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Medical Ultrasound RF Processing using Adaptive Activity Dependent Rule Based Wavelet De-noising Approach

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Abstract : Enhancement of Medical US for automated analysis poses tough challenge to the researchers due to the multiplicative nature of Speckle noise. The raw US RF data is Time-Gain and Log Compensated, Envelope detected, before converting it to B-Mode. These process induces artifacts at different stages and need to be compensated. As RF data is readily available, direct processing of raw RF ultrasound data is expected to reduce the artifacts as the signal is not affected by Non-Linear post processing operations. In this paper, the highly varying RF data is pre-processed using local variance and an adaptive threshold scheme. The threshold is selected based on the measured region activity. When tested on B-Mode images, the results indicate a high PSNR value compared to the traditional universal approaches.
Keywords : Statistical processing, RF Raw data, Wavelet Filtering, Ultrasound.

1. INTRODUCTION

In spite of the large number of advantages, interpretation of medical ultrasound images are still a challenge due to a variety of reasons. Availability of RF data poses a significant need of RF signal processing in comparison to processing the low quality image data post to the acquisition. Traditional filters use variants of Wavelet transforms for denoising and the quality of depends on threshold [1]. Soft, hard, semi-soft and Garrotte are the popularly available thresholding rules. While soft thresholding rule is generally preferred for low frequency, it may not be ideal for high frequency signals. This article aims in proposing anactivity dependent thresholding scheme. Initially, the signal activity [2] is studied and the thresholding scheme is selected accordingly.

2. PROPOSED METHODOLOGY

Figure 1 and 2 shows the Proposed Scheme flow diagram. As the figure indicates, the signal activity is estimated and based in the signal activity, the corresponding threshold scheme is selected.

The rule based system proposed in this paper has the following considerations. The low frequency region is subjected to soft thresholding, Moderate region to Semi Soft Thresholding, High Frequency components to garrotte thresholding and very high frequency region to hard thresholding[3,4,5]. As RF signal is expected to have all these components, the raw RF data is first decomposed and grouped in terms iof frequencies (LL, LH, HL, HH) based on the wavelet coefficients. Once the Signal Activity is estimated, adaptive thresholding is applied by calculating the variance of each region and correlate it with the frequency component. Depending upon the frequency, either soft, Semi Soft, Garratte or Hard

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Threshold is applied and modified global wavelet coefficients are obtained. The denoiosed RF data is then subjected to post processing algorithms such as envelope detection, Log Compensation, Scan rate Conversion to obtain the enhanced B Mode images.

3. RESULTS AND DISCUSSION

The algorithm was tested on data sets for CCA images and a significant improvement in terms of PSNR as reported in table 1 has been obtained. The proposed method has also reported excellent reconstruction of the noisy signal while preserving the underlying regions of interest. At low variance region, the presence of artifacts can increase the activity and lead to mis-interpretation of the data. The same principle holds good in the high variance region too. But, as an adaptive scheme is used here, the region activity has been compensated and hence the srtifacts are reduced. Also, as the thresholding scheme has been selected based on region activity, the problem of global thresholding is avoided. As the filtering is done before log compensation, we have an rich source of RF data to process. In the other case, where we post process the data, the noise and artifacts which are generated by the system gets multiplied as the various operations are being carried out and hence the efficiency is found to be less. Studies were also conducted on signals at various signal variances and a notable improvement in terms of PSNR has been achieved.

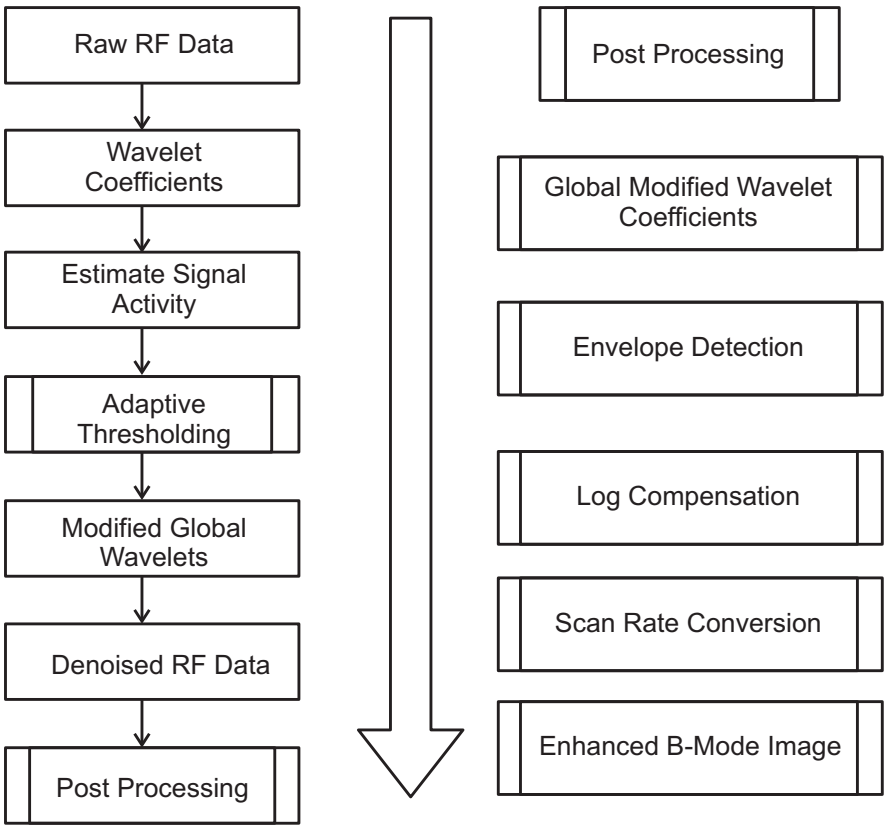
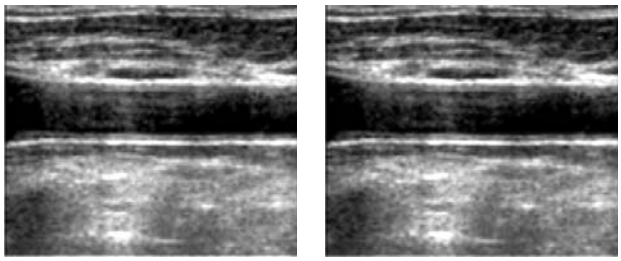


Figure 1: (*a*) Process flow Diagram for the proposed approach (*b*) Post Processing Algorithms for B-Mode US

Table 1

Signal to Noise ratio of proposed and global threshold schemes

	Global Threshold	*Proposed*
Data Set 1	17.42	21.62
Data Set 2	19.16	22.63
Data Set 3	18.42	23.87
Data Set 4	15.03	21.16
Data Set 5	18.62	22.59



(*a*) (*b*)

Figure 3: (*a*) Post Processed Image and (*b*) Pre Processed image from raw ultrasound data

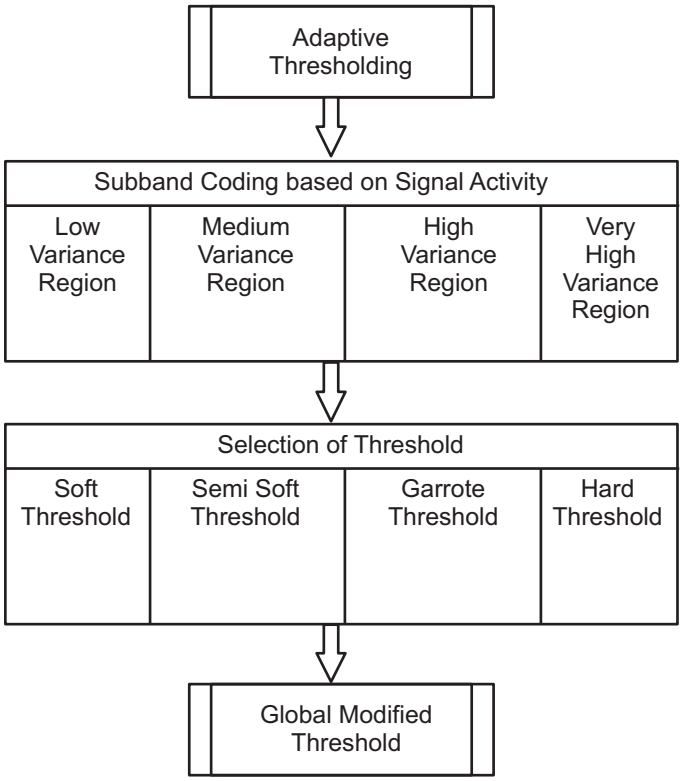


Figure 2: Activity Based Adaptive Threshold Scheme

4. CONCLUSION

In this paper the system for statistical denoising scheme for raw ultrasound data is presented. The system consists of a two step process, where the signal activity is measured first and based on the variance, corresponding thresholding scheme is deployed. Performance indices in terms of Signal to Noise Ratio provide better results.

5. REFERENCES

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