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Image Preprocessing

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ABSTRACT

An image can represent a lot of ideas, meanings, and words. Images can describe more things if and only if they are noise free. In image, a different type of noise occurs and there are different types of filters, used to reduce/remove the noise.The image distorted during acquisition, pre-processing, storage, transmission. In this paper, we concentrate on Median filter, Gaussian filter and Averaging filter. For comparative analysis of image, PSNR & MSE plays a role of parameter for measurement of quality.

Keywords: **Median filter, Gaussian filter, Averaging filter, PSNR, MSE.**

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I. INTRODUCTION

An image refers to a 2D light intensity function f(x,y), where (x,y) denote spatial coordinates and the value of f at any point (x,y) is proportional to the brightness or gray levels of the image at that point[1].Digital image processing is one of the arising field, whose application meet the requirements like communications, tracking signals, television, space, Intelligent transportation systems etc. The main two applications of digital image processing are to improve the picturing information for better human understanding as well as processing image information for machine representation which means to establish a bridge between human & machine communications by improving both ends[2].In the digital image processing, the most critical issue is to remove the noise from image. Why the filtering is needed? The answer is that, the filters are used as noise removal, sharpen contrast, highlight contours, detect edges etc. Image filters are operating on the pixel values & produce a new image from an original image[3].Image processing operations implemented with filtering include smoothing, sharpening and edge enhancement. For enhancing the image quality, various filtering techniques are available in image processing. There are various filters which can remove the noise from images and preserve image details and enhance the quality of image[1].Image filters can be classified as linear and nonlinear. Linear filter are the filtering techniques whose output value is linear combination of pixels[4]. The linear filtering of an image is achieved by using the operation of convolution, as they can be represented using a matrix multiplication. Linear filter are good for the noise reduction but they blur the edges and weaker the thin lines of images.Edge and the image details are blur when we can applied linear filter. To overcome this disadvantage we used non-linear filter[3]. Non-linear filters are more powerful than that of linear because they are able to reduce noise level without simultaneous blurring edges. Image enhancement and analysis can be done by non-linear filter. The nonlinear filtering technique contains two separated steps, Impulse noise detection and reduction step that preserves edge sharpness. Thresholding and image equalization are examples of nonlinear operations[5]. In this paper, PSNR & MSE are used as measurement of quality of image[6].

Methods of Filtering:

A] Average Filter:

Average filter is also called as mean filter. It is simple linear filter and easy to understand. Generally, linear filters are smoothing filters, used for blurring and noise reduction[1].In this filter, the masks are applied to neighborhood pixels which calculate the average of intensity level and every value of pixel is replaced by these average intensities. Because of this process, sharp transition in intensities is reduced.As noise occurs at sharp transitions in intensity levels, the smoothing is very effective in noise reduction[8].For filtering an M X N image, mathematically, average filter of size m x n, where m & n are odd, is given by[8],

$$g(x,y) = \frac{\sum_{s=-a}^{a}\sum_{t=-b}^{b}\omega(s,t)f(x+s,y+t)}{\sum_{s=-a}^{a}\sum_{t=-b}^{b}\omega(s,t)}$$

Where x=0,1,2,…..,M-1 and y=0,1,2,……,N-1.

The side effect of average filter is that it blurs the edges. As edges are almost always the desirable feature of image, are characterized by sharp transitions. Hence are affected when average filters are applied[7].Another application of averaging filter are smoothing of false contours and irrelevant detail in image.

B] Gaussian Filter:

The gaussian filter is another linear filter used for smoothing images, but it blurs the edges of image. Generally, this filter is applicable for low pass filters.or running averages. The gaussian is best implemented for the filter having finite number of samples[8].

For this filter the, gaussian function is defined as,

$$g(t;\sigma) = \frac{1}{\sqrt{2\pi\sigma}}e^{-t^2/2\sigma^2}$$

Where σ is standard deviation of distribution.

2D distribution can be worked for gausian filter as point spread function. This can be achieved by convolving 2D distribution function with image[9].Gaussian is low pass filter & non-uniform filter.

σ denotes percentage of blurring. For large value of σ, image gets blurred. Image brightness is not preserved by this filter. For salt & pepper noise this filter is not effective as compared to median filter.

C] Median Filter:

Median filter is a nonlinear filter. It is a fundamental filter and widely used in many images and videos. It is useful in preserving edges in an image while reducing random noise and to improve an image which is severely corrupted by defective pixels[9]. In the median filter, each pixel of image replace by the median value of neighboring pixels .The pattern of neighbors is called the window or kernel or mask. This window slides over the entire image, pixel by pixel.

Algorithm of median filter for 2D images can be given by:
1. Take mask of pixels of odd length as 3x3, 5x5, 7x7, etc.
2. Here we have to replace the central pixel by median value.
3. Now ordering the pixels of that mask in ascending order.
4. Find the median value i.e. middle value from pixels.
5. Replace central pixel by median value.

In this way we can perform median operation on image[9].

Consider example of 6x6 matrix which shows pixel values of image. Suppose the pixel values within a 3x3 window are 1, 4, 0, 2, 2, 4, 1, 0, 1, as shown below.

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

By ordering, we get 0,0,1,1,1,2,2,4,4.The central pixel 2 is now replaced by 1.This is the median filter.
Here, only middle pixel values are changed but the boundary pixel values are unchanged. As a result the boundary pixel values are not smooth. For this reason we extending the boarder values outside with either zero value or values at the boundary.

Median filter mathematically can be expressed as[10],
Median [A(x) +B(x)] ≠ median [A(x)] +median B(x)].

D] MSE and PSNR:

MSE:
MSE is the Mean squared normalized error. It should be very less.
The mean squared error (MSE) is calculated for two m x n images I and K where K image is considered a noisy image of the I image as,

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

When MSE value of two images is zero, meaning that two similar images are noise free, as MSE is the value calculated by subtracting noisy image from original image[11].

PSNR:
PSNR is the peak signal-to-noise ratio. It is ratio of maximum value of pixel to corrupting pixels of the image. The PSNR is measured in decibels scale, between two images[6]. For higher the PSNR, the image quality is better.The *MSE* and *PSNR* are the two error metrics used to compare image compression quality. The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error. The lower the value of MSE, the lower the error[11].
The PSNR is defined as,

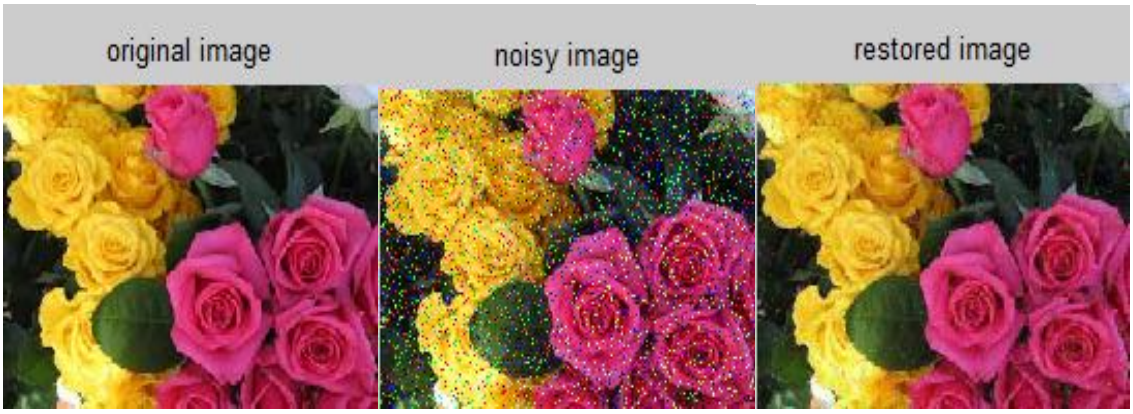
$$PSNR = 10\log_{10}\frac{MAX_I^2}{MSE}$$

$$PSNR = 20\log_{10}\frac{MAX_I}{\sqrt{MSE}}$$

Here, MAXI is the maximum possible pixel value of the image.

Results & Discussion:

Average filter:



Gaussian filter:

Fig2. (a) Fig2. (b) Fig2. (c)

Median Filter:

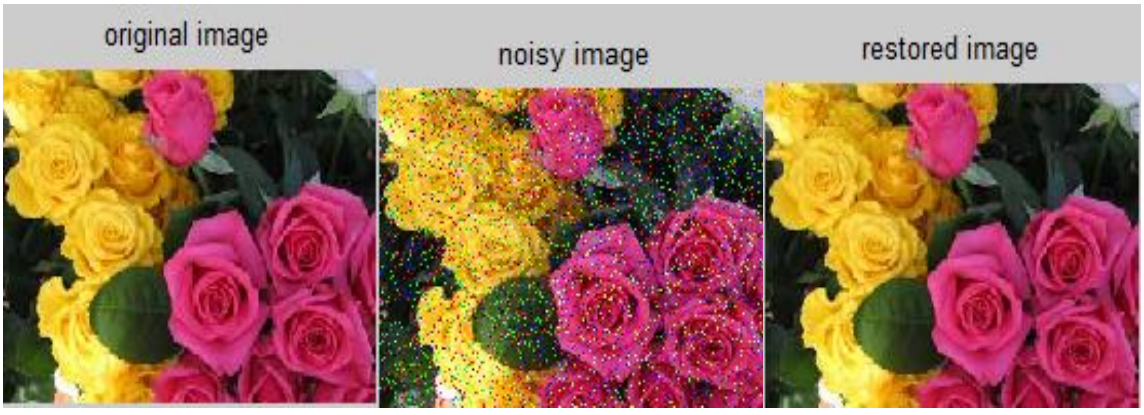


Fig3. (a) Fig3. (b) Fig3. (c)

Figure above shows the filters applied to noisy images. When we remove noise from the image , we get noise free output image. The filters are then compared by using PSNR & MSE values of output images as shown in below table (1):

Filters →	**Gaussian filter**			**Average filter**			**Median filter**		
Parameters ↓	R	G	B	R	G	B	R	G	B
MSE	948.62	911.41	926.00	117.17	101.91	107.70	16.69	16.28	20.21
PSNR	18.35	18.53	18.46	27.44	28.04	27.80	35.90	36.01	35.07

For image to be better the PSNR value must be higher & MSE value must be smaller for filter. From above table, we can easily identify which filter is better for noise reduction. Thus, median filter is better than that of average & Gaussian.

CONCLUSIONS

There are various filtering techniques are available for noise reduction. In this paper, we proposed three filter viz., average, gaussian & median filter. By calculating values of PSNR & MSE, we conclude that median filter is better than that of two filters.

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