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ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 6, Issue 11, November 2018

An Efficient Hybrid Spatial Filter for Removal of Speckle Noise in Ultrasound Image

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Abstract: Ultrasound imaging may be a largely used medical procedure, attributable to its low value, non-invasive nature, safe and capability of forming real time imaging. The quality of ultrasound image is affected by the presence of signal dependant noise referred to as speckle. It tends to cut back the medical practitioner interpretation and designation. The pattern of speckle depends on image tissue structure and various imaging parameters. Noise removing in ultrasound image may be a difficult task in image process. Speckle may be a multiplicative noise in nature. Multiplicative noise removal is harder than additive noise. Many number of hybrid filtering approaches are introduced for speckle reduction in ultrasound image. we have a tendency to focus on hybrid filter such as, Modified Median(N4 max) and Modified Median(ND max) for speckle reduction in abstraction domain. While reducing speckle noise, it is to think about that sure speckle contains useful data and should be retained. Performances of all filters are measured in terms of MSE, RMSE, PSNR and Efficiency.

Keywords: Test image, Speckle noise analysis, Modified Median (N4 Max) and Modified Median (ND Max) filter, Reconstruction, validation

I. INTRODUCTION

Digital images play a vital role both in daily life applications such as satellite television, magnetic resonance imaging, computer tomography as well as in the area of research and technology such as medical images etc. In medical imaging Ultrasound is an indispensable diagnostic tool because of its non-invasive, non-ionizing, real time portable and low cost nature [1]. Ultrasound imaging uses high frequency sound waves to view soft tissues such as muscles and internal organs. Since speckle is a major shortcoming of Ultrasound, reducing or eliminating speckle is great interest to system designers. Reducing noise from Medical images is a challenge for researchers in digital image processing. Speckle noise is commonly found in synthetic aperture radar images and Medical images [21].

Various methods available in literature for speckle noise reduction are multi look method, spatial averaging and homomorphic filtering [18]. The multi look process is usually done during data acquisition stage and speckle reduction by spatial filtering is performed on the image after it is acquired.

The homomorphic filtering approach operates in logarithmic domain. Irrespective of the method used to reduce speckle noise from images, the ideal speckle reduction method must preserve radiometric information and the textural information i.e. the edges between different area and spatial signal variability [8, 11]. The spatial filters are of two types which are adaptive or non-adaptive. A non-adaptive filter takes the parameters of the whole image signal into consideration and leave out the local properties of the sensors [6]. These kinds of filters are not appropriate for not-stationary scene signal. Fast Fourier Transform (FFT) is an example for such filters. The adaptive filters accommodate changes in local properties as well as the nature of sensors. Adaptive filters reduce speckle while preserving the edges and these filters modify the image based on statistical extracted from the local environment of each pixel [4]. A filter that adapts the stretch to the region of interest produces a better enhancement. These filters are Mean, Median, Lee, Lee-sigma, Frost and Gamma MAP. In homomorphic filtering approach, the multiplicative speckle noise is first converted to additive noise then one of the additive noise model is applied for noise reduction and finally speckle reduced image is obtained by taking the exponential of the image obtained in second step [2]. In this paper we proposed a method for speckle noise reduction using enhanced sticks filtering technique

II. PROBLEM FORMULATION

The scope of ultrasound imaging systems covers many areas like cancer detection, obstetric sonography during pregnancy etc. In Ultrasound images speckle noise shows its presence while doing the visualization process. It will produce negative effect on Ultrasound image which may further leads to human error or individual bias. Existing filters are not much efficient in removing speckle noise, they may cause to loss of details in low contrast border regions.

Alternatively we are proposing a system to use sticks filter as a smoothing filter. The sticks filtering algorithm takes on the challenge of filtering speckle in Ultrasound images without losing edge detail by determining whether a linear feature passes through pixel (x, y) and then calculating the filtered pixel intensity g(x,y), which is the arithmetic mean of neighboring pixel in the direction of sticks. Enhanced sticks filtering method will remove speckle noise completely and produce better results as compared to other existing filters.

III. SPECKLE NOISE IN ULTRASOUND IMAGES

These scans use high frequency sound waves which are emitted from a probe. The echoes that bounce back from structures in the body are shown on a screen. The structures can be much more clearly seen when moving the probe over the body and watching the image on the screen. The main problem in these scans is the presence of speckle noise which reduces the diagnosis ability. It provides live images, where the operator can select the most useful section for diagnosing thus facilitating quick diagnoses.

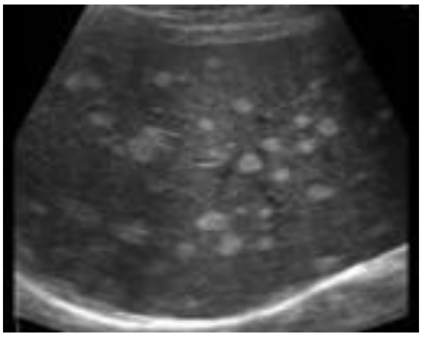

Fig 1 Ultrasound scan image

Speckle noise affects all coherent imaging systems including medical ultrasound. Within each resolution cell a number of elementary scatterers reflect the incident wave towards the sensor. The backscattered coherent waves with different phases undergo a constructive or a destructive interference in a random manner. The acquired image is thus corrupted by a random granular pattern, called speckle that delays the interpretation of the image content.

IV. PROPOSED METHOD

A. Proposed Method Block diagram:

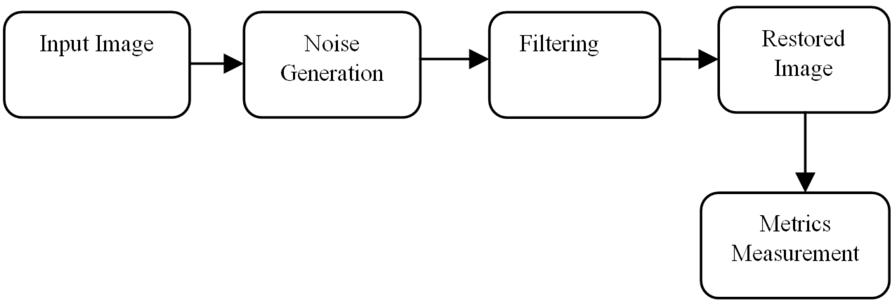

Fig.2 block diagram of proposed method

B Arithmetic Mean Filtering (AMF) Technique

This is the simplest of the mean filtering techniques. Let S_{xy} represent the set of coordinates in a rectangular sub image window of size m × n centered at point (x, y). The AMF technique computes the average value of the corrupted image g(x, y) in the area defined by S_{xy}. The value of restored image ***f*** at any point (x, y) is simply the Noise impulses can be either negative or positive. Impulse noise generally is digitized as extreme (pure black and white) values in an image. Hence the assumption usually is that **a** and **b** are "Saturated values", in the sense that they are equal to the minimum and maximum allowed values in the digitized image. As a result, negative impulses appear as black (Pepper) points in an image. For the same reason positive impulses appear as white (Salt) noises. For an 8 bit image this means that a=0 (black) and b=255 (white). Arithmetic Mean computed using the pixels in the region defined by S_{xy}. We can express AMF by the equation.

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

C. Modified Median (Median):

The value of a pixel in modified median(median) filter at point p is altered by the median of median pixel value of 4-neighbourhood of some extent ‘p’, median pixel value of cross neighbours of some extent ‘p’ and pixel value of ‘p’. This filter is defined as

$$g(p) = median\begin{cases} median\{f(p), p\in N_4(p)\} \\ median\{f(p), p\in N_D(p)\} \\ f(p) \end{cases} \qquad (2)$$

D. Modified Median (Max):

The value of a pixel in modified median(maximum) filter at point p is altered by the maximum of median pixel value of 4-neighbourhood of some extent ‘p’, median pixel value of cross neighbors of some extent ‘p’ and pixel value of ‘p’. This Modified Median (Max) filter is defined as

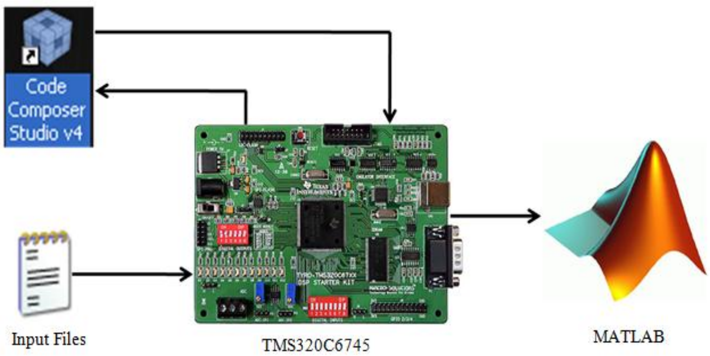
$$g(p) = maximum\begin{cases} median\{f(p), p\in N_4(p)\} \\ median\{f(p), p\in N_D(p)\} \\ f(p) \end{cases} \qquad (3)$$

E. Modified Median (N4 Max) and Modified Median (ND Max)

In this filter the value of pixel at point p is altered by the maximum value of modified median(N4 maximum) pixel value of 8-neighbourhood of some extent ‘p’ and modified median(ND maximum) pixel value of 8- neighbourhood of some extent ‘p’ and pixel value of ‘p. This filter is defined as

$$g(p) = maximum \begin{cases} modified\ median(N_4 max)\ \{f(p), p\in N_8(p)\} \\ modified\ median(N_D max)\{f(p), p\in N_8(p)\} \\ f(p) \end{cases}$$

F. Hardware Diagram



V. PERFORMANCE EVALUATION

To quantify the performance improvements of the speckle reduction methods, various measures are used. The commonly preferred measures are mean squared error (MSE) and peak signal to noise ratio (PSNR). The parameters of measures are listed below.

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

$$PSNR = 20 \times \log_{10}(255/\sqrt{MSE})$$

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

VI. RESULTS AND DISCUSSION

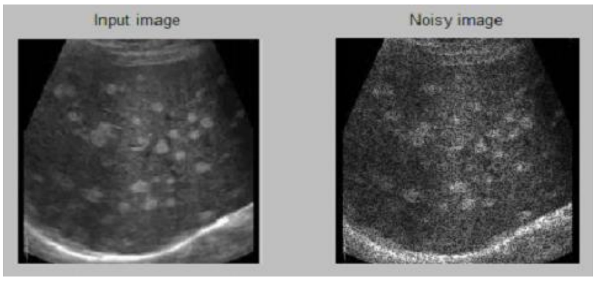


Fig2. Input image and Noisy image

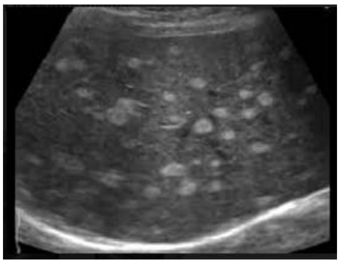


Fig3. De-Noised image

Filters	MSE	PSNR	Efficiency
Median Filter	31.76746	33.11098	9.383664
Mean Filter	20.0022	35.12003	16.02065
Wiener Filter	52.46518	30.93209	7.8956
Frost Filter	30.31732	33.3139	9.56856
Modified Median(N4 Max) and Modified Median(ND Max)	**2.715956**	**40.13245**	**28.17504**

CONCLUSION

This paper provides detail information of Speckle noise removal, here we had discussed various algorithm and we had compare the result of all different methods. This proposed filter is tested with different densities of noise and it shows consistent result over the range of noise densities. This filter is useful for removal of speckle noise even in the ease when image is corrupted by high density of noise.

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