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PEFORMANCE EVALUATION OF VARIOUS SPECKLE NOISE REDUCTION FILTERS ON MEDICAL IMAGES

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Abstract-Today ultrasound and magnetic resonance imaging are essential tools for noninvasive medical diagnosis. One of the fundamental problems in this field is speckle noise, which is a major limitation on image quality especially in ultrasound imaging. The presence of the speckle noise affects image interpretation by human and the accuracy of computer-assisted diagnostic techniques. Low image quality is an obstacle for effective feature extraction, analysis, recognition and quantitative measurements. Image variances or speckle is a granular noise that inherently exists in and degrades the quality of the medical images. Before using ultrasound and magnetic resonance imaging, the very first step is to reduce the effect of Speckle noise. Most of speckle reduction techniques have been studied by researchers; however, there is no comprehensive method that takes all the constraints into consideration. Filtering is one of the common methods which is used to reduce the speckle noises. This paper compares five different speckle reduction filters quantitatively using simulated imageries. The results have been presented by filtered images, statistical tables and diagrams. Finally, the best filter has been recommended based on the statistical and experimental results.

Keywords: - Speckle Noise, Filter, Mean Square Error (MSE), Signal-to-Noise ratio (SNR)

I. INTRODUCTION

Medical images are usually corrupted by noise in its acquisition and Transmission. The main objective of Image de noising techniques is necessary to remove such noises while retaining as much as possible the important signal features. Introductory section offer brief idea about different available de noising schemes. Ultrasonic imaging is a widely used medical imaging procedure because it is economical, comparatively safe, transferable, and adaptable. Though, one of its main shortcomings is the poor quality of images, which are affected by speckle noise. The existence of speckle is unattractive since it disgrace image quality and it affects the tasks of individual interpretation and diagnosis. Accordingly, speckle filtering is a central pre-processing step for feature extraction, analysis, and recognition from medical imagery measurements. Previously a number of schemes have been proposed for speckle mitigation.

An appropriate method for speckle reduction is one which enhances the signal to noise ratio while conserving the edges and lines in the image [1]-[3]. Filtering techniques are used as preface action before segmentation and classification. This paper discusses five different filters for speckle reduction and Compares them using quantitative parameters like MSE and SNR and suggests the best filter for speckle noise reduction from medical images.

II SPECKLE FILTERING

As implicitly mentioned above, speckle filtering consists of moving a kernel over each pixel in the image and applying a mathematical calculation using the pixel values under the kernel and replacing the central pixel with the calculated value. The kernel is moved along the image one pixel at a time until the entire image has been covered. By applying the filter a smoothing effect is achieved and the visual appearance of the speckle is reduced.

2.1 Mean Filter: The Mean Filter [1] is a simple one and does not remove the speckles but averages it into the data. Generally speaking, this is the least satisfactory method of speckle noise reduction as it results in loss of detail and resolution. However, it can be used for applications where resolution is not the first concern.

2.2 Median Filter: The median filter [2]-[4] is also a sliding-window spatial filter, but it replaces the center value in the window with the median of all the pixel values in the window. The Median filter is also a simple one and removes pulse or spike noises. The main problem of the median filter is its high computational cost (for sorting N pixels, the temporal complexity is O (N·log N), even with the most efficient sorting algorithms).

2.3 Local Region Filter: The Local Region filter [5]-[7] divides the moving kernel into eight regions based on angular position (North, South, East, West, NW, NE, SW, and SE). For each region, the variance is calculated, and then the algorithm compares the variances of the regions surrounding the pixel of interest. The pixel of interest is replaced by the mean of all DN values within the region with the lowest variance

2.4 Frost Filter: The Frost filter is an adaptive and exponentially-weighted averaging filter based on the coefficient of variation which is the ratio of the local standard deviation to the local mean of the degraded image. The Frost filter [8]-[9] replaces the pixel of interest with a weighted sum of the values within the nxn moving kernel. The weighting factors decrease with distance from the pixel of interest. The weighting factors increase for the central pixels as variance within the kernel increases. This filter assumes multiplicative noise and stationary noise statistics and follows the following formula:

$$\text{DN}=\sum_{nxn} k\alpha\, e^{-\alpha|t|} \qquad (1)$$

Where $\alpha = \left(\frac{4}{n\bar{\sigma}^2}\right)\left(\frac{\sigma^2}{\bar{I}^2}\right)$

K= normalization constant

$\bar{I}$ = local mean

σ = Local variance

$\bar{\sigma}$ = image coefficient of variation value

$|t| = |X - X_0| + |Y - Y_0|$, and

n= moving kernel size

- **2.5 Diffusion Filter:** The key point in effective speckle noise removing is balance between speckle suppression and feature preservation. Diffusion filter is an effective technique for goal achievement. Behind this development is solution of partial differential equation (PDE) of transient permeability for 2D domain. Due to its nonlinear nature and adaptive anisotropy the filter has excellent both speckle reduction and detail preserving properties [10]-[14].

III. EXPERIMENTAL ANALYSIS AND DISCUSSION

The simulated imagery used for numerical experiment is a 227x167 pixel image with sharp edges. A uniformly distributed multiplicative noise with mean zero and variance 0.04 is added to the simulated imagery. To test the efficiency of the filters mentioned above, at the first step a 3x3 kernel is used for the filters. All of the filters are applied to the noise contaminated imagery. Figure 1 at the end shows the noisy as well as the filtered image using a 3x3 kernel. The performance of noise removing algorithms is measured using quantitative performance measures such as MSE, SNR as well as in term of visual quality of the images. Table I shows the values of MSE and SNR for different type of speckle reduction filters .Performance of all algorithms is tested with medical Images. The Statistical Measurement for MSE [14] and SNR [15] are given below

$$\textbf{MSE} = \frac{1}{k}\sum_{i-1}^{K}(\hat{S}_i - S_i) \qquad (2)$$

Where $\hat{S}$ = noisy image
S=original image
K=image size

$$\textbf{SNR}=10\log_{10}\frac{(\sum_{i=1}^{K}S_i^2 / \sum_{i=1}^{K}(\hat{S}_i - S_i)^2)}{} \qquad (3)$$

Where $\hat{S}$ = noisy image
S=original image
K=image size

It is seen that Diffusion and Frost filters have the best results.

IV. CONCLUSION

The performance of noise removing algorithms is measured using quantitative performance measures such as MSE, SNR as well as in term of visual quality of the images. Many of the methods fail to remove speckle noise present in the medical image, since the information about the variance of the noise may not be identified by the methods**.** Performance of all algorithms is tested with medical images. The computational result showed that Diffusion and Frost filters have the best results Due to its nonlinear nature and adaptive anisotropy the Diffusion filter has excellent both speckle reduction and detail preserving properties. The Frost filter also strikes a balance between averaging and the all-pass filter. The response of the filter varies locally with the coefficient of variation. In case of low coefficient of variation, the filter is more average-like, and in cases of high coefficient of variation, the filter attempts to preserve sharp features by not averaging. In simulated imageries it is seen that regardless of the kernel size, Mean, Median and Local Region filters perform poorly. This sounds a reasonable result as these filters do not take all the statistical characteristics of the image into consideration. The advantage of the median filter is its simplicity and algorithmic straight forwardness. But due to its non adaptive nature it deteriorates not only speckles but details as well and brings more distortions into the picture. The Mean Filter does not remove the speckles but averages it into the data.

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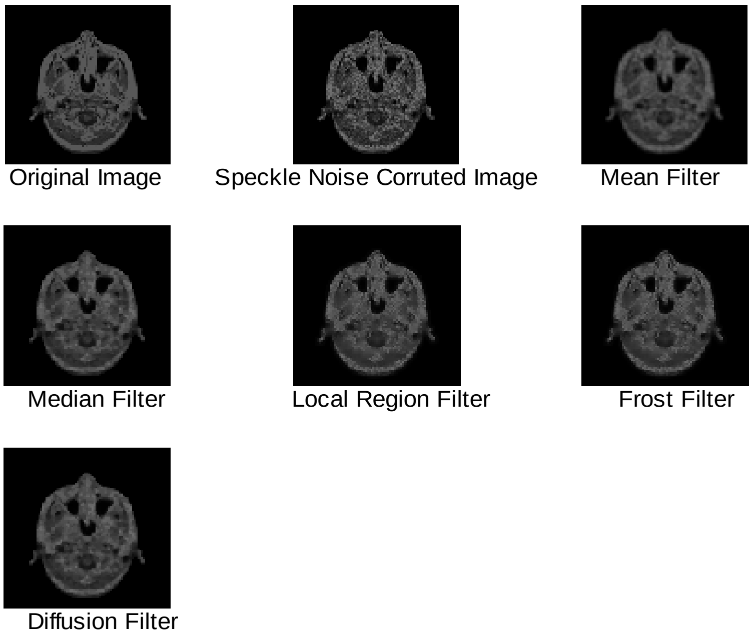

Figure 1. Shows the effect of different filters on Speckle Noise Reduction

Table I. Statistical Measurements

Filter Type	**MSE**	**SNR**
Mean	91.5039	24.6988
Median	152.9449	22.4679
Local Region Filter	150.9129	22.5260
Frost	31.1305	29.3814
Diffusion Filter	20.5826	31.1782