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A Review of DE Speckling of Images using Existing Methods

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ABSTRACT

Images are influenced by the speckle phenomenon, a multiplicative in that aggravate image quality. Various methods for denoising have been designed in present years, based on numerous approaches. Images are becoming widely used in medical field as well as remote sensing applications also. Correct photos are critical to the application's ability to make accurate observations. Medical image despeckling has become a pressing problem in image processing. Samples are dishonoured by Speckle noise as a consequence of fading effects. To minimise the speckle effect, a wide variety of algorithms have been developed. There are currently commercially acceptable semi-automatic techniques in place. Speckle noise has been the subject of substantial investigation in both medical imaging and remote sensing in the past. Edge preservation is a common feature of most approaches, however because of the high levels of noise or the lack of edge distinction, these filters are unable to provide accurate edge detection. This paper discusses few techniques for despeckling photos that uses different approaches. To deal with the multiplicative non-Gaussian nature of speckle noise on data, these methods propose some speckle filtering algorithm. In addition, there is a thorough investigation of each technique's challenges in this study. The essential differences between various methodologies were explored as a result of reviewing multiple research publications.

Keywords--- Speckle noise, Bayesian Estimation, Filter, Segmentation, Recursive Bayesian Algorithm

I. INTRODUCTION

An important aspect in the visual perception and processing of ultrasound and SAR images and movies is the presence of speckle noise. Diagnostic ultrasound imaging's contrast resolution is limited by speckle noise, which makes it difficult to detect small, low-contrast lesions and, as a result, difficult for non-specialists to interpret the ultrasound pictures. Ultrasound experts with significant knowledge may find it difficult to derive meaningful conclusions from the images because of the speckles [1]. Ultrasound speckle noise occurs when ultrasound waves reflected from microscopic scattering through tissue interfere with each other. One definition of ultrasonics is "sound with a frequency greater than or equal to 20 kHz". As a pulsing pressure wave, it carries energy and spreads via several mechanisms. To minimize the speckle effect, a wide variety of algorithms have been developed. There are currently commercially acceptable semi-automatic techniques in place. Coherent accumulation of back-scattered signals and random electromagnetic signal interference result in speckle noise [24]. The nature of degradation makes reducing speckle noise a difficult task in image processing at the moment [3]. Image despeckling [3] is the subject of numerous investigations. In light of the large range of real-world applications in which image processing is used, there is a high need for processing the same. Despeckling big amounts of image data while using as little processing power and memory as possible is a common requirement in today's world [4 and 5]. Consequently, there is always a need for a low-memory recursive framework for image estimation. If we want to reduce the amount of memory used during processing, we need an enhanced and simplified technique that operates on a pixel-by-pixel basis (not an image-by-image basis). Normal despeckling methods require a significant amount of memory, and the new approach is projected to eliminate that requirement. A piece pixel in the image is despeckled and the following pixel is recursively calculated in this method [6]. As a result, compared to iterative approaches, the memory required is drastically reduced. According to Bayesian theory, this technique relies on Bayesian Filtering and Bayesian Theory. However, only a small amount of research has been done on recursive image processing approaches. Because of this, we are more inclined to follow the suggested course of action.

Speckle [15] is another name for this multiplicative noise. It is challenging to understand images taken with coherent imaging techniques like ultrasound because of the speckle noise. Image denoising is therefore necessary in order to separate the nodule from the glandular region. There is a thorough investigation of each technique's challenges in this study. The essential differences between various methodologies were explored as a result of reviewing multiple research publications. Speckle noise reduction can be done by filtering methods and multiscale methods, and Enhanced image is retrieved. Despeckling strategies are discussed in Section 3. Section 4 brings things to a close.

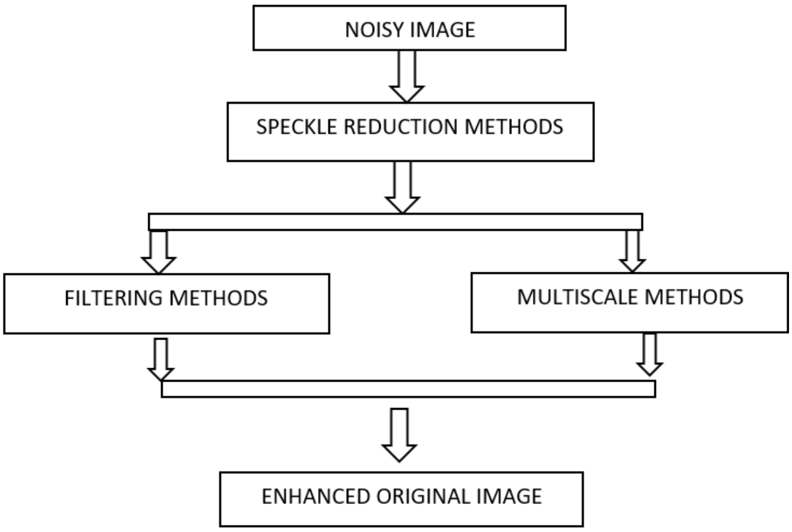

Figure 1: Classification of Speckle Reduction Method

Filters come in a variety of shapes and sizes. Adaptive speckle filters can be categorised as scalar Mean and Median filters. A movable window is used for both sorts of filters. They differ primarily, in that adaptive filters often contain a multiplicative model and utilises local statistics.

II. SPECKLE NOISE

Noise, a random variation in intensity, is a common problem in images taken by sensors. The noise can be caused by changes in brightness, or by the sensor itself, depending on the situation. Using ultrasound images, the noise is directly tied to the intelligible nature of the ultrasound system. Speckle [15] is another name for this multiplicative noise. It is challenging to understand images taken with coherent imaging techniques like ultrasound because of the speckle noise. Image denoising is therefore necessary in order to separate the nodule from the glandular region. Speckle noise is evident in the ultrasound image displayed in figure 2. This is why digital image processing systems aim to remove speckle while keeping key elements such as borders, corners, and textures from the original image.

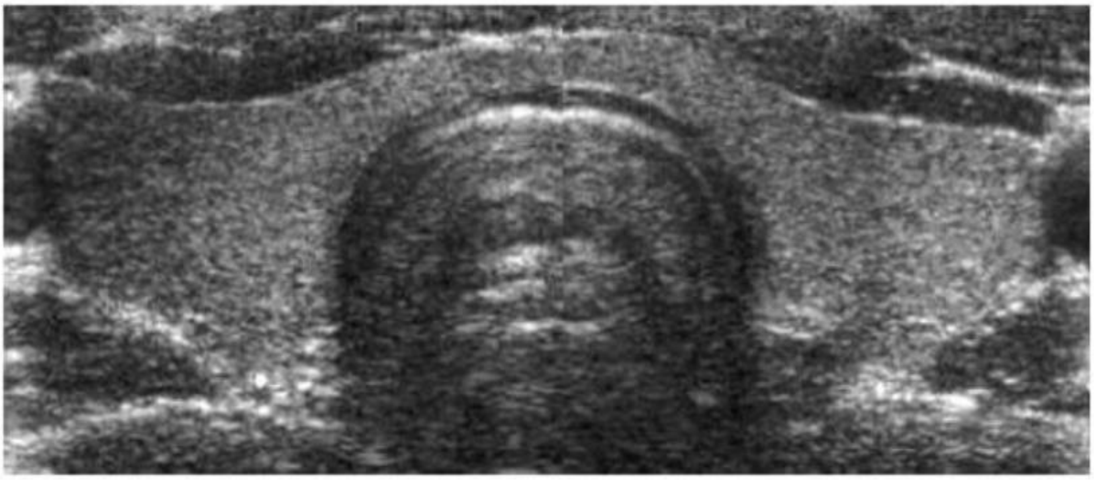

Figure 2: Image corrupted by Speckle noise

III. REVIEW AND CLASSIFICATION

The digital image processing systems aim to remove speckle while keeping key elements such as borders, corners, and textures from the original image. The first method uses a sigma filter to automatically estimate the filter's input parameters. The neural network is used in the second method. This filter is capable of reducing speckle noise and producing an efficient image. These two despeckling methods for ultrasound pictures were devised by Shaimas [7].

Adaptive weighted median filter-based speckle discount approaches for ultrasound images were developed by Loupas et al. [14]. Smoothing has been achieved by modifying weight coefficients based on local statistics. Fixed-width window and restricted noise-reduction capabilities are the main drawbacks of this software.

A speckle reduction filter based on diagnostic ultrasound images' homogeneity map was proposed by Murat Alparslan et al [10]. In order to create a homogeneity map, the local statistics of the window constructed for each pixel are used. The edge-sensitive filter is not as good at smoothing as this method. Better despeckling and edge preservation are the hallmarks of this filter.

In the homogeneity domain, a technique based on directed averaging filters was proposed by Bhateja et al. [8]. Law's mask is employed to glean information from the written word. Pixels are categorised into homogeneous and non-homogeneous regions based on the maximum entropy principle's threshold value. Directional average filter is applied to the non-homogeneous zone, while the homogeneous region is not subjected to a filtering process. Denoising and edge preservation both suffer as a result of the filtering process.

To reduce speckle, Norashikin Yahya and colleagues [9] devised a procedure based on the subspace approach. By eliminating the noise subspace and approximating the noise-free image from the remaining signal subspace, image enhancement is achieved in this method. A linear estimator and a rank abridged subspace model are used for estimation. The filter's noise-reduction capabilities are superior.

Speckle Reduction Anisotropic Diffusion (SRAD) was proposed by Yu et al [59] as a method for removing speckle noise. Using four nearest neighbor windows, a diffusion coefficient is calculated by dividing the local standard deviation by the mean. As a diffusion threshold, it introduces a speckle scale function that acts as the level of smoothness control in this filter. This approach, on the other hand, results in softer edges and more rounded structural content.

Speckle noise reduction in ultrasonic images was proposed by Abd-Elmoniem et al [11] as a nonlinear coherent diffusion. When convolution is applied to the structure tensor, the tensor-valued diffusion function is created. This technique is more effective in reducing speckles and enhancing edges. The main issue is that ultrasound images of tiny features like cysts or lesions are not preserved well by this imaging technique.

The linear approximation of the multiplicative noise model was used by Kuan [12] to suggest a speckle reduction filter. The Lee filter [13] is a good example of how this filter works. The noise model is subjected to the Minimum Mean Square Error criterion, which yields this filter. Based on the weight parameter, it is an adaptive filter. The coefficient of difference of the noisy image and noise is taken into account while determining the weight parameter. In light of this, some minor adjustments have been made to the lines and edges.

A linear grouping of the local mean and the experiential pixel is used to approximate the multiplicative model in the Lee filter. The MMSE criterion is then used to derive the weighting constant (MMSE). Lee's local statistics technique and a non-stationary picture model are employed in the method. Frost [16] is the filter of choice since it is adaptive and exponentially weighted in its average. You can calculate the weights by dividing your image's local standard deviation by its local mean, which is expressed as a coefficient of variation (CV). The Lopes et al. [17] improved Lee and Frost filters by splitting a picture into homogeneous, heterogeneous, and isolated point targets based on the coefficient of variation (low, intermediate, and high, respectively).

3.1. Speckle Noise Removal Filtering Technique

In this paper [18] compared three different techniques, (1) Hybrid Weiner –H Algorithm, (2) LSH frequency domain filtering, (3) Advanced Mexican Hat Linear Spatial Filtering. Among all the three filter Advanced Mexican Hat Linear Spatial Filtering gives a higher PSNR value and lower RMSE value. And it is concluded that AMHLS has better reconstruction technique for ultra sound images. Usage of compression techniques may result in losing of data which cannot be recovered by logarithmic compressed data image or scan converted data image. Envelope detection method is used for optimum result in ultrasound imaging technique.

The PSNR measured in decibels and the equation is given by PSNR. RMSE value is inversely proportional to the equality of image. Outcome of the proposed algorithm is shown in the table.

Table 1 : Filtering Technique model results

Filtering Technique	PSNR	RMSE
Hybrid Weiner–H Algorithm	8.8058	92.8861
LSH frequency domain filtering	6.0148	128.0855
Advanced Mexican Hat Linear Spatial Filtering.	12.0179	64.1723

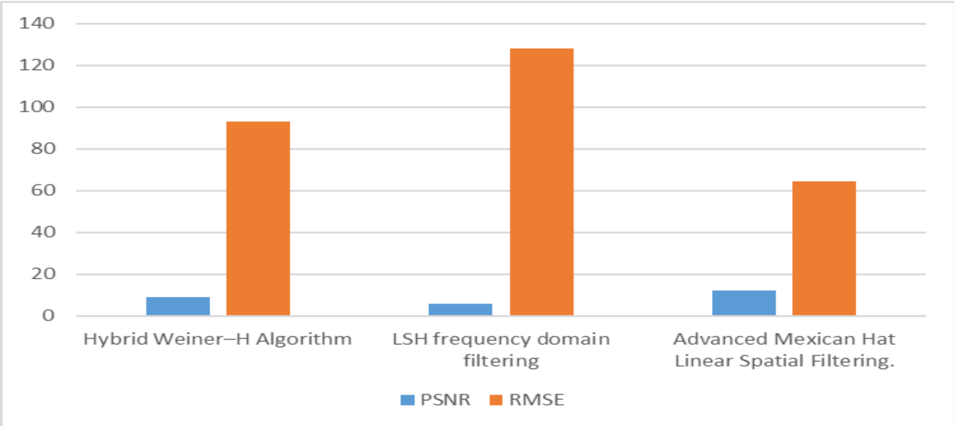

Figure 3: Graphical presentation of Filtering Technique Model results

3.2. Speckle: Modelling And Filtering

The amplitude statistics of coherent imaging may now be modelled using a combination of the Inverse Gaussian distribution [19]. New statistical distributions for modeling amplitude data have been presented by the researchers.

The Rayleigh distribution is not used in this method [20]. The Rician Inverse Gaussian distribution is the name given to this type of distribution. Allows the distribution to be more customizable because it includes three parameters. An EM-type technique can be used to estimate these parameters from real data. For modelling medical ultrasonography and SAR data, the experimental investigation demonstrates that the new pdf is suitable. Their MAP filter has also been updated to account for the new distribution. A closed-form a posterior distribution makes this a simple implementation. The filter output is hence given explicitly. Finally, a comparison of performance of multilook processing, wavelet based despeckling, contourlet based despeckling, and contourlet-based despeckling with cycle spinning is provided for both simulated and actual SAR images. It is shown that the contourlet methods have better performance than multilook or wavelet methods. [4]

A despeckling method based on wavelets for SAR images that uses dyadic wavelet decomposition to break down the original image. On real SAR images, this method blurs strong scatterers but reduces noise in homogenous areas better than any of the other methods examined [20]. SAR speckle reduction using a new curvelet-domain Bayesian technique. SAR picture interpretation relies heavily on the removal of speckles without sacrificing critical textural and structural information [21].

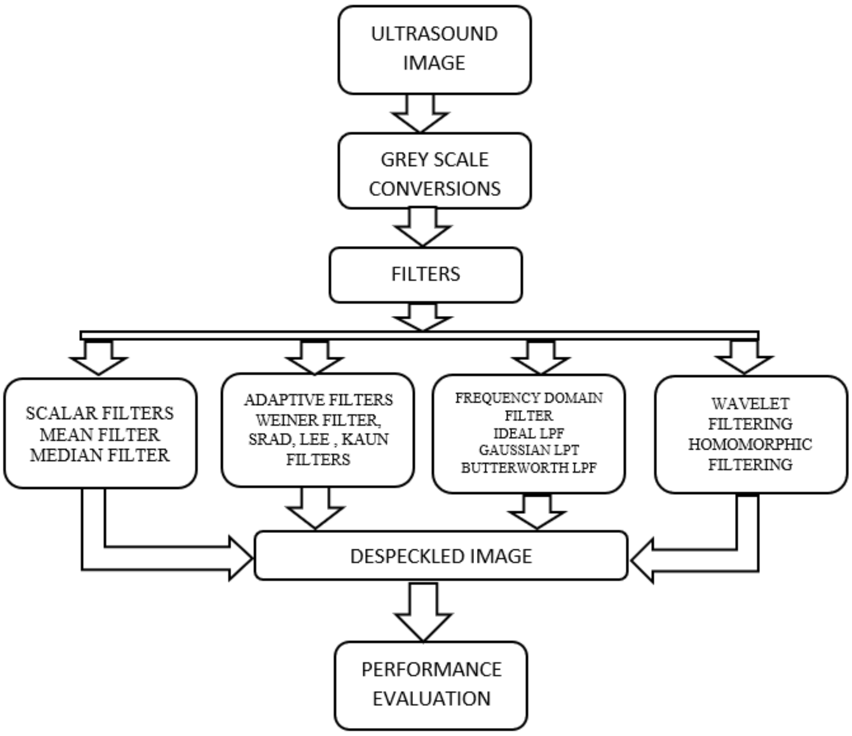

Figure 4: Different kinds of filtering technique

3.3. Image Processing Techniques used in Medical Image

Speckle noise in medical images can be reduced using adaptive median filters and associated to the mean and median filters in this research [22]. This filter, when tested against other options, outperformed them all by 80% in various sorts of medical images. Noises of various kinds are contrasted and analysed. Impulsive Noise, Additive Noise, and Multiplicative Noise are only a few of the noises that are being compared. The most common causes of an Impulsive Noise (Salt & Pepper) include data transmission faults. Natural noise processes, such as those caused by electrical noise in an image acquisition system, are typically modelled using Additive Noise. There are two steps to the proposed adaptive median filter: the first begins with the mean filter, and the second stage begins with the median filter. Using ultrasound images, all algorithms are tested. Based on simulations, the Proposed Adaptive Median Filter was found to perform better than the competition.

3.4. A Bilateral Filter for Ultrasound Images De-speckling

In this paper Sameera et al., [23] proposes an algorithm which works on two steps. In high frequency band non parametric wavelet approximation and in low frequency band guided bilateral filter. Wavelets give both the time and frequency representation of a particular signal simultaneously. The size of the wave is determined by a finite window function. A wavelet is a wave like oscillation in amplitude of the signal.

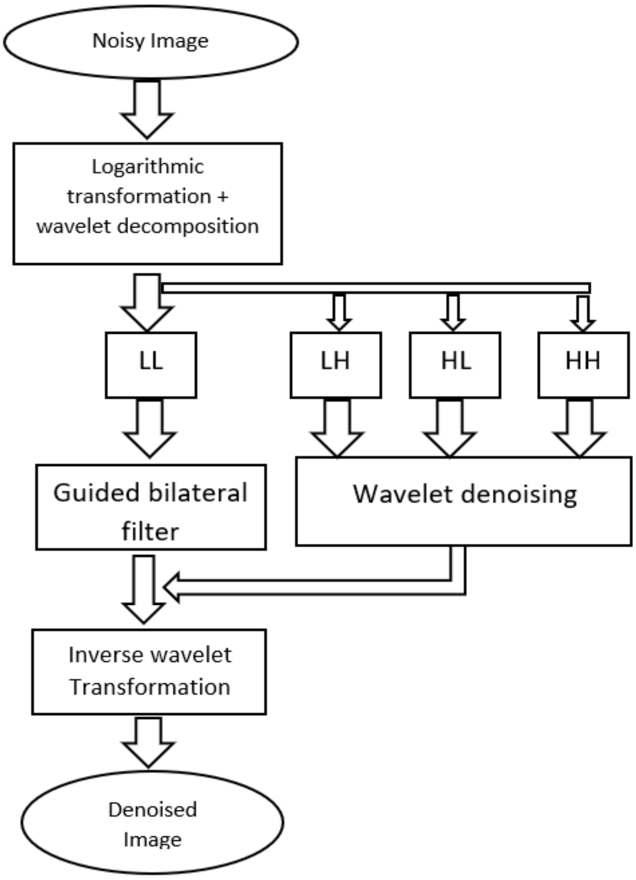

Figure 5: Transformation Technique for Denoising

Wavelet decomposition is used to obtain the frequency component of the image and Bayesian framework is applied to despeckle the low noise components. Existing methods such as the Bayesian non-local means filter (OBNLM), wavelet estimation using a non-parametric model, and fast bilateral filtering were all compared to the suggested method. Both edge preservation and visual quality were shown to be improved quantitatively by the proposed technique. The good edge preservation of a bilateral filter makes it a popular choice for reducing speckle noise from images in three-dimensional (3D) space. Wavelets and a bilateral filter work together to reduce noise while maintaining the edges. In the suggested approach, the PSNR and EPI values are improved by using a MAP estimator and a guided bilateral filter.

IV. MULTISCALE METHODS

In the Multiscale Methods, we describe the four technologies to reduce the noise in the images as Recursive Filter, Comprehensive Guided Filter With Bayesian Nonlocal Means, Wiener Filtering and Adaptive Wavelet Thresholding and Image Segmentation. These methods are discussed in following section.

4.1. A Despeckling SAR Images using Recursive Filter.

A recursive technique for image despeckling is presented in this publication [24]. A discontinuity-adaptive Markov random field prior is included into the unscented Kalman filter architecture through significance sampling to provide outstanding despeckling and feature preservation. On both synthetic and actual photos, the performance is demonstrated. Random multiplicative noise is used to represent fully-developed speckle. It is assumed that noise is uncorrelated with variance and has a unit mean and standard deviation.

SAR image speckle noise can be effectively suppressed while still keeping the image's properties, thanks to a new recursive technique based on the unscented Kalman filter (UKF).A discontinuity-adaptive Markov conditional PDF can be incorporated into the UKF. When estimating, UKF incorporates multiplicative noise. The UKF multiplicative measurement equation uses a collection of sigma points to compute the final image estimations using the prior and the speckle noise statistics. This method is less computationally intensive but more flexible in terms of location. With this filter, there is no need for an explicit detection of edges because of the discontinuity preserving prior. It is not necessary to deduce the AR parameters of the original image, as in the ABKF [25]. Non-Gaussian priors can be incorporated into the proposed filter without the need for parameter estimation or optimization.

4.2. Generalized Guided Filter

It is suggested in this study [29] that a generalized guided filter with Bayesian nonlocal means be used as an expanded despeckling strategy (GGFBNLM). An original image and a guiding picture are both taken into account when determining how the guided filter's output should be computed. The desired guided filter does the following: When it comes to the first phase, it stretches the linear-guided filter (GGF) to a nonlinear one (BNLM framework) and uses input images and original images to figure out a nonlinear weight kernel.

In the second step, it creates a guiding image based on the homogeneity of local regions and the ML algorithms used. The BNLM framework is used to derive the expression of the GGF with a nonlinear weight kernel in guided filter. Frost, GM, BNLM, BM3D and LHRS-PRM are compared to the suggested technique in terms of speckle filters. Filtering and multi-look processing are the two most common approaches for reducing speckle. Speckle noise is reduced, but the spatial resolution of the image is degraded. It is possible to reduce noise in particular sections of an image by using local pixel intensity statistics, but this can result in the loss of features when applied to edges and textures, which are more difficult to deal with in terms of noise removal.

4.3. Wiener Filtering and Adaptive Wavelet Thresholding for Speckle Noise Reduction in Images

Using spatial and frequency field approaches, this paper [30] removes speckle noise. The Wiener Filter is used for spatial preprocessing, while the wavelet transform coefficient of adaptive soft thresholding is used for frequency preprocessing. Logarithmic transform to Wiener filtered image is used since speckle is multiplicative in this work. The wavelet transform is decomposed into two levels, and only the detail coefficients are subjected to thresholding. The standard deviation of each decomposition level and subband is used to calculate the threshold value. For this image, the threshold is calculated by selecting the most homogeneous sub-block of the image. PSNR and SSIM measures are used to quantitatively analyze the data. It has already been stated that the Despeckling Algorithm is used.1) Filtering is done using Wiener filtering on the speckled image. 2) The logarithm of the resulting image transforms the multiplicative noise model into an additive one. 3) The picture is subjected to Discrete Wavelet Transform and decomposed using Meyer Wavelet up to level 2. Each subband except the lowest level LL band has a threshold calculated. All LH, HL, and HH subbands are soft-thresholded. Approximation and thresholded detail coefficients are used to construct the Inverse Wavelet transform on the approximation coefficients. This image is despeckled using the exponent. This new approach has the potential to drastically reduce speckle noise while still being applicable to a wide range of tasks.

4.4. Image Segmentation and Ultrasound Imaging

This paper [31] emphasised a medical imaging technique, segmentation is still necessary in order to collect both qualitative and quantitative measures. This includes the position of an object of interest as well as its volume, area, or dynamic behaviour over time. They're important since they can be produced at video-rate and so allow for dynamic analysis of touching structures. In addition, compared to additional medical imaging procedures, the gathering of these pictures is non-invasive, inexpensive, and does not necessitate the use of ionising radiation. Anatomical features in ultrasound images, on the other hand, are difficult to segment due to the inherent acoustic interference (speckle noise) and artefacts in these images

4.5. Improved Non-Local Means Filtering

Non-local means approaches uses Euclidean distance for finding similar blocks. Euclidean distance is a good choice for additive noises where the noise statistics is known. But in multiplicative random scenario like speckle where the noise statistics is unpredictable, Euclidean is not a good choice. Herefore the computational efficiency of NLMF can be improved by modifying the distance. Refining the similarity estimates in different iterations Brox and Cremers. Distance is the measure of dissimilarity that is smaller distance corresponds to better similarity between the patches. Similarity is a factor that quantifies the dependency between the pixels in the image. Euclidean Distance represents the shortest distance between two points. It is given as the square root of the sum of the squares of the differences between two data points. Identical points will have Euclidean distance as zero and points with less similarity will have higher values. In additive noise statistics Euclidean distance makes perfect sense but in multiplicative scenario like SAR where noise statistics constantly changes, Euclidean distance loses its significance. So, in order to find out suitable distance measure that can improve the efficiency of non-local means filtering, different distance measure.

4.6. Despeckling Using Lee Filter

Lee is a non-adaptive filter using the first order local statistics of the neighborhood pixels. It converts the multiplicative model into additive and approximates the value by a linear combination of the local mean of the pixel. The MSE can be easily estimated from the local mean and variance. Brighter areas are affected more by noise than dark areas. Therefore, the brighter regions near the neighborhood are redefined by incorporating local gradient. Then the weighting constant is determined by a MMSE estimator. Lee uses a linear statistic for approximation. Mean and variance of the pixel of interest is the local mean and local variance of all pixels within the moving window selected by the user. That is Lee uses the statistical distribution of the pixels in the area of interest in order to carry out denoising.

V. CONCLUSION

We've looked at a variety of methods for despeckling photos in this literature study. We could learn and evaluate despeckling strategies so that the best method for each case can be selected This paper provides a quick overview of a brand-new despeckling method. A review of many works led us to conclude that a Bayesian strategy can yield superior results since speckle noise is multiplicative. An enhanced, more straightforward method that uses pixels rather than images like it does in wavelet transform, filtering techniques, wavelet transformation, soft/hard thresholding, multi-spinning concepts and normalized convolution would help reduce processing memory requirements. We hope that this document will be useful to others in their search for the best despeckling method.

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