A Procedural Performance Comparison of Soft Thresholding Techniques for Medical Image Denoising

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ABSTRACT - It is still a challenging problem for researchers to remove noise from medical image. To remove Noise from the images is not easy. Several algorithms are published and each approach has its advantages, and limitations. This paper presents some significant work in the area of image denoising and finds the one is better for image denoising. From the introduction we can conclude that the Multiwavelet Soft Thresholding technique is the best technique for image denoising. In this method Penalized method gives better result and performance.

Keywords - *wavelet, Multiwavelet, Image denoising, Gaussian noise, Speckle noise Linear filters, Wavelet transform.*

I. INTRODUCTION

Today there is an important issue of denoising in digital imaging in medicine, the quality of digital medical images is essential for diagnosis [1]. It is important for medical images to be sharp, clear, and free of noise to achieve the best possible diagnoses. Removing noise is major challenges in the study of medical imaging. In this paper the technique used for image denoising is Multiwavelet Soft-Thresholding. Multiwavelets are said to be new addition to the body of wavelet theory. Multiwavelets are having orthogonality, symmetry, and short support [1]. There is a variety of noise types they are; Gaussian noise, speckle noise, salt and pepper noise etc. [2]. Multiwavelet Soft Thresholding method is nonlinear process. Images are two-dimensional signals and Multiwavelet transformation is directly applicable only to one dimensional signals, so there should be a way to process them with a one-dimensional transform [3]. When we obtain a noisy image, Image denoising is used. We want to remove as many of the Gaussian from the image as possible, without removing any feature in it [4]. First part of paper describes introduction, 2nd part describe procedural structure, 3rd part describes method used for image denoising. We compare between other soft thresholding techniques on the performance of image de-noising algorithms in terms of PSNR in the 4th part and the last part is conclusion of this paper.

II. PROPOSED SYSTEM STRUCTURE

1) The shifted image is prefiltered into multiple streams by a resolution.
2) Transform the preprocessed image into the Multiwavelet as domain using an orthogonal periodic Multiwavelet transform.
3) Calculate the thresholds by using the proposed method.
4) Post process the image.
5) Apply Inverse transform the result. Image is reconstructed by using the inverse Multiwavelet transforms.

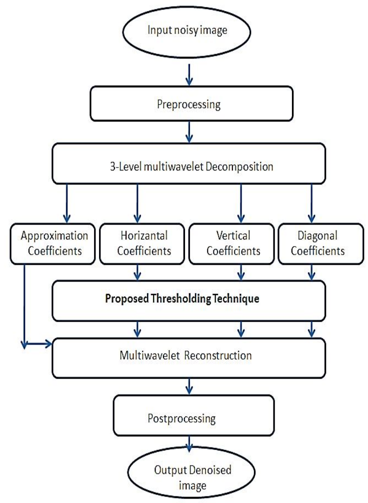

Fig. 1: General Block diagram for 1D Discrete Multiwavelet Transform

By this a denoised signal is obtained based on thresholding level. The whole process shown in the Fig.1 is implemented using Matlab.

To analyze the signal Multi-wavelet can provide a newer means. Experimental Results indicate the quality of denoised image based on multi-wavelet and it is best method.

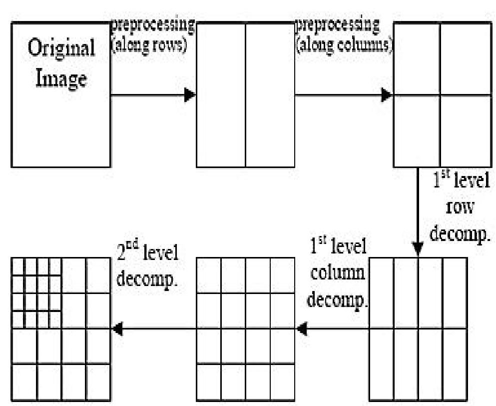

Fig. 2: Decomposition of Multiwavelet image

III. MULTI-WAVELET TRANSFORM

In image signals the Multi-Wavelet[3][4][9] Transform produces a non-redundant image representation compared with other multi scale representations such as Gaussian pyramid which provides better spatial and spectral localization of image formation. Recently, Multi-Wavelet Transform has attracted more and more interest in image de-noising. Multi-wavelet iteration is done on the low-frequency components generated by the first decomposition. After scalar wavelet decomposition, the low-frequency components is having only one sub-band, but after multi-wavelet decomposition, the low-frequency components is having four small sub-bands, one low-pass sub band and three band-pass sub bands. The next iteration continued to decompose the low frequency components *L= {L1L1, L1L2, L2L2, L2L1}*. In this situation, a structure of 5(4**J*+ 1) sub bands can be generated after J times decomposition, as shown in figure 2. Similar to single-wavelet, multi-wavelet can also be decomposed to three to five layers The Gaussian noise will nearby be averaged out in low frequency Wavelet coefficients. Therefore the Multi-Wavelet coefficients in the high frequency level only need to hard be threshold [7].

IV. THRESHOLD FOR WAVELET

Three methods of threshold selection method are given. According to the computer simulation, the rule of estimating the threshold is found, and it is combined with three kinds of threshold processing methods to denoise the same noisy signal. For image denoising the best method of threshold processing is obtained by comparing the performance of three methods of threshold processing that are applied to denoising.

4.1 FIXED THRESHOLD

De-noise using soft fixed form thresholding is done by the method available in
MATLAB. This selection rules are implemented in the thselect. tptr option in the command uses 'sqtwolog' for fixed form threshold method.
thr = thselect(y,tptr) which returns the threshold value.

4.2 PENALIZED THRESHOLD FUNCTION

In this, the value of threshold is obtained by a wavelet coefficients selection rule using a penalization method provided by Birge-Massart. Here MATLAB code is provided for Penalized Threshold.

THR= wbmpen(C, L, Sigma, Alpha)

Where **[C, L]** represents the wavelet decomposition structure of the signal or image to be de-noised. SIGMA represents the standard deviation of the zero mean Gaussian white noise in de-noising model.

ALPHA is a tuning parameter for the penalty term and it must be a real number greater than 1. Here the sparsity of the wavelet representation of the de-noised signal or image grows with ALPHA. Typically ALPHA = 2.

4.2 BALANCE SPARSITY NORMS

Balancing can improve the accuracy of computed eigen values by sometimes reducing the norm of the matrix. Method used for balance sparsity norm is `[XC,DECCMP,THRESH]=mswcmp('cmp',DEC, METHOD)` Where METHOD is 'bal_sn'.

V. DE-NOISING PROCESS FOR MULTI-WAVELET

If the noised image is

$$I(i,j)=X(i,j)+n(i,j) \quad (1)$$

where i,j=1,2,3,4….,N

Where *n (i,j)* is white Gaussian noise whose mean value I zero, σ is its variance, and X(i,j) the original signal. The problem of de-noising can be thought as how to recover *X (i, j)* from *I(i, j)*. Transform the formula (3) with multiwavelet, formula (4) is obtained

$$W_1(i,j)= W_x(i,j)+ W_n(i,j) \quad (2)$$

It is known that the multi-wavelet transformation of Gaussian noise is also Gaussian distributed, and there are components at different scales, but the energy distributes evenly in high frequency area, and the specific signal of the image has projecting section in every high frequency components. So we can say that image de-noising can be performed in high frequency area of multi-wavelet transformation. The above said methods are evaluated using the quality measure Peak Signal to Noise ratio which is calculated using the formulae,

$$PSNR= 10log\ 10\ (255)\ 2/MSE\ (db) \quad (3)$$

Where MSE is the mean squared error between the original image and the reconstructed de-noised image. Therefore it is used to evaluate the different de-noising scheme like Wiener filter, Visu shrink, Neigh shrink [11], Modified Neigh shrink and multi-wavelet.

VI. RESULT AND DISCUSSION

Image de-noising is performed using Multiwavelets from the second level to fourth level decomposition for the above mentioned Wavelet and Multiwavelet methods, and the results are shown in fig (3) and table if formulated for second level decomposition for different noise variance as follows. It was found in earlier experiment that three level decomposition and fourth level decomposition gave optimum results. However, we can say that third and fourth level decomposition resulted in more blurring and unclear image. The experiments were done in Gaussian Noise. As per result Penalized low method gives better performance.

Table 1: Effect of Peak Signal to Noise Ratio

S.No.	Threshold Method		Db4	Coif5	Sym8
			PSNR	PSNR	PSNR
1	Fixed form Threshold	Unscaled Noise	19.6639	19.6668	19.6551
		Scaled Noise	29.0445	28.9825	28.8018
		Nonwhite Noise	29.0424	28.9802	28.7983
2	Penalized	Low	29.0458	28.9878	28.8098
		Medium	29.0422	28.9819	28.8029
		High	29.0362	28.967	28.7793
3	Balance Sparsity Norms	Unscaled Noise	20.2442	20.2849	20.278
		Scaled Noise	20.2718	20.281	20.278
		Nonwhite Noise	20.2839	28.9583	20.278

Table 2:Effect of Mean Square Error

S.NO.	Threshold Method		Db4	Coif5	Sym8
			MSE	MSE	MSE
1	Fixed form Threshold	Unscaled Noise	7.67E-05	7.66E-05	7.67E-05
		Scaled Noise	2.60E-05	2.62E-05	2.68E-05
		Nonwhite Noise	2.60E-05	2.62E-05	2.68E-05
2	Penalized	Low	2.60E-05	2.62E-05	2.67E-05
		Medium	2.60E-05	2.62E-05	2.68E-05
		High	2.61E-05	2.63E-05	2.68E-05
3	Balance Sparsity Norms	Unscaled Noise	7.17E-05	7.14E-05	7.14E-05
		Scaled Noise	7.15E-05	7.14E-05	7.14E-05
		Nonwhite Noise	7.14E-05	2.63E-05	7.14E-05

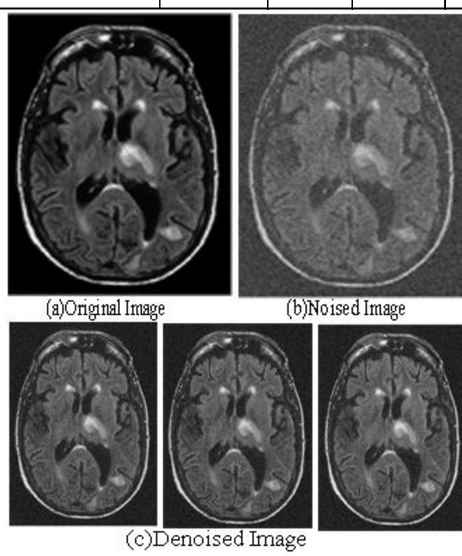

Fig. 3: Results of Various Image Denoising Methods

VII. CONCLUSION

In this paper, the image de-noising Multi-Wavelet transform is analyzed the experiments were conducted to study the suitability of different wavelet and multi-wavelet bases. Experimental Results also shows that multi-wavelet with Penalized method gives better result than other.

In the body of wavelet theory Multiwavelets are a new addition. The proposed threshold method mentioned in this paper shows better performance over other techniques. Based on the result we can say that the proposed threshold method may find applications in image compression, image recognition system, medical ultrasounds and a host of other applications.

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