International Institution for Technological Research and Development
Volume 1, Issue 3, 2016

Analysis of the denoising technique of Wavelet Transform using Thresholding Approach

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Abstract
The images obtained from the different sensors or satellites are often corrupted by noise and not suitable for human perception or any further processes. In order to improve the quality of the images, the image restoration technique is used in the image processing. It improves the objectivity of the image and removes the noisy content from the image. This paper represents the best known image denoising technique-Wavelet Transform.
Keywords: *Denoising, Image Restoration, Gaussian noise, Hard Thresholding, Soft Thresholding, Wavelet Transform.*

1. Introduction

Image Processing is a method to enhance the raw images received from the sensors placed on satellites, space probes and aircrafts or pictures taken in normal day-to-day life for various applications for which they were first developed. The result obtained by processing has a greater quality with clear visibility of the objects present in the sensed image. Image processing can be used in remote sensing, medical imaging, forensic studies, textiles, material science, military, graphic arts, printing industry, etc. Some of the fundamental steps involved in image processing are image representation, image preprocessing, image enhancement, image restoration, image reconstruction and image data compression. In this paper, a novel approach for image restoration has been explained.

Images are produced to record or display useful information. But due to imperfections in the imaging and capturing process, however, the recorded image invariably represents a degraded version of the original scene. The degradations may have many causes, but the two types of degradations that are often dominant are noise and blur, each of which introduces peculiar problems in image restoration.

Noise can be defined as any undesired information that contaminates an image. The principal sources of noise in digital images arise during image acquisition and/or transmission.

In this paper, the best known method for image denoising has been studied. The paper aims to present a better restored image with minimum amount of noise present in it.

Blind image restoration is the process of estimating both the true image and the blur from the degraded image characteristics, using partial information about the imaging system [1].

Noise reduction plays a fundamental role in image processing, and wavelet analysis has been demonstrated to be a powerful method for performing image noise reduction [2].

The procedure for noise reduction is applied on the wavelet coefficients achieved using the wavelet decomposition and representing the image at different scales. After noise reduction, the image is reconstructed using the inverse wavelet transform. Section 2 summarizes the review of wavelet transform. Section 3 deals with the types of the threshold functions used. Section 4 explains Wavelet Transform method. Section 5 consists the performance evaluation and simulated results. Section 6 describes the conclusions.

2. Literature Review

Various research and review papers have been published over the past many years in the field of Image Denoising. Various parameters have been used to compare the results of different approaches and conclude the best one out of all the denoising techniques.

Gupta et al. 2013 [3] "Image Denoising using Wavelet Transform Method" described the performance of 3 approaches of wavelet based image denoising methods. Various kinds of noises affecting the images were considered in this paper viz., Gaussian, Poisson's, Salt and Pepper, and Speckle.

Hassan et al. 2011 [4] "Still Image Denoising Based on Discrete Wavelet Transform" performed image denoising on the noisy images using different approaches. Image corrupted by Gaussian noise is attempted to be denoised by Discrete Wavelet Transform (DWT) denoising technique.

Balster et al. 2005 [5] "Feature-Based Wavelet Shrinkage Algorithm for Image Denoising". Here the

coefficients are selected due to their magnitude, and only a subset of those selected coefficients which exhibit a spatially regular behavior remain for image reconstruction. Therefore, two thresholds are used in the coefficient selection process. The first threshold is used to distinguish coefficients of large magnitude and the second is used to distinguish coefficients of spatial regularity.

Hongqiao et al. 2009 [6] "A New Image Denoising Method Using Wavelet Transform". In this paper, the method of wavelet image denoising based on soft-threshold image denoising and correlation of wavelet coefficients are proposed. This method is also used to deal with noise images which join a Gaussian white noise.

3. PROPOSED WORK

In this paper we lay focus on the denoising technique, Discrete Wavelet Transform and its thresholding styles and their purpose.

Noise is unavoidable and it makes the image defective for further use. The image denoising technique is applied to the raw images and we get a denoised image.

The DWT (Discrete Wavelet Transform) can be used to analyze, or decompose signals and images. The image is first decomposed into several parts so that it becomes easy to analyze the image. This process is therefore known as decomposition or analysis. Then the analyzing filters like soft and hard threshold are chosen carefully in order to remove the noise content from the image effectively. The other half of the process involves how those components are assembled back into the original signal without loss of information. This process is called reconstruction, or synthesis. This reconstruction is done using the inverse discrete wavelet transform (IDWT) method.

Two types of filters can be used for DWT- hard threshold and soft threshold. Hard threshold keeps the wavelet coefficients with values greater than the threshold value unchanged and eliminates the others. The soft threshold filter shrinks the wavelet coefficients greater than the threshold values and eliminates the others. The selection of the type of the filter depends on the type of the application. Each has its own merits and demerits.

4. DENOISING TECHNIQUE

4.1 Wavelet Transform

Wavelet transform (WT) has been a powerful and wildly used tool in image denoising because of its energy compaction and multi-resolution properties. It overcomes some limitations of Fourier transform with its ability to represent a function simultaneously in frequency and time domain. It is a widely used denoising method that successfully eliminates all types of noises from the image.

The image is decomposed into low-level and high-level frequency components through the LPF & HPF filters. This is termed as the 1st level decomposition of the image. Thus the image is divided into sub-bands-LL, LH, HL and HH. The low frequency component contains the maximum information as compared to the high frequency components.

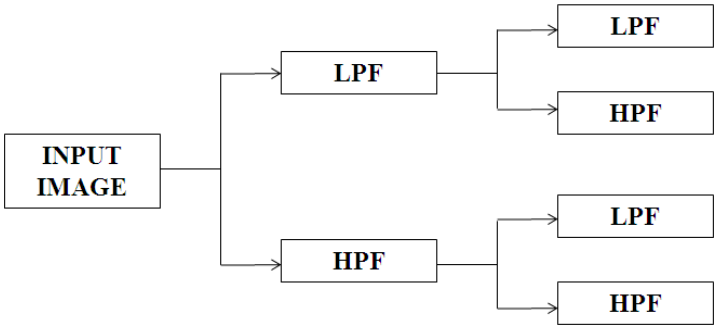

Figure 1: Image Decomposition in DWT

The HH sub band gives the diagonal details of the image; the HL sub band gives the horizontal features while the LH sub-band represents the vertical structures. The LL sub-band is the low resolution residual consisting of low frequency components and it is this sub-band which is further split at higher levels of decomposition.

The low frequency component LL is now further decomposed into low-level and high-level frequency components, which is termed as 2nd level decomposition of the image. Thus, image is now divided into sub-bands LLL, LLH, LHL and LHH. The LLL band contains the maximum information out of all the sub-bands.

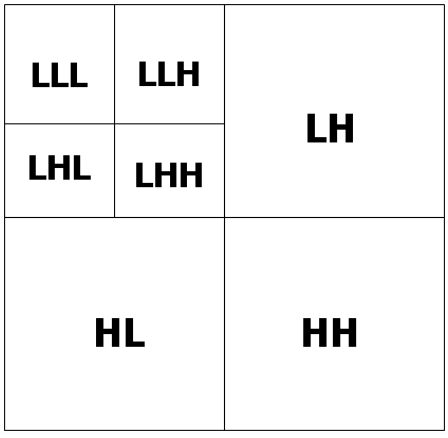

Figure 2: Second level Image Decomposition in DWT

This process goes on till 4th level decomposition is obtained. The more the number of decompositions, the more accurate the method is in the removal of noise.

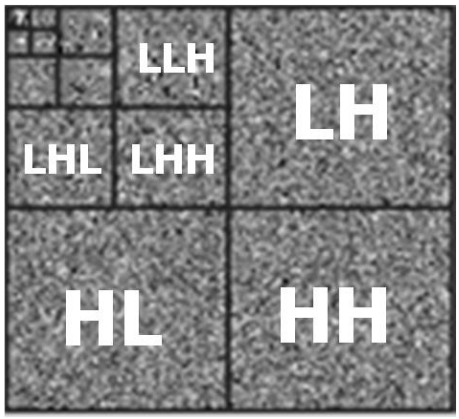

Figure 3: Four level Image Decomposition in DWT

5. RESULTS

The noisy image is worked upon for 4 types of noises- Gaussian, Salt & Pepper, Speckle and Poisson noise, using the Wavelet Transform method of denoising which results in a noise-free image but the blurs in the image remain unaffected.

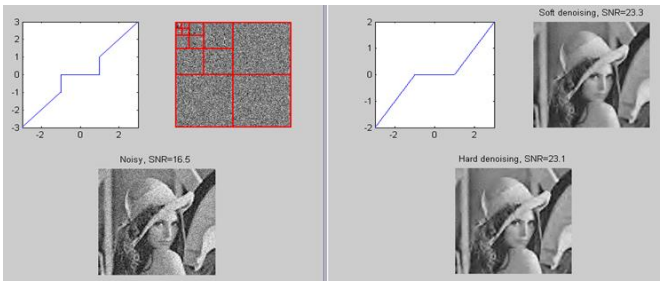

Figure 4: Denoising using Wavelet Transform

The system generates any kind of random noise on its own and is unknown to the user. Then the DWT works on the image as described in the above section and results in a noise-free image at the output with a much better SNR value.

6. CONCLUSION

From the simulated results, the working of the DWT along with the hard and the soft thresholding can be observed. With the observation of the SNR values for the noisy image and the end result denoised image, it can be concluded that the DWT method is very effective and results in a much better output sans the noise. Thus it removes noise from the image completely. Also, this method works just the same for every kind of noise with equal impact which is a major advantage of this method.

7. FUTURE WORK

The remaining several kinds of noises can be worked upon and which denoising method suits them the best can be determined and the same can be used for even better results. Although it is observed that in the presence of any kind of blurry content in the image, this method fails to give a satisfactory result. Thus, a method that serves the purpose of both-denoising and deblurring of the image can be worked upon.

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