ISSN:0975-9646

Taranjot Kaur / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 5 (5) , 2014, 6135-6137

Image Denoising Algorithms and DWT: A Review

Taranjot Kaur

Department of Computer Science,
Asra College of Engineering and Technology,
Bhawanigarh, India

Abstract— **A great challenge in the field of image processing nowadays, is image denoising. Although, there have been proposed various methods and algorithms for the same, but, most of them have not attained the desirable results. The performance does not match with the assumed one. The wavelet theory is relatively the newest concept in this field. The main aim of this study (paper) is to examine various algorithms and discrete wavelet transform, and understanding the concept of denoising thoroughly.**

Keywords— **Image, Denoising, Discrete Wavelet Transform.**

I. INTRODUCTION

Denoising is a process of removing noise from a signal. All recording devices, both analog and digital have traits which make them susceptible to noise. Noise can get introduced into the image while capturing or transmission of the image. For this, there have been introduced various linear (such as Weiner filtering) and non linear techniques (such as Thresholding) [4]. Thus, the traditional way of image denoising is filtering. But the wavelet transforms have also emerged during the last decade[12]. There are two main types of wavelet transform that is continuous and discrete. Where, the Discrete Wavelet Transformation is now considered more suitable over methods like Fourier and Cosine transforms. Wavelets provide a framework for signal decomposition in the form of a sequence of signals known as approximation signals with decreasing resolution supplemented by a sequence of additional touches called details[1][10]. Many other methods developed are anisotropic filtering, bilateral filtering, total variation method and non local methods [8].

II. IMAGE DENOISING ALGORITHMS

Various techniques for denoising the images based on wavelet transform have been described below.

A. Universal Thresholding

$$Tc= \sigma \sqrt{(2 \log M)} \quad (1)$$

Where Tc is threshold value, M is the data length, σ is the noise variance of data estimated according to equation. Universal thresholding is non-data dependent because it is not inspecting each data statistically. However it is certainly an adaptive threshold method due to parameters such as M and σ in its expression [9].

B. VisuShrink

$$T= \sigma\sqrt{2\log n^2} \quad (2)$$

Where T is the threshold to be calculated. This method performs well under a number of applications because wavelet transform has the compaction property of having only a small number of large coefficients[6].

C. BayesShrink

Bayes shrink was proposed by Chang, Yu and Vetterli[1][4]. It was proposed to minimize the Bayesian risk. It is different from other thresholding techniques as the results come from the Bayesian approach but not from soft or hard thresholding.

$$\sigma_s=\sqrt{\max(\sigma_w^2 - \sigma_s, 0)} \quad (3)$$

where σ_s^2 is the variance of the signal.

D. Neigh Shrink

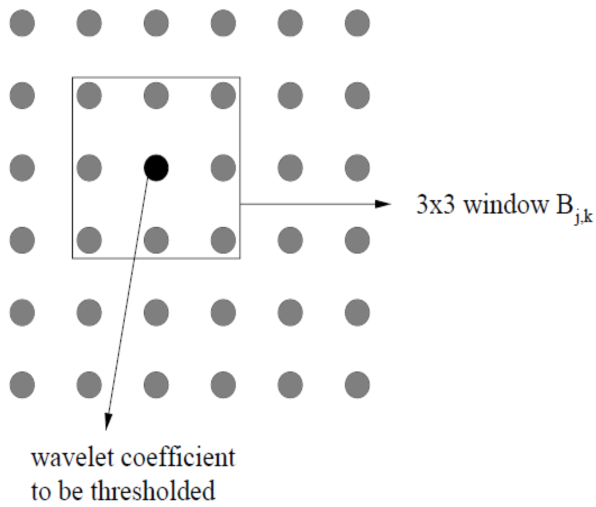

Fig. 1 Example of neigh shrink neighbouring window, size 3x3

Let g= {g_{ij}} will denote the matrix representation of the noisy signal. Then, w (Wg) denotes the matrix of wavelet coefficients of the signal under consideration. For every value of w_{ij}, let B_{ij} is a neighboring window around w_{ij}, and w_{ij} denotes the wavelet coefficient to be shrinked. The neighboring window size can be represented as L x L, where L is a positive odd number. A 3x3 neighboring window centered at the wavelet coefficient to be shrinked is shown in fig. 1.

E. Sure Shrink

A threshold chooser based on Stein's Unbiased Risk Estimator (SURE) was proposed by Donoho and Johnstone and is called as Sure Shrink. It is a combination of the universal threshold and the SURE threshold [11]. This method specifies a threshold value t_j for each resolution level j in the wavelet transform which is referred to as level dependent threshold. The goal of Sure Shrink is to minimize the mean squared error [10], defined as,

$$\text{MSE} = \frac{1}{n^2}\sum_{x,y-1}^{n} (z(x,y) - s(x,y))^2 \quad (4)$$

F. Normal Shrink

The optimum threshold value for normal shrink which is adaptive to different sub band characterstics is given by

$$\mathrm{TN} = \frac{\gamma\,\sigma^2}{\sigma_y} \qquad (5)$$

where γ is calculated as

$$\gamma = \sqrt{\log\frac{L_k}{j}} \qquad (6)$$

where σ^2 is the estimated noise variance, and σ_y is the standard deviation of the sub-band of noisy image, L_k is the length of the sub-band at kth scale. And, j is the total number of decomposition. Normal Shrink also performs soft thresholding with the data driven sub-band dependent threshold TN, which is calculated by the equation (5)[10][2][1].

III. DISCRETE WAVELET TRANSFORM

The non linear methods for denoising have gained the attention of the researchers these days. These methods are mainly based on thresholding the Discrete Wavelet Transform (DWT) coefficients, which have been affected by additive white Gaussian noise[12]. The DWT is basically the decomposition of the signal that provide better spatial and spectral localization. When a signal is decomposed, it is known as analysis, that in mathematical manipulation means discrete wavelet transform. When this decomposed signal is reconstructed, it is known as synthesis that mathematically means inverse discrete wavelet transform. Basically the denoising algorithms that use wavelet transform: calculating the wavelet transform of the noisy signal, modifying the noisy wavelet coefficients and computing the inverse transform using the modified coefficients.

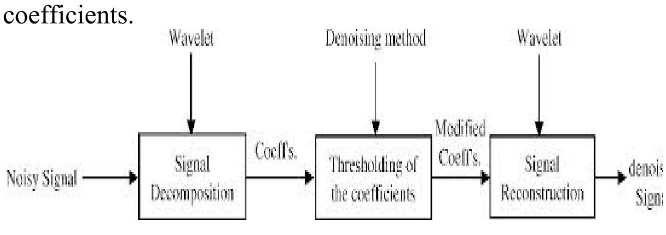

Fig. 1 Diagram of wavelet based denoising

In the process of decomposition of an image by DWT, the transform coefficients are modeled as independent identically distributed random variables with generalized gaussian distribution (GGD). The coefficients are then analysed on the basis of thresholding that can be either soft or hard thresholding:

1) *Hard Thresholding*: Hard thresholding is a keep or kill procedure. This method produces artifacts in the images as a result of removing large coefficients. Hard thresholding does not even work with some algorithms like sure shrink. to overcome the demerits of hard thresholding, the wavelet transform with soft thresholding was introduced.

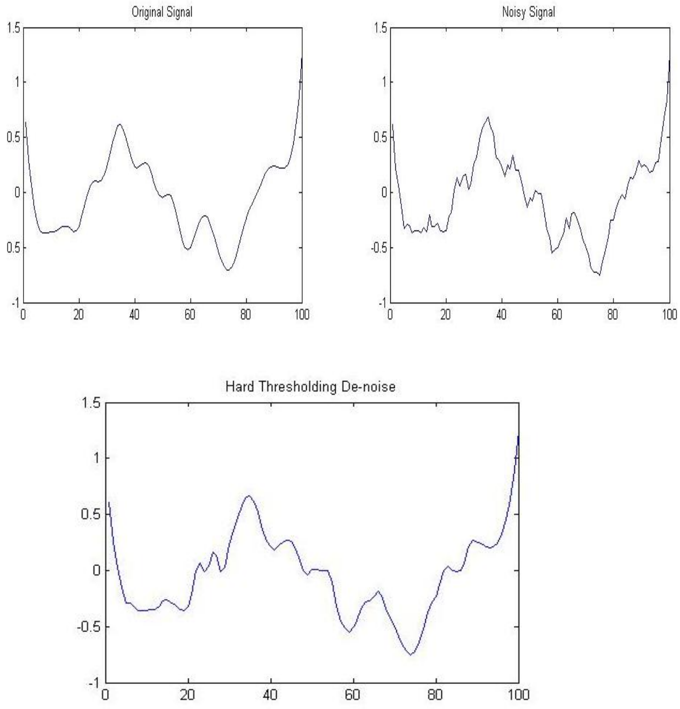

Fig. 2 Example of hard thresholding

2) *Soft Thresholding:* Soft thresholding preserves the edges by smoothening them. The soft thresholding shrinks the coefficients above the threshold in absolute value. It is a shrink or kill rule[2].

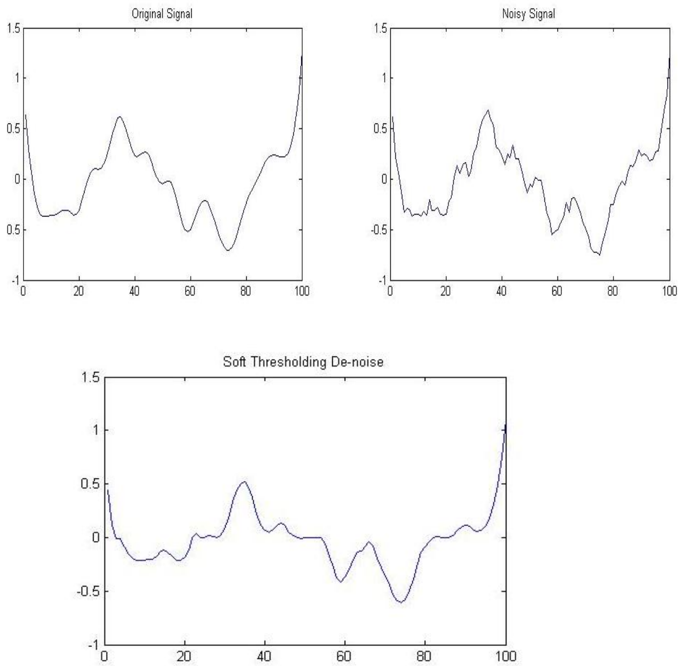

Fig. 4 Example of soft thresholding

In DWT, an image can be decomposed into a series of different spatial resolution images. For a 2D image, an N level decomposition may result in providing 3N+1 sub bands LL, HL, LH and HH. Then the wavelet transform is applied to the low frequency sub band image. The gaussian noise will nearly be eliminated in the lower band. Thus, only the wavelet coefficients in high frequency are to be threshold[4][6][12].

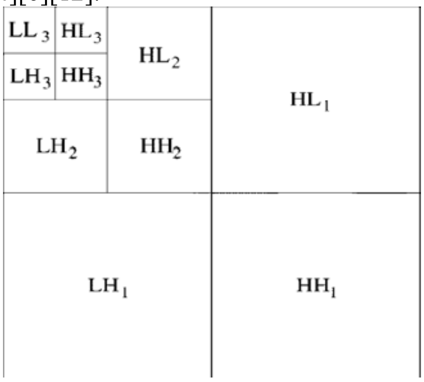

Fig. 5 2D DWT with 3 level decomposition.

After the thresholding process, the image is reconstructed using inverse wavelet transform. The quality of the image is then evaluated by peak signal to noise ratio (PSNR).

PSNR: Peak signal to noise ratio is the ratio of the maximum possible power of signal to the power of corrupting noise that affects the fidelity of its representation. It is an approximation to human perception of reconstruction quality.

IV. CONCLUSIONS

This paper is a review on the ongoing trends in the field of image denoising techniques. It includes the study of various denoising algorithms and discrete wavelet transform. The wavelet transform has emerged in the last decade and has now gone to the next level. In order to find the best method, many combinations have also been applied.

The study shows that the discrete wavelet transform is computationally faster and gives better results. As for future, I am trying to develop a technique using DWT, combining it with a hybrid of thresholdings and intensity transformations.

REFERENCES

[1] Asem Khmag, Abd Rahman Ramli, Syed Abdul Rahman Al-Haddad, Shaiful Jahari Hashim. "A detailed study of image denoising algorithms using discrete wavelet transformation" IJCST Vol. 5 (2014).

[2] David L. Donoho. "De-noising by soft thresholding" IEEE Transactions on Information Theory, Vol. 41, No. 3 (1995)

[3] Maarten Jansen and Adhemar Bultheel. " Multiple wavelet threshold estimation by generalized cross validation for data with correlated noise". Report TW250, 1997.

[4] S. Grace Chang, Bin Yu, Martin Vetterli. "Adaptive wavelet thresholding for image denoising and compression" IEEE transactions of Image Processing Vol. 9, No. 9 (2000).

[5] A. Buades, B. Coll, J. M. Morel. " A review of image denoising algorithms, with a new one". (2005)

[6] S. Kother Mohideen, Dr. S. Arumuga Perumal, Dr. M. Mohamed Sathik. "Image Denoising using discrete wavelet transform" IJCSNS Vol. 8, No. 1 (2008).

[7] A. Buades, B. Coll, J. M. Morel. "A non local algorithm for image denoising" IEEE International Conference on Computer Vision and Pattern Recognition, Vol. 2 (2005).

[8] Sudipta Roy, Nidul Sinha & Asoke K. Sen. " A new hybrid image denoising method" International Journal of Information Technology and Knowledge Management, Vol. 2, No. 2 (2010).

[9] Aarti, Gaurav Pushkarna. "Comparative Study of Image Denoising Algorithms in Digital Image Processing" COMPUSOFT, An international journal of advanced computer technology, Vol. 3 (2014).

[10] Sachin D. Ruikar, Dharmpal D. Doye. "Wavelet based image denoising technique". IJACSA, Vol 2, No. 3 (2011).

[11] Florian Luiser, Thierry Blu and Michael Unser. "A new SURE approach to image denoising: Interscale orthonomal wavelet thresholding". IEEE transactions on image processing. Vol. 16, No. 3 (2007).

[12] J. N. Ellinas, T. Mandadelis, A. Tzortzis, L. Aslanoglou. "Image denoising using wavelets".

[13] Bela Khurana, Ankita Mittal. "Review on image denoising usint DWT algorithm". IJSRD Vol. 2 (2014).