

Removal of Speckle Noise from Ultrasound Images: A Review

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Abstract: Image de-noising is the pre-processing task which is most important step in image processing. It reduces the impact of the noise signals in the images. Noise signals are unwanted signals which deteriorate the quality of images and suppress the important details in the images. Image processing is one of the important research area in various fields viz. remote sensing, law enforcement, surveillance, astronomy, medical science etc. In the area of medical field; various types of imaging techniques are to be used. Some of the most common techniques are X-ray imaging, computed tomography imaging, ultrasound imaging, magnetic resonance imaging, positron emission tomography imaging etc. These imaging techniques are severely affected by different types of noises; e. g. computed tomography images, ultrasound images and magnetic resonance images are affected by additive white Gaussian noise, speckle noise and rician noise respectively. Many researchers have developed various techniques to reduce the impact of the noise signals from medical images however no any technique is so efficient enough to reduce the all types of noise signals from all types of images because all the noise signals have different characteristics. Gaussian noise is additive in nature while speckle noise is multiplicative. There are still room to develop more efficient de-noising techniques which have better efficacy than the existing techniques. The main objective of our research is to suppress speckle noise signals from ultrasound images hence to understand the characteristics of speckle noise and existing techniques various research papers have been studied and findings and limitations to be found so that a novel technique can be developed which may give better performance.

Keywords: Medical Images, PSNR, SNR, Speckle Noise, SSIM, Ultrasound Images.

I. INTRODUCTION

Digital images are the two dimensional information[1]. Let us consider an image is represented by $x(i, j)$ where i and j are spatial coordinates and x is called as the intensity of the gray scale image[2]. If the values of pixel coordinates and amplitude of x both are discrete and finite quantities then image is referred as digital image[3]. Medical imaging is one of the most area for the researchers because it helps the doctors and radiologists to diagnose any abnormalities in the body without any surgical operation[4-7]. There are different types of imaging techniques used for the different purposes in which ultrasound is one of them[8-11].

II. ULTRASOUND IMAGES

Ultrasound imaging is most popular technique which is used to examine soft tissues in the human body[12-14]. If there is any problem in some organs viz. stomach, pancreases, liver, kidney, intestines, spleen, urine bladder etc. [15] then doctor refers the patients to the radiologist so that ultrasound images can be obtained[16-19]. Below is the illustration of some ultrasound images.

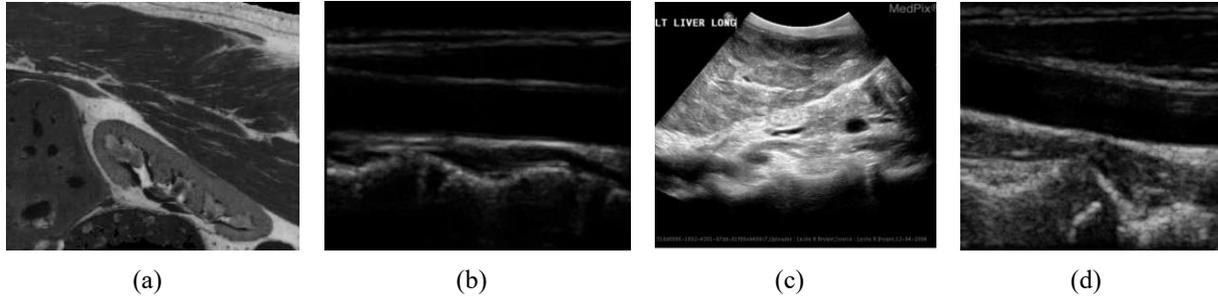


Fig. 1 ultrasound images

III. NOISE IN ULTRASOUND IMAGES

Noise in an image may be either additive or multiplicative. Ultrasound images are affected by speckle noise which is the example of multiplication noise[20]. Let us consider the original image is $x(i, j)$ in which noise introduced is $n(i, j)$ as a result noisy image is obtained which is denoted by $y(i, j)$. Since, speckle noise is an example of multiplicative noise then,

$$y(i, j) = x(i, j) \times n(i, j) \quad \dots$$

The above two operations is done at pixel level. speckle noise introduces in ultrasound image and reduces the quality of image due to which human interpretation and accuracy of clinical diagnosis are affected[21]. Thus speckle noise must be reduced to preserve the texture and edge information of the

ultrasound images. Many researchers developed various techniques to reduce the effect of speckle noise from the ultrasound images but no technique suppress the speckle noise completely[22]. Hence there is still scope to develop or modify the existing techniques so that speckle noise can be suppress to acceptable extent and useful information can be retained to avoid any false interpretation done by doctors or radiologists[23-26].

IV. LITERATURE REVIEW

To understand the procedure of de-speckling; it is desire to review the existing techniques. Various research papers have be studied in which some of the good researches have been discussed in the tabulator form. This table illustrates the findings and limitations of that research so that gap analysis can be done.

S.No	Authors	Title, Publisher, Year	Findings	Limitations
1	Sivaanpu et. al.	Speckle Noise Reduction for Medical Ultrasound Images Using Hybrid CNN-Transformer Network <i>IEEE Access (2024)</i>	<ul style="list-style-type: none"> Reduce the speckle noise effectively. CNN captures local texture details. Hybrid technique improves the efficiency and performance. 	<ul style="list-style-type: none"> It may struggle for extreme noise condition. Accuracy decreases with increasing in noise level. Requires significant computational resources.
2	Salazar et al.	Speckle Noise Reduction in Ultrasound Images for Improving the Metrological Evaluation of Biomedical Applications: An Overview <i>IEEE Access (2020)</i>	<ul style="list-style-type: none"> Various techniques have been discussed. Almost all the techniques emphasizes for edge and boundary preservation. Deep learning and hybrid techniques provides promising results. 	<ul style="list-style-type: none"> No single method is effectively for all the requirements. Many algorithm reduces the noise but compromise with details. Deep learning technique requires large dataset and high computation.

3	Sikhakhane et al.	Evaluation of Speckle Noise Reduction Filters and Machine Learning Algorithms for Ultrasound Images <i>IEEE Access (2024)</i>	<ul style="list-style-type: none"> • Single filter viz. Median, Bilateral filter etc. reduces the noise. • Performance of hybrid filters are better than the single filters. • Deep learning techniques removes high level of speckle noise as well. 	<ul style="list-style-type: none"> • Single filters require less time but not very effective to remove speckle noise. • Hybrid filter have better efficacy as compare to single filters but its performance cannot beat Deep learning techniques.
4	Lan et al.	Real-Time Ultrasound Images Despeckling Using Mixed Attention Mechanism Based Residual UNet <i>IEEE Access (2020)</i>	<ul style="list-style-type: none"> • Residual UNet for speckle noise reduction. • Preserves image features. • Effective for real-time images. 	<ul style="list-style-type: none"> • Computational cost may be high. • Difficult in tuning attention mechanisms. • Performance degrades in extreme noise conditions.
5	Vieira et al.	Ultrasound Despeckling with GANs and Cross Modality Transfer Learning <i>IEEE Access (2024)</i>	<ul style="list-style-type: none"> • Preserves the features. • Improvement in PSNR, SSIM etc. 	<ul style="list-style-type: none"> • GAN generated images may have artifacts. • Performance may affect in extreme noise condition.

V. METHODOLOGY

After extensive survey; it is clear that almost all the techniques follow the simple methodology as discussed below:

- Collection of database which are the set of speckle noise free ultrasound images.
- Select any one ultrasound image from the database.
- Add some amount of speckle noise to get noisy image.
- Apply de-noising technique to get de-noised image.
- To know the efficacy of applied method, calculate some performance evaluation parameters viz. PSNR, SNR, SSIM etc.
- Repeat the procedure for other images from the database with different amount of noise signals.
- Compare with existing techniques to know the efficacy of proposed method.

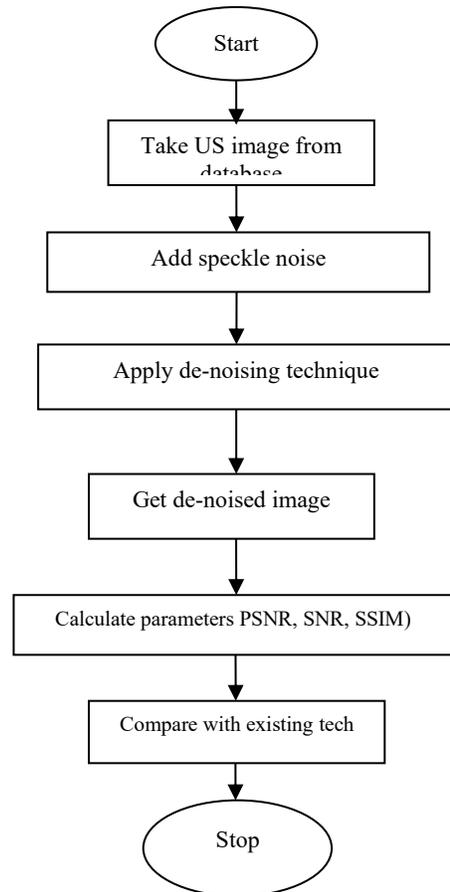


Fig. 2 illustrates the flow diagram for the de-noising technique.

Fig. 2 Flow diagram of de-noising technique

VI. CONCLUSION

From the above discussion it is clear that ultrasound images are severely affected by speckle noise which hampers the image quality and suppresses the details. These details are very important to for the diagnosis purpose hence the main goal of the filtration is not only suppression of speckle noise but retain the fine details also. Researchers have implemented many techniques which efficiently suppresses the noise signals and retain the details but there are still hope to improve the image quality. This survey gives many information about the characteristics of spackle noise and ultrasound images which may help to implement a novel technique or improvement the efficacy of the existing techniques.

VII. FUTURE SCOPE

After the extensive survey of related literatures it may be said that; there are still many research gap to suppress the effect of speckle noise. In future new techniques may be developed which can give better results quantitatively and qualitatively. In other words we have to improve the results of the de-noising techniques in terms of PSNR, SNR and SSIM. There are many scope to improve the efficacy of existing techniques by changing their parameters.

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