Segmentation of Brain MRI Images using Gene-Fuzzy c Means Clustering Technique

B.Prasanthi[1], Dr. N.Nagamalleswararao[2]

Asst Professor, Dept. of CSE, R.V.R&J.C College of Engineering, Guntur, Andhra Pradesh, India[1]

Professor, Dept. of IT, R.V.R&J.C College of Engineering, Guntur, Andhra Pradesh, India[2]

ABSTRACT: Segmentation is a difficult and challenging problem in the magnetic resonance images, and it considered as important in computer vision and artificial intelligence. Many researchers have applied various techniques however fuzzy c-means (FCM) based algorithms is more effective compared to other methods. This paper describes an evolutionary approach for unsupervised gray-scale image segmentation that segments an image into its constituent parts automatically. The aim of this algorithm is to produce precise segmentation of images using intensity information along with neighborhood relationships. In this paper, fuzzy c-means clustering helps in generating the population of Genetic algorithm which there by automatically segments the image. This technique is a powerful method for image segmentation and works for both single and multiple feature data with spatial information. Validity index has been utilized for introducing a robust technique for finding the number of components in an image. Experimental results shown that the algorithm generates good quality segmented image.

KEYWORDS: Image Segmentation, Fuzzy C-means, Genetic Algorithm

I. INTRODUCTION

The brain[1] is the most important part of the central nervous system. Tumor is two types namely malignant and benign[2]. Malignant tumor is referred to as cancer. Abnormal growth of cell inside brain is called brain tumor. There are general groups of brain tumor. Primary brain tumor starts in brain and tends to stay there. Secondary brain tumor starts somewhere else in the body but travels to brain. The reason for brain tumor is unknown till now.

Segmentation[3] is an important process in the analysis of medical images for diagnosis. It divides the image into its constituents parts and groups the homogeneous pixels into clusters. Segmentation is an important process to extract suspicious region from complex medical images.Segmentation[4] is one of the most significant requirements in the analysis of medical images. However,the complicated structures of the inside of the human body cause problems in segmentation i.e. prescribing appropriate therapy. Magnetic resonance imaging (MRI) is a technique primarily used in medical conditions to get high quality images of organs, soft tissues, bone and virtually all other internal human body structures. In other words, "MRI possesses good contrast resolution for different tissues and has advantages over computerized tomography (CT) for brain tissues due to its superior contrast properties [1]". On account of those advantages, MRI images have become a basic source of medical image segmentation, especially brain segmentation. Brain MRI segmentation is mainly applied to the following fields:

1) Automatic or semiautomaticdiagnosis of regions to be treated prior to the surgery,
2) Diagnosis of tumors before and after surgical intervention for response assessment,
3)Tissue classification.

Clustering[5] is usedinsegmentation [3]-[5]of images that can be used to unionize set of pixels into groups based on similarities among theindividual data items in such a way that data points of the same groups are more identical to one another than samples belonging to different groups. It is interesting to use fuzzy clustering methods, which holds large information from the image as compared to hard clustering methods. FCM provides flexibility which admits pixels to

belong to multiple classes with changing degree of membership[2].But the disadvantages with FCM is time taken for convergence[3]. The drawback of the Fuzzy c-means is improved by the improved Fuzzy C Means algorithm. Various improvements have been done on existing work to achieve good Performance. The Segmenting an image is splitting the image into various regions having some similar attribute.The segmenting MR abnormal brain images is an important task but time devouring task. Several segmentation methods are developed, Some common segmentation techniques are:1)texture segmentation,2)amplitude thresholding3)region-growing segmentation, and 4)template matching. These algorithms divides the brain images into three families (a)PixelBased (b) Region or Texture Based(c)StructuralBased[6].Kwon and Han proposed hierarchical FCMalgorithmapproach which was based on template matching but it had disadvantage of need of an precise template[4]. Cluster center initialization method using Silhouette method improves efficiency of segmentation[5]. Fast clusteringalgorithmbased on random sampling was proposed by Chengand Goldgof[6] which afford a speed-up

Fractor of 2-3 times as compared toFCM algorithm. The quantizationbasedFCMalgorithm vector, Fastfuzzyclusteringforwebdocumentation,EschrichandKeimplementedtheclusteringalgorithmthroughquantizationandaggregationwhichincludesaweightfactorforclustercenterupdation,are some techniquestoimproveperformance.

Siyaletal[5]acquainted a new method on FuzzyC-means for segmentating .Application of FCM for Segmentation for tissue distinction in MR Images of a hemorrhagic Glioblastom a MultiformewasdescribedbyPhillips,W.Eetal. S. Murugavallil et al , A high speed parallel fuzzyc-mean algorithm for brain tumour segmentation.S.Murugavallil, introduced an Improved Implementationof Brain Tumor Detection Using Segmentation Based onNeuroFuzzy Technique. VaidyanathanMet alldescribed Comparison of Supervised MRI Segmentation methodsforTumour Volume Determination During Therapy.JayaramK et al described Fuzzy Connectedness andImageSegmentation. Kannan et al described segmentationof MRI Using New Unsupervised Fuzzy C meanAlgorithmRuspini, E Described Numerical methods forfuzzyclustering[18]. Dunn, J.C., described A fuzzy relative oftheISODATA process and its use in detecting compact,wellSeparated clusters. Bezdek, J.C., describedClustervalidity with fuzzysets.

II. RELATED WORK

A number of research papers related to medical image segmentation methods were studied. A report of the literature survey is presented here. Datta et al (2011) introduced colour-based segmentation[6] using k-means clustering for brain tumor detection. The developed algorithm shows better result than Canny based edge detection [6]. Nandha et al (2010) designed intelligent system to diagnose brain tumor through MRI using image processing clustering algorithms such as Fuzzy c-means along with intelligent optimization tools, such as Genetic Algorithm (GA), and Particle Swarm Optimization (PSO) [7]. Jobin et al (2012) proposed a method which integrated the k-means clustering algorithm with the marker controlled watershed segmentation algorithm [8]. Yang et al (2010) presented a new image segmentation algorithm W-SPK (combining watershed and K-means clustering method based on simulated annealing particle swarm optimization) to overcome the shortcomings of watershed and realize fast and accurate image segmentation [9]. Sasikala et al (2006) presented an automatic segmentation of malignant tumor in magnetic resonance images (MRI's) of brain using optimal texture features. Texture features are extracted from normal and tumor regions (ROI) in the brain images under study using spatial gray level dependence method and wavelet transform [10].

.Fuzzy c-means(FCM) is a data clustering technique in which a dataset is grouped into n clusters with every datapoint in the dataset belonging to every cluster to a certain degree.For example, a certain datapoint that lies close to the center of a cluster will have a high degree of belonging or membership to that cluster and another datapoint that lies for away from the center of a cluster will have a low degree of belonging or membership to that cluster. But medical images are considered fuzzy due to the uncertainty present in terms of region/boundaries, non-uniform intensity variations. The field of medical imaging is greatly improved by using the fuzzy theory[3]. Fuzzy c means is one of the fuzzy clustering methods which was proposed by J.C Bezdek in 1981[11].Although Fuzzy clustering algorithm works well on segmenting most noise free images it fails to segment image corrupted by outliers, noise and other imaging artifacts. Traditional FCM leads to its non robust mainly due to 1.Not utilizing the spatial information in the image. 2.Use of Euclidean distance. To overcome the first problem many researches incorporated the local spatial information into

traditional FCM. In literature numerous researches have addressed the effectiveness with the modified object function of the FCM[12].Tolias and Panas[13] used a fuzzy rule based to impose the spatial constraints by post processing the FCM clustering results.

Clustering technique can be seen as data compression technique. In this dimensionality of input is reduced to goodextent. Here huge number of input sampIes is converted to less number of representative clusters [2]. The quantization of thefeature space is performed by masking the lower 'm' bits of thefeature value. The quantized output will result in the commonintensity values for more than one feature vector. In next step grouping of feature vector having same intensity values isdone, this process is called aggregation. One representative vector from each group is taken and given as input to Fuzzy CMeans algorithm. When c1ustering is done representative feature vector membership values are distributed identically toall members of quantization levels. As modified FCM uses reduced dataset convergence rate in improved as compared tonormal FCM technique.

Chromosomes set that is obtained is used as the center points of the cluster, and get final segmented image. After that the thresholding is applied on the segmented image to generate a binary image having two values 0 and 255. A value γ is chosen and every pixel that has intensity value less than γ is made 0 otherwise 255. This operation helps in identifying the region that contains tumor and also helps in extracting it. Hence a binary image *I* is constructed, where g is original image and γ is threshold value.

The term Genetic is derived from Greek word "genesis" which means "to grow" or"tobecome", and therefore the algorithm makes a function grow. This algorithm was introduced by John Holland on the basis of a heuristic method. The method grows in search of "survival of the fittest"[13]. Since fittest is searched by the algorithm and hence used in optimization tasks, The implementation of genetic algorithm begins with an initial population of chromosomes which are randomly selected. Achromosome is a long thread of DNA (deoxyribonucleic acid). Particulars traits determine the hereditary of an individual where each trait is coded by some combination of DNA bases. The fourmain bases of DNA are A (Adenine), C (Cytosine), T (Thymine) and G (Guanine). Just like Englishalphabet, the combinations of various letters give some meaningful information; GA also follows thesame conceptGenetic algorithm(Gas) [3] are powerful methods in medical image processing[32][33]. Genetic algorithm have the ability to forego a local optimum to reach a global optimum and the ability to efficiently find an optimal solution from within a large search space. The genetic algorithm is flexible and robust compared to other optimization methods. In literature, many techniques successfully applied the genetic algorithm to solvemedical image segmentation problem [14] - [18].combined GA and fuzzy clustering in which genetic algorithm is adapted to optimize the initial cluster centers. In GA, [4]each individual known as chromosome represents a solution of the handled problem.

A chromosome comprises bit strings called as genes. The main purpose is to evolve chromosomes through crossover and mutation operators. To evolve chromosomes, new generation, called offspring, are generated by merging two chromosomes using a crossover operator and by modifying bit string of a chromosome using a mutation operator. In this way, the crossover operator satisfies cooperation and the mutation operator satisfies diversity in population. Then, new population is selected from the current and generated chromosomes according to their fitness values.

III. PROPOSED ALGORITHM

1.Preprocessing
Otsu's Method:

In image processing, segmentation is often the first step to pre-process images to extract objects of interest for further analysis. Segmentation techniques can be generally categorized into two frameworks, edge-based and region-based approaches. As a segmentation technique, Otsu's method is widely used in pattern recognition, document

binarization, and computer vision. In many cases Otsu's method [19] is used as a pre-processing technique to segment an image for furtherprocessing such as feature analysis and quantification. Otsu's method searches for a threshold that minimizes the intra-class variances of the segmented image and can achieve good results when the histogram of the original image has two distinct peaks, one belongs to the background, and the other belongs to the foreground or the signal. The Otsu's threshold is found by searching across the whole range of the pixel values of the image until the intra-class variances reach their minimum. As it is defined, the threshold determined by Otsu's method is more profoundly determined by the class that has the larger variance, be it is the background or the foreground .As such, Otsu's method [19] may be create suboptimal results when the histogram of the image has more than two peaks or if one of the classes has a large variance. Otsu's thresholding method is used to find the threshold value T which minimizes the intra-class variance (within class variance) or maximizes the inter-class variance (between – class variance) to separate the input image into two classes to produce the binary image. The intra-class variance is defined as the weighted sum of variances of each class.

2. Clustering Techniques

Cluster analysis or clustering [20] is the task of grouping a set of objects in such a way that objects in the same group (called a cluster) are more similar to each other. Clustering is mainly used when classes are known in advance. A similarity criterion is characterized between pixels, and then similar pixels are mutually grouped to build clusters. Thegrouping of pixels into clusters is created on the principle of maximizing the intra class similarity and maximizing the inter class similarity [21]. The quality of a clustering result depends on both the similarity measure used by the method and its implementation. Clustering algorithms are classified into hard clustering, Fuzzy clustering, etc

A.   K-means Clustering Algorithm

A popular and well known hard clustering algorithm is K-Means clustering algorithm [20].K-Means is one of the easiest unsupervised learning algorithms developed by Macqueen 1967. K-means clustering algorithm is a simple clustering method with less computational complexity. Additionally, it is suitable for biomedical image segmentation as the number of clusters (k) is generally known for images of particular regions of human anatomy. For example, the MRI brain images generally consists soft tissues like GM, WM and CSF, then k will be number 3 [12]. Finally, this algorithm aims atminimizing an objective function is in eqn

$$ J = \sum_{j=1}^{k} \sum_{i=1}^{n} \ \left\| x_i{}^{(j)} - c_j \right\|^2 $$

where$\|xi(j)-cj\|^2$is a chosen distance measure between adata point xi(j)and the cluster centre cj, is an indicator of thedistance of the ndata points from their respective clustercenters. K-means is a straightforward algorithm that has beenmodified to many problem domains.

Although these steps can be proved that the process will always terminate. The k-means algorithm does not find the most optimal configuration, equivalent to the global objective function minimum. This algorithm is very sensitive for selecting the initial random cluster centers. So, this algorithm can be run several times to reduce this outcome. The K-Means algorithm is easier for segmenting the MRI brain tissues into three clusters like WM, GM and CSF. Visually, it is cleared that figure2 shows the real MRI original slice, skull stripped image by using mathematical morphology operations, clustered image by using K-Means and separation of GM, WM and CSF images

B. Fuzzy C-means Clustering Algorithm

Fuzzy C-means (FCM) [22] is a method of clustering which allows one pixel to belong to two or moreclusters [18]. The FCM algorithm attempts to partition a finite collection of pixels into a collectionof "C" fuzzy clusters with respect to some givencriterion. Depending on the data and the application,different types of similarity measures may be used to identify classes. Some examples of values that can be used as similarity measures include distance,connectivity, and intensity. In this work, the images are segmented into four clusters namely white matter, grey matter, CSF and the abnormal tumor region based on the feature values.

Fuzzy c-means algorithm is based on minimization ofthe following objective function:

$$J(U, c_1, c_2, ..., c_c) = \sum_{i=1}^{\upsilon} J_i = \sum_{i=1}^{\upsilon} \sum_{j=1}^{n} u_{ij}^{m} d_{ij}^{2}$$

u_{ij} is between 0 and 1;
c_i is the centroid of cluster i;
d_{ij} is the Euclidian distance between ith centroid (c_i)
andjth data point.
m c [1,oo] is a weighting exponent.
Fuzzy partitioning of the known data sample is carried out through an iterative optimization ofthe objective function shown in, with the update of membership U and the cluster centers C, by

$$u_{ij} = \frac{1}{\sum_{i=1}^{c} \left(\frac{d_{ij}}{d_{kj}}\right)^{2/(m-1)}} \quad ; \quad c_i = \frac{\sum_{j=1}^{n} u_{ij}^{m} x_j}{\sum_{j=1}^{n} u_{ij}^{m}}$$

Algorithm
The entire algorithm can be summarized follows
Step 1:
Initialize the membership matrix, U=[uij].
Step 2:
At kth number of iteration:[22]
Calculate the center vectors c.with uij

$$c_i = \frac{\sum_{j=1}^{n} u_{ij}^{m} x_j}{\sum_{j=1}^{n} u_{ij}^{m}}$$

Step 3:
Update the membership matrix U for the kth step and (k+ l)th step.

$$u_{ij} = \frac{1}{\sum_{k=1}^{c} \left(\dfrac{d_{ij}}{d_{kj}} \right)^{2/(m-1)}}$$

$$\text{where } d_{ij} = x_j - c_i$$

**Step 4:**

If 11 U(k+1) - U(k)JJ< e then STOP; otherwise return to step 2.

Thus FCM algorithm yield the clustered image based on the number of clusters used.The tumor portion of the input image is grouped in to one particular cluster which can be easily extracted..But the drawback of the histogram is the slow training process to achieve the stabilization condition A modified FCM algorithm which speed up the training process is highly essential for real time applications.

C.   Genetic Algorithm based Fuzzy C-means Algorithm

Genetic Algorithm [20] is introduced to develop an optimized fuzzy segmentation technique which will optimize the performance of pure FCM. Various works have applied GA to image processing and to segmentation particularly. GA is well adapted to achieve this goal. The major advantage of usingGA is to decide the global optimal value of the criterion by simulating the evolution of a population until survival of best fitted individuals. The survivors are individuals achieved by crossing-over, mutation and selection of individuals from the previous generation [20].Genetic Algorithms (GAs) are adaptive heuristic search algorithm introduced on the evolutionary themes of naturalselection. The essential components of genetic algorithm arethe following:
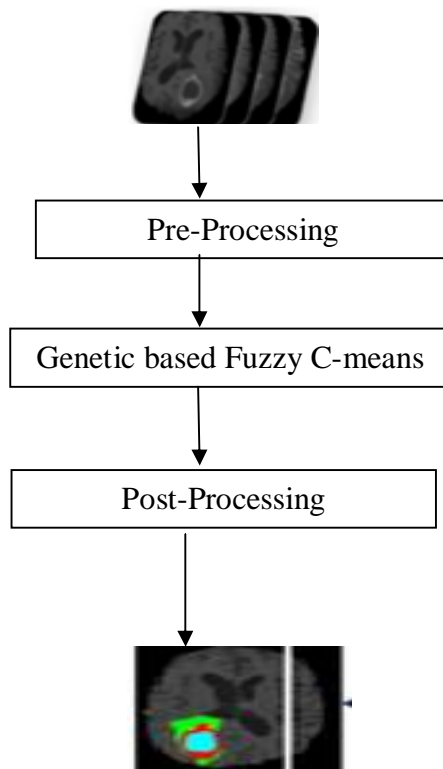
1) Representation Strategy: Genetic algorithm starts with representation strategy called chromosomes,where the parameter set is encoded as finite size string over an alphabet of finite length.
2) Population: A set of chromosomes in a generation is called population.
3) Fitness function: The fitness function is chosen dependingon the problem in such a way that the strings representing good points in the search space have highest fitness value.
4) Selection: Selection process copies individuals intomating pool for genetic operation.
5) Genetic operators: There are two genetic operators: crossover and mutation. The main purpose ofthe crossover is to exchange the information between randomly selected parents. Common crossover techniques are single point crossover, multi point mcrossover and uniform crossover. The main purpose of the mutation is to introduce the genetic diversity into the population.

The searching capability of GAs can be used for clustering a set of n unlabeled points in N dimension into Kclusters [21]. In this proposed system, the similar idea can be applied on MRI brain images. The input image is converted into a gray level image of size m×n.

Population initialization
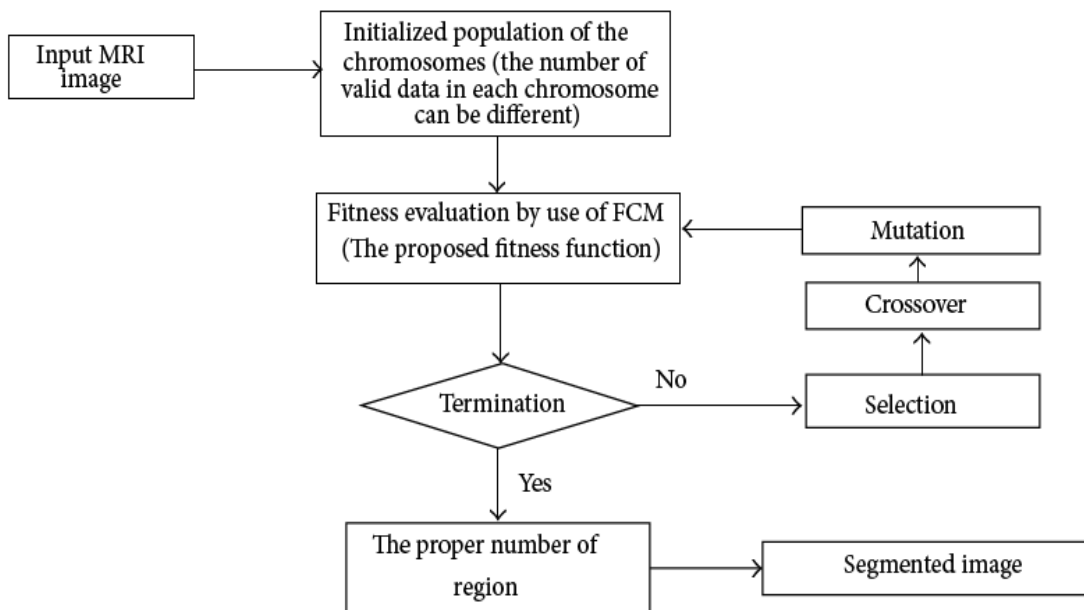
Population initialization
The chromosomes are made up of real numbers which represent microarray spot BG and FG pixel intensity centers respectively. These values are randomly initialized by taking all possible intensity values in the search space under evaluation.

Fitness computation
Fitness of a chromosome is calculated in two steps. In the first step membership values of the image data points to the different clusters are computed by using FCM algorithm. In the second step fitness value is computed. This is used as a measure to evaluate the fitness of the chromosome. The membership degree function uijcan be computed using the FCM algorithm. Saha et.al has given a fitness function for the segmentation of satellite images.

Selection, Crossover and Mutation

Roulette wheel selection method is applied on the population where, each chromosome receives a number that is proportional to its fitness value. Crossover and Mutation are the two Genetic Operators used for the creation of new Chromosomes. After repeating steps A, B, C for a fixed number of iterations the best cluster centers are selected . The flow chart for performing GAFCM

Step 1: Set the parameters. Set the number of clusters c, population size N, crossover probability pcand mutation probability pm.
Step 2: Set the chromosome from 1 to n.
Step 3: Initialize the population. Select the chromosome randomly c*n.
Step 4: The individuals of c clusters corresponding to cluster dataset are taken as the cluster center and calculate the fitness function.
Step 5: Optimal preservation. Pick up the worst individualafter mutation operation, which has smallest value of fitness to compare with the best individual of selection operation. If the latter's fitness value is better than the former, then the worst individual is replaced by the best one.
Step 6: Judge the terminating condition of evolution. Judge the terminating condition of evolution, if it is satisfied then the evolution stops, otherwise go to step 3.
Step 7: Decoding. The best individual generated by genetic algorithm is decoded and got the cluster centers.
Step 8: FCM algorithm. Set the cluster center generated by genetic algorithm as the initial value of FCM algorithm. And then get the final cluster results by FCM

IV. EXPERIMENTS AND RESULT

The proposed paper is initialized with Preprocessing step. In this step noise in an image is removed and quality of an image is improved using wiener filter successfully.The method is developed in MATLAB version 13a platform. The result of the proposed method is shown in Figure 1 and 2.
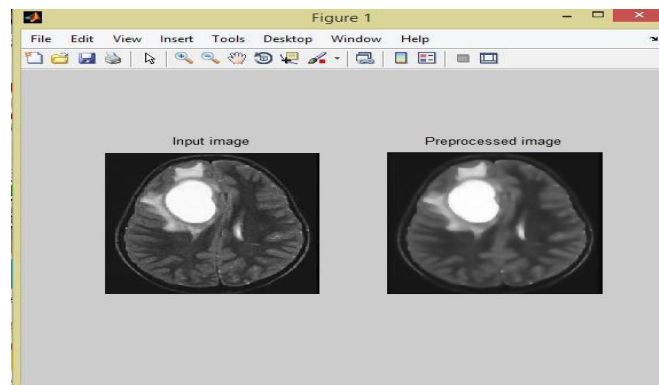

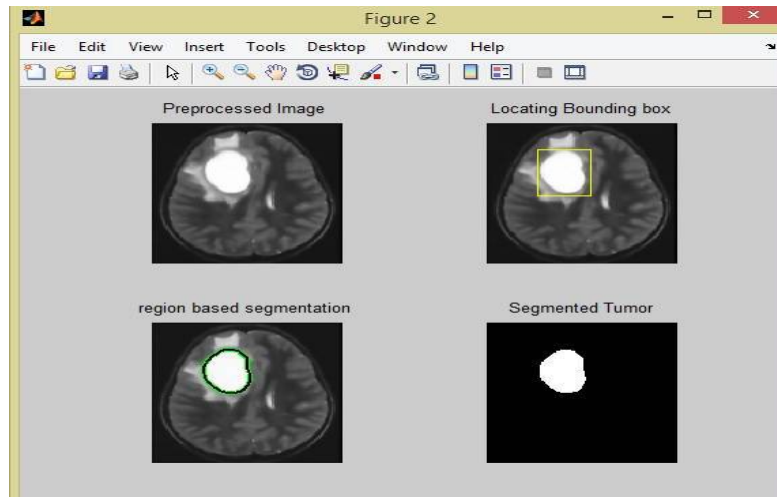**Figure 1 Input and Preprocessed image**

Figure 2 Segmented tumor image

It can be seen from the segmented image that the proposed method segment the tumor part clearly form the given MRI brain image.

V. CONCLUSION

We have presented a new approach for improving semantic image segmentation system using a genetic algorithm. The presented genetic based fuzzy-cmeans algorithm is an optimization algorithm which applies the global minima finding capability of genetic algorithms to find the optimal cluster partitions using the GFCM method. The proposed method allows higher accuracy than traditional FCM . The results are experimented by using MR images and validated the output using cluster validity functions. This paper has some limits, the computational complexity of the objective function is very high.

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[6]**"***Efficient Segmentation methods for tumor for tumor detection in mri images***"**Kailash Sinha1, G.R.Sinha2*1Research Scholar, Department of Electronics & Telecommunication Engineering, Faculty of Engineering &Technology, Shri Shankaracharya Technical Campus Bhilai, India Email: kailash_sinha1310@rediffmail.com2Professor and Associate Director, Faculty of Engineering & Technology, Shri Shankaracharya Technical Campus Bhilai, India*
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