Performance Comparison of Transform Domain for Speckle Reduction in Ultrasound Image

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Abstract: Image Denoising has remained a fundamental problem in the field of image processing. Ultrasonic images are inherently affected by speckle (multiplicative) noise, which is due to the coherent wave inference in tissue. This paper described a comparative study of various frequency domain filters for speckle suppression in ultrasound image. In this paper mainly comparative study of wavelet, ridgelet and curvelet transform. The performance of image denoising algorithm in term of PSNR

Keywords: **Image Denoising, Speckle noise, ultrasonic image, wavelet, curvelet, multiscale Ridgelet transform.**

INTRODUCTION

The noise of image is not usually easily removed in image processing. Noise statistical property and frequency spectrum distribution rule actually calculated according to image characteristic, there are many researchers developed many methods of removing noises that approximately are divided into space and transformation fields Digital images play an important role in daily life application such as television, magnetic resonance imaging as well as in areas. Image denoising is process is used to remove the noise. Ultrasonic images suffer from a special kind of noise called Speckle [1]. There are several technique is used to remove the speckle noise such as wavelet, ridge let and curvelet transform. Speckle noise degrades the quality of the image and affects the performance of important image processing technique such as detection, segmentation and classification. The wavelet analysis which is usually described as "Mathematical microscope" has recently attracted more attention in image processing. The popular Mallat's algorithm has serious disadvantage in the application in signal analysis, pattern recognition and data fusion [2-3].

I. BACKGROUND

Noise reduction is the process of removing noise from an image medical images are corrupted with different kinds of noise while image acquisition. Some noise removal techniques are described Background history below.

S.Sudha et al. have proposed the wavelet based image denoising using adaptive thresholding which describes a new method for suppression of noise in image by fusing the wavelet Denoising technique with optimized thresholding function, improving the denoised results significantly [6]. M.Singh et al. described a comparative study of various spatial domain filters for speckle suppression in Ultrasound images [7]. K.R.Joshi et al proposed the quality metrics for speckle in coherent imaging and their limitations. It also describes a new metric-SDI, its uniqueness in quantifying the speckle and comparison of performance with existing metrics [8]. Li Hongqiao and W.Shengqian have proposed a new method of wavelet based image denoising with soft-thresholds [9]. M.N. Nobi et al. proposed an efficient and simple method for noise reduction from medical images. They modified median filter by adding more features [10]. Jean-Luc Starck et al. have proposed the radon, ridgelet and curvelet transforms for image denoising. They apply these digital transforms to the denoising of some standard images embedded in white noise [11]. Rayudu et al. have proposed the curvelet transform for ultrasound image denoising. Speckle reduction/filtering i.e. visual enhancement techniques are used for enhancing the visual quality of the images [12].

II. ORGANIZATON OF THE PAPER

Section IV describes the Wavelet based Image Denoising. Sections VI give brief summary of Curvelet and section IX about Ridgelet transform. Section XII and XIII shows results and conclusion.

III. WAVELET BASED IMAGE DENOISING

Wavelets are basically mathematical functions which break up the data into different frequency components, and then we study each component with a resolution matched to its scale [19]. Wavelets are the better technique to handle the different type of noises which is present in an image [4].Wavelets, although good at representing point discontinuities, are not good at representing edge discontinuities A comparative study between wavelet coefficient shrinkage filter and several standard speckle filters that are being largely used for speckle noise suppression which shows that the wavelet-based approach is deployed among the best for speckle removal [7] [8]. The wavelet decomposition of an image is done as follows: In the first level of decomposition, the image is split into 4subbands, namely the HH, HL, LH and LL sub bands as shown in Figure 2. The HH sub band gives the diagonal details of the image; the HL sub band gives the horizontal features while the LH subband represents the vertical structures[5][6]. The LL subband is the low resolution residual consisting of low frequency components and it is this subband which is further split at higher levels of decomposition [13].

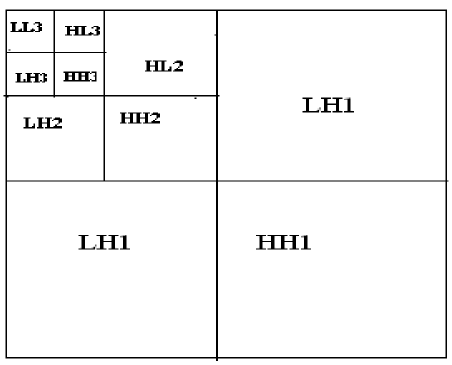


Figure 1: **Decomposition of image**

IV. WAVELET BASED NOISE THRESHOLDING ALGORITHM

All the wavelet filters use wavelet thresholding operation for de-noising [14]-[20]-[21]. The basic Procedure for all thresholding method is as follows:

• Calculate the DWT of the image.

•Threshold the wavelet coefficients (Threshold may be universal or sub band adaptive)

• Compute the IDWT to get the denoised estimate.

• There are two thresholding functions frequently used, i.e. a hard threshold, a soft threshold.

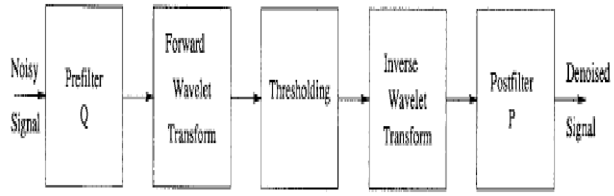


Figure 2: Diagram of wavelet transform

V. BRIEF DESCRIPTION OF CURVELET

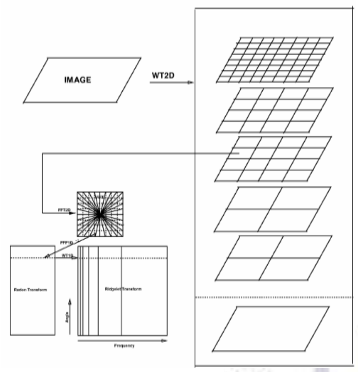
Curvelet are initially introduced by E.J Candes and D.L.Donoho. In recent year there is new multiscale transform based on wavelet transform called curvelet transform. Curvelet transform has been developed to overcome the limitations of wavelet and Gabor filters. Curvelet transform is a special member of the multiscale geometric transforms. [22, 15, 16] Basically, Curvelet transform extends the ridgelet transform to multiple scale analysis. The digital curvelet transform is implemented using the fast discrete curvelet transform. The image and curvelet are transformed into fourier domain, then the convolution of the curvelet with the image in spatial domain becomes the product in fourier domain. Finally the curvelet coefficients are obtained by applying inverse fouier transform on thr spectral product. Recently, Starck et al. [18] showed that "a trous" subband
Filtering algorithm [17] is especially well-adapted to the needs of the digital Curvelet transform.

VI. CURVELET TRANSFORM ALGORITHM

Starck et al. [18] presented a sketch of the discrete Curvelet transform algorithm:

1. apply the `a trous algorithm with J scales [17];
2. set $B_1 = B_{\min}$;
3. for j = 1,...., J do
   i) partition the subband ω_j with a block size B_j and apply the digital ridgelet transform to each block;
   ii) if j modulo 2 =1 then $B_{j+1} = 2B_j$;
   iii) else $B_{j+1} = B_j$;

Note that the coarse description of the image c_J is not processed. Fig. 3 gives an overview of the organization of the algorithm. Extensive literature of Curvelet Transform theory can be

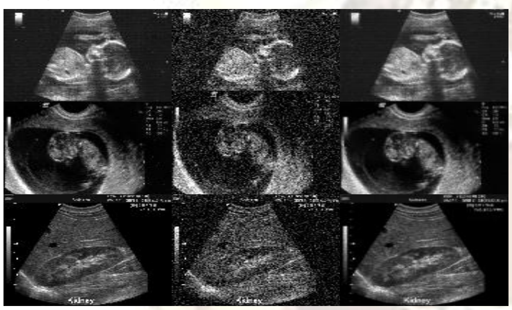


found in the

Figure 3: Curvlet Transform flow graph.

VII. RESULTS OF CURVLET

Original image Noise image Denoise image



VIII. RIDGLET TRANSFORM(RT)

Ridgelet analysis was developed by E.J. Candes and D.L Donoho [23, 24] for solving important problems such as constructing netural networks or approximating and estimating multivariate functions by linear combinations of ridge functions. Ridegelet transform is a new multiscale representation for functions on continuous spaces that have some discontinuities along lines.wavelet are good to represent the point singularities and ridgelets repress.

Basic algorithm for discrete radon transform is as follows.

1. Compute the two-dimensional Fast Fourier Transform (FFT) of function *f*.

2.Using an interpolation scheme, substitute the sampled values of the Fourier transform obtained on the square lattice with sampled values of $\hat{f}$ on a polar lattice: that is, on a lattice where the points fall on lines through the origin.

3. Compute the one-dimensional Inverse Fast Fourier Transform (IFFT) on each line; i.e., for each value of the angular parameter.

IX. DISCRETE RIDGELET TRANSFORM(DRT)

A continuous ridgelet transform is calculated by applying 1D wavelet transform to the slices of radon transform $R_f(\theta,.)$. In radon transform a famous projection-slice theorem is used

$$\hat{f}(\omega\cos\theta,\omega\sin\theta)=\int R_f(\theta,t)e^{-2\pi i\omega x}dt \quad (1)$$

This theorem says that the Radon transform can be obtained by applying the one-dimensional inverse Fourier transform to the two-dimensional Fourier transform of function restricted to radial lines through the origin

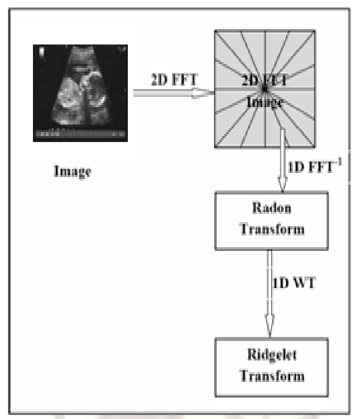
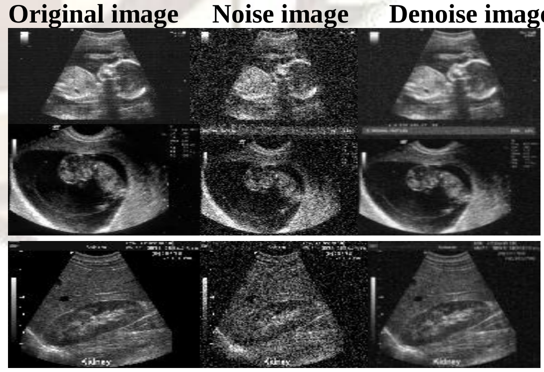


Figure 2: Flowchart of Discrete Ridgelet Transforms

XI RESULT OF RIDGELET TRANSFORM

Original image Noise image Denoise image



X. RESULTS

The PSNR for all three transforms is tabulated. The PSNR values using Multiscale Ridgelet are better. In some cases the Curvelet gives better PSNR. The PSNR in Wavelet

Image No.	Wavelets	Curvelet	Multiscale Ridgelet
1	27.5	34.74	34.81
2	24.88	35.15	33.52
3	18.57	25.80	23.76
4	33.73	39.05	41.19
5	15.42	20.25	17.9

TABLE I: DENOISING RESULTS OF VARIOUS METHODS IN TERMS OF PSNR UNDER SPECKLE NOISE OF 0.01 VARIANCE

Image No.	Wavelets	Curvelet	Multiscale Ridgelet
1	26.89	30.98	32.4
2	23.64	32.05	29.81
3	17.69	24.58	21.6
4	32.64	35.47	37.21
5	14.64	18.91	16.49

TABLE II Denoising Results of Various Methods In terms of PSNR under Speckle Noise of 0.02 Variance.

XI. CONCLUSIONS

In most of the image processing applications, a suitable noise removal phase is often required before any relevant information could be extracted from analyzed images. In this study we compare the performance of the three transform. The Ridgelet transform gives the best performance for PSNR. The quantitative PSNR values in case of curvelet transform are better in case of few images. There is still a further step toward the 2D transform contourlet transform. The work can be extended for the contourlet transform.

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