International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

An Efficient Method for Image Denoising Using Orthogonal Wavelet Transform

Akshata S Kori[1], Manjunatha A S.[2]

Department of Computer Science & Engineering, Mangalore Intitute of technology & Engineering
Mangalore, Karnataka, India

Senior Assistant Professor, Department of Computer Science & Engineering, Mangalore Institute of Technology and Engineering, Mangalore, Karnataka, India

Abstract: ***Digital images are noisy due to environmental disturbances. To ensure image quality, image processing of noise reduction is a very important step before analysis or using images. Image denoising is one such powerful methodology which is deployed to remove the noise through the manipulation of the image data to produce very high quality images. In this paper, we analyzed several methods of noise removal from degraded images with Gaussian noise and salt & pepper by using adaptive wavelet threshold and compare the results in term of PSNR and MSE. After simulation can find that stein unbiased risk estimator is one of the best techniques for removing the noise from the image in terms of PSNR.***

Keywords: Wavelet, Image denoising, OWT, stein Unbiased Risk Estimator, PSNR.

1. Introduction

A digital image is a 2-D matrix given by a function f(u,v) where the value at co-ordinate (u,v) specify the intensity of the pixel whose co-ordinate is given by (u,v). In our everyday schedule, we come across various kinds of digital images such as television and computer images, MRI images, space and heavenly body images, images taken with the help of remote sensing. In all the above fields, noise gets added due to interference of unwanted high frequency electromagnetic signals with desired digital image during its transmission. The noise may also get added because of improper lighting, inherent noisy characteristics of channel or due to mechanical degradation of equipments. Image denoising is necessary to obtain best approximation of the original digital image from the received noisy image. Before couple of decades, denoising was a challenging task. But after the advent of wavelet theory, denoising has been simplified to a great extent.

2. Literature Survey

Adapting to Unknown Smoothness via Wavelet Shrinkage[1] We attempt to recover a function of unknown smoothness from noisy sampled data. We introduce a procedure, SureShrink, that suppresses noise by thresholding the empirical wavelet coefficients. The thresholding is adaptive: A threshold level is assigned to each dyadic resolution level by the principle of minimizing the Stein unbiased estimate of risk (Sure) for threshold estimates. The computational effort of the overall procedure is order N log(N) as a function of the sample size N. SureShrink is smoothness adaptive: If the unknown function contains jumps, then the reconstruction (essentially) does also; if the unknown function has a smooth piece, then the reconstruction is (essentially) as smooth as the mother wavelet will allow. The procedure is in a sense optimally smoothness adaptive: It is near minimax simultaneously over a whole interval of the Besov scale; the size of this interval depends on the choice of mother wavelet. We know from a previous paper by the authors that traditional smoothin methods- kernels, splines, and orthogonal series estimates-even with optimal choices of the smoothing parameter, would be unable to perform in a near-minimax way over many spaces in the Besov scale. Examples of SureShrink are given. The advantages of the method are particularly evident when the underlying function has jump discontinuities on a smooth background.

De-Noising by Soft-Thresholding[2] Donoho and Johnstone (1994) proposed a method for reconstructing an unknown function f on [O, I] from noisy data d, = f(tz) + oz,, i = 0,. . . ,n - 1, t, = i/n, where the z, are independent and identically distebuted standard Gaussian random variables. The reconstruction f: is defined in the wavelet domain by translating all the empirical wavelet coefficients of d toward 0 by an amount U. dm. We prove two results about this type of estimator. [Smooth]: With high probability f: is at least as smooth as f, in any of a wide variety of smoothness measures. [Adapt]: The estimator comes nearly as close in mean square to f as any measurable estimator can come, uniformly over balls in each of two broad scales of smoothness classes. These two properties are unprecedented in several ways. Our proof of these results develops new facts about abstract statistical inference and its connection with an optimal recovery model.

Image Denoising using Wavelet Thresholding Methods[3] This paper presents a comparative analysis of various image denoising techniques using wavelet transforms. A lot of combinations have been applied in order to find the best method that can be followed for denoising intensity images. In this paper, we analyzed several methods of noise removal from degraded images with Gaussian noise by using adaptive wavelet threshold (Bayes Shrink, Neigh Shrink, Sure Shrink, Bivariate Shrink and Block Shrink) and compare the results in term of PSNR and MSE.

3. Problem Definition

The main aim of an image denoising algorithm is then to reduce the noise level, while preserving the image features.

Licensed Under Creative Commons Attribution CC BY

The multiresolution analysis performed by the wavelet transform has been shown to be a powerful tool to achieve these goals. Indeed, in the wavelet domain, the noise is uniformly spread throughout the coefficients, while most of the image information is concentrated in the few largest coefficients.

4. Methodology

4.1 Denoising

De-noising plays a important role in the field of the image preprocessing. It is often a necessary to be taken, before the image data is analyzed. It attempts to remove whatever noise is present and retains the significant information, regardless of the frequency contents of the signal. It is entirely different content and retains low frequency content. De-noising has to be performed to recover the useful information. In this process much concentration is spent on, how well the edges are preserved and, how much of the noise granularity has been removed.

4.2 Wavelet

A Wavelet is a waveform of efficiently limited duration that has an average value zero. Compare wavelets with sine wave, which are the basis of Fourier analysis. Sine waves so not have limited duration, wavelets tend to be irregular and asymmetric

4.3 Wavelets Thresholding for Denoising

In the first step of denoising, a digital image is divided into approximation and detail sub band signals. Approximation signal shows the low frequency or general trend of pixel values. The detail sub band signals are horizontal, vertical and diagonal details of an image and contain high frequency information of an image. As noise is a high frequency signal and hence it is majorly distributed over these three sub band signals. If the details provided by these sub band signals are low, then they can be set to zero. The value below which the details are considered to be zero is called as „Threshold" value. This threshold value changes from image to image. There is variety of methods to calculate the threshold value for sub bands. Some of them are as follows:

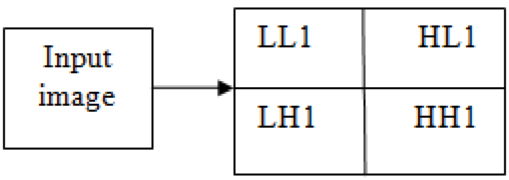

Figure 1: Single level Image decomposition

4.4 Thresholding Technique

Image denoising using orthogonal wavelet transform can be performed by using different thresholding techniques, such as Hard thresholding and Soft thresholding. Reducing the noise level, along with preserving the image features is done by using Sure thresholding.

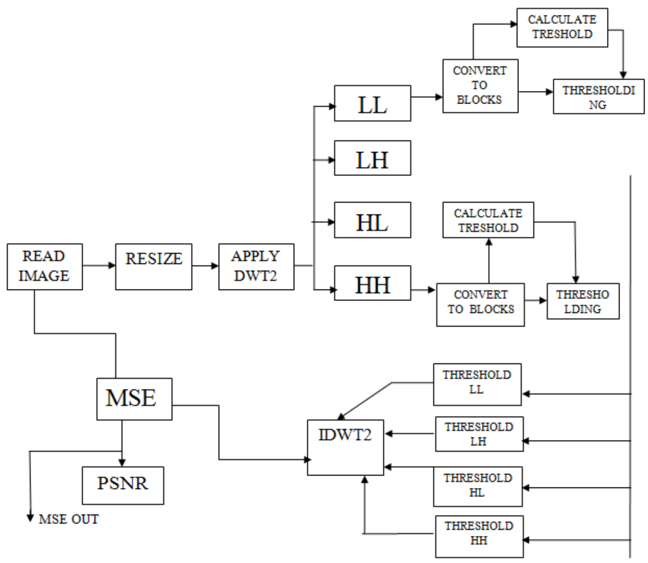

Figure 2: Block diagram of denoising using wavelet transformation and thresholding techniques

- Initially retrieve the image.
- Add noise to retrieved image. Noise can be any type for example guassian, salt & pepper, Rayleigh etc..
- For removing noise apply discrete wavelet transform in 2D that will give two types of coefficients i.e..is approximation coefficients and detailed coefficients that are nothing but low frequency and high frequency components.
- Depend upon the image choose threshold value.
- Apply soft or hard thresholding function to noisy coefficients
- Perform the inverse DWT to reconstruct the denoised image.
- Evaluate performance parameters like peak signal to noise ratio(PSNR) and mean square error(MSE).
- For better system PSNR should be high and MSE should be low.

4.5 Hard thresholding

Hard thresholding can be defined as,

D (U, λ) =U for all |D|> λ

=0 otherwise

Hard threshold is a "keep or kill" procedure and is more intuitively appealing. The transfer function of the hard thresholding is shown in the figure. Hard thresholding may seem to be natural. Hard thresholding does not even work with some algorithm such as GCV procedure. Sometimes pure noise coefficients may pass the hard threshold and appear as annoying 'blips' in the output.

4.6 Soft Thresholding

Soft Thresholding is given by a function,

f(x,y) = sgn(x).max(0,|x|-y)

Soft Thresholding not only makes the values below threshold zero but also shrinks the coefficients above threshold in absolute value. Hard threshold method is concentrated on the edges and high frequency features

Licensed Under Creative Commons Attribution CC BY

where the wavelet coefficient have discontinuous point on the threshold λ and - λ, which may cause Gibbs shock to the useful reconstructed signal they are removed by the algorithm. On the other hand, the soft wavelet threshold method noise presents much more structure than the hard thresholding, but when the wavelet coefficients are greater than the threshold value, there will be a constant bias between the wavelet coefficients that have been processed and the original wavelet coefficients, making it impossible to maintain the original characteristics of the images effectively There are three soft thresholding methods are as follows:

- Visu Shrink
- Bayes Shrink
- Sure Shrink

4.6.1 Visu Shrink

VisuShrink is proposed by Donoho and Johnstone. This is also called as Universal threshold. VisuShrink is threshold by applying the Universal threshold. This threshold is given by

$$t=\sigma\ 2logm$$

where σ is the noise variance and m ia the number of pixels in the image.

It follows the hard thresholding rule. An estimate of the noise level σ is defined based on median absolute deviation given by

$$\sigma = \frac{\mathrm{median\ (\ abs\ (gj}\ -1, \mathrm{k} : \mathrm{k} = 0,1, \ldots \ldots 2\mathrm{j}\ -1\})}{0.6745}$$

where $gj\ -1,k$ corresponds to the detail coefficients in the wavelet transform.

This asymptotically yields a mean square error(MSE) estimate as m tends to infinity. As m increases, we get bigger and bigger threshold, which tends to over smoothen the image.

4.6.2 Bayes Shrink

Bayes shrink is an adaptive data driven threshold for image denoising via wavelet soft thresholding. The threshold is driven in a Bayesian frame work and its assume Generalized Gaussian distribution (GGD) for the wavelet coefficient in each detail sub band and try to find the threshold T minimizes the Bayesian Risk.The BayesShrink performs better than sure shrink in terms of MSE.

4.6.3 Sure Shrink

The subband adaptive threshold is applied for calculating the SureShrink threshold. A separate threshold value is calculated for each detail subband based upon SURE (Stein‘s unbiased estimator for risk), a method for estimating the unbiased loss $|| \mu\hat{} - \mu ||^2$. In our case let wavelet coefficients in the ith subband be $\{X_i: i = 1,\ldots, d\}$, $\mu\hat{}$ is the soft threshold estimator $X\hat{}_i = \eta_t(X_i)$, Stein‘s result is applied to get an unbiased estimate of the risk $E||\mu\hat{}_{(t)}(x) - \mu||$:

$$SURE\ (t,X) = d-2\#\ \{i{:}Xi \le t\} + \sum_{i=1}^{i} min\ (|Xi|, t)^2$$

For an observed vector x (set of noisy wavelet coefficients in a subband), we could find the threshold as

$$T_{SURE} = \mathrm{argmin}\, SUR(t,X)$$

As the SureShrink gives better result than VisuShrink in terms of PSNR as it is subband adaptive technique.

4.7 Calculation of PSNR

PSNR values can be calculated by comparing two images one is original image and other is distorted image .The PSNR has been computed using the following formula:

$$\mathrm{PSNR} = 10log_{10} + \left(\frac{\mathrm{R}^2}{\mathrm{MSE}}\right)$$

Where R is the maximum fluctuation in the input image data type. For example, if the input image has a double-precision floating-point data type, then *R* is 1. If it has an 8-bit unsigned integer data type, *R* is 255, etc.

4.8 Wavelet Based Comparison of MSE

Mean Squared Error (MSE): One obvious way of measuring this similarity is to compute an error signal by subtracting the test signal from the reference, and then computing the average energy of the error signal. The mean-squared-error (MSE) is the simplest, and the most widely used for image quality measurement.

$$\mathrm{MSE} = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} (\mathrm{x(i,j)} - \mathrm{y(i,j)})^2$$

Where x (i, j) represents the original image and y(i , j) represents the denoised (modified) image and i and j are the pixel position of the M×N image.MSE is zero when x(i, j) = y(i, j) .

5. Results and Discussion

The various images are used for denoising which are representative set of standard 8-bit grayscale images such as LENA, CAMERA MAN. All corrupted by simulated salt & pepper additive Gaussian white noise. The denoising process has been performing with minimum threshold of 0 can be inserted up to maximum threshold of 100. In this process, we are sampled Orthonormal wavelet transform with eight resisting moments (sym8) over time decomposition stage. The below Table shows the PSNR and MSE values. The image test through Visu Shrink shows the PSNR value is 31.23 dB and Bayes Shrink value is 31.28.

Table 1: Using gaussian noise the image test of camera man, lena through Sure Shrink

Image type	PSNR	MSE
Camera man	72.1554660 dB	0.0040
Lena	73.0020332 dB	0.0033

Original Image Noisy Image De-Noised Image

Licensed Under Creative Commons Attribution CC BY

Table 2: Using salt & pepper noise the image test of camera man, lena through Sure Shrink

Image type	PSNR	MSE
Camera man	75.1374955 dB	0.0020
Lena	77.3806397 dB	0.0012

6. Conclusion

In this paper, the advantages and applications of popular standard DWT and its extensions are realized for image denoising. The experiments were conducted for the study and understanding of different thresholding techniques which are the most popular. It was seen that wavelet thresholding is an effective method of denoising noisy signals. We first tested hard and soft on noisy versions of the standard 1-D signals and found the best threshold. We then investigated many soft thresholding schemes such as VisuShrink, SureShrink, BayesShrink. The results show that SureShrink gives better result than other shrinkage techniques in terms of PSNR

7. Future Work

The above principles are valuable only for square images. Future plan is to make valuable for variable size of images and To extract good spectral resolution by applying edge preserving filter.

References

[1] David L. Donoho and Iain M. Johnstone “Adapting to Unknown Smoothness via Wavelet Shrinkage” Journal of the American Statistical Association, Vol. 90, No. 432 (Dec., 1995), pp. 1200- 1224

[2] David L. Donoho, “De-noising by Soft-thresholding” IEEE transactions on information theory, vol. 41, no. 3, may 1995

[3] Anutam and Rajni “Performance Analysis of Image Denoising with Wavelet Thresholding Methods for Different Levels of Decomposition” The International Journal of Multimedia & Its Applications (IJMA) Vol.6, No.3, June 2014

[4] Mr. Manish Yadav, Swati Yadav, Dr. Dilip Sharma, “Image Denoising using Orthonormal Wavelet Transform with Stein Unbiased Risk Estimator”, 2014 IEEE’ Conference on Electrical, Electronics and Computer Science

[5] Debalina Jana, Kaushik Sinha, “ Wavelet Thresholding for Image Noise Removal” International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169 Volume: 2 Issue: 6.

[6] M.Neelima, Md. Mahaboob Pasha, “Wavelet Transform Based On Image Denoising Using Thresholding Techniques” International Journal of Advanced Research in Computer and Communication Engineering Vol. 3, Issue 9, September 2014.

[7] Kuldeep Singh Badwer, Simarjeet Kaur, “Image Denoising using different Wavelet Transforms with Hard and Soft Thresholding” International Journal of Advanced Research in Computer Science and Software Engineering, Volume 4, Issue 8, August 2014.

[8] Namrata Dewangan, Agam Das Goswami, “Image Denoising using Wavelet Thresholding methods” International journal of engineering sciences & management, [Dewangan, 2(2): April-June, 2012] ISSN: 2277-5528.

Author Profile

Akshata S Kori completed the bachelor’s degree in Computer Science &Engineering from visvesvaraya technological University (VTU) currently pursuing Masters in Engineering in Computer Science & Engineering at Mangalore Institute of Technology, Mangalore

Manjunatha A S completed bachelors and masters degree in Computer Science and Engineering. Currently working as senior assistant Professor in Mangalore Institute of Technology, Mangalore. He has got 3 years of experience in industry. He was working in Trianz Consulting Pvt Ltd, Bengaluru as Software Engineer. He had presented a paper in International Conference.

Licensed Under Creative Commons Attribution CC BY