Wavelet Thresholding for Speckle Noise Reduction

Bikramjeet Kaur

Department of Computer Engineering

Yadavindra College of Engineering

Punjabi University Guru Kashi Campus

Talwandi Sabo(Bathinda), Punjab

Seema

Department of Computer Engineering

Yadavindra College of Engineering

Punjabi University Guru Kashi Campus

Talwandi Sabo(Bathinda), Punjab

Abstract

Image de-noising is a vital image processing task. It is a process itself as well as a component in other processes. There are many ways to de-noise an image and various methods exists. The important property of a good image denoising model is that it should completely remove noise as far as possible as well as preserve edges. This paper describes an efficient threshold estimation method for image denoising based on wavelet transform. In this work speckle noise is used. The noisy image is firstly decomposed into many levels to obtain different frequency bands. Then apply soft thresholding method to remove noisy coefficients, by fixing optimum thresholding value. Experimental results on noisy image by using proposed method show that this method yields superior image quality and better Peak Signal to Noise Ratio (PSNR). Further results have been compared with traditional filters like wiener filter and median filter to prove the efficiency of propose method.

Keywords: **Thesholding, Speckle Noise, Image Denoising, Filters.**

1.INTRODUCTION

An image is often corrupted by noise during its acquisition or transmission. Removing noise from the original image is still a challenging problem for researchers [1]. The main objective of image-de-noising techniques is to remove such noises while retaining as much as possible the important signal features. Ultrasonic imaging is a widely used medical-imaging procedure. One of its main shortcomings is the poor quality of images, which are affected by speckle noise.

The traditional way of image de-noising is filtering. Recently, a lot of research about non-linear methods of signal de-noising has been developed. Wavelet transform have become a powerful tool for de-noising an image. Wavelet provides an appropriate basis for removing noise from the noisy image. For denoising signals using Discrete Wavelet Transform (DWT), the method consists of applying the DWT to the original data, thresholding the detailed wavelet coefficients and inverse transforming the set of threshold coefficients to obtain the denoise signal.

The purpose of this study is to propose noise removal algorithm based on Discrete Wavelet Transform (DWT) and results comparison with traditional filters like wiener filter and median filter.

The rest of the paper is organized as follows. Section 2 introduces Discrete Wavelet Transform (DWT). Section 3 explains wavelet thresholding. Section 4 explains wavelet based image de-noising algorithm. Experimental results and discussion are presented in section 5. The conclusion and references are presented in section 6 and 7.

2. DISCRETE WAVELET TRANSFORM

Discrete Wavelet Transform (DWT) is a type of wavelet. There are several denoising techniques to reduce speckle noise with using the wavelets. In wavelet noising filtering, we will use the wavelet noise thresholding which is Discrete Wavelet Transform (DWT). In the case of DWT, first the image is divided into the four parts HH, HL, LH, and LL and the further the approximation part is divided into two sub-bands. Approximation part is LL and the other part is detailed part in which we have all three parts HH, HL and LH. We will work on the detailed part because the noise will occur on the high frequency part which is detailed part.

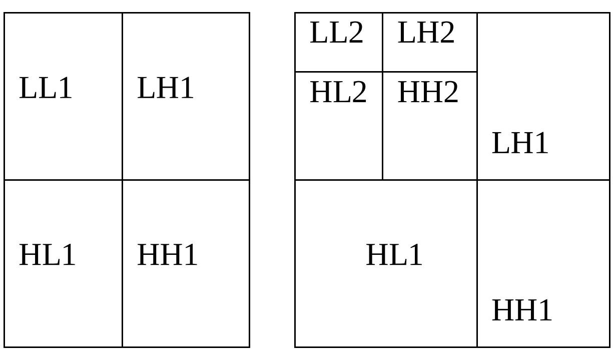


***Figure 1*: Image Decomposition by DWT**

3. WAVELET THRESHOLDING

One of the most effective ways to remove speckle without smearing out the sharp edges features of an ideal image is to threshold only high frequency components while preserving most of the sharp features in the image. The approach is to shrink the detailed coefficients (high frequency components) whose amplitudes are smaller than a certain statistical threshold value to zero while retaining the smoother detailed coefficients to reconstruct the ideal image without much loss in its detail. This process is sometimes called wavelet shrinkage since the detailed coefficients are shrunk towards zero.

The schemes to shrink the wavelet coefficients, namely the "keep-or-kill" hard thresholding, and "shrink-or-kill" soft thresholding. The criterions of each scheme are described as follows: given λ denotes the threshold limit, X denotes the input wavelet coefficients and Y denotes the output wavelet coefficients after thresholding[4].

3.1 Hard Thresholding

$$Y = T_{hard}(X, Y) = \begin{cases} X & \text{where } |X| \geq \lambda \\ 0 & |X| < \lambda \end{cases} \qquad (1)$$

In the hard thresholding scheme, the input is kept if it is greater than the threshold λ, otherwise it is zero. The hard thresholding procedure removes the noise by thresholding only the wavelet coefficients of the detailed sub-band, while keeping the low-resolution coefficients unaltered [4].

3.2 Soft Thresholding

$$Y=T_{soft}(X,Y)=\begin{cases} sign\{X\}(X-\lambda) & \text{where } |X| \geq \lambda \\ 0 & |X| < \lambda \end{cases} \qquad (2)$$

In soft thresholding scheme, if the absolute value of the input X is less than or equal to λ then the output is forced to zero. If the absolute value of X is greater than λ the output is $|y| = |x - \lambda|$.

In practice, soft thresholding is more popular than hard thresholding because it reduces the abrupt changes that occurs in hard thresholding and provides more visually pleasant recovered images [4].

4. ESTIMATION PARAMETERS FOR THRESHOLDING

Finding an optimum threshold value (λ) for soft thresholding is not an easy task. A small threshold value will pass all the noisy coefficients and hence the resultant denoised signal may still be noisy. A large threshold value on the other hand, makes more number of coefficients as zero which leads to smooth signal and destroys details and in image processing may cause blur and artifacts. So, optimum threshold value should be found out, which is adaptive to different subband characteristics. Here, we describe an efficient method for fixing the threshold value for denoising by analyzing the statistical parameters of the wavelet coefficients. The threshold value (T), we proposed for soft thresholding technique is

$$T = C\,\sigma - (AM - GM) \qquad (3)$$

Here σ is the noise variance of the corrupted image. In the DWT of the image, the HH1 subband contains mainly noise. For estimating the noise level we use the relation proposed by Donoho which is denoted as

$$\sigma = \frac{(Median\,|Yij|\,\square)}{0.6745} \qquad Yij\ \varepsilon\ subband\ HH \qquad (4)$$

The term C in included for this purpose to make the threshold value as decomposition level dependent which is given as,

$$C = 2\,(L - k) \qquad (5)$$

Where, L is the no.of wavelet decomposition level

k is the level at which the subband is available

(for HL2, k=2)

The term |*AM* - *GM*| is the absolute value of difference between Arithmetic Mean and Geometric Mean of the subband coefficients. This term is the measure of the smoothness of the image to be denoised. The Arithmetic Mean and Geometric Mean of the subband matrix X(i,j) are denoted as[4].

$$Arithmetic\ mean\ (AM) = \frac{1}{m^2}\sum_{i=1}^{m}\sum_{j=1}^{m} x(i,j) \qquad (6)$$

$$Geometric\ mean(GM) = \left[\prod_{i=1}^{m}\prod_{j=1}^{m}[x(i,j)]\right]^{\frac{1}{m^2}} \qquad (7)$$

5. PROPOSED IMAGE DE-NOISING ALGORITHM

1. Load the input image of size [m n] where m=n=128,256,512,1024.

2. Add the noise into an image.

3. Apply log transformation to the input noisy image or apply homomorphic filtering approaches to the input noisy image.

g(x,y)=f(x,y).η(x,y)

Where f(x,y)=input noise free image.

η(x, y) =noise corrupted image

Then by homomorphic filtering .take the logarithm on above equations

Log [f(x,y).η(x,y)]

z(x,y)=log f(x,y)+logη(x,y).

4. Apply Discrete wavelet transform (DWT) on z^(x,y)=log f(x,y)+logη(x,y) to decomposed the image into detail part and approximation part using equations.

5. Now find the variance of each sub band by using the equation:
Var=median (median (HH)', 1)/0.6745;

Which is also known as Median absolute deviation method (MAD).

6. Threshold the each sub band by calculating the threshold computing by the following formula:

$Threshold = \frac{c * MAD - Q}{2}$, Where MAD is given by step 5

C=Decomposition of wavelet at level 2.

Q=abs (M-I)

Where M is calculated by applying wiener filtering on each band sub band(H,V,D,HL,LH,HH) and I is calculated by taking the only positive value of each sub band.

7. After apply soft thresholding technique we should take inverse discrete wavelet transform to the modified wavelet coefficient

8. After take the inverse wavelet transform of the wavelet coefficient we should applying wiener filtering on the denoised image to get the further improved result.

9. Finally take the exponential of about output to get the final denoised image.

10. Finally calculate it's PSNR value of denoised image by the following formula:

$$PSNR = 10 * log10\left(\frac{255 * 255}{MSE}\right)$$

Where MSE is Mean Square Error calculated by:

$$\mathbf{MSE} = \frac{1}{MN}\sum_{i=1}^{m}\sum_{j=1}^{m}[(X(i,j) - P(i,j))]^2$$

M-Width of Image
N-Height of Image
X-Original Image
P-Noisy Image or Processed Image

6. EXPERIMENTAL RESULTS AND DISCUSSION

The above algorithm has been applied on natural gray scale test image leena at different speckle noise levels like at standard deviation σ = 0.01,0.02,0.03,0.04,0.05 to evaluate the performance of our proposed method, we compared with wiener filter, median filter, homomorphic wiener and homomorphic median using Peak Signal to Noise Ratio(PSNR). It is obvious from Table 1, the proposed method removes noise significantly with highest PSNR using Db family of wavelet. Figure 2 presents graphical representation of comparision of various de-noising methods for Leena image of different noise levels means different standard devaiation (SD).

TABLE 1
COMPARISON OF PSNR OF VARIOUS FILTERS FOR IMAGE CORRUPTED BY SPECKLE NOISE USING DB WAVELET

Filters	Peak Signal to Noise Ratio in dB (PSNR)				
	0.01	0.02	0.03	0.04	0.05
Wiener filter	30.0688	27.9199	26.5473	25.4530	24.6176
Median filter	27.3958	25.8326	24.7182	23.8427	23.0325
Homomorphic (M.F)	28.3813	26.4253	25.0645	24.1470	23.3067
Homomorphic (W.F)	29.5600	28.2397	27.2255	26.3909	25.6474
DWT +(W.F)	32.8242	31.8213	31.1201	30.3212	29.8277

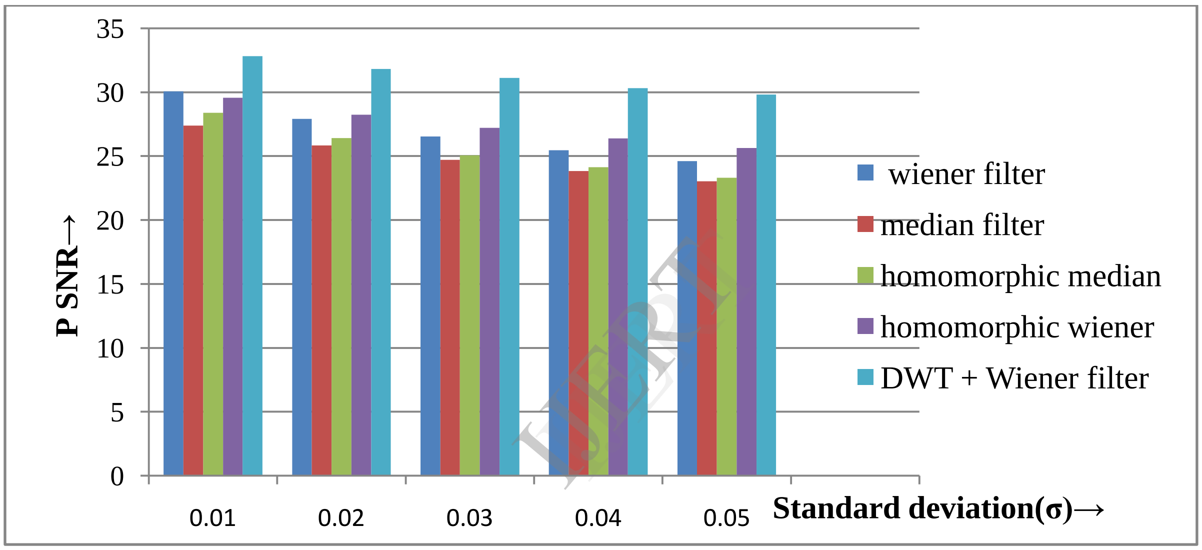


Figure 2: Variation between PSNR values and S.D using DB wavelet foe "leena" Image

TABLE 2
COMPARISON OF PSNR OF VARIOUS FILTERS FOR IMAGE CORRUPTED BY SPECKLE NOISE USING HAAR WAVELET

Filters	Peak Signal to Noise Ratio in dB (PSNR)				
	0.01	0.02	0.03	0.04	0.05
Wiener filter	30.0688	27.9199	26.5473	25.4530	24.6176
Median filter	27.3958	25.8326	24.7182	23.8427	23.0325
Homomorphic (M.F)	28.3813	26.4253	25.0645	24.1470	23.3067
Homomorphic (W.F)	29.5600	28.2397	27.2255	26.3909	25.6474
DWT +(W.F)	32.8991	31.8632	31.0562	30.4016	29.9713

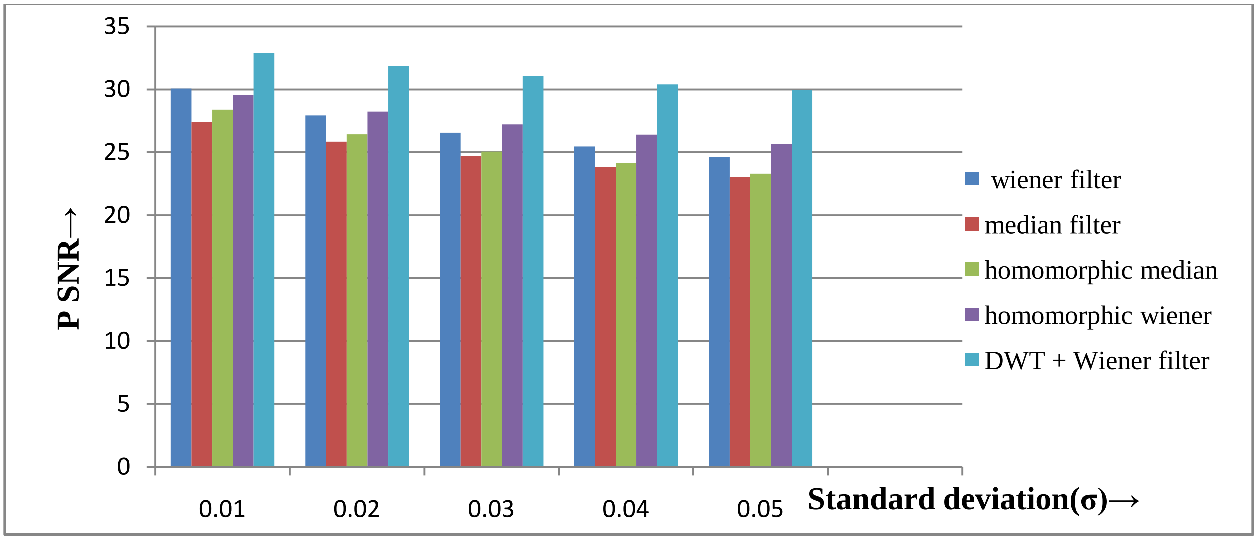
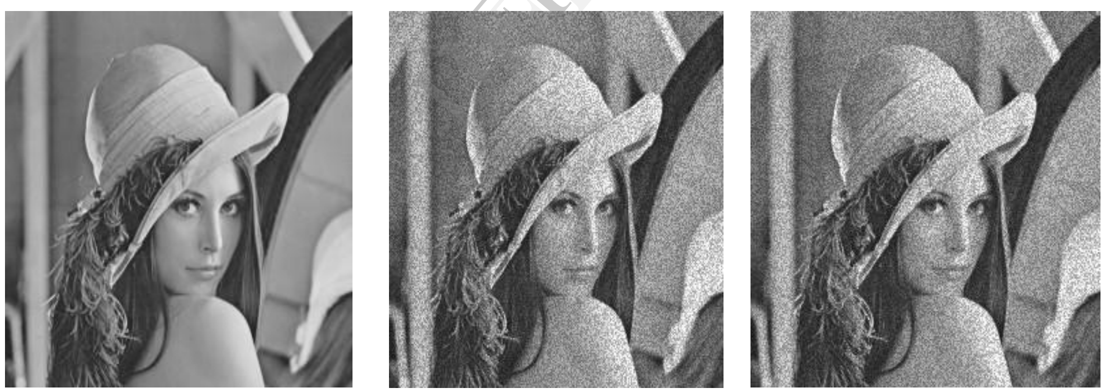


***Figure 3*:** Variation between PSNR values and S.D using Haar wavelet

It is obvious from Table 2, the proposed method removes noise significantly with highest PSNR using haar family of wavelet.

Figure 3 presents graphical representation of comparision of various de-noising methods for Leena image of different noise levels means different standard devaiation (SD).



(a) (b) (c)

(d)

(e)

(f)

(g)

(h)

Figure 4: Denoising of "Leena" image corrupted by Speckle Noise of Standard deviation of 0.02

a) Original Leena image b) Noisy image (σ = 0.02) c) Wiener filter(27.91 dB)

d) Median filter(25.83 dB) e) Homomorphic median filter(26.42 dB) f) Homomorphic Wiener filter(28.23 dB) g) DWT(DB wavelet) and wiener filter(31.82 dB) h) DWT(Haar wavelet) and wiener filter(31.86 dB).

7. CONCLUSION

In this paper, the effectiveness of wavelet for removal of noise from an image and compare its effectiveness again some other promising noise removal filters like wiener filter, median filter, homomorphic filters. We try to explore the wavelet based method for noise reduction and performance of wavelet based method is compared with existing traditional techniques in terms of Peak Signal to Noise Ratio (PSNR) and visual results of various filters. So we can conclude that proposed method has much better results than other noise removal filters.

REFERENCES

[1] Bobby and Manish Mahajan (2011**), "Performance Comparision between Filters and Wavelet Transform Image Denoising for**

[2] C. Zanchettin and T.B. Ludermir (2007), **"Wavelet filter for noise reduction and signal compression in an artificial nose",** *Applied Soft Computing 7* , pp:246–256.

[3] **"Definition of Digital Image Processing**" [online] http://www.elearning.vtu.ac.in

[4] D. Gnanadurai and V.Sadasivam (2006),**"An Efficient Adaptive Thresholding Technique for Wavelets Based Image Denoising",** *International* Journal of Information and Communication Engineering.

[5] David L. Donoho (1995)**, "De-Noising by Soft-Thresholding",** *IEEE Transactions on Informarion Theory, Vol. 41, No. 3.*

[7] Jappreet kaur, Jasdeep Kaur and Manpreet Kaur, **"Survey of Despeckling Techniques for**

different Noises", *International Journal of Computer Science and Communication, Vol. 2, No. 2,* pp: 637-639.

Medical Ultrasound Images", *Int. J. Comp. Tech. Appl., Vol 2 (4),* pp: 1003-1007.

[8] R.C. Gonzalez and R. E. Woods, **"Digital Image Processing",** *Second edition, Pearson Education*,2003.

[9] Rohit Sihag, Rakesh Sharma and Varun Setia (2011), **"Wavelet Thresholding for Image De-noising",** *International Journal of Computer Applications.*

[6] Pawan Patidar, Manoj Gupta, Sumit Srivastava and Ashok Kumar Nagawat (2010), **"Image De-noising by Various Filters for Different Noise",** *International Journal of Computer Applications (0975 – 8887), Vol 9, No.4.*