Comparative Analysis of Speckle Reduction Techniques in Ultrasound Images

Rajneet Kaur[1], Jaspreet Kaur[2]

[1,2]*Department of Computer Science, SGGSW University, Fatehgarh Sahib Punjab, India*

[1]rosy.rajneet@gmail.com, [2]jassikhattra20@gmail.com

***Abstract*—Ultrasound images play an important role in current day diagnosis due to its non harmful nature. But it suffers from a problem that is speckle noise. Speckle noise degrades the image quality which affects the diagnosis. So in this paper we compare the various speckle reduction techniques and conclude that wavelet thresholding techniques provide better results.**

***Keywords*—Ultrasound, Speckle noise, Filtering techniques, Wavelet Thresholding, Shrinkage Rules.**

I. Introduction

In medical field different modalities like MRI, CT scan, Ultrasound images are used for diagnosis. But from these ultrasound images are harmless and not much expensive. But these images contain speckle noise. Speckle noise is multiplicative noise so it is difficult to remove. Noise is introduced due to loss of proper contact or gap between transducer probe and body. Speckle noise degrades image quality by blurring image details and making it more complex to detect small injuries in tissues.

Speckle noise texture contains important information about the tissues. The method which enhances the image quality by minimizing mean square error and conserving edges is the appropriate method for speckle reduction. The first step for noise suppression is filtering techniques. But these techniques remove image details along with noise. But now a days, wavelet thresholding techniques performed well.

II. Matrices Used To Compare Image Quality

Image quality of denoised image is compared with original image using measures like Signal to Noise Ratio(SNR), Peak Signal to Noise Ratio(PSNR) , Mean Square Error(MSE) , Root Mean Square Error (RMSE).

$MSE = 1/MN \sum_{f,fe} [f(i,j) - f_e(i,j)]^2$

f= original image

fe=enhanced image of size M*N

$RMSE=\sqrt{MSE}$

$SNR=10\log_{10}(\sigma^2/\sigma_e^2)$

Peak $SNR= 20 \log_{10}(255/RMSE)$

III. Techniques Used For Speckle Reduction In Digital Images

A. Spatial Domain Filters

Spatial domain filters like Mean filter, Median filter, Gaussian filter, diffusion filter, Lee filter and wiener filters are used to reduce speckle noise. But they remove some information content along with noise [1].

B. Frequency Domain Filters

1) Low Pass Filters

Low Pass Filters like Butterworth and Gaussian low pass filter are used for image enhancement. They produce image that have less sharp details. But these filters produce blurring and ringing effect.

2) High Pass Filters

These Filters provide images with sharp edges and that have less gray level variation in smooth areas.

3) Band Pass Filters

These filters process specific bands of frequencies or small regions of frequency rectangle,

But all these filters suffer from same problem as spatial domain filters as they also remove important information with speckle [1]. All these filters give slight improvement so we then use wavelet transform to improve image quality.

C. Wavelet Transform

Wavelet denoising attempts to remove the noise present in the signal while preserving the signal characteristics, regardless of its frequency content. As the discrete wavelet transform (DWT) corresponds to basis decomposition, it provides a non redundant and unique representation of the signal.

During a two-level decomposition of an image using a scalar wavelet, the two-dimensional data is replaced with four blocks. These blocks correspond to the subbands that represent either lowpass filtering or highpass filtering in each direction. The procedure for wavelet decomposition consists of consecutive operations on rows and columns of the two-dimensional data. The wavelet transform first performs one step of the transform on all rows. This process yields a matrix where the left side contains down-sampled low pass coefficients of each row, and the right side contains the high pass coefficients. Next, one step of decomposition is applied to all columns; this results in four types of coefficients, viz., HH, HL, LH, LL.

1) Wavelet Thresholding

It is signal Estimation Technique that removes noise by removing coefficients that are not significant relative to some threshold [2] the steps involved in this are:

- Find wavelet coefficients of original image using DWT.
- Thresholding wavelet coefficients that gives a threshold of zero to the first wavelet coefficient and others are shrunk.
- Remove small noise coefficients
- Compute inverse DWT to reconstruct Denoised image.

2) Thresholding Techniques

Subband Thresholding: In this measure noise variance of horizontal, vertical and diagonal subband of each decomposition level (from higher levels towards lower levels) and compute threshold value using BayesShrink or Universal Shrinkage Rule.

Global Thresholding: In this determine threshold value from only diagonal band but apply this to all subbands (Horizontal, Vertical and Diagonal) and assume that noise content should high in diagonal subband because it contains high frequency components [3].

3) Shrinkage Scheme

The thresholding approach is to shrink high frequency components with small amplitudes to zero and keeping smoother detailed coefficients to reconstruct ideal image with loss in details. So this process is called wavelet Shrinkage where the detailed coefficients are shrunk towards zero[3].

There are 3 shrinkage schemes to shrink the wavelet coefficients:

Hard thresholding procedure remove noise by thresholding wavelet coefficients of detailed subband but keeping low resolution coefficients as it is.

Soft thresholding avoid discontinuities and extension of hard thresholding. It reduces sudden sharp changes and provide more enhanced images.

Semisoft thresholding compromise between hard and soft thresholding.

4) Shrinkage Rule

Very large threshold λ; shrink all coefficients to zero and over smoothing image.

Small value of λ provide image with sharp edges and details but fail to remove speckle noise.

- *Universal Shrinkage*: introduced by Donoho to denoise in the wavelet domain

  $\lambda_{univ=\sigma\sqrt{2\log N}}$

  N=signal length

  σ = noise variance

It is applicable where most of the coefficients are zero [3].

- *BayesShrink*: It is wavelet shrinkage method of removing noise from image in wavelet domain. In wavelet transform, compute DWT to get wavelet coefficients, the components with coefficients below a threshold are replaced with zeros and image is reconstructed. The main focus of this method is to minimize the Bayesian Risk[3].

  Bayes Threshold

  $T_B = \sigma^2/\sigma_s$

  W= S + N

  W= Wavelet Transform of degraded Image

  S = Wavelet Transform of Original Image

N = Wavelet Transform Of Noise Image

$W(x,y) = S(x,y)+N(x,y)$

$\sigma_w^2= \sigma_s^2+\sigma^2$

$\sigma_w^2= 1/n^2\sum^n_{x,y-1} w^2(x,y)$

$\sigma_s^2= \sqrt{\max(\sigma_y-\sigma^2,0)}$

IV. Conclusion

The techniques such as filtering provide slight improvement. They also remove important information content along with speckle noise. Wiener Filter gives better results than that of mean and median filter. To improve image Quality then we use wavelet thresholding techniques .From these techniques BayesShrink Perform better and provide more enhanced image than that of all other techniques. These techniques also used to remove other types of noises like gaussian noise, salt and pepper noise and on other types of medical imaging like CT Scan, MRI and EEG images.

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