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An Adaptive Method of Image De-noising based on Discrete Wavelet Transform

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Abstract — This paper presents the Wavelet based Image De-noising. The search for efficient image De-noising methods is still a valid challenge at the crossing of functional analysis and statistics using discrete wavelet transform. De-noising of stationary images corrupted by Gaussian noise using wavelet techniques is very effective because of its ability to capture the energy of a signal in few energy transform values. This paper is an investigation that has been made out on suitability of image de-noising based on in thresholding normal and adaptive technique. De-noising of image is shown in terms of PSNR. Some other way of result evaluation in terms of MSE and visual performance is also shown.

Index Terms — PSNR (Peak Signal to Noise Ratio), MSE (Mean Square Error), DWT (Discrete Wavelet Transform), Wavelet De-noising, Normal Thresholding, Adaptive Thresholding, Soft and Hard Thresholding

1 Introduction

Images are often corrupted with noise during processing of retrieval from storage media. Image also corrupted during transmission and reception. Because in digital communication image transmitted in form of bit in which error occupied. For purpose of photography when digital camera is used under poor lighting conditions, many black spot or dots can be observed in captured image. Image also degraded. Degradation comes from blurring as well as noise due to electronic and photo-metric sources.

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Reduction in Bandwidth of the image caused by the imperfect image formation process is Blurring. Just like as when there is a motion between the camera and the object. Another reason, when setting of focus is not well in optical system then also Blurring occurs in image. Atmospheric turbulence creates Blur. When aerial photographs are produced for remote sensing purposes creates blurring. Then work is to make image suitable for analysis. The visual information transmitted in form of image is naturally corrupted by Gaussian noise which is classical problem in image restoration and enhancement. This random noise ,when it is a Gaussian noise (additive in nature) can be removed using wavelet denoising technique due to the ability to capture the energy of a signal in few energy transform values [1]. Discrete Wavelet Transform offer adaptive spatial-frequency resolution (better spatial resolution at high frequencies and better frequency resolution at low frequencies). In this paper an image denoising method is proposed using Adaptive Discrete Wavelet Transform. First corrupted image is denoised by normal discrete wavelet transform then corrupted image is denoised by using adaptive technique.

This paper is organized as follows. Sections II introduce of discrete wavelet transform (DWT). Section III introduce of wavelet denoising. Section IV explains the methodology of image denoising. Section V explains the

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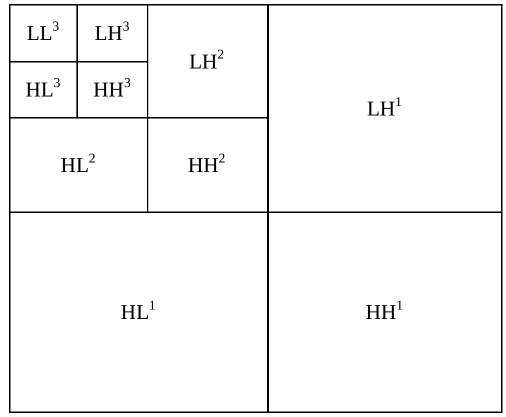
experimental result and discussion and Section VI explains the conclusion of the result.

2 Discrete Wavelet Transform

As compared to other multi scale representation discrete wavelet transform provides better spatial and spectral localization of image formation because it produces a non redundant image representation [1]. DWT allows clipping, thresholding, and shrinking (i.e. estimation step) of the amplitude of the coefficients to separate signals or remove noise. Actually the DWT work on assumption of distinguishes the amplitude of noisy coefficient from the original coefficient rather than the location of the spectra of the signal to be as different as possible from the amplitude of noise [4] [5]. The DWT decomposes signal into a set of independent, separately oriented frequency channel. Mathematically it involves two steps:

1. Decomposition and Analysis (Discrete wavelet transform)-The signal is passed through two convolution function and emerges as two signals, coarse (also called approximation) and details. Basically convolution functions are filters (complementary) .One is low pass filter and another is high pass filter.
2. Synthesis and Reconstruction (Inverse Discrete wavelet transform) - The component can be assembled back in to original signal without loss of information.

DWT decomposes a 2D image in to 3N+1 where N is the no of decomposition level (LL, LH, HL and HH) different frequency sub-bands. Which shown in figure 1 these are also known by other names, called first average image (a1), horizontal fluctuation (h1), vertical fluctuation (v1) and the first diagonal fluctuation (d1). The sub image a1 is formed by computing the trends along rows of the image followed by computing trends along its columns. Computing trends along rows followed by trends along the columns creates remaining band. Repeated operation is applied to the low frequency sub band image LL only. In LL all noise will be collected. Now wavelet coefficient available in high frequency band so only the wavelet coefficients in the high frequency levels need to be threshold.



Where,

1,2,3----------Decomposition Levels

H--------------High Frequency Band

L--------------Low Frequency Band

Figure 1: Two D DWT with 3 levels decomposition

3 WAVELET DE-NOISING

De-noising of natural images corrupted by Gaussian noise using wavelet techniques is very effective because of its ability to capture the energy of a signal in few energy transform values. The discrete wavelet transform based image de-noising has the following three steps:

1. Forward wavelet transform -Transform the noisy image in to orthogonal domain by discrete 2D wavelet transform.
2. Estimation- Clean coefficients are estimated from noisy one.
3. Inverse wavelet transform -Perform inverse Discrete wavelet transform to obtain the De-noised image.

There are many way of performing Estimation step, in this paper estimation is performed by wavelet thresholding technique. The term wavelet thresholding is explained as decomposition of the data or the image into wavelet coefficients which contains energy transform value, comparing the detail coefficients with a given threshold value, and shrinking these coefficients close to zero to take away the effect of noise in the data. Thresholding is a simple non-linear technique, in which one wavelet coefficient

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operated at a time then another coefficient. There are two type of thresholding is used hard thresholding and Soft thresholding. In the hard thresholding scheme the input is kept if it is greater than the threshold T; otherwise it is set to zero. The hard thresholding procedure removes the noise by thresholding only the wavelet coefficients of the detailed sub bands, while keeping the low-resolution coefficients unaltered. It is keep or kill rule. Soft thresholding shrinks the coefficients above the threshold in absolute value. It is a shrink or kill rule. In practice, it can be seen that the soft method is much better and yields more visually pleasant images. The hard method yields abrupt artifacts in the recovered images because it is discontinues. Also, mean squared error is very less as compared to hard form of thresholding. As compared to global thresholding adaptive thresholding give more PSNR, less MSE and better visual performance. In many lighting situations shadows or dimming of light cause thresholding problems as traditional thresholding considers the entire image brightness. Adaptive technique of Thresholding will perform binary thresholding (i.e. it creates a black and white image) by analyzing each pixel with respect to its local neighborhood. Due to localizations of each pixels to be considered in a more adaptive environment [6].

4 Methodology

The hard and soft thresholding method is used to Compose the noisy data into an orthogonal wavelet basis in order to suppress the wavelet coefficients to be smaller than the given amplitude and to transform the data back into the original domain [7][8]. One original image is applied with Gaussian noise with variance. The methods proposed for implementing image de-noising using wavelet transform take the following form in general. The image is transformed into the orthogonal domain by taking the wavelet transform. Estimate the Threshold using 'rigrsure' (adaptive threshold selection using principle of Stein's Unbiased Risk Estimate). This section describes the image de-noising algorithm, which achieves near optimal soft thresholding in the wavelet domain for recovering original signal from the noisy one. The algorithm is very simple to implement and computationally more efficient.

1. Resize Image to 256x256 pixels Size.
2. Add Gaussian Noise of given mean and variance to Image.
3. Estimate the Threshold using 'rigrsure' (adaptive threshold selection using principle of Stein's Unbiased Risk Estimate).
4. Perform N Level Discrete Wavelet Decomposition of Image using given Wavelet.
5. Apply Soft or Hard Thresholding on Decomposed Wavelet Coefficients.
6. Perform N Level Inverse Discrete Wavelet Transform using given Wavelet.
7. Calculate the PSNR and MSE.

The quality of compressed image depends on the number of decomposition; J the number of decomposition determines the resolution of the lowest level in wavelet domain [2]. For resolving important DWT coefficients from less important coefficients a larger number of decomposition is used. a larger number of decomposition can causes the loss of coding algorithm efficiency and blurring to the image [3]. Therefore, have to be a balance between computational complexity and image quality. PSNR tends to saturate for a larger number of decomposition. In this paper decomposition level is taken as 1. For taking the wavelet transform of the image, available MATLAB routines are taken [2]. In each sub-band by using threshold selection individual pixels of the image are shrinked. A de-noised wavelet transform is created by shrinking pixels. The inverse wavelet transform is the de-noised image.

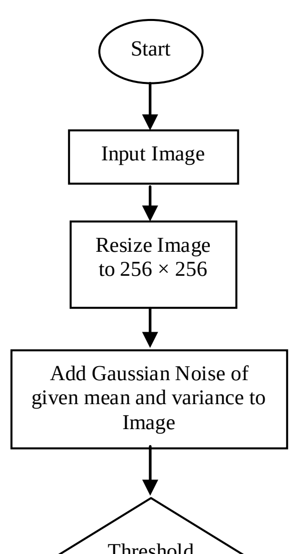

Figure 2: Flow diagram of methodology

5 Result and Discussion

For above mentioned methods, Symmlet wavelet gave better PSNR as shown in Table 1 and also with less MSE in cameraman image, as shown in Table 2. In Figure 2 and 3, Adaptive thresholding gave better PSNR with compare to Normal thresholding in both cases either hard or soft thresholding method. In case of Haar and Daubchies wavelet give approximate same value of PSNR. Coiflet is better than both wavelets in terms of PSNR values.

(a) Normal Thresholding (b) Adaptive Thresholding

Figure 3: Soft Thresholding

(a) Normal Thresholding (b) Adaptive Thresholding

Figure 4: Hard Thresholding

Table no.1

Performance of de-noised image with different analyzing wavelet in PSNR value

	Soft Thresholding		Hard Thresholding	
	Normal (dB)	Adaptive (dB)	Normal (dB)	Adaptive (dB)
Haar	23.0027	23.1515	23.32	23.5452
Daubechies	23.0027	23.1515	23.32	23.5452
Symmlet	23.5435	23.6293	23.727	23.8642
Cofilet	23.4875	23.5673	23.64	23.7591

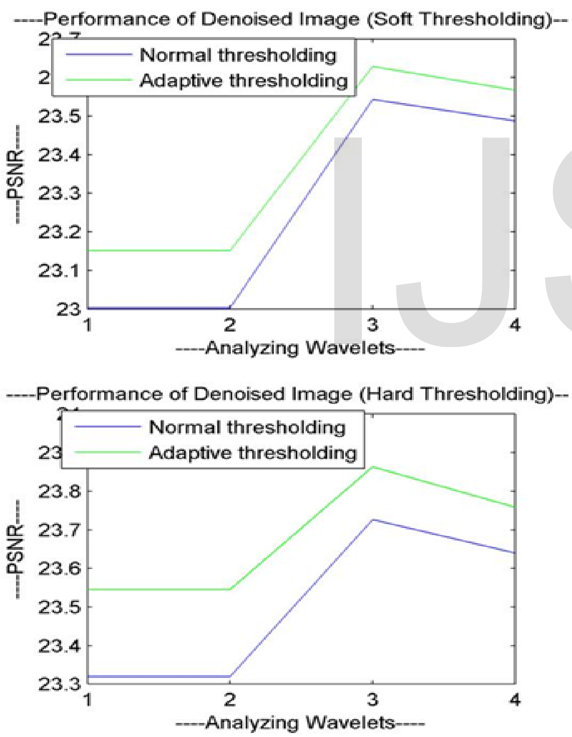

Figure 5: PSNR

Table no.2
Performance of de-noised image with different analyzing wavelet in MSE value

	Soft Thresholding		Hard Thresholding	
	Normal	Adaptive	Normal	Adaptive
Haar	325.6916	314.7277	302.4996	287.4494
Daubechies	325.6916	314.7277	302.4996	287.4494
Symmlet	287.562	281.9345	275.6642	267.0893
Coiflet	291.2929	285.9886	281.244	273.6349

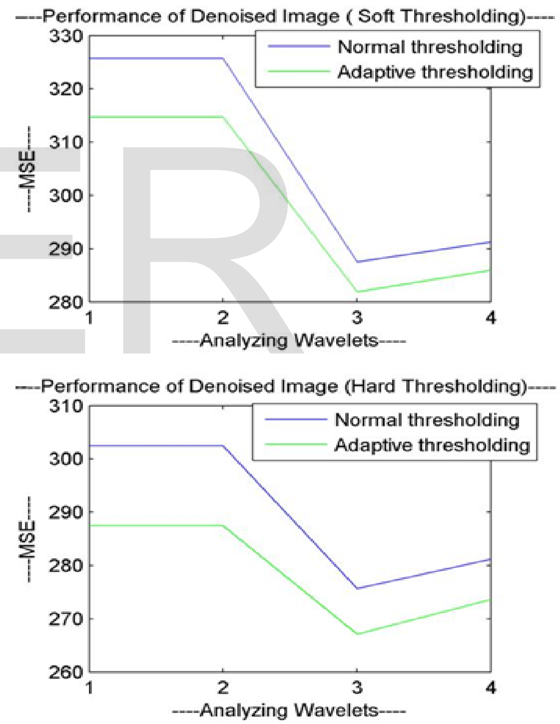

Figure 6: MSE

6 CONCLUSION

In image denoising, Adaptive Thresholding performed better performance in both PSNR and visual quality than wavelet denoising (hard thresholding or soft thresholding). The PSNR performance and visual quality can be enhanced by using

Translation invariant method. Translation invariant capability of attenuating Gibbs oscillation and adaptation to discontinuities gave an advantage to provide better result.

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