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Research Article

ENHANCED SPECKLE NOISE REDUCTION TECHNIQUE BASED ON WAVELETS BAYES THRESHOLDING AND ANISOTROPIC FILTER FOR ULTRASOUND IMAGES

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ABSTRACT
In this paper the approach of denoising is solved by using a new hybrid technique which associates the different denoising methods. Wavelet thresholding and anisotropic diffusion filter are the two different filters in our hybrid techniques. The Wavelet thresholding removes the noise by removing the high frequency components with lesser edge preservation, whereas an anisotropic diffusion filters is based on partial differential Equation, (PDE) to remove the speckle noise. This PDE approach is used to preserve the edges and provides better smoothing. So our new method proposes a combination of these two filtering methods which performs better results in terms of Peak signal to Noise Ratio (PSNR), Coefficient of Correlation (COC) and Equivalent No of Looks (ENL).

Keywords: *Denoising, Anisotropic Diffusion Filter, Multiplicative Noise, Speckle, Wavelets*

INTRODUCTION
Now- a -days an image is very much essential in our daily life applications such as Medical imaging, Computer Tomography, Ultrasound Imaging and Satellite television. Each imaging system suffers with a common problem of "noise". Noise may arise due to an unwanted data which may reduce the size of object, their shape, and blurring of edges in an image. Noise may occurs due to the following reasons
(1) Physical Nature of the system.
(2) Shortcomings of image acquisition devices.
(3) Due to the environment.
Additive and Multiplicative are the two basic types of noise models. Additive Noise is systematic in nature and can be removed very easily. Whereas multiplicative is image dependent complex to model and cannot be removed very easily. When multiplicative noise is caused by the de-phased echoes from the scatters appears, is termed as "Speckle Noise". Speckle Noise is mostly found in medical imaging system and SAR images (Synthetic Aperture Radar) Images. Speckle Noise is the diffuse scattering when sound waves interfere with the small particle or object comparable to its sound wavelength. Speckle Noise is always in granular pattern due to the formation of coherent waves. The major disadvantages of Speckle Noise are it tends to reduce the image resolution, blur the important details and contrast. There are different techniques for removal of multiplicative Noise reduction. Several adaptive filters are proposed for speckle noise reduction such as Lee (Adib and Charles), Kuan (Shibin *et al.,* 2013), and Frost (Shibin *et al.,* 2013). Hence these are not able to reduce the full speckle without losing edges and blurring the important details, because these filters are mainly depends upon the local statistical data (Adib and Charles) and this local statistical data depends upon the fixed window size over an area (Adib and Charles). So an alternative approach is to use wavelet transform (Adib and Charles; Shibin *et al.,* 2013; Asaduzzaman and Mahmoud, 2013; Balasubramanian *et al.,* 2012) which does not depend upon the fixed window size since it is frame based approach. So we proposed a hybrid technique using wavelet based thresholding and an enhanced version of anisotropic diffusion filter presented in (Balasubramanian *et al.,* 2012) in order to smooth the approximation image than the other filtering techniques. The remainder of this paper is organized as follows. Wavelet denoising is explained in Section 3 and the proposed solution that combines the wavelet based Thresholding and adaptive versions of anisotropic diffusion filter Section 4 than experimental results are concluded in Section 5. And then finally the conclusion is drawn in section 6.

Related Work

Adib and Charles proposed a technique for image despeckling that combines wavelet denoising and an enhanced adaptive version of the old Kuan filter, which gives better results with respect to speckle noise filters than the simple wavelet denoising. Shibin *et al.,* (2013) proposed different filters, namely Lee, Frost, Median, Anisotropic Diffusion (SRAD), (PMAD) filter, Speckle Reduction Bilateral Filter (SRBF) and Speckle Reduction filter based on Wavelet based Soft Thresholding. Thus a comparative study of these filters has been made in terms of preserving the features and edges as well as effectiveness of de-noising. The experimental results have been demonstrated by filtered images. Asaduzzaman and Mahmoud (2013) proposed a hybrid scaling factor that reduces edge dislocation and preserves the sharpness of edges. The proposed technique is based on ratio-based edge detection for an estimation of the homogeneity of the initially selected region. Balasubramanian *et al.,* (2012) proposed a combination of three filtering techniques that is Wavelet thresholding; bilateral filtering and median filtering are the three different filters in our hybrid technique which performs the different Results in terms of PSNR and edge Preservation. Santhanamari *et al.,* (2012) proposed a dual-tree complex wavelet transform (DTCWT) based which combines fourth order Partial Diffusion Equation (PDE) and adaptive Thresholding for Gaussian noise corrupted images. In the proposed algorithm the fourth order PDE technique is applied on the detail sub band and the adaptive Thresholding is applied to the approximate subband tested on Gaussian noise corrupted images. The Experimental results shows that it gives better results in terms of PSNR and SSIM than the other existing techniques. Zeinab *et al.,* proposed a. Hybrid Median filter for noise reduction, which calculates the median and mean of the diagonal elements, horizontal and vertical elements in a moving window. Thus the median of the two values will be the new pixel value. The results show that our hybrid proposed method performs better in terms of denoising quality. Mohamed and Jayanthi (2011) proposed an algorithm for removal of speckle noise using Particle Swarm Optimization (PSO) technique is presented. This algorithm firstly uses the Modified Hybrid median filter to reduce speckle noise present in the corrupted image, diagonal elements of the median thus can be calculated and maximum of the horizontal and vertical elements in a moving window and then finally the two values are compared with the central pixel and the median value of the these values will be the new pixel value. It uses PSO to return optimized weighting factor of median of diagonal element and maximum of horizontal and vertical element to recover the corrupted image. The performance of the algorithm is tested and compared with these different types of filters. Experimental results show that the proposed method reduces the speckle noise effectively without destroying the information in the images Roopa and Abhishek (Roopa and Abhishek, 2011) proposed different filtering techniques for the removal of speckle noise. The quality of the enhanced images is measured by following parameters: Noise Variance, Mean Square Error (MSE), Equivalent Numbers of Looks (ENL), Signal-to-Noise Ratio (SNR), and Peak Signal-to-Noise Ratio (PSNR) Gregorio *et al.,* (2013) proposed a Thresholding technique for removal of speckle noise in ultrasound (US) medical images. The method comprises the use of an adaptive data-driven exponential operator that operates on wavelet coefficients of the US image to suppress undesired effects of disturbances, preserving signal details. The results show that the proposed denoising method increases the medical image quality. Pierrick *et al.,* (2009) proposed a Bayesian thresholding and NL-means filter in Ultrasound images Quantitative results on synthetic images show the performances of the proposed method compared to well-established methods. Results on real Images shows that the proposed method gives better preserve accurately edges and structural details of the image. Sudha *et al.,* proposed a wavelet-based Thresholding scheme for noise reduction in ultrasound images. Comparison of the results obtained by the proposed method with the results achieved from the other speckle noise reduction techniques demonstrate its higher performance for speckle reduction in terms of peak signal to noise ratio. Sabahaldin and Sami (2012) proposed a hybrid denoising algorithm which combines spatial domain bilateral filter and hybrid Thresholding function in the wavelet domain. The results show that the performance of the proposed denoising algorithm is better to that of the conventional denoising approach. Manish and Gianetan (2011) proposed wavelet based hybrid thresholding techniques: first technique by using statistical method and second technique based on bayes threshold. Result of both

methods is averaged and apply threshold for soft thresholding.for post processing wiener filter is used. Experimental results show that proposed method yields significantly better image quality and better Peak Signal to Noise Ratio (PSNR) on high noise. Udomhunskal and Wongsita (2010) proposed a method for Ultrasonic speckle denoising using the combination of wavelet transform and wiener filter to reduce the speckle noise while preserving the resolvable details. In this method, the first step is to apply the 2D discrete wavelet transform of the noisy image. Then, the wiener filter is applied over areas in each detail subband (HH, HL and LH. From the experimental results, found that this method gives better results for removal of ultrasonic speckle denoising. Akl *et al.*, (2012) proposed the Kuan filter for automatically estimating the optimal filter parameter value, which results in near-optimal performance, where the PSNR loss does not exceed 0.1 dB most of the time, compared to the best possible filter output, and yielding a significant gain with respect to the basic filter used with the default parameters.

The major drawbacks of this related work is that the Existing filters are very much sensitive to the window size and shape of the filter window.

If the window size is very much larger than the over smoothing will occurs and edges will become blurred. If the window size is small than the smoothing capability of the window will decrease and it leaves the speckle noise. Secondly, in the existing filters they do not enhance edges. These existing filters can do inhibit smoothing. Thirdly these filters are not directional. Last, the thresholds used in the existing filters, although motivated by statistical arguments, are ad hoc improvements that only demonstrate the insufficiency of the window-based approach.

Proposed Work

In the present work, two techniques, namely, Wavelet based thresholding and enhanced anisotropic diffusion filter are combined to form a hybrid speckle denoising model. These
Techniques are explained below

Wavelet Denoising

Wavelet means a small "wave". It is independent on both space and time and it is always periodic. Wavelets are localized Waves (Manish and Gianetan, 2011). The main applications of wavelets are their compression and detection techniques. Some properties of Wavelets are: (Manish and Gianetan, 2011).

- Multiresolutional – In this different sizes of image details are analyzed at the appropriate resolution scales
- Sparsity - the majority of the wavelet coefficients are small in magnitude.
- Edge detection - large wavelet coefficients coincide with Image Edges
- Edge clustering - the edge coefficients within each sub band tend to form spatially connected clusters.

A speckled image can be in the form of

k=m*n…….. (1)

Where m is the original image and the noise n is assumed to be as unitary mean and unknown variance (Adib and Charles). We will use the wavelet Denoise thresholding which is discrete wavelet transform (DWT). DWT is used to reduce the Speckle Noise from the image. It involves three steps.

- Calculate the DWT to the Noisy Image k.
- Than Thresholding the Details coefficients which is known as Wavelet Shrinkage.
- Then finally the inverse of Threshold Coefficients to obtain the original image l as shown in the figure 1.

As Speckle Noise is Multiplicative Noise Jain developed a Homomorphic approach to convert the Speckle noise into the additive model by applying the log transformation. Also the additive model is to convert them into the multiplicative model by applying the exponential transform which is cleared from this e.g. (Manish and Gianetan, 2011).

Equation 2 becomes by taking the logarithm

Log (k) =Log(m*n)=Log(m)+Log(n)…….(2)

Equation 3 becomes by taking the exponential to become an additive noise is:

k=m+n……. (3)

$e^k = e^{m+n} = e^m . e^n$ …….. (4)

A one level, 2D Wavelet Decomposition is shown in figure 2 (Adib and Charles). The output of low pass filter consists of high magnitude and low frequency components which are known as approximation coefficients. And the output of high pass filter which consists of low magnitude and high frequency components which is known as detailed coefficients

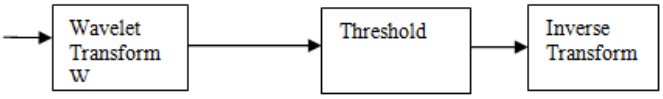


Figure 1: Block diagram of DWT-Denoising

At the result of low pass filter and high pass filter than a Down sampling process is applied to the wavelet coefficients. As a result Wavelet is divided into four blocks. The scaling approximation subband (LL). Horizontal detail subband (LH), Vertical detail subband (HL), and the diagonal detail Subband (HH). A better Visualization is shown in Figure 2. Than at the next level of decomposition only the approximation subband is further decomposed into the blocks as shown in Figure 3 (Adib and Charles). The Reconstruction process consists of assembling back, without the loss of Wavelet coefficients in order to get the original Reconstruct image. The Main idea of wavelet denoising is very much simple that is to set the zero the smaller wavelet coefficients (high frequency coefficients) which are very much belong to the noise by applying a Non linear Thresholding Technique to remove the noise while keeping the underlying image. There are mainly two Thesholding Techniques Hard Thresholding and Soft Thresholding. Hard thresholding means "keep or kill "and Soft thresholding means "Shrink or Kill "the idea behind the thresholding is very much simple. But to decide the suitable threshold is an important task. Sometimes when the large threshold value will considered than it will shrink to the zero. And over smoothing will takes place. When the smaller threshold value will considered than it contains noisy results.

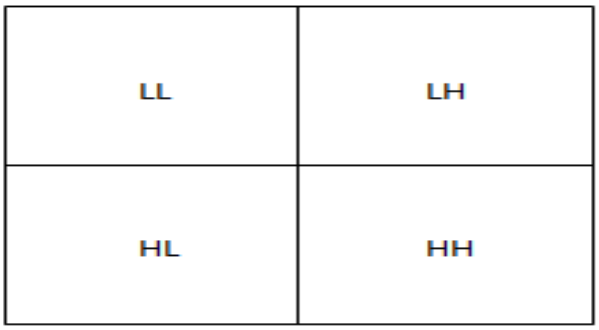


Figure 2: Sub bands of one level 2D wavelet transform

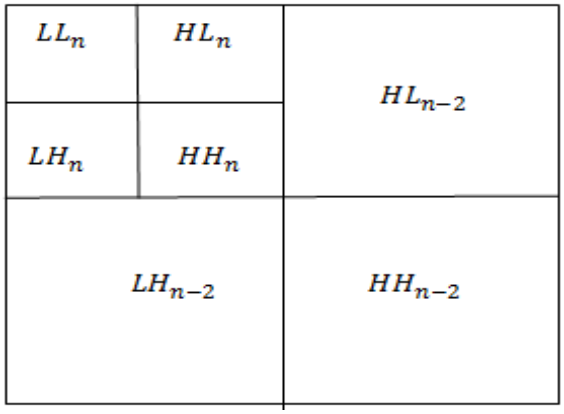


Figure 3: Sub bands of n levels 2D wavelet transform

So the suitable threshold is considered. The most common used methods for threshold selection are: VishuShrink (Roopa and Abhishek, 2011) introduced by Donoho and Johstone which uses a Universal or a global (general) threshold applied to all sub bands and scales after decomposition, and bayesshrink which uses a specific threshold for each sub and assuming a generalized Gaussian distribution before applying the soft thresholding (Roopa and Abhishek, 2011).

In Wavelet denoising, only detail coefficients are threshold, but it is not true, thus approximation image also contains the speckle noise it is not noise free wavelet coefficients. So our aim is to smooth out the approximation image in addition to detail coefficients without blurring the final output.

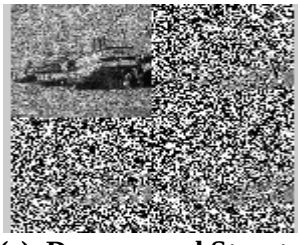
Anisotropic Diffusion Filter

Anisotropic diffusion filter is a Non linear smoothing filter for speckle noise reduction. And it is based on partial differential equation (PDE) to remove the speckle noise reduction. It is based on Minimum Mean square error approach. The PDE-based speckle removal approach allows the generation of an image scale space (a set of filtered images that vary from fine

To coarse) without bias due to filter window size and shape. this filtering capability not preserve the edges but also enhance the edges by inhibiting diffusion across the edges and allowing diffusion on either side of the edges. As mentioned in Section 3, only detailed coefficients are thresholded in Wavelet denoising, since the approximation coefficients is having low frequency coefficients which is assumed to be noise free. But it is not true since the approximation image also contains the noise in Figure 4. Figure 4 clearly shows an existence of noise in the approximation image, and, noise can still be noticed in the output of (lower-right image in Figure 4 after denoising. For this reason, the approximation coefficients should be smoothed in addition to detail coefficients thresholding. The denoising algorithm must efficiently smooth out the noise in the approximation image without over blurring its details or reducing its contrast and quality. Otherwise, it will distort the wavelet reconstruction. So to improve the performance of Wavelet denoising we proposed a hybrid filtering that applies wavelet thresholding and an enhanced anisotropic diffusion filter in an approximation image (Adib and Charles).

(a) Original image

(b) Noisy image



(c) Decomposed Structure

(d) Denoised image

Figure 4: Boat image (up-left), corrupted by speckle noise (up-right), decomposed structure (down left), denoised image (down right).

Performance Evaluation and Results

We apply Wavelet denoising with one decomposition level on 512*512 boat image corrupted by speckled noise of unity mean and 0.3 variance using Bayesshrink thresholding and Haar Wavelet type. The same

algorithm is then applied with an enhanced anisotropic diffusion filter. Result shows that the proposed filter gives better results than the other existing filters.

Table 1: Performance Metrics for Denoised Lena Image

	PSNR	COC	ENL
Gaussian speckled image	19.1163	0.1754	13.0852
Wavelet denoising	23.9578	0.2713	33.5392
Hybrid(Kuan filter)	25.2180	0.2672	55.5392
Hybrid(proposed) Anisotropic filter	29.5672	0.0352	58.7045

Figure 5 presents the corresponding visual results using the Lena image, (upper left image), and the upper right image corrupted by speckle noise, the decomposition level at one level wavelet (upper left image), and the hybrid wavelet based spatial anisotropic filter (upper right image).A comparison between two filtered images shows that the proposed wavelet filter at one decomposition level gives better results in removing speckle noise without image smoothing.

(a) Original image

(b) Noisy image

(c) Wavelet at one Decomposition level

(d) Denoised image

Figure 5: Lena image (up-left), corrupted by speckle noise (up-right), one level wavelet Denoised without spatial filtering (down left), Denoised the proposed hybrid wavelet-based denoising filter using one wavelet decomposition level (down right)

Conclusion

In this paper, we proposed a hybrid technique for speckle noise reduction that combines the wavelet based denoising and the enhanced anisotropic diffusion filter for approximation image smoothing. Simulation results shows that the proposed filter gives better results than the other filtering techniques in terms of Peak Signal to Noise Ratio, Coefficient of Correlation and Equivalent No of Looks.

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