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RESEARCH ARTICLE

A Novel Approach for Despeckling of Ultrasound Images

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Abstract— Ultrasound imaging is a widely used medical imaging modality. But the major issue with ultrasound images is the presence of speckle noise, which is an inherent limitation of ultrasound images. This research work focuses on speckle noise reduction in ultrasound images. Various predefined techniques for despeckling are studied thoroughly and a novel approach is proposed. In addition, comparison of predefined and proposed technique is done both on qualitative and quantitative level. Four different metrics are used for comparative study of various image filtering techniques.

Keywords— Denoising Filters, Digital Image Processing, Image Enhancement, Qualitative Metrics

I. INTRODUCTION

Ultrasound is a widely used medical imaging modality. The use of ultrasound has expanded enormously over the last two decades, largely due to the fact that it is safe, allows real-time visualization of moving structures, suitable for many clinical applications, and is relatively inexpensive. Medical images are usually degraded by noise during image acquisition and transmission process. But the most important is 'speckle', which is an inherent limitation of ultrasound images.

A. Speckle Noise

Speckle noise is a random and deterministic in an image. Speckle has negative impact on ultrasound imaging which reduces contrast and clarity of the image. Generalized model of the speckle is represented as [2]

$g(n,m) = f(n,m)*u(n,m)+\xi(n,m)$……………………………………..………..…………………....................(1)

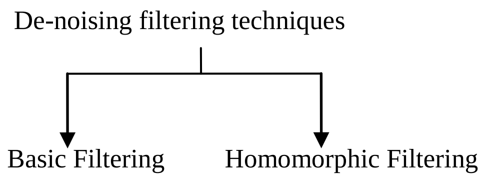
where, '$g(n,m)$' is the observed image, '$u(n,m)$' is the multiplicative component and '$\xi(n,m)$' is the additive component of the speckle noise. Here n and m denotes the axial and lateral indices of the image samples. For the ultrasound imaging, only multiplicative component of the noise is to be considered and additive component of the noise is to be ignored. Hence, equation (1) can be modified as [3]:

$g(n,m) = f(n,m)*u(n,m)$...(2)

II. DENOISING FILTERING TECHNIQUES

De-noising filtering techniques includes various filters that are used for removing noise from the images. Input to the filter is a noised image and output is a filtered (denoised) image. Filtering of the image is done on the basis of various formulas used in different filters.

Denoising filtering techniques are broadly classified into two categories:



A. Basic Filtering Technique

Filtering of the image is done on the basis of various formulas used in different filters. Basic filtering technique use mathematical formulae for filtering noise from the images. Some basic filters used for the purpose of speckle noise reduction in ultrasound images are median filter, weiner filter, lee filter etc. Basic functioning of this technique is shown in Fig. 1.

Fig. 1 Steps of Basic Filtering Technique

B. Homomorphic Filtering Technique

Homomorphic filtering technique is one of the important ways used for digital image enhancement, especially when the input image is suffers from poor illumination conditions. Illumination and reflectance combine multiplicatively, the components are made additive by taking the logarithm of the image intensity, so that these multiplicative components of the image can be separated linearly in the frequency domain. Basic functioning is illustrated in Fig. 2.

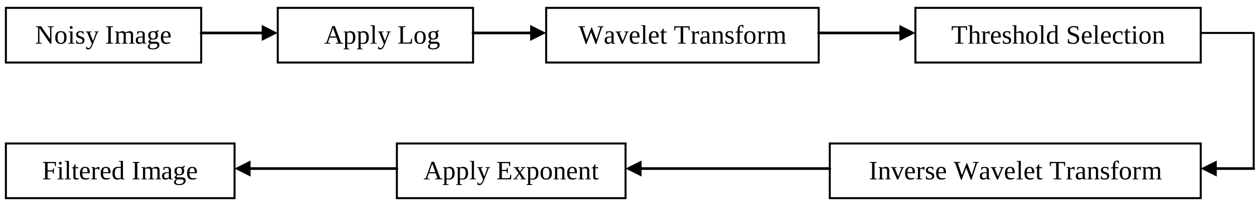


Fig. 2 Steps of Homomorphic Filtering Technique

III. QUANTITATIVE METRICS

Quality of an image is a characteristic of an image that best measures the perceived image degradation. Quantitative metrics are quantitative measures that automatically predict the perceived image quality. Commonly used quantitative metrics are described below.

A. Peak Signal to Noise Ratio (PSNR)

The term peak signal-to-noise ratio (PSNR) is an expression for the ratio between the maximum possible value (power) of a signal and the power of distorting noise that affects the quality of its representation. The PSNR is usually expressed in terms of the logarithmic decibel scale.

B. Signal to Noise Ratio (SNR)

Signal-to-noise ratio (SNR or S/N) is a measure used in engineering that compares the level of a desired signal to the level of background noise. It is defined as the ratio of signal power to the noise power, often expressed in decibels.

C. Correlation Coefficient (CoC)

A measure that determines the degree to which two variable's movements is associated. The correlation coefficient varies from -1 to +1. For better results its value should be close to 1.

D. Edge Preservation Index (EPI)

EPI is a measure that calculates edge preservation index of the image. Its value varies from 0 to 1. For better results its value should be close to 1.

IV. SIMULATION RESULTS

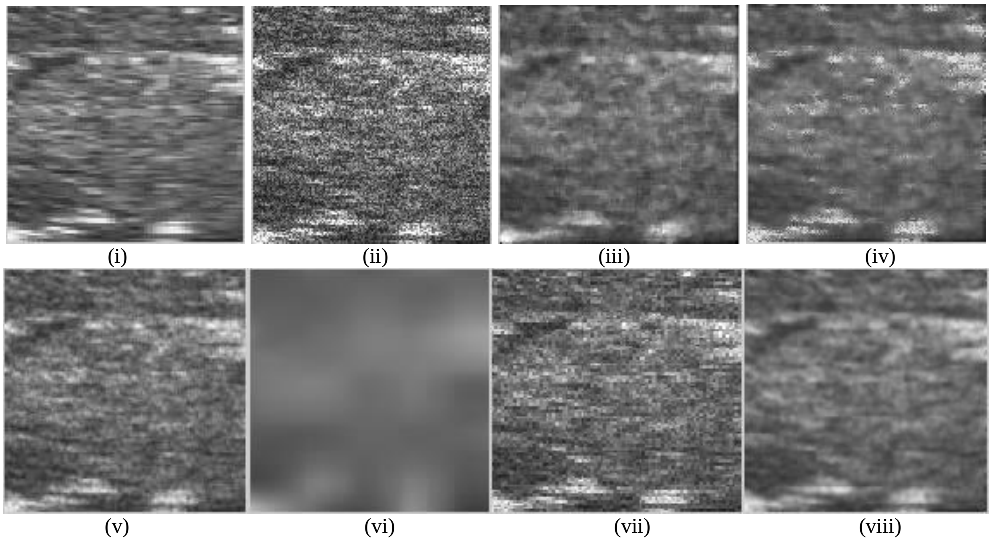


Fig. 3 Denoising of Ultrasound image corrupted by Speckle Noise of Variance of 0.1.

(i) Original Image (ii) Noisy Image (iii) Median filter (iv) Weiner filter (v) Lee filter (vi) Visu Shrink (vii) Bayes Shrink (viii) Proposed Method.

V. RESULTS AND COMPARISON

Values of four metrics of various methods when noise variance is 0.1 are shown in Table 1:

TABLE I .

METRICS VALUES OF FILTERS WHEN NOISE VARIANCE IS 0.1.

Filtering Techniques	**Quantitative Metrics**			
	PSNR	***SNR***	***CoC***	***EPI***
Median	28.7467	14.3932	0.7700	0.5118
Weiner	29.8502	15.8958	0.8358	0.7155
Lee	29.9848	15.9608	0.8363	0.5735
Visu	29.4277	11.8167	0.4882	0.3559
Bayes	29.3580	14.9577	0.8234	0.7768
Proposed	**30.5694**	**17.4666**	**0.8903**	**0.7833**

Comparison of various image filtering techniques can be illustrated with the help of graphs.

A. Comparison based on Peak Signal to Noise Ratio (PSNR)

Comparison of various filtering techniques based on PSNR value is shown in Fig. 4. For better image quality, value of PSNR should be as high as possible.

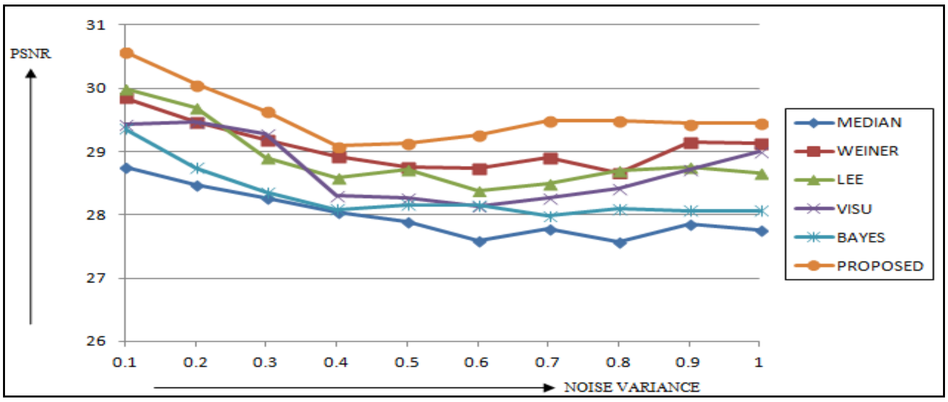


Fig. 4 Comparison of various filtering techniques based on PSNR.

B. Comparison based on Signal to Noise Ratio (SNR)

Comparison of various filtering techniques based on SNR value is shown in Fig. 5. For better image quality, value of SNR should be as high as possible.

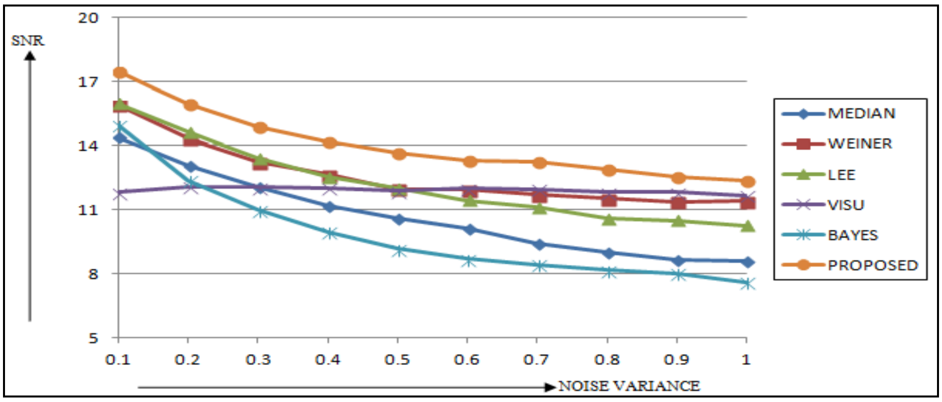


Fig. 5 Comparison of various filtering techniques based on SNR.

C. Comparison based on Correlation Coefficient (CoC)

Comparison of various filtering techniques based on CoC value is shown in Fig. 6. Value of CoC ranges from 0 to 1. For better image quality, its value should be close to 1.

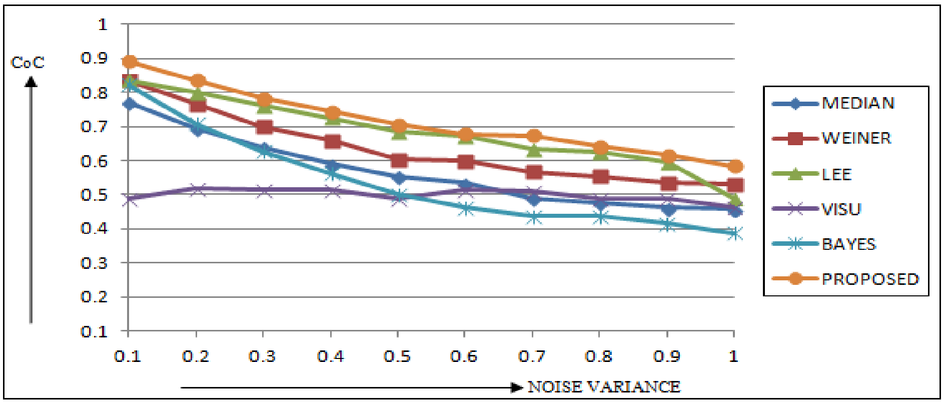


Fig. 6 Comparison of various filtering techniques based on CoC.

D. Comparison based on Edge Preservation Index (EPI)

Comparison of various filtering techniques based on EPI value is shown in Fig. 7. Value of EPI ranges from 0 to 1. For better image quality, its value should be close to 1.

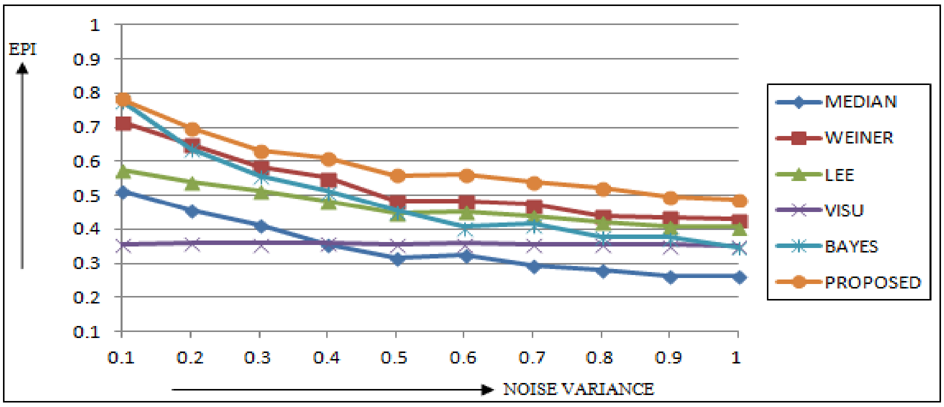


Fig. 6 Comparison of various filtering techniques based on EPI.

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