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A Novel Dual Tree Complex Wavelet Transform Based Ultrasound Image Denoising Algorithm

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Abstract- ***Various noises present in the ultrasound images are the main hindrance of accurate detection and diagnose of the disease. These noise degrades the quality of the ultrasound image to that extent that it become impossible for the expert to deduce some conclusion out of this. In this paper, A dual tree complex based DWT is used for de-noising ultrasound image. Comparison with the existing technique with the help of simulation program designed for this very purpose reveals that the proposed method is able to remove the noise better than the existing technique.***

Keywords-Ultrasound Imaging, PSNR, MSE, DT-CWT, DWT

I. INTRODUCTION

Ultrasound Medical Imaging has been considered as one of the essential and safest tool for medical diagnosis of biological tissue. One of the problem associated with the ultrasound imaging is its speckle noise. This noise put some limitation on the accuracy of the diagnosis based on ultrasound Imaging. Most of the B-mode ultrasound images are known to have speckle noise. Wavelet after scattering from various tissue component produce constructive and destructive interference at the transducer which receive this signal which is responsible for the speckle noise in ultrasound image[1],[2].

Apart from degrading the quality of the ultrasound imaging, speckle noise also deteriorate the contrast and resolution of the ultrasound images which leads to the poor accuracy of the ultrasound imaging [3]. Speckle noise produce so many problem in ultrasound Imaging[4]. Speckle noise mask the small differences in gray level images[5]. Due to the above mentioned problems associated with the speckle noise, pre-filtering stage for removing the noises are essential in ultrasound imaging for better accuracy. This pre-filtering stage enhance the accuracy and diagnostic ability of ultrasound imaging [6]. Pre-filtering stages are advantageous for removing the speckle and other noise but at the same time this process also eliminates some of the important diagnostic feature of the ultrasound imaging.

II. LITERATURE SURVEY

Some of the noteworthy contribution in ultrasound image de-noising is present in this section as follows-

Kabir S.M[7], "Speckle noise modeling in the contour let transform domain", International Conference on Electrical Information and Communication Technology (EICT), 2013.

In this paper the Bessel K-Form (BKF) the probability density function (pdf) is planned like an extremely appropriate prior for the modeling the log-transformed noise of speckle in the well-known transform of contour-let domain. An extreme method of likelihood founded is obtainable for the approximating the parameters of BKF pdf. The correctness of BKF pdf in demonstrating the speckle is studied for the different levels of noise in contourlet domain of transform, in addition the appropriateness of the model of BKF is examined for the case of the real images of US. It is exposed that, in general the BKF can model the statistics of contour-let coefficients of transform corresponding to the log-transformed speckle better than the normalinverse Gaussian pdfs& the traditional Gaussian.

Anshita Aggarwal[8], "Medical image enhancement using Adaptive Multi-scale Product Thresholding", International Conference on Issues and Challenges in Intelligent Computing Techniques (ICICT), 2014.

This paper proposed the method which is based on the edge enhancement & the image de-noising of the noisy multidimensional imaging sets of data. For the determined of the image de-noising, the Adaptive Multi-scale Product Thresholding based on the 2-D transform of wavelet is used.

Banazier A[9],"Modified non-local means filter for effective speckle reduction in ultrasound images, *IEEE 28th National Radio Science Conference (NRSC), 2011.*

In this paper, a new form of Non Local (NL-) means strainer adapted for the images of US is planned based on the function of Similarity just depend on the exact features of the alteration noise of speckle in the images of ultrasound.

S.Sudha,[10]" Speckle Noise Reduction in Ultrasound Images by Wavelet Thresholding based on Weighted Variance", *International Journal of Computer Theory and Engineering, Vol. 1,April 2009.*

These paper offerings the scheme of wavelet-based thresholding for the noise suppression in the images of ultrasound. The evaluations between quantitative & qualitative of results found by proposed method with the results attained from the other noise of speckle lessening techniques demonstrate its advanced performance for the speckle reduction.

Aleksandra Piˇzurica[11],"A Versatile Wavelet Domain Noise Filtration Technique for Medical Imaging",*IEEE transaction on medical imaging vol.22, NO.3, 2003*.

In this paper, author proposes the robust method of wavelet domain for the noise filtering in the images of medical. The proposed method familiarizes itself to numerous kinds of the image noise as well as to fondness of expert of medical: the single parameter can be used to equilibrium the conservation of the (expert-dependent) applicable details against degree of the reduction of noise.

Alin Achim[12],"Novel Bayesian Multi-scale Method for Speckle Removal in Medical

Ultrasound Images", *IEEE transaction on medical imaging, vol.20, 2001.* In this paper, author shows that the decompositions of the sub-band of images of ultrasoundhave meaningfully non-Gaussian statistics that are the best defined by the families of theheavy-tailed distributions like the alpha-stable. Then, the author design the Bayesian estimator that feats those statistics. Author use model of alpha-stable to improve the processor of blind noise-removal that achieves the nonlinear operation on data. Lastly, the author relate our technique with the current state-of-the-art i.e. hard & soft methods of thresholding applied on the actual ultrasound images of medical & the author enumerate the achieved presentationdevelopment.

AlinAchim[13],"wavelet-based ultrasound image de-noising an alpha-stable prior probability model", *International Conference on Image Processing, 2001.*

Author presents the algorithm of novel speckle removal within the frame work of the analysis of wavelet. First, author present the sub-band disintegrations of the logarithmically images of transformed ultrasound are best defined by the alpha-stable disseminations, the family of the

densities of heavy-tailed. Accordingly, the author design a Bayesian estimator that activities that the prior info. Using the model of alpha-stable author improve the processor of noise removal that executes the non-linear operation on data. Lastly, the author associates the proposed technique to the current state-of-the-art methods of speckle reduction. The algorithm successfully decreases speckle, it conserves the step edges, & it improves the details of fine

signal, better than the existing methods.

Yang Wang[14],"Total Variation Wavelet-Based Medical Image De-noising", International

Journal of Biomedical Imaging Volume 2006. Author proposes the algorithm of de-noising for the medical images based on the mixture of variation of the total scheme of minimization &also the wavelet scheme. Author presents that the scheme provides effective noise elimination in the real noisy medical images while preserving the objects sharpness. More prominently, this scheme permits us to appliance an actual automatic criterion of stopping time.

José V. Manjón[15], "New Methods for MRI De-noising based on Sparseness and Self-

Similarity" *Medical Image Analysis, 2012.*

This paper proposes 2novel methods for 3-dimensional de-noising of the images of magnetic resonance that activity the properties of sparseness &the self-similarity of images. The proposed methods connected on the 3dimensionalmoving-window separate the cosine transform hard thresholding & the3-dimensional rotationally invariant type of well-knownfilter of non local means. The proposed methods were associated with the methods of related state-of the-art&created very modest results. Both of the methods run in less compare to a single minute, making them practical in the most clinical &the settings of research.

Arnaud Ogier[16], "A Modified Total Variation De-noising Method in the Context of 3D Ultrasound Images", *Medical Image Computing and Computer-Assisted Intervention –MICCAI 2004.*

This paper proposes the method of renovation based on the principles of vibration modified to the statistics of ultrasound images. The improved scheme of TV to integrate the nature of multiplicative of the noise of ultrasound &the author propose to adjust the parameter λ spontaneously consequently to distribution of local noise thanks to kurtosis info. The author present qualitative& quantitative results on the numerous ultrasound volumes.

III. METHODOLOGY

In the proposed method, dual tree complex based de-noising techniques has been proposed for removing the speckle noise from the ultrasound image. In order to compare the performance of the proposed method, Adaptive dwt based ultrasound image de-noising method has also been implemented for comparison.

A. Dual Tree Complex Wavelet Transform

The Dual-Tree DWT proposed which is designed to simultaneously possess the properties of the DWT and the Dual-Tree DWT is based on two distinct scaling functions and four distinct wavelets where the two wavelets are offset from one another by one half and where the two wavelets form an approximate Hilbert transform pair. One pair of the four wavelets are designed to be offset from the other pair of wavelets so that the integer translates of one wavelet pair fall midway between the integer translates of the other pair. Simultaneously, one pair of wavelets are designed to be approximate Hilbert transforms of the other pair of wavelets so that two complex (approximately analytic) wavelets can be formed. Therefore, they can be used to implement complex and directional wavelet transforms. The design procedure for the Dual-Tree CWT is based on the flat-delay filter; spectral factorization andpara-unitary filter bank completion. The solutions have vanishing moments and compact support. The resulting wavelets are much smoother than the Dual-Tree wavelets and unlike the DWT wavelets; they form approximate Hilbert transform pairs. The design procedure also includes a parameter L that determines the degree to which the approximation is satisfied.

The Dual-Tree DWT proposed in this thesis is based on concatenating two oversampled

DWTs. The filter bank structure corresponding to the Dual-Tree DWT consists of two oversampled iterated filter banks operating in parallel similar to the DWT.The iterated oversampled filter bank corresponding to the implementation of the Dual-TreeCWT is illustrated in figure 4.1. We will denote the filters the first filter bank by hi(n) and thefilters in the second filter bank by gi(n), for i=0,1,2.

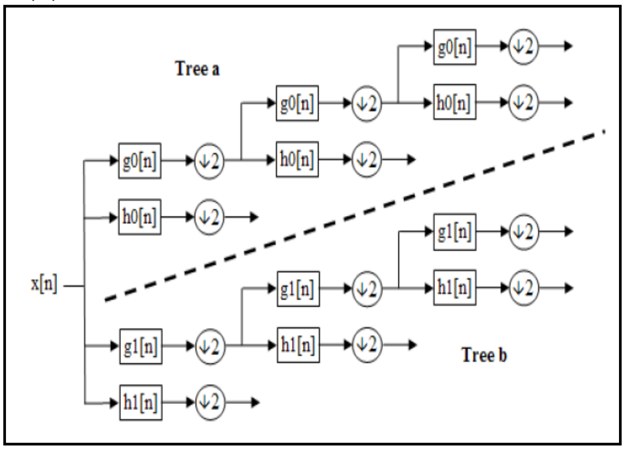


Figure 2. Oversampled Filter Bank of DTCWT.

de-noising of ultrasound image using adaptive DWT based method and hybrid approach is presented. In this approach first of all, adaptive threshold based DWT method is used de-noise the ultrasound image. The ultrasound image obtained after this step is again de-noised by

The goal will be to design the six FIR filters so that they do the following:-

i. They satisfy the perfect reconstruction property.
ii. The wavelets form two (approximate) Hilbert transform pairs.
iii. The wavelets have specified vanishing moments.
iv. The filters are of short support.

Following are the algorithm step adopted for the proposed method-

Step1 Input the ultrasound Image.

Step2 Convert the image in to gray scale image.

Step3 Resize the Image.

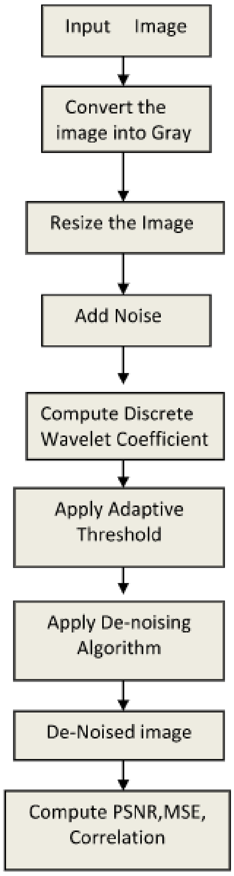


Figure1 Block Diagram of Adaptive DWT based method of de-noising

Step4 Add Gaussian noise with known variance or Add salt and Pepper noise with known noise density.

Step5 Apply DT-CWT based De-noising algorithm.

Step6 Apply Adaptive DWT based algorithm for de-noising the ultrasound image.

Step7 Compute the PSNR, MSE, correlation and between original ultrasound image and noise free image obtained in step5.

Step8 Compute the PSNR, MSE, correlation between original image and the noise free image obtained in step 6.

Step9 Compute the computational time of DT-CWT based de-noising algorithm.

Step10 Compute the computational time adaptive DWT based de-noising algorithm.

Step11 With the help of above data draw the conclusion and compare the performance of both the method.

IV. EXPERIMENTAL RESULTS

Proposed DT-CWT based ultrasound de-noising algorithm and adaptive DWT based de-noising algorithm have been implemented in MATLAB 2009B. For performance evaluation, parameter like PSNR(Peak signal to noise ratio), MSE(Mean Square Error), Computational time and Correlation factor have been computed.

The properties of CWTs shift invariance and directionality are used in many areas of image processing like de-noising, feature extraction,object segmentation and image classification.

Here we shall consider the de-noising example to analyze the effectiveness of the DT-CWT, different thresholds points and noise variance were selected from 0.01 to 0.05.But optimal thresholds points were giving the minimum square error from the original image and less noise variance values were giving the more PSNR value, showing a great effectiveness

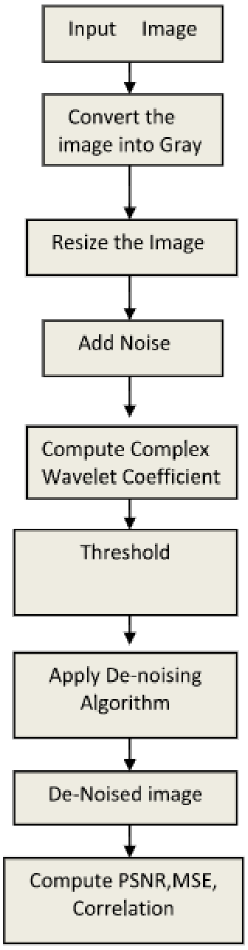
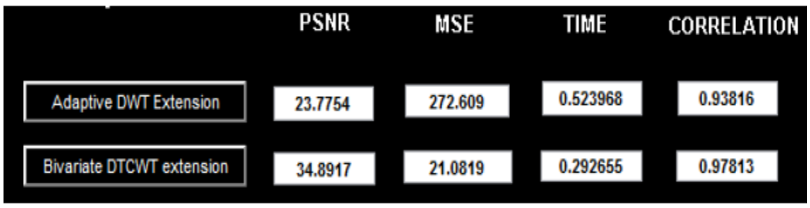


Figure 2 Block Diagram of Dual-tree Complex wavelet based method of de-noising

in removing the noise compared to the classical discrete wavelet transform.



	PSNR	MSE	TIME	CORRELATION
Adaptive DWT Extension	23.7754	272.609	0.523968	0.93816
Bivariate DTCWT extension	34.8917	21.0819	0.292655	0.97813

Figure 3 Value of PSNR, MSE and Correlation when Ultrasound Images are corrupted by Salt and Paper Noise (density = 0.01).

	PSNR	MSE	TIME	CORRELATION
Adaptive DWT Extension	21.4151	469.431	0.50104	0.89867
Bivariate DTCWT extension	34.4708	23.2274	0.282906	0.97363

Figure 4 Value of PSNR,MSE and Correlation when Ultrasound Images are corrupted by Gaussian Noise (variance=0.01).

Ultrasound images are corrupted with different noise variance ranging from 0.01 to 0.05. The first test involved reduction of Gaussian noise applied in an additive form on the ultrasound images.

	PSNR	MSE	TIME	CORRELATION
Adaptive DWT Extension	26.9004	132.753	0.505085	0.96913
Bivariate DTCWT extension	34.5559	22.7765	0.293396	0.97726

Figure 5 Value of PSNR,MSE and Correlation when Ultrasound Images are corrupted by Speckle Noise (variance=0.01).

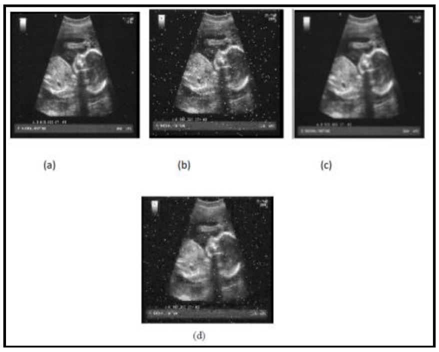


Figure 6 (a) Original Image, Fig (b) Noisy Image, Fig (c) Output from DTCWT, Fig (d) Output from ADWT when noise density 0.01 with salt and paper noise.

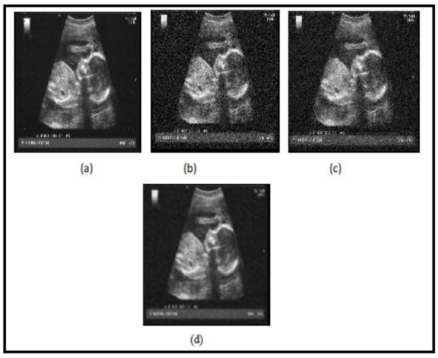


Figure 7 (a) Original Image, Fig (b) Noisy Image, Fig (c) Output from DTCWT, Fig (d) Outputfrom ADWT when noise variance 0.01 with Gaussian noise

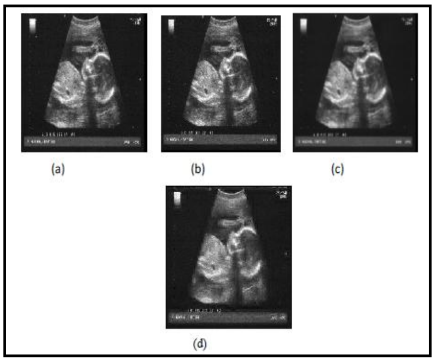


Figure 8 Figure 5.9 (a) Original Image, Fig (b) Noisy Image, Fig (c) Output from DTCWT, Fig (d)Output from ADWT when noise variance 0.01 with Speckle noise.

V. CONCLUSION

CWTs perform better than DWTs and other conventional techniques for 2-D image. It is concluded that CWTs (having separable implementation, perfect reconstruction, limited or no redundancy and improved properties over real-valued DWTs) has a potential for many signal and image processing applications yet to be explored. The DT-CWT is chosen for its key advantages compared to other wavelet transforms. The main reason for the DT-CWT outperforming is the increased number of sub-bands that allow more accurate orientation discrimination. The DT-CWT has limited redundancy with very good properties of shift invariance, directional selectivity, perfect reconstruction, limited redundancy and efficient computation. But, to obtain further improvements, it is also necessary to develop principled statistical models for the behavior of features under addition of noise and their relationship tothe uncorrupted wavelet coefficients.

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