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A New Approach for Follicles Detection from Ovarian Images Research on Medical Imaging

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This paper produces an efficient technique to identify the follicles from the ultrasound ovary images. Nowadays, ultrasound imaging technique is widely used as a diagnostic instrument in the medical field. The radiologist suggests the ultrasound examination to the patient who undergoes infertility treatment in order to monitor the follicle growth inside the ovary. The radiologist examines the ultrasound images manually, to obtain the required details for diagnosis. This can leads to error in diagnosis. In this paper, hybridization of modified Particle Swarm Optimization (PSO) with active contour is proposed. The proposed hybrid method is applied on ultrasound images of the ovaries. The proposed method detects the follicles accurately from the ovarian images. The classification is done using the feature details, extracted from the detected follicles. The results are compared with the medical experts given results. The experimental results show the efficacy of the proposed method for ovarian images.

Key words: Radiologist, infertility, threshold, contour, segmentation, ultrasound imaging.

The women's reproductive system has performs numerous process. During the follicular phase[1], the dominant follicle increases the estrogen level which increases the amount of Luteinizing Hormone (LH). Since, the egg covered by the follicles has been released from the ovary. Along with various reasons, the hormonal imbalance is the major cause for sterility. The luteinizing hormone and Follicle Stimulating Hormone (FSH) are exudes by the brain used for the ovulation to occur[2]. In the ovulation stage, the matured follicle releases the egg for reproduction. The hormonal imbalance results in ovulation failure. Nowadays, there are large varieties of imaging modalities are used in the medicinal field. Even though, for accurately evaluating the fitness of the organs for instance, kidney, ovary, uterus and liver, ultrasound imaging technique has been a valuable tool to the medical practitione[3]. The main advantage of ultrasound is known as its non-ionizing nature, low-cost and safety. The women who undertake infertility rehabilitation, the size of the follicles are measured periodically for examination by the radiologist or gynecologist[4]. The exact detail about the follicles is necessary for effective therapy. These days the follicles are monitored in a non-automatic way and these leads to inaccuracy in diagnosis.

The main objective of this paper is to introduce an automatic follicle detection system using the hybridization of modified PSO with active contour method for accurate diagnosis. In the literature, Brijesh Shah *et al*. proposed modified Otsu method for image segmentation[5]. Yinhui Deng *et al*. developed an automatic follicle detection system using region growing algorithm. For region growing algorithm, the initial seed point is given manually by the user[6]. P.S. Hiremath and Jyothi R Tegnoor proposed active contour without edges method for ultrasound ovary image segmentation.

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The performance of the proposed algorithm has been tested on ovary images[7]. Kennedy and Eberhart introduced a well known optimization technique called particle swarm optimization[8,9]. Ratnaweera *et al*. who first proposed the variant of PSO by changing the inertia weight[10]. Sushil kumar *et al*. developed new variant of evolutionary method called MRLDE. The Otsu method is hybridized with the new variant of MRLDE method. This method was applied on different set of sample images[11].

Azadeh Yazdanpanah et.al developed a method using active contour method introduced by Chan Vese for retinal layer segmentation. However, this method needs the user interaction [12]. For segmenting region of interest from the medical images, Chan and Vese developed active contours method. The active contour method used the level set method[13]. The multilevel thresholding method is optimized using particle swarm optimization algorithm. The quantitative evaluation function is taken as a fitness function, this method segment the image into set of regions[14]. Image segmentation, feature extraction and classification are the essential approaches of image processing. GokilaDeepa proposed fuzzy c means (FCM) algorithm for the segmentation of mammogram images. The micro calcification identification is done by FCM with PSO algorithm[15].

The rest of the paper is organized as follows. Section II explains the automatic detection of follicles system. Section III presents the overview of PSO, modified PSO and proposed hybrid method for the segmentation of follicles. The section IV explains the experimental results. Finally, conclusion is described in section V.

METHOD

The ultrasound image of ovary is taken as an input image. The input ultrasound ovary image is a RGB image. For experimentation, the input image is converted into gray scale image. Then, the modified PSO method is used to optimize the threshold value given by the Otsu method. The optimized threshold value is applied on the input image. The output image is given as an input to the active contour method. The initial position for the active contour is chosen manually. In the proposed method, the output of the modified PSO method is taken as an initial mask for active contour method. The proposed hybrid method efficiently segmented the follicles. From the segmented follicles, the features are extracted from the follicles and the follicles are classified as normal and abnormal. The block diagram of the proposed method is shown in Fig. 1.

PSO and modified PSO

The well known swarm intelligence algorithm Particle Swarm Optimization algorithm (PSO) is proposed by Kennedy and Eberhart. The PSO imitates the actions of the bird, searching for the food in the search space. Each and every particle in the population has its own fitness value. The particles look to find the optimal solution from the search space. The velocity and position of the particles is updated using Eq. 1 and Eq. 2. In each iteration, the *PAbest* and *GLbest* values are obtained, based on this value the distance of the particle from the optimal solution is obtained. The variables in the Eq. 1 and Eq.2 are represented here.

$$E_{j,m}^{g+1} = w_0 E_{j,m}^{g} + \lambda_1 r_{a1}.(PA_{best\,j,m} - PA_{j,m}^{g}) + \lambda_2 r_{a2}.(GL_{best\,j,m} - PA_{j,m}^{g}) \quad ...(1)$$

$$PA_{j,m}^{g+1} = PA_{j,m}^{g} + E_{j,m}^{g+1} \quad ...(2)$$

where $E_{j,m}^{g}$ stores the earlier velocity and which is known as momentum component, $PA_{j,m}^{g}$ is

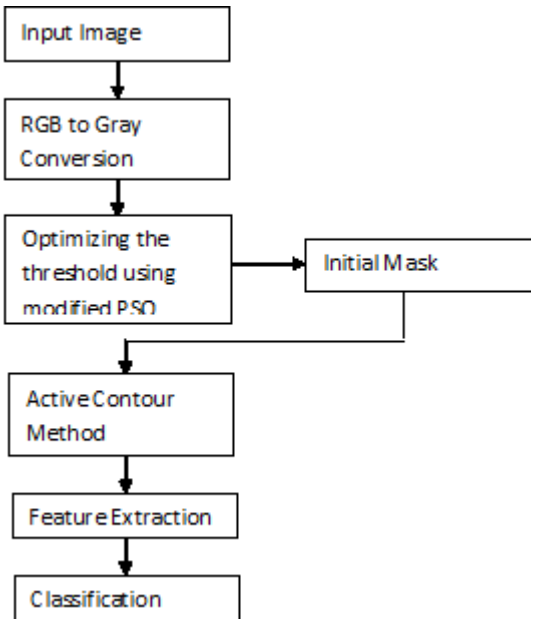

Fig.1. Block diagram of the proposed method

the position of the particle. The variable g represents the current iteration, m is the search space and w_0 is the inertia. The results of acceleration coefficient and the inertia are observed. The parameter w_0 can be set as constant value or time varying. $\ddot{e}_1$ and $\ddot{e}_2$ are the acceleration coefficients and these parameters values are set as constant in the conventional PSO method. The r_{a1} and r_{a2} are random values, always in the range of 0 to 1. In the standard PSO, the acceleration coefficients values are set as constant. The values of acceleration coefficients are tuned and chosen carefully in the modified PSO method. The equation of the tuning of cognitive and social component is given in Eq. 3 and Eq. 4.

$$E_{i,m}^{g+1} = w_e E_{i,m}^{g} + P_1 r_{a1}(PAbest_{i,m} - PA_{i,m}^{g}) + P_2 r_{a2}(GLbest_{i,m} - PA_{i,m}^{g}) \quad ...(3)$$

$$P_1 = (P_{1ss} - P_{1kk}) * \frac{1}{itr_{\max}} + P_{1kk}$$

$$P_2 = (P_{2ss} - P_{2kk}) * \frac{1}{itr_{\max}} + P_{2kk} \quad ...(4)$$

where P_{1ss}, P_{1kk}, P_{2ss}, *and* P_{2kk} are constants and $itr_{\max}$ is the maximum number of iterations. The value for $P_{1ss,}$ P_{2ss} are set as 0.6 and $P_{1kk,}$ P_{2kk} are set as 2.60 in this paper.

Proposed method

To extract the follicles from the ultrasound images of ovaries, the Otsu method is applied to calculate the threshold value. The threshold value is optimally finds by using the modified PSO method. Now, the resultant image is taken as an initial mask to the active contour method. The exact placing of initial contour gives the accurate segmented result. But, manually doing this process is a difficult task. In this paper, the initial mask is taken from the result of modified PSO method. In active contour method[16] initial contour can be placed in the image anywhere and this contour initialization is a difficult task. Poor initialization can produce the contour away from the follicle region. Analogy to this, the Level Set method[17-19] uses manual initialization of contour for segmentation. Thus, this paper segments the follicles from the image by hybridizing the active contour method with modified PSO method.

Here, the proposed hybrid method detects the follicles automatically, without the human interaction. The results obtained from the proposed modified Otsu method[20] is set as the initial mask. The initial mask for the active contour method is obtained from the modified PSO method and is shown in Fig. 2(b). The number of iteration is chosen as 50.The active contour method identifies the follicles in its 389th iteration. Since, initial mask is placed manually. However, the proposed hybrid method identifies the follicles in its 43rd iteration itself. Also, the proposed method accurately identifies the exact number of follicles.

Feature Extraction

The features of the follicles segmented by proposed hybrid method are measured. The objective of feature extraction is to extract representative information which is useful for infertility treatment[21]. The shape based features Area, Perimeter, Eccentricity, Major axis and Minor axis, Circularity, Extent, Tortuosity are extracted from ultrasound images of ovary. Based on the size of the follicles the classification is done.

Area

Area of a follicle in an ovary image is computed as the number of pixels inside the segmented follicle. This defines the size of the follicle.

Perimeter

The perimeter is the overall length of the follicle boundary which is calculated by the distance among each neighboring pair of pixels around the edge of the follicle region.

Eccentricity

It is calculated by approximating the follicle to be an ellipse and taking the ratio of the distance between the foci of the ellipse and its major axis length.

Major axis & Minor axis

Longest diameter of the follicle is taken as major axis and shortest diameter of the follicle is taken as minor axis.

Extent

Extent is a scalar quantity that is given by dividing the number of pixels in the follicle region to pixels in the total bounding space. The extent of a follicle varies from 0.2 to 0.7.

Circularity

Circularity is a two-dimensional metric that indicates how much the follicle can deviate from a perfect circle. The circularity of a follicle lies in the range of 0.2 to 0.8.

Tortuosity

Tortuosity of the follicle is calculated by taking the ratio of the longest diameter which is major axis length of the follicle to perimeter. The tortuosity of a follicle varies from 0.1 to 0.4.

RESULTS AND DISCUSSION

The proposed hybrid method is evaluated by applying it on 45 ultrasound ovarian images. The images used for experimentation are collected from scan centers in Coimbatore. The testing have been performed on Hp Pavilion dv5 with Intel® Core™ 2 Duo CPU @ 2.00GHz with 3 GB RAM running on Microsoft Windows 7 platform.

The Matlab 2012a software is used to develop the proposed hybrid method. The parameter values of modified PSO method is given in Table 1. The parameter values are chosen with care. The input ultrasound ovarian image is shown in Fig. 2(a). The modified PSO finds the optimal threshold value. The obtained threshold value is applied on input image and the result is shown in Fig. 2(b). The initial mask for the active contour method is seen in Fig. 2(b). Fig. 2(c) shows the result of the proposed hybrid method. The proposed hybrid method accurately extracts the follicle from the image. Fig. 2(d) represents the edge detected image. The extracted follicle is overlaid on input image which is shown in Fig 2(e) and the manual expert result is seen in Fig. 2(f). The proposed hybrid method results have been exactly match with the medical expert results. The radiologist measures the size of the follicles for infertility treatment. The size of the follicles is extracted from the segmented follicle. For calculate the size of the follicles, Area is measured. The Area of the follicle shown in Fig 2(c) is 3999. The Extent value is 0.5610, the measured Circularity value is 0.5183 and the Tortuosity value is measure as 0.3104. In this paper, the Support Vector Machine (SVM) is a linear classifier which is used to classify the follicles into normal and abnormal. The sample test image results are given in Fig. 3. The

Table 1. Parameter values of modified PSO

Parameters	Parameters value
Population	100
Iteration	100
w_e	0.8
P_{1ss}, P_{2ss}	0.5
P_{1kk}, P_{2kk}	2.65

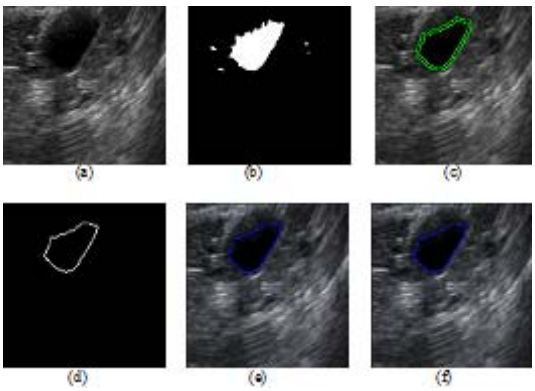

Fig. 2. Follicles Detection: a) Original Image b) Segmentation result by modified PSO method c) Segmentation result by proposed hybrid method d) Edge detected result e) Overlaid on original image f) Follicles cyst detection by medical expert.

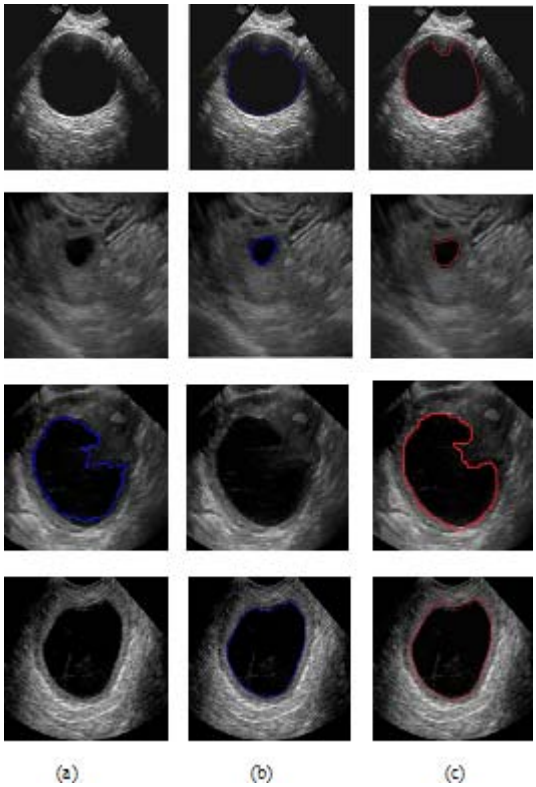

Fig.3. a) Original image. b) Segmented result by proposed hybrid method. c) Medical expert results.

experimental results proved that the proposed hybrid method produces the better results than the existing method. Moreover, this automatic method has been helpful to the radiologist and gynecologist for the accurate and fast extraction of follicle for diagnosis.

CONCLUSION

In this paper, an efficient automatic follicle identification method is presented to extract the follicles from the ultrasound ovary images with the proposed hybrid method. The ultrasound image of ovaries contains more soft tissues, extracting the follicle from the complex background leads to error diagnosis. The proposed hybrid method efficiently extracts the follicles. From the results, it is to be observed that the proposed hybrid method performs better than the other existing algorithm. Moreover, the results satisfied the medical expert result. Hence, this automatic detection method can detect the follicles accurately and extract their features correctly. This method will be useful for the radiologist to diagnose the patient who undertakes infertility treatment.

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