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Modified Gaussian Noise De-Noising using Discrete Wavelet Transform

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***Abstract* – Image De-noising of noisy image is play an important role in the field of image processing. Different Image De-noising methods are used for different noisy images. In this paper we have shown the different results of image De-noising of noisy image using Discrete Wavelet Transform (DWT). De-noising of natural images used in this paper corrupted by Gaussian noise using wavelet techniques are very effective because of its ability to capture the energy of a signal in few energy transform values.The performance of image de-noising of noisy image is shown in terms of PSNR, MSE and visual perception. The performance of calculated result shows improved Mean Square Error and Peak Signal to Noise Ratio.**

***Keywords* – De-noising, Discrete Wavelet Transform (DWT), Gaussian noise, Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR).**

I. Introduction

An image de-noising is achieved by linear processing such as spatial averaging filter, Gaussian smoothing filter, and Wiener filter. Spatial domain methods perform operation directly on image pixels itself. However, those conventional methods often fail in producing satisfactory results for a broad range of low contrast images contaminated by noise This additive random noise can be removed using wavelet de-noising technique due to the ability to capture the energy of a signal in few energy transform values [1]. The wavelet transform is a simple and elegant tool that can be used for many digital signal and image processing applications. Its ability to represent a function simultaneously in the frequency and time domains using a single Prototype function (or wavelet) and its scales and shifts which is lack of Fourier Transform, Discrete Wavelet Transform offer adaptive spatial-frequency resolution (better spatial resolution at high frequencies and better frequency resolution at low frequencies). However it has several limitations, for example shift invariance, poor directional selectivity and also some time Gibbs phenomena as occurred in Fourier transform.

In this paper an image denoising method is proposed using Adaptive Discrete Wavelet Transform. First Gaussian noise added to the image and then it is de-noised by normal discrete wavelet transform. Same procedure is performed using an Adaptive method of wavelet thresholding. At last both results are compared in terms of MSE and PSNR. Results are also shows time minimum required for whole processing for calculations.

II. Discrete Wavelet Transform of an Image

The Discrete Wavelet Transform (DWT), which is based on sub-band coding, is found to yield a fast computation of Wavelet Transform. It is easy to implement and reduces the computation time and resources required. The foundations of DWT go back to 1976 when techniques to decompose discrete time signals were devised [5]. Similar work was done in speech signal coding which was named as sub-band coding. In 1983, a technique similar to sub-band coding was developed which was named pyramidal coding. Later many improvements were made to these coding schemes which resulted in efficient multi-resolution analysis schemes.

In CWT, the signals are analyzed using a set of basis functions which relate to each other by simple scaling and translation. In the case of DWT, a time-scale representation of the digital signal is obtained using digital filtering techniques. The signal to be analyzed is passed through filters with different cutoff frequencies at different scales.

II. Wavelet THRESHOLDING

Wavelet Thresholding can considered as an application of nonlinear approximation theory in estimation. The term wavelet Thresholding is explained as decomposition of the data or the image into wavelet coefficients. Then 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. The image is reconstructed from the modified coefficients. This recombining process is also known as the inverse discrete wavelet transform. In thresholding, a wavelet coefficient is compared with a given threshold and is set to zero if its magnitude is less than the threshold; otherwise, it is kept left or modified depending on the threshold rule. Thresholding distinguishes between the coefficients due to noise and the ones consisting of important signal information. Thresholding is a simple non-linear technique. At a time it operates with only one wavelet coefficient then so on. 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, Generally Hard thresholding has disadvantages of abrupt artifacts in denoised image, more mean squared error and discontinuity so that the soft method is much better and yields more visually pleasant images. But in many stationary image it can be violate and hard technique is better than soft. as compared to global thresholding adaptive thresholding give more PSNR, less MSE and better visual performance In traditional thresholding it considered that brightness level is uniform in all region but it is not necessarily true for image in this situation normal thresolding cause problem. Adaptive Thresholding will perform binary thresholding (i.e. it creates a black and white image) by analyzing each pixel with respect to its local neighborhood. By considering different thresholding level for different region gives better denoising result [7].

III. 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.

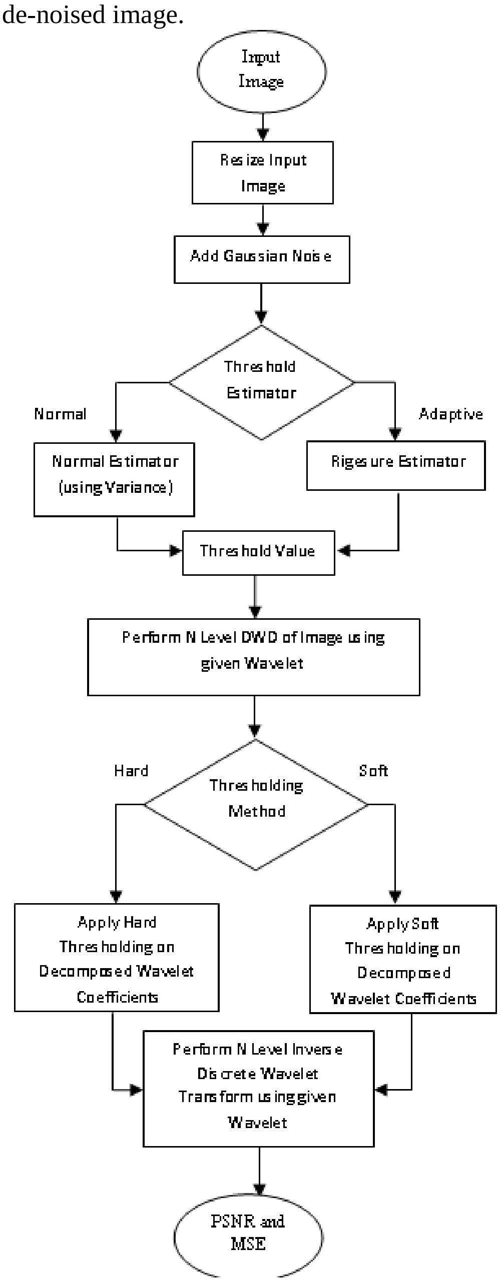

Fig. 1. Flow diagram of methodology

Figure 1 shows flow diagram of methodology used in this paper for improved PSNR and MSE of noisy images.

IV. Results and Discussion

The two parameters, PSNR (peak signal to noise ratio) and MSE (Mean Square Error) are calculated for all the standard images with their noisy and denoised counterparts, respectively. Hence, we get a good amount

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of comparison between the noisy and denoised images keeping the set standard image intact.

PSNR – PSNR stands for the peak signal to noise ratio. It is an engineering term used to calculate the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. It is expressed in dB because large range of signals can be very easily expressed in logarithmic scale. It is most commonly used as a measure of quality of reconstruction in image compression etc. It is calculated as the following:

$$PSNR=10 \log (255/MSE)^2$$

At one time, we calculate PSNR for original with noisy image and refer it as PSNR (O/N). After the image is denoised, it is calculated for original with denoised image and is then referred as PSNR (O/D). Hence, it shows the improvement in the noisy image after denoising, if any. An identical image to the original will yield an undefined PSNR as the MSE will become equal to zero due to no error. This shows that a higher PSNR value provides a higher image quality, In this case the PSNR value can be thought of as approaching infinity as the MSE approaches zero [8].

MSE - MSE indicates average error of the pixels throughout the image. In our work, a definition of a higher MSE does not indicate that the denoised image suffers more errors instead it refers to a greater difference between the original and denoised image. The formula for the MSE calculation is given in equation.

$$MSE = 1/N \sum_{j=0}^{N-1} (X_j - \overline{X}_j)^2$$

Where I and K are the original and noisy denoised image, respectively. I MAX is the maximum possible pixel value of the image. 8 bits per sample pixel is equivalent to 255, and in this work as well it is 255.

Figure 2 shows the GUI windows of MATLAB. It shows Original Taj Mahal image with mean and variances. Another image is also shows with after added Gaussian noise with MSE and PSNR.

Figure 3 shows the denoised image of Taj Mahal with improved MSE and PSNR. It is also shows time in second for the processing of this process. This figure shows normal method, Haar Wavelet,and Soft thresholding used for De-noising.

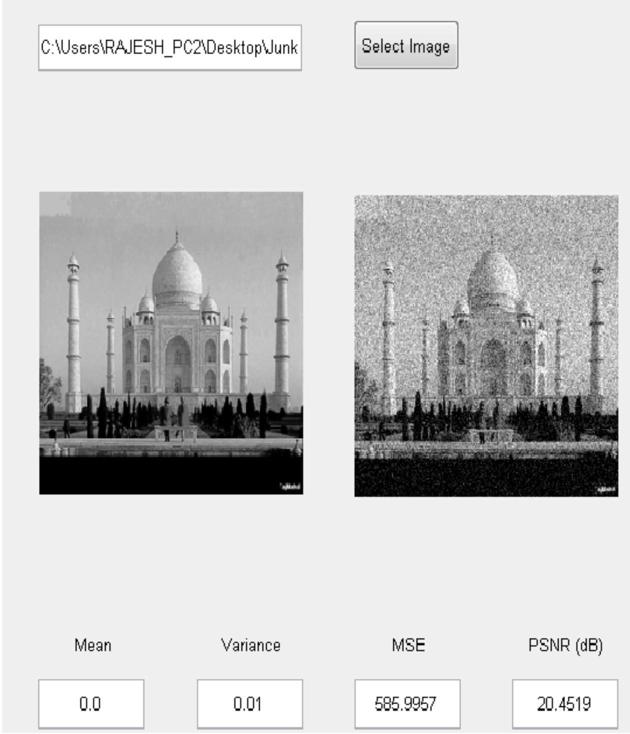

Fig.2. Original and noisy Taj Mahal Image with MSE and PSNR.

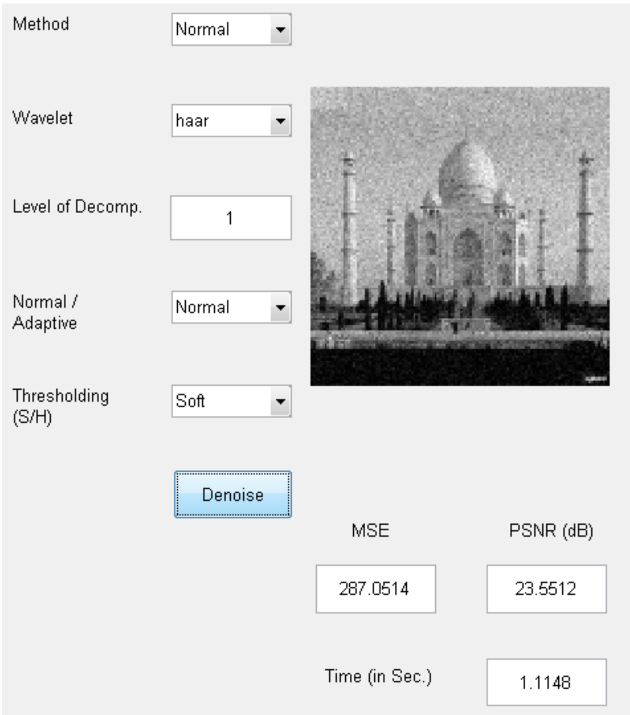

Fig.3. De-noised image with soft thresholding using normal method.

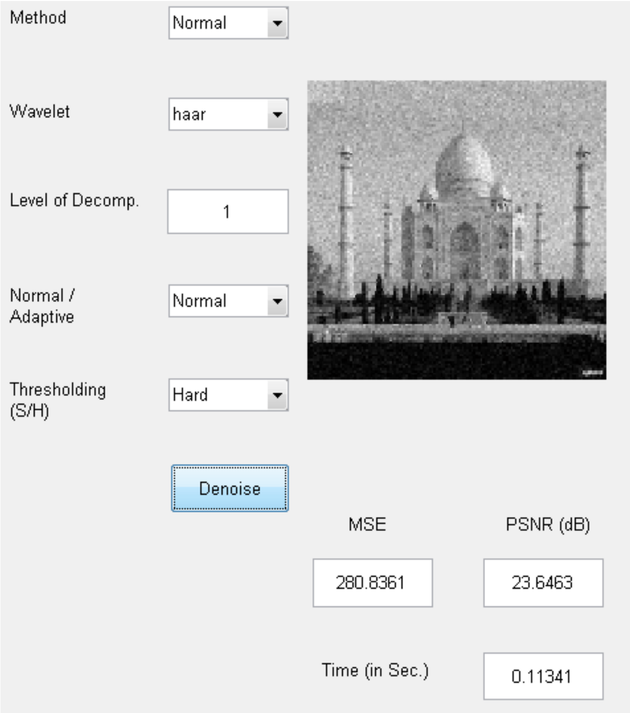

Fig.4. De-noised image with hard thresholding using normal method.

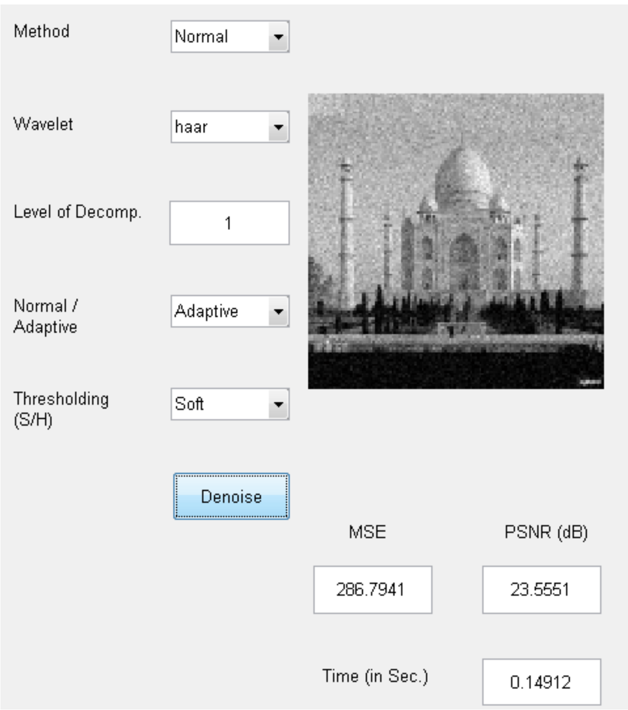

Fig.5. De-noised image with soft thresholding using Adaptive method.

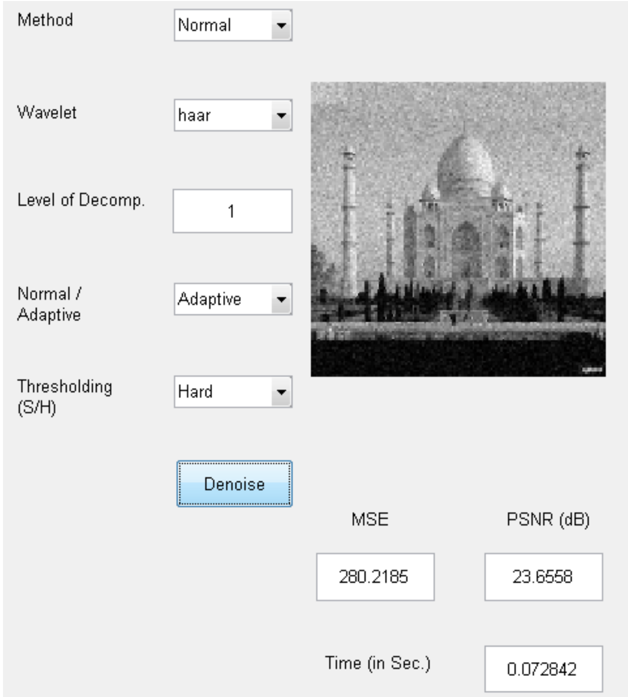

Fig.6. De-noised image with hard thresholding using adaptive method.

Figure 4 shows De-noised image with hard thresholding using normal method with MSE and PSNR. Figure 5 and 6 are shows De-noised image with soft and Hard thresholding using Adaptive method with different MSE and PSNR and Time required for processing.

V. Conclusion and Future Scope

All results shows better performance in both PSNR (Peak Signal to Noise Ratio), MSE (Mean Square Error) and visual quality than wavelet denoising (hard thresholding or soft thresholding). All results also shows better performance for adaptive method rather than normal method. It is also shows improved time required in second for processing of whole process. In the future many others wavelets are used for better performance of De-noising method. 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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