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Spatial filtering techniques on reducing speckle noise in medical images

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ABSTRACT

Filtering is one of the main pre-processing techniques in digital image processing techniques characterized by the fact that both its input and output are images. One of the most commercially successful applications of spatial filtering is ultrasound medical images. The main purpose of spatial filtering is blurring and noise removal in the original images. Many challenges have been made to remove the speckle noise from the ultrasound medical images. Thereby some common spatial filtering enhancement techniques are used for it; hence some more techniques have been introduced for it. But generally each spatial filtering technique has its own aspects, assumptions, draw backs and benefits. This paper compares various spatial filtering techniques based on the statistical method for the speckle noise removal in ultrasound medical images. The enhanced ultrasound medical image quality is measured

by the statistical quantity parameters: Like Peak signal-to-Noise Ratio (PSNR) and Root Mean Square Error (RMSE) with standard variance ($\boldsymbol{\sigma = 0.03}$) ultrasound medical images.

Key words- Speckle noise in medical image, Filtering techniques, RMSE and PSNR.

1. INTRODUCTION

The digital image processing plays a vital role for computer applications and their developments. Digital image processing is a wide area and it is used for large applications. One of the major application areas of digital image processing is medicine industry. Medicine industries are highly improved in analyzing medical images, especially in the ultrasound medical images. The term ultrasound medical images referred as studying the function of moving structures in real time. Thus, the ultrasound medical image was first used in obstetrics for checking unborn babies. These images are used to determine their health conditions and body developments after that it is used in some other application areas like abdominal organs, heart, breast, muscles, tendons, arteries and veins [1]. In ultrasound medical images the speckle noise may be occurred during the processing of image acquisition and image transmission. This speckle noise plays a major critical role in image distortion, in order to overcome this problem various spatial filtering techniques are used. The term spatial filtering defined as, some neighborhood operations work with the values of the image pixels in the neighborhood and the corresponding values of a sub image that has the same dimensions as the neighborhood. The denoising sub images is getting by the way of using traditional frequency domain filtering techniques that are performed directly on the pixels of an image [2]. This paper focuses on problem analyzing in ultrasound images, types of spatial filtering techniques and experimental analysis and conclusion drawn with help of the data collected for this paper.

2. PROBLEM ANALYZING IN ULTRASOUND IMAGES

Ultrasound most widely used as diagnostic tools in developed medicine industry because it is inexpensive and portable when compared with other imaging techniques like MRI and CT. The ultrasound provides live images, where the operator can select the most useful section for diagnosing. The speckle noise may be occurred in during the ultrasound image processing of scanning (or) recording (or) playback operations. The removing speckle noise from the original image is done by the pre-processing techniques such as filter, especially spatial filtering. A spatial filter is defined by a kernel which is a small array applied to each pixel and its neighbours with an image. Filtering an image is a basic pre-processing technique for removing noises (or) denoising ultrasound images by the way of using special algorithms and various mathematical formations in it [3, 4, and 11]. If the image is in poor quality it might be affected by the speckle noise. The existence of speckle is disgrace image quality and also it affects the tasks of an individual interpretation and diagnosis. The level of noise is measured by the value of grey level(z).The term grey level referred as an 2D function f(x,y) where x&y are plane/spatial co-ordinates and the amplitude of 'f' at any pair of co-ordinates(x,y) is called the grey level[5]. The standard deviation (z) define the speckle noise is the corrupted pixels are either set of maximum value, which is something have single bits flipped over the data dropouts noise is referred by

$$f(z) = \frac{g^{\propto-1}}{(\propto-1)!a^{\propto}} e^{g/a} \qquad (1)$$

3. TYPES OF SPATIAL FILTERING TECHNIQUES

Many challenges have been made to remove the speckle noise using filtering techniques as a resolution image pre-processing tool. One of the familiar methods exploited for speckle noise reduction is spatial filtering [10]. The objective of spatial filtering techniques is to make the image resemble the natural scene. Various spatial filtering techniques are described as follows.

(a) *Adaptive Filter*

Adaptive filters are capable of giving superior performance in noise image. The statistical measures of a random variable are its mean and variance. The mean gives a measure of average gray level in the region over which the mean is computed, and the variance gives a measure of average contrast in that region[4]. An adaptive expression may be written as,

$$f(x,y) = g(x,y)\frac{\sigma\eta^2}{\sigma L^2}\, g(x,y) - m_L \quad (2)$$

Here g(x, y), the value of the noise image at(x, y) $\sigma\eta^2$the variance of noise corrupting f(x, y) to g(x, y). m_L The local mean of the pixels in Sxy and $\sigma L^2$the local variance of the pixels in Sxy.

(b) *Wiener Filter*

The method is founded on considering images and noise as random processes and the objective is to find an estimate of the uncorrupted image f such that the mean square error between them is minimized [6]. This error measure is given by

$$e^2 = E\{(f - \hat{f})^2\} \quad (3)$$

Where E {} is the expected value of the argument.

(c) *Non Linear Filter*

The speckle noise reduction can be achieved effectively with a nonlinear filter whose basic function is to compute the median grey-level value in the neighbourhood in which the filter is located [7, 8].

(d) *Bilateral Filter*

It is one of the filtering techniques used for speckle noise removal in ultrasound medical image with the help of low pass domain filtering techniques in the form of an output image f(x).

$$f(x) = Kd^{-1}(x) \iint_{-\infty}^{\infty} f(\Sigma)\, c(\Sigma, x) d\Sigma \quad (4)$$

(e) *Bilateral Median Filter*

The Bilateral median filter preceding the techniques of weighted averaging of an neighborhood.It replacing the summation value of it. Here the pixels are combined by using a weighted median [9]. Exploring the alternative kernels for both range and domain filtering function.

$$f(\sigma, x) = \frac{1}{\sqrt{\frac{1}{(x/\sigma)^2}}} \text{ (domain)} \quad (5)$$

$$f(x, \sigma) = \frac{e^{-x^2}}{2\sigma^2} \text{ (range)} \quad (6)$$

4. RESULT ANALYSIS AND DISCUSSIONS

The performance of the various spatial filtering techniques has been investigated in this paper. Denoising is carried out for ultrasound image with speckle noise of variance (σ^2=0.03). The quality of denoising ultrasound images is measured by the statistical quantity parameters like RMSE and PSNR.

Root Mean Square Error (RMSE): It is used to find the total amount of difference between two images. It indicates average difference between original and denoise image.

$$RMSE = \sqrt{\frac{\Sigma(f(i,j) - g(i,j))^2}{mn}}$$

Peak Signal-to-Noise Ratio (PSNR): It is an assessment parameter to measure the performance of the speckle noise removal.

$$PSNR = 20\log_{10} {}^{255}/_{RSME}$$

Bilateral filter is used to prevent the outlier pixels from unduly distorting the result because of the grey level value is low. Non-linear filter modifies the grey levels of the image as low as possible resulting in a maximum preservation of an image. Adaptive filter the variance gives a measure of average contrast in that region but the Weiner filter while comparing with other filters like Bilateral filter, Non-linear filter and Adaptive filter this Weiner filter obtains high efficiency.

Even though the Median filter gives the best efficiency for denoising ultrasound medical images because of its grey level value is replaced with high value of its each output pixels. The results are based on analysis, the future experiments may be carried out using MATLAB tool.

TABLE 1 PSNR VALUE TABLE

F.NO	FILTERS USED	PSNR
01	WEINER FILTER	30.82
02	BILATERAL MEDIAN FILTER	23.22
03	ADAPTIVE FILTER	22.19
04	NON-LINEAR FILTER	22.13
05	BILATERAL FILTER	20.90

Table 1 shows the evaluating values of PSNR for list of filtering

Chart 1 & 2 shows various spatial filtering performance according with quality parameters PSNR and variance $\sigma = 0.03$.

Figure 1 shows the output images from the various spatial filtering.

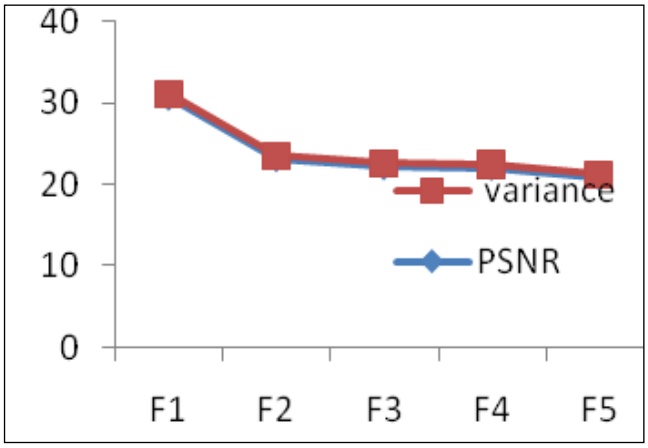

CHART 1 OVER ALL FILTERING PERFORMANCE CHART

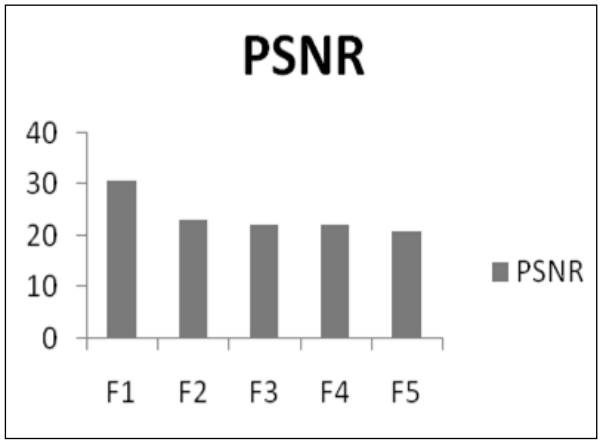

CHART 2 VARIOUS SPATIAL FILTERING PERFORMANCE LEVEL

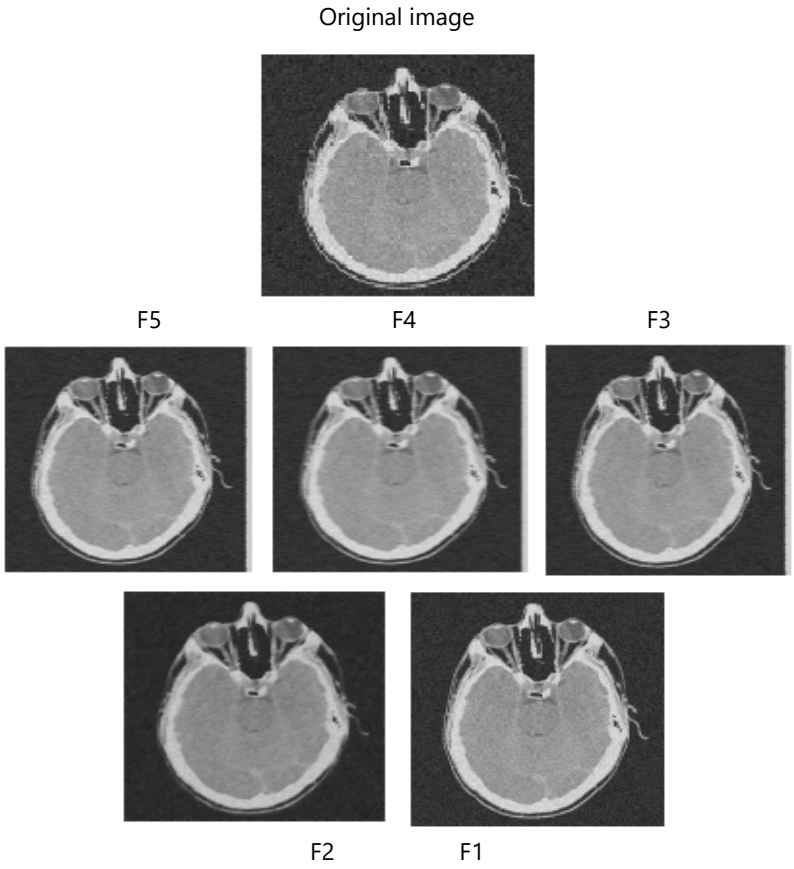

FIGURE 1 PERFORMANCE LEVEL OF THE SPATIAL FILTERING TECHNIQUES

5. CONCLUSION

This paper is to present about using the special spatial filters for ultrasound medical image noise removal. The various image filters like Bilateral filter, Non-linear filter, Adaptive filter, Weiner filter and Median filter are compared by the statistical quantity parameters with same variance ($\sigma = 0.03$). After that result analysis and literature survey this paper realized the median filter produced the highest gray level value of each output pixel by the way of selecting maximum gray level value of the output pixel value. Hence, it is concluded that the Median filter is better one from the all other filters.

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