Tumor Detection using Particle Swarm Optimization to Initialize Fuzzy C-Means

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Abstract— Image processing techniques are extensively used in different medical fields for earlier detection and treatment stages, where time factor is more important to find abnormality issues in target images in several tumors. Now a days tumor is discovered at advanced stages with the help of Magnetic Resonance Imaging (MRI).This paper proposes an approach which combines the Particle Swarm Optimization (PSO) techniques and Fuzzy C-Means (FCM) algorithm to perform image segmentation on Magnetic Resonance Imaging (MRI).The FCM algorithm has some limitations that it requires initialization of cluster centroids and the number of cluster. In this work, the PSO techniques is applied to the MRI medical images for the purpose of initialization of cluster centroids, which could overcome the requirement of manual initialization of FCM algorithm. Natural Computing (NC) is a novel approach to solve real life problems inspired in the life itself. A diversity of algorithms had been proposed such as evolutionary techniques and particle swarm optimization (PSO). This approach, together with fuzzy c means (FCM), give powerful tools in a diversity of problems of optimization, classification, data analysis and clustering.

Key words: Segmentation, Particle Swarm Optimization, Fuzzy C-Means, Magnetic Resonance Imaging, Natural Computing

I. INTRODUCTION

Image processing is one of the swift growing areas in signal processing. Image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two dimensional signal and applying standard signal-processing techniques to it [11].Normally, the anatomy of brain tumor can be examined by MRI scan or CT scan. MRI is a one type of scanning device, which use magnetic field and radio waves [8]. It is also use computer to create images of the brain on film. Brain tumors affect the normal brain activity. So accurate detection of tumor is important for human and increase the lifetime of the 1 to 2 years [12]. In medical imaging, an image is captured, digitized and processed for doing segmentation and for extracting important information [6].

Fuzzy C-Means is the most popular algorithm for soft clustering [11].It has been widely used to make good separated clusters. The FCM is based on the minimization of an objective function and iterations through update the membership of degrees and centroids of cluster.FCM is frequently used with the image segmentation because it can retain more images information than the hard clustering algorithm[11].Although FCM algorithm works better than the hard clustering algorithm, but in FCM also unavoidable defects that cluster centroids and the number of cluster should not be decide in advance [3] to overcome the drawbacks of FCM in this paper we mainly focus on how to decide the cluster centroids and the number of cluster for better clustering.

In this paper suggested an approach which combines the Particle Swarm Optimization (PSO) techniques and Fuzzy C-Means (FCM) algorithm to perform image segmentation .on Magnetic Resonance Imaging (MRI). Natural Computing (NC) is a novel approach to solve real life problems inspired in the life itself. A diversity of algorithms had been proposed such as evolutionary techniques, and particle swarm optimization (PSO) [4].Particle Swarm Optimization (PSO) technique developed by Kenny and Eberhart in 1995[16].In Particle Swarm Optimization, simple software agents, called particles moves in the search space of an optimization problem. This approach,together with Fuzzy C-Means (FCM), give powerful tools in a diversity of problems of optimization, classification, data analysis and clustering [12].

On the whole, for good segmentation we use the Particle Swarm Optimization technique to trigger FCM For good initialization. we can randomly initialize the cluster number, Initialize initial random cluster centre values (initial random particle position),the degree of fuzziness m>1, and velocity of each particle and calculate the initial membership value, Until the termination conditions for new center we calculate the new membership values and also fitness function of PSO. Then calculate the velocity of particles for find the new center .these centers are given to FCM for good initialization.

The rest of paper is organized as follows .The backgrounds are given in Section II, including the FCM algorithm and the PSO technique. Section III presents our new proposed PSO based technique to determine cluster centroids and the number of cluster before carrying out FCM for image segmentation. Experiments and analysis are provided in section IV.finally, conclusion is made in the last part.

II. BACKGROUND

A. The Fuzzy C-Means Algorithm

Fuzzy clustering Fuzzy C-Means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters with different membership degrees between o and 1.it was first introduced by Dunn[13] and modified by Bezdek[14] .it is an iteration based method on optimization of the weighted squared error function J_m

$$J_m = \sum_{i=1}^{N} \sum_{j=1}^{C} u_{ji}^{m} \| x_i - c_j \|^2 \qquad (1)$$

where N is the number of data items ,c is the number of cluster ,m is a fuzzy factor with m>=1,c_j is the centroids of the j^{th} cluster,x_i is the i^{th} data, u_{ij} is the membership degree of x_i in the j^{th} cluster. The detailed FCM algorithm is described as follows.

1) Algorithm 1 Fuzzy C-Means

1) Set values for iteration terminating threshold ″, cluster number *c* and fuzzy factor *m*.
2) Randomly initialize cluster centroid matrix $C^{(q)}$ with $ck(k = 1; 2; :::; c)$.
3) Calculate the membership matrix $U^{(q)}$ according to $C^{(q)}$ with the following equation:

$$u_{ij}=\frac{1}{\sum_{k=1}^{c}\left(\frac{d_{ji}}{d_{ki}}\right)^{\frac{2}{m-1}}} \quad (2)$$

4) Calculate $C^{(q+1)}$ according to U(q) with the following equation:

$$c_j = \frac{\sum_{i=1}^{N} u_{ji}^{m} x_i}{\sum_{i=1}^{N} u_{ji}^{m}} \quad (3)$$

5) Update $U^{(q+1)}$ according to $C^{(q+1)}$ with Eq. (2).
6) If max $\{U^{(q+1)} - U^{(q)}\} \leq$ ꜀, then stop, otherwise, set q = q + 1 and go to step 3.

B. The Particle Swarm Optimization Technique

The algorithm of particle swarm optimization is an evolutionary computational model and is introduced by Kennedy and Eberhart (1995)[16]. Particle Swarm Optimization belongs to the class of swarm intelligent techniques that are used for to solve the Optimization problem in real life itself [2].PSO simulates the behavior of bird flocking .means, a group of bird finding the food randomly in an area. There is only one piece of food in the area being searched .all the birds do not know where is food is, but they know how far the food is in each iteration. So the best way to find the food is to follow the bird which is nearest to the food. Frocking behavior is exhibited when group of birds are foraging [4].

Each particle in PSO is updated by two best values [4]:

pbest - Each particle keeps track of its coordinates in the solution space which are associated with the best solution (fitness) that has achieved so far by that particle. This value is called personal best, pbest.

gbest - It is tracked by the PSO is the best value obtained so far by any particle in the neighbourhood of that particle. This value is called Global Best, gbest.

C. Algorithm 2 Particle Swarm Optimization

1) For each particle Initialize particle
2) For each particle Calculate fitness value
3) If the fitness value is better than the best fitness value (pbest) in history set current value as the new pbest
4) Choose the particle with the best fitness value of all the particles as the gbest
5) For each particle Calculate particle velocity according

$$v_{id}^{best} = w * v_{id}^{pre} + c_1 * rand * (p_{id}^{best} - x_{id}) + c_2 * rand() * (p_{gid}^{best} - x_{id}) \quad (4)$$

6) Update particle position according

$$p_{id}^{new} = p_{id}^{pre} + v_{id}^{new} \quad (5)$$

Where, v_{id} is the velocity of particle in the *d*-dimension search space and is limited into [*Vmin, Vmax*]. *Vmin* and *Vmax* are respectively, the minimum and maximum the moving distance in one-step, p_{id} is the position of *i*th particle *i*, p_{id}^{best} is the individual best position of particle *I*, p_{gid}^{best} is the *gid*th global best position in all particles, x_{id} is the current position of particle *i*, rand () is a random number function and its value are between 0 and 1, w is the inertia weight, c1 and c2 are constants[4].

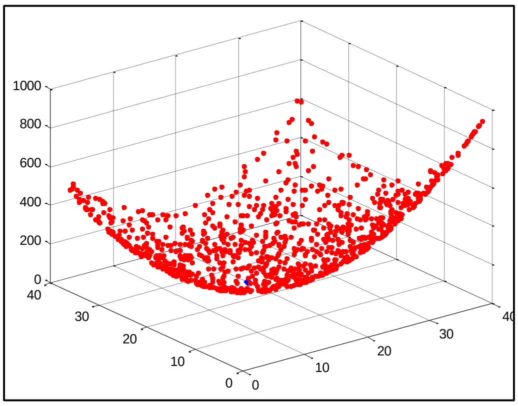


Fig. 1: PSO results for finding global best value among the search space

III. SUGGESTED APPROACH

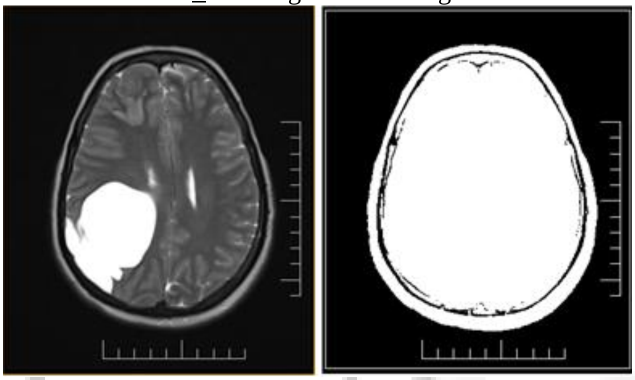
The Suggested algorithm is an approach which combines the Particle Swarm Optimization (PSO) techniques and Fuzzy C-Means (FCM) algorithm to perform image segmentation on Magnetic Resonance Imaging (MRI).The MRI images dataset are taken from the different MRI centre. The FCM algorithm has some limitations that it requires initialization of cluster centroids and the number of cluster. So the PSO technique is applied to the MRI medical images for the purpose of initialization of cluster centroids, which could overcome the defects of FCM algorithm. On the whole, for good segmentation we use the Particle Swarm Optimization technique to trigger FCM For good initialization. We can randomly initialize the cluster number, Initialize initial random cluster centre values (initial random particle position),the degree of fuzziness m>1, and velocity of each particle and calculate the initial membership value. until the termination conditions for new center we calculate the new membership values and also fitness function of PSO. After that update the pbest and gbest values and calculate the velocity of particle for find the new center .These centers are given to FCM for good initialization. The proposed algorithm is as follows.

A. Algorithm 3 PSO_FCM algorithm

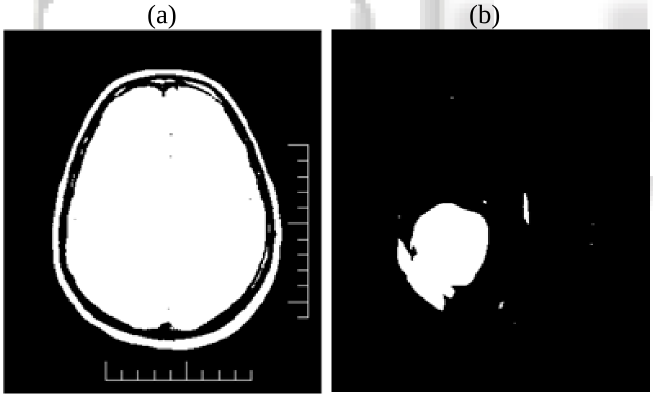
1) Calculate the filtered image.
2) Initialize Cluster numbers, Initialize initial random cluster centre values (initial random particle position), the degree of fuzziness m>1, and velocity of each particle.
3) Calculate the initial membership value U
4) Repeat until Termination Condition
5) for each centre
   -Calculate next membership value U(k+1)
   -Calculate the fitness function or Objective Function
   -Update the pbst and gbest values
   -Calculate the velocity and position of particle (new centre calculation)
   -End for (step 5)
6) If not termination condition Go to 5
   -End for (step 4)

IV. RESULT AND DISCUSSION

As can be seen from fig.2 the results of FCM are shown. The segmentation results of MRI images are seen. Here the segmentation can be done as first cluster, second cluster an third cluster. In this we are taking the cluster value three so here only three clusters have shown. As seen in table the initial center was taken by FCM randomly so after 70 iteration we got the results but using PSO_FCM we first take initial center randomly but after PSO finding the global best value and find the initial centers, that initial center we gives to FCM .The PSO_FCM results are shown in fig.3 .In table 2 we seen the initial center it given by PSO to trigger FCM and also calculate the cluster center value by PSO .So after 40 iteration we got the results. So the computation time is very less than FCM. Sometimes FCM can be stuck between local minima but in PSO_FCM it gives better segmentation results.



(a) (b)



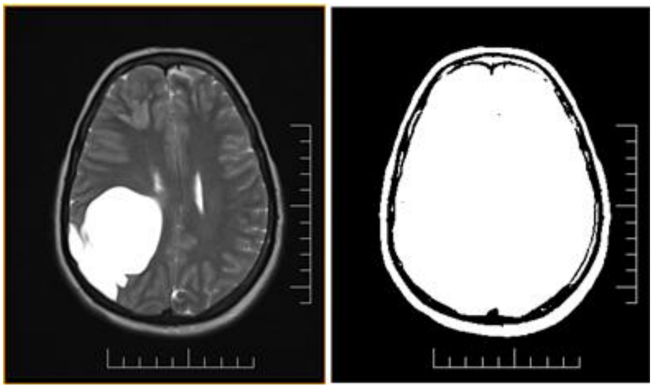
(c) (d)

Fig.2. Segmentation results of FCM (a)original image, (b) first cluster, (3)second cluster, (4)third cluster

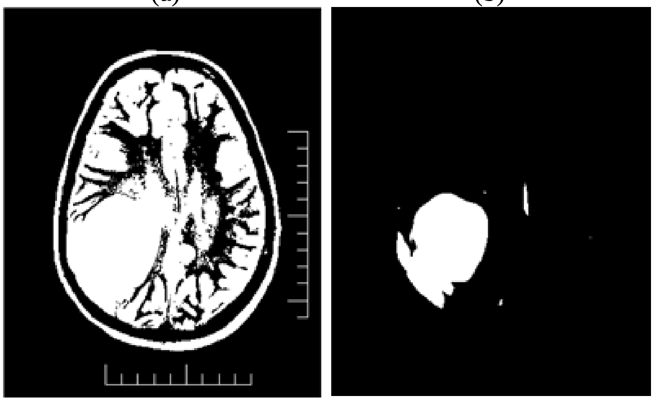
Initial center FCM	Final center FCM	Total iterations
0.2134	0.2938	
0.2132	0.0445	
0.2138	0.9975	
0.2144	0.6936	70
0.2135	0.3726	
0.2131	0.1221	
0.2138	0.5079	

Table 1.Results of FCM

The Experimental results of MR images using PSO_FCM results are shown as below. PSO_FCM gives better segmentation results over FCM algorithm, also less computation complexity.



(a) (b)



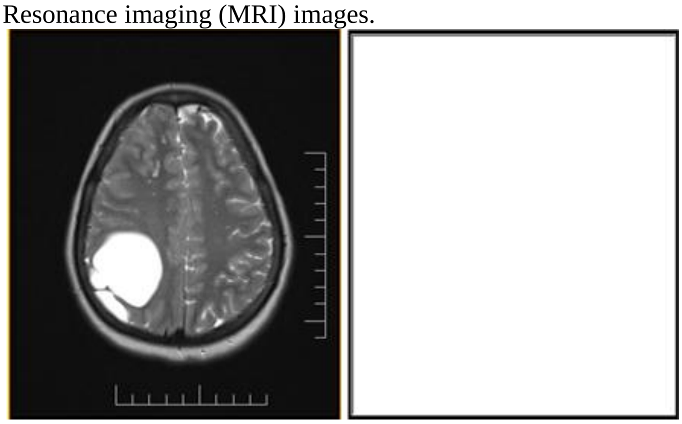
(c) (d)

Fig.3. Segmentation results of PSO_FCM (a)original image, (b) first cluster, (3)second cluster, (4)third cluster

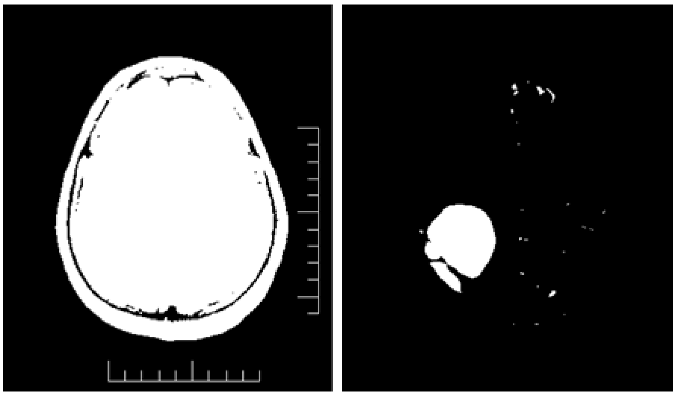
Initial center PSO	Final center PSO	Total iterations
0.0213	0.0471	
0.1384	0.4123	
0.1401	0.3362	
0.1303	0.2715	40
0.1382	0.5446	
0.1389	0.7364	
0.1389	0.9978	

Table 2.Results of PSO_ FCM

Simulations are carried out for different Magnetic Resonance imaging (MRI) images.



(a) (b)



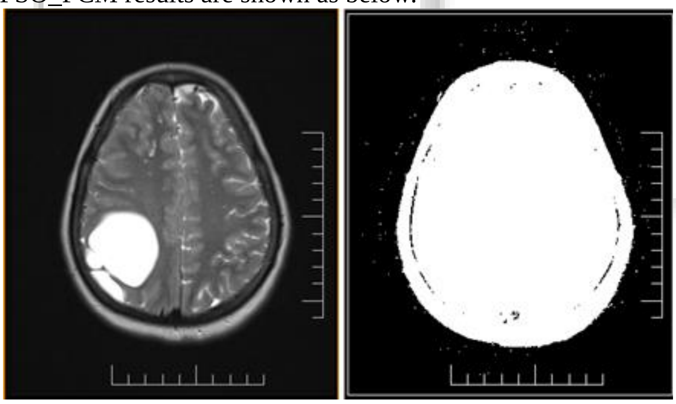
(c) (d)

Fig.4. Segmentation results of FCM (a)original image, (b) first cluster, (3)second cluster, (4)third cluster

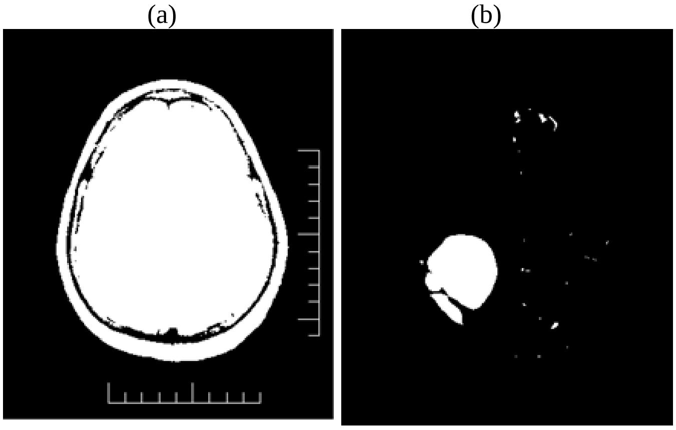
Initial center FCM	Final center FCM	Total iterations
0.2097	0.0027	
0.2098	0.1958	
0.2101	0.4632	
0.2101	0.3568	44
0.2105	0.9932	
0.2105	0.6521	
0.2097	0.0618	

Table 3.Results of FCM

The Experimental results of MR images using PSO_FCM results are shown as below.



(a) (b)



(c) (d)

Fig.5. Segmentation results of PSO_FCM (a)original image, (b) first cluster, (3)second cluster, (4)third cluster

Initial center PSO	Final center PSO	Total iterations
0.1569	0.3598	
0.1601	0.4650	35
0.1401	0.0569	
0.1473	0.2160	
0.1732	0.9933	
0.1463	0.1001	
0.1756	0.6529	

Table 4.Results of PSO_ FCM

V. Conclusions

In this paper, we have combined the Particle Swarm Optimization (PSO) and Fuzzy C-Means (FCM) algorithm to perform image segmentation for MRI images. Our Suggested algorithm called PSO_FCM could decide the number of cluster and cluster centroids and pass these two values to carry out FCM algorithm. Showing the usefulness of global best values .It has made improvement on FCM for no need of random initialization. Extensive experimental results are shown and comparison with FCM and PSO_FCM.

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