DENOISING USING FRAMELET TRANSFORM

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ABSTRACT:Images are produced to record or display useful information or details .Due to flaws in the imaging and capturing process or transmission and compression process, the recorded image always represents noisy version of the original one. The undoing of these imperfections is critical to many of the successive image processing tasks. The visual quality of images plays an important role in accuracy of diagnosis which can be seriously degraded by existing noise. The noise affects both the diagnostic tasks and the ability of automatic computerized analysis, like segmentation, classification, image reconstructions and registration. There are two typical ways for noise reduction in the image processing. One way is that acquiring the data several times and averages them. However this processes is time consuming. Another way for denoise the images by post processing methods. For this purpose construction of efficient, less time consuming and high Quality technique need to be introduce. There are many techniques exist for denoising using wavelet transform but having drawbacks of losing high frequency component containing fine details. Wavelet transform has proved to be effective noise removal technique and also reduce computational complexity with better noise reduction performance. This paper describe the difference between image denoising using DWT and Framelet transform. Framelet transform provide shift invariance property. So using Framelet transform which is nearly similar to wavelet transform only with the difference is that framelet transform contains two or more high frequency filter bank which is used to produce more subband in decomposition.

KEYWORDS: DWT, Framelet Transform, AWGN Noise, Image denoising

I. INTRODUCTION:

Image denoising is preprocessing step in image processing. In day to day life too many images are captured in so many fields. Those images are transferred to many different locations. Like in MRI center and also Astronomical application, images are taken and transferred to different locations for analysis but during acquisition or transmission images are corrupted by some noise. Noise modeling in images which are greatly affects images because of instruments used in capturing, data transmission media, image quantization. Depending on noise models different algorithms are used. Most of the natural images are assumed to have additive random noise which is modeled as a Gaussian. In ultrasound images Speckle noise is observed whereas Rician noise affects MRI images[2]. Due to the presence of noise, the information which needs to analyse should be hidden. So that proper prediction is not possible in that case. Some of the standard algorithms use to remove noise from images and perform filtering process but the image is either over smoothen or blur due to loss of edges. Algorithm which remove noise from the image without loss of edges and reconstruct the Image nearer to original is needed. The common assumption during image denoising is that the image is contaminated with Additive White Gaussian noise with zero mean and known variance. It is also assume that the noise in image is stationary and uncorrelated among pixels.

An ideal image x is measured when additive white Gaussian noise with zero mean and constant variance is present in the image. We can formulate the observed image as:

$$y = x + n \tag{1}$$

Where y is the observed noisy image, x is the original image and n is the noise added in an image. So many transforms like FFT, STFT, (DWT)wavelet transform, etc. are available for removing noise from images with each have its own advantages and limitations. Images contain the low frequency component and high frequency component. Noise in the low frequency component can be removed easily with certain available techniques. But noise present in high frequency component which contains fine details of image cannot be removed easily. Because when we try to remove noise from high frequency component then there is possibility for losing fine details of the image. Transforms like wavelet transforms are used for image denoising using sub-band decomposition. Wavelet transform [6] is effective technique in noise removal and also reduce computational complexity, better noise reduction performance. But shift invariance property is absent in DWT. Shift variance exist due to critical sub sampling in DWT. Due to this property every second wavelet at each decomposition level is discarded automatically. So there is a need for enhancement of image quality.

In this paper, we discuss about Framelet Transform for noise reduction from noisy image. The organization of this paper is as follows: section II contains the types of noise and Methodes of Elliminating noise, Section III contains Frmalet Trnsform and requirements, Section IV contains Image denoising using Framelet Transform and Section V contain the Results and Discussion. Last section contains the conclusion and references

II. NOISE MODELS AND ASSUMPTION

Additive Noise[1]: Additive white Gaussian noise is evenly distributed over the signal which is added in each pixel evenly and it is also called as Gaussian noise. Each pixel in the noisy image is equal to the sum of the original pixel value and randomly distributed Gaussian noise value.

Substitutive Noise[1]: Substitutive noise like salt and pepper noise. Due to data transmission error, white and black dots are added in the output image.

Multiplicative Noise: This type of noise is occurred in all coherent imaging systems like laser and synthetic aperture radar imagery [1]. Speckle noise is multiplicative noise. In MRI images, noise like speckle noise is observed due to thermal effect[2].

Methods of Eliminating Noise:

Two areas of operations are available for removal of noise i.e. Space field and Transformation field. In space field [3], the data operation is carried on the original image, and processes the image grey value, like neighborhood average method, wiener filter, center value filter and so on. Transformation field has the operational area in the transformation domain of images, and the coefficients after transformation are processed for denoising.

III. FRAMELET TRANSFORM AND REQUIREMENT

From Fourier theory signal can be expressed as the summation of a possibly infinite series of sine and cosine waves. The disadvantage of the Fourier extension is that it has only frequency resolution and no time resolution. So to get both at a time, both Time-Frequency joint representations is the solution to the problem i.e. cut the signal of interest into several part and then analyze the part separately. But problem of cutting the signal has been arises i.e. How to cut? Short time window gives the solution to the this problem. We can cut the signal using short time window which gives us the time frequency representation of the interest. Short term Fourier transform gives spectrum of frequency band at specific time interval. Again the problem here is cutting the signal resultant to a convolution among the signal and the cutting window as convolution in time domain is one and the same as multiplication in frequency domain and frequency components are smeared out all over the frequency axis. In fact this condition is the opposite of the standard Fourier transform since here is time resolution but no frequency resolution at all. The wavelet analysis is possibly the most current solution to overcome the shortcoming of the Short time Fourier transform. The use of fully scalable modulated window resolves the signal cutting problem. The window is shifted next to the signal and for every spot spectrum is calculated. Then this process is repeated numerous times with slightly shorter or longer window for each new cycle then the result is time frequency collection of the signal all with different resolution. By using varying window, one can deal resolution in time for resolution in frequency. In order to separate discontinuity in signal requires short basis function and for fine frequency analysis requires long low frequency basis function. This is realize by wavelet transforms where the basis functions are obtained from a single model wavelet by shift and extraction/ contraction [8]

Discrete wavelet transform which transforms the discrete data from time field into frequency field. The value of the transformed data in time frequency field are called the coefficients where large coefficients correspond to the signal and small one corresponds to usually noise [1]. The noise free data is obtained by inverse transforming the proper threshold coefficients.

Orthonormal wavelets have many applications such as in image processing and image denoising. We are interested in tight wavelet frames that are derived from refinable function through a multiresolution analysis. A tight wavelet frame is an overview of an orthonormal wavelet basis by introducing redundancy into a wavelet system. Tight wavelet frames also called as framelet have advantageous features like shift invariant wavelet frame transforms and it may be helpful in recognize patterns in a redundant/repeative transforms. In order to get fast wavelet frame transform also called framelet transform, tight wavelet frames are generally derived from refinable function through MRA[9].

IV. IMAGE DENOISING USING FRAMELET TRANSFORM

Tight frame is generated by B-spline scaling function and two framelets with vanishing moment of order 2 and 1 respectively. It means that the unvarying signal cannot pass through the high pass filter h2 and neither unvarying nor linear signal can pass thought the h1. For large numbers of images these two framelets are capable of capturing the crucial texture information since the natural images are often piecewise smooth and locally uncorrelated. Lifting factorization of this tight frame provides the sparse approximation. If we are combining the lifting factorization of tight frame that is polyphase matrix with the directional lifting structure then we are getting specific translation invariant directional framelet transform. TIDFT is considered as one of the effective sparse approximation tools with edge preserving property for analysis of images.

TIDFT will be used for noise reduction which is based on the MAP estimator. First of all images are transfer into transform domain, and then the denoising algorithm is applied on the framelet coefficient. Since distribution of framelet coefficients take over the behavior like peaked long tail Gaussian like distribution, SCE and ECE distributions[4] are used. Algorithm for noise reduction using TIDFT is as follows:

- After applying Translation invariant directional framelet transform on the noisy signal, at the output noisy framelet coefficients are obtained.
- Maximum A Posteriori estimation criteria based shrinkage rules like SCE and ECE distribution will be applied on the framelet coefficient.
- Calculation of variance of noise and signal is necessary to estimate standard deviation of signal

For checking sparse representation potential of TIDFT, Spherically contour exponential distribution is used and for checking noise suppression capability, elliptically contour exponential distribution is used. This will gives us denoised output image.

IV. RESULT AND DISCUSSION

Noise level of 10dB and 20 dB is added to the original image which is removed by Framelet transform as shown below. Noise such as AWGN noise, Salt and pepper noise and Speckle noise is added in original image and analyze the Framelet output. Framelet can remove AWGN noise from the original image and give denoised output. But Salt and pepper noise and Speckle noise cannot be removed totally by the Framelet because Framelet is additive which can not remove multiplicative noise and the salt and pepper noises which are shown below:

a. For AWGN Noise

Figure 1 Image Denoising usings Framelet (AWGN Noise)

Figure 1 shows image denoising using framelet transform for AWGN noise, left hand side figure shows original image, figure in middle shows noisy image and right side figure shows denoised image.

b. For Salt and Pepper Noise

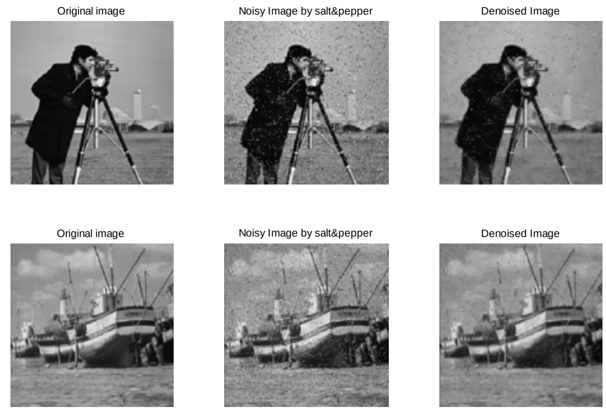

Figure 2 Image Denoising using Framelet (Salt and Pepper)

Figure 2 shows image denoising using framelet transform for Salt and pepper noise, left hand side figure shows original image, figure in middle shows noisy image and right side figure shows denoised image.

c.For Speckle Noise

Figure 3 Image Denoising using Framelet (Speckle Noise)

Figure 3 shows image denoising using framelet transform for Speckle noise, left hand side figure shows original image, figure in middle shows noisy image and right side figure shows denoised image.

PSNR Comparison of Framelet Transform for different Noises and for Different Images

Noise Type	Noise Level	Image (Size)	PSNR
Gaussian Noise	σ=10	Barbara (512*512)	38.9166
	σ =20	Barbara (512*512)	34.9317
	σ =10	Boat (512)	39.1966
	σ =20	Boat (512)	35.8367
	σ =10	Lena (512)	40.3816
	σ =20	Lena (512)	37.2659
	σ =10	Cameraman (256*256)	32.3110
	σ =20	Cameraman (256*256)	28.4591
Speckle Noise	v=0.04	Barbara (512*512)	31.4797
	v=0.1	Barbara (512*512)	27.2388
	v=0.04	Boat (512)	31.9199
	v=0.1	Boat (512)	26.7032
	v=0.04	Lena (512)	32.9565
	v=0.1	Lena (512)	27.5127
	v=0.04	Cameraman (256*256)	25.3606
	v=0.1	Cameraman (256*256)	20.5166
Salt and Pepper Noise	d=0.05	Barbara (512*512)	28.5246
	d=0.1	Barbara (512*512)	25.4921
	d=0.05	Boat (512)	29.3226
	d=0.1	Boat (512)	26.0635
	d=0.05	Lena (512)	29.5559
	d=0.1	Lena (512)	26.1100
	d=0.05	Cameraman (256*256)	22.1859
	d=0.1	Cameraman (256*256)	19.1493

IV. CONCLUSION

Image Denoising Using Framelet Transform is implemented and improved PSNR value and recover the corrupted image with high visual quality. Compared PSNR value using Framelet transform for different types of noise such as AWGN, Salt and pepper noise and speckle noise. Framelet Transform have the capability of Noise reduction with edge preserving. Framalet Transform removes the AWGN noise and achieved good PSNR value but can not remove salt and pepper noise and speckle noise completely because Framelet transform is additive and can not remove multiplicative noise.

REFERENCES

[1] S. Sulochana , R.Vidhya , " Image Denoising using Adaptive Thresholding in Framelet Transform Domain ",(IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 3, 2012

[2] J. Mohan, V. Krishnaveni, Yanhui Guo, "A survey on the magnetic resonance image denoising methods", *Biomedical Signal Processing and Control*, Vol. 9, pp. 56-69, Elsevier, 2014

[3] Sachin D Ruikar, Dharmpal D Doye, "Wavelet Based Image Denoising Technique", (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 2, pp. 49-53,March 2011

[4] Yan Shi, Xiaoyuan Yang, and Yuhua Guo, "Translation Invariant Directional Framelet Transform Combined With Gabor Filters for Image Denoising", IEEE Transactions On Image Processing, Vol. 23, pp. 44-55, January 2014

[5] Kostadin Dabov, Alessandro Foi, Vladimir Katkovnik, and Karen Egiazarian, "Image denoising by sparse 3-D transform-domain collaborative filtering," *IEEE Transactions On Image Processing*, vol. 16, no. 8, pp. 2080–2095, Aug. 2007.

[6] Xiaoyuan Yang, Yan Shi, Liuhe Chen, and Zongfeng Quan, "The Lifting Scheme for Wavelet Bi-Frames: Theory, Structure, and Algorithm", *IEEE Transactions On Image Processing*, Vol. 19, pp. 612 -624,March 2010

[7] A. Ben Hamza and Hamid Krim, "Image Denoising: A Nonlinear Robust Statistical Approach", *IEEE Transactions on Signal Processing*, Vol. 49, No. 12, pp.3045-3054, December 2001

[8] Martin Vetterli and Cormac Herley, "Wavelets and Filter Banks: Theory and Design", *IEEE Transactions On Signal Processing*, Vol. 40, No 9, pp. 2207-2232, September 1992

[9] Bin Han, QunMo, "Symmetric MRA tight wavelet frames with three generators and high vanishing moments", *Applied and computational Harmonic analysis*, Vol. 18, pp. 67–93, Elsevier, December 2005

[10] Pengliang Yang; Jinghuai Gao; Wenchao Chen, "Noise attenuation of the geophysical data using the framelet transform," *IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*, pp.2300-2303,July 2012

[11] Lixin Shen, Papadakis, M. Kakadiaris, I.A. Konstantinidis, I. Kouri, D. Hoffman, "Image denoising using a tight frame," *IEEE Transactions on Image Processing*, vol.15, no.5, pp.1254-1263, May 2006

[12] X. Wang, G. Shi, and L. Liang, "Image denoising based on translation invariant directional lifting", *IEEE conference on ICASSP*, pp. 1446–1449, July 2010.

[13] Zhou Dengwen, "An Image Denoising Algorithm With An Adaptive Window", *IEEE conference on ICIP* , pp. 333-336, 2007.

[14] Claude Knaus, Matthias Zwicker, "Progressive Image Denoising", IEEE Transactions On Image Processing, Vol. 23, No. 7,pp. 3114-3125, July 2014

[15] K.P. Soman, K.I. Ramachandran, N.G.Resmi, "Insight into Wavelets", 3rd Edition, Asoke K. Ghosh, PHI Learning Private Limited, New Delhi, pp.278-289, March 2010.