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Design and Implementation of Enhanced Hybrid Butterworth Wavelet Filter

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Abstract: ***The aim of the study is to assess the performance of the proposed hybrid butterworth wavelet filter on the ultrasound image of liver having a cyst which contains speckle noise. The results show the improved image quality in terms of image metrics SNR, PSNR and MSE.***

Keywords: Ultrasound image, Butterwor Wavelet filter, Speckle Noise

1. Introduction

An accurate anatomical display of organs such as the heart, kidney, prostate, liver, etc., would be a beneficial aid to health practioners in diagnosing ailments or assessing the health of that organ [1]. Medical ultrasound incorporates high frequency broadband sound waves in the range of megahertz that are reflected by tissue to an extent such that 3D images of the organs can be formed. Other important uses in which the imaging of the abdominal organs, heart, breast, muscles, tendons, veins and arteries takes place. Medical images are also corrupted by noise as in a ultrasound system which interrogates a target medium with acoustic pulses, and the medium's non-uniform density and compressibility result in returned echoes [2]. Each ultrasound pulse encompasses a spatial volume which defines the smallest detectable structure, known as the resolution cell [3]. Two distinct processes contribute to echo formation: specular reflection and scattering. Speckle noise is a specific type of noise which exists in forms of granules in an image and because of its existence the quality of ultrasound image becomes very poor[4]. Several filtering techniques have been researched and employed to reduce speckle noise free ultrasound image like weiner filter, mean filter, median filter, wavelet filter, fourier filter and butterworth filter.

Wavelet filter, fourier filter and butterworth filter have been used individually a lot for despeckling of the images [5].Wavelet filter has been the most extensively used filtering technique for despeckling still the perfection in terms of hundred percent efficiency has not been achieved [6]. In our work we recommend a combination of wavelet and butteworth filter to produce efficient results for reduction of speckle noise in ultrasound image.

2. Speckle Noise Reduction

2.1 Speckle Noice

Imaging systems which are coherent like ultrasound imaging systems are affected by speckle noise[7] .The incident wave is reflected to the sensor ,this takes place in a resolution cell which has elementary scatterrers [8].The waves which are sent back are the coherent waves having different phases and they go through interference (constructive or destructive) in a random fashion[9].The output image has a pattern which is granular and is random in nature ,is termed as speckle which obstructs the actual interpretation of the image[10].Therefore we can state that speckle is undesirable product which is caused by the backscattered incident waves through different points on the surface of the objects[11].

2.2 Enhanced Hybrid Butterworth Wavelet Filter

In medical image processing when diagnosing an ailment of an organ is necessity up to perfection mark [12]. Hence there is a need to process the speckle present in the images to detect the actual defect in the organ which hinder its quality [13]. Our new approach of combination of butterworth and wavelet filter forms a new enhanced hybrid butterworth wavelet filter which improves the quality of the ultrasound image.

The steps involved in the formation of new filter are-
1) Input Image is selected .
2) Preprocessing of the image is performed.
3) Wavelet filter is applied to the pre-processed image.
4) The cut off frequency of the Butterworth filter will then work on the image obtained from the step 3 mentioned above.
5) Image metrics are calculated for the output image
6) Filtered Image is obtained.

2.3 Performance Metrics

To assess the performance of the v filter the parameters which are taken into consideration are mean square error MSE, signal to noise ratio (SNR) and peak signal to noise ratio(PSNR).

$$MSE= \frac{1}{M.N}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}[I(m,n) - I'(m,n)]^2$$

$$SNR=10\log_{10}\frac{\frac{1}{M.N}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}I^2(m,n)}{MSE}$$

$$PSNR = 10.\log_{10}\frac{255^2}{MSE}$$

In the above expressions the I and I' represent the original and estimated image which has been obtained from the noisy image.

2.4 Butterworth Filter

The common method to reduce or remove speckle noise in an image is to use smoothing filters. The Butterworth low pass filter allows lower frequency but they do not allow the high frequencies. The important attributes of this filter are the order (or power) and the cut off frequency [14]. The noise is eliminated above the cut off frequency of the filter .The resolution and the noise of the image is determined by the cut off frequency. The low pass butterworth filter is given by the equation

$$H(u,v)=\frac{1}{1+[D(u,v)/D_0]^{2n}}$$

Where D_0 is the cut off frequency and n is the order of the filter.

2.5 Wavelet Filter

In wavelet filtering operation is performed using the discrete wavelet transform. The main criteria are to determine coefficients so that we can analyse the signal for its noise content. Wavelet filtering is performed using two filters a high pass filter and a low pass filter through which the signal is passed and down sampled because each signal generates a lot of data[15].The signal output that we obtain has two major components first is the coefficient called approximation(trends) and second coefficient is called the detail coefficient .The approximation coefficient is further processed by the procedure called decomposition which yields levels of decomposition of the signal[16].The wavelet transform applied on an image which yields first level decomposition will be represented as

$$M = \begin{bmatrix} LL & HL \\ LH & HH \end{bmatrix}$$

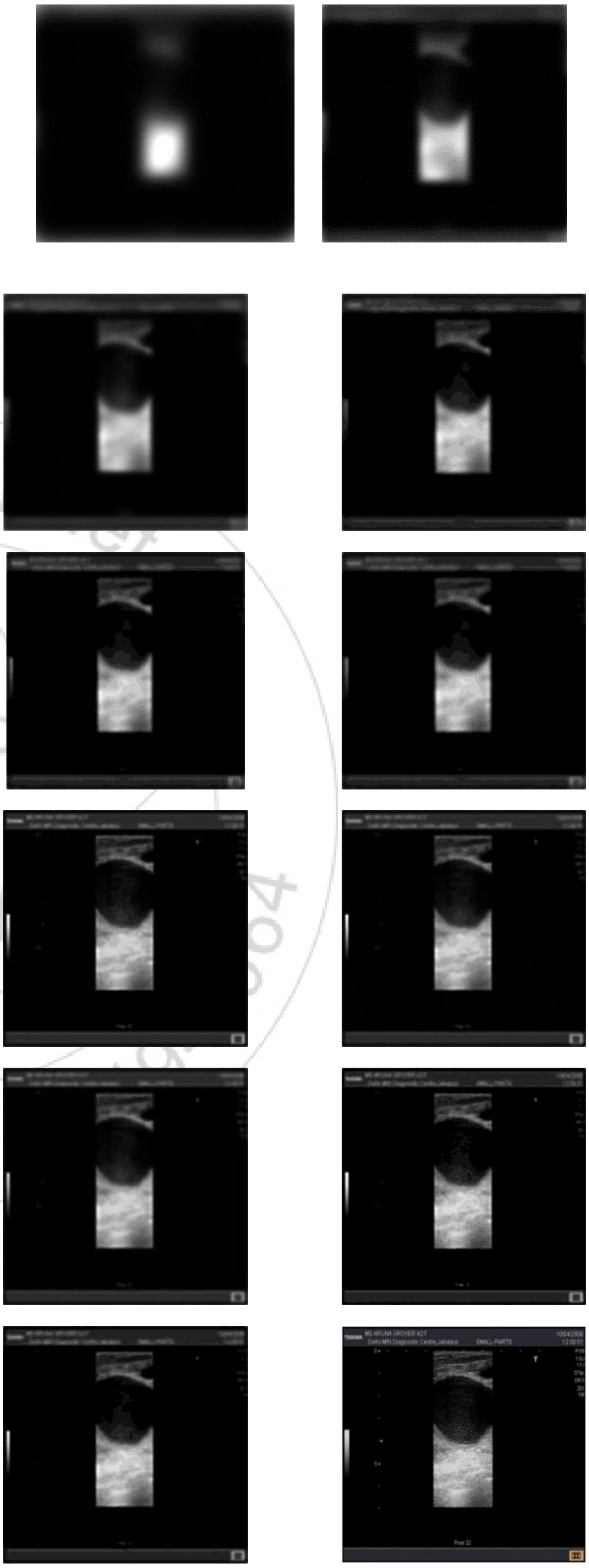
In the above matrix LL, HL, LH and HH represents the sub images of the original image. The LL subimage is formed by computation of approximation coefficients along the rows and columns of the image. This subimage contains the low frequency components of the image.

The HL subimage is formed by computation of approximation coefficient (trends) along the rows and the computation of detail coefficients (fluctuations) along the columns. The edges which are horizontal are detected by these fluctuations in the image. The LH subimage helps in the detection of the edges which are vertical. The HH subimage is formed by computation of the fluctuations for row and columns both and it detects the edges which are diagonal [17].

3. Experimental Results

3.1 Filtering Speckle by Butterworth Wavelet Filter

We have applied the proposed butterworth wavelet to a single image for frequencies from 10 to 100 Hz. Fig 3 shows the output image results obtained .Fig 3.Output Results for butterworth wavelet filter at different frequencies(a)selected ultrasound image (b)10 Hz(c) 20Hz (d) 30 Hz (e)40 Hz (f) 50Hz (g) 60 Hz (h)70 Hz(i)80 Hz (j)90 Hz(k) 100Hz. (fig from L TO R).



3.2 Comparative Study

We compared the proposed filter with the wavelet filter in terms of MSE,PSNR and SNR metrics.Below are the tabular results for each metric for comparison of the efficiency of the proposed filter.

Table 1: Comparison of MSE Metric for Wavelet & Butterworth Wavelet Filter

S.No.	Frequency	Wavelet filter		Butterworth wavelet filter
		Level 1	Level 2	
1	10	0.002756222	0.057090536	0.019637636
2	20	0.003170863	0.056603368	0.01417636
3	30	4.39034E-05	0.056812268	0.012337165
4	40	0.002756222	0.057090536	0.011404585
5	50	0.003170863	0.056603368	0.010755427
6	60	4.39034E-05	0.056812268	0.010269615
7	70	0.002756222	0.057090536	0.009895382
8	80	0.003170863	0.056603368	0.009588212
9	90	4.39034E-05	0.056812268	0.009304933
10	100	0.003214767	0.056503922	0.009014952

Table 2: Comparison of PSNR Metric for wavelet & butterworth wavelet filter

S.No.	Frequency	Wavelet filter		Butterworth wavelet filter
		Level 1	Level 2	
1	10	73.72766132	60.56516239	65.19991153
2	20	73.11902822	60.6023809	66.61515614
3	30	91.70582028	60.58638236	67.21864996
4	40	73.72766132	60.56516239	67.56000872
5	50	73.11902822	60.6023809	67.81452718
6	60	91.70582028	60.58638236	68.01526205
7	70	73.72766132	60.56516239	68.17647807
8	80	73.11902822	60.6023809	68.31342737
9	90	91.70582028	60.58638236	68.44367093
10	100	73.05930879	60.61001768	68.58116956

Table 3: Comparison of SNR Metric for wavelet & butterworth wavelet filter

S.No.	*Frequency*	*Wavelet filter*		*Butterworth wavelet filter*
		Level 1	Level 2	
1	10	64.994533	51.83203406	65.19991153
2	20	64.3858999	51.86925258	66.61515614
3	30	82.97269195	51.85325403	67.21864996
4	40	64.994533	51.83203406	67.56000872
5	50	64.3858999	51.86925258	67.81452718
6	60	82.97269195	51.85325403	68.01526205
7	70	64.994533	51.83203406	68.17647807
8	80	64.3858999	51.86925258	68.31342737
9	90	82.97269195	51.85325403	68.44367093
10	100	64.32618046	51.87688936	68.58116956

Experimental results show that the Speckle noise reduction ultrasound image of liver with a cyst as it can be observed from the improved values of the image metrics MSE, PSNR & SNR. It can be inferred from the values presented in the table that all the comparison metrics prove to be better than the existing wavelet filter due to the values of MSE decreasing and PSNR & SNR values increasing which shows positive aspect of the image quality being improved with the increasing frequencies from 10 Hz to 100 Hz.

4. Conclusion

In this work we presented a new approach for filtering the undesirable speckle noise present in the medical images. This method was simulated on the ultrasound image and then a comparative study in tabular form was carried out .The experimental results show that our approach shows better image quality results than the other denoising technique available in literature. The proposed method significantly reduces the speckle noise while preserving the resolution and details of the original ultrasound image.

References

[1] Tao Hou, Yuan Yang Wang,Yi Guo , “Despeckling Ultrasound Image Based on Blind Deconvolution & Maximum Likelihood Estimation” Bioinformatics and Biomedical Engineering (iCBBE), 2010 4th International Conference.

[2] Kaveh Houshmand, Increasing Segmentation Accuracy In Ultrasound Imaging Using Filtering And Snakes”, *IEEE Transactions on* Electrical and Computer Engineering, 2008 CCECE 2008. Canadian Conference ISBN 978-1-4244-1643-1.

[3] H Prasana Kumar and S Srinivasan, “Performance analysis of filters for speckle reduction in medical polycystic ovary ultrasound images.” *IEEE Transactions on* Computing Communication & Networking Technologies (ICCCNT), 2012 Third International Conference on 26-28 july 2012.

[4] R. Sivakumar, M.K. Gayathri and D. Neduraman, “speckle filtering of ultrasound BScan images a comparative study between spatial and diffusion filters, *IEEE Conference* on open systems (ICOS 2010), December 2010.

[5] Millind Kumar V. Sarode, Prashant R. Deshmukh, “Reduction of Speckle noise And Enhancement of images Using Filtering Techniques , International Journal of Advancements in Technology ISSN 0976-4860 Vol 2, No 1 (January 2011).

[6] S. Rakshit, A. Ghosh, Uma Shankar, “Fast Mean Filtering Technique” The journal of Pattern recognition society Pattern Recognition 40 (2007) 890 – 897 Elseveir.

[7] Tao Hou, Yuanyan Wang and Yi Guo, “Despeckling Medical Ultrasound images based on blind deconvolution and maximum likelihood estimation, IEEE Transactions on Bioinformatics and Biomedical Engineering (iCBBE), 2010 4th International Conference on 18-20 June 2010 ISBN- 978-1-4244-4713-8.

[8] Shengwen Guo, Xiaoming Wu, Quanguo He, “An Approach on suppressing speckle in ultrasound images, IEEE Transactions on Bioinformatics and BiomedicalEngineering, 2007. ICBBE 2007. The 1st International Conference on 6-8 July2007”ISBN- 1-4244-1120-3

[9] J. Saranya and S. Malarkhodi, “filtering and segmentation of a uterine fibroid with an ultrasound images,” Proceedings of the international conference on pattern recognition,

informatics and medical engineering (PRIME) ,IEEE Mar. 2012.

[10] Mandeepsingh, Dr. Sukhwindersingh, Dr. Savita Kansal, "Comparative analysis of spatial filters for speckle reduction in ultrasound images Computer Science and Information Engineering, 2009 WRI World Congress on (Volume: 6) March 31 2009-April 2 ISBN - 978-0-7695-3507-4.

[11] Ines Njeh, Olfa Ben Sassi, Khalil Chtourou and Ahmed Ben Hamida, "Speckle noise reduction in breast ultrasound images: SMU (SRAD MEDIAN UNSHARP) Approach, Systems, Signals and Devices (SSD), IEEE Transactions on 8th International Multi-Conference" on 22-25 March 2011 ISBN - 978-1-4577-0413-0

[12] Sean Finn, Martin Galvin, Edward Jones, "Echocardiographic Speckle Reduction Comparison," *IEEE Transactions on* ultrasonics, ferroelectronics and frequency control, Ultrasonics, Ferroelectrics, and Frequency Control, IEEE Transactions on (Volume: 58 , Issue: 1) ISSN - 0885-3010.

[13] D. J. Field, "Relations Between the statistics of natural images and the response properties of cortical cells," J.Opt.Soc. Am.A, Vol. 4, No.12, pp 2379, Dec, 1987.

[14] P. Kruizinga, N. Petkov and S.E. Grigorescue, "Comparison of texture features based on Gabor filters," in Proc. 10th Int. Conf. Image Analysis and Processing, pp142-147, sep 1999.

[15] M.R. Turner, "Texture segmentation by gabor functions," BiolCybern, vol. 55,pp.71-78,1986.

[16] B. Julesz, "Nonlinear and Cooperstive processes in texture perception," MIT press: Cambridge, MA, pp 93-108-,1981

[17] R.K Makkavilli, J.S Sahambi and P.K. Bora, "Modified Homomorphic Wavelet Based Despeckling of Medical Ultrasound Images," Electrical and Computer Engineering, 2008. CCECE 2008. Canadian Conference on 4-7 May ISBN- 978-1-4244-1643-1.