Statistical Analysis for the Removal of Noise in Medical Imaging

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Abstract — **In Medical digital images, produced by various imaging devices like x-ray, CT, magnetic resonance imaging (MRI), ultrasound, etc., use for diagnosis of diseases. Ultrasonic imaging is a widely used medical imaging procedure because it is economical, comparatively safe. The main problem during diagnosis is the distortion. These distortions are termed as 'Noise'. This study focus on one type noise, namely, 'Speckle Noise', produced by ultrasonic devices. This paper concentrated to reduce speckle noise and the studies the effect of different filtering techniques for speckle reduction. The paper introduces the speckle reducing anisotropic diffusion (SRAD) method that reduces the noise effectively without loss of original image. The experimental results proved that SRAD gives higher PSNR. The performance of SRAD was superior compared to traditional lee, frost, kaun filter.**

Keywords— **Speckle Noise, lee, frost, kaun, speckle reducing anisotropic diffusion SRAD, Peak Signal to noise ratio (PSNR), Introduction**

INTRODUCTION

Medical digital images have become an essential part in the healthcare industry for diagnosis of diseases. These images are produced by various medical imaging devices like x-ray, CT / MRI scanners and electron microscope all of which produce high resolution images. Medical images are usually corrupted by Noise during their acquisition and transmission, and noisy images often lead to incorrect diagnosis. The main objective of Image Denoising techniques is to remove such noises while retaining as much as possible the important signal features. Ultrasonic imaging is a widely used medical-imaging procedure because it is economical, comparatively safe, transferable and adaptable.

Images produced by these devices can be displayed, captured, and broadcast through a computer using a frame grabber to capture and digitize the analog video signal. The captured signal can then be post-processed on the computer itself. Ultrasonography is inexpensive and portable when compared with other imaging techniques such as Magnetic Resonance Imaging (MRI) and Computerized Tomography (CT). It is widely used by practitioners as they have no known long-term side effects and has the added advantage that it is non-intrusive to the patients. The device provides live images, where the operator can select the most useful section for diagnosing thus facilitating quick diagnoses.

One of the major problems of ultrasound images is that they suffer from a special kind of noise called 'speckle'. Speckle is a complex phenomenon and it significantly degrades image quality. Speckle appears interference of back-scattered wave from many microscopic diffused reflection which passing through internal organs and makes it more difficult for the observer to discriminate fine detail of the images in diagnostic examinations.

Generally speaking there are two techniques of removing/reducing speckle noise, i.e., multi-look process and spatial filtering. Multi-look process is used at the data acquisition stage while spatial filtering is used after the data is stored. No matter which method is used to reduce/remove the speckle noise, they should preserve radiometric information, edge information and last but not least, spatial resolution. In simple terms, the goal of any speckle removal algorithm should be to enhance the corrupted images by maintaining the quality of the image.

This paper is an effort made to produce a speckle noise removal using various filtering technique. This paper is organized as below. The second section gives an overview to the noise under discussion, while Section 3 discusses the filters uses to reduce noise. Section 4 presents results of experimented images and comparison of parameters. Section 5 presents a short conclusion.

II. SPECKLE NOISE

Speckle is a random, deterministic, interference pattern in an image formed with coherent radiation of a medium containing many sub-resolution scatterers. Speckle has a negative impact on ultrasound imaging. Presence of speckle noise prevents Automatic Target Recognition (ATR) and texture analysis algorithm to perform efficiently and gives the image a grainy appearance. Several adaptive filters have been implemented for speckle noise removal.

A. *Mathematical Model Of Noise*

Mathematically the image noise can be represented With the help of these equations below:

$$V(x, y) = g[u(x, y)] + \eta(x, y) \tag{1}$$

$$g[u(x,y)] = \iint h(x, y; x', y')\, u'(x', y')\, dx'\, dy' \quad (2)$$

$$D(x, y) = f\,[g(u(x, y))]\, \eta 1(x, y) + \eta 2(x, y) \quad (3)$$

Here u(x, y) represents the objects (means the original image) and v(x, y) is the observed image. Here h (x, y; x', y') represents the impulse response of the image acquiring process. The term (x, y) represents the additive noise which has an image dependent random components f [g(w)]1 and an image independent random component A different type of noise in the coherent imaging of objects is called speckle noise. Speckle noise can be modeled as

$$V(x, y) = u(x, y)\, s(x, y) + \eta\, (x, y) \quad (4)$$

Where the speckle noise intensity is given by s(x, y) and n(x, y) is a white Gaussian noise. The main objective of image-de-noising techniques is to remove such noises while retaining as much as possible the important signal features. 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 disgraces image quality and affects the tasks of individual interpretation and diagnosis. An appropriate method for speckle reduction is one which enhances the signal-to-noise ratio while conserving the edges and lines in the image.

B. Model of Speckle Noise

The most critical part of developing a method for - recovering a signal from its noisy environment seems to be choosing a reasonable statistical (or analytic) description of the physical phenomena underlying the data-formation process. The availability of an accurate and reliable model of speckle noise formation is a prerequisite for development of a valuable de-speckling algorithm. In ultrasound imaging, however, the unified definition of such a model still remains arguable. Yet, there exist a number of possible formulae whose probability was verified via their practical use. A possi.ble generalized model of the speckle imaging is

$$g(n, m) = f(n, m)u(n, m) + \xi\ (n, m) \quad (5)$$

Where g, f, u and ξ stand for the observed image, original image, multiplicative component and additive component of the speckle noise basically. Here (ξ, m) denotes the axial and lateral indices of the image samples or, alternatively, the angular and range indices for B-scan images. When applied to ultrasound images, only the multiplicative component of the noise is to be considered; and thus, the model can be considerably simplified by disregarding the additive term, so that the simplified version of (5) becomes

$$g(n, m) = f(n, m)u(n, m) \quad (6)$$

Holomorphic de-speckling methods take advantage of the logarithmic transformation, which, when applied its converts the multiplicative noise to an additive one. Denoting the logarithms of g, f *and u* by *gl, fl,* and *ul,* respectively, the measurement model becomes

$$g_l(n, m) = f_l\ (n, m)u_l\ (n, m) \quad (7)$$

At this stage, the problem of de-speckling is reduced to the problem of rejecting an additive noise, and a variety of noise-suppression techniques could be evoked in order to perform this task.

III. SPECKLE FILTERING

In speckle filtering a kernel is being moved over each pixel in the image and applying some mathematical calculation by using these pixel values under the kernel and replaced the central pixel with calculated value. The kernel is moved along the image only one pixel at a time until the whole image covered. By applying these filters smoothing effect is achieved and speckle noise has been reduced to certain extent.

A. Median filter:

The best known order-statistics filter is the median filter in image processing. The median filter is also the simpler technique and it also removes the speckle noise from an image and also removes pulse or spike noise

B. Lee filter:

The lee filter is basically used for speckle noise reduction. The lee filter is based on the assumption that the mean and variance of the pixel of the interest is equal to the local mean and variance of all pixels within the moving kernel.

C. Kaun filter:

In this filter given kaun et al., the multiplicative noise model is first transformed into a signal-dependent additive noise model. Then the MMSE criterion was applied to this model. The resulting filter has the same form as the lee filter but with the different weighting function which is given as kaun filter is much better than the lee filter.

D. SRAD filter:

SRAD filter is known as speckle reducing anisotropic diffusion. The SRAD can eliminate speckle without distorting useful image information and without destroying the important image edges. The SRAD PDE exploits the instantaneous coefficient of variation in reducing the speckle. The results which are given below tells the SRAD algorithm provides superior performance in comparison to the conventional techniques like lee, frost, kaun filters in terms of smoothing and preserving the edges and features.

IV. EXPERIMENT RESULTS

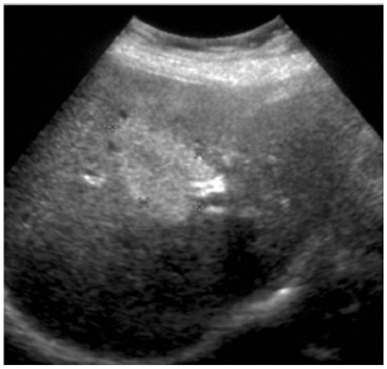

Fig. 1 Original Image

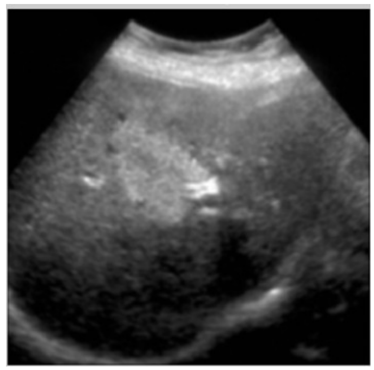

Fig. 2 Mean Filtered Image

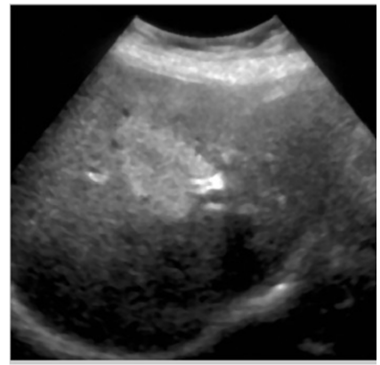

Fig. 3 Median Filtered Image

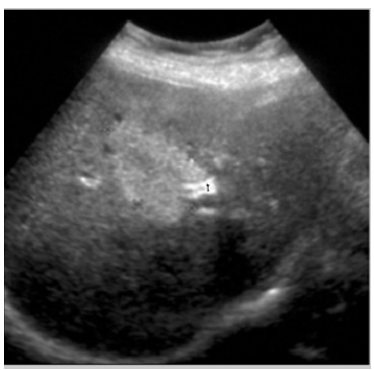

Fig. 4 Lee Filtered Image

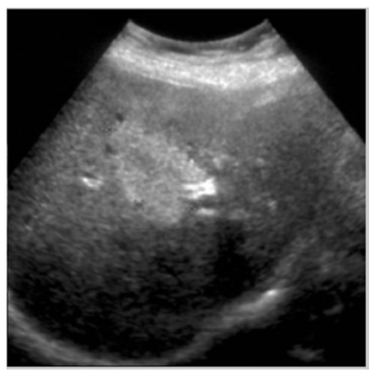

Fig. 5 Kaun Filtered Image

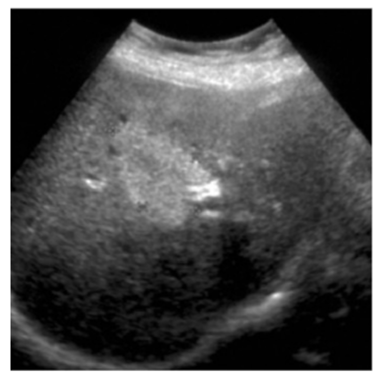

Fig. 6 Frost Filtered image

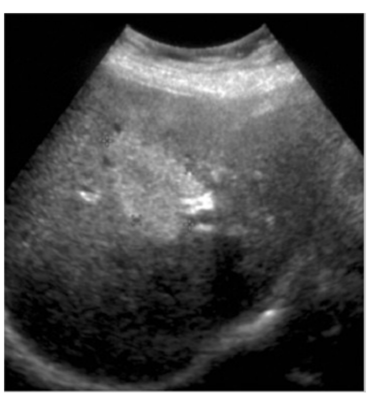

Fig. 7 SRAD Filtered Image

The filtered image can be mathematically calculated by the parameters also. The amount of noise removed can be calculated with the MSE, SNR and PSNR parameters.

(1) Mean Squared Error (MSE)

The MSE calculates the difference between the original image and filtered image. MSE can be represented in mathematically by

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(g_{ij} - f_{ij})^2$$

(8)

(2) Signal To Noise Ratio (SNR)

The signal to noise ratio measure the noise per image.

It can be represented by

$$SNR = \frac{\sum_{M,N}\left[I_1^2(m,n) - I_2^2(m,n)\right]^2}{\sum_{M,N}\left[I_1(m,n) - I_2(m,n)\right]^2}$$

(9)

It measures the signal to noise ratio between the original and processed images in an *M X N* window.

TABLE 1

COMPARISON OF VARIOUS FILTERS PARAMETERS

Filter	MSE	SNR	PSNR
Mean	8.9579	65.9734	38.6087
Median	6.7583	67.197	39.8324
Lee	2.3797	71.7302	44.3656
kaun	2.2694	71.9363	44.5716
Frost	1.2124	74.6591	47.2945
SRAD	0.3862	79.6272	52.2626

(3) Peak Signal to Noise Ratio (PSNR)

The PSNR is a quality measurement between the original and a denoised image. The higher the PSNR, the better is the quality of the compressed or reconstructed image.

$$PSNR = 10\log_{10}\left[\frac{R^2}{MSE}\right]$$

(10)

R is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255.

V. CONCLUSION

In this paper, we experimented various techniques for speckle noise reduction like lee, kaun, frost, SRAD, Mean and Median filtering techniques and seen that speckle noise has been reduced as shown in Table 1. The experiment results prove that the SRAD gives better noise reduction and the output images proves that SRAD filtered the image with less information loss.

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