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Image Denoising using Local Adaptive Wiener Filter in Spatial and Temporal Domain

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Abstract — **Denoising of image is an important task in image processing, and it plays a decisive role in modern affairs of different fields. This noise is introduced during acquisition, transmission and storage and regeneration processes. In this paper we have compared the performance of wiener filter for denoising and then used wiener filtering over wavelet decomposition of image. This method gives improved results of modified denoising method and the local adaptive wavelet image denoising method. Firstly the modified denoising method is used over noisy image which is based on temporal domain and spatial domain and then local adaptive wavelet image denoising method which is based on temporal domain. In this paper, we have calculated and correlated the performances of modified denoising method and the local adaptive wavelet image denoising method. Comparision of above two methods done with the values of their PSNR between original image and noisy image. We have also calculated the MSE between noisy image and denoised image. Experimental results demonstrate that the MSE of the local adaptive wavelet image denoising method is least as compare to modified denoising method. The PSNR of proposed denoising method was reported higher than the other methods. Therefore, the denoised image has a better visual effect after denoising. In this paper, these two methods are implemented by using MATLAB R2014a for denoising of image.**

Keywords—Image denoising ; Adaptive wiener filter; PSNR;

I. INTRODUCTION

Digital images play an important role both in daily Life applications such as satellite television, computer tomography as well as in areas of research and technology such as geographical information systems and astronomy. In reality, an image is mixed with certain amount of noise which decreases visual quality of image. Therefore removal of noise is very typical problem from an image in image processing. The image gets corrupted with noise during acquisition or at transmission due to channel errors or in storage media due to faulty hardware. Removing noise from the noisy image is still a challenging problem for researchers.

Noise can be classified as substitutive noise (impulsive noise: e.g., salt and pepper noise, random valued impulse noise, etc.), additive white Gaussian noise) and multiplicative noise (e.g. speckle noise). However, in this paper we have investigated additive white Gaussian noise. In general, the aim of any noise removal process is to suppress noise and further preserve the details in edges of image as per the possibility.

Elimination of noise is an important in the image processing. Fig. 1 shows the basic model for denoising of image. In the implementation of these methods, firstly the image having noise use to decomposed by wavelet transform. After this, thresholding shrinkage get used on decomposed images and then apply adaptive wiener filter over decomposed images. Finally the inverse wavelet transform get applied to the noisy images. Hence, the denoised image obtained by this technique. This overview of technique is shown in fig.1

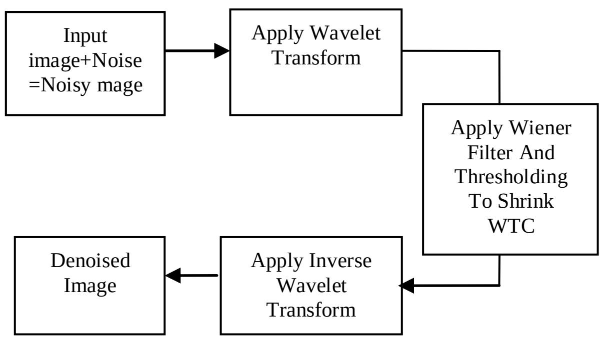

Fig.1 Basic model for denoising of image[2]

In the recent year most of the denoising strategy in wavelet domain depend on threshold selection and Shrinking of wavelet transform coefficients for image denoising. Wavelet decomposes the image and separate noisy signal from original signal on appropriate basis in [2]. Adaptive wiener filtering is one of filtering techniques to remove the noise from noisy images. Owing to its simplicity and effectiveness, more attention is considered on wavelet based adaptive wiener denoising in. Modified wiener filter is proposed by C. M. Leung and W. S. Lu which is shown that how the conventional wiener filters can be improved for the restoration of blurred images in, afterward various wavelet based wiener filtering and thresholding approaches have been proposed. However, this paper has the consideration of two different denoising methods for image. In these methods adaptive wiener filter employed to suppress additive noise i.e. AWGN in noisy image.

In modified denoising method which is based on wavelet domain and spatial domain, wavelet transform is used for decomposition of image but wavelet domain adaptive wiener filtering has some drawbacks. To overcome these drawbacks, we can use a modified denoising method for image denoising which is based on combination of wavelet and spatial domain adaptive wiener filtering and results of this modified denoising method can also increase by using the local adaptive wavelet image denoising method in which 1-D window is constructed in wiener filter design.

In this paper, the Mat lab based two methods performances are evaluated. Finally the comparison results are obtained.

II. LOCAL ADAPTIVE WIENER FILTERING

In 1994 Norbert Wiener proposed the method of optimal filter called as wiener filter [2] which can give satisfactory results for image denoising. Due to its simplicity and effectiveness, we use adaptive wiener filter in modified denoising method and the local adaptive wavelet image denoising method.

Consider an image is corrupted with AWGN. The noisy image can be modelled as:

$$y(i,j) = x(i,j) + n(i,j) \quad (1)$$

Where *y(i, j)* is the noisy image, *x(i ,j)* is the original image and *n(i,j)* is additive Gaussian white noise. The goal of image denoising is to suppress noise from noisy image with minimum mean square error. Here, the wiener filter minimizes the mean square error between the estimated image *x^(i,j)* and the original image *x(i,j)*. This error measure can be expressed as:

$$e^2 = \mathrm{E}[(x(i,j) - x^{\wedge}(i,j)^2)] \quad (1)$$

The image using pixel-wise adaptive Wiener filtering, using neighbourhoods of size M-by-N to estimate the local image mean and standard deviation. Here it assumes that the noise is stationary with zero mean and variance σ_n^2 and uncorrelated with the original image *x(i,j)*. Based on these assumptions wiener filter estimates local mean and variance around each pixel using (3) and(4)

$$\mu = \frac{1}{\mathrm{NM}} \sum_{(j\epsilon k)} y(i,j) \quad (3)$$

And

$$\sigma^2 = \frac{1}{NM} \sum_{i,j\epsilon k} y^2(i,j) - \mu^2 \quad (4)$$

Where σ is local mean and σ^2 is local variance. Then wiener filter creates a pixel wise filtering using these estimates and the estimated image is given in (5) as below:

$$x^{\wedge}(i,j) = \mu + \frac{\sigma^2 - \sigma_n^2}{\sigma^2}(y(i,j) - \mu) \quad (5)$$

Where σ_n^2 is the noise variance. These forms of equaition can be documented in [2].

The wiener filtering technique fails to produce satisfactory result for broad range of low contrast images and also computationally expensive. To overcome the weakness of the wiener filter, Donoho discussed the wavelet based image denoising threshold that removes the noise significantly.

III. MODIFIED DENOISING METHOD

Wavelet transform (WT) has been a powerful and wildly used tool in image denoising because of its energy compaction and multiresolution properties. It overcomes some limitations of Fourier transform with its ability to represent a function simultaneously in frequency and time domain. In WT, DWT (Discrete wavelet transform) i.e. critically sampled form of WT provides most compact representation. Therefore, in this paper the DWT is applied to the image for separation of horizontal, vertical and diagonal details of image. We apply the DWT based on Haar wavelet as a Family of Daubechies Wavelet. The Daubechies wavelet is the first known wavelet and was proposed by Daubechies. It is the simplest of all wavelets and its operation is easy to understand since it defines the discrete wavelet transform and helps in multiresolution analysis. Daubechies wavelets have their limitations too. They are piecewise constant and hence produce irregular, blocky approximations.

As wavelet coefficients calculated by a Wavelet transform. Then it is possible to filter out the noise from wavelet coefficients by wiener filter. Wavelet transform decomposes image into sub images and make easy to denoise the image. Normally, the purpose of denoising is to remove the noise while retaining the edges and other detailed features as much as possible. But when we use wavelet domain adaptive wiener filtering to remove noise, the results are not satisfactory because image suffers from more ripples like artifacts i.e. ringing effects of image around edges and provides low the peak signal to noise ratio (PSNR). Fig. 2 shows one example of image with ringing effect and without ringing effect. This decreases the visual quality of denoised image.

Fig. 2 a) Image with ringing effect and b) Image without ringing effect [2]

This will affect our extreme goal which is to reduce noise from noisy image and to preserve details and edges of image as much as possible. One of the ways to solve this problem use a modified denoising method which is based on combination of both wavelet domain adaptive wiener filtering and spatial domain adaptive wiener filtering

In this type denoising of image has been carried out firstly on the basis of adaptive wiener filtering in the wavelet domain and then on the basis of an adaptive wiener filter in the spatial domain. In the implementation of this method, first a predenoised image is obtained with the thresholding in the wavelet domain. Then an adaptive wiener filtering in spatial domain is applied to the reconstructed image to improve the accuracy. Here, the spatial wiener filtering is one of the classical linear filtering in the spatial domain, while the wavelet domain wiener filtering is a new signal estimation method. To form a modified denoising method, we can combine the methods of the image denoising in spatial domain and the one in wavelet domain.

The Modified denoising algorithm described in the following manner:

1. First select an image, check, is it gray image or color image? If color image then firstly convert this image into gray image. Then use it as input image.
2. Now take the noisy image and apply wavelet transform (DWT) to decompose it into four sub bands(images),i.e., in LL, HL, LH, and HH.
3. After this apply the wiener filter to LL sub image.Wiener filter also adopts to get denoised image by spatial domain adaptive wiener filtering and also we get denoised image by wavelet.
4. After this apply the thresholding to remaining sub images i.e. for HL,LH, and HH.
   This threshold is an important denoising method, which is proportional to the standard deviation of noise. It follows the soft thresholding rule which is also referred to as the universal threshold[2]. The threshold is defined by
   $$T = \sigma\sqrt{2logs}$$
   Where 'σ' is the standard deviation of noise and 's' is the showing subbands other than LL band. This threshold would apply to different bands separately.
5. Now combine all four sub bands and apply inverse wavelet transform to reconstruct the image.
6. To process the result of modified denoising method again apply wiener filter to the reconstructed image.
7. Finally, calculate PSNR between original image and noisy image and PSNR between the denoised image and original image, to make sure a match between wavelet domain adaptive wiener filtering and spatial domain adaptive wiener filtering.

SDWF minimizes the mean square error between denoised image and original image and estimation of denoised image is documented in.

The main benefit of using this method is that it reduces ripples like artifacts around image edges. Hence the denoised image has a better visual effect. Fig.3 shows the denoised images that have denoised by modified denoising method denoising of image in spatial domain, by wavelet and denoising of image in both domain. It can be seen that the visual quality of denoised image obtained by modified denoising method is better than other.

IV. THE LOCAL ADAPTIVE WAVELET DENOISING METHOD

Local adaptive wiener filter in wavelet domain can be used to improve the signal to noise ratio of image. We can improve the PSNR result of modified denoising method using local adaptive filters in this method. Local adaptive filters can be obtained from several 1-D windows which could be constructed on the direction character of sub image in the wiener filter. We can use 1-D windows for the LH and HL and HH sub images as shown in fig. 5 from left to right.

Different 1-D window structure to be used to estimate the mean and variance of sub-image. The window in Mat lab wiener2 filter is 5 by 5. Fig. 4 shows the shape of the 1-D window [15].

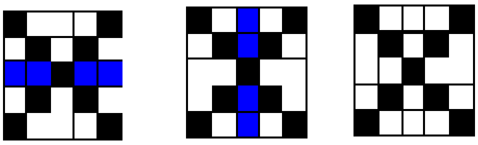

Fig.4 1-D window structures: from left to right: a) 1-D windows for LH, b) 1-D windows for HL and c) 1-D windows for HH.[2]

In this paper, to improve the signal to noise ratio of image by local adaptive wavelet image denoising method following steps follows:

1. First we apply wavelet transform (DWT) i.e. to decompose the noisy image into four sub images: LL, HL, LH and HH.
2. The next step will be to construct local adaptive Filters using several 1-D windows on the direction information contained in each sub image.
3. After this apply wiener filter for LL sub image and apply both local adaptive filters and thresholding to remaining sub images.
4. Then reconstructs image by wavelet inverse transform and we got the denoised image.

Finally, to calculate PSNR between original image and noisy image and PSNR between denoised image and the original image.

Figures below values for denoising methods applied for daubechies wavelet(db4)

Original Image

Noisy Image :: PSNR = 12.2335 dB :: MSE = 3888.0492

LOCAL ADAPTIVE WIENER FILTERING :: PSNR = 21.2674 dB :: MSE = 485.6658

Discrete Wavelet Transform :: PSNR = 18.0256 dB :: MSE = 1024.5102

MODIFIED DENOISING METHOD :: PSNR = 24.4329 dB :: MSE = 234.3078

THE LOCAL ADAPTIVE WAVELET DENOISING METHOD :: PSNR = 24.6416 dB :: MSE = 223.3159

TABLE I. RESULTS OF DENOISED IMAGE BY LOCAL ADAPTIVE WIENER FILTER FOR LENA IMAGE IN DAUBECHIES(DB4) WAVELET.

Image (Lena)	Noisy Image	Local Adaptive Wiener Filtering	Discrete Wavelet Transform	Modified Method	Local Adaptive Wavelet Denoising Method
PSNR	12.2335	21.2674	18.0258	24.4329	24.6416
MSE	3888.04	485.665	1024.510	234.307	223.3159

V. RESULTS

The performance of above method for denoising of image were tested on set of grayscale images such as Lena image, at noise variance 0.075. The quality of an image is examined by objective evaluation as well as subjective evaluation. For subjective evaluation, the image has to be observed by a human expert. But the human visual system (HVS) is so complicated and this cannot give the exact quality of image. The various factors used for evaluation of an image are mean square error (MSE) and peak signal to noise ratio (PSNR).

VI. CONCLUSION

The denoising of image is an important factor in terms of the quality image used for various purposes. For proper Denoising we have two major parts: wavelet transform for decomposition of image and adaptive wiener filtering in wavelet domain and spatial domain. The performance of the local adaptive wavelet image denoising method is good compared to modified denoising method in terms of PSNR between denoised image and original image. Hence, from these results it can be concluded that the local adaptive wavelet image denoising method is more effective for evaluation of noisy image than others. Thus the image after denoising has better details of evaluated values and preserves of edges of image.

REFERENCES

[1] H. Om, M. Biswas, “An adaptive image image denoising method based on local parameters optimization,” Sadhana vol. 39, Part 4, Aug 2014, pp.879-900.
[2] J. M. Parmar, and S. A. Patil, “Performance Evaluation and Comparison of Modified Denoising Method and Local Adaptive Wavelet Denoising Method,” *International Conference on Intelligent System and Signal Processing*, 2013.
[3] C. Zaiyu, L. Zengali, Liu yang, Tang Hui, “The selection of wavelet Function In Singular Signal Detection,” *International Conference on Computer Science and Electronics*,” 2013.
[4] K. Gupta, S. K. Gupta, “Image Denoising Techniques- A Review Paper,” *International Journal of Innovative Technology and Exploring Engineering*, vol. 2, 2278-3075, March 2013.
[5] D.Mistry, A. Banerjee, “Discrete wavelet Transform using Mat lab,” *International Journal of Computer Engineering and Technology*, , vol. 4, 0976-6367, Mar.-Apr. 2013.
[6] M. Kaur, G. Kaur Ap, “A Survey on Implementation of Discrete Wavelet Transform for Image Processing,” *International Journal of Communications Networking*, vol. 02, 2278-2427, June 2013.
[7] V.Gupta, V. Chourasia, M. Shandilya, “A Review on image denoising Techniques,” *V. Gupta et al., International Journal of Emerging Technology in Computational and Applied Sciences* , Jun-Aug 2013, pp. 204-208.
[8] Robi Polikar, Fundamental Concepts and An Overview of the Wavelet Theory, 2nd Edition, Tutorial in ppt., Rowan University: Glassboro, NJ 08028, october 2013.
[9] S.Sultana, M. Varun Kumar, N. Asha, “Comparision of image restoration and denoising techniques,” *International Journal of Advanced Reasearch in Computer Science and Engineering*, Vol. 3, 2277 128x, November 2013.
[10] S. Malik and V. Verma, “Daubechies wavelet for image compression,” vol.7, no. 11, 2012.
[11] H. Om, M. Biswas, “An Improved Image Denoising Method Based on Wavelet Thresholding,” *Journal of Signal and Information*, 2012,3, 109-116.
[12] Abdullah Al Jumah, “Denoising of an Image using Discrete Stationary Wavelet Transform and Various Thresholding Techniques,” 2012.
[13] S. Ruikar, D. D. Doye, “Wavelet Based Denoising Techniques,” *International Journal of Advanced Computer Science and Applications*, vol.2, No.3, Mar. 2011.
[14] S.Dangeti, “Denoising Techniques- A Comparision,” M. Sci. Thesis, Andhra University College of Engineering, Visakhapatnam, India, 2000, May 2003.
[15] R.C.Gonzalez, and R.E. Wood, “*Digital image processing*,”

2nd ed., New Jersy Prentice Hall, 2002.

[16] J. s. Lim,(1990) IEEEtrans, [online]. Available:in.mathworks.com/help/images/ref/wiener2.html.

[17] L.Shao, R.Yan, X. Li, Y. Liu, "From Heuristic Optimization to Dictionary Learning: A Review of and Comprehensive Comparision of Image Denoising Algorithm,".

[18] M. C. Motwani, M. C. Gadiya, R. C. Motwani, F. C. Harris, "Survey of Image Denoising,".

[19] J. C. Principe, Y. Dana N. Rao, D Erdogmus, "Error Whitening Wiener Filters: Theory and Algorithms," Univ. Of Florida, Gainsville, FL 32611.

[20]The IEEE website. [online]. Available: http//www.takeoffprojects.com/