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Rule Based Fuzzy Image Segmentation for the Detection of Breast Cancer from Ultrasound Image

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Abstract*— Early detection of breast cancer is the most important to reduce the number of deaths among women. Computer aided diagnosis plays a vital role in all clinical diagnosis and hence used in the proposed work for detection of breast cancer. To reduce the speckle noise in ultrasound image Median filter, Non Local Means filter and Lee filter was applied for preprocessing. The non-Local means filter had been used as it provides the highest PSNR values. Fuzzy clustering method is applied for the segmentation of the denoised image. After segmenting the image into set of clusters fuzzy level set algorithm is applied for more accurate detection of edges in the tumour region. PSNR value of 35.86dB had been obtained after denoising using Non Local mean filter. The mean, entropy and standard deviation parameters are analyzed for the different cluster size of the benign and malignant image. From the results it had been observed that the cluster size 4 provides better segmentation as it provides almost constant parameters for different images. From the cluster that belongs to the region of interest, fuzzy level set algorithm had been applied for minute edge detection. The segmented image after applying fuzzy level set provides better perception compared to the image without level set. After the segmentation, in the feature extraction, important features such as edge, intensity, contrast and orientation are extracted using Feature-based morphometry approach (FBM). Specifically to extract orientation, the images are scaled at 0o, 45 o, 90 o and 135 o using Gabour filter. The features such as mean, standard deviation and entropy are calculated for all the seven features and the results are compared for more number of benign and malignant images. These extracted features are used for the classification stage. In the classification, 50 ultrasound breast cancer images consist of 14 benign images and 36 malignant images are used. The images are trained by Support Vector Machine using the Generalized Multiple Kernel Learning with the help of regularization 0 and 1. From this training, the maximum accuracy, sensitivity, specificity and BAC obtained as 73, 100, 38 and 69 respectively with regularization 1.

Keywords— centroid, fuzzy, clustering, computer aided diagnosis.

I. INTRODUCTION

Breast cancer is the most widely spreaded cancer among women in the developing world now-a-days. The occurrence of breast cancer is increased in the developing world due to large number of population. There are several techniques to reduce the breast cancer, but those techniques are not sufficient to predict the breast cancer in its early stage. Therefore early detection is the most important one in the breast cancer detection to prevent the women from deaths.

Computer-aided diagnosis (CAD) systems help the radiologists to detect the mass in the cancer and to classify the various types. The classification accuracy in the detection of mass is greatly improved using the CAD system and the knowledge of the experts. A CAD system used for the detection of mass in the ultrasound images consist of four stages: Pre-processing, Segmentation, Feature extraction and classification. The pre-processing, segmentation and some basic features such as entropy, mean and standard deviation for choosing the right cluster for further processing were concentrated in this paper.

- Pre-processing: BUS images are in low contrast due to the presence of speckle noise. Speckle noise is produced in ultrasound images depending on the placement of the ultrasound microphone in the tumour portion of the body. In the pre-processing suppress the high intensities to reduce the noise and enhances the contrast between the tumour and background tissue.
- Segmentation: Segmentation is the process of classification of the pixel to understand the information in the images. Fuzziness is applied in the segmentation process to make the segmentation more accurate. A single BUS image is segmented into number of images with only black and white matter.
- Feature extraction and selection: The features from the segmented image are extracted and it is used for the classification. Here some features are extracted not for the classification purpose. It is actually extracted to understand information in the clustered images.
- Classification: Classification is the process to separate the object into its category belongs based the extracted features.

II. LITERATURE REVIEW

Qinghua Huang et al. [1], presented a robust graph-based segmentation method and an object recognition method that can automatically detect and extract the tumour regions in BUS images. The two versions of Evolving Fuzzy Image Segmentation that one for single parameter outputs and one for multi parameter outputs (SEFIS and MEFIS, respectively) is proposed by Ahmed A. Othman and Hamid R. Tizhoosh [2]. Huang , *et al.* [3], presented graph-based segmentation algorithm overcome the problems of under-segmentation or over-segmentation. Semih Ergin and Onur Kilinc [4], proposed lesion detection utilizing the most contemporary methods. Yi Zhan and Xuming Zhang [5], presented a novel nonlocal means method by weight refining for despeckling the ultrasound images. Shichong Zhoua, *et al.* [6], presented a new texture feature extraction method

based on shearlet transform for characterizing breast tumour in ultrasound image. Wen-Jie Wu and Woo Kyung Moon [7], proposed a CAD system that can classify the benign and malignant tumour in quick and accurate compared to some other techniques. Samy A. Salamah and Umi Kalthum Ngah [8], presented four new clustering algorithms namely the fuzzy k-means (FKM), fuzzy moving k-means (FMKM), adaptive moving k-means (AMKM) and fuzzy adaptive moving k-means (AFMKM) for the segmentation of the images. Y. Guo and Y. Wang,T.Hou [9], proposed a modified NL-means filter to reduce the speckle noise in ultrasound images. Chunming Li and Chenyang Xu [10], proposed a variational level set framework for segmentation and bias correction of images with intensity inhomogeneities. H.D. Chenga,*et al.* [11], reviewed CAD systems for the detection of breast cancer. Different performance evaluation metrics are and also studied the different performance evaluation metrics. Xiangjun Shi and Jiawei Tian [12], proposed a novel Fuzzy Support Vector Machine (FSVM) which can produce a high accuracy rate of mass classification. Chunming Li, et.al [13], presented Distance Regularized Level set Evolution (DRLSE) formulation for accurate computation and stable level set evolution.

III. Pre-Processing

Generally ultrasound medical images contain noises called speckle noises which are removed in the pre-processing stage. Large numbers of filters are there to reduce the speckle noises. The filters such as Median filter, Non Local Means Filter and Lee Filter are used to reduce the speckle noises.

Non Local Means filter

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

Considered a pixel at (x,y) in the noisy image I, the overall filtered image is obtained as[5],

$$\hat{u}(x,y) = \sum_{(p,q)\in\Omega(x,y)} I(p,q)\omega(x,y,p,q)$$

Where $\Omega(x,y)$ is a search window and $\omega(x,y,p,q)$ denotes the weight that give the structure similarity between (p,q) and (x,y).

IV. Proposed Fuzzy Segmentation Method

In general segmentation process, classify the pixel into different groups in a single image itself. But using the fuzzy clustering method, it segments the image into different clusters using fuzzy logic. Fuzzy is the concept which is used to provide the trueness of the information more accurately. So using the fuzzy logic to segment the BUS image is more effective when compared to any other segmentation techniques.

Algorithm

Step 1: Consider an ultrasound image

Step 2: Reduce the speckle noise using Non Local Means Filter

Step 3: Segment the denoised image by considering number of clusters in fuzzy clustering method.

Step 4: To make the segmentation more accurate Fuzzy level set algorithm is applied.

Step 5: Segmented ultrasound breast cancer image is obtained.

A. Fuzzy Clustering Method

In the fuzzy clustering method initially number of cluster is assigned. Based on the number of cluster, membership function is generated. Using that membership function, calculate the centroid for each cluster. After calculating the centroid value, update the membership function and the centroid for every time. Numbers of pixels are grouped to make the cluster. The pixels which are belonging to one cluster may also belong to another cluster in fuzzy logic [2].

Algorithm:

Step 1: Consider the number of clusters.

Step 2: Calculate the membership function according to the number of cluster assumed [15].

$$J = \sum_{n=1}^{K}\sum_{m=1}^{C} \mu_{mn}^{l} \|i_n - v_m\|^2$$

where μ denotes the fuzziness of the pixel which it belongs to cluster and v is the centroid of each cluster.

Step 3: Update the membership function and the centroid of each cluster iteratively [15]

$$\mu_{mn} = \frac{\|i_n - v_m\|^{-2/(l-1)}}{\sum_{k=1}^{C}\|i_n - v_k\|^{-2/(l-1)}}$$

$$v_i = \frac{\sum_{n}^{N} \mu_{mn}^{l} i_n}{\sum_{n=1}^{N} \mu_{mn}^{l}}$$

Step 4: Stop the classification of pixel if the membership function provides the complete possibility of one which belong to a cluster.

B. Fuzzy level set algorithm

The main goal of fuzzy level set algorithm is to make the segmentation more accurate. Fuzzy clustered image is taken as the initial segmented image and then applying the fuzzy level set algorithm.

Initiate the level set function as [10],

$$\phi_0(x,y) = -4\varepsilon(0.5 - B_k)$$

Where ε is a constant regulating the Dirac function and

$$B_k = R_k \geq b_0$$

where b_0 ($\in(0, 1)$) is an adjustable threshold and R_k is the results of fuzzy clustering method.

After initial evolution, consider the pixel at the boundary region are 0, the pixel which present inside the boundary region are negative and the pixel which present outside the boundary region are positive.

For every time it calculates the length and area of the image [13],

$$l = \int_l \delta(\phi_0) dxdy$$

$$\alpha = \int_l H(\phi_0) dxdy$$

Where l and α are the length and area of the image.

A fuzzy level set algorithm provides the membership function to each and every pixel in an image [8].

$$G(R_k) = 1 - 2R_k$$

where G (R_k)($\in$[1, 1]) denotes the matrix with a variable pulling or pushing force at each pixel.

C. FEATURE EXTRACTION PROCESS

It is the most important stage for the classification process. A large number of features makes the classification more accurate. Here some of the important features are considered such as edge, intensity, orientation for 0, 45, 90 and 135 degree, and contrast. From this 7 feature extracting the features such as mean, entropy and standard deviation. So totally 21 features are extracted using various techniques such as sober operator, image enhancement and gabour filter. And all other features such mean, entropy and standard deviation are extracted directly from the featured image.

D. SUPPORT VECTOR MACHINE- CLASSIFICATION

Support vector machines (SVM) can be applied to classification or regression and it uses a supervised learning

A support vector machine gives an extension for the generalized portrait algorithm. The SVM algorithm is based on the learning theory statistically. These features are not directly feed into the support vector machines Generalized Multiple Kernel Learning Method is used to convert the high dimensional values into low dimensional values.

$$\min_{\substack{w,\Gamma \\ s.t. \\ \Gamma \geq 0}} C \sum_{i=1}^{N} max\left(0,1 - y_i g_{W,\Gamma}(f_i)\right) + \|W\|_2^2 + \|\Gamma\|_1$$

where f_i represents a training volume, $y_i \in \{-1,1\}$ represents the label which is the number of training samples, and controls the regularization of the system. The first term in the objective function is a loss function that gives the wrong classification of training samples, the second and the third terms are regularizers of the W and Γ parameters respectively. The important parameters for the system performances are as follows:

a. $Accuracy = \frac{(TP+TN)}{(TP+TN+FP+FN)}$

Where TP – True Positive (Malignant as Malignant)

TN – True Negative (Benign as Benign)

FP – False Positive (Benign as Malignant)

FN – False Negative (Malignant as Benign)

b. $Sensitivity = \frac{(TP)}{(TP+FN)}$

c. $Specificity = \frac{(TN)}{(TN+FP)}$

d. $Balanced\ Accuracy\ (BAC) = \frac{(Sensitivity\ +Specificity\ )}{2}$

V. SIMULATION RESULT AND DISCUSSION FOR THE PROPOSED FUZZY CLUSTERING METHOD AND A FUZZY LEVEL SET ALGORITHM

A. Simulation result for Pre-processing:

Pre-processing is the first stage in the computer aided diagnosis. Filters such as median filter, Non local means filter and Lee filter are applied to the ultrasound breast cancer images and different PSNR values are obtained. Filter which contains highest PSNR value is chosen as the better filter for to reduce the speckle noise in the ultrasound image.

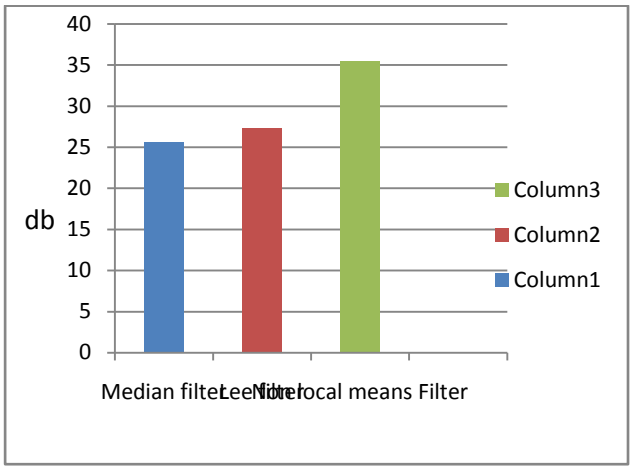
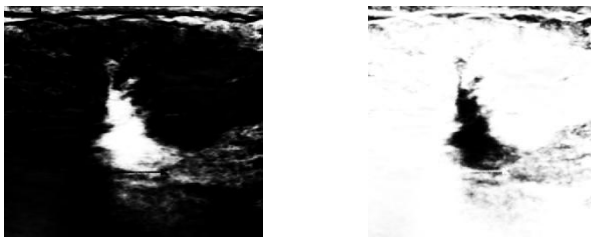


Fig. 1. PSNR Comparison

B. Simulation result for segmentation:

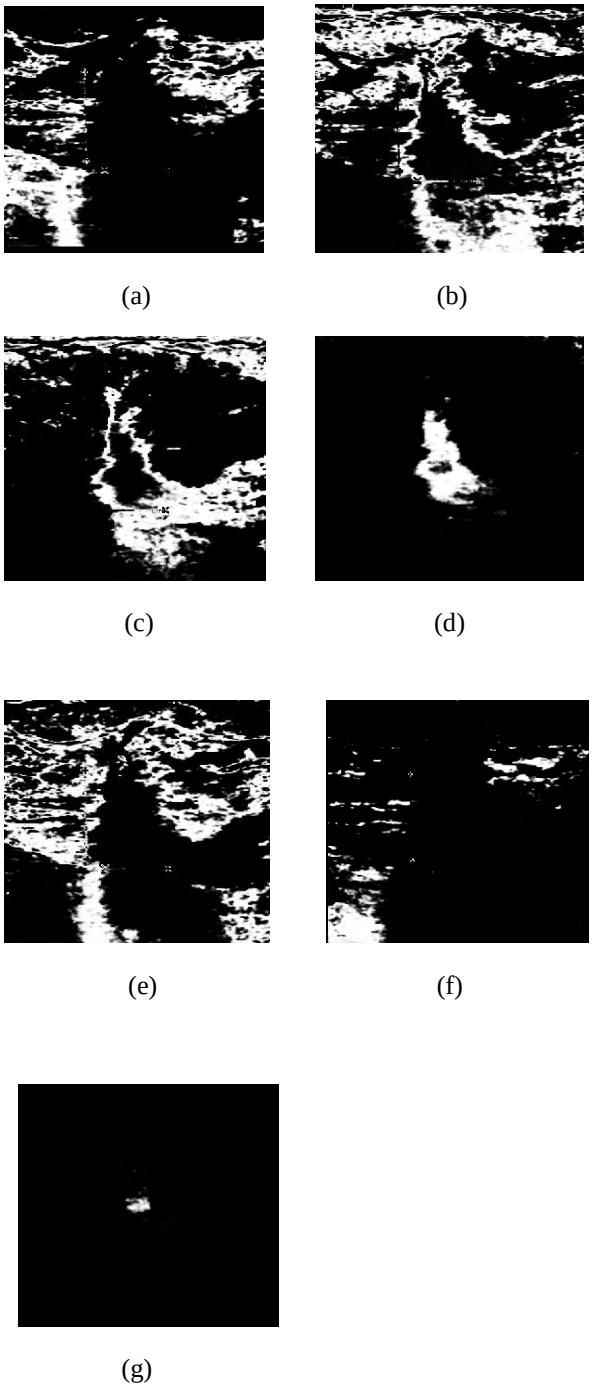
For segmentation a fuzzy clustering method is applied. Images are segmented for different number of clusters.

Number of cluster N=2



(a) (b)

Number of cluster N=7



(a) (b) (c) (d) (e) (f) (g)

Fig. 2. Fuzzy clustered image. (a) for cluster 1, (b) for cluster 2, (c) for cluster 3, (d) for cluster 4, (e) for cluster 5, (f) for cluster 6 and (g) for cluster 7

Above results shows that the fuzzy clustering segment the ultrasound breast cancer image based on the number of cluster assigned. If the cluster is 2, then it segment the image into 2 clustered image. It does not provide any clear information compared with higher order cluster. If the number of cluster get increased, it segment the ultrasound breast cancer image more clear. And at one stage if the cluster is more, then over segmentation takes place. It means using fuzzy logic the pixel which belongs to one cluster may also belong to another cluster.

C. Features extracted for choosing a cluster:

Entropy, mean and standard deviation are the features extracted for 2 benign and 2 malignant images. It clearly observed that cluster 3 gave constant features. So the cluster 3 was chosen for further processing. Here the standard deviation result was given:

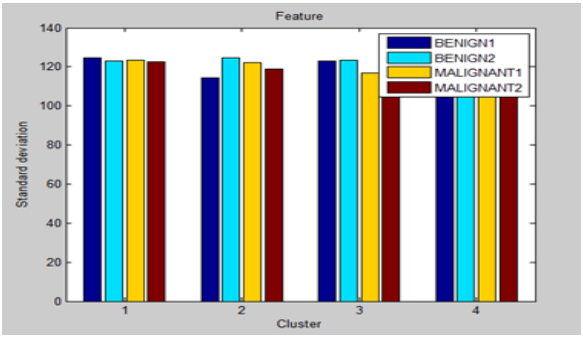
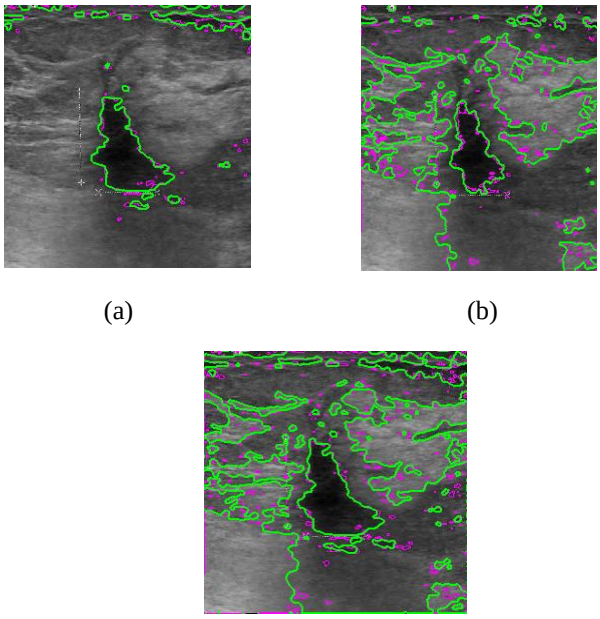


Fig. 3. Standard deviation

D. Simulation result for fuzzy level set algorithm:

A fuzzy level set algorithm is applied to any one of the clustered image to make the segmentation more accurate.



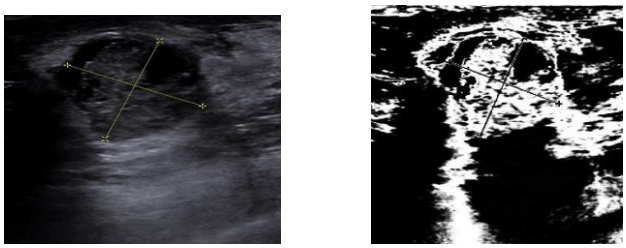
(a) (b) (c)

Fig. 4. Fuzzy level set method, (a) for N=2, (b) for N=3 and (c) for N=3.

It considered the fuzzy clustered image as the initial stage to make the segmentation more accurate. Pixel which were belong inside the initial level is considered as negative and pixel which were belong outside the initial level is considered as positive. Here fuzzy level set algorithm is applied for different number of clusters. If the cluster get increased it shows the clear segmentation.

E. Simulation result for the feature extraction

Features are extracted such as edge, intensity, orientation (0, 45, 90 and 135 degree) and contrast. Also the features mean, entropy and standard deviation for the above features are extracted. So totally 21 features were extracted for the single ultrasound image.

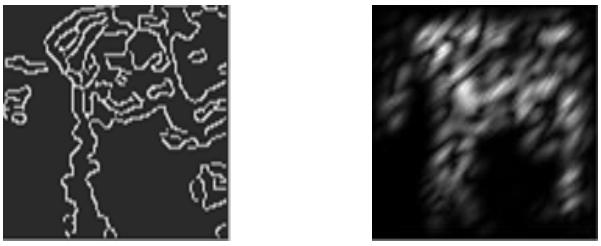


(a) (b)

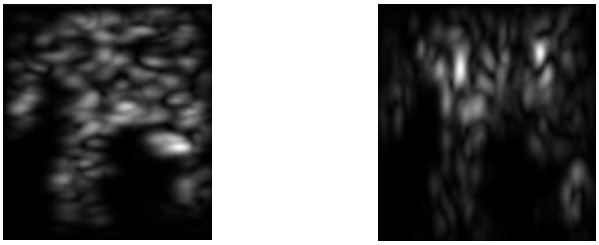
Fig. 5. (a) Original image (b) Segmented image

Fig 5 (a) shows the original ultrasound breast cancer image and (b) shows the segmented image using fuzzy clustering method.

(a) (b)



(c) (d)



(e) (f)

(g)

The above result shows the output results for the extracted features. Figure a,b,c,d,e,f and g is edge, intensity, orientation with 0 degree, orientation with 45 degree, orientation with 90 degree, orientation with 135 degree and contrast respectively. In which edge is detected using Sobel operator, intensity is extracted with image enhancement technique, orientation of the breast cancer image is extracted using Gabour filter and contrast is also extracted using image enhancement technique.

F. Simulation Results for Classification using SVM

Images	Regularization	Accuracy	Sensitivity	Specificity	BAC
10	0	40	38	63	51
	1	45	38	67	53
20	0	50	50	60	55
	1	50	50	60	55
30	0	54	47	63	55
	1	57	62	53	58
40	0	64	85	47	66
	1	62	95	35	67
50	0	65	84	43	64
	1	73	100	38	69

Fig. 6. Tabulation for accuracy, sensitivity, specificity and BAC

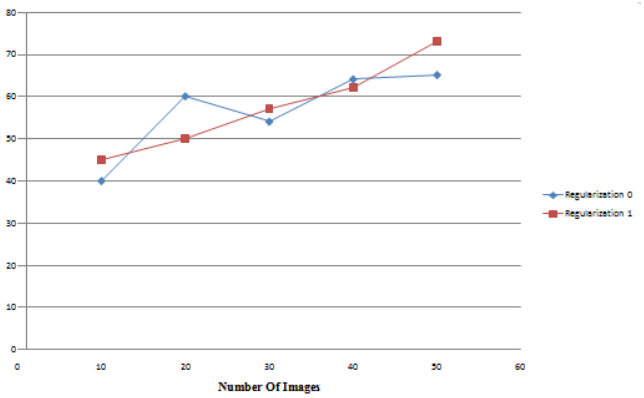


Fig. 7. Accuracy with regularization 0 and 1

Figure 7 shows the accuracy for various group of images with regularization 0 and regularization 1. Accuracy gets increased when the number of images increased.

VI. Conclusion

Computer aided diagnosis is the technique used to detect the breast cancer in its early stage. For pre-processing, it is necessary to reduce the speckle noise in the ultrasound image. Filters such as median filter, non-local means filter and Lee filter is applied. Based on the PSNR value, choose the better filter to suppress the high intensities in the ultrasound image. The PSNR values which are obtained from the simulation results are 25.33, 35.85 and 28.62 for Median filter, Non Local Means filter and Lee filter respectively. Non Local means filter with highest PSNR valve is chosen as the better filter compared other filters applied. After pre-processing, fuzzy clustering method is used to segment the ultrasound image into number of clusters. Due to the problem of under segmentation and over segmentation, a

proper cluster is chosen. To make the segmentation more accurate, a fuzzy level set algorithm is applied.

REFERENCES

[1] Qinghua Huang, Feibin Yang, Longzhong Liu, Xuelong Li, "Automatic segmentation of breast lesions for interaction in ultrasonic computer-aided diagnosis", Journal of Information Sciences, Vol. 52, pp. 832-838, January 2014.

[2] Ahmed A. Othman and Hamid R. Tizhoosh, "EFIS—Evolving Fuzzy Image Segmentation", IEEE Transactions on Fuzzy Systems, Vol. 22, pp.72-83, February 2014.

[3] Qinghua Huang, Xiao Bai, Yingguang Li, Lianwen Jin and Xuelong Li, "Optimized graph-based segmentation for ultrasound images", Journal of Neurocomputing, Vol. 129, pp.216–224, Sep 2014.

[4] Semih Ergin and Onur Kilinc, "A new feature extraction framework based on wavelets for breast cancer diagnosis", Journal of Computers in Biology and Medicine, Vol.51, pp.171–182, May 2014.

[5] Yi Zhan, Mingyue Ding, Liangxia Wu and Xuming Zhang, "Nonlocal means method using weight refining for despeckling of ultrasound images", Journal of Signal Processing,Vol.103, pp.201–213, January 2014.

[6] Shichong Zhou, Jun Shi, Jie Zhu, Yin Cai and Ruiling Wang, "Shearlet-based texture feature extraction for classification of breast tumor in ultrasound image", Journal of Biomedical Signal Processing and Control, Vol.8, pp.688 – 696, June 2013.

[7] Wen-Jie Wua, Shih-Wei Lin and Woo Kyung Moonb, "Combining support vector machine with genetic algorithm to classify ultrasound breast tumor images", Journal of Computerized Medical Imaging and Graphics , Vol. 36, pp.627– 633, July 2013.

[8] Samy A. Salamah and Umi Kalthum Ngah, "Adaptive Fuzzy Moving K-means Clustering Algorithm for Image Segmentation", IEEE Transaction on Fuzzy System, Vol.103, pp.201–213, January 2012.

[9] Y.Guo,Y.Wang and T.Hou, "Speckle filtering of ultrasonic images using a modified non local-based algorithm", Journal of Biomedical Signal Processing and Control, Vol.6, pp.129–138, November 2012.

[10] Chunming Li, Rui Huang, Zhaohua Ding, J. Chris Gatenby, "A Level Set Method for Image Segmentation in the Presence of Intensity Inhomogeneities With Application to MRI", IEEE Transactions on Image Processing, Vol. 20, pp.2007-2016, July 2012.

[11] H.D. Chenga, Juan Shan, Wen Ju, Yan hui Guo and Ling Zhang, "Automated breast cancer detection and classification using ultrasound images: A survey", Journal of Pattern Recognition, Vol. 43, pp.299 – 317, August 2011.

[12] Xiangjun Shi, H.D. Cheng, Liming Hu,WenJu and Jiawei Tian, "Detection and classification of masses in breast ultrasound images", Journal of Digital Signal Processing, Vol. 20, pp.824–836, October 2011.

[13] Chunming Li and Chenyang Xu, "Distance Regularized Level Set Evolution and Its Application to Image Segmentation", IEEE Transactions On Image Processing, Vol. 19, pp. 278-283, December 2011.