International Journal of Engineering Research And Management (IJERM)
ISSN : 2349- 2058, Volume-02, Issue-01, January 2015

An Novel Approach for image denoising using Wavelet Transforms

Manmohan, Swati gupta, Kuldeep

***Abstract*— The noise is unwanted signal which change the parameters of the original signal or original data. So it is necessary to remove the noise from the signals or from the data, many image denoising techniques based on filtering and wavelet thresholding have been published in earlier research papers and each technique has its own assumptions, advantages and limitations. Image filtering and wavelet thresholding algorithms are applied on different image samples to eliminate noise which is either present in the image during capturing or injected into the image during transmission.**

In this paper, we used the Median filter ,Wiener filter, Penalised threshold, Global threshold method, Proposed threshold for remove the Gaussian or salt & pepper noise from the images, and we compare their performance with the help of PSNR.

***Index Terms*— Wavelet-transform; MATLAB; Threshold function,penalised threshold,global threshold,Gaussian noise; Salt & Pepper noise; Median filter; Wiener Filter; PSNR.**

I. INTRODUCTION

The image usually has noise which is not easily removed in image processing. According to actual image feature, noise arithmetical property and frequency scale distribution rule, people have developed many methods of eliminating noises, which in the order of are divided into space and transformation fields The space field is data operation carried on the original image, and processes the image grey value, like neighborhood average method, wiener filter, Median filter and so on. The configuration and features of the given signal may be better understood by transforming the data into another domain. There are several transforms like Fourier transform, Laplace transform, wavelet transform etc. However the Fourier transform gives only the frequency-amplitude representation of the signal. So we cannot use the Fourier transform in applications which require both time as well as frequency domain at the same time. Then the aim of eliminating noise is achieved by inverse transformation, using the wavelet transform

II. MEDIAN FILTER

The Median Filter [13] is performed by taking the scale of all of the vectors within a cover and sorted according to the magnitudes. The pixel with the median magnitude is then used to swap the pixel studied.

The Simple Median Filter has an improvement over the Mean filter since median of the data is taken as an alternative of the mean of an image. The pixel with the median size is then used to replace the pixel studied. The median of a set is stronger with respect to the presence of noise. Median is much less responsive than the mean to extreme values therefore; median filtering is capable to remove these outliers without reducing the irregularity of an image.

The median filter is given by –

$$Median\ filter(x1..xN) = Median(\| x1 \|2 \ldots\ldots \| xN \| 2)$$

III. WIENER FILTER

The aim of the Wiener filter [12] is to filter out noise that has degraded a signal. It is based on a statistical come within reach of. Typical filters are planned for a desired frequency response. The Wiener filter approaches filtering from a diverse angle. One is understood to have knowledge of the spectral properties of the original signal and the noise, and one seeks the LTI filter whose output would come as close to the original signal as likely.

The Wiener filter is:

$$w(f1,f2) = \frac{H'(f1,f2)Sx(f1,f2)}{|H(f1,f2)|^2 Sx(f1,f2) + Sn(f1,f2)}$$

Where

H (f1, f2) = Degradation function

H’ (f1, f2) = Complex conjugate of degradation function

Sn (f1, f2) = Power Spectral Density of Noise

Sx (f1, f2) = Power Spectral Density of un-degraded image

IV. WAVELET THRESHOLD DENOISING PRINCIPAL

The two methods are effective and practical methods for removing the noise of the images. In general, the signal is more smoothness by using soft threshold method [1] to remove the noise, while using hard threshold method, the de-noising signal has a lower error with the real signal. These methods also have some defects. In the hard threshold method, the wavelet coefficients processed by the threshold are discontinuous at the two point’s λ and - λ therefore, which may lead to Gibbs oscillation in the soft threshold method, the continuity of soft threshold function is good, but when the wavelet coefficients are greater than the threshold, there will be a constant deviation between the original wavelet coefficients and the wavelet coefficients after de-noising, which makes it impossible to reserve the features of the images effectively. The soft and hard threshold

Manuscript received Jan 24, 2015

Manmohan, Department of Electronics & Communication, PIET, PANIPAT, INDIA

Swati gupta, Department of Electronics & Communication, PIET, PANIPAT, INDIA

Kuldeep, Department of Electronics & Communication Engineering, RNCET, PANIPAT, INDIA

function method proposed by Donoho has been widely used in practice. In the hard threshold method, the wavelet coefficients processed by the threshold value have discontinuous point on the threshold **λ** and ,-**λ** which may cause Gibbs shock to the useful reconstructed signal.
In the soft-thresholding method, its continuity is good, 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 features of the images effectively.

V. GLOBAL THRESHOLD FUNCTION

The global threshold is also known as Universal threshold .After several decades of research & development; it has been found that shrinkage function is of many types, such as, bayes shrinkage, SURE shrinkage, visu shrinkage [6]. All these thresholds and shrinkage functions promoted the application of wavelets in signal denoising extremely. The soft- and hard-thresholding schemes are defined by [6]

(a) Hard-Thresholding:
The Hard-Thresholding function keeps the input if it is larger than the threshold; otherwise, it is set to zero [6]It is described as:

$$W'j,k = \begin{cases} W\,j,k, & |w\,j,k| \geq \lambda \\ 0, & |w\,j,k| < \lambda \end{cases} \quad \ldots\ldots (1)$$

Soft- thresholding:
The soft-thresholding function has a somewhat different rule from the hard-thresholding function. It shrinks the wavelet coefficients whose values are less than threshold value, and keeps the wavelet coefficients whose values are larger than threshold value [6], which is the reason why it is also called the wavelet shrinkage function.

$$w'j,k = \begin{cases} \mathrm{sgn}(Wj,k).\left(|Wj,k| - \lambda\right), & |Wj,k| \geq \lambda \\ 0, & |Wj,k| < \lambda \end{cases} \quad \ldots..(2)$$

Where sgn is a sign function, $w_{j,k}$ stands for wavelet coefficients, $w'_{j,k}$ stands for wavelet coefficients after treatment, λ stands for threshold value and it can be expressed as follows:

$$\lambda = \sigma\sqrt{2\log(k)} \quad \ldots\ldots\ldots(3)$$

$$\sigma = \mathrm{median}(|c|)/0.6745 \quad \ldots\ldots\ldots.(4)$$

…(4)

Where *K* is the number of data samples deviation of zero-mean additive white Gaussian noise (AWGN), estimated by Donoho and Johnston, and *c* is the detail coefficients of wavelet transform.
The soft-thresholding rule is chosen over hard-thresholding, for the soft-thresholding method yields more visually pleasant images over hard thresholding [1].

VI. PENALIZED THRESHOLDING

In this, the value of threshold is obtained by a wavelet coefficients selection rule using a penalization method provided by Birge-Massart. [12]

MATLAB code for Penalized Threshold
THR=wbmpen (C, L, Sigma, Alpha)

Where
[C,L] is the wavelet decomposition structure of the signal or image to be de-noised.

SIGMA is the standard deviation of the zero mean Gaussian white noise in de-noising model.

ALPHA is a tuning parameter for the penalty term. It must be a real number greater than 1. The sparsity of the wavelet representation of the de-noised signal or image grows with ALPHA. Typically ALPHA = 2.

VII. PROPOSED THRESHOLD

Finding an optimized value for threshold is a major problem. A small threshold will exceed all the noise coefficients so the denoised signal is still noisy. in opposition a large threshold value makes more number of coefficients as zero which leads to smooth signal and destroys details that may cause blur and artifacts [1]. So, optimum threshold value should be found out, which is adaptive to different sub band characteristics. Here we select an efficient threshold value for different types of noise to get high value of PSNR as compared to previously explained methods.
The PSNR computes the peak signal-to-noise ratio, in decibels, between two images. This ratio is often used as a quality measurement between the original and a compressed image. The higher the PSNR, the better the quality of the reconstructed image.
The *Mean Square Error (MSE) [9]* and the *Peak Signal to Noise Ratio (PSNR) [9]* are the two error metrics used to compare image compression quality. The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error. The lower the value of MSE, the lower the error.
To compute the PSNR, the block first calculates the mean-squared error using the following equation:

$$MSE = \frac{\Sigma\,[I1(m,n) - I2(m,n)]^2}{M*N} \quad \ldots\ldots\ldots\ldots\ldots.. (5)$$

In the previous equation, ***M*** and ***N*** are the number of rows and columns in the input images, respectively.I1 & I2 are input images. Then the block computes the PSNR using the following equation:

$$PSNR = 10\log\left(\frac{R^2}{MSE}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots..(6)$$

In the equation, ***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.

VIII. IMAGE NOISE

Image noise is the random variation of brightness or color information in images produced by the sensor and circuitry of a scanner or digital camera. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector [9]. Image noise is generally regarded as an undesirable by-product of image capture. Although these unwanted fluctuations became known as "noise" by analogy with unwanted sound they are inaudible and actually beneficial in some applications, such as dithering. The types of noise which are mostly present in images are:-

1. **Gaussian noise**

The standard model of amplifier noise is additive, Gaussian, independent at each pixel and independent of the signal intensity. In color cameras where more amplification is used in the blue color channel than in the green or red channel, there can be more noise in the blue channel .Amplifier noise is a major part of the "read noise" of an image sensor, that is, of the constant noise level in dark areas of the image[9].

The probability density function of *n*-dimensional Gaussian noise is

$$f(x) = ((2\pi)^{n} \det K)^{\wedge} - 1/2 \ - \exp(-(x - \mu)^{T} K^{-1} (x - \mu)/2)$$
………………………………………(7)

Where x is a length-n vector, K is the n-by-n covariance matrix, μ is the mean value vector, and the superscript T indicates matrix transpose.

2. **Salt-and-pepper noise**

Impulsive noise is sometimes called salt-and-pepper noise or spike noise. An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions. This type of noise can be caused by dead pixels, analog-to-digital converter errors, bit errors in transmission, etc.

IX. SIMULATION RESULTS

The Original Image is natural image, adding two types of Noise (Gaussian noise, Salt & Pepper noise) and De-noised image using Median filter, Wiener filter, Penalized Threshold, Global Threshold and Proposed method and comparisons psnr among them .

Table which shows the Performance analysis of Median filter, Wiener filter, penalized threshold, global threshold and proposed threshold for different type of noise is given below:

Type of Noise / Type of Filter	Salt & Paper Noise	Gaussian Noise
Wiener Filter	26.0775	27.7285
Median Filter	29.0698	26.9428
Penalized Threshold	27.2122	26.1635
Global Threshold	27.6027	27.502
Purposed Threshold	30.2966	30.1945

Table: PSNR of test image corrupted by different types of noise using various denoising methods

original gray scale image

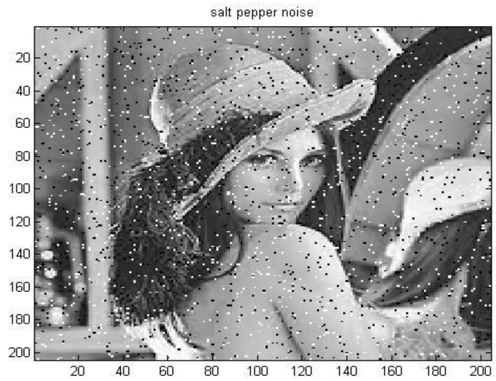


Image with salt & pepper noise

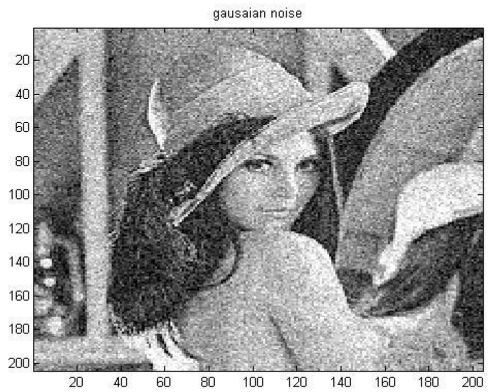


Image with Gaussian noise

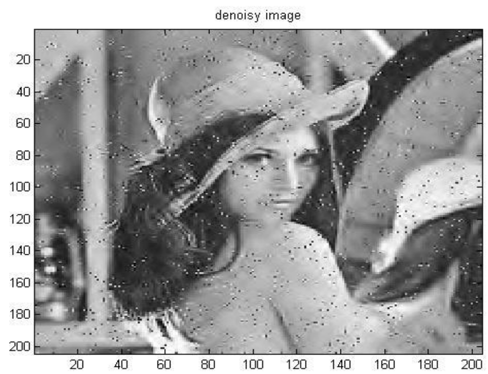


Image denoising using proposed threshold (for salt &pepper noise)

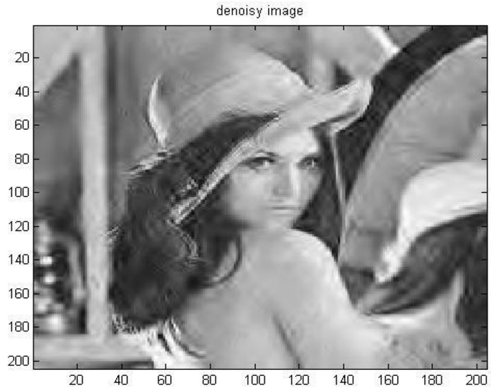


Image denoising using proposed threshold (for Gaussian noise)

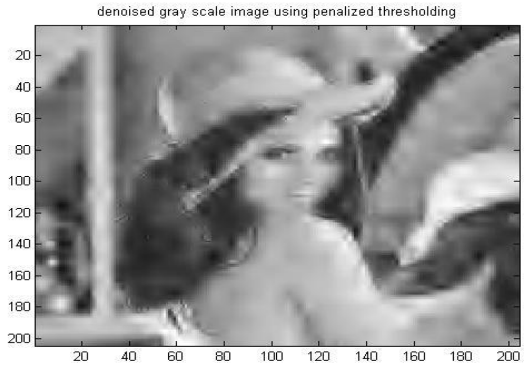


Image denoising using penalized threshold (for Gaussian noise)

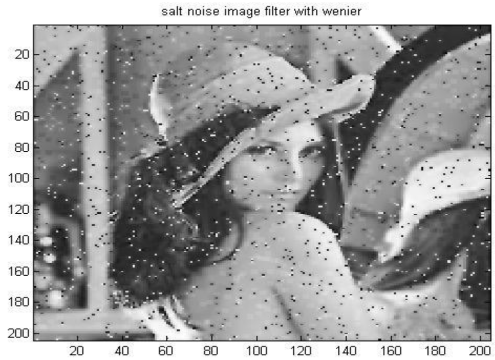


Image denoising using wiener filter (for salt &pepper noise)

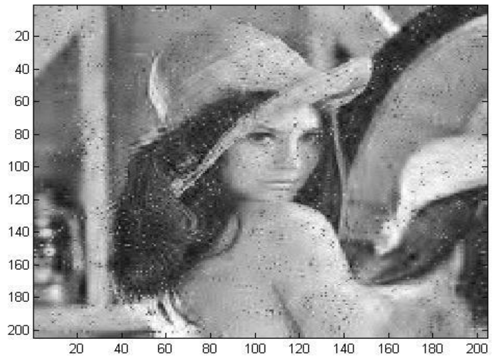


Image denoising using penalized threshold (for salt &pepper noise)

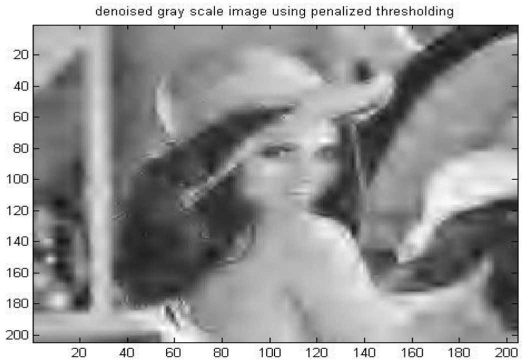


Image denoising using penalized threshold (for Gaussian noise)

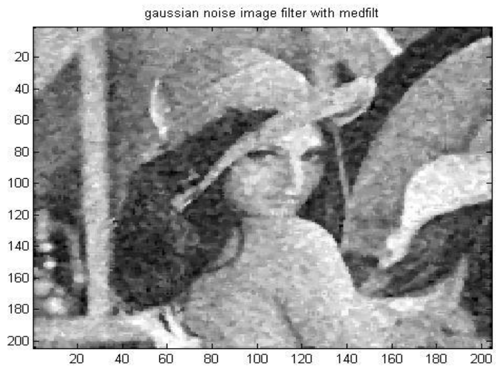


Image denoising using median filter (for Gaussian noise)

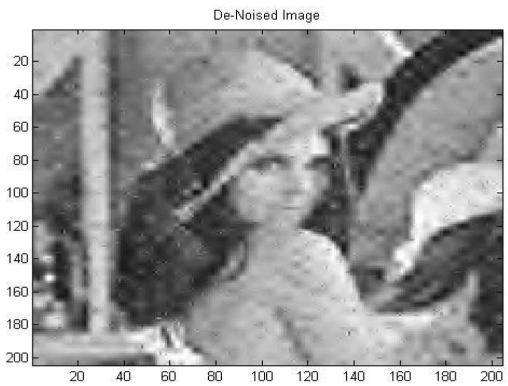


Image noising using global threshold (for salt & pepper noise)

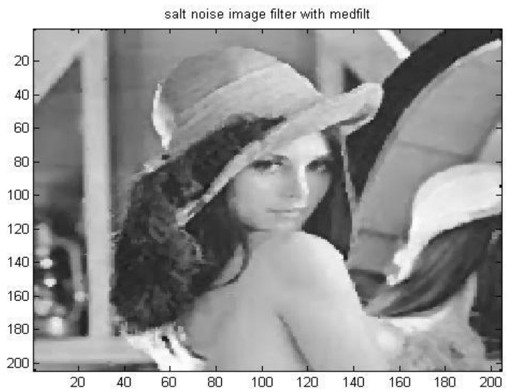
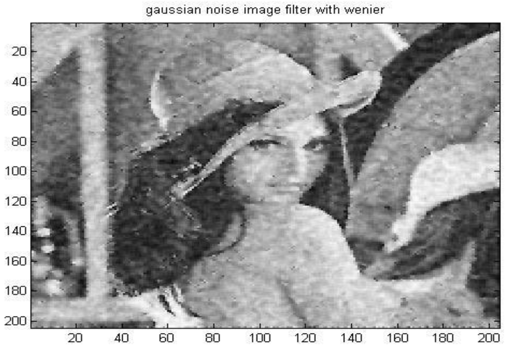


Image denoising using median filter (for salt &pepper noise)



xiii) Image denoising using the wiener filter (for Gaussian noise)

CONCLUSION

In this paper, we have proposed a new threshold technique in which a gray scale image in jpeg format is injected noise of different types such as Gaussian and Salt & Pepper. Further, the noised image is denoised by using different filtering and denoising techniques. From the results (figure (iv) to figure (xiii)) we conclude that:-

The proposed threshold mentioned in this paper shows better presentation over other techniques. Thus we can say that the proposed threshold may find applications in image processing system, image denoised medical ultrasounds and use of other application

REFERENCES

[1] "A wavelet denoising method based on the improved threshold function" Jian-Fei Wang Wavelet Analysis and Pattern Recognition (ICWAPR), 2014 International Conference on *DOI: 10.1109/ICWAPR.2014.6961293* Publication Year: 2014 , Page(s): 70 – 74

[2] "Channel noise reduction for compressed images usingsin gular value decomposition" Manchanda,M. ; Gambhir, D. Confluence The Next Generation Information Technology Summit (Confluence), 2014 5th International Conference - *DOI: 10.1109/CONFLUENCE.2014.6949241* Publication Year: 2014 , Page(s): 613 – 618

[3] "A New Thresholding Technique for Despeckling of Medi cal Ultrasound Images" Kaur, R. ; Girdhar, A. ; Kaur, J. Advances in Computing and Communications (ICACC), 2014 Fourth International Conference on *DOI: 10.1109/ICACC.2014.26* Publication Year: 2014 , Page(s): 84 - 88

[4] "Medical image denoising using neighboring coefficients preservation" Yang, Ying ; Wei, Yusen ; Yang, Ming Natural Computation (ICNC), 2014 10th International Conference on *DOI: 10.1109/ICNC.2014.6975826* Publication Year: 2014 , Page(s): 149 - 154

[5] "A novel wavelet based denoising algorithm using level" dependent thresholding Gopi, V.P. ; Pavithran, M. ; Nishanth, T. ; Balaji, S. ; Rajavelu, V. ;Palanisamy, P. Electronics and Communication Systems (ICECS), 2014 *International Conference on DOI: 10.1109/ECS.2014.6892687* Publication Year: 2014 , Page(s): 1 – 6

[6] "Signal denoising based on wavelet transform using a mult i-level threshold function "Golroudbari, M.A. Application of Information and Communication Technologies (AICT), 2013 *7th International Conference on DOI: 10.1109/ICAICT.2013.6722677* Publication Year: 2013 , Page(s): 1 – 5

[7] "Adaptive image denoising using wavelet thresholding" Liwen Dong Information Science and Technology (ICIST), 2013 *International Conference on DOI: 10.1109/ICIST.2013.6747675* Publication Year: 2013 , Page(s): 854 – 857

[8] "Image DeNoising Algorithm Using Adaptive BayesThres hold by Subband Based on Nonsubsampled Contourlet Transform" Ou Yang ; Hong Bo Intelligent System Design and Engineering Applications (ISDEA), 2013 *Third International Conference on DOI: 10.1109/ISDEA.2012.197* Publication Year: 2013 , Page(s): 832 – 835

[9] "A new wavelet hard threshold to process image withstron g Gaussian Noise" Cheng Chen ; Ningning Zhou Advanced Computational Intelligence (ICACI), 2012 IEEE *Fifth International Conference on DOI: 10.1109/ICACI.2012.6463226* Publication Year: 2012 , Page(s): 558 – 561

[10] "Gaussian noise removal in gray scale images using fast Multiscale Directional Filter Banks" E.J. ; Sutha, S. Recent Trends in Information Technology (ICRTIT), 2011 *International Conference on DOI: 10.1109/ICRTIT.2011.5972377* Publication Year: 2011 , Page(s): 884 – 889

[11] "Perfprmance Comparison of Median and WienerFilter in image denoising" Suresh Kumar, Papendra Kumar, Manoj Gupta, Ashok Kumar Nagawat (2010)..*International journal of Computer Applications (0975 - 8887)* Volume 12 - No.4, November 2010, pp27 – 31.

[12] "Two dimensional signal and image processing" Lim, Jae S., Englewood Cliffs, NJ, *Prentice Hall, 1990*, p. 548, equations 9.44-9.4

[13] "Two dimensional signal and image processing," Lim, Jae S., Englewood Cliffs, NJ, *Prentice Hall, 1990*, pp. 469-476.

[14] "wavelet based image denoising using adaptive thresholding". S. Sudha, G. R. Suresh, R. Sukanesh (2007). *International Conference on Computational Intelligence and Multimedia Applications 2007*, pp296-299.

[15] "Wavelet domain image de-noising by thresholding and Wiener filtering". Kazubek, M. Signal Processing Letters *IEEE, Volume: 10, Issue*: 11, Nov. 2003 265 Vol.3.