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Performance Comparison of Various Filters on Despeckling of Medical Ultrasound Imaging

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Abstract

Ultrasound Imaging plays vital role in diagnoses a disease. US image suffers from speckle noise. Despeckling is an important task for accurate diagnosis. In this paper experiment has been performed to measure the effectiveness of various filters available for despeckling. Results are compared qualitatively and quantitatively the Peak Signal to Noise Ratio and SSIM parameters are used to quantify the results. On the basis of these parameters the performance of various filters are shown.

Keywords: PSNR, SSIM, Speckle Noise, Median Filter

1. Introduction

Medical imaging is very much useful to investigate the anatomy of the human body to diagnose diseases. Currently in medical imaging technologies, ultrasound imaging is widely used modality, practically harmless to human body, portable, non surgical and cost effective. US images are obtained in real time by processing the echo signals reflected by body tissues, have different acoustic impedances. Due to this it can also show the movement of body's internal organ movement as well as the blood flowing through the blood vessels. These features enable ultrasound imaging the most adaptable diagnostic tool around the world in almost all hospitals.

For many years ultrasound imaging has been considered the best technique for organ andsoft tissue imaging. Unfortunately ultrasound imaging gives low quality images, which makes their interpretation difficult as they strongly, depends on the operator's skill. This limitation is due to presence of speckle noise [1].

Beside this Ultrasound images suffers from strong speckle noise because of the imagingprinciple. Image variances or speckle is a granular noise that inherently exists in and degrades the quality of the active radar SAR images and medical ultrasound. Speckle noise is primarily due to the interference of the returning wave at the transducer aperture. The origin of this noise is seen if we model our reflectivity function as an array of scatterers. Because of the finite resolution, at any time we are receiving from a distribution of scatterers within the resolution cell. These scattered signals add coherently; that is, they add constructively and destructively depending on the relative phases of each scattered waveform. Speckle noise results from these patterns of constructive and destructive interference shown as bright and dark dots in the image. The speckle noise reduces the contrast of ultrasound image and blurs image details, thereby decreasing the reliability of the image that leads to the wrong diagnosis of the diseases. As a result, speckle noise reduction is an important prerequisite, whenever

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ultrasound imaging is used for tissue characterization. Image processing methods especially image denoising method for speckle noise reduction has been proven useful for improving the quality and enhancing thediagnostic potential of ultrasound image.Our objective is to improve the quality of the images by reducing the effect of speckle noise from the US imaging. For this many algorithm are evolved that are describe in next section. There are several parameters that are used to measure the quality of filtered image like SNR, PSNR, MSE, HVM, Covariance, SSIM, UIQI and many more. Some of these parameters are also used in all below described methods. In this paper we compare the quality of filtered images on the basis of parameters PSNR and SSIM.

2. Related work

Various methods have been proposed for the speckle reduction of ultrasound images to improve the US image quality, from single scale to multi scale methods. In single scale method we apply the denoising filters like Wiener and Median filters directly on the original image [2][3][4][5]. These filters are easy to implement but fail to preserve many useful details.

Another method used the concept of image morphology [6]. In this a structuring element used to model the characteristics of the speckle, such as shape and size. Multiscale methods apply the single scale method to sub-images obtained by using wavelet decomposition. Currently wavelet transform has been widely used to recover signals from noisy ultrasound image [7][8][9].

The Nonlinear Coherent Diffusion (NCD) filter [10] is proposed by transforming the

multiplicative speckle signals in ultrasound images into an additive Gaussian noise in Log-compressed images. Speckle reducing anisotropic diffusion (SRAD) method [11][12] is the extension of the PM diffusion model by casting the typical spatial adaptive filers into diffusion model. The diffusion coefficient is noise- dependent in every iteration step. Oriented SRAD (OSRAD) filter [13] is the extension of SRAD, it was proposed by analyzing the properties of the numerical scheme associated with SRAD filter using a semi-explicit scheme. OSRAD method is based on matrix anisotropic diffusion and can make the different diffusion across to the principal curvature directions. Using the Rayleigh distribution metric, different methods [14][15][16] are proposed for ultrasound image denoising. Guo [17] proposed using nonlocal method for ultrasound image denoising. He modified the original nonlocal method by using MAP method of Rayleigh distribution. The performance is good but the computation efficiency is very low. Deka [18] use sparse coding method for speckle noise removal. The speckle noise removal scheme using the sparse representations over a learned over complete dictionary. The proposed model can be used effectively for the removal of speckle by combining an existing pre-processing stage before an adaptive dictionary could be learned for sparse representation. The results are good but the dictionary learning is also a time consuming work. Wang [19] introduced a variational method for ultrasound image denoising for speckle suppression and edge enhancement.

As discussed previously there are several parameters that are used to evaluate the image. Inthis paper we compare the quality of filtered images on the basis of parameters PSNR andSSIM.

3. Image quality metrics

The quality of the image can be affected due to distortions created by many factors from the time it is being captured and visualize to human observer. This may be during storing, processing, compressing and transmitting. To evaluate the image quality two methods are followed the subjective method and objective method.

Subjective method of evaluation is considered expensive and time consuming; here we haveto select the observers, show them a number of images and ask them to rate the quality of images on the basis of their opinion. While in the objective evaluation we use algorithms to assess the quality of the image without intervention of human being.

Image quality assessment is used to measure the degradation in the images so that the qualityof the resultant image gets improve. For objective evaluation lots of efforts have been made to develop objective image quality matrices. MSE, PSNR, HVM, SSIM, UIQI are commonly used to measure image quality. In this paper we compare the two image quality measure: PSNR and SSIM.

i. Peak Signal-to-Noise Ratio (PSNR), Signal-to-noise ratio (SNR) is a mathematicalmeasure of image quality based on the pixel difference between two images [3]. TheSNR measure is an estimate of quality of reconstructed image compared with originalimage. PSNR is defined as in (1)

$$s^2$$

$$PSNR = 10log — \qquad \textbf{(1)}$$

$$MSE = \quad 2 \qquad \textbf{(2)}$$

Where MSE is the Mean Square error is computed by averaging the squared intensity of original image and resultant image pixels and can be describe as (2)

ii. Structural Similarity Index (SSIM), is a method for measuring the similarity between two images. The SSIM index can be viewed as a quality measure of one of the images being compared provided the other image is regarded as of perfect quality. Wang et. al [10], proposed

Structural Similarity Index as an improvement for Universal image quality index UIQI in which comparison between original and distorted image is based on three components: luminance, contrast, and structural comparison as in Fig. 1.

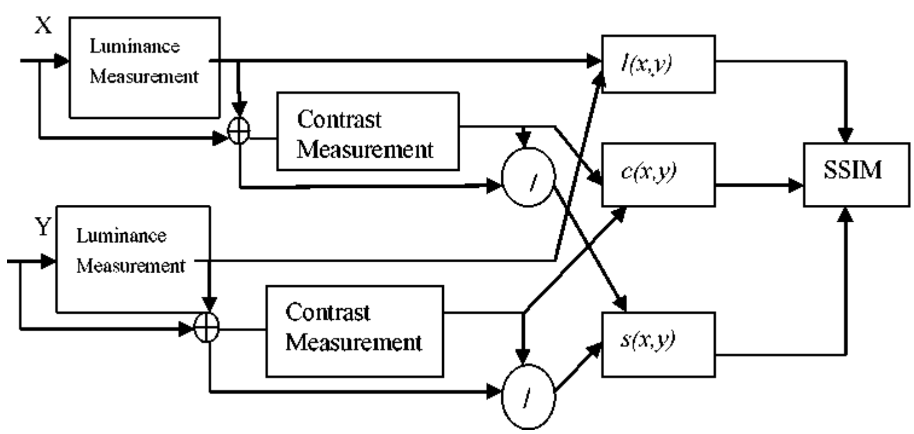

Figure1. Diagram of structural similarity index (SSIM) measurement system

Steps to compute SSIM:

1. Divide the original and distorted images into blocks of size 8x8 and then the blocks are converted into vectors.
2. Compute two means and two standard derivations and one covariance value from theimages as in equation (3), (4), and (5).

4. Methodology

Initially we select the images in 8 bpp, then the metrics were implemented on these images and last a comparison is made between two objective evaluations: PSNR and SSIM. Metrics by simulating them using MATLAB-2015a software on Intel core i3 with 3 GB RAM.Ten different types of US images are selected for observation. The speckle noise withvariance 0.01, 0.05 and 0.1 respectively has been introduced in each image. To compare the performance mean filter, median filter are applying on these noisy images. The resulting filtered images have been compared with original image and the parameters PSNR and SSIM have been measured. In this paper the results of only two images are shown.

5. Results

The image quality metrics used here are objective measurement that is based on some predefined mathematical algorithms. Measuring image quantity for the two images gave the results included in Table1 and Table2.

Table 1. Comparison between PSNR and SSIM parameters values for image1

Filters	PSNR			SSIM		
	0.01	0.05	0.1	0.01	0.05	0.1
MeanFilter3x3	23.8709296	22.7770830	21.7391609	0.8234327	0.7337966	0.6509414
MedianFilter 3x3	23.8863072	22.5341645	20.6887918	0.8091166	0.6440268	0.5292942
MedianFilter 5x5	20.9841364	20.5005558	20.9841364	0.6504458	0.5785102	0.6504458

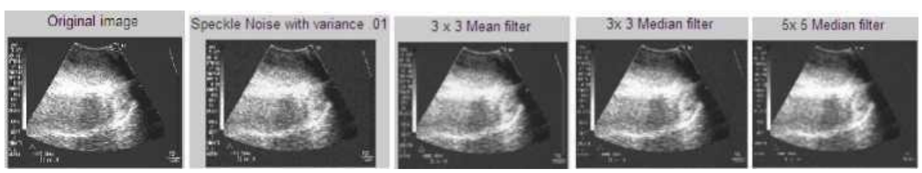

Figure 2. Effect of Speckle noise with variance 0.01 on image1

Figure 3. Effect of speckle noise with variance 0.05 on image1

Figure 4. Effect of speckle noise with variance 0.1on imageI

Table 2. Comparison between PSNR and SSIM parameters values for image 2

Filters	PSNR			SSIM		
	0.01	0.05	0.1	0.01	0.05	0.1
Mean	24.2923123	23.6403303	22.9741790	0.9078632	0.8788005	0.8496808
Median Filter3x3	23.3333334	22.5207797	21.7602976	0.9032612	0.8488546	0.7960444
Median Filter5x5	21.6358293	21.1713106	20.6846945	0.8083313	0.6504458	0.7552753

Figure 5. Effect of speckle noise with variance 0.01 on image 2

Figure 7. Effect of speckle noise with variance 0.1 on image 2

6. Discussion

It can be observe by experimenting that from Table 1 and Table 2 that for different types of ultrasound images by increasing the speckle noise variance the PSNR value for mean filter gives better result than 3x3 median filters and 5x5 median filter. It means mean filter perform better than other filter also from Table 1 and Table 2 the SSIM value of mean filter is better than other filter which means the mean filter also restore the original image better than other filter. By visual inspection of images shown in figure (2)-(7) the quality of images filtered by mean filter is better than images filtered by other filter. At all noise level. It is clear from the above discussion that mean filter perform well than in despeckling of medical ultrasound images both in terms of noise filtering and restoring the original structure of the images.

7. Conclusion and future work

Experiment has been performed on the sampled ultrasound images shows that mean filter gives better result than median filter by varying the intensity of the speckle noise. This experiment is performed on very basic filtering techniques which can be enhanced by using various types of others filters like bilateral filter, trilateral filter, wavelet based filters, entropy based filters and many more.

References

[1] R.F. Wagner, S.W. Smith, J.M. Sandrik and H. Lopez, "Statistics of speckle in ultrasound B-Scans,"IEEE Transactions on Sonics Ultrasonic's, Vol. 30, pp. 156-163, May, **(1983)**.

[2] T. Loupas, W.N. McDicken and P.L. Allan, "An adaptive weighted median filter for speckle suppression in medical ultrasonic images", Circuits and Systems, IEEE Transactions on, Vol. 36, No.1, pp. 129-135, **(1989)**.

[3] Y. Chen, R. Yin, P. Flynn and S. Broschat, “Aggressive region growing for speckle reduction inultrasound images”, Pattern Recognition Letters, Vol. 24, No. 4, pp. 677-691**, (2003).**

[4] J.I. Koo and S.B. Park, "Speckle reduction with edge preservation in medical ultrasonic images using a homogeneous region growing mean filter (HRGMF)", Ultrasonic imaging, Vol. 13, No. 3, pp.211-237**, (1991).**

[5] F. Jin, "Adaptive Wiener filtering of noisy images and image sequences", Image Processing, ICIP 2003, Proceedings 2003 International Conference on, IEEE, Vol. 3, **(2003)**.

[6] V. Shrimali, "Medical feature based evaluation of structuring elements for morphological enhancement of ultrasonic images", Journal of medical engineering & technology, Vol. 33, No. 2, pp.158-169, **(2009).**

[7] S. Gupta, R.C. Chauhan and S.C. Sexana. "Wavelet-based statistical approach for speckle reduction in medical ultrasound images", Medical and Biological Engineering and computing, Vol. 42, No. 2, pp. 189-192, **(2004).**

[8] S. Sudha, G.R. Suresh and R. Sukanesh, "Speckle noise reduction in ultrasound images by wavelet thresholding based on weighted variance", International journal of computer theory and engineering, Vol. 1, No. 1, pp. 7, **(2009)**.

[9] A. Achim, A. Bezerianos and P. Tsakalides, "Novel Bayesian multi scale method for speckle removal in medical ultrasound images", Medical Imaging, IEEE Transactions on, Vol. 20, No. 8, pp.772-783, **(2001).**

[10] Abd-Elmoniem, Z. Khaled, A.B.M. Youssef and Y.M. Kadah, "Real-time speckle reduction and coherence enhancement in ultrasound imaging via nonlinear anisotropic diffusion", Biomedical Engineering, IEEE Transactions on, Vol. 49, No. 9, pp. 997-1014, **(2002)**.

[11] Y. Yu and S.T. Acton, "Speckle reducing anisotropic diffusion", Image Processing, IEEE Transactions on, Vol. 11, No. 11, pp. 1260-1270, **(2002)**.

[12] Y. Yu, J.A. Molloy and S.T. Acton, "Three-dimensional speckle reducing anisotropic diffusion", Signals, Systems and Computers, 2004. Conference Record of the Thirty-Seventh Asilomar Conference on, IEEE, Vol. 2, **(2003)**.

[13] Krissian, Karl, "Oriented speckle reducing anisotropic diffusion." Image Processing, IEEE Transactions on, Vol. 16, No. 5, pp. 1412-1424, **(2007).**

[14] Denis, Loi'c, "SAR image regularization with fast approximate discrete minimization", ImageProcessing, IEEE Transactions on, Vol. 18, No. 7, pp. 1588-1600, **(2009).**

[15] [15] Sarti, Alessandro, "Maximum likelihood segmentation of ultrasound images with Rayleigh distribution", Ultrasonic’s, Ferroelectrics, and Frequency Control, IEEE Transactions on, Vol. 52, No.6, pp. 947-960, **(2005).**

[16] A. Gregorio, "A suitable threshold for speckle reduction in ultrasound images", Instrumentation and Measurement, IEEE Transactions on, Vol. 62, No. 8, pp. 2270-2279, **(2013)**.

[17] Y. Guo, Y. Wang and T. Hou, "Speckle filtering of ultrasonic images using a modified non local-based algorithm", Biomedical Signal Processing and Control, Vol. 6, No. 2, pp. 129-138, **(2011).**

[18] B. Deka and P.K. Bora, "Removal of correlated speckle noise using sparse and over complete representations", Biomedical Signal Processing and Control, Vol. 8, No. 6, pp. 520-533, **(2013).**

[19] W. Guodong, "Ultrasound image denoising using backward diffusion and frame let regularization", Biomedical Signal Processing and Control, Vol. 13, pp. 212-217, **(2014).**