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Computer Aided System For Segmenting Region Of Interest In Medical Images Using Optimization Algorithm

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Abstract
The tumour is an abnormal growth of tissues which should be diagnosed and treated properly at earlier stages. The objective of this research is to provide an efficient mechanism to segment lesion in brain, breast or any part of the body and classify normal and abnormal tissues growth. In this research, the cuckoo search algorithm is used to segment the medical images. The objective of the cuckoo search algorithm is to maximize the between class variance of the Otsu method. The proposed algorithm is used to find the optimal threshold value and they are used to achieve the best solution from the initial random threshold values. The local optimum trapping can be overcome using this optimization algorithm. The performance of the proposed research work is compared with the existing segmentation methods such as Otsu method, and FODPSO. GLCM (Gray level Cooccurence Matrix) and shape based features are extracted from the segmented output. The obtained values are taken for SVM (Support Vector Machine) classification. The values obtained from the feature extraction are used to train and predict the lesion in the medical images. The ROC curve is plotted from the results. From the classification results, it is to be identified that the proposed method produces efficient results than the existing algorithms.

Keywords— FODPSO; cuckoo search; segmentation; optimization; medical image.

I. INTRODUCTION

Presently, there are many researches going on the medical field for finding a drug to cure cancer, because it is a serious issue, as it causes death once it affects the host. At present, cancer is detected in the early stages, it can be rectified and the life span of the host can be increased from his deadline. Cancer occurs due to the rapid growth and multiplication of infected cells. Once, the growth of tissues has been identified it should be properly diagnosed and treated. There are different types of tumour, but all the tumours are not cancerous, some tumours may present inside the body and malfunctioning the normal activity. Image segmentation is the method of fragmenting the image to give a consequential object. These methods can be applied on medical images, so that the diagnosis process becomes more efficient to the physician. The image segmentation methods are widely used for image processing functions such as classification and object identification. It plays an imperative task in medical image processing for recognizing lesion in MRI/CT scan images.

A tumour is an abnormal growth of tissues may perhaps solid or else fluid. A tumour can be benign malignant, otherwise pre-malignant. Based on the tumours shape and from the structure of tissues, the tumours are classified into many types. The tumours are effectively segmented form medical images using different image segmentation techniques. The segmentation are mainly classified into four discrete types including region based method, thresholding, texture based analysis.

Pedram Ghamisi et al. proposed multilevel image segmentation technique using fractional order particle swarm optimization. The algorithm was applied on remote sensing images and the performance of the algorithm is compared with the other variants of the PSO (Particle Swarm Optimization) [1]. Samy Ait Aoudia et al. introduced medical image segmentation method. Many of the researchers used optimization technique for segmentation purposes [2]. Hao Gao et al. modified the FODPSO technique by introduced quantum behaved particle swarm optimization [3]. Sourav Samantaa et al. presented cuckoo search algorithm to efficiently calculate the threshold for multilevel segmentation [4]. Mohammad Talebi et al. have used genetic active contour method for ultrasound image segmentation [5].

Threshold based segmentation and clustering based segmentation technique is taken into account for segmenting images and optimized for better diagnosis. Otsu method is a familiar threshold based method to segment the image, which is a process of obtaining the optimal threshold value in a grayscale image. This method may be recommended as the most simple and standard one for automatic threshold selection that can be applied to various practical problems. Particle Swarm Optimization is an influential optimization technique enthused by the collective etiquette of bird and fish schooling. This optimization method is based on the

association between individuals. Each individual in the swarm is conscious about the speed and position of its neighbours. Based on the experience, the particles find the solution to the problem. Fractional derivative and calculus are used in PSO to improve the efficiency of the segmentation. So, that the algorithm is commonly known as FODPSO. In this paper, the Cuckoo search algorithm is applied to segment the image by maximizing the objective function. Cuckoo search is one of the optimization for segmenting region of interest in medical images. Cuckoo search is the new method which is implemented for segmenting the medical image. This technique can be implanted because many parameters present in cuckoo are convenient parameter that can be easily optimized, but computational time may vary from other optimization techniques. The proposed algorithm is compared with FODPSO technique. From the segmented output the feature informations are extracted. The extracted features are taken as training and testing parameters for SVM Classifier.

Section II describes the existing segmentation algorithms such as Otsu and FODPSO. Section III presents the proposed segmentation method developed for medical image segmentation and classification. Section IV describes about the results and discussion and finally, the conclusion is deliberated in Section V.

II. SEGMENTATION METHODS

A. *Otsu Method*

Otsu method is a threshold based segmentation method [8]. It is a process of segmenting the image, which converts the grayscale image into binary image by means of threshold. Based upon the threshold, the bi-modal histogram is calculated with the help of occurrence of pixel in the image. From the histogram, the regions are classified. The regions are: Foreground and Background. The foreground region is a set of pixels above the threshold value whereas the background region is a set of pixels below the threshold value. Mean and variances are calculated using the probabilities.

The intra-class variance is divided into two,

- Within-class variance
- Between-class variance

The within-class variance is a sum of variances which are multiplied with their own probabilities which is given by,

$$S_W^2\ i\ = \mathrm{w}_1 s_1^2\ i\ + \mathrm{w}_2 s_2^2\ i \tag{1}$$

The Between-class variances is a square of difference between means which are multiplied with their own probabilities which is given by,

$$S_B^2\ i\ = \mathrm{w}_1\ i\ \mathrm{w}_2\ i\ *\left[m_1\ i\ - \mathrm{m}_2\ i\ \right]^2 \tag{2}$$

Where
w1, w2 are the probabilities of two region
m_1, m_2 are the mean of two regions.
s_1^2, s_2^2 are the variance of two regions.

B. *FODPSO*

Particle Swarm Optimization is a powerful optimization method inspired by the social behaviour of birds. The particles fly through the search space to obtain the optimal solution. Particles are changing their position and velocity to find the better position. The two values, particle best and global best values are identified in each iteration. The convergence of the optimal solution is occurred in any iteration. The Fractional derivative and calculus is introduced in particle swarm optimization.

Each particle a within each different swarms [6] moves in a multidimensional space according to position. Each particle a within each different swarm S moves in a multidimensional space according to position, $(x_a[t]),\mathbb{C}$, and velocity. The position and velocity values are highly dependent on the local best and global best (ga[t]) information.

The coefficients *w*, *ρ1*, and *ρ2* are assigned weights [6], which control the inertial influence, i.e., according to "the globally best" and "the locally best," respectively, when the new velocity is determined. Typically, the inertial influence is set to a value slightly less than 1. *ρ1* and *ρ2* are constant integer values, which represent "cognitive" and "social" components. However, different results can be obtained by assigning different influences for each component. Depending on the application and the characteristics of the problem, tuning these parameters properly will lead to better results. The parameters *r1* and *r2* are random vectors, with each component generally a uniform random number between 0 and 1. The intentisy to multiply a new random component per velocity dimension, rather than multiplying the same component with the velocity dimension of each particle. The flow chart of the FODPSO is shown in Fig 1.

Note that this may be accomplished since the three algorithms require the same initial computation that depends on the size of the image. After that initial setup, the three algorithms may be adjusted in such a way to ensure a similar computational complexity. Likewise, the computational complexity of the three algorithms will increase with the number of desired thresholds n. Nevertheless, while the PSO depends on the number of particles NP within the population, the DPSO and FODPSO depend on the accumulated number of particles within each swarm, i.e., $\forall s NS$. In other words, one may ensure that the computational complexity of both DPSO and FODPSO will be inferior to the PSO by defining the maximum number of particles within each swarm as $Nmax \leq NP/Nsmax$, wherein *Nsmax* represents the maximum number of allowed swarms.

It is, however, noteworthy that one may avoid holding [6] this assumption since the evolutionary features of both DPSO and FODPSO are stochastic and depend on uniformly distributed variables. In other words, by setting an adequate combination between the minimum and maximum acceptable numbers of particles to form a swarm Nmin and Mmax and the minimum and maximum numbers of swarms within the population *Nmin and Nmax*, one may ensure that $O(n \forall s\ NS) \leq O(nNP)$ for a steady-state regime. Such a condition may be achieved by adhering to the following condition: $NP \geq (NsminNmin +$

NsmaxNmax/2).

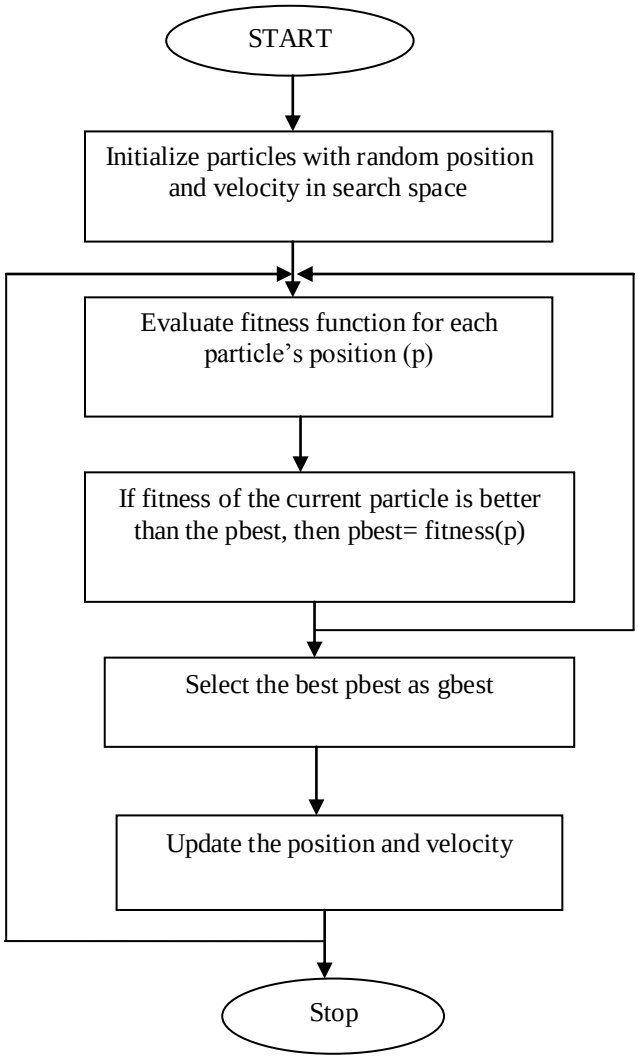


Fig. 1. Flow chart of the FODPSO

III. PROPOSED WORK

The main aim of this research is to detect the tumour regions from the medical images with the help of proposed method. The GLCM features and shape based features of the tumours are extracted. Finally, the classification is done to identify the normal and abnormal images. The block diagram of the proposed method is given in Fig. 2. The input to the proposed method is medical images and the images are segmented using proposed method. The medical images are initially segmented using Otsu method.

For getting the optimal value, the proposed optimization algorithms cuckoo search is applied to optimize the threshold obtained by Otsu method. The performance of the proposed technique is compared with FODPSO. The cuckoo search algorithm efficiently identifies the maximum between class variance than FODPSO. The extracted features are taken for classification using SVM classifier. From the results, the ROC curve has been plotted. Sensitivity and accuracy of the proposed method is identified from classification output.

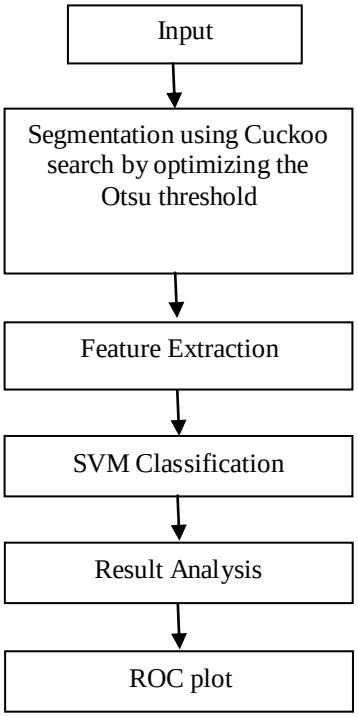


Fig. 2. Block diagram of the proposed method.

A. Cuckoo Search

Cuckoo Search is proportionally a recent algorithm developed by xin-sheyang and suash Deb in the year 2009 [7], which has found to be an efficient for global optimization and also it is a meta heuristic algorithm. It deploys on brood parasitism and enhanced by levy flight, which is more preferred than isotropic random walk. Current studies exhibit that CS is more efficient than FODPSO. Cuckoos are fascinating birds, not only because of the beautiful sounds they can make, but also because of their aggressive reproduction strategy. There are some species like Ani and Guira which lay eggs in join nests, yet they may remove other eggs to improve hatching probability of their own eggs. Quite other species captivate the obligate brood parasitism by laying eggs in the nest of distinct host birds. This procedure is inspired for the cuckoo search algorithm.

Some host birds can engage direct conflict with the intruding cuckoos. If a host bird discovers the eggs are not their owns, they will either throw these alien eggs away or simply abandon its nest and build a new nest elsewhere. This reduces the probability of their eggs being abandoned and thus increases their reproductivity. In addition, the timing of egg-laying of some species is also amazing. Parasitic cuckoos often choose a nest where the host bird just laid its own eggs. In general, the cuckoo eggs hatch slightly earlier than their host eggs. Once the first cuckoo chick is hatched, the first instinct action it will take is to evict the host eggs by blindly propelling the eggs out of the nest, which increases the cuckoo chick's share of food provided by its host bird.

- Rules to be followed in cuckoo search

1. At a time one egg is laid by each cuckoo and abandons its egg in an arbitrarily selected nest.
2. The finest nests with high excellence of eggs will bring

over to the next generation. Using the probability $P_a \in (0,1)$, the egg laid by the cuckoo is determined by host bird. Here, the number of available host's nests is fixed.

3. Discovering operates on some set of worst nests, and discovered solutions dumped from farther calculations.

- ***Pseudocode for cuckoo search***

Objective function: f(x), x= (x1, x2,…., x_d);
Generate an initial population of host nests;
While (t<MaxGeneration) or (stop criterion)
Get a cuckoo randomly (say, i) and replace its solution by performing Lévy flights;
Evaluate its quality/fitness
[For maximization, $F_i \propto f(x_i)$];
Choose a nest among n (say, j) randomly;
if ($F_i > F_j$),
Replace j by the new solution;
end if
A fraction ρ_a of the worse nests are abandoned and new ones are built;
Keep the best solutions/nests;
Rank the solutions/nests and find the current best;
Pass the current best solutions to the next generation;
end while.

B. Implementing medical image segmentation

In this paper, various medical images are taken for experimentation. The fitness function for the proposed work is given in (2). The cuckoo search algorithm identified the optimal threshold value by using (2). From the segmented output features are extracted for further diagnosis. The GLCM is a way of extracting second order statistical texture features. Third and higher order textures consider the relationships among three or more pixels. These are theoretically possible but not commonly implemented due to calculation time and interpretation difficulty.

According to co-occurrence matrix, 23 features can be extracted generally. But 14 features are sufficient enough for images. Based on the medical practitioner suggestions, for this medical image only 5 features are enough to train and predict the tumour. The features extracted from the segmented image are given below,

a) Textural features

Entropy
Energy
Correlation

b) Geometrical features

Area
Perimeter

These extracted features are given to the SVM classification. SVM is trained and classification is carried out.

C. SVM Classification

Support Vector Machine classification is used to classify the normal and abnormal tissues in the scanned images. SVM were introduced by Vladimir Vapnik. SVM are a relatively new learning method used for binary classification. The basic idea is to find a hyperplane which separates the d-dimensional data perfectly into its two classes. Mainly there are two steps involved in SVM classification. They are,

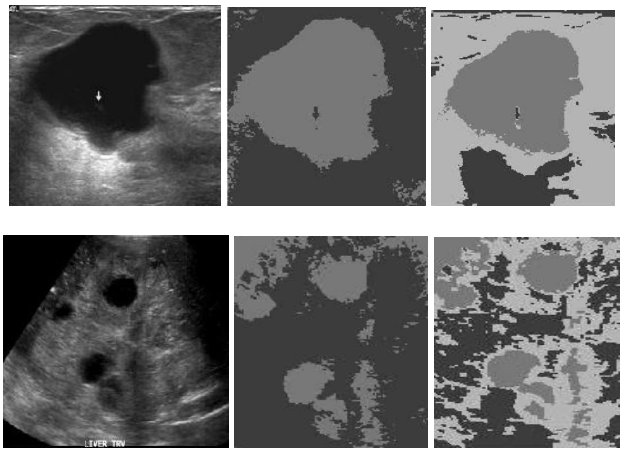
- SVM TRAIN – Values are given from feature extraction
- SVM PREDICT - Predicts values based on a model trained by SVM.

These two steps are carried using the features extracted from the train and test image given to the GLCM feature extraction. It extracts the features to train the algorithm using that trained values and the test images are classified. The values obtained from the GLCM is given as an input to the SVM TRAIN and PREDICT.

IV. RESULTS AND DISCUSSIONS

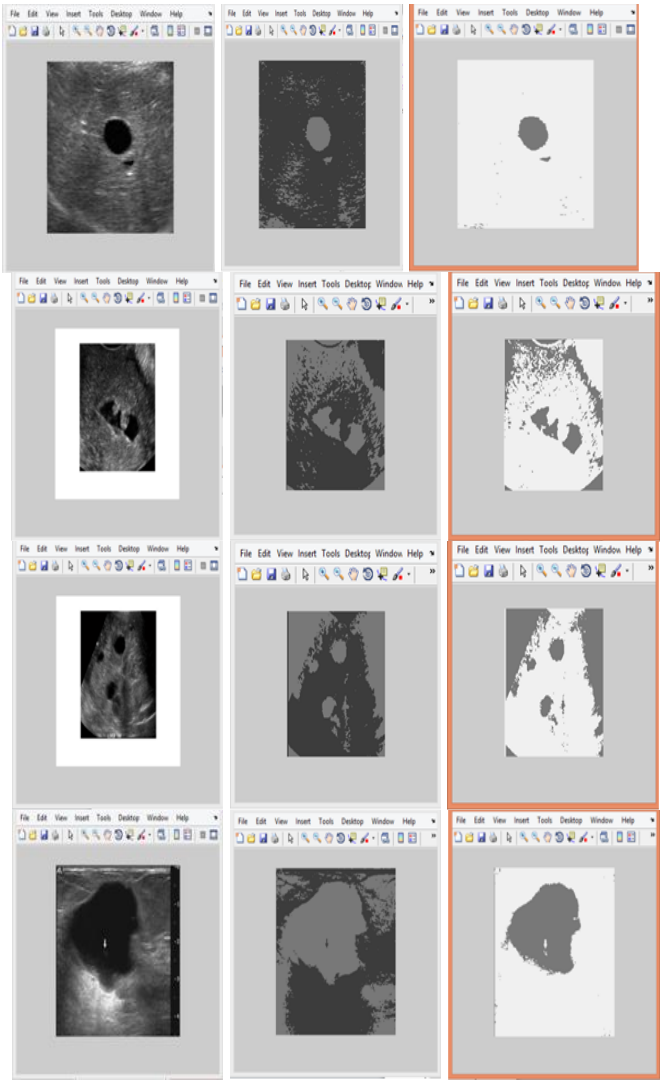
This work was implemented using MATLAB software version 2012. The name MATLAB stands for Matrix Laboratory. MATLAB was initially written to offer simple way to matrix software. MATLAB is a software development environment presents high-performance numerical computation, data analysis, visualization capabilities and application development tools.

The segmentation is performed using the proposed method. The output of the Otsu method and the PSO results are given in Fig. 3. Fig. 3(a) shows the original medical images. The Fig. 3(b) is the segmented output of the Otsu method. The Otsu method failed to segment the tumor exactly. Fig 3(c) displays the segmented result of the PSO method. Sometimes, PSO dominates the Otsu method.



a) b) c)

Fig. 3. Segmented Results: a) original image b) Otsu Result c) PSO result.



a) b) c)

Fig. 4. a) original image b) segmented result by FODPSO c) segmented result by proposed method

TABLE I. EXTRACTED FEATURES FROM THE MEDICAL IMAGES BY PROPOSED METHOD

IMAGES	AREA	PERIMETER	ENERGY	ENTROPHY	CORRELATION
1	2375	1	95.59	4.03E+08	0.381
2	804	1	98.83	3.38 E+08	0.561
3	2254	1	99.35	4.47 E+08	0.274
4	2039	1	87.10	2.236 E+08	0.224
5	2584	1	87.94	2.49 E+08	0.270
6	1693	1	87.68	2.43 E+08	0.186

By comparing two optimized results, the proposed method produces better result than the FODPSO, because detection of lesion region is more accurate for diagnosis in Cuckoo Search. Fig. 4 presents the segmented results of the proposed method. The original images are seen in Fig. 4(a) and the FODPSO results are given in Fig. 4(b). Fig. 4(c) shows the segments results by proposed method. Table I gives the features extracted from the segmented image and used to train the algorithm and using these features the algorithm can easily predict the tumour from the test image that has been given as a test image and if that test image satisfy these criteria then it produces the result as abnormal growth in tissues. Fig. 5 shows the ROC, describing the accuracy of the algorithm.ROC is a graphical plot that illustrates the performance of the proposed method. The curve is created by plotting the true positive rate against the false positive rate at various threshold. These values are obtained from the confusion matrix

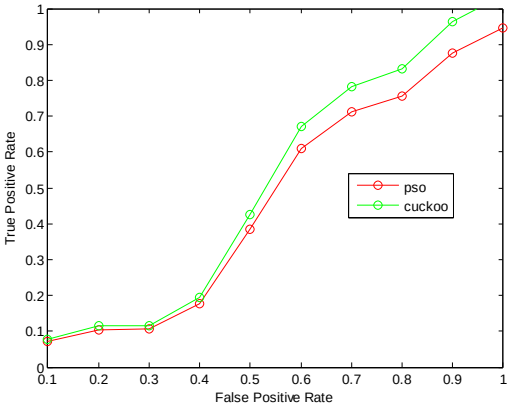


Fig. 5. ROC plot comparing FODPSO with proposed method

V. CONCLUSION

In this paper, cuckoo search algorithm is developed to obtain the optimal threshold. This algorithm is applied on medical images to maximize the between class variance. The segmented results are both visually and experimentally evaluated. Compared to existing methods such as Otsu, PSO, and FODPSO, the proposed method produces the successful results. The cuckoo search algorithm finds the optimal threshold in effective manner. The experimental results proved that the proposed method outperforms the existing methods.

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