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To enhance the quality of ultrasound images by reducing speckle noise and edge detection using hybrid Weiner-H Filtering technique

Shrusti Porwal[1], K.D Gupta[1] and Manju Mandot[2]

[1]Department of Computer Science and IT, Jayoti Vidyapeeth Women's University, Jaipur.

[2]Department of Computer Science and IT, JRNRVU, Udaipur.

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ABSTRACT

In this world of emerging technology ultrasound imaging is widely used in medical field for disease diagnosis and treatment. Ultrasound imaging is a safe medical technique, due to its non-invasive nature, low cost, portable ultrasound system and the capability for forming real-time imaging. However the main problem with the ultrasound imaging is the image quality of ultrasound image which degrades by the presence of noise called as speckle. The speckle noise depends on the structure of tissue and various imaging parameter. This paper proposed the filtering techniques to reduce the speckle noise from ultrasound image and edge detection in ultrasound image. In this paper we describe a hybrid wiener-H filtering technique to remove speckle noise. This gives a better resulting ultrasound image for disease diagnosis and treatment by clinician.

Introduction

The medical imaging devices namely X-ray, CT/MRI and ultrasound are produces images which are used by medical practitioners in the process of diagnosis [9]. Ultrasound imaging is widely used in medical procedure due to it is economical, comparatively safe, transferable, and adaptable [5]. The main problem with the ultrasound image is noise. The noise is comes due to the consequence of the coherent nature of wave transmitted [1]. This noise corrupts the images and this often leads to incorrect diagnosis by clinician. The main type of noise present in the ultrasound medical image is speckle noise. This speckle noise is a multiplicative noise. There are two main purposes for despeckling is in medical ultrasound imaging. First is to improve human interpretation of ultrasound images and second speckle reduction is the preprocessing step for many ultrasound images processing task such as segmentation and registration [2]. The main disadvantage with ultrasound imaging is its poor quality. And to enhance the quality of ultrasound imaging two techniques used. For despeckling the image techniques sued are multi-look process and spatial filtering. Multi-look process is used at the data acquisition time and spatial filtering is used after storing the data. Among the two methods any of method can be used to remove speckle noise but these techniques also should preserve the edges of image, radiometric information and spatial resolution [3] [4]. Some adaptive filtering is generally uses Lee filter, Kaun filter, Frost filter and Gamma filters [10] [11] [12].

In our work we recommended a new hybrid Weiner-H algorithm for removal of speckle noise in ultrasound image and enhancing the quality of image.

This paper is organized as follows: section I, describes about ultrasound image. Section II, briefly describes the ultra sound system. Section III, briefly describes the speckle noise and speckle noise model. Section IV describes proposed hybrid filtering technique. Finally Section V gives the conclusion of the paper.

Tele:

E-mail addresses: shrusti72@gmail.com

Ultrasound Imageing System

Ultrasound imaging system is a system used for image acquisition process. Figure 2 shows the construction of ultrasound B-mode imaging system. This involves capturing the echo signals returned from human tissue at the surface of piezoelectric crystal transducers [13]. And these transducer than coverts the ultrasonic RF mechanical wave into electrical signals. Convex ultrasound probes collect the echo from human tissue in a radial from. Each group of transducer simultaneously activated to look at certain spatial direction from which they generate a raw line stick to be used later for raster image construction. These sticks are than demodulated and logarithmically compressed to reduce their dynamic range to suit commercial display device. The final image is constructed from the sampled sticks in a process in a process called scan conversion [2].

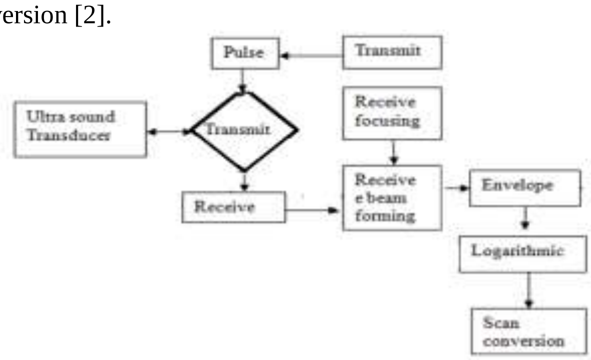


Figure 1: block diagram shows ultrasound imaging System

In ultrasound images some speckle noise reduction techniques also can be applied on envelop detection data, scan converted data or log compressed data. However, some results are different from different techniques. Some times in compression techniques some information about the image object may destroy or lost. However, envelop detection method preserve more information about image object.

For optimum result in ultrasound imaging technique envelope detection method is used. Because information that lost after the compression techniques cannot be recovered by log compressed data image or scan converted data image.

Speckle Noise

Medical images are usually corrupted by speckle (multiplicative noise) during image acquisition and transmission [5]. Speckle is a noise and it is a multiplicative noise which degrades the spatial and contrast resolution. That why it is sensible to remove speckle artifacts before image analysis. The main motive of this thesis is to development of a good method for suppression of speckle in medical ultrasound image by some filtering techniques [8]. The main objective is to remove noise while retaining the signal feature and information for diagnosis.

Model of speckle noise:

The most critical part of digital image processing is to develop a technique for recovering a signal from its noisy environment. It seems to be choosing a reasonable statistical description of the physical phenomena underlying the data-formation process. The availability of an accurate and reliable model of speckle noise formation is previously requested for development of a valuable de-speckling technique (or algorithm). In ultra sound imaging, however, the suitable definition of such a model still remains a matter of argument. Yet there have many formulas for practical use of image de-speckling.

A possible generalized model of the speckle imaging is as follows:

$$\boldsymbol{g(i,j) = f(i,j), u(i,j) + \sum(i,j)} \quad \ldots\ldots (1)$$

Where, **g** is observed image, **f** is original image $\boldsymbol{\sum is}$ Multiplicative component and additive component of the speckle noise, respectively. **(i, j)** denotes the axial and lateral indices of the image samples or the angular and range indices for B-scan images.

Note: when this equations and model is applied to ultrasound images, only multiplicative component of the noise is to be considered. Thus the simplified model is considered. This model is as follows:

$$\boldsymbol{g(i,j) = f(i,j), u(i,j)} \quad \ldots\ldots (2)$$

Homomorphism de-speckling techniques take advantage of the logarithmic transformation, which, when applied to both parts of images, converts the multiplicative noise and additive one. We denote the logarithms of g, f and u by $\boldsymbol{g_1, f_1}$ **and** $\boldsymbol{u_1}$ respectively, and now the measurement model becomes:

$$\boldsymbol{g_1(i,j) = f_1(i,j), u_1(i,j)} \quad \ldots\ldots (3)$$

At this stage, the problem of de-speckling is reduced to the problem of rejecting an additive noise, and a variety of noise-suppression technique could be invoked in order to perform de-speckling task. So we only take multiplicative noise and perform all de-speckling tasks to remove multiplicative noise from ultrasound images [7].

Generation of speckle noise:

The speckle noise is generated from matlab command:

$$\boldsymbol{S = imnoise(f,'speckle', v)} \quad \ldots\ldots (4)$$

Where f is image and v is noise variance [6].

Proposed Filtering Technique

Hybrid wiener-H filter (HWH filter)

Hybrid wiener-H filter is proposed with the hybridization of wiener and high-pass filtering technique. This filtering technique reduces the speckle noise present in the medical ultrasound image. Mainly the wiener filter used for reducing speckle noise and high pass filter is used for maintaining the quality and for preserving important data in ultrasound image. The Unsharp filter is used to sharpen the edge of ultrasound image.

Mathematical equation of proposed HWH filtering technique:

$$\boldsymbol{H(n,m) = wiener2(I, mask)} \quad \ldots\ldots (5)$$

$$\boldsymbol{R(n,m) = a + b \sum H_{hp}(n,m)} \quad \ldots\ldots (6)$$

$$\boldsymbol{O(n,m) = unsharp \sum R(m,n)} \quad \ldots\ldots (7)$$

Figure 2 shows the flow diagram of proposed filtering technique. In this shows how proposed filtering technique works and then the algorithm is given which shows how filtering techniques work and shows the steps of the filtering procedure.

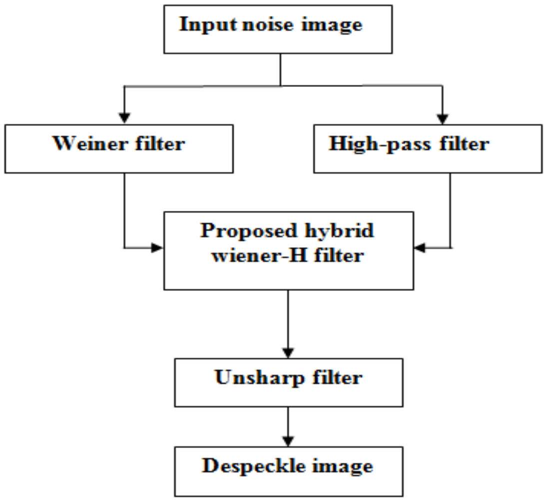


Figure 2: Flow chart of proposed Technique

Algorithm:

Step 1 : Take a synthesis ultrasound image corrupted with speckle noise and noise variance is 0.1 as an input.

Step 2 : Convert the input ultra sound image to gray scale image.

Step 3 : Apply the wiener filter with 5×5 mask on grayscale image and store this filtered image.

Step 4 : Double the image of step 3.

Step 5 : Take image comes from step 4 and apply high pass filter on doubled image for feature highlighting.

Step 6 : Perform addition on the step 5 histeq image with itself only.

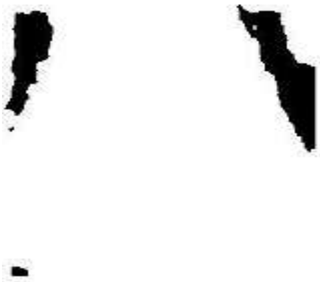
Step 7 : Now apply unsharp method on step 6 image for sharpening the main features of the ultrasound image. This gives final output hybrid wiener-H filtered image.

Step 8 : Apply segmentation on final output image.

Figure 3 (a) shows the ultrasound synthesis image which is corrupted with speckle noise. After applying wiener filter figure 3 (b) shows the resulting noise free image. Result of double of wiener filtered image is show in figure 3 (c). Now apply high pass filter is applied on double *histeq* image which is show in figure 3 (d). Figure 3 (e) shows additive image with same image. Figure 3 (f) shows the high pass filter result. Figure 3 (g) shows the high-pass image with H value. Figure 3 (h) shows wiener-H filter result with unsharp filter. Figure 3 (i) show the segmentation of final hybrid wiener-H filtered image. Figure 4 shows histogram of proposed technique. Figure 4 (a) shows the histogram of noisy image. Figure 4 (b) shows the wiener filtered image's histogram. Figure 4 (c) shows histogram of doubled image. Figure 4 (d) shows the histogram of *Histeq* with wiener filtered image. Figure 4 (e) shows histogram of hybrid filters additive image. Figure 4 (f) show histogram of high-pass resulting image. Figure 4 (g) shows histogram of high-pass with *dftfilt H* image. Figure 4 (h) shows the histogram of final sharp image from HWH proposed filter. Figure 4 (i) show histogram of the segmentation of HWH proposed filtered image.


(a)


(b)


(c)


(d)


(e)

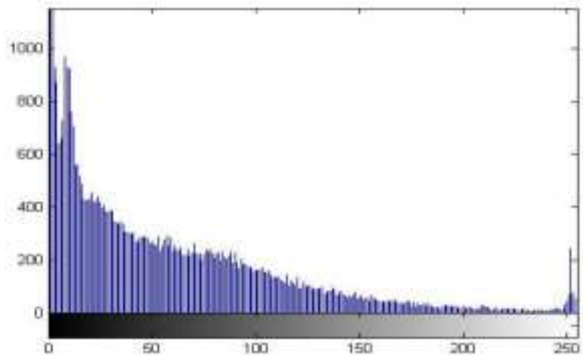

(f)


(g)

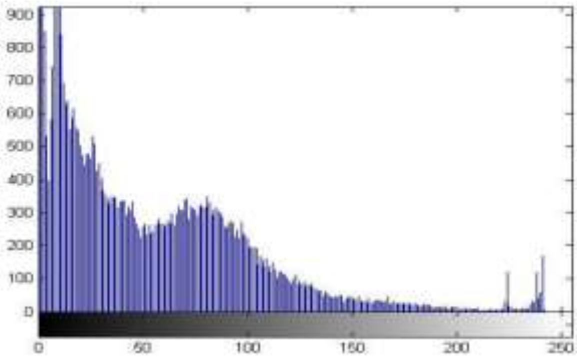

(h)


(i)

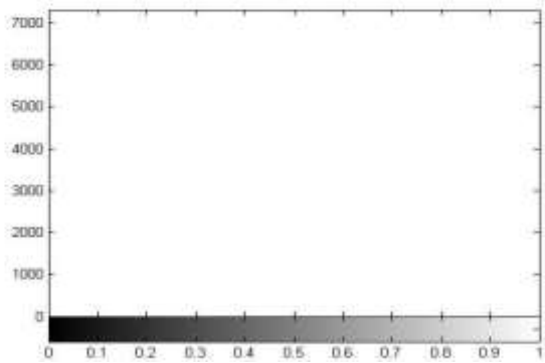
Figure 3: images of proposed hybrid wiener-H filtering technique
(a)Speckle noise corrupt image (b) Wiener filtered image (c) Double image (d) Histeq image (e) Additive image (f) High-pass result (g) High pass with dftfilt H (h) Unsharp output image (i) segmentation of final output image



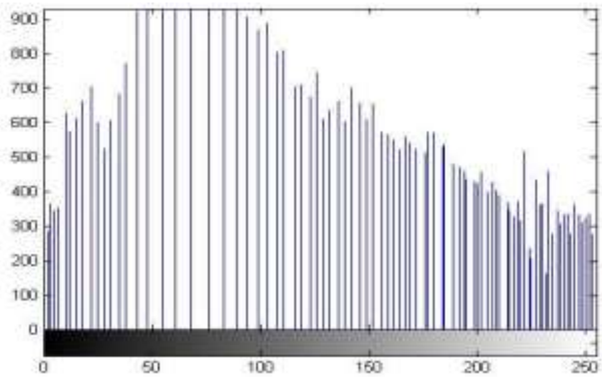
(a)



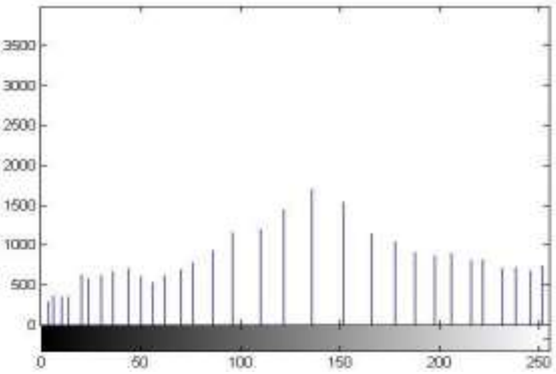
(b)



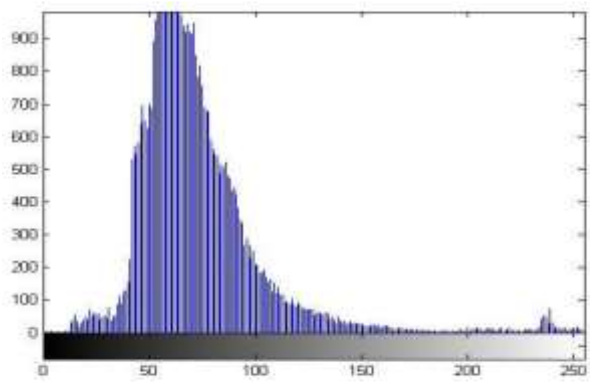
(c)



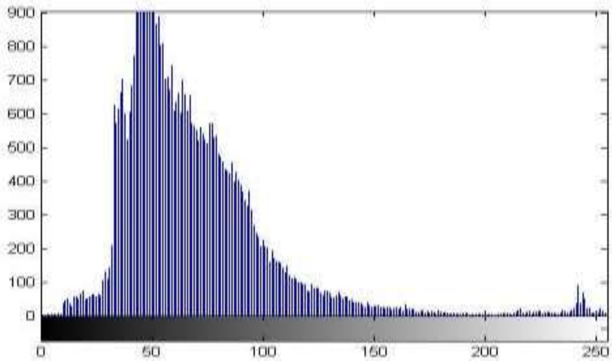
(d)



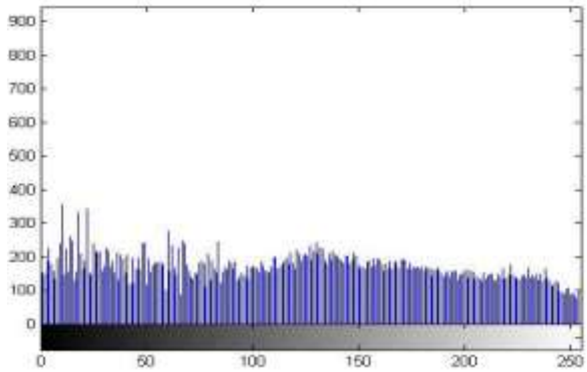
(e)



(f)



(g)



(h)

(i)

Figure 4: histogram of proposed hybrid wiener-H filtering image
(a)histogram of corrupt image (b) histogram of Wiener filtered image (c) histogram of Double image (d)histogram of Histeq image (e) histogram of Additive image (f)histogram of High-pass resulting image (g) histogram of High pass with dftfilt H (h) histogram of final sharp output image (i) histogram of segmentation of output final image

Conclusion

This paper shows the filtering technique to reduce speckle noise in ultrasound image. In this paper we take synthesis image and apply proposed filter to reduce speckle and improve the quality of image. This papers result is based on the visualization of ultrasound image. The resulting image is better in visualization and noise free.

Future Scope

In future this proposed filtering technique can be compared with standard filter by statistical measures like SNR and PSNR.

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