Performance Analysis of Different Filters with Various Noises In Preprocessing Of Images

Janaki K, Dr.M.Madheswaran
Research Scholar, AnnaUniversity, Chennai-25
karur.janaki@gmail.com, madheswaran.dr@gmail.com

ABSTRACT-- An image is considered as a collection of information and the occurrence of noises in the image causes degradation in the visual appearance of the images. So the information associated with an image tends to loss or damage. It should be important to renovate the image from noises for achieving maximum information from images. In this paper it has been seen that quality of image and the information in images affected by different types of noise. As a remedy, the visual quality and the information from the noisy image can be retrieved using different types of filters. In this work Gaussian noise, Speckle noise and random noise ,Salt and Pepper noise are being considered and it can be reduced using Gaussian filter, Average filter, Median filter and Adaptive Median filter. The experimental result shows the comparison and the various types of filters performance to de-noise the noisy images with mean square errors and PSNR values.
Keywords -Gaussian noise, Speckle noise,Salt and Pepper noise, Average filter, Adaptive Median filter.

I INTRODUCTION

Noise is an unwanted signal that interferes with the original signal and degrades the visual quality of digital image. The main sources of noise in the digital image are imperfect instruments, image acquisition process, transmission and compression, environmental conditions during image acquisition, insufficient light levels and sensor temperature, which affect the imaging sensor. Further noise in the image will be introduced when dust particles are present on the scanner screen. The image will be corrupt when there is interference of noise in the transmission channel. In the modern age, visual information is transmitted in the form of digital images by way of communication. But the image secured after transmission is often corrupted. Before it can be used in application, the received image requires processing to produce a visually high quality image. To eliminate noise from the original image, the digital image processing introduces image that have occurred at the time of image capturing due to the electronic and photometric sources. Degradation comes from blurring as well as noise. Identification of de-noising algorithm is application dependent. Therefore it is better to know about the type of noise present in the image to enable selection of the required de-noising algorithm. Still image de-noising poses a challenging problem for researchers as image de-noising causes blurring and introduces artifacts. Different types of image poses various types of noise. Different noise models are made use of to present different noise types. Hence de-noising method depends on the problem specific and relies on the type of image and noise model.Digital images find an important role in research and technology like geographical information systems in the field of medical science such as ultrasound imaging, X-ray imaging, computer tomography and MRI as well. Blurring is the type of bandwidth reduction of images due to imperfect image formation process such as relative motion between camera and original scene or by an optical system that is out of focus.

II LITERATURE REVIEW

1.To find different applications in image segmentation this paper [3] presented a new clustering-based segmentation. In this paper authors introduced a version of adaptive clustering based segmentation techniques. The basic concept behind this technique was to remove impulsive noises i.e., Salt-andPepper noise. Salt-and-Pepper noise contaminations, caused by errors in the image acquisition/recording/or transmissionare detectable at the minimum and maximum intensities. It is important to eliminate Salt-and-Pepper noise contained in theimage because its occurrence severely damage the information or data embedded in original image

2. In study of coherent imaging systems for e.g. ultrasound and laser imaging, multiplicative noise (also known as speckle noise)models are central. With respect to the standard Gaussian additive noise scenario these models have two additional layer of difficulties: 1) the noise is multiplied by (rather than added to) the original image; 2) the noise is not Gaussian, with Rayleigh and Gamma being commonly used densities [4].In this paper author performed a set of experiments and presented that their proposed method named MIDAL (multiplicative image denoising by augmented Lagrangian), yields state-of-the-art results in terms of speed as well as in denoising performance.

3.Author of this paper [5] proposed a recursive filter, called the Cluster-based Adaptive Fuzzy Switching (CAFSM)for removing impulse noise from digital images. This filter is composed of a cascaded easy to-implement impulse detector and a noise filter (for detail preserving restoration). During digital images acquisition process images are commonly get contaminated with impulse noise.

III PREPROCESSING FILTER WITH GRAYSCALE IMAGES

There may be a chance of noise to come in real time. Depends on real time scenario it is focused to add different kind of noise. Noise can be additive or multiplicative. Additive noise further classified into Gaussian noise, salt

372

and pepper noise, random noise. Multiplicative noise is speckle noise. Gray Scale Image or color image was taken for processing. If the input image is color, then it is converted into grayscale image. A color image has three components namely y-luminance, Cb-chrominance for blue, Cr- chrominance for red. After applying RGB to grayscale only y samples out of three input Y,Cb,Cr is obtained by skipping Cb,Crpixels.Noise was generated in the Sigma value ranging between 0.1 and 0.05.

Random number is generated between the range of 0 to 255. 0 represents value of black pixel, 127 represents value of gray pixel, 255 represents value of white pixel. It means that a random number will generate pixels within range of black to white pixels. Each pixel in the noisy image will have some random number between the range 0 to 255. $N(X)x\sum$ is general noise function where $\sum$ indicates value ranging from 0.1 to 0.05 and n(x) is a value from 0 to 1. Highest value of sigma gives more noisy and lowest value of sigma gives less noise. Noise function is nothing but noise generation algorithm which will be varying for salt and pepper noise, speckle noise, random noise, Gaussian noise.

The generated noise was added to the original input image to obtain noisy image.0 to 255 is unsigned integer which is converted to double format which is ranging from 0 to 1 where 0 indicates black pixel value, 0.5 indicates gray pixel value, 1 indicates white pixel value. The entire image has to be converted into double format which haspixel values between 0 and 1. Since Noise is in double format, input image has to be converted to double format for summing of both noisy image and input image. Noise is added to input image to obtain noisy image.

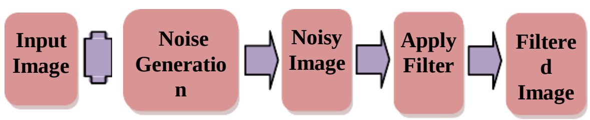

Figure 1. Block diagram of preprocessing filter for different noises

Filter is applied to noisy image to enhance certain features in the data and to remove noise from image, the image is subjected to different processing operations which involve changing the quality of an image in order to improve the pictorial information of an image for human interpretation, render the image should be more suitable for independent machine perception. The following equation is used to obtain noise free image from the noisy image.

Reconstructed image = $\sum h(m,n) \times x(m,n)$
where h(m,n) represents filter coefficients
and x(m,n) represents noisy image

Thus Filter is applied to the noisy image to reconstruct the noisy image. The filter coefficient values may be varying for different filters like Gaussian filter, average filter, median filter, adaptive median filter. This filtering process helps in maximize the clarity, sharpness of image and details of features of interest towards extraction of information & further analysis. The working of filter is depicted in the figure 1.

The original input image is compared with noisy image and Objective measurement parameters like PSNR-P1, MMSE-M1, SSIM-S1 and ENERGY RATIO-E1 were thus obtained. In the comparison of Original image with noisy image, the filter performance parameters have been PSNR,MMSE,ER,SSIM referred to as P1,M1,S1,E1 respectively

The noisy image is compared with filtered output image, Objective measurement parameters like PSNR-P2, MMSE-M2, SSIM-S2 and ENERGY RATIO-E2 were thus obtained. In the comparison of noisy image with filtered image, the filter performance parameters PSNR,MMSE,ER,SSIM are here shortly referred to as P2,M2,S2,E2 respectively.

The performance parameters of both comparison are and it is ensured that as P2>P1, M2<M1, S2>S1, E2>E1 which implied that the filtered output image gave good visual quality and less MMSE and appropriate SSIM and ER when compared to noisy image.

IV RESULTS AND DISCUSSION

Gaussian Noise (Amplifier Noise) noise has a probability density function pdf of the normal distribution. It is also known as Gaussian distribution. It is a major part of the read noise of an image sensor that is of the constant level of noise in the dark areas of the image.Gaussian noise is nothing but normal noise model. This model is additive in nature and follows Gaussian distribution. Each pixels in the noisy image is the sum of true pixel value in the noisy image and random, Gaussian distributed noise value. At each point, the noise is independent of intensity of pixel value. The PDF of Gaussian random variable is given by: $P(x) = 1/ (\sigma\sqrt{2\pi})\ xe(x\text{-}\mu)2\ /\ 2\sigma\ 2\ \text{-}\infty < 0 < \infty$ where: $P(x)$ is the Gaussian distribution noise in image; μ and σ is the mean and standard deviation respectively.

In many cases, noise in digital images is detected to be additive in nature with uniform power in the whole bandwidth and with Gaussian probability distribution. It can be referred to as Additive White Gaussian Noise (AWGN). Suppressing AWGN is rather difficult as it corrupts almost all pixels in an image. To eradicate noise without excessive smoothing of major details, a de-noising technique needs to be spatially adaptive. Depending on the noise model, various techniques are attempted. The wavelets naturally facilitates such spatially adaptive noise filtering due to the properties such as sparsity, edge detection and multi resolution. Median filters are good for Gaussian noise.

AWGN noise is added with original image of grayscale cameraman image as shown in Figure 3.2(left), and AWGN noisy image of grayscale cameraman image as shownin Figure 3.2(right)is generated this is done to compare original image and noisy image and thus to compute objective measurement parameters. These parameters have been found to be as PSNR=28.1191,MSE

= 101, ER=0.99438, SSIM=0.63213.

AWGN noisy grayscale cameraman image is reconstructed with Gaussian filter. AWGN noisy image as shown in figure 3.3(left) is compared with Gaussian filtered output image as shown in figure 3.3(right) to get objective measurement parameters and they have been found to be at the values PSNR=32.482,MSE = 68, ER=1.0098 ,SSIM=0.76095.

In this comparison, it is that the PSNR value is found to be increasing from 28 to 32.482 and MSE value getting reduced from 101 to 68, ER ranging between .99 to 1,0098 and SSIM getting increased from 0.63 to 0.76095 which is close to 1. Therefore preprocessing the input image with Gaussian filter gives better image quality compared to unprocessed image.

AWGN noisy imageis reconstructed with Average filter. AWGN noisy image as shown in figure 3.4(left) and Average filtered output image as shown in figure 3.4(right) are compared to find the values at which they change as exhibit fixed changes. To do so, objective measurement parameters are found to be PSNR=32.4262, MSE =210, ER=1.028, SSIM=0.78896.

In this comparison, it is noted that the PSNR value is increased from 28 to 32.4262 and but MSE is not reduced and is increased from 101 to 210 ER comes from .99 to 1.028 and SSIM is increased from 0.63 to 0.78896 which is close to 1. Also Average filter gives better objective measurements for image quality parameters than Gaussian filter. Therefore preprocessing the input image with Average filter gives better image quality compared to un-processed image. Since MSE not reduced with average filter, noisy image is preprocessed with another filter.

Using median filter, noise in AWGN noisy image is removed. In comparison with AWGN noisy image as shown in figure 3.5(left) with Median filtered output of grayscale cameraman image as shown in fiure 3.5(right), objective measurement parameters are computed as PSNR=35.5768, MSE =44, ER=1.0131 , SSIM=0.77695.

In this comparison, it is verified that the PSNR value is increased 28 to 35.5768 and MSE reduced from 101 to 44 ER comes from .99 to 1.0131 which is near to 1 and SSIM is increased from 0.63 to 0.77695 which is also close to 1. Also Median gives filter better objective measurements for image quality parameters than average filter. Therefore preprocessing the input image with median filter gives better image quality compare than average filter, Gaussian filter to some extent. Still little bit improvement needed for SSIM parameter. So input image is intended for preprocessing with another filter.

AWGN noisy image is reconstructed with Adaptive Median filter. In comparison of AWGN noisy image as shown in figure 3.6(left) with Adaptive Median filtered output of grayscale cameraman image as shown in figure 3.6(right), objective measurement parameters are computed as PSNR=36.497, MSE =144, ER=1.0131 , SSIM=0.78216.When comparing AWGN noisy image with Adaptive Median filtered outpu

Median filter give much improved PSNR value for and better image quality parameters than median filter. Therefore preprocessing the input image with adaptive median filter can be said to give better quality of image when compared to Gaussian,average,median filter. Thus for AWGN noise, performance of filters are analysed and it is ensured that AMF outperforms. For other noises also, performance of filters are analysed inthe following sections.

Similarly speckle noise andrandom noise, salt and pepper noise added with original image of grayscale cameraman images and each and every noisy image is de-noised with four filtering techniques Gaussian filter, average filter, median filter and adaptive median filter. Thefilter parameters obtained for four kind of noisy images of grayscale image with various filtering techniques during preprocessing of image are shown in tables 1 to 4.

To estimate the performance analysis of Gaussian Filter, Average Filter, Median Filter, Adaptive Median Filter, the quality parameters such as PSNR, MSE, ENERGY RATIO, MAXERR, SSIM arecalculated for a given image. Performance of four different filters is tested against AWGN noise, speckle noise, random noise and salt n pepper noise which is generated or injected during image capturing or transferring image from scanner to computer.Experiments are conducted using Matlab 7.12.0.635(R20011a). Clinical dataset of grayscale image with image size of 256 x 256 pixels are taken as input image. Here 2D images are taken and dimension of original and noisy image are same. Noisy image is given as input to all the four different filters. The filtered outputs of each filter are given inFig.3 to 6.

Figure 2 Original Image Vs AWGNNoisy image

Figure 3 AWGN NoisyImage Vs Gaussian Filter output

Noise Type /Filters	PSNR	MSE	Energy Ratio	MAXERR	SSIM
Speckle Noisy Image	25.6057	178.8594	0.9928	43	0.0100
Gaussian Filter Output	33.1563	99.9928	1.0105	69	0.7024
Average Filter Output Image	32.8493	219.1137	1.0301	143	0.7457
Median Filter Output Image	29.8782	177.5321	1.0213	198	0.6795
AMF Filter Output Image	**34.7976**	**177.5321**	**1.0213**	**198**	**0.6901**

Figure 4 AWGN Noisy Image Vs Average Filter output

Figure 5 AWGN NoisyImage Vs Median Filter output

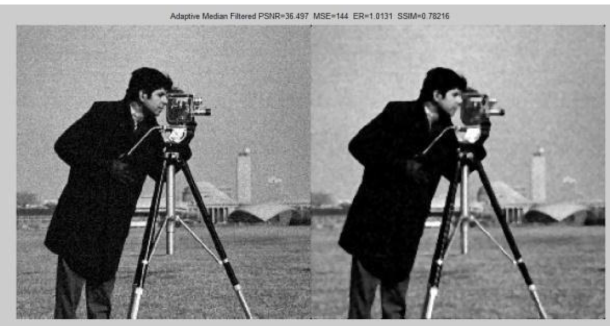

Figure 6 AWGN Noisy Image Vs Adaptive Median Filter output

Table 1Comparison of filter parameters of AWGN noise

Noise Type /Filters	PSNR	MSE	Energy Ratio	MAXERR	SSIM
AWGN Noisy Image	28.0991	100.7331	0.9946	44.3551	0.6325
Gaussian Filter Output Image	32.4820	67.4698	1.0098	65.3837	0.7610
Average Filter Output Image	32.4262	209.1787	1.0280	142.8303	0.7890
Median Filter Output Image	35.5768	143.5727	1.0131	192.9070	0.7770
AMF Output Image	**36.4970**	**143.5727**	**1.0131**	**192.9070**	**0.7822**

Table 2 Comparison of filter parameters for speckle noise

Table 3 Comparison of filter parameters for random noise

Noise Type /Filters	PSNR	MSE	Energy ratio	MAXER R	SSIM
Gray scale Image					
Random Noisy Image	25.059 4	202.835 2	0.9892	56.8186	0.5089
Gaussian Filter Output	29.712 1	109.679 0	1.0076	60.6594	0.6452
Average Filter Output Image	31.493 6	221.040 8	1.0276	138.0273	0.7342
Median Filter Output Image	33.039 2	165.322 7	1.0140	195.6642	0.7028
AMF Filter Output Image	**33.487 0**	**165.322 7**	**1.0140**	**195.6642**	**0.7083**

Table 4 Comparison filter parameters for Salt n Pepper noise

Noise Type /Filters	PSNR	MSE	Energy Ratio	MAXERR	SSIM
Salt N Peppers Noisy Image	25.31124	191.4062	0.99185516 7	247	0.010128
Gaussian Filter Output	40.93399	106.0367	1.00982122 4	172	0.827722
Average Filter Output Image	33.02128	221.3326	1.02952124 2	138	0.773086
Median Filter Output Image	44.31463	125.4986	1.01183007 1	199	0.87471
AMF Filter Output Image	**44.43203**	**125.4986**	**1.01183007 1**	**199**	**0.880131**

From the Tables 1 to 4, it can be understood that after the removal of noise from noisy image using different filtering techniques, the parameter values computed seen to varying. It is found that the filtered image by other filters having better PSNR values along with other parameters when compare to noisy image. However, of all the filtering process, adaptive median filter is good and the output received is under to have a better quality of image because PSNR is high.

V CONCLUSION

In this paper four types of noises (Salt and Pepper, Gaussian, Speckle and random noise) have been added to input –Cameraman‖ image. It is observed that all noise causes degradation in the image quality which results in loss of information.In this analysis, Filters are used for picture quality evaluation. It should use objectivepicture quality measures such as PSNR,MSE, ER and SSIM.With respect to performance parameters PSNR, MSE, ER, MAXERR, SSIM, different four filters are analyzed for grayscale cameraman image and it is proved that Adaptive median filter outperforms as best de-noising technique in preprocessing of images .

FUTURE WORK

Filtering methods along with detection algorithms shows better results and once the filtering schemes are done in wavelet domain then efficient results will be found.

[1] http://en.wikipedia.org/wiki/Image_noise

[2] Rafael C. Gonzalez, Richard E. Woods, ―Digital Image Processing‖, 3rd edition, Pearson Education, 2008.

[3] SitiNorainiSulaiman, Nor Ashidi Mat Isa,―Denoising-based Clustering Algorithms for Segmentation of Low Level Salt-and-Pepper Noise-Corrupted Images,‖IEEE Transactions on Consumer Electronics, Vol. 56, No. 4, pp. 2702-2710, November 2010.

[4] José M. Bioucas-Dias, Mário A. T. Figueiredo, ―Multiplicative Noise Removal Using Variable Splitting and Constrained Optimization,‖ IEEE Transactions on Image Processing, vol. 19, No. 7, pp. 1720-1730, July 2010.

[5] Kenny Kal Vin Toh, Nor Ashidi Mat Isa, ―Cluster-Based Adaptive Fuzzy Switching Median Filter for Universal Impulse Noise Reduction,‖ IEEE Transactions on Consumer Electronics, Vol. 56, No. 4, pp. 2560- 2568, November 2010.

[6] Florian Luisier, Thierry Blu, Michael Unser, ―Image Denoising in Mixed Poisson–Gaussian Noise,‖ IEEE Transactions on Image Processing, Vol. 20, No. 3, pp. 696-708, March 2011.

[7] Kenny Kal Vin Toh, Haidi Ibrahim, Muhammad NasiruddinMahyuddin, ―Salt-and-Pepper Noise Detection and Reduction Using Fuzzy Switching Median Filter,‖ IEEE Transactions on Consumer Electronics, Vol. 54, No. 4, pp. 1956-1961, November 2008.

[8] PeihuaQiu and ParthaSarathi Mukherjee, ―Edge Structure Preserving 3D Image Denoising by Local Surface Approximation,‖ IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 34, No. 8, pp. 1457- 1468, August 2012.

[9] M.Vijay, L.Saranya Devi, M.Shankaravadivu and M.Santhanamari –Image Denoising Based On Adaptive Spatial and Wavelet Thresholding Methods‖, IEEE-International Conference On Advances In Engineering, Science And Management, (ICAESM -2012) March 30, 31, 2012 161

[10] R.C. Gonzalez and R.E. Woods –Digital Image Processing‖, 2nd ed. Englewood Cliffs, NJ: Prentice-Hall; 2002.

[11] S.G.Chang, B.Yu and M.Vetterli, 2000, –Spatially adaptive wavelet thresholding with context modeling for image denoising,‖ IEEE Trans. on Image Processing, Vol.9, No.9, pp. 1522-1531

[12] Kenny Kal Vin Toh,Nor, Ashidi Mat Isa,‖ Noise Adaptive Fuzzy Switching Median Filter for Salt-and-Pepper Noise Reduction‖, IEEE Trans. Image Processing, Vol 17, No. 3, March 2010.

[13] Sheng-Fu Liang, Shih-Mao Lu, Jyh-Yeong Chang, and Chin-Teng (CT) Lin, –A Novel Two-Stage Impulse Noise Removal Technique Based on Neural Networks and Fuzzy Decision‖, IEEE Trans. Image Processing, Vol 16, No. 4, August 2008.

[14] H. Guo, J. E. Odegard, M. Lang, R. A. Gopinath, I.W. Selesnick, and C. S. Burrus, "Wavelet based speckle reduction with application to SAR based ATD/R," First Int'l Conf. on Image Processing, vol. 1, pp. 75-79, Nov. 1994.

[15] Robert D. Nowak, –Wavelet Based Rician Noise Removal‖, IEEE Transactions on Image Processing,vol. 8, no. 10, pp.1408, October 1999

[16] R. Yang, L. Yin, M. Gabbouj, J. Astola, and Y. Neuvo, –Optimal weighted median filters under structural constraints,‖ IEEE Trans. Signal Processing, vol. 43, pp. 591–604, Mar. 1995.

[17] R. C. Hardie and K. E. Barner, –Rank conditioned rank selection filters for signal restoration,‖ IEEE Trans.Image Processing, vol. 3, pp.192–206, Mar. 1994.

[18] A. Ben Hamza, P. Luque, J. Martinez, and R. Roman, –Removing noise and preserving details with relaxed median filters,‖ J. Math. Imag. Vision, vol. 11, no. 2, pp. 161–177, Oct. 1999.