Artificial Bee Colony Algorithm to improve brain MR Image Segmentation

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***Abstract* - Image segmentation is a primary step in image analysis used to separate the input image into meaningful regions. MRI is an advanced medical imaging technique widely used in detecting brain tumors. Segmentation of Brain MR image is a complex task. Among the many approaches developed for the segmentation of MR images, a popular method is fuzzy C-mean (FCM). In the proposed method, Artificial Bee Colony (ABC) algorithm is used to improve the efficiency of FCM on abnormal brain images.**

Key terms: ABC, FCM, medical imaging, optimization, segmentation

I. INTRODUCTION

A brain tumor is an abnormal mass of tissue in which some cells grow and multiply uncontrollably, apparently unregulated by the mechanisms that control normal cells [1]. According to the Central Brain Tumor Registry of the United States (CBTRUS), there will be 64,530 new cases of primary brain and central nervous system tumors diagnosed by the end of 2011 [2]. This necessitates greater effort in the field of brain tumor diagnosis.

Magnetic Resonance Imaging (MRI) is an advanced medical imaging technique used to produce high quality images of the parts contained in the human body [3]. It provides greater contrast between the different soft tissues of the body than computed tomography (CT) does, making it especially useful in neurological (brain), musculoskeletal, cardiovascular, and oncological (cancer) imaging [4] [5].

The segmentation of an image involves the division or separation of the image into regions of similar attribute. The ultimate aim in a large number of image processing applications is to extract important features from the image data. The segmentation of brain tumour from magnetic resonance images is an important but time-consuming task performed by medical experts and it is considered as a huge challenge in image processing. The aim of this work is to segment the MR brain image to detect the tumor.

Among the numerous algorithms proposed for brain MR image segmentation, the popular one is fuzzy C-means (FCM) algorithm. FCM is an unsupervised clustering algorithm that outperforms the other clustering algorithms in terms of computational complexity and accuracy of segmentation [6][7]. The main drawback it faces is in terms of its stability of results (over/under segmentation) with respect to the user provided number of clusters. Applying domain specific knowledge resolves this problem. MR images always contain a significant amount of noise caused by operator, equipment, and the environment. This leads to serious inaccuracies in the segmentation as any changes in pixels intensity such as noise, significantly affect the clustering results. One way to improve accuracy of the results is to use optimization method.

Optimization is a technique used to seek values for a set of parameters that maximize or minimize objective functions subject to certain constraints [8]. Artificial Bee Colony algorithm is a novel optimization algorithm inspired by the natural behavior of honey bees in their search process for the best food sources [9].

In our proposed method in order to enhance the results of FCM segmentation we combine FCM with ABC optimization algorithm.

II. FUZZY C-MEANS

An image can be represented in various feature spaces, and the FCM algorithm classifies the image by grouping similar data points in the feature space into clusters [10]. This clustering is achieved by iteratively minimizing a cost function that is dependent on the distance of the pixels to the cluster centres in the feature domain.

Pseudo code for FCM algorithm:

1. Initialize the number of clusters and their centers.
2. Calculate the membership grade of each data point.
3. Update the cluster center.
4. Repeat steps 2 & 3 until the objective function is minimized.

It is based on minimization of the following objective function:

$$J = \sum_{i=1}^{N} \sum_{j=1}^{C} u_{ij}^{m} \left\| x_i - c_j \right\|^2 \qquad 1 \leq m < \infty$$

where m is any real number greater than 1, u_{ij} is the degree of membership of x_i in the cluster j, x_i is the i^{th} of d-dimensional measured data, c_j is the d-dimension center of the cluster, and ||*|| is any norm expressing the similarity between any measured data and the center.

Fuzzy partitioning is carried out through an iterative optimization of the objective function shown above, with the update of membership u_{ij} and the cluster centers c_j by:

$$u_{ij} = \frac{1}{\sum_{k=1}^{C} \left(\frac{\left\| x_i - c_j \right\|}{\left\| x_i - c_k \right\|} \right)^{\frac{2}{m-1}}} , \qquad c_j = \frac{\sum_{i=1}^{N} u_{ij}^{m} \cdot x_i}{\sum_{i=1}^{N} u_{ij}^{m}}$$

This iteration will stop when $\max_{ij}\left\{ \left| u_{ij}^{(k+1)} - u_{ij}^{(k)} \right| \right\} < \theta$, where θ is a termination criterion between 0 and 1, whereas k are the iteration steps. This procedure converges to a local minimum or a saddle point of J_m.

FCM has few shortcomings like, it works effectively on normal brain MR images but not so efficient on abnormal (with tumor, edema etc.,) brain MR images. And also FCM takes care of pixel's intensity and does not consider the neighbourhood properties. The random cluster centre selection procedure of FCM makes its iterative process fall into local optimal solution easily [11]. Better feasible solution can be obtained by using optimization technique. Feasible solutions with objective function values as good as the values of any other feasible solutions are called optimal solutions [9]. The aim of this work is to improve efficiency of FCM by using ABC optimization algorithm.

III. ARTIFICIAL BEE COLONY OPTIMIZATION ALGORITHM

Karaboga proposed a simple yet powerful population-based algorithm, Artificial Bee Colony, to solve the numerical optimization problems [12]. The original Artificial Bee Colony algorithm is powerful meta-heuristic optimization tool used for solving unconstrained problems. ABC has the advantages of very simple, strong robustness, fast convergence, high flexibility and fewer setting parameters. Numerous ABC algorithms are developed based on foraging behaviour of honey bees for different optimization problems [13]. The comparative study of algorithms shows that result produced by ABC is better than many evolutionary and population based algorithms [14].

In Artificial Bee Colony algorithm, a probable solution to the optimization problem is represented by the location of a food source and the fitness of corresponding solution by the nectar amount of a food source. The total number of the employed bees is equal to the total number of available solutions in the population. This algorithm is an iterative process, starts by initializing all employed bees with randomly generated food sources i.e., solution represented by a D-dimensional real-valued vector. For each iteration every employed bee finds a food source in the neighbourhood of its current food source and evaluates its nectar amount i.e., fitness [12].

In general the position of i^{th} food source is represented as Si = (S_{i1}, S_{i2}, ………, S_{iD}). Information is shared by the employed bees for returning to the hive, onlooker bees go to the region of food source explored by employed bees at S_i based on probability P_i defined as

$$\mathrm{Pi} = \frac{fit_i}{\sum_{k=1}^{FS} fit_k}$$

Where, FS is total number of Food Sources. Fitness value fit_i is calculated by using the equation

$$fit_i = \frac{1}{1+f(S_i)}$$

Where $f(S_i)$ denotes the objective function considered. The onlooker finds its food source in the region of Si by using the following equation

$$S_{new} = S_{ij} + r*(S_{ij} - S_{kj})$$

Where S_{new} is the new food source exploited by onlooker and k is the solution in the neighborhood of I, r is a random number in the range -1 to +1 and j is the dimension of the problem considered.

If the new fitness value is comparatively better than the fitness value achieved so far, then the bee moves to the new food source, otherwise retains the old one. The information is shared with onlookers after all employed bees complete this process. Each onlooker bee selects its food source according to the probability given above. Hence good food sources are well accommodated with onlookers. Every bee will search for a better food source for a certain number of cycles or limit and if the fitness value doesn't improve then that particular bee becomes scout bee.

Pseudo code of the ABC algorithm:

1. Initialization
2. Move the employed bees onto the food sources and evaluate their nectar amounts.
3. Place the onlookers depending upon the nectar amounts obtained by employed bees. The onlooker bees determines and evaluates the nectar amount and compares it with the neighbours and replaces it with best pixel value
4. Send the scouts for exploring abandoned food sources.
5. Memorize the best food sources obtained so far.
6. If a termination criterion not satisfied go to step 2; otherwise stop the procedure and display the best food source obtained so far.

IV. PROPOSED METHOD AND METHODOLOGY

In the proposed method the following steps are used:

Step 1: Input the Brain MR image
Step 2: Pre-Processing procedure to enhance the quality of input image
Step 3: Segmentation of enhanced input image using
- i) FCM method
- ii) ABC with FCM method

Step 4: Output - the segmented tumor portion and size from i) and ii) of Step 3

In the pre-processing step, the identification of tumor is made easier by converting the input MR image into grayscale image. The median filtering is then applied to remove noise from the image. This step produces an enhanced image. Figure 1 represents the pre-processing.

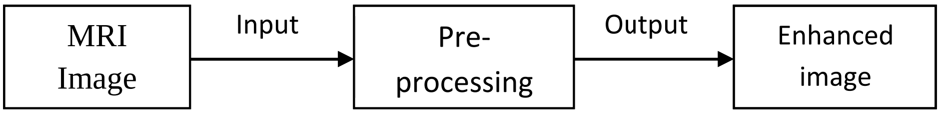

Figure 1: Block diagram of Pre-processing

Figure 2 indicates the working of processing step, enhanced image is segmented to locate the tumor. The different methods used for segmentation are Fuzzy C-Means and Artificial Bee Colony Optimization with Fuzzy C-Means.

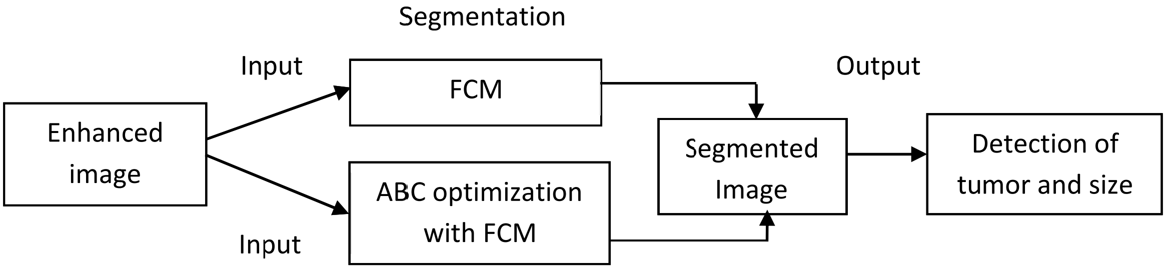

Figure 2: Block diagram for processing

V. EXPERIMENTS AND RESULTS

All the experiments were processed on Intel core 2 Duo with 2.2GHz processor and 4GB memory, running MATLAB R2010a on windows 7. We used real brain MR images for the experiment. The performance of FCM algorithm and proposed (ABC and FCM) algorithm is depicted in Figure 3 and Figure 4. As seen in Figure 3c and Figure 4c, the proposed algorithm performs better than FCM method by optimizing tumor segmentation.

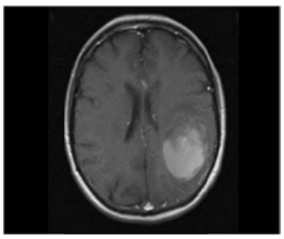

Figure 3a: Original image

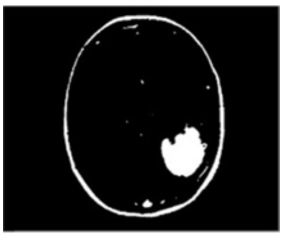

Figure 3b: FCM segmented image

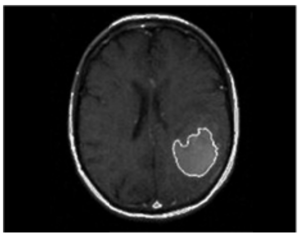

Figure 3c: ABC and FCM segmentation

Figure 3: Tumor detection

Figure 4a: Original image Figure 4b: FCM segmented image Figure 4c: ABC and FCM segmentation

Figure 4: Tumor detection

Comparison of tumor area calculation by proposed (ABC and FCM) method, FCM and watershed [15] is shown in Table 1.

Table 1: Comparison of tumor size in pixel

Image	Tumor size (in pixel)		
	Watershed Method	FCM	ABC and FCM
Figure 3	4913	4942	4920
Figure 4	2144	2091	2176

VI. CONCLUSION

In this paper, We implemented FCM segmentation algorithm and the proposed hybrid (ABC and FCM) segmentation algorithm to detect the tumor and its size using real Brain MR images. In the proposed method, ABC algorithm used for optimizing fuzzy clustering process. The result obtained shows that ABC algorithm improves the efficiency of FCM segmentation process. As a future plan, we plan to apply ABC algorithm to classify the type of tumor and compare the performance of the same with other algorithms.

VII. REFERENCES

[1] T. Logeswari and M. Karnan, An improved implementation of brain tumor detection using segmentation based on soft computing, International Journal of Computer Theory and Engineering, Vol. 2, No. 4, August, 2010.
[2] Central Brain Tumor Registry of the United States (CBTRUS). Fact Sheet. Available at: http://www.cbtrus.org.
[3] http://www.cis.rit.edu/htbooks/mri/chap-1/chap-1.htm
[4] Hynynen, K., MRI-guided focused ultrasound treatments, Ultrasonics, Vol. 50, No. 2, 221,229, 2010.
[5] Ravaud, R. and G. Lemarquand, Magnetic field in MRI yokeless devices: Analytical approach," Progress In Electromagnetics Research, Vol. 94, 327341, 2009.
[6] M.R.Rezaee, P.M.J.Zwet, B.P.E.Lelieveldt, R.J.Geest, and J.H.C.Reiber, "A multiresolution image segmentation technique based on pyramidal segmentation and fuzzy clustering", IEEE Transaction on Image Processing, vol.97, 2000, pp.1238-1248.
[7] Tong Hau Lee, Su-Cheng Haw, "Unsupervised abnormalities extraction and brain segmentation", Intelligent System and Knowledge Engineering, 2008.
[8] F. Van den Bergh and A.P. Engelbrecht, A New Locally Convergent Particle Swarm Optimizer, In Proceedings of the IEEE Conference on Systems, Man, and Cybernetics, ammamet, Tunisia, 2002.
[9] R. Rardin,Optimization in Operations Research, Prentice Hall, New Jersey, USA, 1998.
[10] Ming-Chuan Hung and Don-Lin Yang, "An Efficient Fuzzy C-Means Clustering Algorithm", proceeding of the 2001 IEEE International conference on Data Mining (ICDM'01), pp.225-232, 2001.
[11] Dervis Karaboga and Celal Ozturk,"Fuzzy Clustering with Artificial Bee Colony Algorithm", Scientific Research and Essays, Vol 5 (14), 201
[12] Karaboga D. An Idea Based On Honey Bee Swarm For Numerical Optimization, Technical Report-TR06, Erciyesniversity,Engineering Faculty, Computer Engineering Department, 2005.

[13] Karnan Marcus, Kamalam Balasubramani, A Survey on Artificial Bee Colony Algorithm, IEEE ICCIC, 2011
[14] Karaboga D, AkayB , A comparative study of Artificial Bee Colony algorithm, Appl. Math. Computing, pp.108–132, 2009
[15] Sudipta Roy, Samir K. Bandyopadhyay, Detection and Quantification of Brain Tumor from MRI of Brain and it's Symmetric Analysis Department of Computer Science and Engineering, University of Calcutta, 92 A.P.C. Road, Kolkata-700009, India.