Despeckeling Method for Ultrasound Thyroid Nodules Using Innovative Wiener Filter

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Abstract: Ultrasound (US) imaging may analyze human bodies of different ages; nevertheless, speckle noise is produced when a US image is obtained. A speckle noise removal technique is crucial technology since it prevents doctors from accurately assessing lesions due to the speckle noise. Although there are several methods for denoising thyroid images, an unfavorable over smoothing of the images results in the loss of structural edge features, which impairs diagnosis. This paper explores a new Wiener filter-based method for noise reduction. The suggested improved Wiener filter has the ability to locally modify itself in comparison to the traditional Wiener filter. The proposed novel algorithm that takes advantage of speckle noise characteristics as well as filtering techniques wiener filtering to improve the removal of speckle noise. An excellent balance between the preservation of edges and details and efficient noise reduction can be achieved by automatically fine-tuning its kernel. Moreover, we have got satisfactory performance with help of CQE i.e CQE value we have got is 10.932 which is more as compared to other conventional methods. Moreover, FI is 0.948 which is nearer to one. Thus our improved method can be used preprocessing of US images.

1 INTRODUCTION

Ultrasound (US) instruments have been used to check the bodies of both young and old people; in fact, US ultrasound is one of the most commonly used imaging methods in the area of medical diagnostics. US imaging equipment can be more affordable, radiation-protected, and portable than other medical imaging therapies like computed tomography, magnetic resonance imaging, and X-ray imaging. A characteristic of US photos is speckle noise. The speckle noise in medical US images is caused by backscattered echo signals (Chen, and Lin, 2006), (Chikui, Okamura, et al. 2006).Both multiplication noise & Rayleigh distribution are characteristics of speckle noise, which lowers the resolution of images and contrast because of the granular pattern shown in the photos. Doctors are unable to effectively identify lesions since speckle noise on medical US images make it more difficult to identify, analyse, and recognize the features of lesions. One essential pre-processing technique for achieving a trustworthy lesion detection and analysis using US imaging is a speckle noise reduction algorithm (Ciresan, Giusti, et al. 2012).

Several methods for eliminating speckle noise from digital and US images have been developed in recent years. In this work, five different kinds of speckle noise reduction strategies are compared: Lee diffusion filter (LDF), anisotropic diffusion filters (ADF), single filter, and nonlocal means (NLM) algorithm.

To eliminate speckle noise from ultrasonic images, a variety of single filter techniques have been employed, including the Lee, Kuan, Frost, modified Lee filter, improved Frost filter, and anisotropic diffusion filtering. Because they often result in a smoothing phenomenon at the margins, these filtering methods are not the most effective at removing speckle noise (Ciresan, Meier, et al. 2012).

OBNLM, or optimized Bayesian-based nonlocal mean, is a strategy proposed by Coupe et al. (Boyat, and Joshi, 2015) to reduce speckle noise. It was combined with the OBNLM methodology and the block-wise not local means (NLM) method. The Pearson distance parameter in the OBNLM technique

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was then used to determine how similar both patches in the picture were in order to minimize speckle noise. Using local statistics and the NLM filter, Yang et al. developed an approach to reduce speckle noise. Radlak and Smolka presented an adaptable solution based on NLM filters.

A number of techniques were employed in (Fukushima, 1980), including as the enhanced Wiener filter, fast Fourier transform (FFT), a Markov random field (MRF). The upgraded Wiener filter controls the mask size to accomplish each noise reduction & detail conservation. The methodology for speckle noise removal reduces the computational cost of the program by using the MRF technique method in the FFT domain.

In this paper improved wiener filter have been implemented which will get good result as compared to other conventional despekeling methods.

While images are formed utilising coherent illumination, like acoustic imagery, Synthetic Aperture Radar (SAR) data, etc., speckle noise is discovered (Fukushima, 1980). It is created as a result of the variation in backscatter from heterogeneous cells. The received signal varies arbitrarily due to the many echoes from image pixels' constructive and destructive interference, and the appearance of the image is distorted as a result.

The useable signal and the noise make up the two components of the spekeled US image. Both multiplicative and additive noise make up the noise. While additive noise is noise produced by the sensor, multiplicative noise is connected to the principle of medical US imaging. The image generated by SRAD has the following speckle noise model:

$$f(p,q) = I_{ori}(p,q) * W_{mul}(p,q) + A_{ad}(p,q) \quad (1)$$

Where the $I_{ori}(p,q)$, $W_{mul}(p,q)$, and $A_{ad}(p,q)$ represents the initial signal, multiplicative noise, & additive noise, respectively. Because its impact is much smaller than that of the multiplicative noise $W_{mul}(p,q)$, the additive noise $A_{ad}(p,q)$ is left out of the equation (He, Zhang, et al. 2015), (Michailovich, and Tannenbaum, 2006).

The three items listed below comprise the principal findings of this work:

1. We use an enhanced Wiener filter to despekel ultrasound images. Additionally, an improved wiener algorithm is used to improve the effectiveness of the upgraded wiener filter.

2. We substituted mode parameter which calculating the new pixel value approaches for traditional Wiener filter.

3. Our suggested method got satisfactory result as compared to conventional method.

We use the color quality enhancement (CQE) and Noise index (NI) as performance metrics for preprocessing technique evaluation. The experiment demonstrates that Improved wiener filter, which achieves good performance and preserve needed information (Agaian, Lentz, et al. 2000), (Gao, Panetta, et al. 2012).

2 MATERIALS AND METHOD

2.1 Improved wiener filtering method

In order to diagnose thyroid nodules using the images more effectively, we preprocessed the US images in the dataset 1, using Improved Weiner filtering Model. The improved Wiener filter's flow diagram is shown in Fig. 1.

2.2 Image ultarsound dataset and preprocessing

The scientific community can access the digitized database of thyroid ultrasound images for free. There are 134 snaps and 99 cases in the database (Do, and Vetterli, 2005).

For images by additive noise and blur, the Wiener filter is the MSE-optimal stationary linear filter. Typically, Wiener filters are used in the frequency domain. One uses the Discrete Fourier Transform (DFT) to get

$X(u,v)$ from a degraded image, x(n,m). By adding the Wiener filter $G(u,v)$ to the product of $X(u,v)$, one can estimate the original image spectrum:

$$s(u,v) = G(u,v)X(u,v) \quad (2)$$

The Wiener filter is:

$$G(u,v) = \frac{H^*(u,v)P_s(u,v)}{|H(u,v)|^2 P_s(u,v) + P_n(u,v)} \quad (3)$$

It is a method of filtering noise that is added. The low pass wiener filters practice a pixel-wise adaptive scheme to adjust their operation based on information obtained from each pixel's immediate surroundings. It computes the local average in addition to the variance while filtering (Madsen, Ilavarasi, et al. 2007). De-convolution is produced by inverse filtering, and noise is removed using compression.

The improved Wiener filter utilizes a 3 × 3 filter in order to determine the median value of every pixel. The resulting matrix is then subjected to further processing that is comparable to

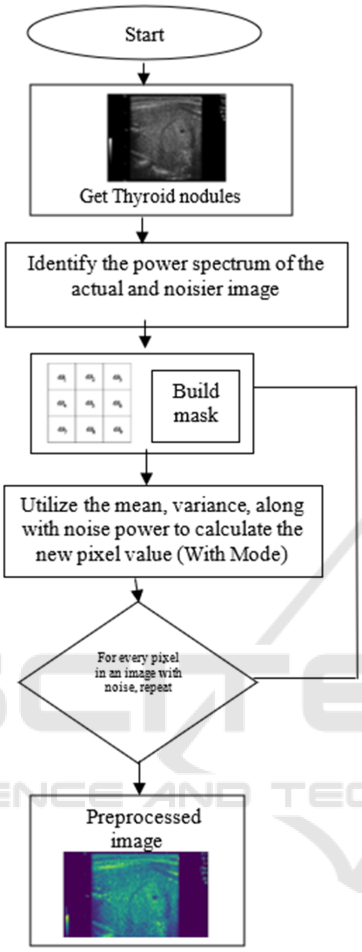

Figure 1: Workflow of Improved Wiener filter

the wiener filter. The improved wiener filter functions as follows:

Step 1: Calculate power spectral density of $I_{ori}(x,y)$ and noise image and calculate Signal to noise ration (Hussien, El-Gwad, et al. 2017) using following equation:

$$SN\ Ratio = 10\log\left(\frac{Power_{Sig}}{Power_{noise}}\right) \quad (4)$$

Step 2: Covering a pixel in a noisy image, build a mask

Step 3: Filter all of the pixels that are covered by the mask by pixel intensity.

Step 4: Set the median to the mask's central pixel by finding it.

$$Mean = \frac{1}{pq}\sum_{xy} I(p,q) \quad (5)$$

$$Varience = \frac{1}{pq}\sum_{xy}(I(p,q) - mean)^2 \quad (6)$$

Step 5: As in equations (5 and (6), calculate the local mean along with variance.

Step 6: As per equation (7), determine the new pixel value, where is noise variance, is median value.

$$O(pq) = mode + \frac{Mean^2+Varience^2}{Varience^2} I(p,q) - mode)(7)$$

3 RESULT

The following table shows the result of US images of conventional wiener filter and improved wiener filter.

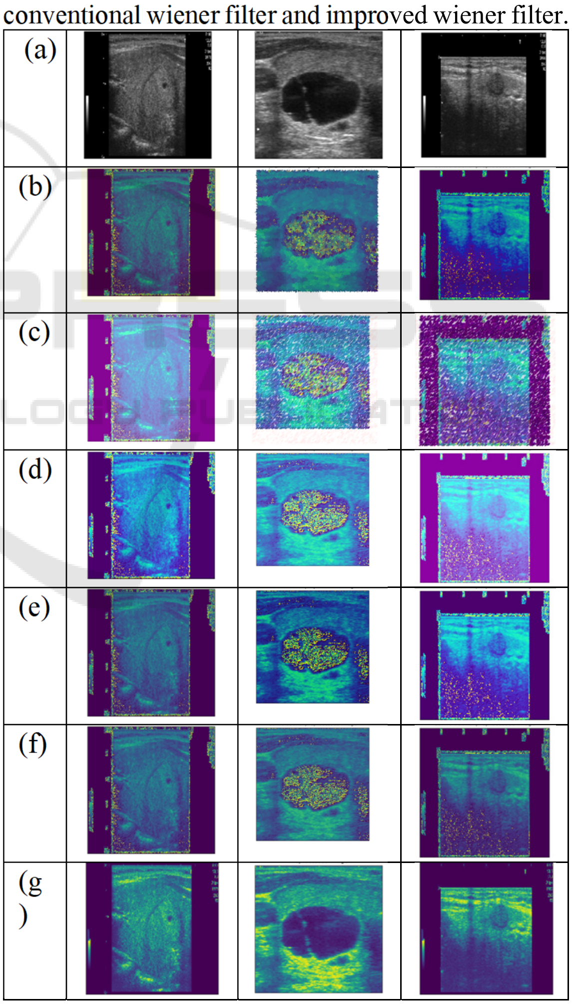

Figure 2: Images after filtering a) Sample US image b) NLM filter c) LDF filter d)ADF filter e) Hybrid method f) b) Convention wiener filter c) Improved wiener filter

As there is no noise free image available in real time ultrasound images we have used no reference image quality measures like CQE and noise index and full reference like PSNR and SSIM for measuring the quality of our novel algorithm.

Table 1: Performance Measures For Denoisisng

Quality Metric	Wiener filter	NLM	LDF	ADF	Hybrid methods	Improved Wiener filter
CQE	4.82	8.86	9.93	7.90	10.01	10.9
FI	0.76	0.75	0.89	0.92	0.90	0.94
MSE	0.90	1.23	7.56	8.89	2.30	0.23
PSNR	19.80	18.7	9.2	8.90	14.78	21.3
SSIM	0.82	0.67	0.92	0.78	0.80	0.98

The graphical representation of performance is shown below:

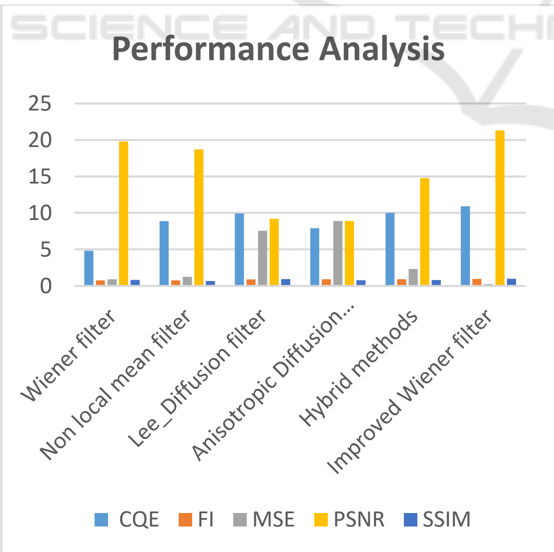

Figure 3: Performance Analysis of Improved wiener filtering Method

4 CONCLUSION

The granularity of speckled images makes them challenging to interpret for both the human eye and computer segmentation and classification techniques. Despeckling is crucial to do as a pre-processing step before moving on to the feature withdrawal, investigation, and recognition phases of image handling jobs. Despeckling's main objective is to cut down on speckle noise without losing any of the information. In order to reduce speckle, a improved Wiener filter is applied. Comparing the suggested approach, the speckle noise can be greatly reduced, and the new method finds use in remote sensing. Our innovative approach has been contrasted with five filtering ways, and the results have been examined using both full reference quality metrics and results without reference. Moreover, we have got good result to parameters like CQE and Filter index and SSIM. In our ongoing research, we will concentrate on processing darkened areas in ultrasound images of thyroid nodules.

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