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# Speckle Noise Reduction in Ultrasound Fetal Images Using Edge Preserving Adaptive Shock Filters

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***Abstract-*** In image processing, image is corrupted by different type of noises. But generally medical image is corrupted by speckle noise. So image de-noising has become a very essential exercise all through the diagnosis. Noises are of two type additive and multiplicative noise. Speckle noise is multiplicative noise, so it's difficult to remove the multiplicative noise as compared to additive noise. The traditional techniques are not very good for especially speckle noise reduction. In this paper, an attempt has been made to compare and evaluate the performance of famous filters for speckle noise removal in ultrasound fetal image. Out of traditional filters, Adaptive Shock filter gives desirable results in terms of Mean Square Error and Peak Signal to Noise Ratio.

***Index Terms*-** ultrasound images, speckle, biomedical imaging, MSE

## I. Introduction

Each imaging system suffers with a common problem of "Noise". Mathematically there are two basic models of Noise; additive and multiplicative. Additive noise is systematic in nature and can be easily modeled and hence removed or reduced easily. Whereas multiplicative noise is image dependent, complex to model and hence difficult to reduce. When multiplicative noise caused by the de-phased echoes from the scatterers appears, it is called "Speckle Noise". Speckle may appear distinct in different imaging systems but it is always manifested in a granular pattern due to image formation under coherent waves.

Medical imaging like Ultrasound is very popular due to its low cost, least harmful to human body, real time view and small size. But this imaging has major disadvantage of having Speckle.

### *A. Speckle Noise In Ultrasound Images*

It is an ultrasound-based diagnostic medical imaging technique used to visualize muscles and many internal organs, their size, structure and any pathological injuries with real time tomographic images. It is also used to visualize a fetus during routine and emergency prenatal care. Obstetric sonography is commonly used during pregnancy. It is one of the most widely used diagnostic tools in modern medicine. The technology is relatively inexpensive and portable, especially when compared with other imaging techniques such as magnetic resonance imaging (MRI) and computed tomography (CT). It has no known long-term side effects and rarely causes any discomfort to the patient. Small, easily carried scanners are available; examinations can be performed at the bedside. Since it does not use ionizing radiation, ultrasound yields no risks to the patient. It provides live images, where the operator can select the most useful section for diagnosing thus facilitating quick diagnoses.

This work aims to suppress speckle in Ultrasound fetal images. Speckle noise affects all coherent imaging systems including medical ultrasound. Within each resolution cell a number of elementary scatterers reflect the incident wave towards the sensor. The bac kscattered coherent waves with different phases undergo a constructive or a destructive interference in a random manner. The acquired image is thus corrupted by a random granular pattern, called speckle that delays the interpretation of the image content.

## II. Model of Speckle Noise

A speckled fetal image is commonly modeled as 1 $v_1 = f_1 J$ : Where f = {$f_1$, $f_2$, $f_3$, …. , $f_n$} is a noise-free ideal fetal image, V ={$V_1$, $V_2$, … , $V_n$} is a speckle noise and J = {$J_1$, $J_2$, … , Jn}is a unit mean random field.

In the medical literature, speckle noise is referred as "texture", and may possibly contain useful diagnostic information. The desired grade of speckle smoothing preferably depends on the specialist's knowledge and on the application. For visual interpretation, smoothing the texture may be less desirable.

Physicians generally have a preference of the original noisy fetal images more willingly than the smoothed versions because the filters even if they are more sophisticated can destroy some relevant fetal image details. Thus it is essential to develop noise filters which can secure the conservation of those features that are of interest to the physician. The shock filter has recently entered the field of image de-noising and it has firmly recognized its stand as a dominant de-noising tool.

## III. Speckle Filtering

In speckle filtering a kernel is being moved over each pixel in the image and applying some mathematical calculation by using these pixel values under the kernel and replaced the central pixel with calculated value. The kernel is moved along the image only one pixel at a time until the whole image covered. By applying the proposed filter smoothing effect is achieved and speckle noise has been reduced to certain extent.

### *A. Adaptive Shock Filter*

The term shock filtering has been introduced by Osher and Rudin in 1990. They proposed a continuous class of filters based on PDEs. The relation of these methods to the discrete Kramer, Bruckner fillter became evident several years later. To explain the idea behind adaptive shock filtering, let us consider a

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continuous image $f : R2 \rightarrow R$. Then a class of filtered images $\{u(x; y; t) \mid t \geq 0\}$ of $f(x; y)$ may be created by evolving f under the process

$$u_t = - \text{sign}(\Delta u) \mid \nabla u \mid ;$$
$$u(x; y; 0) = f(x; y) ;$$

where subscripts denote partial derivatives, and $\nabla u = (ux; uy)^T$ is the (spatial) gradient of u. The initial condition ensures that the process starts at time t = 0 with the original image f(x; y). The image evolution proceeds in the following way. Assume that some pixel is in the influuence zone of a maximum where its Laplacian $\nabla u := uxx + uyy$ is negative. Then becomes

$$U_t = \mid \nabla u \mid ;$$

Evolution under this PDE is known to produce at time t a dilation process with a disk-shaped structuring element of radius t. At the influence zone of a minimum with $\nabla u < 0$, the above equation can be reduced to an erosion equation with a disk-shaped structuring element:

$$U_t = - \mid \nabla u \mid ;$$

These considerations show that for increasing time, increases the radius of the structuring element until it reaches a zero-crossing of $\Delta u$, where the influence zones of a maximum and a minimum meet. Thus, the zero-crossings of the Laplacian serve as an edge detector where a shock is produced that separates adjacent segments. The dilation or erosion process ensures that within one segment, the image becomes piecewise constant.

A number of modifications have been proposed in order to improve the performance of shock filters. For instance, it has been mentioned that the second directional derivative $U\eta\eta$ with $\eta \mid\mid \nabla u$ can be a better edge detector than $\Delta u$. In order to make the filters more robust against small scale details, Alvarez and Mazorra replaced the edge detector $U\eta\eta$ by $V\eta\eta$ with $V := K\sigma * u$. In this notation, $K\sigma$ is a Gaussian with standard deviation $\sigma$, and $*$ denotes convolution. Taking into account these modifications the adaptive shock filter becomes

$$U_t = - \text{sign}(V\eta\eta) \mid \nabla u \mid$$

## IV. RESULTS AND DISCUSSIONS

The performance of the filters was tested on an Ultrasound fetus image taken using B (brightness) mode. For analysis, speckle noise were added and the performance was analyzed based on Peak Signal to Ratio (PSNR), Mean Absolute error (MAE) and Mean Squared Error (MSE),. The response of the adaptive Shock filter was appreciable than other filters.

Figure 1: Original Image

Figure 2: Frost Filter

Figure 3: Kaun Filter

Figure 4: Lee Filter

Figure 5: Gabour Filter

Figure 6: Adaptive Shock Filter

Figure 1 shows the original image, Figure 2 to 6 shows the filtered output obtained using Frost, Kaun, Lee, Gabour and proposed Adaptive Shock filter.

Table I: Comparison of the performance of proposed filter with other conventional filters.

| Filter | PSNR | MAE | MSE |
|---|---|---|---|
| Kaun | 16.578 | 18.770 | 733.609 |
| Lee | 18.579 | 18.540 | 776.403 |
| Frost | 20.654 | 18.375 | 714.16 |
| Gabour | 20.738 | 18.495 | 720.204 |
| Adaptive Shock | 21.531 | 18.598 | 704.254 |

The above table shows the performance comparison of the proposed filter with other conventional filters. It shows that the proposed filter has marginally higher PSNR value and good MSE compared to other de-speckling filters.

## V. CONCLUSION

The performance of noise removing algorithms is measured using quantitative performance measures such as PSNR, MAE and MSE as well as in term of visual quality of the images. Many of the methods fail to remove speckle noise present in the ultrasound medical image, since the information about the variance of the noise may not be identified by the methods. Performance of all algorithms is tested with ultrasound image regard to foetal. The computational result showed that Adaptive Shock Filter performed better than others.

## REFERENCES

[1] Edund Hui-on Ng, "Speckle Noise Reduction Via Homomorphic Elliptical Threshold Rotations in Complex Wavelet Domain", A MS Thesis Presented to University of Waterloo, Canada, 2005.

[2] Z.Shi and K.B.Fung, "A Comparision of Digital Speckle Filters" in proc. IEEE on IGARSS, Vol 4, pp. 2129 – 2133, August 1994S.

[3] J.S Lee, "Refined Filtering of Imge Noise using Local Stastics", Journal of Computer Graphic and Image Processing, Vol 15, pp. 380 – 389, 1980.

[4] D.Kaun, A.Swachuk, T.Strand and P.Chavel, "Adaptive noise smoothening filter for images with signal-independent noise", Journal of Computer Graphic and Image Processing, Vol 7, no 2, March 1985

[5] V.Froast, J.Stiles, K.Shanmugam, and J.Holtzman, "A model for radar images and its application to adaptive digital filtering of multiplicative noise", Journal of Computer Graphic and Image Processing, Vol 4, no 2, March 1982.

[6] S. Mansoor Roomi, I.M.Lekshmi, V Abhai Kumar, "A Recursive Gaussian Weighted Filter for Impulse Noise Removal" GVIP Journal, Volume 6, Issue 3, pp: 33 – 37 December 2006.

[7] Khaled, Abou-Bakr, Yaser, "Real Time Speckle Reduction and Coherence enhancement in ultrasound imaging via nonlinear anisotropic diffusion", IEEE Transactions on Bio Medical Engineering, Vol 49, No 9, September 2002.

[8] Alin Achim, Anastasios, Panaigiotis, "Novel Bayesian Multiscale method for Speckle removal in ultrasound images" IEEE Transactions on Medical Imaging, Vol 20, No 8, August 2001.

[9] A.C.Volker, P.Zakharov, B,Webber., et.al., "Lase Speckle Imaging with an active noise reduction scheme" Journal of Optic Express, Vol 13, No 24, November 2005.

[10] Sudha, G.R.Suresh, R.Sukanesh, "Wavelet based image de-noising using adaptive sub-band thresholding", International Journal of Soft Computing, Volume 2, Issue 5, PP: 628-632, 2007.

[11] Khalifa Djemal, "Speckle Reduction in Ultrasound Images by Minimization of Total Variation", IEEE International Conference on Image Processing, 2005, Vol.3, pages: III- 357-60

[12] Peter C. Tay, Scott T Acton, and John A. Hossack, "Ultrasound Despeckling using an Adaptive Window Stochastic Approach", IEEE International Conference On Image Processing, 2006, pages: 2549-2552

[13] Edund Hui Ng, "Speckle Noise Reduction Via Homomorphic Elliptical Threshold Rotations in complex Wavelet Domain", A MS Thesis Presented to University of Waterloo, Canada, 2005

[14] Mark Fashing and Carlo Tomasi,"Mean Shift is a Bound Optimization ",IEEE Transaction of Pattern Analysis And Machine Intelligence,2004.

[15] D. Hillery, "Iterative wiener filters for Images restoration. IEEE Transaction on SP, 39, pp. 1892-1899, 1991.

[16] Javier Portilla, Vasily Strela, Martin J.Wainwright and Eero P.Simoncelli, " Adaptive Wiener Denoising using a Gaussian Scale Mixture Model in the wavelet Domain", Proceedings of the 8th International Conference of Image Processing Greece. Thessaloniki, 2001.

[17] D.T.Kaun, Sowchauk, T. C.Strand, P.Chavel. "Adaptive noise smoothing filters for signal dependent Noise", IEEE Transaction on pattern analysis and machine intelligence, Vol. PMAI -7, pp.165-177, 1985.

[18] J.S. Lee, " Refined filtering of image noise using local statistics", Computer Vision, Graphics, and Image Processing.

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