

Degraded Image Enhancement through Double Density Dual Tree Discrete Wavelet Transform

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Abstract

Background/Objectives: Denoising is the first pre-processing step in image processing. Image denoising is the removal of noise from the corrupted image without deleting the useful information. **Methods/Statistical Analysis:** Wavelet transform is a main tool for image processing applications in modern existence. In this paper Double Density Dual Tree Discrete Wavelet Transform is used and investigated for image denoising. The proposed techniques give the better performance when comparing other two wavelet techniques. **Findings:** Images are considered for the analysis purpose and the performance is compared with other two wavelet transform discussed 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. **Applications/Improvements:** The reduced RMSE and increased PSNR value resultant shows the good visual perception of the image which is used to image analysis.

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

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 knack to represent a function at the same time as 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}. The core intention of this paper is to reduce the noise in the corrupted image. In this paper the section II describe the DWT and DDDWT for noise reduction, the section III

deals about the new algorithm and the section IV presents the experimental results and discussion. The suggestion and conclusion are discussed in the section V.

2. Noise Reduction using DWT and DDDWT

The corrupted images are passed through the series filter bank scheme for performing the discrete wavelet disintegration. The four sub sampled images are created by wavelet and represented by the combination of approximation and detailed coefficients. Then one sub band contains only approximation coefficients and these coefficients proceed to the next level of computation. The way of chosen proper filter is used to retrieve the inventive image. The DDDWT will give excellence images because of more detailed sub-bands^{5,7}. At the achievement of the next step consist 16 sub bands with one approximation and 15 detailed coefficients. Then inverse decomposition takes place to get the denoised image.

3. Noise Reduction using DDDTDWT

The proposed technique is a combination of DWT, dual tree and double density DWT. The iterated filter bank is shown in figure 1.

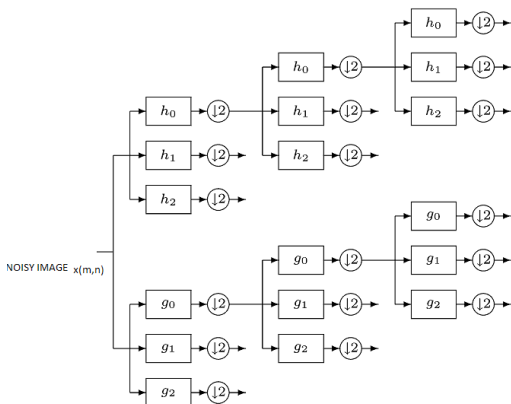


Figure 1. Iterated filter bank for DDDTDWT.

- Compute the forward DDDTDWT for the noisy image
- For each sub-band, determine the threshold value
- Apply soft thresholding on each sub-band
- Perform the IDDDTDWT to obtain the denoised image
- 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^{8,9}. The more detailed coefficients provide information about the image. Once the decomposition process is over, next necessary to apply threshold for each sub-band^{10,11}.

The hard threshold coefficient x is given as (1)

$$T^{hard}(x) = \begin{cases} 0, & \text{if } |x| \leq T \\ x, & \text{if } |x| > T \end{cases} \quad (1)$$

The coefficient x in soft threshold can be represent as (2)

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

The Root mean square error can be calculated as

$$\text{Root Mean Square Error} = \sqrt{\frac{1}{N} \sum (x_i - y_i)^2} \quad (3)$$

Where, N = number of elements in the image, x and y represents the Coefficient of corrupted and filtered images respectively

4. Results and Discussion

The noisy test images like peppers, mandrill and ovary are chosen as test images. The corrupted images are filtered through DWT, DDDWT and DDDTDWT techniques with variance 15dB. For the denoising process the same level of decomposition and noise variances are maintained the systems are same. The table 1 shows the calculated RMSE values using equation 3 and the figure 2 shows the rectified noisy images. The size of the images for all methods is 512×512. The PSNR has been computed for three different denoising methods and the results noted in Table 2. Figure 3 shows the PSNR magnitude graphical representation for different Denoising methods. The simulation output of Double Density Dual Tree Discrete Wavelet Transform with more detailed coefficients show that high Peak signal to noise ratio. The PSNR values are high compared with the other two methods like DWT and DDDWT.

Table 1. Comparison of RMSE value

Noise Reduction Method	Noisy RMSE	Denoised RMSE
DDDTDWT	401.3	64.53
DDDWT	401.3	82.04
DWT	401.3	198

Table 2. Comparison of Denoised PSNR value

IMAGES	NOISY	DWT	DDDWT	DDDTDWT
LENA	22.09	25.88	26.84	30.37
PEPPERS	22.09	25.56	27.05	30.03
MAN-DRILL	22.09	24.15	28.99	31.21
OVARY	22.09	25.92	28.60	34.40

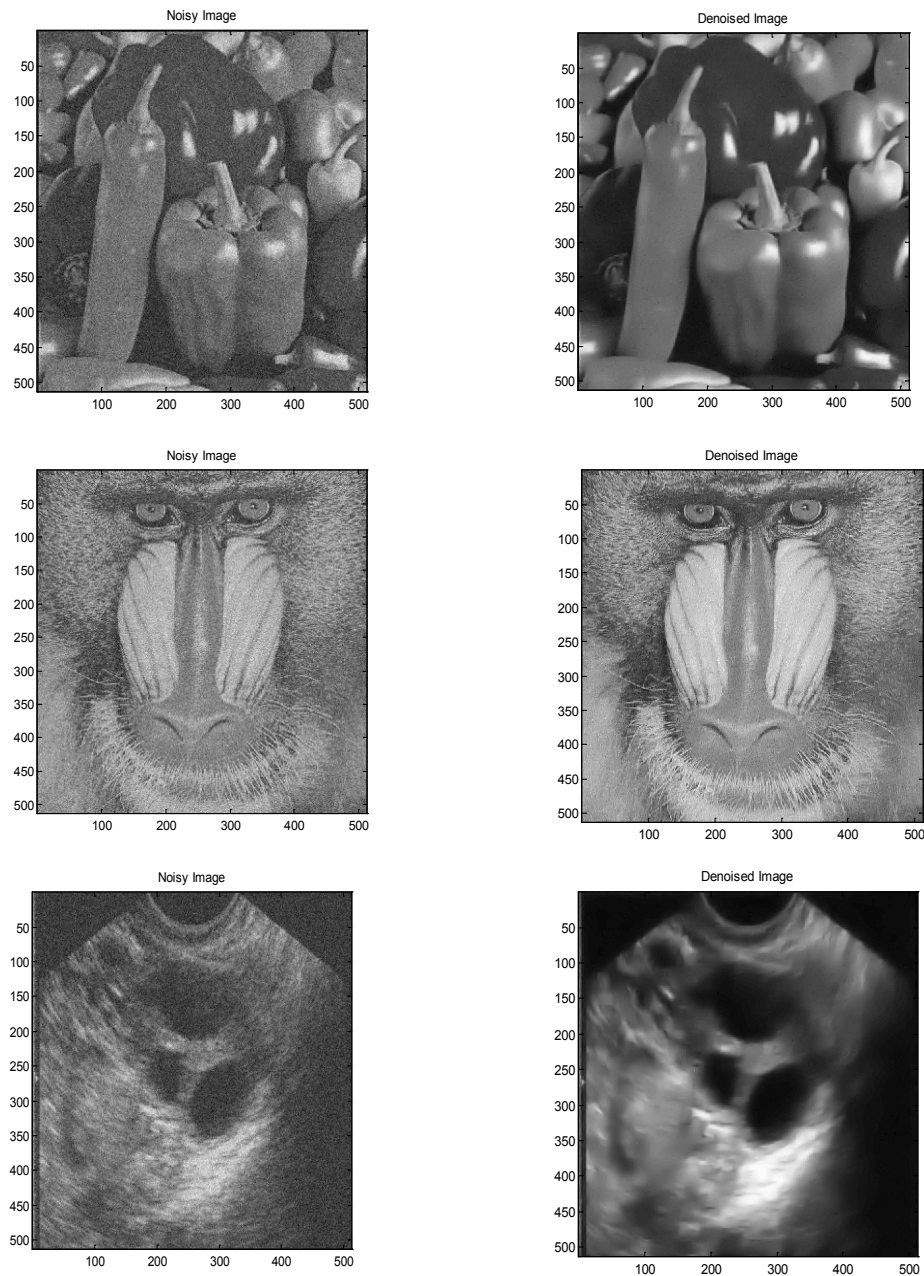


Figure 2. Noisy and denoised images by DDDTDWT method.

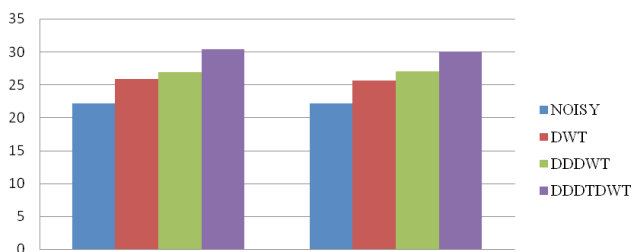


Figure 3. Graphical representation of PSNR value for different Denoising Methods.

5. Conclusion

This paper deals with the performance of three different wavelet techniques for image denoising of degraded images. The noisy test images are denoised using discrete wavelet transform, double density discrete WT and double density dual tree discrete WT. The RMSE values and PSNR value in percentage has been calculated for three different methods of wavelet transform and the results

are compared. The denoised PSNR value of DDDTDWT increased by 37.29% than DWT and DDDWT. The performance measurement shows the DDDTDWT gives the best result for image denoising and can also be applied for various applications such as medical image denoising and satellite image denoising.

6. References

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