Research Paper Engineering

Reduction of Speckle Noise in Ultrasound Images Using Wavelet Techniques and its Performance Analysis

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ABSTRACT

Noise can be of different types in Image processing but in medical images the noise which generally corrupts the image is speckle noise. Thus image De-noising has become very essential in the field of the biomedical image pre-processing. It is often done before the image data is to be analyzed. This paper gives a review of various different techniques for reduction of speckle noise in ultrasound images. Ultrasonic imaging is a widely used medical imaging procedure because it is comparatively safe, economical, adaptable, and transferable. Though, one of its main disadvantages is the poor quality of images, which are corrupted by speckle noise. The presence of speckle is unattractive since it degrades image quality and it affects the tasks of individual interpretation and diagnosis. This paper demonstrates wavelet based techniques for improving visual image quality in ultrasound images and de-noising. With the help of variable window technique, region based processing and discrete wavelet transform technique provides better noise rejection in ultrasound images by removing the speckle noise.

KEYWORDS De-noising, Speckle Noise, Ultrasonic Imaging, Wavelet transform.

I. INTRODUCTION

Biomedical images are generally corrupted by Speckle noise and Gaussian noise. Speckle noise is multiplicative type whereas other noises are additive type and it is difficult to remove multiplicative noise from images. Speckle noise is high frequency content in ultrasound images and can be easily removed using wavelet based thresholding technique. In medical imaging, such as ultrasound images, image is generated with the help of ultrasonogram, but the basic problem in ultrasound images is that speckle noise gets introduced in it. Speckle noise becomes a dominating factor in degrading the image visual quality and perception in many other images. Noise is introduced at all stages of image acquisition. There could be noises due to loss of proper contact or air gap between the transducer probe and body or noise could be introduced during the beam forming process and also during the signal processing stage.

De-noising is often done before the image data is to be analyzed. It is mainly used to remove the noise that is present and retains the important information, regardless of the frequency contents in the signal. De-noising has to be performed to restore the useful information.

There are several transforms available like Fourier transform, Wavelet transform, Hilbert transform, etc. The Discrete wavelet transform(DWT) is better than fourier transform because it gives frequency representation of raw signal at any interval of time, but fourier transform provides only the frequency- amplitude representation of the raw signal, but the time information is lost. So we cannot use the Fourier transform where we need time as well as frequency information at the same time. DWT follows a quantization approach that divides the input image in four filter coefficients and then performs further quantization on the lower order filter of the previous step.

Matlab software is used to implement the design. DWT will be applied to construct the detail and approximation coefficients and after multilevel decomposition and filtering, reconstructed image will be created using reconstruction coefficients. Results would be both qualitatively and quantitatively analyzed by obtaining the de-noised version of the input image by using DWT Technique and comparing it with the input image used.

In Recent years, many studies have been made on wavelets. An exceptional overview of what wavelets have brought to the fields of wireless communications, computer graphics or turbulence, biomedical applications, is given in [1].

II. Literature Review

Digital image acquisition and processing techniques play an important role in current day medical diagnosis. Images of living objects are taken using different modalities like X-ray, Ultrasound, Computed Tomography (CT), Medical Resonance Imaging (MRI) etc. [2] highlights the importance of applying advanced digital image processing techniques for improving the quality by removing noise components present in the acquired image to have a better diagnosis. [2] also shows a survey on different techniques used in ultrasound image denoising. [3] has presented the work on use of wiener filtering in wavelet domain with soft thresholding as a comprehensive technique. Also, [3] compares the efficiency of wavelet based thresholding (Visushrink, Bayesshrink and Sureshrink) technique in despeckling the medical Ultrasound images with five other classical speckle reduction filters. These filter's performance is determined using the statistical quantity measures such as Peak-Signal-to-Noise ratio (PSNR) and Root Mean Square Error (RMSE). Based on the statistical measures and visual quality of Ultrasound B-scan images the wiener filtering with Bayes shrink thresholding technique in the wavelet domain performed well over the other filter techniques. [4] has presented different filtration techniques (wiener and median) and a proposed novel technique that extends the existing technique by improving the threshold function parameter K which produces results that are based on different noise levels. A signal to mean square error as a measure of the quality of denoising was preferred.

Figure1. Ultrasound image corrupted by speckle noise

Figure2. Ultrasound image

III. Justification of research
This research is dissimilar from the related literature in he following way:

i. In previous techniques results of speckle noise reduction in ultrasound images have been presented using Median and Weiner filter alone but now enhancements of results is being done by combining Median and Weiner filtering using DWT technique.
ii. Quantitative analysis would be performed by checking Peak Signal to Noise Ratio (PSNR) and Mean Square Error estimation of the de-noised image.
iii. A comparative analysis of different wavelet families will be performed.
iv. DWT will be applied to construct the detail and approximation coefficients and after multilevel decomposition and filtering, reconstruction image will be created using reconstruction coefficients using MATLAB.
IV. Research Methodology
V. Steps to be followed

Research methodology will be done by the following steps shown in a form of flowchart given in figure 2.

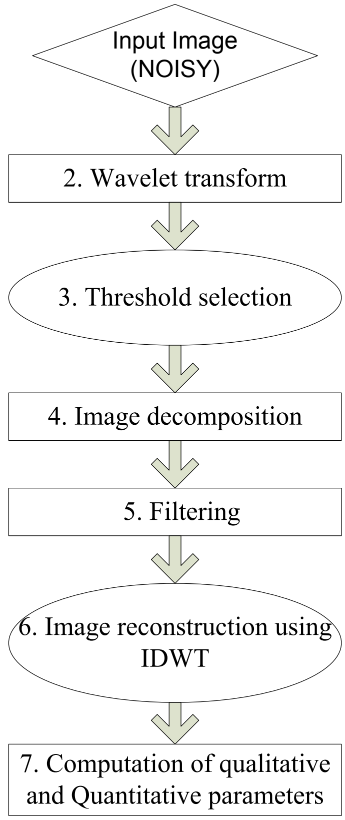

Figure 3.

VI. Different Techniques For Image De-noising
Various techniques for Image enhancement include Fourier Transform, but it involves only frequency domain analysis but no information in time domain. Then the detailed analysis for both time and frequency domain was introduced in a block by block processing technique, Discrete Cosine transform that had the disadvantage of fixed window size. This was the major problem in previous techniques explained below. This problem was overcome in discrete wavelet transform.

The detailed description of these techniques is explained below:

A. Discrete Cosine Transform
The discrete cosine transform (DCT) helps to divide the image into parts (or spectral sub-bands) of differing importance (with respect to the image's visual quality). The DCT is like the discrete Fourier transform: it transforms a signal or image from the spatial domain to the frequency domain (Fig 4)

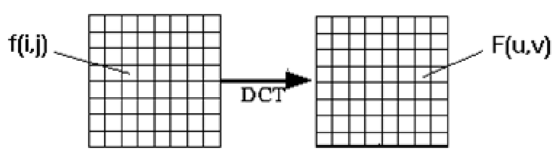

Figure 4: DCT Block Processing

A discrete cosine transform (DCT) expresses a sequence of finitely many data points in terms of a sum of cosine functions oscillating at different frequencies. DCTs are important in numerous applications like science and engineering, from lossy compression of audio (e.g. MP3) and images (e.g. JPEG) (where small high-frequency components can be discarded), to spectral for the numerical solution of partial differential equations. The use of cosine rather than sine functions is critical in these applications: for compression, it turns out that cosine functions are much more efficient (as described below, fewer are needed to approximate a typical signal), whereas for differential equations the cosines express a particular choice of boundary conditions.

In particular, a DCT is a Fourier-related transform similar to the discrete Fourier transform (DFT), but using only real numbers. DCTs are equivalent to DFTs of roughly twice the length, operating on real data with even symmetry (since the Fourier transform of a real and even function is real and even), where in some variants the input and/or output data are shifted by half a sample. There are eight standard DCT variants, of which four are common.

B. Discrete Wavelet Transform

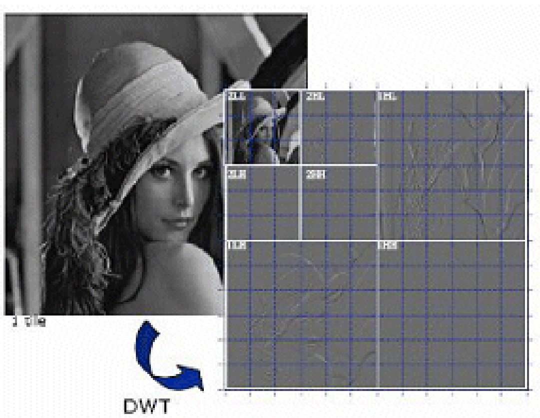

Figure 5: Discrete wavelet transform of an image

The discrete wavelet transform (DWT) refers to wavelet transforms for which the wavelets are discretely sampled. A transform which localizes a function both in space and scaling and has some desirable properties compared to the Fourier transform. The transform is based on a wavelet matrix, which can be computed more quickly than the analogous Fourier matrix. Most particularly, the discrete wavelet transform is used for signal coding, where properties of the transform are exploited to represent a discrete signal in a more redundant form, frequently as a preconditioning for data compression.

Wavelet analysis represents the next logical step: a windowing technique with variable-sized regions. Wavelet analysis permits the use of long time intervals where we want more defined low-frequency information, and shorter regions where we want high-frequency information.

Wavelet Transform in contrast with the time-based, frequency-based, and STFT views of a signal:

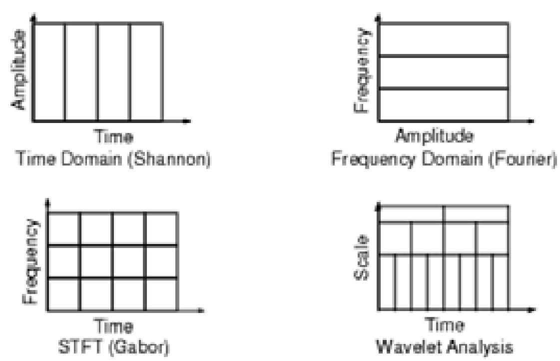

Figure 6: Comparison of Various Transform Techniques

The discrete wavelet transform (DWT) refers to wavelet transforms for which the wavelets are sampled discretely. A transform which localizes a function both in space and scaling and has some desirable properties compared to the Fourier transform. The transform is basically based on a wavelet matrix, which can be computed more rapidly than the analogous Fourier matrix.

Previous techniques of thresholding includes filtering in spatial domain, however, in wavelets, the complete analysis is shifted from spatial domain to frequency domain having both time –scale aspects. Wavelet transform (WT) represents an image as a sum of wavelet functions (wavelets) with different locations and scales. Any decomposition of an image into wavelets involves a pair of waveforms: one to represent the high frequencies corresponding to the detailed parts of an image (wavelet function ψ) and one for the low frequencies or smooth parts of an image (scaling function Ø). The Discrete wavelet transform (DWT) has gained wide popularity due to its excellent de-correlation property, many modern image and video compression systems embody the DWT as the transform stage. It is widely recognized that the 9/7 filters are among the best filters for DWT-based image compression. In fact, the JPEG2000 image coding standard employs the 9/7 filters as the default wavelet filters for lossy compression and 5/3 filters for lossless compression. The performance of a hardware implementation of the 9/7 filter bank (FB) depends on the accuracy with which filter coefficients are represented. Lossless image compression techniques find applications in fields such as medical imaging, preservation of artwork, remote sensing etc [4] . Day-by- day Discrete Wavelet Transform (DWT) is becoming more and more popular for digital image compression. The process of row-wise convolution will divide the given image into two parts with the number of rows in each part equal to half that of the image. This matrix is again subjected to a recursive line-based convolution, but this time column-wise. The result will DWT coefficients corresponding to the image, with the approximation coefficient occupying the top-left quarter of the matrix, horizontal coefficients occupying the bottom-left quarter of the matrix, vertical coefficients occupying the top-right quarter of the matrix and the diagonal coefficients occupying the bottom-right quarter of the matrix[3] .

Speckle noise is a high-frequency component of the image and appears in wavelet coefficients. One widespread method exploited for speckle reduction is wavelet thresholding procedure. The basic Procedure for all thresholding method is as follows:

- Calculate the DWT of the image.
- Threshold the wavelet coefficients. (Threshold may be universal or sub band adaptive)
- Compute the IDWT to get the de-noised estimate.
- There are two thresholding functions frequently used, i.e. a hard threshold, a soft threshold. The hard-thresholding is described as
  $\eta 1$ (w) = wI (| w |> T)
  Where w is a wavelet coefficient, T is the threshold. The Soft-thresholding function is described as
  $\eta 2$ (w) = (w – sgn (w) T) I (| w | > T)
  where sgn(x) is the sign function of x. The soft-thresholding rule is chosen over hard-thresholding, As for as speckle (multiplicative nature) removal is concerned a preprocessing step consisting of a logarithmic transform is performed to separate the noise from the original image. Then different wavelet shrinkage approaches are employed. The different methods of wavelet threshold denoising differ only in the selection of the threshold.

VII. Wavelet Families

Several families of wavelets that have proven to be especially useful are included in the wavelet toolbox. The details of these wavelet Families have been shown below:

A. Haar Wavelets

Haar wavelet is the first and simplest. Haar wavelet is discontinuous, and resembles a step function. It represents the same wavelet as Daubechies db1.

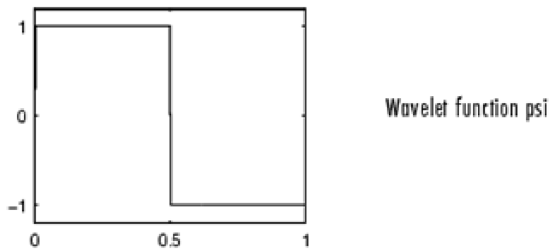

Figure 6: Haar Wavelet Function Waveform

B. Daubechies Wavelet

Ingrid Daubechies, one of the brightest stars in the world of wavelet research, invented what are called compactly supported orthonormal wavelets -- thus making discrete wavelet analysis practicable.

The names of the Daubechies family wavelets are written dbN, where N is the order, and db the "surname" of the wavelet. The db1 wavelet, as mentioned above, is the same as Haar wavelet. Here is the wavelet functions psi of the next nine members of the family:

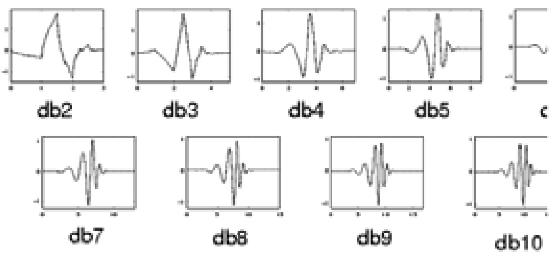

Figure 8: DB Wavelet Function Waveforms

WAVELET DECOMPOSISTION

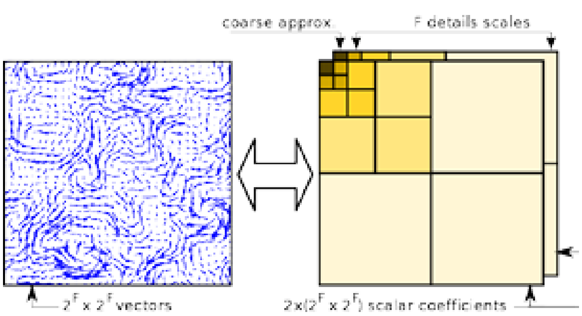

Figure 9: Decomposition for image compression using wavelets

Algorithm follows a quantization approach that divides the input image in 4 filter coefficients as shown below, and then performs further quantization on the lower order filter or window of the previous step. This quantization depends upon the decomposition levels and maximum numbers of decomposition levels to be entered are 3 for DWT.

VIII. Conclusion

Comparative analysis of Speckle noise reduction in ultrasound images and Results would be both qualitatively and quantitatively analyzed by obtaining the de-noised version of the input image with DWT approach and comparing it with the input image used.

Discrete wavelet transform will be applied to construct the detail and approximation coefficients and after multilevel decomposition and filtering, reconstruction image will be produced using reconstruction coefficients. Results would be both Qualitative and Quantitative analyses by obtaining the de-noised version of the input image by DWT Technique and comparing it with the input image used. Best PSNR is to be attained using wavelet for image de-noising using wiener and median filter and different wavelets. It has been concluded the picture quality improves as speckle noise is reduced form the images using discrete wavelet transform technique.

REFERENCES

[1] N.K. Ragesh, A.R. Anil, DR. R. Rajesh, Digital Image Denoising in Medical Ultrasound Images: A Survey, IGCST AIML – 11 Conference, Dubai, UAE, 12-14 April 2011. | [2] M. Antonini, M. Barlaud, P. Mathieu, and I. Daubechies, Image coding using wavelet transform, IEEE Trans. Image Processing, vol. 1, pp.205-220, 1992. | [3] Haryali Dhillon, Gagandeep Jindal, Akshay Girdhar, A Novel Threshold Technique for Eliminating Speckle Noise in Ultrasound Images, International Conference on Modelling, Simulation and Control, IPCSIT vol.10 (2011) IACSIT Press, Singapore. | [4] S-T. Hsiang and J.W. Woods, Embedded image coding using zeroblocks of subband/wavelet coefficients and context modeling, IEEE Int. Conf. on Circuits and Systems (ISCAS2000), vol. 3, pp.662-665, May 2000. | [5] S. Mallat, Multifrequency channel decompositions of images and wavelet models, IEEE Trans. Acoust., Speech, Signal Processing, vol. 37, pp.2091-2110, Dec. 1989. | [6] A. Said and W.A. Pearlman, A new, fast and ef_cient image codec based on set partitioning in hierarchical trees, IEEE Trans. on Circuits and Systems for Video Technology 6, pp. 243-250, June 1996. | [7] M. Antonini, M. Barlaud, P. Mathieu, and I. Daubechies, Image coding using wavelet transform, IEEE Trans. Image Processing, vol. 1, pp.205-220, 1992. | [8] N.K. Ragesh, A.R. Anil, DR. R. Rajesh, Digital Image Denoising in Medical Ultrasound Images: A Survey, IGCST AIML – 11 Conference, Dubai, UAE, 12-14 April 2011. | [9] J.M. Shapiro, Embedded image coding using zerotrees of wavelet coef_cients, IEEE Trans. Signal Processing, vol. 41, pp.3445-3462, Dec. 1993 | [10] I.H. Witten, R.M. Neal, and J.G. Cleary, Arithmetic coding for data compression, Commun. ACM, vol. 30, pp. 520-540, June 1987. | [11] Thomas W. Fry, Hyperspectral image compression on recon_gurable platforms, Master Thesis, Electrical Engineering, University of Washington, 2001. | [12] J.M. Shapiro, Embedded image coding using zerotrees of wavelet coef_cients, IEEE Trans. Signal Processing, vol. 41, pp.3445-3462, Dec. 1993. | | [13] S-T. Hsiang and J.W. Woods, Embedded image coding using zeroblocks of subband/wavelet coefficients and context modeling, IEEE Int. Conf. on Circuits and Systems (ISCAS2000), vol. 3, pp.662-665, May 2000. |