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An effective wavelet thresholding filter for image denoising

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ABSTRACT- Image denoising is the basic problem of signal recovery in Image process and is required to reduce or eliminate the noise of the observed images. The image will be contaminated by random noise in the process of collection and transmission, which would inevitably lead to the degradation of the image quality in the subsequent process such as image compression and feature extraction. Hence, it is important to estimate the original image from the noisy image. Most of the existing techniques use hard and soft thresholding functions for denoising the image in which the large value of threshold results in too many zero coefficients. So the useful information is removed along with the noisy data. In proposed method using below threshold value will be processed, So the useful information of the image is does not affected. The performance is evaluated and the results are compared. The results in the proposed method enhance the peak signal to noise ratio and preserves the details of an image.

Keywords: Salt and pepper noise, medical image, Bayes threshold, Stationary wavelet transform, PSNR, MSE.

1. INTRODUCTOIN

Images are affected by noise during capturing or transmission. There are many modalities of medical imaging, X-ray images are used for diagnosing the diseases in bones. It will not be useful for imaging the soft tissues. Magnetic Resonance Imaging (MRI) can be used for imaging the soft tissues. But it is not suitable for imaging the movements and it will also attracted by the metals such as watch, jewelleries of the patients. So it is difficult to diagnose the diseases in moving tissues by MRI scans. Computer Tomography (CT) can be used for imaging, but the radiation from the scan causes the skin cancer. Image denoising is the basic problem of signal recovery in image process and is required to reduce or eliminate the noise of the observed images, Many scholars have devoted a lot of energy to the study of image denoising and put forward many effective methods over the past few decades. Wavelet analysis has good Localization properties and multi resolution characteristics in either time domain or frequency domain, which makes it more effective to distinguish useful signal and noise. Therefore, wavelet has become a very effective method for the image denoising . At present, there are mainly three kinds of wavelet denoising techniques to remove noise from image data. The first is to separate signal from noise through the singularity detection with wavelets, the second is to reduce image noise through the wavelet coefficient thresholding method and the third is to reduce image noise through the wavelet domain Bayesian threshold criterion coefficient of shrinkage method. Among them, wavelet coefficient thresholding method is the most widely used method for the image denoising because of its simpleness and effectiveness. In this paper we propose a new thresholding function to adapt to the TNN. This method used to process the above and below thresholding level of image. Finally, wavelet coefficients are inversely processed to obtain the denoised image. The experimental results show that this method can not only remove the noise without blurring and important characteristics of images but also highlight the characteristics of image compared with the existing methods. The denoised images obtain higher PSNR and lower MSE. What is more, the denoising effect is better than the previous article. Hence, the method is of great application value.

2. EXISTING METHOD

1. WAVELET THRESHOLDING:

Wavelet threshold denoising is used for removing the noise present in the image while preserving the details of an image. Wavelet thresholding performs in various steps. (1) Noisy image is decomposed into detail and approximation subbands by using wavelet transform . (2)The noisy signals in the detail subbands coefficients are filtered by applying the thresholding function. (3) The denoised coefficients are reconstructed by applying inverse wavelet transform[3].

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2. BAYES THRESHOLD:

The Bayes Shrink minimizes the Bayesian risk, and hence its name, Bayes Shrink. It uses soft thresholding and is sub band dependent, which means that the thresholding is done at each band of resolution in the wavelet decomposition[5]. Like the Sure Shrink procedure, it is smoothness-adaptive.

The Bayes threshold t_B

$$t_B = \sigma^2/\sigma_s \quad (1)$$

Where, σ^2 is the noise variance σ_s is the signal Variance

The signal variance is then given by,

$$\sigma_X = \sqrt{\max(\sigma_y^2 - \sigma_n^2, 0)} \quad \textbf{(2)}$$

$$\sigma_y^2 = \frac{1}{N}\sum_{n=1}^{N} y_n^2 \quad \textbf{(3)}$$

The noise variance is then given by,

$$\sigma_n^2 = \left[\frac{median(HH1(n,m))}{0.6745}\right]^2 \quad \textbf{(4)}$$

3. PROPOSED METHOD

3.1.1 HARD THRESHOLDING:

In hard thresholding, the coefficients below threshold are considered as noises are completely removed. Then value above threshold is considered as signal coefficients and these are kept unchanged in equation(5). Hard thresholding equations are given below.

$$ht(u_{j,k}) = \begin{cases} 0 & , |u_{j,k}| < v_j \\ u_{j,k}, & |u_{j,k}| \ge v_j \end{cases} \quad \textbf{(5)}$$

Where, v_j is the threshold value and then $u_{j,k}$ the wavelet subband coefficients. The drawback of the hard thresholding is that the useful information gets removed along with the noisy pixels in an image. So that there will be higher smoothening of an image.

3.1.2. SOFT THRESHOLDING:

In soft thresholding function, the value below threshold is made as zero completely and the value above threshold is denoised by using the equation (6) given below.

$$st(u_{j,k}) = \begin{cases} 0 & , |u_{j,k}| < v_j \\ sign(u_{j,k})(|u_{j,k}| - v_j), & |u_{j,k}| \ge v_j \end{cases} \quad \textbf{(6)}$$

Where, v_j is the threshold value and then $u_{j,k}$ is the wavelet subband coefficients. In the above thresholding the signal components are processed and then a noisy component (below threshold) gets removed completely. This also provides higher smoothing of an image.

3.1.3. PROPOSED THRESHOLD ALGORITHM:

The proposed approach uses as thresholding function. Here, the noisy coefficients below the threshold are not completely made zero in equation (7), instead the threshold zone is increased to set the wavelet coefficients gradually to zero as shown in figure. The thresholding equation is given by,

$$L(u_{j,k}, v_j) = \begin{cases} u_{j,k} - \frac{0.5 v_j^2}{u_{j,k}}, & |u_{j,k}| \ge v_j \\ \frac{0.5 u_{j,k}^3}{v_j^2} & , |u_{j,k}| < v_j \end{cases} \quad \textbf{(7)}$$

Where, v_j is the threshold value, and then is the detail $u_{j,k}$ wavelet subband coefficients. The *u* and *v* are the positive constant values. Different values for *u* and *v* parameters have been tested. The proposed method offers an improvement in PSNR and MSE.

3.1.4 THRESHOLDING PARAMETERS:

Selection of threshold is a critical task in any denoising algorithm. A small threshold will give a result close to the input, but the result will be still noisy. A large threshold produces a signal with a large number of zero coefficients. This leads to a smooth signal. This destroys the necessary details of an image. Hence an optimal selection of threshold is necessary.

3.1.5 PROPOSED THRESHOLD:

In this proposed method, we process the below the threshold value, so the image clarity will improved and MSE will decreased in equation (7). Noisy image is decomposed into detail and approximation subbands by applying stationary wavelet transform. The noise variance for L level decomposition is calculated by using the diagonal HH1 subband. The threshold is found by calculating between the coefficients of various levels of detail subbands using the equation. The detail sub-band coefficients are processed by using the thresholding function using equations. All the detail subbands such as horizontal, vertical and diagonal subbands are denoised by applying the thresholding function.

The denoised subband coefficients are reconstructed by using inverse wavelet transform. Then comparing the noisy image and reconstructed image. The PSNR value improved and MSE value is reduced.

3.1.6. ALGORITHM:

Step 1: Noisy image is decomposed into detail and approximation subbands by applying stationary wavelet transform.

Step 2: The noise variance for L level decomposition is calculated by using the diagonal HH1subband as shown in equation .

Step 3: The proposed threshold is found by calculating between the coefficients of various levels of detail subbands using the equation.

Step 4: The detail sub-band coefficients are processed by using the thresholding function using equation. All the detail subbands such as horizontal, vertical and diagonal subbands are denoised by applying the thresholding function.

Step 5: The denoised subband coefficients are reconstructed by using inverse wavelet transform.

4. RESULTS

The experiment are conducted for different noise variances and their performance measures are calculated in terms of Peak Signal to Noise Ratio PSNR), Mean Square Error (MSE).

The performance of the proposed filter is tested with the image of size 512*512 by adding the salt and pepper noise with the variance 0.01, 0.03, 0.05, 0.07 and 0.1. The PSNR value of the proposed method is found to be improved and MSE value gets decreased than the previous soft thresholding method. The graphical analysis of comparison of PSNR, MSE values of various proposed filters.

Original image is shown in figure(1). The Figure shows that the visual quality of the denoised images for different noise variance. The noisy images for different variances are shown in figures.

The denoised images of filters such as bayes shrink , thresholding with bayes threshold and thresholding with proposed threshold are shown in figures.

To overcome the shortcomings of previous thresholding techniques, a new thresholding function based on an operator [6] is used in paper. This exponential thresholding function preserves.

In thresholding, the coefficients below threshold are considered as noise and are removed. The standard thresholding functions used are hard and soft thresholding. The drawback of above methods is that the useful information gets removed along with the noisy components in an image. So there will be higher smoothening of an image and necessary details that are required for diagnosis will also be lost.

A new threshold is used in this paper by determining the between the various levels of the horizontal, vertical and diagonal subbands. In this correlation threshold, if the coefficients has the signal components then threshold will be higher. The threshold value will be lower when the coefficients are noisy. Hence the noisy coefficients are removed effectively and the details of an image are preserved comparing to the existing methods.

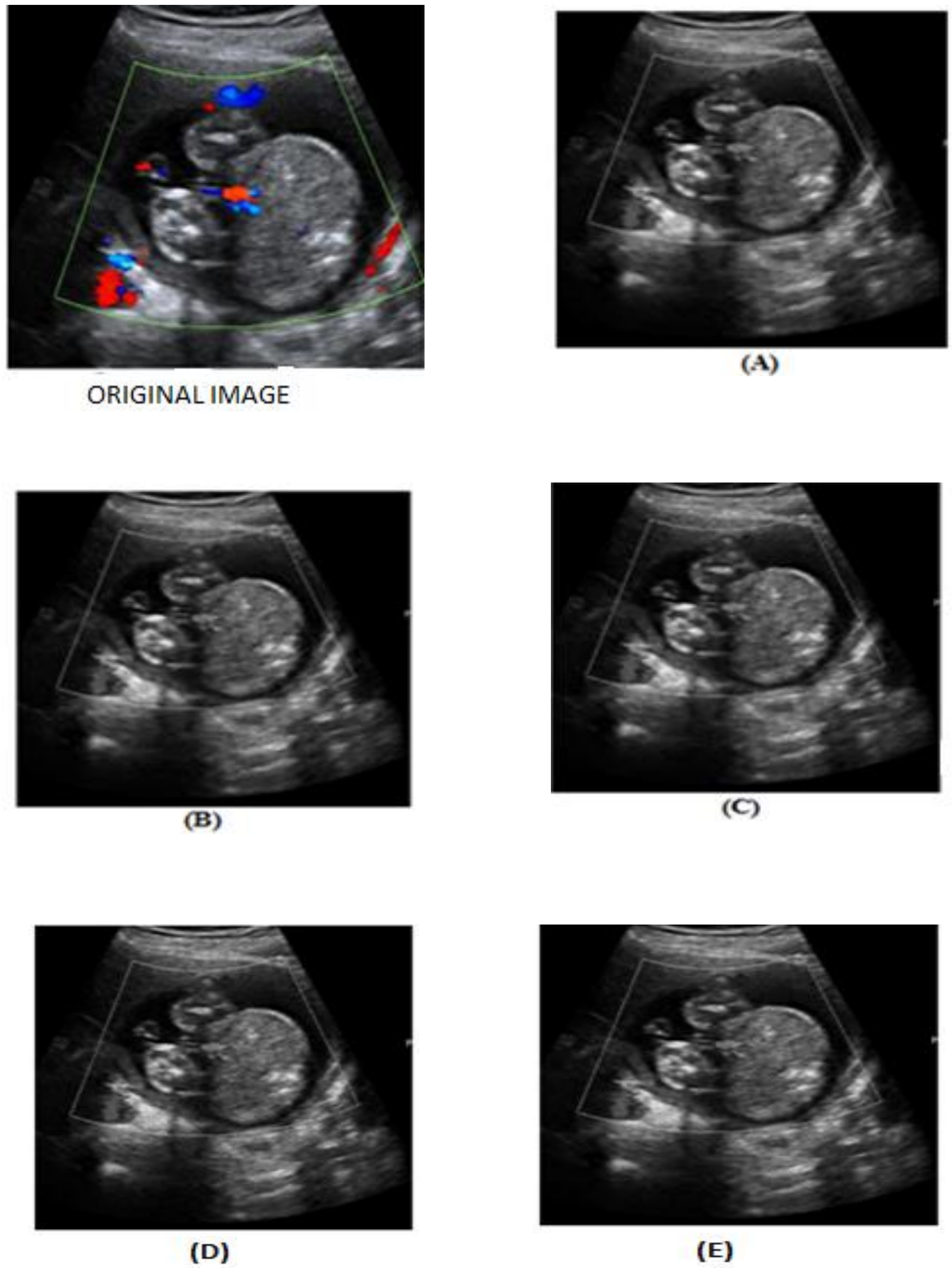
In wavelet based denoising, the threshold is used to separate the wavelet coefficients into signal components and noisy components. The coefficients below the threshold are highly dominated by noise. The thresholding functions [3] are used for denoising the coefficients by replacing noisy coefficients (small coefficients below a certain threshold value) by zero [5].

3.1.7 PERFORMANCE EQUVATION:

PSNR is increasing and MSE will decreasing based on noise variance value. Then the PSNR and MSE are inversely proportional in equ(8) and (9).

$$MSE = \frac{1}{M * N} \sum_{i=1}^{M} \sum_{j=1}^{N} [f(i,j) - D(i,j)] \quad (8)$$

$$PSNR = 10 log_{10} [\frac{255^2}{MSE}] \quad (9)$$



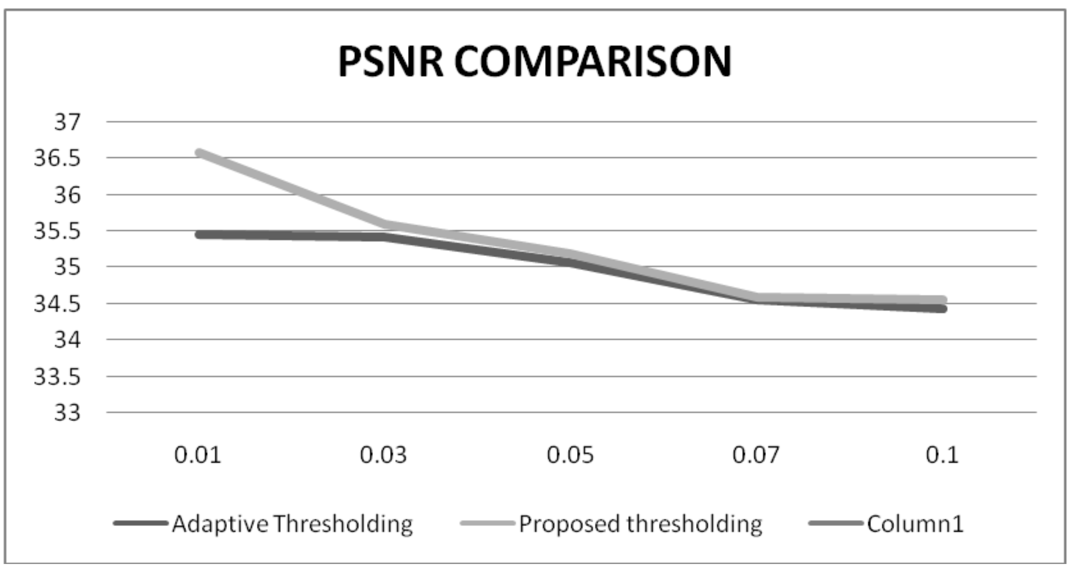
Figure(1) OUTPUT IMAGES OF VARIOUS NOISE VARIANCE IMAGES FIG(A) OF 0.01, FIG(B) OF 0.03, FIG(C) OF 0.05,FIG(D) OF 0.07 AND FIG(E) OF 0.1

Table 1 .Comparison of performance measures for various denoising filters

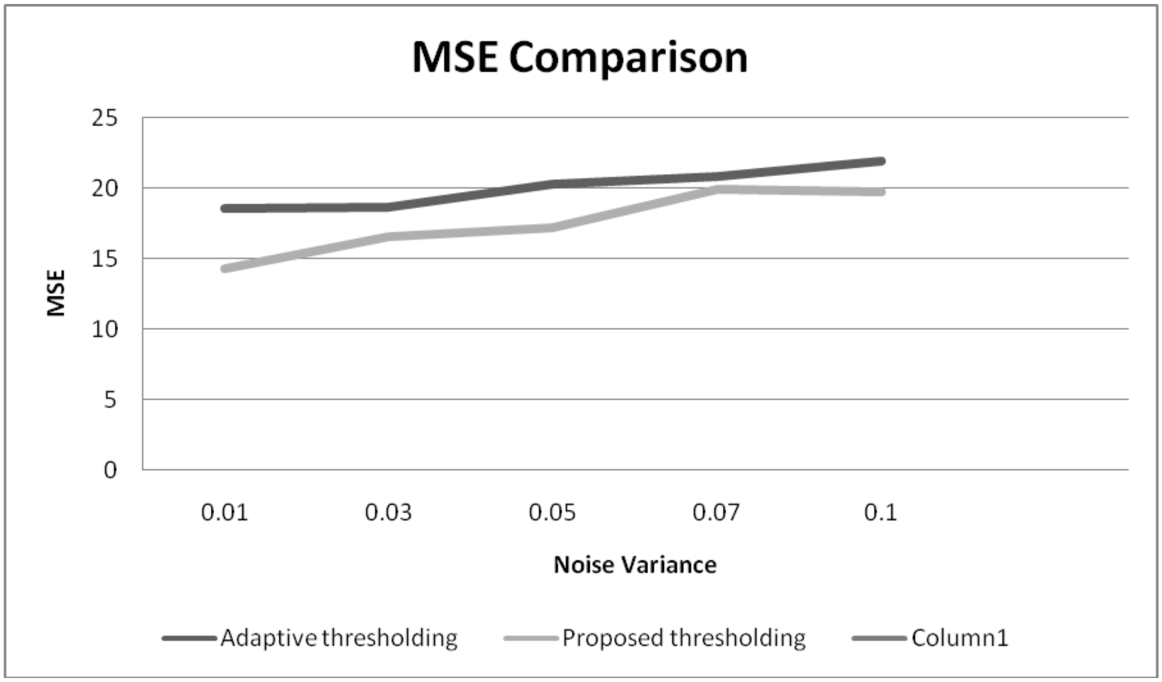
Noise variance	Performance measures	Adaptive Thresholding	Proposed Thresholding

0.01	PSNR	35.4520	**36.5744**
	MSE	18.5304	**14.3099**
0.03	PSNR	35.4244	**34.4000**
	MSE	18.6484	**23.6089**
0.05	PSNR	35.0617	**35.2966**
	MSE	20.2726	**19.2052**
0.07	PSNR	34.9444	**35.5891**
	MSE	20.8277	**17.9544**
0.1	PSNR	34.7256	**25.1619**
	MSE	21.9039	**19.8101**

Figure (2).Graphical analysis of comparison of PSNR values for various Denoising filters



Figure(3).Graphical analysis of comparison of MSE values for various Denoising filters



4. DISCUSSION

The multiresolution analysis of an image is done using stationary wavelet transform, to obtain the approximate and detail subbands. A new threshold is proposed by combining the first and second level subbands coefficients.

An adaptive thresholding function is used instead of hard and soft thresholding function. The operator is used sets the noisy coefficients gradually to zero by increasing the threshold zone in order to preserve important image details. The peak signal to noise ratio increases when both *u* and *v* parameters increase in thresholding

The performances are evaluated and are compared as shown in table1. The based threshold applied with the thresholding provides the further enhancement of the image.

Thus the details of the denoised image are preserved and the quality of an image is improved than the existing techniques.

5. CONCLUSION

In this paper, a new threshold function is proposed. By increasing the threshold zone, using thresholding function and making use of the relation between wavelet coefficients of a level the denoising performance is found to be improved.

The experimental results show that this method can not only remove the noise without blurring of image and important characteristics of images but also highlight the characteristics of mage compared with the existing methods The denoised images obtain higher PSNR and lower MSE; what is more, the denoising effect is better

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