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Research Article

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Comparison of Speckle Noise Reduction in Ultrasound Images with Different Filtering Techniques

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Abstract The purpose of this study is to find an optimal filtering technique to remove speckle noise from ultrasound images. For this purpose, we apply the existing filtering method which consists of Non Local means, Guided, Frost, Lee, Median, Gaussian, and Bitonic filtering techniques to images showing different characteristics. The root mean square error, signal-to-noise ratio, peak signal-to-noise ratio, and structural similarity were used to quantitatively evaluate the quality of the noise-free image. Experimental results show that the Bitonic filtering technique has the best performance among different filtering methods.

Keywords Speckle noise, Ultrasound image, Image filtering, Despeckling

Introduction

The ultrasound imaging device is safe, portable, and real-time. In addition, this device has been widely used because it is relatively inexpensive compared to other medical diagnostic devices such as X-ray, Computer Tomography (CT), and Magnetic Resonance Imaging (MRI). In recent years, it has become possible to implement 3D images as well as dynamic images, enabling accurate diagnosis of lesions. Therefore, the application range of ultrasound imaging ultrasound imaging device is widening and the frequency of use is also increasing. Despite these advantages, there is a disadvantage that the diagnostic accuracy is low due to the degradation of resolution and image quality compared to other medical diagnostic devices. The cause of quality degradation in ultrasound imaging is caused by speckle noise. The speckle noise is smaller than the ultrasonic wavelength and appears as a granular pattern in the image due to the relative phase overlap of the signals obtained from the uneven cellular tissue [1]. Such deterioration due to speckle noise may adversely affect image recognition and diagnosis [2]. That is, this noise makes diagnosis by medical image difficult. Therefore, speckle noise reduction is required for accurate diagnosis, and noise reduction in ultrasound images plays an important role in medical image processing. The effect of speckle noise can be solved by filtering techniques. In this study, we aim to derive optimal image processing techniques for ultrasound images by quantitatively and qualitatively evaluating the noise reduction performance according to various filtering techniques.

Materials and Methods

In this study, 8-bit gray level Lena and Peppers standard images were selected as shown Figure 1. Speckle noise was added to each standard image. All image processing was performed with MATLAB® (R2016a MathWorks®, Natick, MA, USA). In order to evaluate the noise reduction performance for different filtering techniques, we were compared to the existing representative filtering techniques which is classified into Non Local means (NL-means) [3], Guided [4], Frost [5], Lee [6], Median, Gaussian, and Bitonic [7]. The noise reduction performance of the filtering technique was evaluated quantitatively using Root Mean Square Error (RMSE), Signal-to-Noise Ratio (SNR), Peak Signal-to-Noise Ratio (PSNR), and structural similarity (SSIM).

(a) (b)

Figure 1:Two images of the (a) Lena image, (b) Peppers image

Results and Analysis

Tables 1 and 2 show the extraction results of RMSE, SNR, PSNR, and SSIM according to different filtering techniques. The noise reduction performance of different filtering techniques for *Lena* image was highest in Bitonic filtering technique (RMSE=9.32, SNR=22.80, PSNR=28.75, SSIM=0.78), NL-means technique showed the lowest performance (RMSE=19.80, SNR=16.49, PSNR=22.43, SSIM=0.43). For the *Peppers* image, the Bitonic filtering technique showed the highest noise reduction performance with RMSE=9.92, SNR=22.46, PSNR=28.20, andSSIM=0.82, and the Guided filtering technique displayed the lowest noise reduction performance (RMSE=23.46, SNR=14.99, PSNR=20.72, SSIM=0.42).

Table 1: RMSE, SNR, PNSR and SSIM results for *Lena* image with different filtering techniques

	RMSE	**SNR**	**PSNR**	**SSIM**
Noisy	29.90	12.68	18.62	0.24
Non-local means	19.80	16.49	22.43	0.43
Guided	19.67	16.31	22.26	0.41
Frost	15.45	18.41	24.35	0.45
Lee	11.98	20.62	26.56	0.61
Median	11.80	20.75	26.69	0.61
Gaussian	9.93	22.25	28.19	0.61
Bitonic	**9.32**	**22.80**	**28.75**	**0.78**

Table 2: RMSE, SNR, PNSR and SSIM results for *Peppers* image with different filtering techniques

	RMSE	**SNR**	**PSNR**	**SSIM**
Noisy	30.08	12.83	18.56	0.29
Guided	23.46	14.99	20.72	0.42
Non-local means	20.27	16.26	21.99	0.49
Frost	17.37	17.60	23.33	0.45
Lee	13.38	19.86	25.60	0.64
Median	12.02	20.80	21.99	0.49
Gaussian	10.54	21.94	27.67	0.76
Bitonic	**9.92**	**22.46**	**28.20**	**0.82**

Figures 2 and 3 show the results of different filtering applications for *Lena* and *Peppers* images. Figure 2 shows an image containing high-frequency components with many edge regions compared with Figure 3. The Bitonic filtering technique displayed excellent speckle noise reduction and edge preservation performance in the image including many edge regions compared with other filtering techniques. Figure 4 shows a *Peppers* image containing a lot of low frequency components, In the image with many low frequency components, the Bitonic filtering technique shows superior speckle noise reduction performance than other filtering techniques.

Figure 2: Results of speckle noise reduction in Lena image

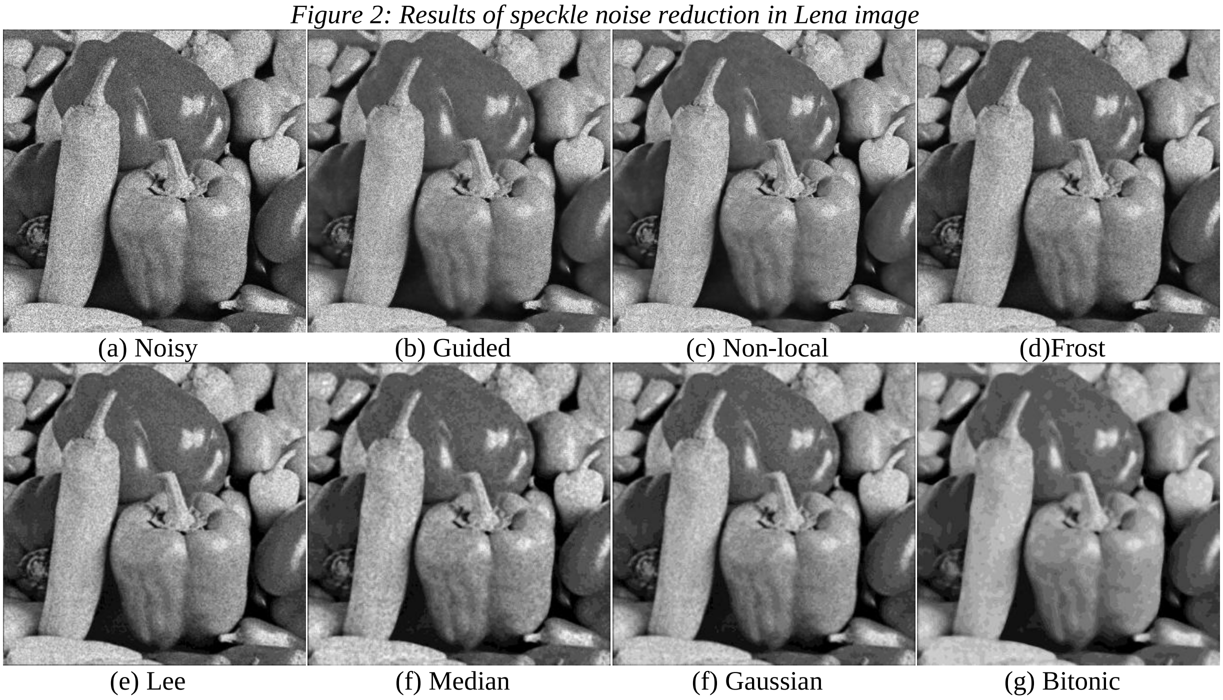

Figure 3: Results of speckle noise reduction in Peppers image

Conclusion

In this study, the noise reduction performance according to different filtering techniques is quantitatively and qualitatively evaluated to derive an optimal filter for the ultrasound image. In the experiment, existing filtering techniques such as NL-means, Guided, Frost, Lee, Median, Gaussian and Bitonic are applied to images showing different characteristics. Experimental results show that Bitonic filtering has the best performance among different filtering methods. Future research will develop a novel speckle noise reduction technique based on these results.

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References

[1]. Hiremath, P. S., Akkasaligar, P. T., &Badiger, S. (2013). Speckle Noise Reduction in Medical Ultrasound Images.*InTechOpen, Published on*,201-241.
[2]. Loizou, C. P., Pattichis, C. S., Christodoulou, C. I., Istepanian, R. S. H., Pantziaris, M., & Nicolaodes, A. (2005). Comparative Evaluation of Despeckle Filtering in Ultrasound Imaging of the Carotid Artery. *IEEE transactions on ultrasonics, ferroelectrics, and frequency control*. 52(10), 1653-1669.
[3]. Buades, A., Coll, B., & Morel, J. M. (2005). A Non Local Algorithm for Image Denoising.*San Diego, CA, IEEE Computer Society*. 20-25.
[4]. He, K., Sun, J., & Tang, X. (2013). Guided Image Filtering. *IEEE Trans. Pattern Anal. Mach. Intell.* 35(6), 1397-1398.
[5]. Frost, V. S., Stiles, J. A., Shanmugan, K. S., & Holtzman, J. C., (1982). A model for radar images and its application to adaptive digital filtering of multiplicative noise. *IEEE Trans. Pattern Anal. Mach. Intell.*4(2), 157-165.
[6]. Lee, J. S., (1980), Digital image enhancement and noise filtering by use of local statistics. *IEEE Trans. Pattern Anal. Mach. Intell.*2(2), 165-168.
[7]. Treece, G., (2016), The Bitonic Filter: Linear Filtering in an Edge-Preserving Morphological Framework. *IEEE Transactions on Image Processing*. 25(11), 5199-5211.