Performance Analysis of Various Two-Stage Median Denoising Filter for Ultrasound Images

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Abstract: The concept of preprocessing such as noise removal and enhancement is not limited to the field of image processing application. Medical image preprocessing is the mandatory field to provide the better visual quality of any organs and tissues. The ultrasound scanning devices uses the sound therapy for scanning the human organ. The imaging from this device is usually affected with the speckle noise. The main objective of this paper is to analyse the speckle noise from ultrasound image and to find the effective filter for removing it. We have compared four different median based denoising filters to remove the speckle noise. The comparative analysis is also made in terms of PSNR, MSE and SNR.

Index Terms- preprocessing, noise removal, speckle noise, medical image.

I. Introduction

Image acquisition is a mechanism that encloses the convert electronic signals to an image. The image acquisition technology needs only a lens and some considered drive functions to yield an output signal. In an image processing the images are processed from any receiving authority based on hardware. Digital image is collection of a bounded number of elements, each of which has a distinct region and value [1]. Image processing application can be extended to the field of medical image analysis.

Medical image processing is a visualizing the human interior organs and texture. Medical image processing is useful in monitoring the screened tissues to diagnose the diseases. Medical images are obtained from various examine method such as computed tomography (CT) magnetic resonance (MR) images, positron emission tomography (PET), ultrasound images. In medical image, does not contain similar geometric shapes [2].

Noise is the unwanted signal which occurs due to transmission or acquisition as it reduces the image quality and details. There exists kinds of noise specified in image processing functions are impulse noise, Gaussian noise, and speckle noise. The noise presented in the images destroys the values of each pixel from its original value with slight amount of variations and it also change the pixels circumstance condition [3]. Inadequacy image system collection, medium of transmission and noises are affected in various degree are introduced by the image signals reduce the fine image quality [4]. Noise elimination is a key step in image processing, in post treatment of a image, the noise elimination process is based on the kind of noise occurs [5]. Speckle noise is commonly presented in the ultrasound medical images it degrades the edges and the resolution that makes more difficulty in diagnose the diseases in the human body [6].

Image Denoising is the essential part of the image processing by using the filtering techniques. There are two major types of filtering linear and the non-linear filters. Linear filtering is the combination of neighbourhood input pixels and the output pixels. Conventional smoothing filter may cause blurring of images in filtering techniques [7]. But it achieves the poor quality of the image by its performance [8].

This paper is organized as follow: Section 2 discussed about the median based denoising filtering techniques. Section 3 briefly explains the performance metrics for image preprocessing. Experimental results of four different filters are discussed in section 4. Finally, in Section 5 derives the conclusion.

II. Median based denoising filtering techniques

(i) Median Filter

Median filter is a commonly used nonlinear denoising filter for removing the noise from an image. Median filter is processed by using the each and every pixels of an image that it first arranged the pixel in a ascending order when it calculates the centre value as a median value and replace them with median value [9]. It is the commonly used method because of its effectiveness and high accuracy [10].

$$median\,[A(x)+B(x)] \neq median\,[A(x)] + median\,[B(x)] \tag{1}$$

From Equation 1, *A(x)* and *B(x)* is the original image and the noisy image respectively.

(ii) Adaptive Median filter

Adaptive Median (AM) filter calculates the noise pixel from the selected window and replaces with the median value [11]. If it asserts there is no noise contaminated pixels, then it process the next stage that test at the centre pixel for the noise presented in the output of the median filter and it removes the noisy pixels, by estimate the size of the pixel window [12]. Adaptive filter contains coefficient factor to improve the performance [13].

$$f = adpmedian(g, S\max) \tag{2}$$

From Equation 2, *g* is the image to be filtered and the *Smax* is the maximum allowed size of the window.

(iii) Iterative Median filter

Iterative median filter is the three step process by considering window size and the value of the pixel is arranged in increasing order. The first step is the noise detection process in this step it finds the corrupted pixels and that are determined into a flag image [14]. The second process is the refinement process it is processed by the increased order of pixel. Damaged pixel takes larger or smaller of its neighbour pixels and the algorithm performs the process of refinement. Final stage is the noise cancellation is performed by calculated pixel function is replaced by the difference between the original and median value to get the restored value [15].

$$y_{i,j} = (1-n_{ij}) \times x_{ij} + n_{ij} \times m_{ij}(\mathrm{I}) \tag{3}$$

From Equation 3, n_{ij} is the member function to be calculated for the each pixel, x_{ij} is replaced by combination of original value x_{ij} and the m_{ij} *(I)* is the median value.

(iv) Directional Weighted Median filter

The weighted median filter gives more weight only to the central value of each window. The difference between the current pixel and its neighbour aligned in four directions and combine with the weighted median filter [16]. Noise free images consist of locally smoothly varying areas separated by edges aligned with four directions sum of all weighted absolute difference is used to specify the *k* directions [17].

$$r_{i,j} = \min\left\{d_{i,j}^{(k)} : 1 \le k \le 4\right\} \tag{4}$$

From Equation 4, $d_{i,j}^{(k)}$ is a direction index and $r_{i,j}$ denotes the information about the direction aligned.

III. Performance Metrics

The computation of the performance metrics for image preprocessing algorithm is one of the important criteria for denoising filters. There exist various performance metrics to check the efficiency of noise removal algorithm; some of the metrics such as Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Signal Noise Ratio (SNR) are used in this paper to measure the performance of the median based denoising filter.

(i) Mean Square Error

Mean Square Error (MSE) is common performance metrics used to calculate the image quality. It only measures the difference between pixel value and the distorted image without considering the neighbourhood pixels.

$$\frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}\left[I(x-y)-I'(x-y)\right]^{2} \qquad (5)$$

From Equation 5, *MN* is the dimension of the image where, *I(x,y)* is the original image and *I'(x,y)* is the distorted image. Highest value of MSE is 255 and it represent that the image has very poor quality and lowest value of MSE indicates high image quality.

(ii) Peak Signal to Noise Ratio

Peak signal to noise ratio (PSNR) is ratio between maximum power of signal and power of noise parameter and it is measured in decibel.

$$PSNR = 20\log_{10}(MAXi) - 10.\log_{10}(MSE) \qquad (6)$$

From Equation 6, *MAXi* is the possible number of pixel value.

(iii) Signal Noise Ratio

SNR is defined as ratio of signal power and noise power and it is measured in decibel. Higher SNR values show the high image quality.

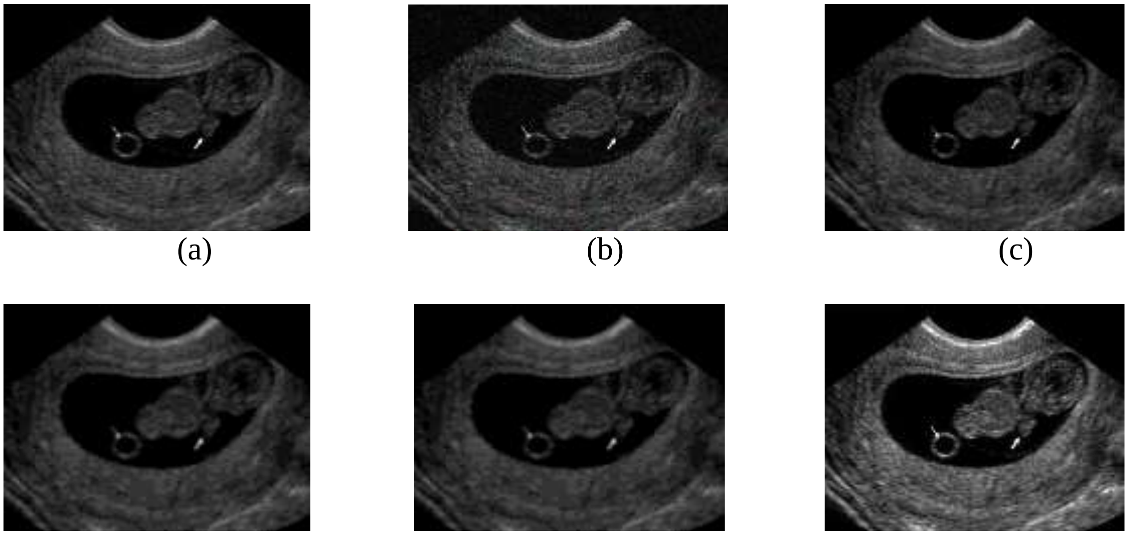
$$SNR = \frac{\mu_{(sig)}}{\sigma_{(sig)}} \qquad (7)$$

From Equation 7, $\mu_{(sig)}$ is the average signal value and $\sigma(sig)$ is variance of the signal. Signal noise ratio compares the signal with background noise.

IV. Experimental Results and Discussion

The performance of the various non-linear filters is tested with ultrasound image corrupted with speckle noise. Experimenting the median based filter for the removal of speckle noise is new to the noise removal research work. The ultrasound images are taken for testing is from "Signal Processing Laboratory (SPLab), an online dataset, of size 372×315.

In this section, the quantitative and qualitative result of four different non-linear filters such as median, Adaptive Median (AM), Directional Weighted Median (DWM), Iterative Median (IM) filters is shown in Figure 1 and tabulated in Table 1 to 3.



(a) (b) (c)

(d) (e) (f)

Figure 1: (a) Original ultrasound fetal image, (b) Speckle noise corrupted image, (c) Median Filter, (d) Adaptive Median Filter, (e) Directional Weighted Median Filter, (f) Iterative Median Filter.

The Figure 1 shows the visual result of median based denoising filter for speckle noise corrupted ultrasound image. Figure 1-(d) and (e) are the result of AM and DWM filter yields a smoothing result and the important features are get blurred. From Figure 1, it is inferred that IM filter yields a better visual result and the noise elements are well restored. Its intensity level is also increased compared to the other denoising filter.

Table1. Comparative analysis of various denoising filters for the Ultrasound Images (measure: MSE)

Sample Images	**Median Filter**	**Adaptive Median Filter**	**Directional Weighted Median Filter**	**Iterative Median Filter**
Images 1	0.0359	0.0173	0.0142	0.0201
Images 2	0.0288	0.0217	0.0189	0.0102
Images 3	0.0382	0.0239	0.0223	0.0101
Images 4	0.0854	0.0381	0.0251	0.0203
Images 5	0.0111	0.0975	0.0402	0.0307
Images 6	0.0716	0.0610	0.0651	0.0203
Images 7	0.0642	0.0208	0.0249	0.0201
Images 8	0.1117	0.0484	0.0554	0.0229
Images 9	0.0860	0.0303	0.0349	0.0207
Images 10	0.0845	0.0551	0.0606	0.0227

Table 2. Comparative analysis of various denoising filters for the Ultrasound Images (measure: PSNR)

Sample Images	**Median Filter**	**Adaptive Median Filter**	**Directional Weighted Median**	**Iterative Median Filter**

			Filter	
Image1	62.57	65.74	76.58	85.47
Image2	63.52	64.75	75.34	83.8
Image3	62.29	64.33	74.63	87.46
Image4	58.81	62.31	74.11	83
Image5	57.66	58.23	72.07	67.81
Image6	69.57	75.27	69.98	82.17
Image7	70.05	79.93	74.15	87.52
Image8	67.64	76.27	70.69	73.49
Image9	68.78	78.3	72.7	79.3
Image10	68.86	75.71	70.3	73.66

Table 3. Comparative analysis of various denoising filters for the ultrasound Images (measure: SNR)

Sample Images	**Median Filter**	**Adaptive Median Filter**	**Directional Weighted Median Filter**	**Iterative Median Filter**
Image1	50.43	53.6	64.44	73.32
Image2	49.66	50.89	61.48	69.94
Image3	50.3	52.34	62.63	75.47
Image4	51.75	55.26	67.06	75.95
Image5	50.76	51.35	62.18	59.07
Image6	60.87	66.57	61.29	73.47
Image7	57.73	67.61	61.83	75.2
Image8	60.09	68.71	63.13	65.93
Image9	58.72	68.25	62.64	69.24
Image10	59.78	66.64	61.22	64.58

The qualitative results are tabulated in Table 1-3 for the median based denoising filter for the speckle noise corrupted ultrasound image in terms of MSE, PSNR, SNR. From the above tabulated result the, the value obtained for IM filter is better than compared to other three filters.

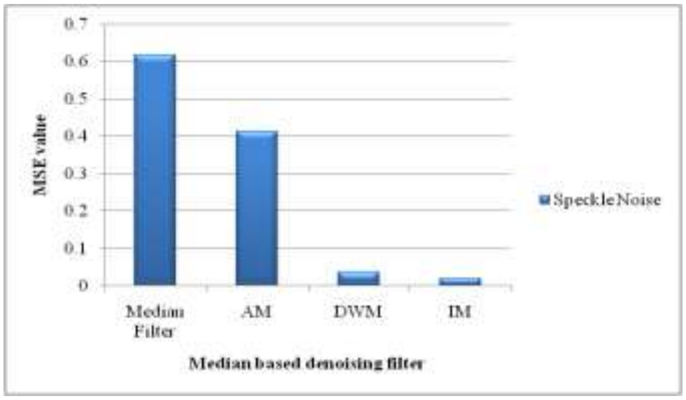


Figure 2. Performance analysis of various denoising filter for speckle noise (Measure: MSE)

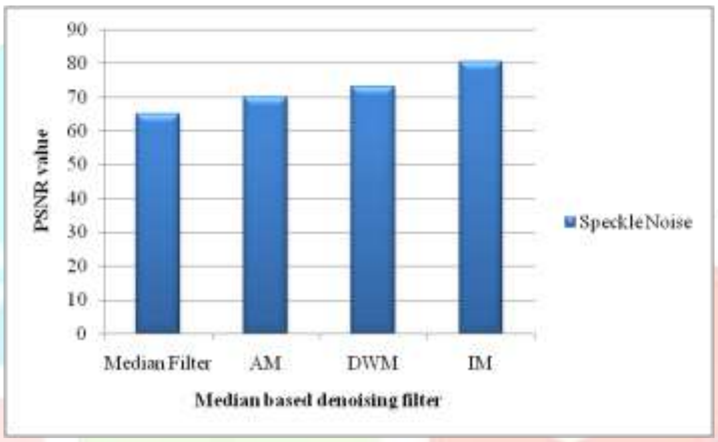


Figure 3. Performance analysis of various denoising filter for speckle noise (Measure: PSNR)

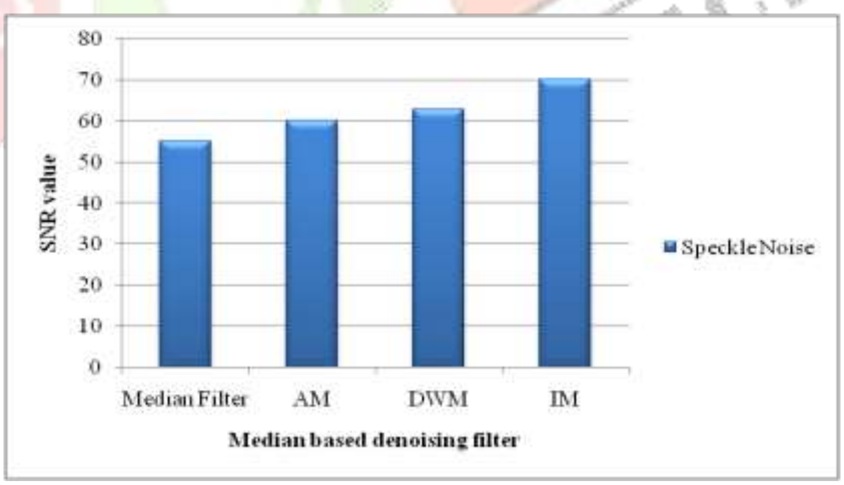


Figure 4. Performance analysis of various denoising filters for speckle noise (Measure: SNR)

The performance analysis of the various denoising filter is studied and reported in Figure 2 to Figure 4. From the above analysis it is inferred that Iterative Median filter yields better result that other existing filters.

V. Conclusion

In this paper, we have used the median based denoising filter to remove the speckle noise from ultrasound image. So far, many of the researches were stated that median based filter does not suit well for the speckle noise. We have tested and compared various median based denoising filter for the speckle noise corrupted image. Therefore, it is inferred that from the qualitatively and quantitative result the median based denoising filter is also suits for speckle noise well. Hence, we have taken few filters and applied to the speckle noise and their results are compared.

References

[1] Gonzalez, Rafael C. et al. "Digital image processing." (2012).

[2] Lester, et. al.,(1999) "A survey of hierarchical non-linear medical image registration." Pattern recognition : 129-149.

[3] Manivel, K et.al., (2013)"A Comparative Study of Impulse Noise Reduction in Digital Images for Classical and Fuzzy Filters." International Journal of Engineering Trends and Technology (IJETT) : 4584-89.

[4] Varade, et. al.,(2013) "A survey on various median filtering techniques for removal of impulse noise from digital images." International Journal of Advanced Research in Computer Engineering & Technology (IJARCET).

[5] Gayathri, R. et al.(2012) "A Survey on Image De-noising Algorithms (IDA)." International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering 456-462.

[6] Benzarti, Faouzi, and Hamid Amiri. "Speckle noise reduction in medical ultrasound images." *arXiv preprint arXiv:1305.1344* (2013).

[7] Leung, et al.(1994) Some filtering techniques for digital image processing. Diss.

[8] Tania, et. al.,(2016) "A comparative study of various image filtering techniques for removing various noisy pixels in aerial image." International Journal of Signal Processing, Image Processing and Pattern Recognition : 113-124.

[9]. Devarajan, G., et. al.,(1990) "Analysis of median filter." ACE'90. Proceedings of [XVI Annual Convention and Exhibition of the IEEE In India]. IEEE.

[10] Hwang, et.al,(1995) "Adaptive median filters: new algorithms and results." IEEE Transactions on image processing : 499-502.

[11] Jiang, et. al., (2010)"An effective adaptive median filter algorithm for removing salt & pepper noise in images." Photonics and Optoelectronic (SOPO), Symposium on. IEEE.

[12] Deng, et. al., (2008)"A new kind of weighted median filtering algorithm used for image processing." Information Science and Engineering, 2008. ISISE'08. International Symposium on. Vol. 2. IEEE,

[13] Juneja, et. al.,(2009) "An improved adaptive median filtering method for impulse noise detection." International Journal of Recent Trends in Engineering : 274-278.

[14] Nallaperumal, et al.(2006) "Iterative adaptive switching median filter." Industrial Electronics and Applications, 1ST IEEE Conference on. IEEE, 2006.

[15] Luo, et. al.,(2006) "An efficient method for the removal of impulse noise." Image Processing, IEEE International Conference on. IEEE, 2006.

[16] Dong, et. al.,(2007) "A new directional weighted median filter for removal of random-valued impulse noise." IEEE Signal Processing Letters : 193-196.

[17] Nawaz, et al.(2010) "Fast directional weighted median filter for removal of random-valued impulse noise." Information and Emerging Technologies (ICIET), 2010 International Conference on. IEEE .