OPEN ACCESS

International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249 – 8958 (Online), Volume-9 Issue-4, April 2020

Despeckling Techniques for Ultrasound Images

Rajeshwar Dass

Check for updates

Abstract: ***Biomedical imaging shows a substantial role in the era for diagnosis of cancer. Ultrasound (US) imaging modality is widely used in comparison to other modalities for disease diagnosis because it not being or involve in invasive medical procedure. US is a real-time imaging modality, economically, reliable and not uses harmful radiation during the diagnosis. The noise present in US, reduces the visuality and quality of US images is called speckle noise. It degrades the fine details of US image which causes difficulty in effective feature calculation, analysis and edge detection. Speckle noise effects image interpretation and causes misdiagnosis due to bed quality of the images. Many speckle noise reduction techniques have been investigated by various researchers for noise free images. In this paper, a detailed overview about different despeckling filters is presented with different evaluation parameters. This study will help the researchers to select efficient despeckling technique for preprocessing of US images.***

Keywords ***: despeckling, denoising techniques, Ultrasound, evaluation parameter.***

I. INTRODUCTION

Medical imaging is the fastest growing field in the world wide. It is the fundamental tools for analyzing, visualizing and diagnosing the biomedical imaging of the patients. Biomedical imaging established a data base using internal images of the body to identified abnormalities that are used for patients and information obtained from images that the radiologist or technologist analyzed the disease for effectiveness medical treatment. Ultrasound imaging is widely used as compare to other modalities due to its various features i.e real-time, economically reliable and harmless radiations[1]. Speckle noise is introduces during image acquisition process due to interference [2][3]. The accuracy of diagnosis decreases due to availability of speckle noise[3]. Despeckling is used to improves the smoothness of the US images but sometimes smaller objects may be detached during filtering process. Despeckling become a challenging job to reduce noise in the ultrasound images where various despeckling filtering or algorithms have been developed from various researchers for enhancing image quality, segmentation and classification of medical ultrasound diagnosis problem. Despeckling filtering provides better edges and preserve diagnosis information in from of visualization of the images. Hence, despeckling filtering becomes a major challenge to remove speckle noise without degrading the image quality [4].

Revised Manuscript Received on April 04, 2020.
* Correspondence Author
Rajeshwar Dass*, Electronics & Communication Engineering Department, DCRUST, Murthal, Sonipat, India. Email: rajeshwardass10@gmail.com

II. NOISE MODEL

In the ultrasound images, a granular pattern is present called as speckle [5]. Speckle noise removes the small grey level information from the image which is objectionable. It is multiplicative in nature and corrupts the important diagnosis information and thus makes problematic to the radiologists for correct interpretation and diagnosing effectively.

Mathematically speckle noise[6] is expressed as in eqn. (1)

$$E(p, t) = O(p, t) * S(p, t) + A(p, t) \quad (1)$$

Where E(p, t) is corrupted image due to noise, O(p, t) is the original image, S(p, t) is multiplicative noise and A(p, t) represents additive noise. If the effect of additive type noise is ignored then speckle noise model may be represented as[6] in eqn. (2)

$$E(p, t) = O(p, t) * S(p, t) \quad (2)$$

Speckle noise is directly depends to the grey level in any area so that they are statistically independent.

III. DESPECKLING FILTERS

There are various type of noise that appears in ultrasound images due to different factors such as image capturing, image acquisitions, compressing images, transforming images etc. Speckle noise removal algorithms are proposed by various researchers called as despeckling filtering for good visual interpretation of the images whereas some filters are good in smoothing capabilities and noise reduction so that selection of the best despeckling filtering becomes a challenging task [7][8]. The despeckling filtering are classified in three categories as Local statistics based or linear filters, non-linear iteration filters and special type despeckling techniques.

A. Local Statistics Based or Linear Filters

The output of local statistics based despeckling filters are used local statistics mean and variance. Local statistics are computed by weighted average value over different kernel size of window varying from 3 to 15

The general form of linear based fitter[10] is given in eqn. (3)

$$\overline{\hat{f}_{i,j}} = \overline{f_{i,j}} + w_{i,j}\,(f_{i,j} + \overline{f_{i,j}}) \quad (3)$$

Where $\overline{f_{i,j}}$ denotes local mean value, $\overline{\hat{f}_{i,j}}$ represent denoised pixel value image, $f_{i,j}$ is the noisy pixel value image, (i, j) represents the co-ordinates of pixels and $w_{i,j}$ is windowing factor.

In local statistics or linear category the filters are: Lee [9], Lee Sigma [10], Kaun [11], Frost [12], Local Statistics Minimum Speckle Index [13],

[14], LSMV [14], Wiener [13]–[15], Mean or Average [13].

B. Non-linear Iterative Filters

During the image acquisition the real time estimation problem occurs in non-linear filtering and to avoid this problem using non-linear iterative filters. Under this category the filters are Shock [13], Bilateral[16] Median[17][18], Hymedian [13], [14], Maximum Homogeneity [13][14], Homomorphic, Geometric [13], SRAD (Speckle Reduction)[13], Anisotropic Diffusion [13], DPAD (Detail Preserving) [13], CA [13], [14], Linear Scaling [13], [14], Linear Scaling And Sorting) [13], [14], Riplet Transform filter [34].

C. Special Type Despeckling Techniques

Under this category different filters are used as fuzzy based, Transformed Based, Multiscale, Non-Local mean (NLM), Total Variation (TV) and hybrid filters.

Median filter adequately removes the speckle noise present in images while edges information are not well-preserved [18], [19]. Fuzzy filter used to remove impulse noise. Fuzzy filters used as Triangulation Median [20], [21], Triangulation Moving Average[20], [21], Asymmetrical Triangulation Median [20], Asymmetrical Triangulation Moving Average [20], [21].

Filtering in frequency domain is straight forward compared to spatial domain when denoising the images. Hence noise can be easily identified in frequency domain. Some transformed based categories are Fourier transformed based filtering [22], Wavelet transformed based filtering and Diffusion filtering. In Fourier filtering there are some filters used as Ideal, Homomorphic Ideal, Butterworth, Homomorphic Butterworth [22] as Fourier operation.

Table- I: Special type algorithms

S. No.	Authors	Techniques	Significance
1	Iman Elyasi et.al (2016) [37]	TV and modified bayes shrink algorithm	Remove speckle noise from US images.
2	Andreia Seixas Leal et.al (2019) [38]	Daubechies, Symmlet, Coiflet and Biorthogonal families	Remove speckle noise from US images.
3	Puu-An Juang et.al (2007) [39]	Utilizes wiener filter with pseudo-inverse technique	Used to cut the speckle noise.
4	Mark P. Wachowiak et.al (2000) [40]	Different Neural Networks used	To classify the noise in ultrasound images.
5	Jing Tian et.al (2010) [41]	Ant colony optimization called Ant Shrink	Used to classify the wavelet coefficients and further used for image denoising.

Multiscale filter noise reduction methods used for reduction of multiplicative and additive noise with texture preservation. These types of filters depend on the changing the original image into diverse scales. Numerous filters included in this category are MPT (Multiscale Product Thresholding)[23], M-band Ridgelet [22], Inter Orthonormal Wavelet Thresholding[23], [24], Block shrink filter [25], Bayes shrink filter [26], ProbShrink [22], Generalized Likelihood Estimation Method[22], NSS (Neigh Shrink Sure) [25].

Total variation filters are used to preserve the texture features. It preserves the sharpness of the images. This technique published by Rudin et al. [27]. Under this category the different filters are Total Variation [27], Adaptive Total Variation [28], Adaptive fidelity Total Variation [28], Rudin, Osher, and Fatmi [22].

There are many filters that are combine to create a hybrid filter. The combination formed by using geometric filter with wiener filter, fuzzy filter with wiener filter etc. [19], [20][29-34].

Non-local mean filters used for the areas around each pixel in the US image and to generate the metric for the filter operation. These filters search the window, and also calculates the value of smoothing parameters. Under this the filters are Bayesian Optimized Non-Local Means[35], Probabilistic Patch [36].

Some other exiting techniques used to reduce the speckle noise are as discussed in table I.

IV. OBJECTIVE ASSESSMENT PARAMETERS

Suppression of speckle noise done using various filters as discussed above. The quality of despeckling filters is judged on the basis of various objective assessment parameters. The image quality metrics/evaluation depends upon these parameters. Table II represents various evaluation parameters used in literature.

Table- II: Assessment parameters

S. No.	Parameters	Merits/Uses
1	SNR- Signal to Noise Ratio [1], [13], [23], [19]	Accepted value of SNR for good quality of images is greater than 20db
2	PSNR- (Peak Signal to Noise Ratio) [13], [14], [19], [22]	Accepted value of PSNR for good quality of images is greater than 20db
3	Contrast to Noise Ratio (CNR) [23]	Quality measurement for medical image interpretation
4	Mean Square Error (MSE) [13], [14]	Accepted value of MSE for good quality of images is equal to zero or nearly equal to zero.
5	Root Mean Square Error (RMSE) [13], [14], [22]	Accepted value of RMSE for good quality of images is equal to zero or nearly equal to zero.
6	Laplacian Mean Square Error (LMSE) [13], [14], [22]	Accepted value of LMSE for good quality of images is equal to zero or nearly equal to zero.
7	Average Difference (AD) [13], [14], [22]	Calculates the average difference between original images and despeckle image.
8	Maximum Difference (MD) [13], [14], [22]	Calculates the maximum error difference between original images and despeckle image.
9	Structural Content (SC) [13], [14], [22]	Range of SC between (-1 to 1).
10	Normalised Average Error (NAE) [13], [14], [22]	Used for the prediction of error accurately.
11	Normalised Cross Correlation (NK) [13], [14], [22]	Used to measure a similarity between the pattern and the underlying part of the images.
12	Normalised Error Summation [13], [14]	Used to measure the dissimilarity between two images.
13	Structure Similarity Index (SSIM) [13], [14], [22], [42]	Range of SSIM between (-1 to 1).

Retrieval Number: D7281049420/2020©BEIESP
DOI: 10.35940/ijeat.D7281.049420
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

14	Mean Structure Similarity Index (MSSIM) [43]	It calculates the similarity between two images for same window size. Range of MSSIM between (-1 to 1).
15	Beta Metric (β) [1], [19], [44]	Used for the performance of edge preservation is calculated (-1 to 1).
16	Image Quality Index (IQI) [1], [19], [44]	Measure the distortion between two images
17	Edge Keeping Index (EKI) [34], [45]	Range of EKI between (-1 to 1).
18	FOM-(Figure of Merit) [44]	Used for edge detection of images, ranges between 0 to 1. FOM=1, for ideal edge detection.
19	Correlation Coefficient (ρ) [22], [44]	Used to measure similarity between images (original and processed of size M × N).
20	Mixture Distribution (MD) [46]	Used to mix two distribution function to reduce the speckle noise.

V. RESULTS

In the literature, a lot of despeckling techniques are available. In this paper, various despeckling techniques were reviewed and categorized under three categories i.e. local statistics filters, non-linear iterative filters, and special type filters and also elaborated 20 different parameters which have been used in literature for the performance evaluation of despeckling techniques. All the exiting denoising filters have the common aim to eliminate the speckling noise available in ultrasound images and to improve visuality of the images.

VI. CONCLUSION

Every despeckling technique has its own advantages and disadvantages. The despeckling technique which is working better for liver ultrasound images may not give you better results for preprocessing of breast ultrasound images. It means that researchers have to take care during the selection of despeckling techniques for their work. This paper will help the researchers to get the idea about the various existing techniques in this field and motivate them to work further.

ACKNOWLEDGMENT

I Dr. Rajeshwar Dass, A.P, ECED, DCRUST, Murthal, Sonepat(HR), India wish to Acknowledge DCRUST, Murthal, Haryana for the financial assistantship through minor research project.

REFERENCES

1. Kriti, J. Virmani, and R. Agarwal, “Assessment of despeckle filtering algorithm for segmentation of breast tumours from ultrasound images,” *Biocybern. Biomed. Engg.*, vol. 39, no. 1, pp. 100–121, 2019.
2. C. Zhu et. al., “Speckle noise suppression techniques for ultrasound images,” *Proc. 4th Int. Conf. Internet Comput. Sci. Eng. ICICSE 2009*, pp. 122–125, 2010.
3. A. Gupta, V. Bhateja, and A. Srivastava, "An improved mammogram classification approach using back propagation neural network," *Information and Communication Technology for Intelligent Systems*, vol. 106 pp-369-376, 2018.
4. D. Ghosh, A. Kumar, P. Ghosal, and D. Nandi, " Speckle reduction of ultrasound image via morphological based edge preserving weighted mean filter," *Advances in Communication Devices and Networking*, vol. 537. Springer Singapore, 2019.
5. Xiaohui Hao et. al., “A novel multiscale nonlinear thresholding method for ultrasonic speckl suppressing,” *IEEE Trans. Med. Imaging*, vol. 18, no. 9, pp 787–794, 2002.
6. S. K. Randhawa, “A comparative analysis of various speckle reduction techniques for ultrasound images,” 4th international conference of signal processing, computing and control(ISPCC), pp. 106–110, 2017.
7. J. Jaybhay et. al., “A study of speckle noise reduction filters,” *Signal Image Process. An Int. J.*, vol. 6, no. 3, pp. 71–80, 2015.
8. Rajeshwar Dass, Priyanka, Swapna Devi, "Speckle noise reduction techniques," International Journal on Electronic and Electrical Engineering, (IJEEE),vol. 16 ,pg.47-57, Sept.-Nov. 2011, ISSN: 0974-2042.
9. J. Sen Lee, “Speckle analysis and smoothing of synthetic aperture radar images,” *Comput. Graph. Image Process.*, vol. 17, no. 1, pp. 24–32, 1981.
10. J. Sen Lee, “Digital image smoothing and the sigma filter,” *Computer Vision, Graph. Image Process.*, vol. 24, no. 2, pp. 255–269, 1983.
11. D. T. Kuan, A. A. Sawchuk, T. C. Strand, and P. Chavel, “Adaptive noise smoothing filter for images with signal-dependent noise,” *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. PAMI-7, no. 2, pp. 165–177, 1985.
12. V. S. Frost, J. A. Stiles, K. S. Shanmugan, and J. C. Holtzman, “A model for radar images and its application to adaptive digital filtering of multiplicative noise.,” *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 4, no. 2, pp. 157–66, 1982.
13. C. P. Loizou and C. S. Pattichis, *Despeckle Filtering Algorithms and Software for Ultrasound Imaging*, vol. 1, no. 1. 2008.
14. C. P. Loizou, C. Theofanous, M. Pantziaris, and T. Kasparis, “Despeckle filtering software toolbox for ultrasound imaging of the common carotid artery,” *Comput. Methods Programs Biomed.*, vol. 114, no. 1, pp. 109–124, 2014.
15. C. B. Burckhardt, “Burckhardt-1978-Speckle in Ultrasound B-Mode Scans,” no. 1, pp. 1–6, 2000.
16. K. N. Chaudhury et. al., “Fast O(1) bilateral filtering using trigonometric range kernels,” *IEEE Trans. Image Process.*, vol. 20, no. 12, pp. 3376–3382, 2011.
17. A. P. L. A. T. Loupas et. al., “An adaptive weighted median filter for speckle suppression in medical ultrasonic images,” *IEEE transsaction*, vol. 36, no. 1, pp. 129–135, 1989.
18. R. N. Czerwinska, D. L. Jones, and W. D. O. Brien, “Ultrasound speckle reduction by directional median filtering,” vol. 9, pp. 358–361, 1995.
19. N. Biradar, M. L. Dewal, and M. K. Rohit, “Edge preserved speckle noise reduction using integrated fuzzy filters,” *Int. Sch. Res. Not.*, vol. 2014, pp. 1–11, 2014.
20. H. K. Kwan and Y. Cai, “Fuzzy filters for image filtering,” pp. III-672–5, 2003.
21. H. K. Kwan, “Fuzzy filters for noisy image filtering,” *IEEE*, vol. 4, no. 3, pp. 161–164, 2003.
22. N. Biradar, M. L. Dewal, and M. K. Rohit, “Speckle noise reduction in B-mode echocardiographic images: A comparison,” *IETE Tech. Rev. (Institution Electron. Telecommun. Eng. India)*, vol. 32, no. 6, pp. 435–453, 2015.
23. P. Bao and L. Zhang, “Noise reduction for magnetic resonance images via adaptive multiscale products thresholding,” *IEEE Trans. Med. Imaging*, vol. 22, no. 9, pp. 1089–1099, 2003.
24. F. Luisier, T. Blu, and M. Unser, “A new SURE approach to image denoising: Interscale orthonormal wavelet thresholding,” *IEEE Trans. Image Process.*, vol. 16, no. 3, pp. 593–606, 2007.
25. Z. Dengwen and S. Xiaoliu, “Image denoising using block thresholding,” *Proc. - 1st Int. Congr. Image Signal Process. CISP 2008*, vol. 3, no. June 2008, pp. 335–338, 2008.
26. S. G. Chang, S. Member, B. Yu, S. Member, and M. Vetterli, “Adaptive wavelet thresholding for image adaptive wavelet thresholding for image denoising and compression,” vol. 9, no. July 2016, pp. 1532–1546, 2004.
27. Leonid I. Rudin et. al, "Nonlinear total variation based noise removal algorithms,” Physica, vol. D-60, pp. 259–268, 1992.
28. G. Gilboa, Y. Y. Zeevi, and N. Sochen, “Texture preserving variational denoising using an adaptive fidelity term,” *Proc. Work. Var. Lev. Set Methods*, vol. 3, p. 8, 2003.
29. Rajeshwar Dass, Swapna Devi, Priyanka, “Effect of wiener-helstrom filtering cascaded with bacterial foraging optimization to despeckle the ultrasound images”, IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 4, No 2, pp.372-380, July 2012.
30. J. L. Mateo and A. Fernández-Caballero, “Finding out general tendencies in speckle noise reduction in ultrasound images,” *Expert Syst. Appl.*, vol. 36, no. 4, pp. 7786–7797, 2009.

31. Rajeshwar Dass, Indiwar, Mukesh Kumar, "Edge detection using biogeography based optimization," International Journal of Electronics & Communication Technology(IJECT),Vol.4, Issue2, pp.413-418, April-June 2013, ISSN:2230-7109 (online), 2230-9543(print).
32. Rajeshwar Dass, Priyanka, Swapna Devi, "Image segmentation techniques," International Journal of Electronics & Communication Technology (IJECT), vol.3, issue1, pp. 66-70, Jan.-March2012, ISSN:2230-7109 (online), 2230-9543 (print).
33. Rajeshwar Dass, Vikas, Priyanka, "Image segmentation performance evaluation methods," International Journal of Science, Engineering & Computer Technology (IJSECT),Vol.2, ,Issue1, pg.125-127, March2012.
34. D. Gupta, R. S. Anand, and B. Tyagi, "Ripplet domain non-linear filtering for speckle reduction in ultrasound medical images," *Biomed. Signal Process. Control*, vol. 10, no. 1, pp. 79–91, 2014.
35. P. Coupé, P. Hellier, C. Kervrann, and C. Barillot, "Nonlocal means-based speckle filtering for ultrasound images," *IEEE Trans. Image Process.*, vol. 18, no. 10, pp. 2221–2229, 2009.
36. C.-A. Deledalle, L. Denis, and F. Tupin, "Weighted maximum likelihood denoising with iterative and probabilistic patch-based weights," *TelecomParisTech*, vol. 18, no. 12, pp. 2661–2672, 2009.
37. I. Elyasi and M. A. Pourmina, "Reduction of speckle noise ultrasound images based on TV regularization and modified bayes shrink techniques," *Optik (Stuttg).*, vol. 127, no. 24, pp. 11732–11744, 2016.
38. A. S. Leal and H. M. Paiva, "A new wavelet family for speckle noise reduction in medical ultrasound images," *Meas. J. Int. Meas. Confed.*, vol. 140, pp. 572–581, 2019.
39. P. A. Juang and M. N. Wu, "Ultrasound speckle image process using wiener pseudo-inverse filtering," *IECON Proc. (Industrial Electron. Conf.*, pp. 2446–2449, 2007.
40. M. P. Wachowiak, A. S. Elmaghraby, R. Smolikova, and J. M. Zurada, "Classification and estimation of ultrasound speckle noise with neural networks," *Proc. - IEEE Int. Symp. Bio-Informatics Biomed. Eng. BIBE 2000*, pp. 245–252, 2000.
41. J. Tian, W. Yu, and L. Ma, "AntShrink: Ant colony optimization for image shrinkage," *Pattern Recognit. Lett.*, vol. 31, no. 13, pp. 1751–1758, 2010.
42. Z. Wang, A. C. Bovik, H. R. Sheikh, and E. P. Simoncelli, "Image quality assessment: From error visibility to structural similarity," *IEEE Trans. image Process.*, vol. 13, no. 4, pp. 600–612, 2004.
43. T. Tasnim, M. M. H. Shuvo, and S. Hasan, "Study of speckle noise reduction from ultrasound B-mode images using different filtering techniques," *4th Int. Conf. Adv. Electr. Eng. ICAEE 2017*, vol. 2018-Janua, pp. 229–234, 2018.
44. D. Mittal, V. Kumar, S. C. Saxena, N. Khandelwal, and N. Kalra, "Enhancement of the ultrasound images by modified anisotropic diffusion method," *Med. Biol. Eng. Comput.*, vol. 48, no. 12, pp. 1281–1291, 2010.
45. M. Gupta and A. Garg, "An efficient technique for speckle noise reduction in ultrasound images," *2017 4th Int. Conf. Signal Process. Integr. Networks, SPIN 2017*, no. 1, pp. 177–180, 2017.
46. H. Rabbani, M. Vafadust, P. Abolmaesumi, and S. Gazor, "Speckle noise reduction of medical ultrasound images in complex wavelet domain using mixture priors," *IEEE Trans. Biomed. Eng.*, vol. 55, no. 9, pp. 2152–2160, 2008.

AUTHORS PROFILE

Dr. Rajeshwar Dass completed his PhD from Deenbandhu Chhotu Ram University of Science & Technology, Murthal in 2014 with specialization in image processing. He received his Masters of Engineering (M.E) Degree in ECE from National Institute of Technical Teachers Training and Research Center (NITTTR) Chandigarh in the year 2007. He received his B.E (Honors) Degree in ECE from Apeejay College of Engineering, Sohna, Gurgaon in 2004. In August 2004 he joined Dept. of ECE of Apeejay College of Engineering, Sohna, Gurgaon. Presently he is working as Assistant Professor in the Department of Electronics & Communication Engineering, DCRUST, Murthal since 2008. His interest includes Medical Image Processing, Artificial Neural Network, Wireless Communication and Soft Computing Techniques. He has contributed more than 45 technical papers in International Journals and Conferences. He has written books on basics of electronics, wireless communication and organised various faculty development programmes, workshopes and conferences.

Email: rajeshwardas10@gmail.com

Retrieval Number: D7281049420/2020©BEIESP
DOI: 10.35940/ijeat.D7281.049420
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication