Filtering and Statistical Feature based Automatic Detection of Breast Lesions in Ultrasound Images

Telagarapu Prabhakar, S.Poonguzhali

***Abstract*: The objective of this paper was proposed to develop a method for a fully automatic detection of breast tumor accurately. In this reduction of speckle noise was done by utilizing Curvelet, Shearlet. The filtered images acted as an input of segmentation in which the contour was initially recognized by statistical features and the region was segmented automatically. The performance analysis was done by comparing the output of the automatic segmentation region algorithm and the ground truth (Segment by radiologist).The Shearlet filtered images gave a high performance with the an accuracy of 91.51%, sensitivity of 92.24%, specificity of 89.44 %, Jaccard of 86.02 % and Dice Similarity of 91.27 % when compared to other filtered images and input image.**

***Index Terms*: Breast Ultrasound Image, Speckle reduction, Statistical Features, Automatic Segmentation.**

I. INTRODUCTION

Breast malignancy is most basic in ladies everywhere throughout the world. As indicated by a gauge, about 1.67 Million ladies over the world are observed to experience the ill effects of breast malignancy in 2012. Consistently more than 5 lakh ladies apparently kick the bucket of breast malignancy [1]. Rayudu et al. created Curvelet-based Denoising Algorithm for Ultrasound Images [2]. The outcomes on clinical ultrasound pictures demonstrate successful edge safeguarding compound with separating strategies utilizing the Adaptive Filters. Be that as it may, these procedures were ineffectual in edge and highlight protection. The Curvelet Filters were fruitful in safeguarding and improving edges. Deng et al. depicted Rayleigh-trimmed channel to survey the standard deviations of neighbourhood signs to determine the parameter that controlled an alpha-trimmed mean channel for concealment of the commotion [3]. Ma et al. played out a relative report on six de-dotting techniques, in particular, altered cross breed middle filter(MHMF), gabor channel, spot decreasing anisotropic dispersion (SRAD), homomorphic channel, Non-nearby mean filter(NLM) and crush box filter(SBF) [4]. Vishwa et al. characterized a wavelet-based thresholding plan for noise concealment in ultrasound pictures [5].This technique offered more noteworthy visual quality and better PSNR. Versatile middle channel, Frost's channel, itemized protected anisotropic dissemination channel and Wiener channel in wavelet area were connected to lessen Speckle commotion in breast ultrasound pictures by Khusna, D.A et al [6]. The execution was looked at based on decrease; assessed based on Peak Signal to Noise Ratio, Mean Squared Error, Average Difference, Mean and Variance as second-arrange surface administrator. A technique that utilized a mix of homogeneity separating and altered bayeshrink was proposed to diminish spot noise in breast disease ultra sound pictures by Elyasi et al. [7]. A homogeneity filtering approach supplanted a pixel power by the mean of homogeneous neighborhood, at that point adjusted bayeshrink strategy recognized homogeneous locales from districts with spot noise acquired from homogeneity separating. Poonguzhali proposed a total programmed area developing strategy for partitioning the majority in ultrasound pictures [8]. The seed point was consequently chosen from the unusual area dependent on textural highlights, for example, co-event highlights and run length highlights. Angle greatness based locale developing was adjusted. Poonguzhali et al. built up an inventive method to identify the seed point from the unusual area base on the textural highlights, for example, co-event and run-length highlights [9]. In the wake of finding the seed focuses dependent on the highlights, the limit for district developing technique was consequently chosen. At last, the angle greatness based locale developing calculation was embraced. In this way the seed point was naturally recognized and the sore was consequently divided without manual mediation. Shan et al. offered a novel method to pick the seed point utilizing spatial trademark and factual highlights [10]. In this technique, the debased picture was sifted utilizing anisotropic channel and afterward every nearby least was found for thresholding. Subsequent to finding the whole nearby least, one of them was taken as a limit and the picture was binarized relying on the edge. At that point the locale which was associated with the limit was distinguished and erased. The picture contained many shut areas. At last, utilizing scoring technique, the district that had more score was distinguished as an injury locale and the seed point was found in the triumphant area. Shan et al. offered a novel and completely mechanized division approach for breast ultrasound pictures [11]. Xian et al. proposed a novel completely programmed breast ultrasound picture division technique. This methodology could display both the space and recurrence area information to play out the tumor division under a likelihood structure [12]. The trials exhibit that both of the proposed ROI age technique and tumor division strategy were more precise and powerful than the current strategies. Gómez-Flores et al.

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proposed a completely programmed division approach dependent on surface investigation for breast sores on ultrasound pictures [13]. Anant Madabhushi et al. (2003) distinguished another technique for consequently dividing the ultrasonic breast injury dependent on the power and surface [14]. Liu et al. (2005) represented a standardized slice with area combining technique to fragment the district of enthusiasm for ultrasound pictures [15]. The work proposed in this paper is an automated system for identification of breast lesion that employs the multi-resolution analysis. Here the first reduction of speckle noise was by utilizing different filters and the lesions in breast ultrasound images are segmented automatically through an active contour approach based on statistical features.

II. METHODOLOGY

The work proposed in this paper is an automated system for identification of breast lesion that employs the multi-resolution analysis. This study focused on Curvelet and Shearlet transform for speckle noise reduction. Then the breast lesions are segmented by automatically with a statistical feature-based active contour method. The proposed method is tested with 110 samples, of which 56 samples are benign masses, and 54 samples are malignant masses. This work developed a scheme which is capable of locating the region of lesions automatically.

A. Speckle reduction

Noise and artifacts are gained during acquisition or transmission, and cause image and signal degradation [16]. The main objective of the techniques is to remove the noise and retain the significant features. Ultrasound imaging is a popular medical imaging procedure being economical, safe, transferable, and adaptable. However, the quality of images is poor because of speckle noise. This study focuses on developing filtering techniques using Curvelet and Shearlet for speckle noise reduction. The filtering techniques that are implemented here based on Curvelet Transform and Shearlet Transform.

Curvelet filter

In the recent past, curvelet based methods for image denoising was developed. The new concept of Curvelets was developed by Candes et al. (2006) [17]. It was observed that the curvelet transform covers whole frequency spectrum so that there was without loss of information. Speckle was reduced with sub-band decomposition, smooth partitioning, renormalization and ridgelet analysis. Finally with ridgelet synthesis, renormalization, smooth integration and rearrangement of sub-bands the image was reconstructed [18].

Shearlet filter

The Shearlet transform, introduced by Guo and Labate, was extended in the past few years [18-20]. The above said algorithm was used for removing speckle from breast ultrasound images.

B. Automatic Segmentation

Initially, the statistical features are extracted from the normal lesion ROI and from the breast lesion ROI. These features are used for training the kNN classifier. Based on the classifier performance seed points are determined and these points are acts as initial contour for automatic segmentation process.

Automatic selection of initial contour

Initially the breast lesion region and the normal region of size 64*64 pixels were given as input to the system to find seed points. For computational simplicity, a block of 36x36 was considered from the regions. Threshold operation and tan processing applied on these blocks. The statistical features like Mean, Standard Deviation and Entropy were extracted from both normal and lesion regions from every 18x18 pixels. Hence, 4 set of features were obtained from each block. In this manner, feature set was developed from 40 lesion as well as 40 normal regions. A set of 160*3 features were available from the lesion as well as from normal regions and then they were used for training the kNN classifier.

Statistical features

- Mean
- Entropy
- Standard Deviation

Most of the lesion region had a low mean when compared to normal region, so mean is used as one of the features. Similarly, most of the breast lesion regions are more homogenous when compared to normal region, so entropy and standard deviation were considered as features. So these parameters could identify a seed pixel from the abnormal regions.

k-NN classifier training

k-nearest neighbours (kNN) classifier was familiar nonparametric learning technique used to classify the feature set into a different class. Using the kNN classifier, the extracted features for the corresponding output was trained. A set of 160*3 features were available from the lesion as well as from normal regions for kNN training phase. Threshold operation and tan processing applied on the train image before feature extraction. All available data in the training was considered by the measure of distance while classifying the new instance. Features in the training set form the cluster with centre point as Centroid based on Euclidian distance.

kNN classifier testing

In this step, Threshold operation and tan processing applied on the test image. Features like mean, entropy and standard deviation were obtained from the test image. These features were given as input to the trained kNN classifier. The distance of the test features with the lesion cluster and normal cluster were computed by means of Euclidean distance. If the test features were closer to the lesion cluster, then a corresponding output of class ‘1’ was produced. Similarly, when it was closer to normal region, output of class ‘0’ was produced.

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Selection of seed point

Based on kNN classification, the normal regions in the test image were deleted and only lesion regions are retained. Some of the normal regions which were boundary connected with lesion regions have similar features compared to lesion region. These regions must be deleted, so that the seed point could be found effectively within the lesion region.

Active Contour Method

Here the seed points acted as an initial contour with the help of Signed Pressure Force (SPF) function that was region-based and it controls the directions. The contours shrunk when initial contour reaches the tumor region, or expand while it was inside the tumor [21]. The contour expanded surrounding the seed point pixel. Figure 1 gives the proposed active contour method

III. RESULTS & DISCUSSION

Speckle reduction

Filtering methods were employed, like Curvelets and Shearlets Transform to reduce the speckle noise in breast ultrasound image. Speckle noise was reduced using Curvelet and Shearlet filters for benign and malignant lesion of breast ultrasound images. The performance measurement was done by using Signal to Noise Ratio (SNR), Peak Signal to Noise Ratio (PSNR) and Edge Preserve Index (EPI). The SNR, PSNR and EPI values were calculated from the 110 images and the average values were compared and shown in Table 1. The performance of speckle reduction filters for each quantity such as mean (μ) value is 0 and standard deviation (S.D) values 0.2 and 0.4 were shown in the Table 1.It is observed from Table that the shearlet filter offers the best-denoised image while edges were preserved. Though the curvele and Shearlet eliminated speckle noise on the image, the Shearlet Filter presented the best performance and yielded high SNR, PSNR and EPI values. Compared to the other filters it was observed that the Shearlet filter preserved the edges and this filter was used for the further processing.

Automatic Segmentation

From the filtered images, the features were extracted and classified using kNN classifier. Based on the classification results, the seed points were automatically obtained and these points were connected and given as an initial contour for further segmentation. When an automatic initial contour determination procedure was finished, region of the lesion was segmented automatically by utilizing statistical feature based active contour method. The different stages of the segmentation techniques are shown in Fig 2. The seed points would act as initial contour, and the active contour segmentation algorithm segments the lesion region correctly. After segmentation, performance measurement was evaluated for 110 images in terms of Accuracy, Sensitivity, Specificity, Jaccard and Dice Similarity between segmented ROIs and ground truth images with the following expressions.

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

$$\text{Sensitivity} = \frac{TP}{TP + FN} \qquad (1)$$

$$\text{Specificity} = \frac{TN}{TN + FP}$$

$$\text{Jaccard}(JC) = \frac{|A \cap B|}{|A \cup B|}$$

$$\text{Dice Similarity} = \frac{A \cap B}{|A| + |B|}$$

A =Segmented image; B=Ground truth image.

The Comparison of the performance of segmentation for different filters are shown in Table 2. From the table it was observed that the statistical feature based active contour method on the Shearlet filtered images gave high performance when compared with other methods. Average of 86.02% with Jaccard (JC) and 91.27% with Dice Similarity (DC) measure were observed indicates that the Shearlet filtered images could able reduce the misclassification of ROIs and non-ROIs elements.

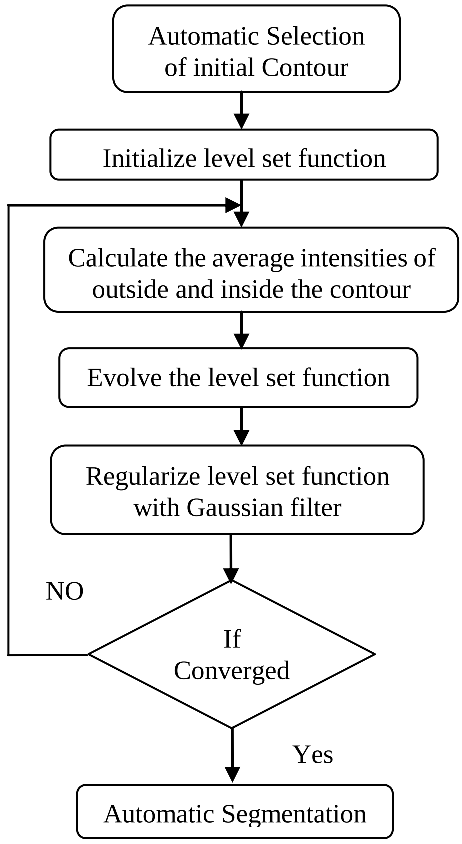

Figure 1 Overview of the proposed active contour method

In this paper developed a method for automatic segmentation of breast lesions from ultrasound images. Here the Shearlet filter is used for speckle reduction, after filtering the seed points were identified automatically, which act as an initial contour and the statistical feature based active contour algorithm segments the lesion region accurately.

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Table 1Comparison of SNR, PSNR & EPI values for various filters with varying noise

Method	SNR		PSNR		EPI	
	μ =0 σ = 0.2	μ =0 σ = 0.4	μ =0 σ = 0.2	μ =0 σ = 0.4	μ =0 σ = 0.2	μ =0 σ = 0.4
Curvelet Filter	12.2014	11.7224	33.1402	32.6118	0.3286	0.3126
Sherlet Filter	13.1965	12.1357	34.2332	33.5565	0.3548	0.3382

Table 2 Performance comparison of segmentation with different filters

	Input Image	Curvelet Filter	Shearlet Filter
Accuracy (%)	83.78	87.1	**91.51**
Sensitivity (%)	86.34	90.9	**92.24**
Specificity (%)	80.43	84.31	**89.44**
Jaccard Index (%)	81.82	84.37	**85.02**
Dice Similarity (%)	82.57	86.59	**91.27**

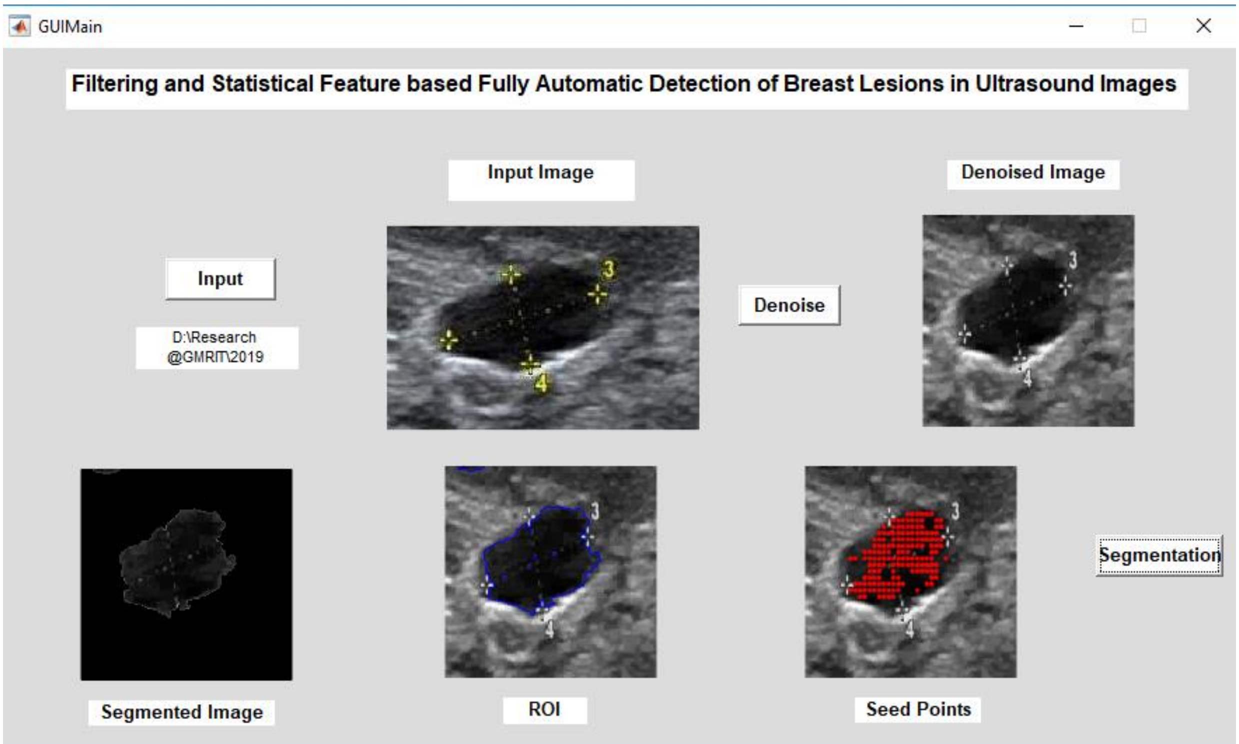

Figure 2 Automatic Segmentation and Classification system for Breast Ultrasound Lesion Image

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IV. CONCLUSION

In this paper, filtering and automated segmentation method was proposed to identify the breast lesions in ultrasound images. The reduction of speckle noise was done by utilizing Curvelet and Shearlet filters. The Shearlet filter gave a high performance with its PSNR as 33.55 dB, SNR as 12.13 dB and EPI 0.3382 for μ is 0.4 as when compared to other filtered images. It reduced the speckle noise while edges were preserved. This methodology was used for segmentation. Then the breast lesions were segmented automatically by using a filtering and statistical feature based automatic segmentation method. This method was implemented on filtered images using different filters like Curvelet, and Shearlet,. The images acted as an input of segmentation in which the contour was initially recognized by statistical features and the region was segmented automatically. The performance analysis was done by comparing the output of the automatic segmentation region algorithm and the ground truth (Segment by radiologist).The Shearlet filtered images gave a high performance with the accuracy of 91.51%, sensitivity of 92.24%, specificity of 89.44 %, Jaccard of 86.02 % and Dice Similarity of 91.27 % when compared to other filtered images and input image. Since the edges were preserved, smoothened and sharpened, this methodology would be useful for accurate detection of breast lesion from ultrasound images.

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