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Abstract: Detection of number, shape and size of follicles in the ovary can play an important role in diagnosis and monitoring of different diseases like infertility, PCOS (Polycystic Ovarian Syndrome), ovarian cancer etc. Now-a-days the identification of these characteristics of follicles is done manually by radiologists and doctors from the Ultrasound Images of ovaries. Sometimes manual analysis can be tedious and thus may lead to erroneous results. In this paper a method is proposed for automatic segmentation of follicles from Ultrasound Images using the K-means clustering technique.

Keywords: *Follicle Detection, Ultrasound Images, Ovary, Segmentation, K-means clustering.*

1. Introduction

For diagnosis of different diseases like PCOS (Polycystic Ovarian Syndrome), ovarian cancer, infertility etc. in woman body, it is important to determine the ovarian status. Ovary is the reproductive organ of female body. Ova or eggs are produced in ovary. Inside the ovary there are some spherical fluid filled structures which are called follicles. The number of follicles present in the ovary plays an important role in these diagnosis processes [1]. Thus ovary is frequently scanned by ultrasound imaging. Now a days in most of the cases the analysis of these Ultrasound Images are done by medical experts manually, which is sometimes a tedious and error prone job. Thus, there is a need of making the process of detecting number of follicles from ultrasound images automatically, so that the monotonous work of medical experts can be reduced as well as the detection accuracy can be improved.

Many researchers have tried different approaches to automatically segment follicles from ultrasound images such as active contour method [2], edge based method [3], object growing method [4], morphology [5] etc. Still there is lot of scopes to explore in this field of detection of follicles automatically from ultrasound images of ovaries. Thus in this paper another method is proposed in this direction mainly based on the clustering technique called K-means clustering.

Image segmentation can be described as the method of dividing a digital image into different regions such that each region contains pixels which has similar attributes. The resulting images obtained from image segmentation are more meaningful and can be analyzed easily to reach to some decisions. Thus it can be said that the efficiency of image analysis mostly depends on the solidity of image segmentation.

Clustering is the technique where same type of objects is grouped together. These groups are called clusters. Objects of one cluster must have different characteristics than the objects of another cluster. There are several algorithms to accomplish the task of clustering. One of these algorithms is K-means clustering algorithm. Now, these clustering techniques can be used for image segmentation [6] as different pixels of an image has different characteristics and based on those characteristics the pixels can be grouped into several clusters. These clusters of pixels can be viewed as different segments of the image.

2. Data Collection

We have collected 19 ultrasound images of ovaries from two radiology centre i.e. Gama Imaging and Diagnostic Center, Singatala, Malda, West Bengal, India, and Swagat Diagnostic Centre, Dhubri, Assam, India respectively. We asked a radiologist to manually detect the number of follicles in each of these sample ultrasound images. These manually segmented images are considered as ground truth for our experiment. We have tried to propose a method which can automatically predict the number of follicles as segmented by the radiologist manually.

3. Proposed Method

Medical images such as ultrasound image can suffer from low contrast issue [7]. So, for enhancing the contrast of the images histogram equalization is used so that the image quality gets improved.

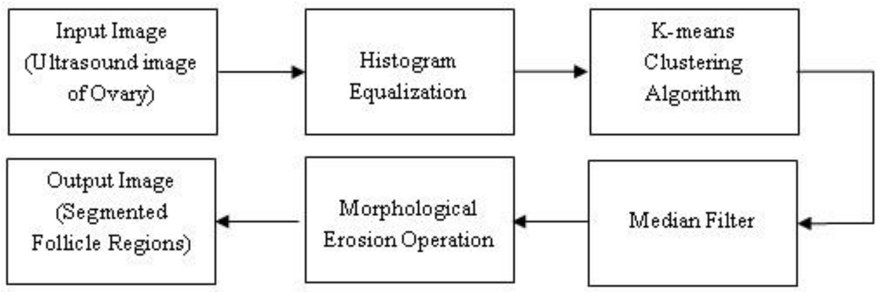

Fig. 1. Flowchart of the Method

K-means clustering algorithm is implemented on the equalized image. Basic working mechanism of k-means clustering is as follows:

Step 1: At first K (number of clusters) points are initialized randomly or based on some heuristics, which are the centers of the clusters and are called as centroids [8]. Let us assume there are X = {x_1, x_2, x_3… x_n} data points and Y = {y_1, y_2….,y_k} are the set of centroids.
Step 2: The Euclidian distance of each data points from K centroids are calculated.
Step 3: Each data point is placed in the cluster from whose centroid it has the minimum distance.
Step 4: After assigning all points, the centroids are updated for each cluster. The new centroids will be the mean of all the points belonging to one cluster. If the ith cluster has q no of data points then the new centroid y_i will be

$$y_i = (1/q)\sum_{j=1}^{q} x_i \tag{1}$$

Step 5: Data points are reassigned based on the distances calculated from the newly obtained centroids.
Step 6: Repeat from step4 until convergence is achieved, i.e. no data points move between clusters and the centroids get stable.

In the proposed method k-means clustering works on the basis of intensity values of pixels. Here initially four cluster centers were chosen, i.e. value of k is 4 and by using the above mentioned method, the centroids were updated until all the data points got stable under one of the four clusters. Thus the total number of pixels was labeled under one of the four clusters (0 to 3). Now, the clustered data points were reshaped into image and we get the segmented image.

On the segmented image median filter is applied as this filter removes any unwanted noise as well preserves the edges of segmented regions. Thus, we get segmented image with smoother edges.

To retain the shape of the segmented follicle regions Morphological Erosion operation is performed. Here convolution operation is performed between the image A and a kernel or structuring element (B). If the resulting image is C, then it is represented as $C = A \ominus B$. The kernel moves over the image, and finds the minimum value from the area where it overlaps the image. Then the value of the pixel which is under the anchor point of the kernel is replaced by that minimum value.

The algorithm for the proposed method is given below:

Step 1: Start

Step 2: Load the ultrasound image to be segmented.

Step 3: Calculate the histogram of the image.

Step 4: The histogram is equalized by removing the pixels having highest and lowest intensity values with cutoff percent of 15 and the image is remapped.

Step 5: Reshape the equalized image into 2-dimentional array.

Step 6: K-means clustering algorithm is performed on the array, where number of cluster k is considered as 4.

Step 7: The pixel positions which are labeled under the cluster which specify the follicle regions are extracted and replaced by the intensity value (0), i.e. black. Rest of the pixel is replaced by value (255), i.e. white.

Step 8: The labeled array is reshaped into image.

Step 9: Median filter is applied.

Step 10: Morphological erosion operation performed with a 5x5 structuring element to get the final segmented image.

Step11: Stop.

4. Experimental Results

The proposed procedure is applied on 19 sample ultrasound images. Few of the results are shown below.

Case I: Correct Segmentation

Fig. 2 shows a sample image for which the medical expert manually segmented 3 follicles and our proposed method also segmented 3 follicles.

(a) (b) (c)

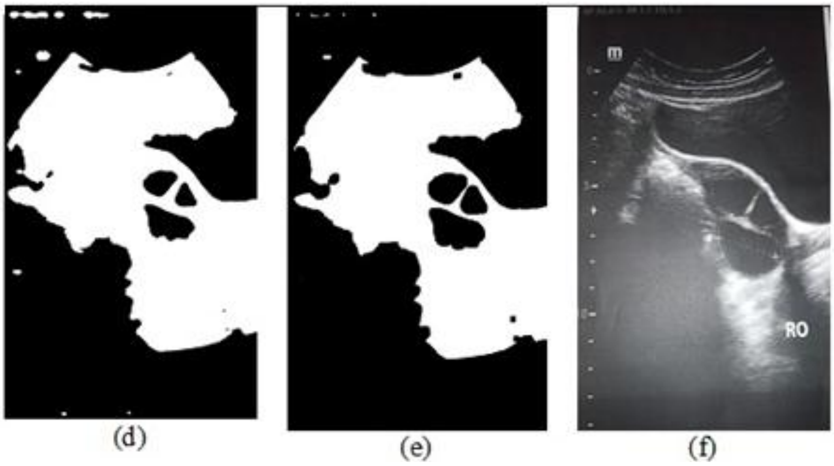

Fig. 2. (a) Sample Image; (b) After performing Histogram Equalization; (c) After performing K-means Clustering; (d) After applying Median Filter; (e) After performing Morphological Erosion; (f) Manually Segmented Image;

Case II: Segmentation with False Rejection

Fig. 3 shows a sample image for which the medical expert manually segmented 5 follicles, but our proposed method is able to segment only 2 follicles. Here 3 regions were not segmented in spite of being follicles.

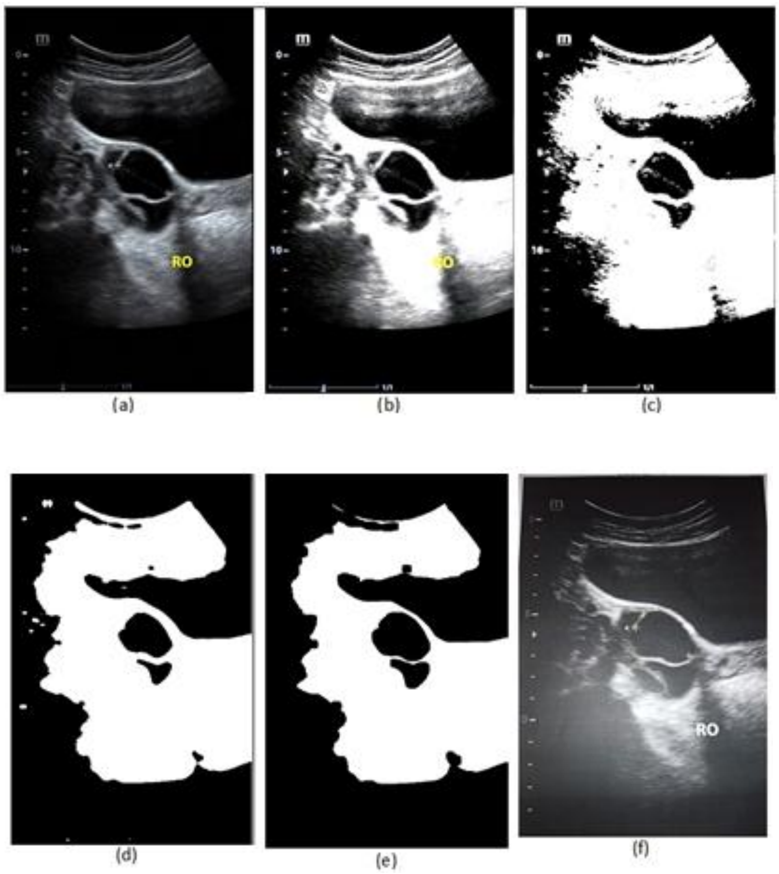

Fig. 3. (a) Sample Image; (b) After performing Histogram Equalization; (c) After performing K-means Clustering; (d) After applying Median Filter; (e) After performing Morphological Erosion; (f) Manually Segmented Image;

Case III: Segmentation with False Acceptance

Fig. 4 shows a sample image for which the medical expert manually segmented 1 follicle, but our proposed method segmented 2 follicles. Here1extra region was segmented which was not follicle originally.

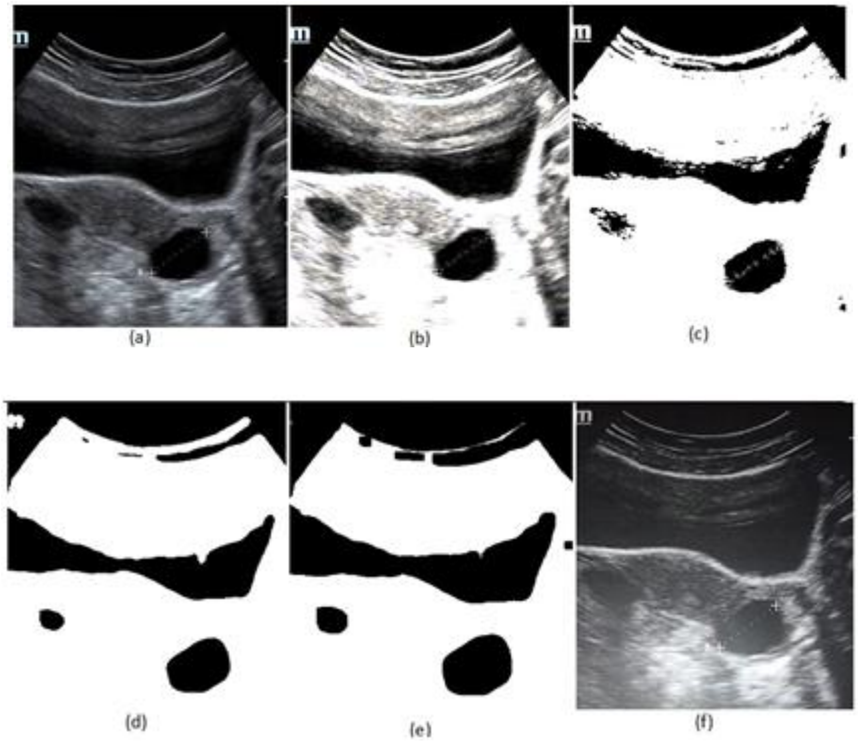

Fig. 4. (a) Sample Image; (b) After performing Histogram Equalization; (c) After performing K-means Clustering; (d) After applying Median Filter; (e) After performing Morphological Erosion; (f) Manually Segmented Image;

Other experimental results are not shown in the pictorial form, but the complete analytical result is depicted in the following section.

5. Performance Evaluation

The proposed method is evaluated on the basis of Type I and Type II error rate. Type I (α) error occurs when the region is not follicle but it is detected as follicle. Type II (β) error occurs when the region is follicle but it is not detected as follicle. For the proposed method the classification rate is 84.61% and the precision is 90.90%. The False Acceptance Rate or Type I Error is 7.69%. The False Rejection Rate or Type II Error is 23.07%. The following table shows the classification results.

No. of Input Images	No. of follicles Detected by Proposed method	No. of follicles Detected by medical expert	Type I Error (α)	Type II Error (β)
19	55	65	5	15

Table 1. Performance evaluation of proposed method

6. Conclusion

The proposed method uses k-means clustering algorithm to automatically segment the follicle regions from the ultrasound images of ovaries. Histogram equalization has been used for Contrast enhancement of the images before applying clustering algorithm. Afterwards morphological operation was applied to make the clustered segments more prominent. Finally Type I and Type II error was calculated to evaluate the performance of the proposed method. From the experimental results we can conclude that the proposed method works well. It seems that the method can contribute to the process of automatic follicle detection from ultrasound images and reduce the burden of manual detection of follicles by the medical experts. Further, the accurate size and shape of the segmented regions can be calculated to extract more information about the follicles so that it can be used to classify different types of ovaries such as normal ovary, cystic ovary and polycystic ovary.

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References

1. O. Rabiu, A. D. Usman, A. M. S. Tekanyi.: A Review on Computer Assisted Follicle Detection Techniques and Polycystic Ovarian Syndrome (PCOS) Diagnostic Systems. International Journal of Computer Trends and Technology (IJCTT) 28(1), 41–45 (October 2015).
2. Hiremath, P. S. and Tegnoor, J. R.: Automatic Detection of Follicles in Ultrasound Images of Ovaries Using Active Contours Method. In the proceedings of IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), 28–29 (2010).
3. Hiremath, P.S. and Jyothi R. Tegnoor.: Automatic Detection of Follicles in Ultrasound Images of Ovaries using Edge Based Method. International Journal of Computer Applications Special Issue on Recent Trends in Image Processing and Pattern Recognition, 15–16 (2010).
4. Yinhui Deng, Yuanyuan Wang and Yuzhong Shen.: An Automated Diagnostic System of Polycystic Ovary Syndrome based on Object Growing. Journal of Artificial Intelligence in Medicine 51(3) 199–209 (2011).
5. Lawrence, M. J., Eramian, M. G., Pierson, R. A. and Neufeld, E.: Computer Assisted Detection of Polycystic Ovary Morphology in Ultrasound Images. Fourth IEEE Canadian Conference on Computer and Robot Vision (CRV), 7, 105–112 (2007).
6. Aarti M. Parekh, Prof. Nidhi B. Shah, M.E Student.: Comparative Study on Ovarian Follicle Detection Using Segmentation Techniques. International Journal of Innovative Research in Computer and Communication Engineering 4(9), 16683–16689 (September 2016).
7. Nameirakpam Dhanachandra, Khumanthem Manglem and Yambem Jina Chanu.: Image Segmentation using K-means Clustering Algorithm and Subtractive Clustering Algorithm. In the Proc. of Eleventh International Multi-Conference on Information Processing-2015 (IMCIP-2015), Elsevier, Procedia Computer Science 54, 764 – 771 (2015).
8. Shehroz S. Khan and Amir Ahmad. Cluster Centre Initialization Algorithm for K-means Cluster, In Pattern Recognition Letters 25(11), 1293–1302 (2004).