Fuzzy C-means Clustering Technique For Cancer Detection In Ultrasound Images

Alamelumangai.N[1], DeviShree.J[2]

ABSTRACT

Detecting tumor areas in breast Ultrasound (US) images is a challenging task. The occurrence of benign areas in breast may result in false identification of malignant areas which may have serious outcome. The CAD system can act as a major function in the early detection of breast cancer and can decrease the death rate among women with breast cancer. This challenge is especially daunting in non homogenous noisy US Images where benign and malignant images are difficult to identify. The US images possess speckle noise which is its inherent property. This study is an attempt to reduce false alarm in Breast cancer detection using computationally efficient fuzzy based image clustering. The images are obtained from the famous American Cancer database for conducting experiments.

Keywords: Cancer detection, Speckle noise, Fuzzy C-Means with repulsion, Ultrasound images

I INTRODUCTION

Fuzzy logic is one of the powerful soft computing tools to overcome ambiguity in the ultrasound image data [1], [2] and [3].These imperfections could possibly relate with image during image capture or while transmission phase. Presence of speckle noise is one of the major imperfections linked with the US image and it may hamper the performance of CAD diagnostic tools. Fuzzy based image segmentation could be used to identify important pattern in noisy breast US images. It can be categorized into following classes: fuzzy clustering, fuzzy rule, fuzzy geometry, fuzzy thresholding and fuzzy integral based clustering techniques [4] [5].

In this study we have performed image clustering using Fuzzy C-means (FCM) algorithm [8] [13] in Ultrasound images which have the property of speckle noise. The motivation of this study is to devise a better diagnostic imaging for breast cancer detection.

Ultrasound imaging systems may introduce some amounts of speckle noise or artifacts in the signal, so the quality assessment is an important factor. Therefore, a matrix based image quality assessments method MSE and PSNR are used to assess the quality of these images.

Mean Square Error (MSE) - Mean Square Error assesses the quality of image based on variation and its un-biasedness. MSE is given by the mean square distance between the pixels of the original image A_{ij} and the pixels in the reconstructed image B_{ij}. It is given as:

$$MSE = \sum_{i=1}^{x}\sum_{j=1}^{y}\frac{\left(\left|A_{ij} - B_{ij}\right|\right)^2}{x \times y} \quad (1)$$

Peak Signal to Noise Ratio (PSNR) - Peak Signal to Noise Ratio is used to analyze the quality of the two images – original and reconstructed image after the de-noising process. Mathematically PSNR is represented as:

$$PSNR = 10 \log \times \left(\frac{255^2}{MSE}\right) \quad (2)$$

[1]Assistant Professor, Department of MCA, Karpagam College of Engineering, Coimbatore, India. Email: alamelumangai.n@gmail.com

[2] Assistant Professor (SG), Department of EEE, Coimbatore Institute of Technology, Coimbatore, India.

The outline of the paper is as follows: A brief discussion of Fuzzy C-Means based clustering technique is presented in Section-II. Section-III discusses the methodology used for US image clustering. Section-IV presents the experiments and results. The paper is concluded with Section-V with future implementations.

II. Fuzzy C-Means (FCM) Based Clustering Technique

The Fuzzy Filters are non-liner filters used to preserve the details in an image. Fuzzy Filters was proposed by Dunn [8] and refined by Bezdek [7] [12] [14] and others. The fuzzy inference model is composed of a group of logic connectors and IF-THEN statements. The outputs of the filters depend on the defuzzifying process, which is a combination of the effects of the established rules [5].

Fuzzy C-Means (FCM) Algorithm has been an admired choice for pattern recognition using clustering. In fuzzy clustering, each point has a degree of belonging to clusters. Thus, points on the edge of a cluster may be in the cluster to a lesser degree than points in the center of cluster. Any point x has a set of coefficients giving the degree of being in the k^{th} cluster $w_k(x)$. With fuzzy c-means, the centroid of a cluster is the mean of all points, weighted by their degree of belonging to the cluster:

$$C_k = \frac{\sum_x w_k(x)x}{\sum_x w_k(x)} \qquad (3)$$

The degree of belonging, $w_k(x)$, is related inversely to the distance from x to the cluster center as calculated on the previous pass. It also depends on a parameter m that controls how much weight is given to the closest centre.

III. Methodology

The proposed methodology describes fuzzy c-means clustering of breast malignant areas in noisy US images with the following steps.

First we synthesis breast image by inducing speckle noise across the breast image [6].

To maintain the consistency among different images Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) is used as metrics.

Fuzzy C-Means clustering [16], [14] is performed on the images obtained in step i of this algorithm. Compare with the original image the noise induced image as in fig.4 and fig.5 to indentify the tumor cells.

Evolutionary Neuro-Fuzzy techniques used to de-noise the images. Repulsive C-Means Fuzzy clustering is again performed on these images obtain after step iv.

Compare with original image [11], the results are as in fig.5 which show a significant improvement in clustering process.

IV. Experiments And Results

The experiment is simulated using Matlab7.5 [18] and the performance of the proposed method is evaluated using 255 X 255 grayscale images [17] with prominent malignant areas. The region of interest (ROI) is the identification of tumor. The effect of increasing noise level on the quality of the image is shown in Table1. MSE is the mean square error between the original and noisy image and original and de-noised image. The improvement in PSNR in the experiments is shown in Table 2. It is inversely related with the MSE. PSNR is the peak signal to noise ratio between the original and noisy image and the original and de- noised image.

Table 1. Standard Deviations (STD) in terms of Mean Square Error (MSE)

σ (Standard Deviation)	MSE (Original and Noisy Image)	MSE (Original and De-Noised Image)
0.010	0.5100	0.4854
0.015	0.4819	0.4623
0.020	0.4726	0.4452
0.025	0.4999	0.4926
0.030	0.4996	0.5014

Table 2. Standard Deviations (STD) in terms of Peak Signal to Noise Ratio (PNSR)

σ (Standard Deviation)	PSNR (Original and Noisy Image)	PSNR (Original and De-Noised Image)
0.010	51.0551	51.2698
0.015	51.3012	51.4816
0.020	51.3859	51.6453
0.025	51.1420	51.2059
0.030	51.1446	51.1290

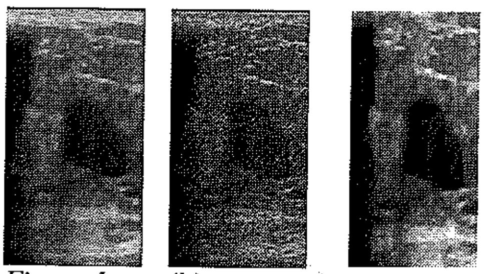


Figure 1. (a) *Original US Image*; (b) *Original image corrupted with noise at σ= 0.015*; (c) *De-noised image using Proposed Method*

Figure 1(b) demonstrates suppression of homogenous noise at σ= 0.015. Figure 1(c) shows the affect of Noise Reduction using Evolutionary ANFIS technique as the presence of speckle noise can hinder the detection of malignant areas.

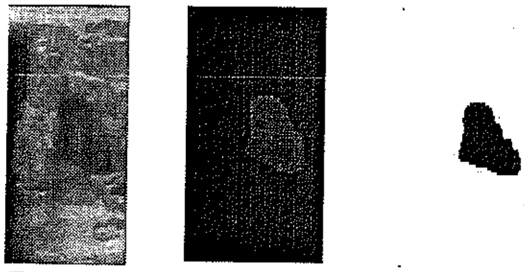


Figure 2. a) Original US image; *b) Standard FCM with For classification*; *c) ROI detection*

Figure 2(b) shows the image clustering using Standard Fuzzy C-Means Clustering applied on Original image. In Figure 2 (c) shows how Standard FCM can be used for finding the region of interest (ROI).

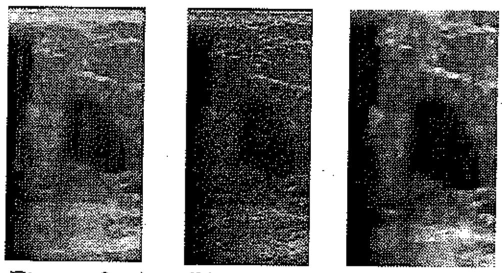
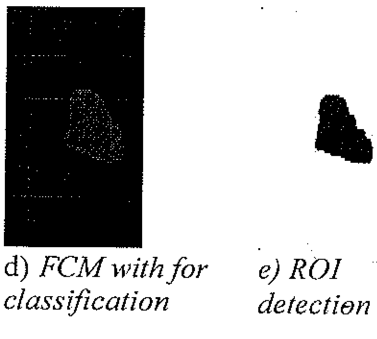


Figure 3. a) Original US image; (b) *Original image corrupted with noise at σ= 0.015*; (c) *De-noised image using Proposed Method*



d) *FCM with for classification*; *e) ROI detection*

In Figure 3 (b) original image corrupted with speckle noise at σ= 0.015. The presence of speckle adversely affects the detection of artifacts. The proposed method is applied on the image corrupted with noise as shown in Figure 3.

FCM analysis on various images is shown in Table 3. This analysis broadly divides into three categories: FCM applied on original image, FCM applied on noise induced image [9] and Repulsive FCM applied on de-noised image. FCM analysis is performed by calculation of cluster centers and then the assignment of members to these centers using the Euclidian distance. It is an iterative process and stabilized after certain computations. In the above experiment the iterations stabilize at 15. The execution time is proportionate with the number of clusters. Since we have only one cluster the time taken is 1.005 sec. In Table 3 the clustering results using Repulsive FCM, the impact of speckle noise on the performance of FCM algorithm is shown and the proposed de-noising technique incorporated into the Repulsive FCM algorithm shows a significant improvement in the clustering of the image.

Table 3. Clustering Results

US Image Data	FCM	FCM for Speckle Noise Induced mage	FCM for De-Noised Image
Image 1	904.3	1415.967	1240.65
Image 2	703.4	1216.467	1189.45
Image 3	960.1	1473.367	1266.25
Image 4	503.5	1015.967	1185.05
Image 5	889.8	1400.967	1205.85

V. Conclusion And Future Research

Fuzzy image processing has widely been used in the context of image segmentation and noise reduction [15] [16]. In this study Repulsive FCM [8] [14] Algorithm has been tested on noisy breast US image. Results showed that our technique effectively clusters the breast malignant areas, which could take more computations by conventional clustering methods. The clustering system identifies various important artifacts, such as cyst, tumor and micro calcifications. Patient clinical history together with better detection mechanisms could be beneficial for early diagnosis. Based on our study we have found number of areas for future research including detecting of tiny micro calcification. In future, we can extend FCM class 2 for non- homogenous noisy image to increase the computational complexity and when applied to de-noised image complexity is expected to decrease. Other potential area could be the classification of tumor based on the sharpness of the contours of artifacts.

References

[1] American Cancer Society, Breast Cancer Facts and Figures 2007- 2008, American Cancer Society.

[2] Drukker K., Giger M.L., Vyborny C.J. and Mendelson E. B. 2004. Computerized detection and classification of cancer on breast ultrasound. Academic Radiology. 11(5): 526-535.

[3] Cheng H.D., Cai X., Chen X., Hu L. and Lou X. 2003. Computer-aided detection and classification of micro calcifications in mammograms: a survey. Pattern Recognition. 36(12): 2967-2991.

[4] Fuzzy Image Processing: Introduction in Theory and Applications, Tizhoosh Hamid R 1997.

[5] Zhang L.C., Wong E.M.C., Zhang F. and Zhou J. 2006, Adaptive primitive filtering for medical ultrasound image enhancement. In 3rd IEEE International Symposium on Biomedical Imaging: Nano to Macro pp-916-919.

[6] Shi X., Cheng H.D., Hu L., Ju W. and Tian J. 2010. Detection and classification of masses in breast ultrasound images. Digital Signal Processing. 20(3): 824- 836.

[7] Rashid Hussain, Ahamed Sikander .M and Abdul Rehman Memon "Fuzzy Clustering Based Malignant Areas Detection In Noisy Breast Magnetic Resonant (MR) Images" Int'l Journal of Acad. Research. Vol.3, No.2, March 2011 Part-I.

[8] Li X. and Liu D.C. 2007. Ultrasound image enhancement using dynamic filtering. In 4th International Conference on Image and Graphics. pp. 106-109.

[9] J. C. Dunn "A Fuzzy Relative of the ISODATA Process and Its Use in Detecting Compact Well-Separated Clusters", Journal of Cybernetics vol(3), 1973.

[10] Rafeal Gonzalez and R. Woods: Digital Image Processing, Pearson Education, Inc., 2nd edition (2002).

[11] Deshmukh K.S. and Shinde G.N. 2005. An adaptive color image segmentation. Electronic Letters on Computer Vision and Image Analysis. 5(4): 12-23.

[12] Madabhushi A. and Mètaxas D.N. 2003. Combining low-, high-level and empirical domain knowledge for automated segmentation of ultrasonic breast lesions. IEEE Transactions on Medical Imaging. 22(2): 155-169.

[13] J. C. Bezdek J, Hall L, Clarke L. Review of MR image segmentation using pattern recognition. Medical Physics 1993;20:1033–48.

[14] R. L. Cannon, J. V. Dave, and J. C. Bezdek. Efficient implementation of the fuzzy c-means clustering algorithms. IEEE Transaction on Pattern Analysis and Machine Intelligence PAM8(2):pp-248-255, 1986.

[15] R. L. Cannon, J. V. Dave, and J. C. Pattern Analysis and Machine Intelligence, PAM8(2): 248-255,1986.

[16] Yao Nie Barner, K.E. "The fuzzy transformation and its applications in image processing" April 2006,IEEE Transactions on Image Processing ,Vol: 15 , Issue: 4 Page(s): 910 – 927.

[17] Image Source. http:// www.medicalartsradiology.com/images.

[18] The Mathworks Inc., http:// www.mathworks.com/ products.

Author's Biography

Ms.Alamelumangai.N, is presently working as Assistant Professor in the Department of MCA at Karpagam College of Engineering-Coimbatore. She received her M.Phil from Bharathidasan University in the Year 2008, MCA Degree in the Year 2002, MBA in the Year 2009 and B.Sc(Applied Science-Computer Technology) in the Year 1999 from Bhrathiar University. She is currently pursuing PhD from Anna University- Coimbatore in field of Image Processing and Analysis. And her intrests include Soft Computing and Networks.

Dr. J. Devi Shree, is presently working as Assistant Professor (Senoir Grade) of EEE Department in Coimbatore Institute of Technology- Coimbatore. She received her Ph.D from Anna University-Chennai in the area of Non Conventional Energy under the guidance of Dr.P.Anbalagan in the year 2009, M.E.(Applied Electronics) from Bharathiar University in 1997 and B.E. Degree in Electrical and Electronics Engineering from Coimbatore Institute of Technology the year 1996. She has more than 12 years of experience as an Academician. She has published ten research and technical papers in various National / International Journal and Conferences. Presently she is guiding 10 Research Scholars and is also an active member of IEEE. Her field of interest include Soft Computing and Image Processing.