ENHANCEMENT METHODS FOR REDUCTION OF SPECKLE IN ULTRASOUND B- MODE IMAGES

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ABSTRACT- *Diagnostic sonography (ultrasonography) is an ultrasound-based diagnostic imaging technique used to visualize subcutaneous body structures including tendons, muscles, joints, vessels and internal organs for possible pathology or lesions. Obstetric sonography is commonly used during pregnancy and is widely recognized by the public. There are a plethora of diagnostic and therapeutic applications practiced in medicine.The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide `better' input for other automated image processing techniques. Generally we get blurred image by acquiring technique. Thus we require increasing sharpness of image. This paper presents different filtering techniques based on Statistical methods for the removal of speckle noise in ultrasound images. The quality of the enhanced images is measured by the Statistical quantity measures: Peak Signal-to-Noise Ratio (PSNR), and Mean Square Error (MSE).*

Keywords: Ultrasound Image, Speckle Noise, PSNR, MSE

1. INTRODUCTION

Ultrasound imaging is a widely used and safe medical diagnostic technique, due to its noninvasive nature, low cost and capability of forming real time imaging. However the

Use fulness of ultrasound imaging is degraded by the presence of signal dependant noise known as speckle. The speckle pattern depends on the structure of the image tissue and various imaging parameters. There are two main purposes for speckle reduction in medical ultrasound imaging

(1) To improve the human interpretation of ultrasound images

(2) De-speckling is the preprocessing step for many ultrasound image processing tasks such as segmentation and registration.

A number of methods have been proposed for speckle reduction in ultrasound imaging. While incorporating speckle reduction techniques as an aid for visual diagnosis, it has to keep in mind that certain speckle contains diagnostic information and should be retained [1,4,5].

2. SPECKLE NOISE

Speckle is not a noise in an image but noise-like variation in contrast. It arises from random Variations

in the strength of the backscattered waves from objects and is seen mostly in medical imaging. Speckle reduction of medical ultrasound images represents a critical pre-processing step, providing clinicians with enhanced diagnostic ability [6].

- Speckle noise is the characteristic seen in computed ultrasound images that contribute to the visual noise.
- Some filtering techniques are applied to speckle noised image.

This noise is, in fact, caused by errors in data transmission. The corrupted pixels are either set to the maximum value, which is something like a snow in image or have single bits flipped over. This kind of noise affects the ultrasound images. Speckle noise has the characteristic of multiplicative noise. Speckle noise follows a gamma distribution and is given as [6].

$$F(g) = \left[\frac{g^{\alpha-1}}{(\alpha-1)!\,a^{\alpha}}\, e^{-\frac{g}{a}}\right] \qquad (1)$$

Where, variance is *a2 α* and *g* is the gray level.

3. IMAGE ENHANCEMENT METHODS

Image enhancement is a very basic image processing task that defines us to have a better Subjective judgment over the images. And Image Enhancement in spatial domain (that is, performing operations directly on pixel values) is the very simplistic approach. Enhanced images provide better contrast of the details that images contain. Image enhancement is applied in every field where images are must to be understood and analyzed [1].

Image enhancement simply means, transforming an image *f* into image *g* using *T*. Where *T* is the transformation. The values of pixels in images *f* and *g* are denoted by *r* and *s*, respectively. As said, the pixel values *r* and *s* are related by the expression.

$$s = T(r) \qquad (2)$$

Where *T* is a transformation that maps a pixel value *r* into a pixel value *s*. The results of this transformation are mapped into the grey scale range as we are dealing here only with grey scale digital images. So, the results are mapped back into the range (0, L-1), where $L=2^k$, k being the number of bits in the image being considered [7]. So, for instance, for an 8-bit image the range of pixel values will be (0, 255).

3.1 MEDIAN FILTER

It is defined as the median of all pixels within a local region of an image. It performs much better than arithmetic mean filter in removing salt and pepper noise from an image and in preserving the spatial details contained within the image. This method is particularly effective when the noise pattern consists of strong, spike like components and the characteristic to be preserved is edge sharpness.

3.2 HARMONIC MEAN FILTER

The harmonic mean filter is a nonlinear filtering technique for image enhancement. The harmonic mean filter is member of a set of nonlinear mean filters, which are better at removing Gaussian type noise and preserving edge features than the arithmetic mean filter. The harmonic mean filter is very good at removing positive outliers [8]. The definition of harmonic mean filter is provided as:

$$f(x,y) = \frac{mn}{\sum_{(s,t)\in S_{xy}} \frac{1}{g(s,t)}} \qquad (3)$$

3.3 CONTRA HARMONIC MEAN FILTER

The contra-harmonic mean filter is nonlinear filtering method. The contra-harmonic mean filter is member of a set of nonlinear mean filters, which are better at removing Gaussian type noise and preserving edge features than the arithmetic mean filter. The contra harmonic filter is very good at removing positive outliers for negative values of Q and negative outliers for positive values of Q [8]. The contra harmonic mean filter operation is given by the expression.

$$\mathbf{F}(x,y) = \frac{\sum_{(s,t)\in S_{xy}} g(s,t)^{Q+1}}{\sum_{(s,t)\in S_{xy}} g(s,t)^{Q}} \qquad (4)$$

Where, Q is called the order of the filter. This filter is well suited for reducing or virtually eliminating the effects of salt-and-pepper noise

3.4 GEOMETRIC MEAN FILTER

The geometric mean filter is member of a set of nonlinear mean filters, which are better at removing Gaussian type noise and preserving edge features than the arithmetic mean filter. The geometric mean filter is very susceptible to negative outliers [8]. The geometric mean filter is defined as:

$$f(x,y) = \left[\prod_{(s,t)\in S_{xy}} g(s,t)\right]^{\frac{1}{mn}} \qquad (5)$$

It is not suitable for removing impulse noise in the image each output pixel is given by the product of the pixels in the sub image window and raised to the power 1/mn. Where m is number of rows in the image and n is number of columns in the image. It is better than mean filter in smoothing but it tends to lose less image detail in the process.

3.5 KAUN & LEE FILTERS

Lee filter form an output image by computing a linear combination of the center pixel intensity in a filter window with the average intensity of the window. Kaun and Lee filter have the same formulation although signal model assumption and derivations are different. These two filters achieve a balance between straight forward averaging in homogeneous regions and identity filter where edges and point features exist. This balance depends on the coefficient of variation inside the moving window.

3.6 FROST FILTER

It achieves a balance between averaging and all pass filter by forming an exponentially shaped filter kernel. The response of the filter varies locally with the coefficient of variation

3.7 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.

4. EXPERIMENTAL ANALYSIS AND DISCUSSION

The proposed algorithms have been implemented using image processing tool box of MATLAB 7.0.

The performance of various spatial enhancement approaches are analyzed and discussed. The measurement of image enhancement is difficult to measure. There is no common algorithm for the enhancement of the image. The statistical measurement could be used to measure enhancement of the image. The Mean Square Error (MSE) and Peak Signal-to-Noise Ratio (PSNR) are used to evaluate the enhancement performance. The noise level is measured by the standard deviation of the image:

$$\sigma = \sqrt{\frac{1}{N}\sum (bi - b)^2}$$

Where, i=1,2,3,…,N , b is the mean gray level value of the original image and bi is the gray level value of the surrounding region and N is the total number of pixel in the image.

4.1 QUALITY MEASUREMENT PARAMETERS

MSE	$\frac{\sum f(i,j) - F(i,j))^2}{MN}$
PSNR	$20log_{10}\frac{255}{RMSE}$
COC	$\frac{\sum(g-\bar{g})(\hat{g}-\bar{g})}{\sqrt{\sum(g-\bar{g})^2\sum(\hat{g}-\bar{\hat{g}})^2}}$

The parameters which are used in the filter performance appraisal are Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR). Correlation of coefficient (COC)

Where, f is the original image F is the filtered image and MN is the size of image.

4.1.1 MSE

MSE is an estimator in many ways to quantify the amount by which an filtered/noisy image differs from noiseless image

4.1.2 PSNR

PSNR is the ratio between possible power of a signal and the power of corrupting noise that affects the fidelity of its representation.

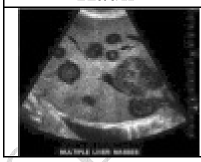
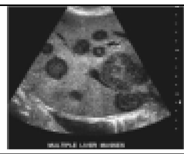
4.1.3 COC

Correlation indicates the strength and direction of linear relationship between two signals and its value lie between +1 to -1.

The original ultrasound image and filtered images of the liver obtained by various filtering techniques are shown in figure. If the value of MSE is low and the values of PSNR are larger than the enhancement approach is better.

The performance analysis of the proposed approaches and existing approaches with the regard to ultrasound medical images for liver. It was observed from the figure that the SRAD Filter removes the speckle noise better than other enhancement approaches.

4.2 .Experimental results

Original	median	Harmonic Mean
		
Contra Harmonic mean	Geometric Mean	Lee
		
Kaun	Frost	SRAD
		

4.3 Computational results

Speckle reduction technique	MSE	PSNR	COC
Median filter	118.46	27.39	0.99
Harmonic Mean	6.87	9.76	0.98
Contra Harmonic Mean	6.87	9.76	0.98
Geometric Mean	6.87	9.75	0.98
Lee	372.80	22.42	0.97
Kaun	372.80	22.42	0.97
Frost	94.78	28.36	0.99
SRAD	0.0024	74.27	0.96

5. CONCLUSION

The performance of noise removing filtering techniques is measured using quantitative performance measures such as PSNR and MSE as well as in term of visual quality of the images. Many of the methods fail to remove speckle noise present in the ultrasound medical image, since the information about the variance of the noise may not be identified by the methods. Performance of all filtering techniques is tested with ultrasound image regard to liver. The computational result showed one of the proposed filtering techniques SRAD Filter performed better than others.

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