

# Image de-noising using wavelet thresholding method

Saurabh Kumar Mishra<sup>1</sup>, Kamal Ahmad<sup>2</sup>, Akanksha Trivedi<sup>3</sup>, Mudit Shukla<sup>4</sup>, Harshita Pandey<sup>5</sup>,  
Amity University Uttar Pradesh Lucknow Campus, India

----- ◆ -----

**Abstract-** Generally images get corrupted during image acquisition and transmission. There are so many techniques for image de-noising and all have some merits as well as some demerits and it's still a big challenge before researchers. This paper has used wavelet thresholding technique for image de-noising. Wavelet thresholding method exploited the fact that small coefficients are more likely due to noise and large coefficients due to essential signal components. De-noising process has been simulated on MATLAB 2010.

**Index Terms-** Global thresholding, Histogram, Mother Wavelet, Speckle noise, Soft thresholding, Wavelet decomposition Wavelet coefficients.

----- ◆ -----

## 1. INTRODUCTION

Image de-noising [2] means to remove the additive noise that may be added in original image during image acquisition or transmission while preserving as much as possible the essential signal features. In the recent years wavelet thresholding and threshold selection [4] have been emerged for signal de-noising [2], because wavelet provides an appropriate basis for removing noisy signal from the image. As the wavelet transform [1] is good at energy compaction, the small coefficients are more likely due to noise and large coefficient due to important signal features. These small coefficients can be truncated without affecting the significant components of the image.

The first important step is to select a mother wavelet. Selecting a mother wavelet depends on the type of the input signal we are using. In this paper we have used 'sym4' wavelet. After choosing mother wavelet we select a decomposition level shown in figure 2. In this paper image has been decomposed at 3 levels. Thresholding is a technique that makes wavelet transform successful for de-noising and compression [2]. There are many theories for threshold selection process and we have to choose appropriate one.

Mainly there two types of thresholding, hard thresholding and soft thresholding [8]. In this paper soft thresholding is used for de-noising purpose. After setting a threshold value we truncate all the coefficients that have values lower than threshold.

Thresholding is applied only in detail coefficients because approximation coefficient contains essential features. Then inverse discrete wavelet transform on the output may lead to reconstruction with the essential signal characteristics and with minimum noise. The entire procedure of image de-noising using wavelet thresholding method has been represented by the block diagram shown in figure 1.

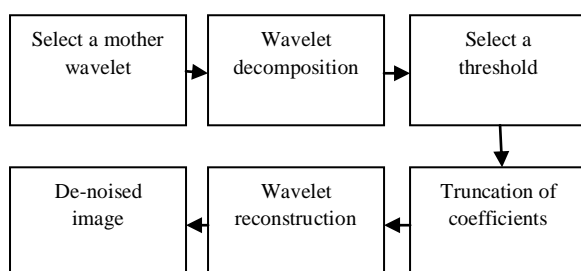


Fig.1 (Process of wavelet de-noising technique)

## 2. DISCRETE WAVELET TRANSFORM

In wavelet transform noisy image has been taken as input image and that image is divided up into low frequency and high frequency components. The output of low pass filter is known as approximation coefficient and the output of high pass filter is called detail coefficient [10]. When we analyze approximation coefficients at level 1 by using MATLAB command *imshow* we can identify the image with loss in the quality of image. This shows that low frequency components contain essential information and that is why the output of LPF is called approximation coefficient. The output of HPF contains only high frequency non-essential information and is known as detail coefficient. For applying wavelet technique first we have to choose an appropriate mother wavelet and level of decomposition of the signal [5]. Choosing a mother wavelet depends on the type of the signal we have to decompose. With image de-noising our objective is to improve quality of the noisy image, so wavelet can be selected on the basis of energy conservation properties in approximation coefficients. For selecting a decomposition level, if the frame based input is applied, then frame size must be a multiple of  $2^n$ , where  $n$  represents the decomposition level.

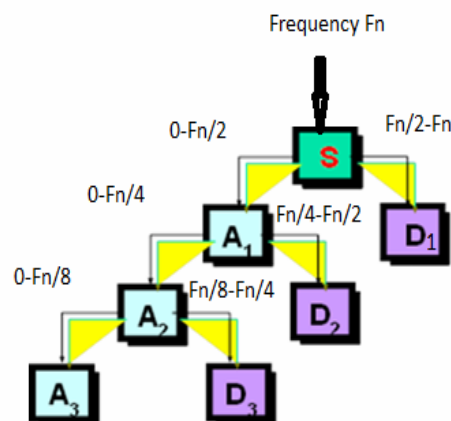


Fig.2 (Wavelet decomposition) [10]

## 3. THRESHOLDING OF COEFFICIENTS

After applying wavelet transform, input signal is divided into coefficients. Then for image de-noising thresholding is done. There are two types of thresholding one is hard thresholding while other is soft thresholding. Generally hard thresholding is used for signal compression and soft thresholding is used for image de-noising. Here we used soft thresholding [8] for signal de-noising. After chosen soft thresholding there are two types for finding a threshold value named by global thresholding and level dependent thresholding [4]. In global thresholding a threshold value is set manually. For level dependent thresholding we use Brige-Massart strategy that yields a different threshold values for each level. To de-noise a signal we use a MATLAB command *wdenomp* that enables us to choose between global and level dependent thresholding. Coefficient thresholding discards the coefficient that has a value below the threshold level and the resulted signal is de-noised signal. In wavelet de-noising method we have taken noisy image as an input image in which speckle noise is added.

De-noising procedure principle [8]

The wavelet thresholding de-noising procedure involves three steps.

### 3.1 Decompose Input Image

Choosing an appropriate mother wavelet; choosing a level  $N$ . Computing the wavelet decomposition of the image  $s$  at level  $N$ .

### 3.2 Thresholding of Detail Coefficients

For each level from 1 to  $N$ , selecting a threshold and applying soft thresholding to the detail coefficients.

### 3.3 Reconstruction

We compute wavelet reconstruction using the original approximation coefficients of level  $N$  and the modified detail coefficients from level 1 to  $N$ .

Thresholding can be done using the function

$$yt = wthresh(y, sorh, thr).$$

This function returns soft or hard thresholding of input  $y$ , depending on the  $sorh$  option.

Let  $t$  denote the threshold. The hard threshold signal is  $x$  if  $|x| > t$ , and is 0 if  $|x| \leq t$ . The soft threshold signal is  $\text{sign}(x)(|x| - t)$  if  $|x| > t$  and is 0 if  $|x| \leq t$ .

Hard thresholding can be described as the usual process of setting to zero the coefficients whose absolute values are lower than the threshold. Soft thresholding is different from hard thresholding in which, first setting to zero the elements whose absolute values are lower than the threshold value, and then shrinking the nonzero coefficients toward 0.

## 4. PERFORMANCE ANALYSIS

In this paper we have taken a JPEG image shown in fig.3 for de-noising purpose. In this paper we have applied thresholding technique at separate planes of noisy image. After applied wavelet thresholding technique extra smoothness existed into de-noised image so we performed image adjustment of de-noised signal. The difference can be seen in figure 8 and 9.



Fig.3 (Original JPEG image)

Speckle noise has been added in original for making it noisy image shown in fig.4. For de-noising purpose we have separated all three planes of noisy image. Thresholding has been applied in all the planes separately and after truncation of non-essential coefficient we have assembled all the planes that yields de-noised image. Histograms of red, green and blue planes are shown in fig.5, 6 and 7 respectively.

noisy image

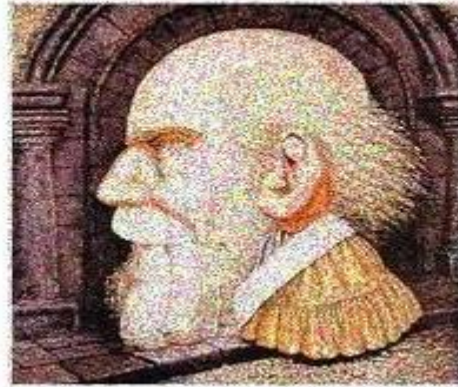


Fig.4 (Noisy image)

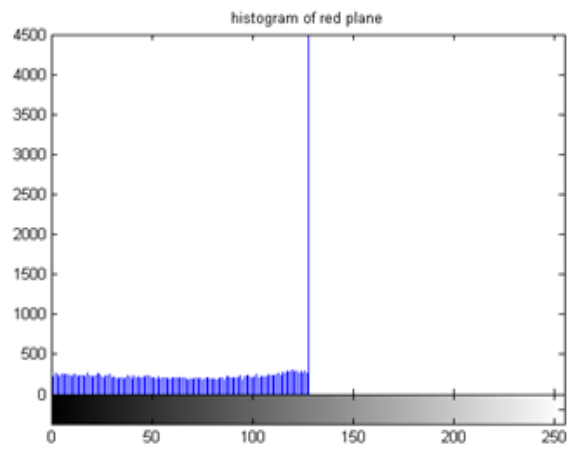


Fig.5 (Histogram of Red plane)

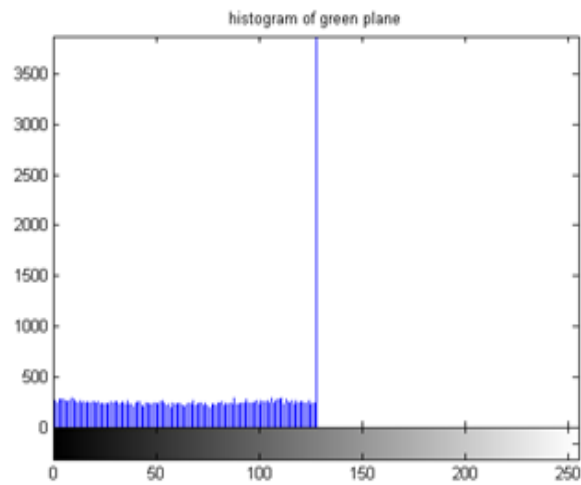


Fig.6 (Histogram of Green plane)

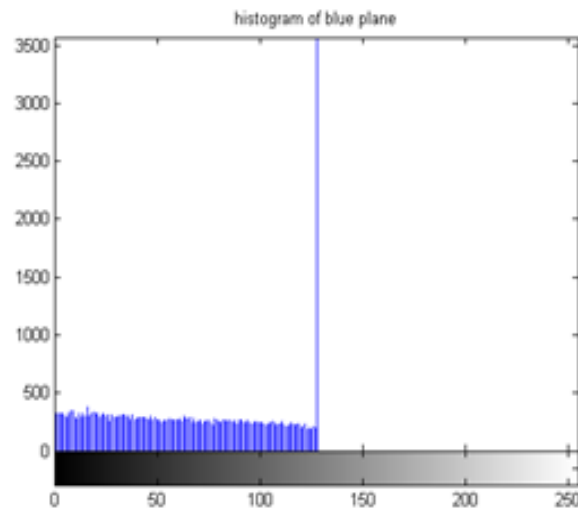


Fig.7 (Histogram of Blue plane)

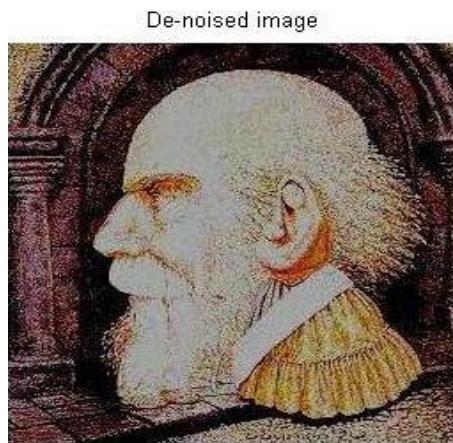


Fig.8 (De-noised image)

Because of soft thresholding extra smoothing existed in image so we used adjustment command at separate planes of de-noised image for better enhanced image shown in fig.9.

de-noise image after adjustment

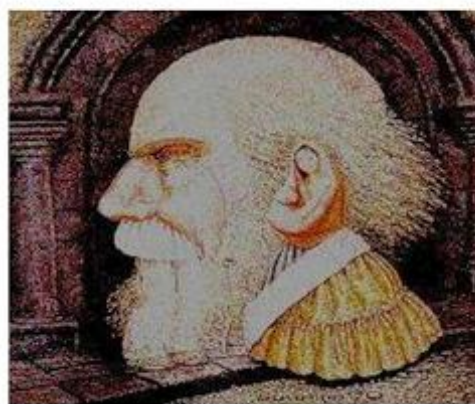


Fig.9 (image after adjustment)

	After de-noising	After adjustment
RMSE	15.5062	13.7123
PSNR(dB)	24.3201	25.3885

Table (a)

In this paper image enhancement has been done in two stages. At first stage we have applied wavelet thresholding technique while at second stage image adjustment has been done. We have shown the quality improvement in terms of Root mean square error (RMSE) and Peak signal to noise ratio (PSNR). To improve the quality of image, value of RMSE should be as low as possible while value of PSNR should be higher. So it's clear from table (a) that there is an improvement in quality of image after image de-noising and adjustment.

## 5. CONCLUSION

In this paper the image de-noising process has been simulated on MATLAB 2010. Wavelet thresholding method has been used for de-noising of the image corrupted by speckle noise. We have used separate planes of noisy image for de-noising and removed the noise at great extent and histograms of all three planes have been shown in figure 5, 6 and 7. Because of extra smoothness in de-noised image we applied adjustment command and result is shown in figure 9. Image quality improvement has been shown in terms of RMSE and PSNR (in table a). This technique will be very useful for de-noising satellite images.

## 6. REFERENCES

- [1] Dai-fei Guo, Wei-hong Zhu, Zhen-ming Gao and Jian-qiang Zhang, "A Study of Wavelet Thresholding De-noising", 0-7803-5747-7/00/\$10.00 02000 IEEE.
- [2] S. Grace Chang, Student Member, IEEE, Bin Yu, Senior Member, IEEE, and Martin Vetterli, Fellow, IEEE, "Adaptive Wavelet Thresholding for Image De-noising and Compression", IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 9, NO. 9, SEPTEMBER 2000.
- [3] Qu Tianshu, Wang Slinxun, Clieii Haihua and Dai Yisong, "Adaptive De-noising Based on Wavelet Thresholding Method", 0-7803-7488-6/02/\$17.00 0 2002 IEEE.
- [4] Birgé, L.; P. Massart (1997), "From model selection to adaptive estimation," in D. Pollard (ed), Festschrift for L. Le Cam, Springer, pp. 55-88.
- [5] DeVore, R.A.; B. Jawerth, B.J. Lucier (1992), "Image compression through wavelet transform coding," IEEE Trans. on Inf. Theory, vol. 38, No 2, pp. 719-746.
- [6] Donoho, D.L.; I.M. Johnstone (1994), "Ideal spatial adaptation by wavelet shrinkage," Biometrika, vol. 81, pp. 425-455.
- [7] Donoho, D.L.; I.M. Johnstone, G. Kerkycharian, D. Picard (1995), "Wavelet shrinkage: asymptopia," Jour. Roy. Stat. Soc., series B, vol. 57 no. 2, pp. 301-369.
- [8] Donoho, D.L. (1995), "De-noising by soft-thresholding," IEEE Trans. on Inf. Theory, 41, 3, pp. 613-627.
- [9] Chui, C.K. (1992a), "Wavelets: a tutorial in theory and applications", Academic Press.
- [10] Satish kumar, O.P. Singh, G.R. Mishra, Saurabh Kumar Mishra, Akanksha Trivedi "Speech Compression and Enhancement using Wavelet Coders", International Journal of Electronics Communication and Computer Engineering Volume 3, Issue 6, ISSN (Online): 2249-071X, ISSN (Print): 2278-4209.