let's take an example in order to understand the noise concept in image processing, suppose we take an image of pool of blue water, where it should contain only blue color pixels. But unfortunately we may find some white and grey color pixels. So, if we find the unwanted pixels then we can come to the conclusion that this image consists of some noise. Now in order to remove that noise we use filters [1].

B. Filter:

In traditional way, filters are used in chemistry, to remove the impurities which are passed through a layer. But we use these filters in image processing to remove the noise which are present in images. Analyzing an image is very difficult, if the image consist of noise. So, for effective analysis we use filters to remove the noise.
In film photography, filtering plays a major role. In this area photographers are use this filtering process to enhance the image quality and to develop the black and white photographs from the color negatives.

Filtering in image processing is a process that cleans up appearances and allows for selective highlighting of specific information. A number of techniques are available and the best options can depend on the image and how it will be used. Both analog and digital image processing may require filtering to yield a usable and attractive end result. This can be a routine part of the editing process used to prepare images for distribution [2].

One of the most filtering technique used in image processing is digital filtering, photographers use digital filtering to enhance the image quality and to add more features to the existing image, rather than using basic filters.

Another use for filtering in image processing is while handling the images, where technicians want to highlight specific objects of interest in the picture. For example, astronomers might pass an image through filters to selectively restrict data from certain wavelengths. This can allow other information in the image to pop into relief. Filters can also remove noise like haze from images to make them clearer and clearer, even if they are not specifically blurred [3].

II.TYPES OF FILTERS

A. Low Pass Filters:

When an image is converting into analog to digital, at this process, high amount of noise is produced. In order to remove that noise we deploy a technique known as smoothing and it also known as low pass filter technique [4].
The low pass filter is one of the basic filtering operation in image processing and it is also called as smoothing or blurring filter. The simplest low-pass filter just calculates the average of a pixel and all of its eight immediate neighbours. The result replaces the original value of the pixel. The process is repeated for every pixel in the image.

Generally low pass filtered images looks blurrier, but why should we take the blur image, because normally image consist of noise. But this noise was introduced, not because of the camera, noise was added due to the climate while taking the photos. In the image, each pixel has its own noise. So, noise can be rapidly changes from pixel to pixel.

Now we'll see how the noise is filtered in image , this can be achieved by using convolution kernel. A kernel is a small grid showing how a pixel's filtered value depends on its neighbours. The following kernel is used to perform a low-pass filter by simply averaging adjacent pixels [4].

+1/9	+1/9	+1/9
+1/9	+1/9	+1/9

+1/9	+1/9	+1/9

When the above kernel is applied, each pixel and its neighbours are multiplied by 1/9 and added together. The pixel in the middle is replaced by the sum. This is repeated for each pixel in the image.

Suppose if we don't want to filter the image harshly, we can change the kernel.

For example the let take the following kernel

0	+1/8	0
+1/8	+1/2	+1/8
0	+1/8	0

In the above kernel center pixel contributes half of its value to the result, and each of the four pixels above, below, left, and right of the center contribute 1/8 each. So, by applying the above kernel, it changes the image, by removing enough noise with blurring the image too much.

If the image consists of large number of pixels, then we can also increase size of the kernel. By increasing the kernel size, filtration process can completed in short amount of time but, it results in large of calculations.

Now we will see an image, which is obtained before and after applying low pass filtering technique.

Fig. 1 Before applying low pass filter [5]

Fig.2 After applying low pass filtering [5]

There are several common approaches to remove the noise from an image they are:

***1) Reconstruction Filtering*:**

In image processing, digital reconstruction filters are used to recreate the images from the samples, and it is mainly used in medical sector.

Re-sampling also performed in this reconstruction filter, in order change the resolution in the image.

2) Enhancement filtering: In order to highlight particular features or specified part in an image we use enhancement filter.

B. High Pass Filters:

High pass filters are mainly used for sharpening purpose. By using high pass filters , the images can became more sharper and unfortunately , while low pass filtering smooths out the noise , high pass filtering does just the opposite . It amplifies the noise.

To become the image more sharpen, there should be change in the intensity and if there is no change in the intensity, we could not increase the sharpness of the image. So, for this purpose we introduce the minus sign in the convolution kernel [6].

0	-1/4	0
-1/4	+2	-1/4
0	-1/4	0

C) Unsharp Mask:

It is another type of high pass filter and it uses the sharpening operator for enhancing the edges and this can be achieved by subtracting the mask formed by low pass filtering of an image from the original image.

This method is mainly used in photographic and printing images[7][8].

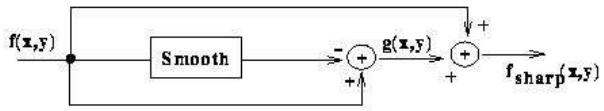
Fig. 3 Unsharp Mask[9]

1) Working procedure of Unsharp mask:

Unsharp masking produce an edge image g(x,y) from image f(x,y) via

$$g(x,y) = f(x,y) - f_{smooth}(x,y)$$

where $f_{smooth}(x,y)$ is a smoothed version of f(x,y)



We can better understand the operation of the unsharp sharpening filter by examining its frequency response characteristics. The following graphs gives you the better understanding of unsharp mask

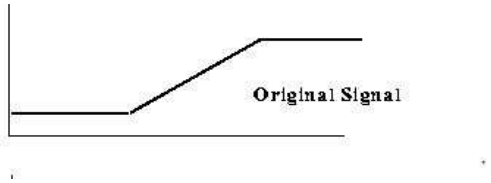


Fig. 4 Frequency of original Image [10]

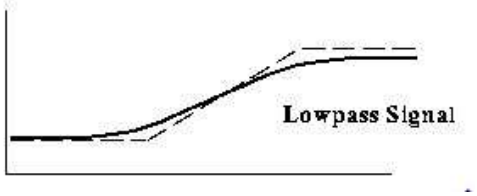


Fig. 5 Signal after applying low pass filter[10]

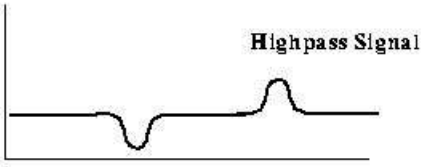


Fig. 6 Signal after applying high pass filter[10]

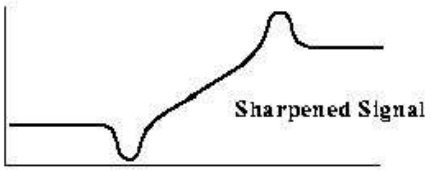


Fig. 7 Signal after applying sharpen filter[10]

III. DIFFERENT EDGE DETECTION ALGORITHMS IN IMAGE PROCESSING

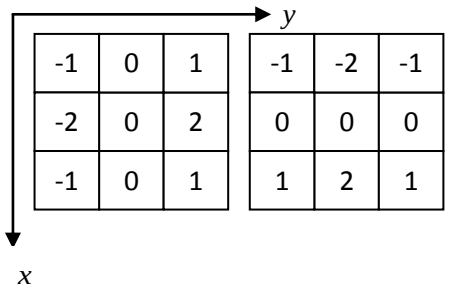
A. Sobel operator:

It is one of the operator used for edge detection in digital image processing and it is also called as sobel-feldman operator or sobel filter. It was invented by Irwin Sobel and Gary Feldman who are colleagues at the Stanford Artificial Intelligence Laboratory(SAIL)[11].

1) Formulation :

Sobel operator uses two 3*3 kernels or matrices and these matrices applied to original image or source image and after, all calculations are performed the resultant matrix displays the edges of the source image.

The following are the kernels for sobel operator



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

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

2) Example:

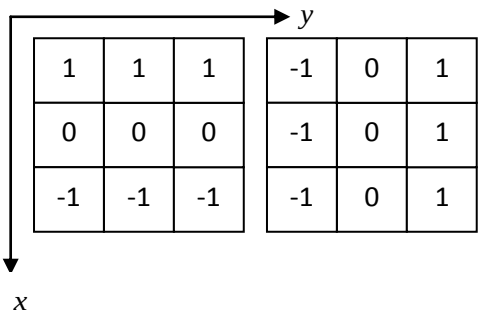
Fig. 8 Source image [11]

Fig. 9 Image after applying sobel operator[11]

B. Prewitt operator:

Prewitt filter is one among the sharpening filters and is all most similar to the Sobel, Kirsch and other operators. It is estimated in 8 possible directions and convolution result of greatest magnitude indicates the greatest direction.

The following are the kernels for prewitt operator



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

1) Example:

Fig. 10 Source Image[12]

Fig. 11 Image after applying prewitt operator[12]

C. Canny Edge detection operator:

It was developed by John F.Canny in 1986 and it is another type of edge detection algorithm and it is also called multi-stage algorithm to detect wide range edges in images. In order to find the edges using Canny edge operator it consists of 5steps they are, Smoothing, Finding intensity values ,Non-Maximum Supression , Double Thresholding and Edge Tracking[13].

1) Example:

Fig. 12 Source Image[13]

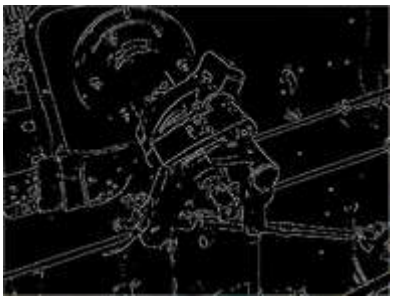


Fig. 13 Image after applying canny edge operator[13].

IV. CONCLUSION

In image processing, filters plays a major role for finding the edges. So that we can efficiently segment the image. In this paper we have discussed different types of filters with examples and gave the brief idea regarding the filters . We have also dealt with different edge detection operators in image processing used for segmentation. Apart from all of these operators, there may be another method for finding edge detection efficiently using the concept of fuzzy.

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