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Speckle Denoising by the Combination of Spatial and Transform Domain Filters

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Abstract: Ultrasound (US) imaging a technique used for non-invasive detection of flaws inside the human body. The quality of such images has to be at par for the use of doctors. US images are corrupted by speckle noise which arises due to the back scattering of the signal. In this work a new method for image denoising is presented. In this method firstly Approximation and detail bands are obtained from 2 level wavelet decomposition and fast bilateral filter is applied on the approximation band. Secondly the thresholding of the detail bands are done. Then filtered approximation and detail bands combined to get final denoised image. For the performance evaluation of proposed method parameters such as Peak signal to noise ratio (PSNR) and Edge Keeping Index (EKI) are used. The results are obtained for a synthetic kidney image generated by Field II program.

Keyword: Bilateral filter, DWT, speckle reduction, stick filter.

I. INTRODUCTION

Human perception is based on sight. Everything one see gets printed like an image in their brain. Images are more effective than text to understand things. This is the reason why images forms a vital part in everyday life like images captured from a camera, satellite images used for weather forecasting and other things, medical images like US images and so on. These images are often degraded by noise and this degradation is ought to be handled.

The process of removing noise is called image denoising [1].There are many types of noise such as salt and pepper, gaussian, speckle etc. that can distort images. Distortion in images can occur during its generation, processing or transmission [2]. The image denoising [3] must be done before the picture is subjected to its genuine applications, to get the results. Image denoising is regularly utilized as a part of image processing where images are some way or another modified or enhanced before they are projected.

In US imaging high frequency waves are sent in human body and their reflected echoes are recorded to diagnose the human organs. Speckle usually occurs in almost all coherent imaging systems such as laser, synthetic aperture radar and US imagery. This noise is an inherent property of medical US imaging and cause reduction in image resolution and contrast of image; hence reduces the diagnostic value of this imaging modality. So, speckle noise reduction is an essential preprocessing step, where ever ultrasound imaging is used for diagnosis. Speckle noise [4] occurs due to the backscattering of the signal from the human organs. Speckle Noise is multiplicative in nature it can be generated by multiplying random value with pixels. Wavelets [2] give a better performance than other denoising methods in image denoising due to its property of multi-resolution structure.

Rest of the paper is organized as follows. Section II briefly describes some of the related work published in the area of speckle denoising. Proposed work is presented in section III. The experimental results are shown in section IV. Finally the conclusion is drawn in section V.

II. RELATED WORK

Image denoising is generally done in two domains i.e. spatial domain and transform domain. Spatial domain filtering includes filtering operation done directly on images while in transformed domain operation is done on transformed image. In spatial domain various filters such as mean, median, wiener etc. are used. Median filter [5]is a primitive but still a popular impulse denoising method.

Here each pixel is replaced by the median of pixels of a window (eg. 3 x 3) around the chosen pixel. Median filter causes over blurring and to solve this problem, a popular variation of median filter i.e. adaptive median filter [6] is developed. In adaptive median filter window size is adaptively varied depending on the local noise characteristics around the chosen window.

When the window size is large, the computation time is high. Recently, non-local (NL) means filters and anisotropic diffusion filters are commonly used filters. NL mean filtering [7] uses NL mean approach i.e. it takes mean of all pixels selected on the basis of similarity to the target pixel. Anisotropic diffusion filtering [8] is proposed by Perona and Malik is a technique in which image noise is reduced without loss of significant information in the image. After Perona and Malik a lot of work has been done in the field of anisotropic diffusion and a brief survey is given in [9]. A new hybrid filtering technique known as

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Stick filtering [10] is also used for image denoising. In stick filter different size of sticks are used instead of the predefined kernel. DWT using wiener [11] combines the goodness of wavelet and spatial domain filter. Combining the advantages of spatial domain and frequency domain filters, removal of mixed noise composed of impulse and speckle noises is proposed in [12].

III. PROPOSED WORK

In this work, a combination of fast bilateral [13] and wavelet thresholding scheme is presented. Fast bilateral filter is used for filtering of approximation band obtained after wavelet decomposition. However soft thresholding is used for filtering of detail bands. The flow chart of proposed algorithm is shown in fig. 1.

A. Applying fast Bi-lateral filter on LL band

The fast bilateral filter is also known as higher-dimensional bilateral filter. In the fast bilateral filter, the gray levels of pixels are combined to form a 3D space from a 2-D image domain.

Thus, the original complex nonlinear component has been shifted to a linear convolution of a three-dimensional Gaussian kernel function and a three-dimensional image function. Using this higher dimensional space, the convolution computation can be down-sampled without significant impact on the resulting accuracy.

It was observed that bilateral filter can be conceived as linear filter acting in three-dimensions. For bilateral filter the σ_d and σ_r are width of spatial gaussian (σ_d) is 1 and range gaussian (σ_r) is chosen as 2. Gaussian polynomial is incorporated in the bilateral filtering which give rise to the fast bilateral filtering. The filtered output image f(x, y) is given by eq. (1):

$$f(x,y) = \frac{\sum_{s=-A}^{A}\sum_{t=-B}^{B} g(x+s,y+t)}{\sum_{s=-A}^{A}\sum_{t=-B}^{b} w_b(s,t)} \quad (1)$$

Where $w_b(s,t)$ is the bilateral kernel and g(x,y) is the noisy image over which the kernel slides.

B. Soft thresholding on detail bands

In this work wavelet soft thresholding scheme is used for denoising of detail bands. For each detail band a separate thresholds is calculated based one q. 2:

$$T = \sigma_N\sqrt{2\log M} \quad (2)$$

Where,σ_N is the noise standard deviation of the image. M is the size of the corresponding detail bands. Based on the universal threshold new shrinkage function is defined by eq. 3:

$$g = \begin{cases} 0 & f \le T \\ \mathrm{sign}(f).\max\left(|f| - \frac{\sigma_N^2}{s}, 0\right) & f > T \end{cases} \quad (3)$$

Where, f is the detail coefficient of the particular band and s is the scale parameter.

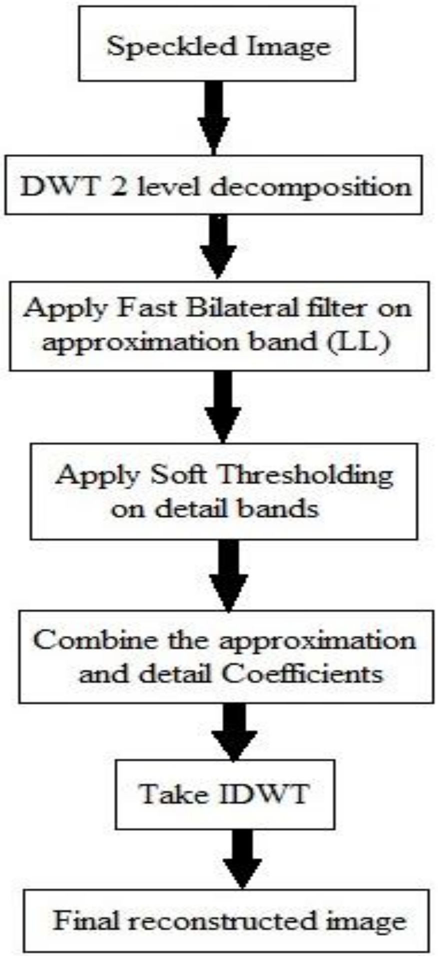

Fig. 1 Proposed algorithm

IV. EXPERIMENTAL RESULTS

The Experimental results are obtained for kidney US image which is generated using field II Program [15]. Kidney image is of 256×256 dimension. The filter performance is evaluated on the parameters PSNR and EKI which are defined by eq. (4) and (6).

$$PSNR = 20\log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \quad (4)$$

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \quad (5)$$

$$EKI = \frac{\sum_{j=1}^{N}(\Delta i_j - \Delta\bar{i})(\Delta ir_j - \Delta\overline{ir})}{\sqrt{\sum_{j=1}^{N}(\Delta i_j - \Delta\bar{i})^2 \sum_{j=1}^{N}(\Delta ir_j - \Delta\overline{ir})^2}} \quad (6)$$

Here MAX_I is the maximum value of image pixel and MSE is the mean square error given by eq. (5). Where i and ir are original image and reconstructed denoised image, respectively. Δi and Δir are high pass filtered version of i and ir by 3 × 3 laplacian operator with its mean value as $\Delta\bar{i}$ and $\Delta\overline{ir}$ respectively. N × N is the size of the image. The comparisons of PSNR and EKI values at noise variance 0.5, 0.1and 0.15for stick filter, DWT wiener, Bilateral filter and proposed method are presented in Table I and Table II respectively.

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TABLE I Comparison of PSNR Values at different noise variance

Methods	Noise Variance		
	0.05	**0.1**	**0.15**
Stick filtering [11]	20.8784	20.1925	19.5981
DWT wiener [12]	20.6023	20.5463	20.3541
Fast Bilateral filter[14]	25.6535	22.4868	20.1501
Proposed method	26.7343	23.6758	21.4016

TABLE II Comparison of EKI Values at different noise variance

Methods	Noise Variance		
	0.05	**0.1**	**0.15**
Stick filtering [11]	0.2528	0.2067	0.1976
DWT wiener [12]	0.1982	0.1672	0.1432
Fast Bilateral filter [14]	0.3210	0.3127	0.2467
Proposed method	0.3597	0.3210	0.2825

Fig. 2 (a) shows the original kidney image (a), Fig. 2 (b) shows the noisy image obtained after adding speckle of noise variance 0.1. Fig. 2(c), 2(d), 2(e) and 2(f) are images obtained after applying stick filter, DWT wiener filter, fast bilateral filter and proposed filter.

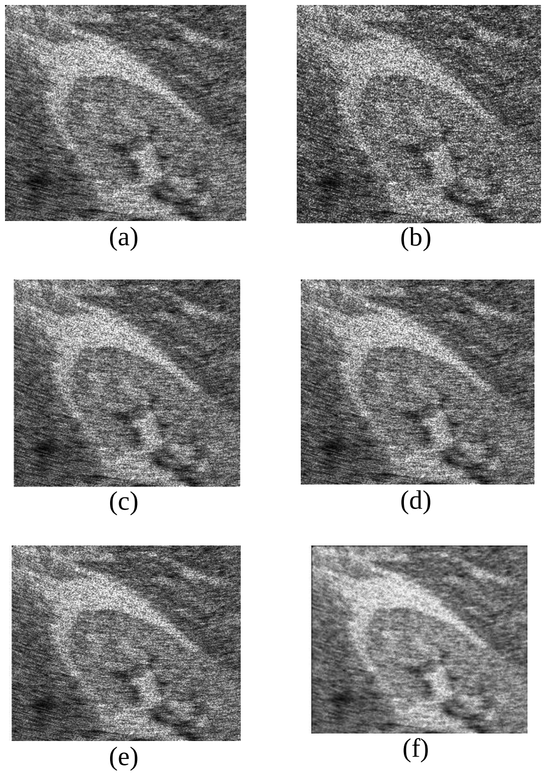

Fig. 2 Synthetic image: (a) original image, (b) noisy image, (c) denoised by Stick filter, (d) denoised by DWT using wiener, (e) denoised by fast Bilateral (f) denoised by Proposed method.

V. CONCLUSION

In this paper, a despeckling method for medical US images based on fast bilateral and wavelet transformation filter is proposed. Objective assessment is done on the basis of parameters such as PSNR and EKI. For subjective assessment images are presented. From the results obtained it can be seen that proposed method is more suitable for US image denoising as compared to the other methods.

REFERENCES

[1] R.C. Gonzalez, and R.E Woods. "Digital Image Processing", 3rd Edition, India, Pearson Publications, 2011
[2] Palwinder Singh, Leena Jain, Noise reduction in Ultrasound images using Wavelet and Spatial filtering Techniques, IEEE 2nd International Conference on Information Management in the Knowledge Economy,2013, pp 57–63.
[3] Gregorio Andria, Filippo Attivissimo, Anna M. L. Lanzolla, Mario Savino, A Suitable Threshold for Speckle Reduction in Ultrasound Images, IEEE Transactions on instrumentation and measurement,2013, Vol. 62, No. 8, pp: 2270-2279.
[4] Zilong Hu, Jinshan Tang, Cluster driven anisotropic diffusion for speckle reduction inUltrasound images, IEEE ICIP, 2016, pp2325–2329.
[5] T.S.Huang,.,G.J. Yang,., and G.Y. Tang, " Fast Two Dimensional Median Filtering Algorithm", IEEE Trans. Acoustics, Speech, Signal Processing, Vol. ASSP.1, no.1,Jan. 1979, pp 8-13
[6] Haidi Ibrahim, Nicholas Sia Pik Kong, Theam Foo Ng."Simple Adaptive Median Filter for the Removal of Impulse Noise from Highly Corruped Images". IEEE Trans. Consumer Electronics, Vol. 54, no.4, Nov.2008, pp 1920-1927.
[7] Beshiba Wilson, Dr.Julia Punitha Malar Dhas, 2013, A Survey of Non-Local Means based Filters for Image Denoising, International Journal of Engineering Research & Technology, Vol. 2, Issue 10, pp. 3768–3771.
[8] Pietro Perona, Jitendra Malik, 1990, Scale-Space and Edge Detection Using Anisotropic Diffusion, IEEE Transactions On Pattern Analysis And Machine Intelligence, Vol. 2, No. 7, pp. 629-639.
[9] Joachim Weickert, 1997, A Review of Nonlinear Diffusion Filtering, Springer: Scale Space Theory in Computer Vision Lecture Notes in Computer Science, Vol. 1252, pp. 3- 28.
[10] Chang-Yan Xiao, Zhang Su, Ya-zhu Chen, 2004, A diffusion stick method for speckle suppression in ultrasonic images, ELSEVIERPattern Recognition Letters, Vol. 25, pp. 1867-1877.
[11] L. Alparone, S. Baronti, A. Garzelli, 1995, A DWT wiener Filter for Unbiased and Edge Preserving Speckle Reduction, IEEE conference, pp. 1409-1411.
[12] Priyam Chatterjee and Peyman Milanfar. "Is Denoising Dead." IEEE Trans. Image Processing, vol.19 [4], Apr.2010, pp. 895-910
[13] Kunal N. Chaudhury, Swapnil D. Dabhade, 2016, Fast and Provably Accurate Bilateral Filtering, IEEE transaction , Vol. 1, pp. 1- 10.
[14] Jorgen Arendt Jensen, 1996, Field: A Program for Simulating Ultrasound Systems, Medical & Biological Engineering & Computing, Vol. 34, supplement No. 1, Part 1, pp. 351-353.

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