A Comparative Study on the Effects of Additive and Multiplicative Noises in the Ultra Sound Despeckling

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Abstract: **Ultra sound images are normally effected by the speckle noise and these speckle noises are typically multiplicative in nature. This study proposes a newdespeckling method over the ultra sound images. It is understood that additive noises are easy to remove from the ultra sound images. The proposed method converts the multiplicative speckle noise in to additive during the first phase. It is followed by the spatial Frost filter. A comparative study of effects of additive and multiplicative noise over the same method is also conducted. Different quality metrics are considered during the evaluation process. The comparison results clearly shows that the ultra sound images with additive noise is providing a better despeckling rate than the normal multiplicative speckle effected images.**

Key words: Frost Filter, Multiplicative noise, Additive noise, Wavelets

1. INTRODUCTION

Medical images are always suffering of the un wanted noises present in them. These noises severely affect the diagnosis purpose of the input images. Ultrasonic imaging is generally real time, it is highly acceptable to most patients, exposures used in current practice are considered to be safe and the equipment is generally less expensive than that of other imaging technologies.

However, its usefulness is degraded by the presence of signal dependent speckle noise. The limiting feature for the use of ultrasound in air is the severe absorption which rapidly reduces the amplitude of the field, as it propagates away from the source, to levels which are too low for most processing activities, or even to provide sufficient signal-to-noise ratios (SNRs) for many diagnostic applications. Ultra sound despeckling can be done in both spatial and frequency domains. Different spatial filters like Lee ,Frost ,Kuan are some filters which can be used for the better despeckling .

Bhuhiyan et al[1] suggested a way of adaptive thresholding in US images. Wavelet transform has been efficiently used as a powerful tool for the removal of noise from digital images.wavelet based image denoising consists of three main activities 1.Decomposition of input data by forward wavelet transform 2.Shrinking the wavelet coefficient by selection of proper threshold and thresholding function 3.Applying inverse wavelet transform for reconstruction of noise free images.

Wavelet transform can be applied for different levels. Wavelet coefficient at each level are correlated with the coefficients at the same level and also in the adjacent level. The dependency exhibited by the coefficients at the same level is called intra scale dependency and with the coefficients in the adjacent level is called inter scale dependency. The threshold in the processed image is the decision factor of the despeckling process. Many research works were carried over the wavelet htresholding.ChenP[2] proposed an inter scale dependency over the coefficients in US images.Donoho[4] and Goodman[5] discussed various thresholding methods. Devi[10] proposed an improved adaptive wavelet filter which is giving a better despeckling rate over the conventional thresholding methods.

2. ADDITIVE AND MULTIPLICATIVE NOISES

Since both the noises are different in nature hence it is difficult to remove both the noises by using single filter. Therefore two different filters are required denoise medical images which are corrupted by either of the noises simultaneously. In this paper WT approach is used to denoise medical images. WT based filter removes additive white Gaussian noise (AWGN) effectively. Since speckle noise is multiplicative in nature; it is converted into logarithmic transform before apply wavelet transform.

An additive noise observes the rule:

$$w(x, y) = s(x, y) + n(x, y)$$

and multiplicative noise has:

w(x, y) = s(x, y) x n(x, y)

where s(x, y) is the original signal, n(x, y) denotes the noise introduced into the signal to produce the corrupted image w(x, y), and (x, y) represents the pixel location. Speckle noise is a multiplicative noise. This type of noise occurs in almost all coherent imaging systems such as laser, acoustics and synthetic aperture radar (SAR) imagery. Speckle noise has the characteristic of multiplicative noise hence it is required to convert a noisy image to its logarithmic transform.

3. FROST FILTER

Invented by Frost in 1982 [12], is linear, convolutional filter used to remove the multiplicative noise from images. As compared to mean and median filter it has adaptive nature and also it is exponentially-weighted averaging filter. Frost filter works on the basis of coefficient of variation which is the ratio of local standard deviation to the local mean of the corrupted image The Frost filter reduces speckle noise and preserves important image features at the edges.

K = e (- B * S)

Where B = D * (LV / LM * LM)

S : Absolute value of the pixel distance from the centre pixel to its neighbors in the filter window

D : Exponential damping factor (input parameter),

LM : Local mean of filter window LV : Local variance of filter window. The resulting gray-level value of the filtered pixel is R = (P1 * K1 + P2 * K2 + ... + Pn * Kn) / (K1 + K2 + .. + Kn) Where P1,P2,...Pn are gray levels of each pixel in the filter window. K1,K2,...Kn are weights (as defined above) for each pixel.

4. EXPERIMENTS

The ultra sound images are severely effected by the speckle noises which in turn causes the quality of the image under consideration. Here we are comparing the effect of noise types in the ultra sound despeckling process. Frost filter, a good spatial domain filter is selected as the despeckling filter. The edge preserving nature of the frost filter makes it well suited for the medical image processing. Two experiments are conducted on in this work over the same datasets of ultra sound images. In the first experiment the images obtained are directly supplied to the Frost filter and the quantitative measurements are calculated. It is quite clear that the natural ultra sound images contains the multiplicative speckle noise. The second experiment is a two phase process. During the first phase the noise in the image is converted to additive format. Application of the image in the Frost filter is the second phase. The measurements for the second experiment is also noted.

5 .RESULTS AND DISCUSSIONS

Experiments were conducted on number of ultrasound images of size 512×512. In the proposed approach results were generated for various noise variance. Quantitative performance was measured with parameters like Peak Signal to Noise ratio (PSNR), Mean Square Error (MSE), Structural Similarity Index Measure (SSIM), And Normalized cross correlation .where

$$MSE=\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(x(i,j)-y(i,j))^2$$

$$PSNR=10log_{10}\frac{(2^n-1)^2}{\sqrt{MSE}}$$

$$SSIM=\frac{(2*\bar{x}*\bar{y}*C1)*(2*\sigma_{xy}+C2)}{(\sigma_x^2+\sigma_y^2+C2)*(\bar{x}^2+\bar{y}^2+C1)}$$

$$NK=\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(x(i,j)-y(i,j)}{\sum_{i=1}^{M}\sum_{j=1}^{N}x(i,j)^2}$$

Table 1: Types of ultra sound images considered

CLASS	ULTRA SOUND IMAGE TYPE
1	Liver
2	Lungs
3	Abdomen

Variance	Noisy image	Frost Filter(With multiplicative noise)	Frost Filter(With additive noise)
.01	30.9	34.4	37.3
.04	26.4	33.5	36.4
.08	25.4	32.54	36.9
.1	25.12	32.67	35.51
MSE(Mean Square Error)			
.01	18.6	4.7	3.8
.04	38.8	9.2	9.1
.08	40.1	14.4	13.2
.1	42.01	15.6	14.5
SSIM(Structural Similarity Index Measurements)			
.01	.96	.98	.985
.04	.882	.960	.961
.08	.810	.9346	.9337
.1	.781	.921	.9285
Normalized Cross Correlation(NK)			
.01	1.06	1.002	1.001
.04	1.08	1.002	1.0008
.08	1.09	1.0018	1.0002
.1	1.11	1.0017	0.997

Table 2: Qualitative values of noisy and despeckled ultra sound images

CONCLUSION

For measuring the effects of noise conversion in ultra sound despeckling a comparative study is conducted. The first experiment is taking the source source image as it is which is further fused to get the result. While the second experiment is converting the noise into additive format and hence do the filtering. It is quite clear from the resultant metrics values that the noise conversion followed by fusion is providing a good despeckling result.

One drawback of this method is the higher time complexity. It requires some additional time for the noise conversion which is not seen in the normal filtering methods.

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