RESEARCH ARTICLE OPEN ACCESS

Segmentation of MRI Brain Image Using Fuzzy C Means For Brain Tumor Diagnosis

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Abstract
Image segmentation aims to separate the structure of interest objects from the background and the other objects. Many good approaches have been developed to segmentation of brain MR images, among them the fuzzy c-mean (FCM) algorithm is widely used in MR images segmentation. Cluster analysis identifies groups of similar objects and therefore helps in discovering distribution of patterns in large data sets. Fuzzy C-means (FCM) is most widely used fuzzy clustering algorithm for real world applications. However accuracy of this algorithm for abnormal brains with edema, tumor, etc is not efficient because of limitation in initialization of this algorithm. In this paper, we have proposed an ant colony algorithm to improve the efficiency of fuzzy c-means clustering. The proposed algorithm is tested in medical images.
Keywords: Magnetic Resonance Imaging (MRI), FIS technique, Fuzzy C-Means, Ant Colony Optimization

I. INTRODUCTION

The basic goal in segmentation process is to partition an image into regions that are homogeneous in nature with respect to one or more characteristics. Segmentation is an important tool in medical image processing and it has been useful in many applications, such as detection of tumors, detection of the coronary border, surgical planning, measuring tumor volume and its volumetric response to therapy, classification of blood cells, detection of micro calcifications on mammograms, heart image extraction from cardiac cine angiograms, etc. In some applications, it may be useful to classify image pixels into regions, such as bones, muscles and blood vessels, while in others into regions, such as cancer, tissue deformities and multiple sclerosis lesions. In recent years, many algorithms have been proposed for brain MRI segmentation. The most popular methods are thresholding, region-growing and clustering. The full automated intensity-based algorithms have high sensitivity to various noise artifacts such as intra-tissue noise and inter-tissue intensity contrast reduction. Clustering is most popular approach for segmentation of brain MR images and typically performs better than the other methods. Clustering is one of the most useful tasks in data mining process for discovering groups and identifying interesting distributions and patterns in the underlying data. Clustering problem is about dividing or partitioning a given data set into groups (clusters) such that the data points in a cluster are more similar to each other than points in different clusters. For example, consider a retail database records containing items purchased by customers. A clustering procedure group the customers in such a way that customers with similar buying patterns are in the same cluster. Hence, the main concern in the clustering process is to reveal the organization of patterns into “sensible” groups, which allows discovering similarities and differences, as well as allowing us to derive useful conclusions about them. This idea of clustering is applicable in many fields such as life sciences, medical sciences and engineering. Clustering may be found under different names in different contexts, such as unsupervised learning (in pattern recognition), numerical taxonomy (in biology, ecology), typology (in social sciences) and partition (in graph theory). In the clustering process, there are no predefined classes and no examples that would show what kind of desirable relations should be valid among the data that is why it is perceived as an unsupervised process. On the other hand, classification is a procedure of assigning a data item to a predefined set of categories. Clustering produces initial categories in which values of a data set are classified during the classification process.

Medical images play vital role to access patients for diagnosis and treatment. Image segmentation is the first step and the most critical tasks of image analysis. Its objective is that of extracting from an image via image segmentation. The computerization of medical image segmentation has found wide application in different areas such as diagnosis, treatment planning, and computer-integrated surgery. Even if computer aided tumor detection is been studied for last two decades, interpretation of MRI image is still a difficult task. Interpretation of this image is very sensitive and multiple radiologists review is needed for reducing probability of misdiagnosis. In this paper, clustering algorithm such as Fuzzy C Mean (FCM) is implemented to extract the suspicious region in MRI image.

II. LITERATURE SURVEY

Martial Heber et al (2005), presented an evaluation of two popular segmentation algorithms, the mean shift-based segmentation algorithm and a graph-based segmentation scheme.

Shen et al. (2005), introduced the new extension of FCM. They introduced two influential parameters in segmentation where address issues of neighborhood attraction. The first parameter is the feature difference between neighboring pixels in the image, and the second one was the relative location of the neighboring pixels. They calculated these two parameters using an artificial neural network through an optimization problem.

Hui Zhang et al (2008), compared subjective and supervised evaluation methodology for image segmentation. Subjective and supervised evaluation are infeasible in various vision applications, so unsupervised methods are necessary. Unsupervised evaluation enables the objective comparison of both different segmentation methods and different parameterizations of a single method.

Ivana Despotovi (2013), presented a new FCM-based method for spatially coherent and noise-robust image segmentation. The contribution was 1) the spatial information of local image features is integrated into both the similarity measure and the membership function to compensate for the effect of noise and neighborhood, based on phase congruency features was introduced to allow more accurate segmentation without image smoothing. The segmentation results, demonstrate that their method efficiently preserves the homogeneity of the regions and is more robust to noise than related FCM-based methods.

Maoguo Gong (2013), presented an improved fuzzy C-means (FCM) algorithm for image segmentation by introducing a weighted fuzzy factor and a kernel metric. The weighted fuzzy factor depends on the space distance of all neighboring pixels and their gray-level difference simultaneously. The new algorithm adaptively determined the kernel parameter by using a fast bandwidth selection rule based on the distance variance of all data points in the collection. Experimental results on synthetic and real images show that the new algorithm is effective and efficient, and is relatively independent of any type of noise.

Salem Saleh Lamari et al (2010), present methods for edge detection techniques for satellite images. They used seven techniques for this category; Sobel operator technique, Prewitt technique, Kiresh technique, Laplacian technique, Canny technique, Roberts technique and Edge Maximization Technique (EMT). They found that Kiresh, EMT and Prewitt are the edge detection technique best techniques for satellite image.

Charbel Fares et al (2011), compared and evaluated image segmentation algorithms. It consists of comparing the performance of segmentation algorithms based on three important characteristics: correctness, stability with respect to parameter choice, and stability with respect to image choice.

In [8] a smoothing filter is applied before using FCM; this is not preferable since some important details may be lost by smoothing filter.

III. ANT COLONY OPTIMIZATION

Ant colony optimization (ACO) is a new metaheuristic developed for composing approximate solutions. Unlike simulated annealing or tabu search, in which a single agent is deployed for a single beam session, ACO and genetic algorithms use multiple agents, each of which has its individual decision made based upon collective memory or knowledge.
Ant Colony Optimization (ACO) is a population based approach first designed by Marco Dorigo and coworkers, inspired by the foraging behavior of ant colonies. Ants are simple insects with limited memory and capable of performing simple actions.
However, the collective behavior of ants provides intelligent solutions to problems such as finding the shortest paths from the nest to a food source. Ants searching for food lay down quantities of a volatile chemical substance named pheromone, marking their path that as it follows. Ants sense pheromone and decide to follow the path with a high probability and thereby reinforce it with a further quantity of pheromone. The probability of an ant chooses a path increases with the number of ants choosing the path at previous times and with the strength of the pheromone concentration laid.

Ants are supposed to be moving over the grayscale image. Doing so, each ant can occupy only one cell, moreover only one ant can be considered in one cell. Each ant has associated with it probability to move to unoccupied region and to leave a pheromone trace. If every adjacent cell is occupied by other ants, the ant will stay in its cell. In a course of processing ants can die and can reproduce.

During initialization ants are placed on grid in random way. Then ants are moved iteration wise. Probability of ant to move and movement direction are chosen by evaluating earlier direction of travel, surrounding ants and pheromone level. Ant movement direction is taken according to data presented in Fig. 1.

1/2	1	1/2
1/4	ANT	1/4
1/12	1/20	1/12

Fig. 1. Ant movement

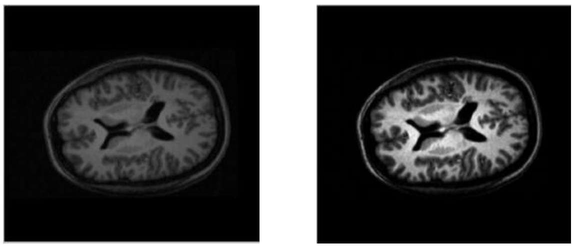
IV. PROPOSED METHOD

Segmentation is partitioning process of image into different parts having similar features. Image pre-processing is done initially, followed by segmentation using clustering technique for extraction of tumour which is region of interest.

A. Pre-processing

Image enhancement is the process of adjusting digital images so that the results are more suitable for display or further analysis. The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide `better' input for other automated image processing techniques. Image enhancement consists of collection of techniques that improve the visual appearance of an image. Whenever an image is converted from one form to another, some degradation occurs at output. Hence, the output image has to undergo image enhancement process. Contrast enhancement is one of the common operations in image processing. It is useful to improve details of images that are over or under-exposed. Hence, in this paper the contrast enhancement is done using the fuzzy inference system. Fuzzy inference system is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping provides the base for making decisions. The process of fuzzy inference involves membership function, fuzzy logic operators and the if-then rules. There are two types of fuzzy inference system in fuzzy logic toolbox: Mamdani-type and Sugeno-type. These two types of inference system varies in the way of output is determined. Fuzzy inference systems are associated with fuzzy-rule-based system and fuzzy-expert system.

The steps followed for image enhancement are:
Step 1: Morphological Processing
Step 2: Conversion of image into fuzzy domain data
Step 3: Membership Modifications
Step 4: Defuzzification
Step 5: Displaying the enhanced image
The fuzzy inference system was compared with other existing techniques based on PSNR values. The following table and figures explains the process of preprocessing stage.



Original image Enhanced image
Fig. 2 Pre-processing

Image Enhancement Techniques	PSNR Values
Median Filtering	17.5904
Histogram Equalization	5.6362
Fuzzy Inference System	20.1790
CLAHE Algorithm	14.9021

Table. 1 Comparison of Image Segmentation Technique on the basis of PSNR values

B. Segmentation

Clustering is the process of classifying objects or patterns in such a way that samples belonging to same group are more similar than that of belonging to different group. There are many clustering strategies, such as hard clustering and fuzzy clustering, each having own special characteristics. In hard clustering, approach to segmentation result is crisp i.e. each pixel of image belongs to exactly one cluster. Therefore issues like poor contrast, overlapping intensities, noise make this segmentation a difficult task. Fuzzy clustering technique is a soft segmentation method, which has been widely studied and successfully applied in image segmentation. Among fuzzy clustering methods, fuzzy C means (FCM) has robust characteristics and retain more information than hard clustering and hence is widely used in image segmentation.

Fuzzy C Means algorithm was developed in 1973 by Dunn and it was enhanced latter by Bezdek in 1981. However the Fuzzy logic was proposed in 1965 by Lofti A Zadak a professor of Computer Science at University of California, Berkeley. Fuzzy logic is a form of many-valued logic simply called as probabilistic logic. It by definition clears that it consider approximate values rather than fixed and

exact. In contrast with traditional logic, having binary values 0 or 1, true or false, fuzzy logic variables have a truth value that ranges in degree between 0 and 1.
Let X is a sample space of points, with a generic elements of X are denoted by x. A Fuzzy set A in X is characterized by a membership function $\mu A(x)$ which is associated with each point in X and is a real number in the interval [0,1], the value $\mu A(x)$ at x represents the grade of membership of x in A. Thus, nearer the value of (x) to unity, higher is the grade of membership of x in A. In the hard clustering process, each data sample is assigned to only one cluster and all clusters are regarded as disjoint collection of the data set but in practice there are many cases, in which the clusters are not completely disjoint and the data could be classified as belonging to one cluster almost as well to another.

This algorithm works by assigning membership to each data point corresponding to each cluster centre, on the basis of distances between the cluster centre and the data points. More the data is near to the cluster centre more is its membership towards the particular cluster centre. Clearly, summation of membership of each data point should be equal to one. After each iteration, the up-gradation of the membership and cluster centres is done.

Parameters:
n : is the number of data points.
v_j: represents the cluster centre.
m : is the fuzziness index m ∈[1, ∞].
c : represents the number of cluster centre.
μ_{ij}: represents the membership of data to cluster centre.
d_{ij}: represents the Euclidean distance between i^{th} and j^{th} data and cluster centre.
Main objective of FCM is to minimize:

$$J(U,V) = \sum_{i=1}^{n} \sum_{j=1}^{c} (\mu ij)^{m} \left\|xi - vj\right\|^{2}$$

Where $\|xi - vj\|$, is the Euclidean distance between ith data and jth cluster centre.
Algorithmic steps for FCM:
Let X ={$x1$, x2, x3 ..., xx}be the set of data points and V = {$v1$, v2, v3 ..., vv}be the set of centres.
Step 1: Randomly select c cluster centers.
Step 2: Calculate the fuzzy membership function μ_{ij} using:

$$\mu_{ij} = \frac{1}{\sum_{k=1}^{c}\left(\frac{dij}{dik}\right)^{\frac{2}{m-1}}}$$

Step 3: Compute the fuzzy centers vj using:

$$v_j = \left(\sum_{i=1}^{n} (\mu ij)^{m} xi\right) \div \left(\sum_{i=1}^{n} (\mu ij)^{m}\right)$$

$\forall j$=1,2,..c.
Step 4: Repeat Step 2&3 until the minimum 'J' value is achieved or $\|Uk+1-Uk\| < \beta$ where,
k: is the iteration step.
β : is the termination criterion between [0, 1].
U = $(\mu_{ij})+c$ is the fuzzy membership matrix.
J: is the objective function.

V. RESULTS

The proposed method was implemented using MATLAB programming language on a computer. At first the basic K means algorithm and fuzzy C mean algorithm was implemented. The parameters such as PSNR, computational time and segmentation accuracy are calculated for both algorithms. Table 2 shows the comparison of basic K means and fuzzy C means algorithm. It is seen that the segmentation accuracy of both algorithms is less. But comparative study shows that fuzzy C means has better accuracy than that of K means. Then to improve the segmentation accuracy Ant Colony Algorithm was implemented for both K means and fuzzy C means algorithm. Table 3 shows the effect of ant colony algorithm on segmentation accuracy.

	FCM	Kmeans
PSNR	14.1293	15.6479
Time	5.4912	1.1232
Segmentation Accuracy	34.0088	12.8662

Table. 2 Comparison of basic K means and fuzzy C means algorithm.

	FCM with ACO	K means with ACO
PSNR	24.5599	25.2458
Time	83.3450	83.6945
Segmentation Accuracy	97.0032	96.7520

Table. 3 Effect of ant colony algorithm on segmentation accuracy.

VI. CONCLUSION

This paper discussed the shortcoming of FCM clustering algorithm for MR images segmentation, which may performs very fast and simple, but this algorithm do not guarantee high accuracy. To improve the accuracy ant colony algorithm was introduced. Results show that fuzzy C means performs well as compared to K means algorithm. After applying the ant colony algorithm the accuracy and the PSNR value of both the algorithm increases but at the cost of time. Further study can be done to reduce the time requirement of ant colony algorithm.

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