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Image De-noising Signal Based on Discrete Wavelet Transforms

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***Abstract*— Removing noise from the original signals and images is still a difficult task for researchers, De-noising the image corrupted by noise is popular problem in image processing, and De-noising methods based on wavelet decomposition is one of the most significant applications of wavelets. This paper is the result of some noise reduction work, which means exploring noise reduction using some threshold methods. The wavelet threshold is a signal recognition technique that utilizes wavelet conversion capabilities to reduce noise and Image De-noising is achieved by Matlab.**

***Keywords*— Wavelet transform , Signal De-noising, Thresholding.**

I. INTRODUCTION

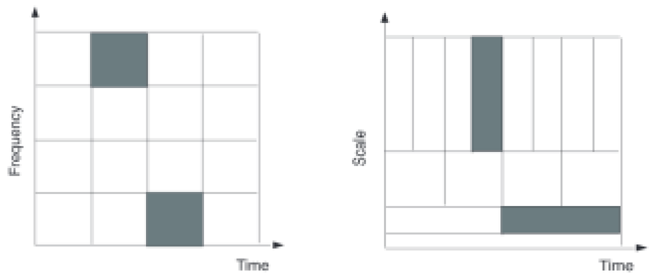
In the real world signals always exist with noise. This noise adds high frequency components to the signal and may cause significant corrupt to it. Therefore, this noise must be removed and the process of removing the noise from data is named signal De-noising. One of methods to reduce noise is wavelet transform which useful in image compression, signal processing and computer graphics [1]. Wavelet transforms are based on small wavelets with limited duration. There are two main types of wavelet transform - continuous wavelet transform and discrete wavelet transform ,computer programs use discrete wavelet transform because the computer is discreet in its nature[2] .

Wavelet transform is important to solve problem of image corrupted by Gaussian noise. Therefore, the wavelets provide a framework for signal decomposition in the form of a sequence of signals known as approximation signals with decreasing resolution supplemented by a sequence of additional touches called details [3][4].

II. WAVELET TRANSFORM

There are many transforms available: Hilbart Transform, Short Time Fourier Transform (STFT) as shown in Fig.1 (a), Wigner Distribution, Radon Transform, and Wavelet Transform as shown Fig.1(b). Every transformation has its own advantages disadvantages and application.

The wavelet transform is very useful tool of signal and image processing that used in signal processing, computer graphics, image compression, and pattern recognition, Wavelet Transform is suitable for the applications of non-stationary. The wavelet transform basis functions are finite in time, while the Fourier sine and cosine functions are not, so the wavelet transform can obtain time information about a signal in addition to frequency information [5].



(a) (b)

Fig. 1 Wavelet Transform

Wavelet transform can give more reliable and detailed time-scale representation for it more than the short time Fourier transform.

A wavelet is a wave-like oscillation with amplitude that starts from zero, increases, and then decreases return to zero. Signals which are not localized in frequency but also in space to deal with it needs to wavelet transform [6]. Wavelet domain is useful because Discreet Wavelet Transform make the signal energy concentrate in a small number of coefficients, noisy image Discreet Wavelet Transform consists of number of coefficients having high Signal to Noise Ratio and big number of coefficients having high Signal to Noise Ratio[7] . The image is reconstructed using inverse Discreet Wavelet Transform after removing the low Signal to Noise Ratio coefficients [8].

III. DISCRET WAVELET TRANSFORM

For one dimensional signal, the signal split into two parts, low frequencies and high frequencies edge components are

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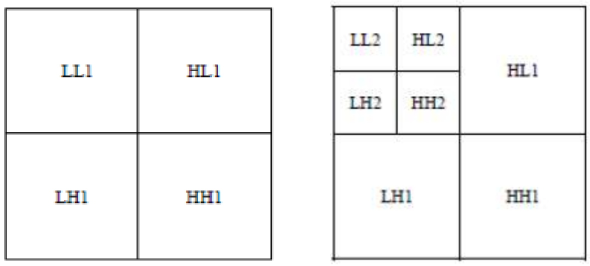
Vol.7 pp. 50-54

limited in high frequency. This process is continued until signal has been completely decomposed or the given application stops it [9].

By 1D transform can implement Two-dimensional discrete wavelet transform (DWT), where it is applied to rows and columns of 2D-signal separately and subsequently is same as hierarchical sub band system where the sub bands are logarithmically spaced in frequency and represent octave-band decomposition.

As a result of one-level 2D-DWT, we get the wavelet spectrum with four squared discrete sets called Sub bands: one with lower frequency components and three Sub bands with higher frequency components associated with horizontal, vertical and diagonals edge directions in discrete wavelet transform domain usually assumes thresholding (threshold zeroing) [9,10].

Wavelet coefficients and critically sampled by applying DWT as shown in Fig. 2(a). These sub bands are formed by separable applications of horizontal and vertical filters. Sub-bands with label LH1, HL1 and HH1 correspond to finest scale coefficient while sub-band LL1 represent coarse level coefficients .The LL1 sub band is further decomposed and critically sampled to find out the next coarse level of wavelet coefficients as shown in Fig. 2(b). It results in two levels wavelet decomposition [11].



(a) One level (b) Two level

Fig. 2 Scheme of decomposition up to the second level

By using simple filter convolution the Discrete Wavelet Transform (DWT) is performed and the original signal can be reconstructed; the reconstruction of original signal from DWT coefficients is known as Inverse DWT (IDWT) [8,12].

The filtering steps of DWT are multiply and accumulate operations. A filter in the algorithmic discrete sense is a number of coefficient values. The number of these values referred to as the width of the signals and also these coefficients are referred to as taps. In each of data-word of the input the filter spans across that data-word and its neighbouring data-words as a window. Within this window the values are multiplied by their corresponding coefficient of filter and all the results are added together to provide the filtered result for this data-word. The filtering operation can extracts certain frequency information from the data depending on the characteristics of the filter. This operation of the filtering can be done also with a systolic array. It is easy to construct the systolic array for each level of the DWT but the arrays are poorly used because the decreasing data-rates of the levels. It is possible through some complex timing to use a single array to carry out all levels of the DWT. Fig. 3 is presented the DWT filtering process[5,8].

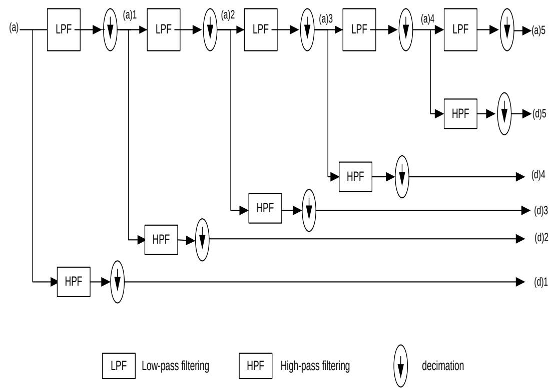


Fig. 3 filtering Process

The IDWT is the computational reverse as illustrated in Fig.4. The lowest low-pass and high-pass data-streams are up sampled (i.e. a zero is located between each data-word and then filtered by using filters related to the decomposition filters). The obtained two results of streams can be cleanly added together to form the low-pass result of the previous level of processing. This can be joint with the high-pass result in a similar fashion to create further levels the process continuing until the original data-stream is implemented [5 ,13].

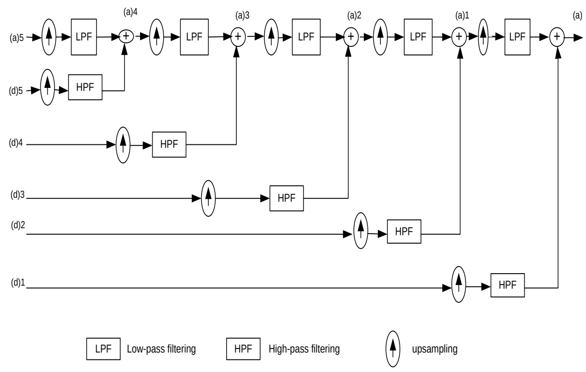


Fig. 4 The Inverse DWT filtering process

IV. WAVELET THRESHOLDING

There are two steps of Wavelet thresholding for image De-noising. These two steps are summarized in the following points:

A. *Step 1*

Calculating the wavelet coefficient carries more signal information than noise.

B. *Step 2*

Setting to zero the coefficients with relatively small or insignificant magnitude by eliminating small coefficients. It is

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Vol.7 pp. 50-54

dominated by noise one gets rid of wavelet-based functions that contain coefficients below a certain threshold. Choosing an appropriate threshold is critical in any process to reduce noise. There are two thresholds, called the hard and soft threshold, respectively [14].

By selecting a significantly large threshold, and multiplying it with the standard deviation of random noise, most noise can be removed by thresholding the wavelets transform coefficients this is known as hard threshold [5, 13, 14].

$$T_\tau^{\text{hard}} = \begin{cases} Y[m,n], |Y[m,n]| > 0 \\ 0 \qquad\quad , |Y[m,n]| \le 0 \end{cases} \tag{1}$$

Where τ, is the threshold value.
With a slight adjustment to the hard threshold approach, a method known as soft threshold can be created [7, 14].

$$T_\tau^{\text{soft}} = \begin{cases} sgn(Y[m,n])(|Y[m,n]| - \tau, |Y[m,n] > 0| \\ 0 \qquad\qquad\qquad\qquad\qquad , |Y[m,n] \le 0| \end{cases} \tag{2}$$

Given a threshold value T, the hard thresholding replaces a wavelet coefficient by zero if its absolute value is smaller than T; instead, the soft thresholding allows a wavelet coefficient to be shrunk by T if its absolute value is less than T [5, 8, 14].

V. MATLAB ANALAYSIS & RESULTS

Matlab as a programming language is used to implement and discuss the problem of retrieving signals from noisy data .The general De-noising procedure involves three steps they are:

- Decompose Threshold detail coefficients and Reconstruct,
- Two points must be addressed in particular,
- How to choose the threshold and how to perform the thresholding.

Hard thresholding can be described as the usual process of setting to zero the elements whose absolute values are lower than the threshold hard threshold signal is *x* if |*x*|>*thr* , and is *0* if |*x*|<=*thr* , Soft thresholding is an extension of hard thresholding, first setting to zero the elements whose absolute values are lower than the threshold ,and then shrinking the nonzero coefficients towards *0* The soft threshold signal is *sign(x)(*|*x*|*-thr)* if |*x*|>*thr* and is *0* if |*x*|<=*thr*.
Four threshold selection rules are implemented in the function *THSELECT*.

Rule-1: Selection using principle of *Stein's Unbiased Risk Estimate (SURE).*
Rule-2: Fixed form threshold equal to *sqrt(2*log(length(y)))*.
Rule-3: Selection using a mixture of the first two options.
Rule-4: Selection using minimax principle.

Min, *Max* and *SURE* threshold selection rules are more conservative and would be more convenient when small details of the signal lie near the noise range. The two other rules remove the noise more efficiently.
Fig.5 is shown the original, noisy and de-noised images

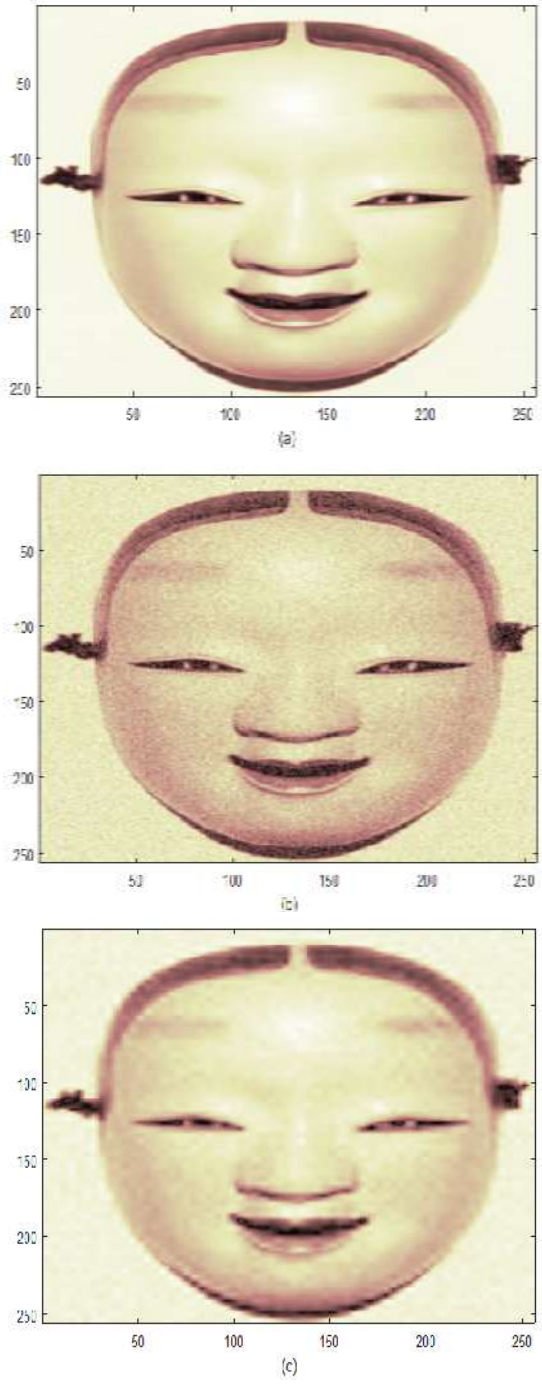

Fig.5 De-noising Image Using Wavelet

(a)Original image, (b) Noisy image and (c) De-noised image

In this case, the fixed form threshold is used with an estimate of the noise level, the threshold mode is soft and the rounding coefficients are retained.
Fig.6 Illustrates original signal, hard threshold and soft threshold using of 0.8 thresholds.

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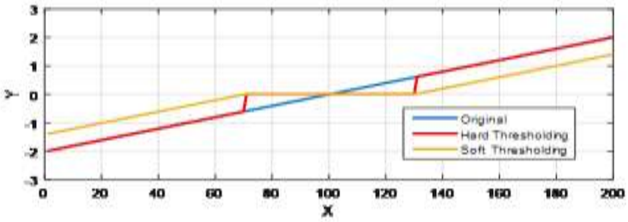

Fig. 6 Original, Hard and Soft Thresholds

Fig.7 used model assuming standard Gaussian white noise with Signal to Noise ratio = 20 db.

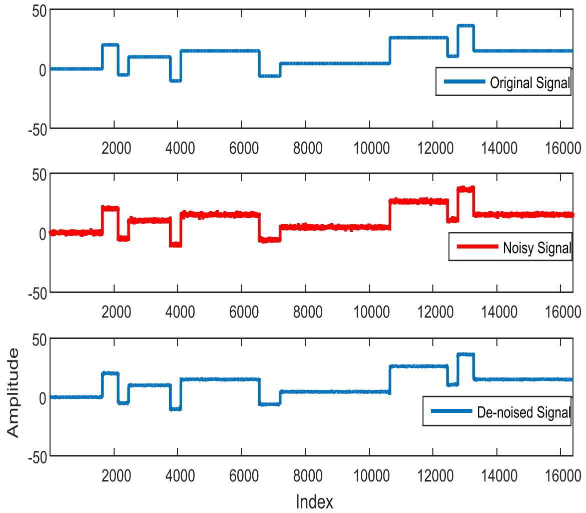

Fig. 7 Original, Noisy and De-noised Signals

Using a level-dependent estimation of the level noise is illustrated in Fig.8.

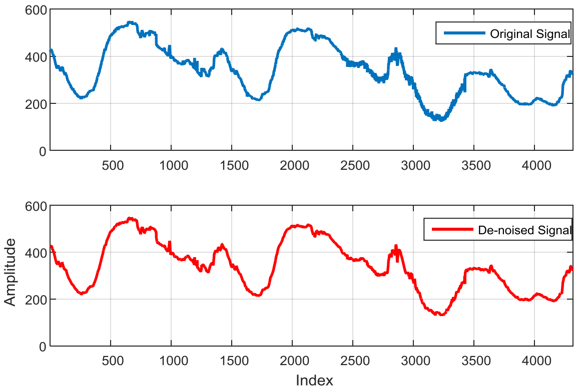

Fig. 8 Original Signal and De-noised Signals

VI. Conclusions

This paper presents signal and image De-noising using soft and hard-threshold for the signal used 0.8 threshold and standard Gaussian white noise with Signal to noise ratio = 20 db and soft-threshold to De-noise image. The threshold is set to higher values for high frequency sub-bands and lower values for low frequency sub-bands. Threshold selection and rebuilt threshold function is the main point to indicate the reduction of the results in the reduced the wavelet threshold De-noising.

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