Comparison of Fuzzy Filter and Median Filter on Ultrasound Image

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ABSTRACT
Ultrasound imaging is one of the popular,cheapest, and non-invasive medical scans. During the time of image acquisition, there is distortion of the quality of image in the form of speckle noise. Nowadays, many researches have made various experiments to improve the quality of medical image.In this paper, comparing fuzzy filter with median filter, as fuzzy filter works on fuzzy rules to detect different gradient and then filtering the noisy, homogenous and edge regions whereas median filter works on the pixel value in a non-linear fashion.The performance comparison of multi-scale schemes shows that fuzzy filter excels over the median filter.

Keywords
Ultrasound imaging,fuzzy filter, median filter.

1. INTRODUCTION
Ultrasound imaging has been considered as one of the most powerful techniques for imaging organs and soft tissue structures in the human body. However, the presence of random speckle noise makes human interpretation and computer-aided ultrasound image diagnosis a highly difficult task. Thus, it is necessary that we remove speckle noise from the images before they are processed further.

Speckle noise is introduced in ultrasound images due scattering of light from different types of cell textures during acquisition of the image. Speckle is a random interference pattern in a deterministic image formed by addition of coherent of the individual scattered signal echoing from a broadcast medium. Nature of the speckled pattern is strongly influenced by the scatters within the resolution cell.

Unlike many other imaging applications where image quality gets enhanced and nice visual interceptions are given to the human eye, in case of medical images, these applications are limited.For the generation of the device, which can be interpreted as clinically interesting, to provide the best possible diagnosis, it is important that the ultrasound medical images are crisp, clear, and free ofnoise and artifacts. While the technology to improve the acquisition of digital medical images using ultrasound continues, resulting in higher resolution image and better contrast, noise remains a problem for many medical images. The main challenge of the review of the various filters is to remove noise without blurring the edges.

In general, there are two techniques to eliminate speckle noise i.e. pre-acquisition and spatial filtering. Multiple-look process is used in the data acquisition stage, while the spatial filtering is used after the data is stored.

Speckle can be reduced using different filters, such as Kaun & Lee filter[1], Frost filter[2],Median filter [3], etc.Many researchers work towards reducingspeckle noise using median filter, where it computes the neighboring pixel, and replaces all the pixels by the middle pixel. In mean filter, it computes the average of the neighboring pixel and replaces by it.Dimitri Van De Ville et.al[4] introduced a novel method of fuzzy filter using eight directions of each pixel and computing the edge, noisy and homogeneous area of the image. But, many of these filters enhanced the quality of image but at same time blurred the edges of the image. When the edges are blurred, then we cannot find the actual region of interest of the image. The next step of enhancement of image is region growing segmentation. In traditional region growing segmentation, random pixel was taken to find neighboring area or region but random pixel may lead to multiple solutions.

In this paper,such situations are overcome, and some of the necessities that must be met, to be of better help in the actual clinical analysis, are improved. Fuzzy filter and median filter are compared on different parameters to derive better results in noise reduction.

The work in this paper is organized as follows – Section 2 gives an overview of the fuzzy filter.Section 3 represents the median filter. In section 4 the experimental results are presented, and finally, the conclusions are stated in section 5.

2. OVERVIEW
A. Fuzzy Filter

The general idea behind this filter is to average a pixel usingother pixel values from its neighborhood, but simultaneouslytaking care of important image structures such as edges.Themain concern of the filter is to distinguish betweenlocal variations due to noise and image structure.In order to accomplish this, for each pixel, we derive a valuethat expresses the degree in which the derivative in a certaindirection is small. Such a value is derived for each directioncorresponding to the neighboring pixels of the processed pixel by a fuzzy rule.The further construction of the filter is then based on the observationthat a small fuzzy derivative most likely is caused bynoise, while a large fuzzy derivative most likely is caused byan edge in the image. Consequently, for each direction we willapply two fuzzy rules that take this observation into account(and thus distinguish between local variations due to noise anddue to image structure), and that determines the contribution ofthe neighboring pixel values. The result of these rules (16 intotal) is defuzzified and a "correction term" is obtained for theprocessed pixel value [4].

In Ultrasound images, three features, "Noisy", "Homogeneous", and "Edge", can be supposed for every under-processed region. Because of combination of these features, each pixel can be specified on different membership function.As, each pixel belong to different characteristic it is hard to define region of pixel according to their characteristic but fuzzy logic can be appropriate solution to deal with this problem. Hence, we are using the concept of fuzzy degree of membership function. The method of the proposed fuzzy filter is divided into two steps viz. Detection, and Filtering.In the detection step the characteristics of each pixel is evaluated relative to its local gradients. As a result a dictionary of the pixelsin noisy image is generated in the detection phase. Then in filteringstep the filtering process is executed using this information fromlocal variations of intensity. More precisely, a pixel which is locatedin an edge region is filtered using fuzzy similarity measures [6] withrespect to its neighbors and similar pixels.

B. *Median Filter:*

The Median filter is a non-linear digital filtering technique, frequentlyaccustomed to reduce noise. Such noise reduction is a characteristicpre-processing step to improve the results of further processing (for example, edge detection on an image). The main idea of the median filter is to run through the signal pixel by pixel, replacing each pixel with the median of neighbouring pixels. If the window has an odd number of entries, then the median is simple to define – it is just the middle value after all the entries in the window are sorted numerically. For an even number of pixels, there is more than one possible median.

The median filter is a robust filter. It is used as smoother for image processing, as well as in signal processing and time series processing. A major advantage of the median filter over linear filters is that the median filter can eliminate the effect of input noise values with extremely large magnitudes. In contrast, linear filters are sensitive to this type of noise - that is, the output may be degraded severely by even by a small fraction of anomalous noise values [6].

3. PARAMETERS

The performance evaluation of proposed algorithm is obtained by statistical methods like MSE and PSNR. The MSE should be of lesser value for a better filtering algorithm. The PSNR value must be high for a better filtering algorithm.

C. *Mean Square Error (MSE)*

MSE indicates average square difference of the pixels throughout the image between the original image (speckled) g(x, y) and despeckled image f(x,y). A lower MSE means that there is a significant filter performance. But small MSE values did not always correspond to good visual quality.

$$\mathrm{MSE}=\frac{1}{\mathrm{MN}}\sum\sum[\mathrm{g}(\mathrm{x},\mathrm{y})-\mathrm{f}(\mathrm{x},\mathrm{y})]^2$$

Where $M \times N$ is the size of image.

D. *Peak signal to Noise Ratio (PSNR)*

PSNR is used to give a quantitative evaluation. It is calculated between the original image and the noisy image. A higher PSNR would normally indicate that the reconstruction is of higher quality. PSNR is usually calculated as

$$\mathrm{PSNR} = 10\log_{10}(225^2/\mathrm{MSE})$$

E. *Signal-to-Noise Ratio (SNR)*

SNR is a common measurement to evaluate the speckle reduction in the case of multiplicative noise by computing the ratio between the original and the de-noised image. Higher SNR values show that the filtering effect is better, and filtered image quality is higher.

F. *SSIM*

Structural Similarity Index Measure which indicates the ability of an algorithm to preserve details and structures of interest in presence of noise as shown:

$$SSIM(x, v(y) = l\big(x, v(y)\big).\, c(x, y).\, s(x, v(y))$$

Where x is the original noise ,$v(y)$ is the denoised output image and $l(.), c(.), s(.)$are comparison functions of luminance, contrast and structure components of two images, respectively.

4. RESULT AND DISCUSSION

As shown in Fig.1 there are three images in which Fig.1-5(a) original image Fig.1-3(b) speckled image in which σ=0.1 speckle noise was added to show how effective will the result be. Fig.1-5(c) Fuzzy filtered image in which different rules applied to find out the feature as edge and noisy and then implemented fuzzy rule to remove the noisy region. Similarly, from Fig.6-10(c) median filtered image, which is a non-linear filter, finding out the median pixel value on each mask and replacing the noisy pixel with median pixel of that mask.

The performance evaluation of fuzzy filter and median filter is obtained by statistical methodssuch as MSE, PSNR, SNR, and SSIM. The MSE should be of less value for a better filtering algorithm. The PSNR value must be high for a better filtering algorithm and SSIM should approx. be in the range of 7 to 8.

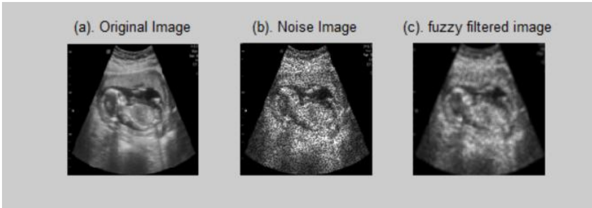

Fig.1(a) - 5(a) Fuzzy original gray scale image 1(b)-5(b) speckled image 1(c)-5(c) Noise free image

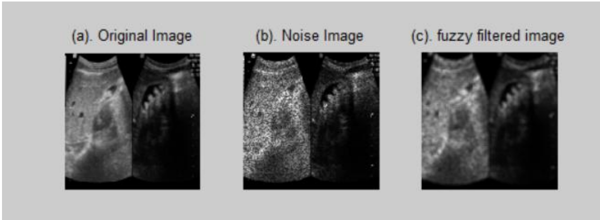

Fig.2. Test image 2 (a) original (b) noisy image (speckle noise=0.1) (c) fuzzy filtered image

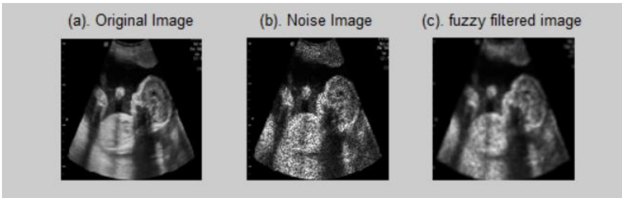

Fig.3.Test image 3 (a) original (b) noisy image (speckle noise=0.1) (c) fuzzy filtered image

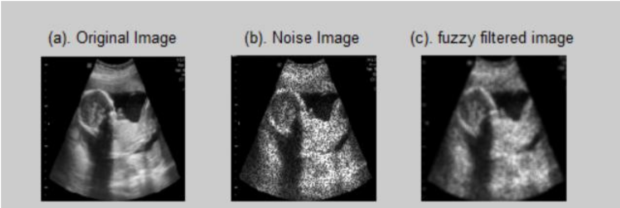

Fig.4.Test image 4 (a) original (b) noisy image (speckle noise=0.1) (c) fuzzy filtered image

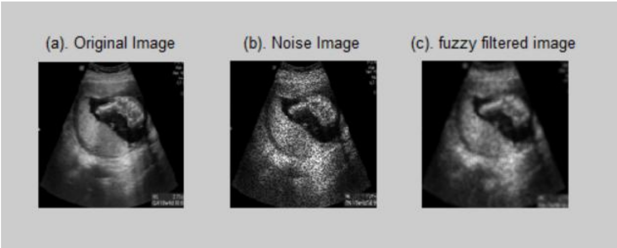

Fig.5. Test image 5 (a) original (b) noisy image (speckle noise=0.1) (c) fuzzy filtered image

Experiment result of Median filter

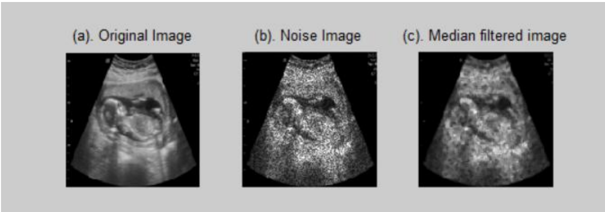

Fig.6.Test image 1 (a) original (b) noisy image (speckle noise=0.1) (c) Median filtered image

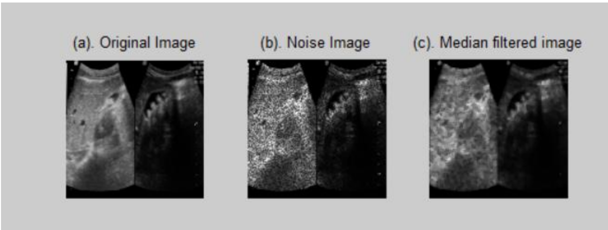

Fig.7.Test image 2 (a) original (b) noisy image (speckle noise=0.1) (c) Median filtered image

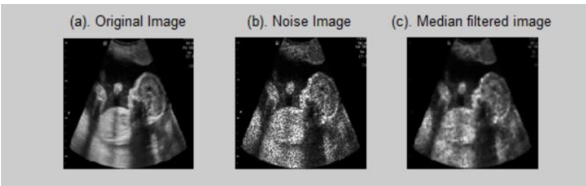

Fig.8. Test image 3 (a) original (b) noisy image (speckle noise=0.1) (c) Median filtered image

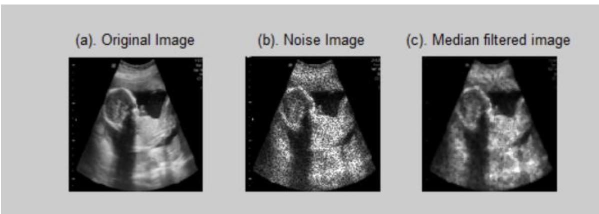

Fig.9.Test image 4 (a) original (b) noisy image (speckle noise=0.1) (c) Median filtered image

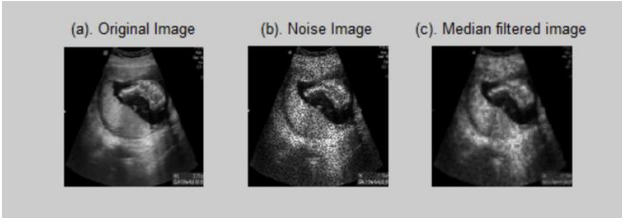

Fig.10.Test image 5 (a) original (b) noisy image (speckle noise=0.1) (c) Median filtered image

Table 1. SNR values of fuzzy and median filter

SNR	Image1	Image2	Image 3	Image4	Image5
Fuzzy filter	17.3280	16.3583	16.5761	17.5504	16.8189
Median Filter	14.7512	13.3713	14.1595	14.7801	14.7093

Table 2. PSNR values of fuzzy and median filter

PSNR	Image1	Image2	Image 3	Image4	Image5
Fuzzy filter	25.8183	25.6792	26.2794	26.8753	27.0628
Median Filter	23.6651	22.6412	24.1810	24.0868	25.3590

Table 3. MSE values of fuzzy and median filter

MSE	Image1	Image2	Image 3	Image4	Image5
Fuzzy filter	132.5968	117.0058	115.0401	128.3376	90.9060
Median Filter	225.5070	226.5386	189.8951	228.5340	139.6322

Table 4. SSIM values of fuzzy and median filter

SSIM	Image1	Image2	Image 3	Image4	Image5
Fuzzy filter	0.8071	0.7774	0.8633	0.8376	0.8470
Median Filter	0.7245	0.7182	0.8104	0.7716	0.7971

5. CONCLUSIONS

The results of experiments shows that the algorithm has a certain degree of adaptability for accuracy. After evaluation of both the filters i.e. fuzzy filter and median filter on different parameters, fuzzy filter demonstrated better values than median, which advocates that fuzzy filter is preserving the edges during noise reduction.In the test results, a much higher deviation was found in the MSE values of the filters, which ranged from 50% to over 100% deviation between fuzzy and median filters, with fuzzy filter consistently providing a lower Mean Squared Error value. Similarly, the SNR and PSNR values of fuzzy filter were always higher than median filter. Same goes for the Structure Similarity Index. The fuzzy filter provides an optimal solution to speckle noise detection and filtering, returning better signal to noise ratio and good visual clarity of the image by eliminating noise while preserving the edges of the image to deliverexact area of interest.

6. REFERENCES

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