IJCTA, 9(14) 2016, pp. 6883-6886

Corrupted Image Enhancement using Double Density Real Dual Tree Discrete Wavelet Transform

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ABSTRACT

Image denoising is the low level process of image processing and also it plays vital role for research. Denoising technique is used to enhance the image details. Wavelet transform is an important tool for image processing applications in recent years. A Double Density Real Dual Tree Discrete Wavelet Transform (DDRDTDWT) is used and investigated for image denoising. Noisy images are considered for the analysis and the performance is compared with discrete wavelet transform and the Double Density DWT (DDDWT) in this paper. Peak Signal to Noise Ratio values and Root Means Square error are calculated in all the three wavelet techniques for denoised images and the performance has evaluated. The DDRDTDWT gives better performance when comparing other two wavelet techniques.

Keywords: Real Dual Tree, Wavelet Transform, Discrete Wavelet Transform (DWT), Image processing, Image Denoising

I. INTRODUCTION

In image processing research field image denoising is an important issue. Due to the various reasons the images are corrupted. The reason may be outside interference, instruments noise and environment problems [1-2]. The researchers are using different methods for reduction of noise in images. Wavelet technique is one of the preferable techniques among them. Earlier method is Fourier transform which used only in time domain or frequency domain. The wavelet technique overcomes this limitation and its ability to represent a function concurrently in the time and frequency domains. The wavelet transform has an oscillating wavelike characteristic but also can allow simultaneous time and frequency analysis. This technique is suitable for transient and time-varying functions. In recent years the Wavelet transform has been studied broadly as a talented tool for denoising [3-4]. Since the presence of noise in images restricts one's ability to obtain the information it has to be removed. Discrete Wavelet Transform is a type of wavelet transform which has one scaling function and one wavelet function [5]. Selecting an appropriate wavelet function is important. Choosing an improper wavelet function will make the wavelet transform complex and difficult. There are many types of mother wavelet such as Harr, Daubechies, Coiflet and Symmlet wavelets. One of the most popular and widely used known ortho-normal wavelets is Daubechies wavelet. In this paper, Daubechies family wavelet is selected as mother wavelet. Daubechies wavelets are orthogonal, compactly supported, and no marginal overlaps will happen during the signal reconstruction [6]. Daubechies6 is chosen since it gives a more accurate solution and minimum reconstruction error [7-8].The main objective of the paper is to improve the image quality regarding Peak Signal to Noise Ratio (PSNR).The organization of the paper as follows; Section II introduces noise reduction using DWT and DDDWT. The proposed algorithm and experimental results reporting the performance are given in section III and IV respectively. Finally, conclusion is given in section V.

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II. NOISE REDUCTION USING DWT AND DDDWT

The discrete wavelet decomposition can be performed by passing the corrupted image through the series of filter bank stages. The Wavelet breaks the image into four different sub-sampled images denoted by combination of high pass and low pass filters. Then one sub band contains only low pass filter coefficients. The low pass filter coefficients proceed to the next level of computation. The way of chosen proper filter is used to retrieve the original image it can be reconstructed from the inverse transform without loss of any information. DWT have some of the limitations such as its Shift-sensitivity, poor directional selectivity. The above restrictions can be overcome by using some of DWT's extensions. The Double Density Discrete Wavelet Transform (DDDWT) is the extension of DWT and it will give good quality images because of more detailed sub-bands. The DDDWT has some additional properties when compared with DWT such as one scaling function and two distinct wavelets, which are designed to be offset from one another and also it is over complete by a factor of two. The DDDWT computation is done by using analysis filter bank. The analysis filter bank consists of three filters. After one level of decomposition, we obtain nine sub bands LL, LH, LH, HL,HH, HH, HL,HH, HH one low pass filter and eight high pass filters. This procedure can be repeated three times on the LL component. Then the only LL component value applied to the next level of decomposition after completing the second level has sixteen sub-bands that are one low pass filter and fifteen -high pass filters. The sub-bands are increased each level by N×8.Inverse Double Density Discrete Wavelet Transform (IDDDWT) is done by using synthesis filter bank. The reverse process of computation is used to get the denoised images. The same number of computation level to be maintained in IDDDWT process in this process used to obtain a denoised image.

III. NOISE REDUCTION USING DDDTDWT.

The proposed technique is a combination of DWT, Real dual tree and double density DWT. The filter bank structure is shown in figure 1. The algorithm shows the implementation of proposed techniques.

(i) Fix the number of stages to be applied.

(ii) Compute the forward DDRDTDWT for the noisy image

(iii)Using local thresholding fix the threshold value.

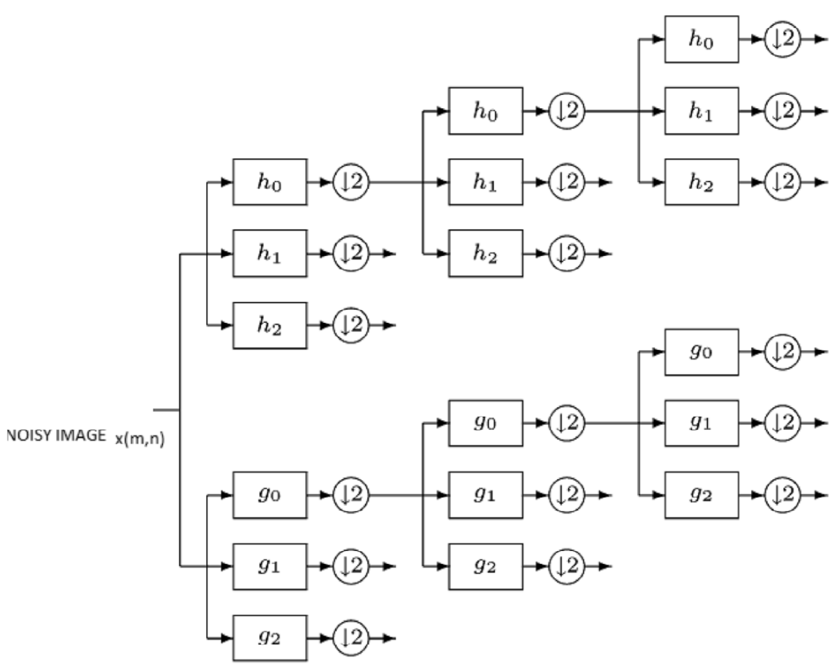

Figure 1: Filter bank structure

(iv) Apply soft thresholding on each sub-band.

(v) Perform the IDDRDTDWT to obtain the denoised image

(vi) Calculate the performance measure of RMSE and PSNR.

The noisy image x (m, n) is transfer through the filter bank. There are two similar set of wavelet filter bank in both upper and lower. The number of coefficients and sub bands are equal in two trees. After one level of decomposition the noisy images are representing by two low pass and twelve high pass coefficients. All the approximation values are stored in low pass filter and the detailed coefficient of the image in combination of the filters. The more detailed coefficients provide information about the image. Once the decomposition process is over then apply threshold value for each sub-band. Thresholding is a fashionable approach for denoising. Two standard thresholding functions are available namely hard thresholding, soft thresholding [9-10]. In hard-thresholding technique is also called keep or kill . For an estimated threshold value T, hard-threshold of a coefficient x can be represented as

$$T^{hrd}(x) = \begin{cases} 0, \ if \,|\ \ | \leq T \\ x, \ if \,|x| > T \end{cases} \tag{1}$$

Hard-thresholding produce unexpected values in the reconstructed image because of that reason in image processing applications soft-thresholding is usually preferred .In soft-thresholding the value are indicated by

$$T^{soft}(x) = \begin{cases} 0 & , if\,|x| \leq T \\ sign(x)(|x| - T), & if\,|x| > T \end{cases} \tag{2}$$

The sub bands are applied through soft thresholding. For fixing the threshold value mini-max rule is applied.] The expression of Root Mean Square Error (RMSE) is given by [11].

$$\sqrt{\frac{1}{N}\sum (x_i - y_i)^2} \tag{3}$$

Where

N =Number of a pixel in the image.

x_i =The noisy image value

y_i = Denoised image value

Table 1
Comparison of RMSE value

Noise Reduction Method	*Noisy RMSE*	*Denoised RMSE*
DDDTDWT	400.4	**63.53**
DDDWT	400.4	81.04
DWT	400.4	195

IV. RESULTS AND DISCUSSION

The noisy test images like peppers, mandrill and ovary are chosen as test images .The noisy images denoised by DWT, DDDWT and DDDTDWT method with variance 15dB. For the denoising process the same level of decomposition and noise variances are maintained the systems are same. The size of the images for all methods is 512×512. The PSNR has been computed for three different denoising methods and the values are tabulated in Table 2. The RMSE values are calculated using equation 3 and the values are tabulated in Table 1. The simulation test results show that with the more detailed coefficients the Double Density Discrete Wavelet Transform provides high Peak signal to noise ratio (PSNR).The PSNR values are high compared with the other two methods like DWT and DDDWT.

Table 2
Comparison of Denoised PSNR value

IMAGES	*NOISY*	*DWT*	*DDDWT*	*DDDTDWT*
LENA	23.32	26.12	28.23	**31.73**
PEPPERS	23.32	26.43	29.37	**31.35**
MANDRILL	23.32	25.71	27.64	**32.46**
OVARY	23.32	26.89	30.08	**35.30**

V. CONCLUSION

This paper deals with the performance of three different wavelet techniques for image denoising of corrupted images. The noisy test images are denoised using discrete wavelet transform, double density discrete wavelet transform and double density real dual tree discrete wavelet transform. The RMSE values and PSNR value are calculated .The improvement shows in terms of increasing the PSNR value and decreasing the mean square error value. The denoised PSNR value of DDRDTDWT increased by 36.24% which is higher than DWT and DDDWT. The performance measurement shows the DDRDTDWT gives the best result for image denoising and can also be applied for various applications such as medical image denoising and satellite image denoising.

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