International Journal of Scientific & Engineering Research Volume 9, Issue 5, May-2018 1566
ISSN 2229-5518

Analysis of Filter Performance in Images Noise

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Abstract— In biomedical image processing the goal of image enhancement to provide a superior appearance of an image. Biomedical image generally suffers from inferior contrast, blurring and noise due to which the detection and analysis of an image becomes very difficult. The existing non-linear enhancement filtering techniques provides the enhancement in the contrast and remove the blurring and noise from the image and give us the better quality of an image. This paper presents three various types of filters that have been used for improving the sharpness of image for human viewing, increasing contrast and suppression of noise. Experiment was performed on MRI scan of human chest image that has been corrupted by various values of Gaussian noise levels and results have been compared in terms of peak signal to noise ratio (PSNR), mean squared error(MSE) and the graphical representation between the Gaussian noise and PSNR, MSE values to measure the performance of denoising techniques.

Index Terms— PSNR, MSE, Gaussian noise, Wiener, Median, and Average Filter.

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1 Introduction

BIOMEDICAL digital image processing involve the analysis improvement and shows the images that is taken by X-ray, MRI scan, ultrasound and optical imaging technologies.[1] The aim of medical imaging to upgrade the visual appearance of the image or to give a superior modified representation for future automated image processing like analysis, detection segmentation and acceptance.[9] The noise elimination algorithm reduce or remove the clarity of noise by smoothing the whole image leaving area close to contrast boundaries, edges, ringing artifacts to understand the background in order of the image. The spatial domain filtering techniques is used for denoising the image.[2] This technique is theoretically easy to understand and the difficulty of these techniques is low which favors real time implementation. It also deals among the image pixels.[1] The value of pixels are manipulated to get the desired quality of image. In this techniques the three filters have been used for Gaussian noise removal. The spatial domain filters are median filter, wiener filter and average filter.[2] The most important noises which are generally used in image processing are salt & pepper noise, Gaussian noise, speckle noise and poisson noise.[10] This paper work is based on Gaussian noise. In Gaussian noise each pixel of an image converted by a little amount from its real pixel value. It is represented as:

$$\mathbf{A(j) = B(j) + C(j)}$$

Where **A(j)** is the noisy pixel value, **B(j)** is the real pixel value of an original image and **C(j)** is the Gaussian noise at a pixel **(j)** with mean and variance. Gaussian noise is also known as additive noise or amplifier noise. In this noise every pixel in the noisy image is the addition of the correct pixel value and a random dispersed noise value.[5] The probability density function of a Gaussian random variable is given by:

$$\mathbf{Q(y) = 1/\ \sigma\ \sqrt{2\pi}\ \ *\ e^{-(y-\mu)^2}/2\sigma^2}$$

Where **Q(y)** is the Gaussian distribution noise in image **μ & σ** is the mean and standard deviation respectively.

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Median filter is a best order static non-linear filter. In this filter the center pixel value is changed by the median of the pixel value. The wiener filter is depend on a statistical approach.[6] The aim of wiener filter is to reduce the mean square error(MSE) as much as possible. The average filter computes the mean value of the corrupted image in pre decided area.[5] Then the middle pixel strength value is replaced by that mean value. It is constant for all pixel values in the image.

2 Filtering Techniques For Denoising

.Image enhancement or de-blurring is very significant task in image processing for the study of image and can be done using linear as well as non-linear denoising methods.[4] Linear methods are very fast and don't protect the information of the images but the non-linear methods preserves the information of the images.

2.1 Median Filter

The most excellent order statistic filter is the median filter.[3] It exchange the value of a pixel by the median of the intensity levels in the locality of that pixel:

$$\mathbf{\hat{A}(x, y) = \underset{(s,\,t)\ \in\ s_{xy}}{median}\{g(s, t)\}}$$

The value of the pixel at (x, y) is added in the calculation of the median. Median filters are famous since for certain types of random noise.[9] It provides outstanding noise reduction capabilities with significantly fewer blurring than linear smoothing filters of comparable size.

2.2 Wiener Filter

This technique is founded on allowing for images and noises as casual variables and the purpose is to find an estimate **Â** of the uncorrupted image **A** such that the mean square error between them is minimized.[3] This error measure is given by:

$$e^2 = R\{(A - \hat{A})^2\}$$

where **R{.}** is the predictable value of the argument. Let the noise and the image are uncorrelated that one or other has zero mean and that the intensity levels in the approximation are a linear function of the levels in the tainted image. [3]The smallest amount of the error function in above equation is given in the frequency domain by the expression:

$$\hat{A}(e, f)=[1/H(e, f)^* \left| H(e, f) \right|^2 / \left| H(e, f) \right|^2 + S_n(e, f)/S_f(e, f)]G(e, f)$$

The multiplication of a complex quantity with its conjugate is equivalent to the magnitude of the complex quantity squared.[10] This result is known as wiener filter. The terms of above equation as follow:

H(e, f) is the degradation function,

$H^*(e, f)$ is the complex conjugate of the **H(e, f)**, $\left| H(e, f) \right|^2$ is $H^*(e, f)H(e, f)$

$S_n(e, f) = \left| N(e, f) \right|^2$ is the power spectrum of the noise,

$S_f(e, f) = \left| F(e, f) \right|^2$ is the power spectrum of the un-degraded image.

2.3 Average Filter

This is the easiest of mean filters. Let P_{ab} represent the set of co-ordinates in a rectangular sub image window size (m×n), centered at point (a, b). [3]It computes the average value of the corrupted image q(a, b) in the area defined by P_{ab}. The value of restored image Â at point (a, b) is simply the average computed using the pixels in the region defined by P_{ab}.

$$\hat{A}(a, b) = 1/mn \sum_{(s,t) \in P_{ab}} q(s, t)$$

It can be implemented using a spatial filter of size m×n in which all coefficients have value **1/mn.**[3] This filter smooth's local variations in an image and noise is reduced as a result of blurring.

3 Parameters For Performance Analysis

In this paper the better presentation of the filter is measured on the basis of two parameter that is Peak signal to noise ratio and mean squared error.[8]

PSNR ratio gives standard quantification between real image & restored image.[4]The quality of restored image is depend on the PSNR value.[7] If PSNR value is high then the quality of restored image is better otherwise not. Mathematically representation is given below:

$$PSNR = 10 \log (255^2/MSE)$$

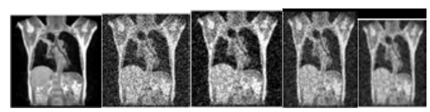
The mean square error given in statistical form can be approximated also in terms of a summation involving the original and restored images.[3]

$$MSE = \frac{1}{mn} \sum_{x=0}^{m-1} \sum_{y=0}^{n-1} [A(x, y) - \hat{A}(x, y)]^2$$

4 Experimental Results and Discussion

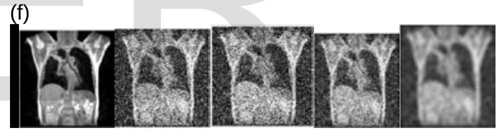
In MATLAB based implementation we measure the performance of the all three filters used in the paper work.[4] For comparing the better quality of de-noised image our experiment has been done on the MRI scan of human chest image of size 203*212 uint8 is corrupted by Gaussian noise of mean value(m= 0.05, 0.10, 0.15, 0.20) and standard deviation value (**σ=** 0.10, 0.20, 0.30, 0.40). In median filtering, every resultant pixel include the median value in a 3-by-3 nearest about the be compatible with pixel in the input image. Wiener method filters the image using pixel wise adaptive wiener filtering using neighborhood of size 3-by-3. In average filtering we uses a 5-by-5 neighborhood for 0.05 mean & 0.10 standard deviation, 10-by-10 neighborhood for0.10 mean & 0.20 standard deviation, 15-by-15 neighborhood for 0.15 mean & 0.30 standard deviation and uses 20-by-20 neighborhood for 0.20 mean & 0.40 standard deviation. The median and wiener filtering methods are applied for each Gaussian noise levels. The results of images are given below.

(a) (b) (c) (d) (e)



MRIscanof PSNR=11.6165 PSNR=17.6438 PSNR=16.6049 PSNR=18.2752 human Chest MSE =127.5193 MSE = 128.9882 MSE = 166.7885MSE = 169.3699

(f)

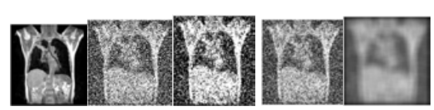


MRI scan of human PSNR= 9.2386 PSNR= 14.3213 PSNR=13.9194 PSNR=14.8163 Chest MSE = 137.6982 MSE = 1154.5788 MSE = 182.2007 MSE = 184.2341

(g)

MRIscanPSNR=7.9797PSNR=12.0867PSNR=12.2812 PSNR=12.9253 of human MSE = 144.5274 MSE = 168.9340 MSE = 189.7499 MSE = 188.84chest

(h)



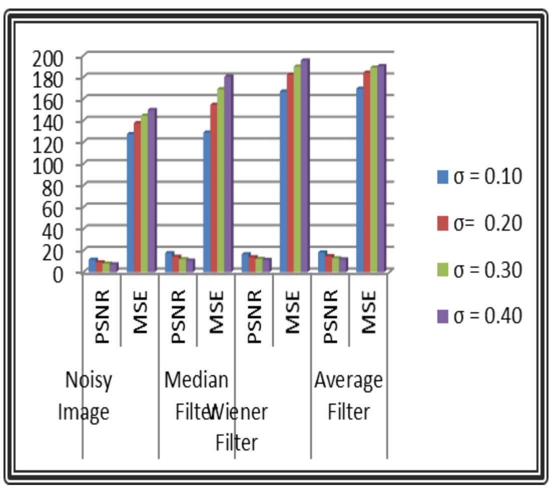
MRI scan of human PSNR= 7.3061PSNR= 10.8055 PSNR=11.3972 PSNR=11.8924 Chest MSE = 149.8066 MSE = 180.4577 MSE = 195.4344 MSE = 190.2767

Fig. 1: Performance Comparison of Median, Wiener, Average Filter of De-noised Image in Terms of [PSNR in dB, MSE] using MRI scan of human Chest image **(a)** Original image (noise free) **(b)** Noisy image (m,**σ** = 0.05, 0.10) **(c)** The result of median filter **(d)** The result of wiener filter **(e)** The result of average filter **(f)** Noisy image (m,**σ** = 0.10, 0.20) **(g)** Noisy image (m,**σ** = 0.15, 0.30) **(h)** Noisy image (m,**σ** = 0.20, 0.40), (m,σ = mean, standard deviation).

Table 1: Average PSNR and MSE Values of MRI scan of human Chest Image at Different mean and standard deviation values of Gaussian noise levels

Gaussian Noise Level	Noisy Image		Median Filter		Wiener Filter		Average Filter	
	PSNR	MSE	PSNR	MSE	PSNR	MSE	PSNR	MSE
σ = 0.10	11.6165	127.5193	17.6438	128.9882	16.6049	166.7885	18.2752	169.3699
σ= 0.20	9.2386	137.6982	14.3213	154.5788	13.9194	182.2007	14.8163	184.2341
σ = 0.30	7.9797	144.5274	12.0867	168.9340	12.2812	189.7499	12.9253	188.8496
σ = 0.40	7.3061	149.8066	10.8055	180.4577	11.3972	195.4344	11.8924	190.2767

Fig. 2: Graphical Representation of PSNR & MSE Values of MRI Scan of human Chest noisy image and all three filters Values at Different Gaussian Noise Levels



V.Conclusion

Matlab based experiment has been performed on MRI scan of human chest image to evaluate the performance of all three filters used in the paper. The results are summarized in terms of peak signal to noise ratio (PSNR) and mean squared error (MSE). Table represents the average PSNR & MSE values of MRI scan of human chest image at different mean and standard deviation levels of gaussian noise. From table results we find that average filter presents the more significant details, texture and edges of an original image from the noisy image because it has the higher PSNR values and lower MSE values in comparision the median and wiener filter. In other side median filter gives the better results of image only for mean and standard deviation levels (0.05, 0.10 & 0.10, 0.20) of gaussian noise because it has the higher PSNR values and lower MSE values in comparision the wiener filter. But after that when we increase the value of mean and standard deviation levels (0.15, 0.20 & 0.30, 0.40) of gaussian noise then the wiener filter gives the better results of an image than the median filter because the PSNR values of wiener filter increases and MSE values decreases respectively.

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ISSN 2229-5518

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