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Using Fuzzy C-Means and K-Means Algorithm for optimized Image Segmentation in MRI

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***Abstract*— In this paper, a hybrid Fuzzy C-mean Algorithm has been proposed to get the better and the optimized results of the output of image segmentation in MRI (Magnetic Resonance Imaging). This method is generally based on the modified method of the Fuzzy C-Mean clustering algorithm, while the conventional Fuzzy C-Mean algorithm does not give an appropriate result. This method does not really serve with totally appropriate results but still they are more appropriate than the previous results.**

***Index Terms*— Fuzzy C-Means; K-Means; Magnetic Resonance Imaging; Image Segmentation**

I. INTRODUCTION

Image segmentation is the process of extraction of the information in image processing; Segmentation subdivides the image into its constituents regions or objects. There are different image segmentation algorithms that can be used for different applications, image segmentation algorithms are generally based on one of two basic properties of intensity values: discontinuity and similarity, in first category it is based on the abrupt changes in the intensity in the image such as edges, and in second category it is done by partitioning the image. It is being used for many purposes such as astronomy, machine vision, medical imaging, object detection, recognition tasks, and many more.

For the medical imaging in MRI (Magnetic Resonance Imaging) FCM technique is generally used. Fuzzy C-Mean technique is a much flexible technique then hard clustering techniques, FCM allows the object to belong to the multiple classes unlike hard clustering in which an object exclusively belongs to just a single class.

We are going to use a two clustering techniques for the optimum results from the image segmentation for the medical imaging process that is FCM and K-means.

The K-means clustering algorithm is a method of clustering analysis whose aim is to partitioning N observations into K clusters in which each observation belongs to the cluster with the nearest mean. Generally it is a technique in which the partitioning of the image is done into K clusters. The cluster are formed by calculating the mean of the objects, and further addition is done by recalculating the mean of the previous cluster by using the value of the new object.

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II. MAGNETIC RESONANCE IMAGING

These days MRI has become one of the most common tool for medical diagnostics, one of the reasons for the success of MRI is that it yield the spatial resolution to a very fine level which helps in the detection and delineation of detailed structures, MRI also allows the differentiation of various classes of structures and tissues.

In MRI systems the most prominent component is the large magnet, and along with it are the two set of coils, the so-called gradient coils and radio frequency (RF) coils. An MRI image is a map of RF intensities emitted by tissues. The MRI imaging process can be briefly explained as follows: the gradient coil is used to inject an out-of-phase pulse to perturb the aligned atoms away from the main magnet field. As the atoms realign with the main field, they transmit the energy back, which is detected by the RF coils which in turn generates an MRI image.

III. FUZZY C-MEAN CLUSTERING ALGORITHM

Fuzzy c-means (FCM) clustering algorithm is practical method to partitioning data sets into c classes

For a given data set$X = \{x_1, x_2, \ldots, x_n\} \subset R^s$, FCM is an iterated process which involves cluster center C = $\{v_1, v_2, \ldots, v_c\} \subset R^s$ and membership matrix
$U = (u_{ij}), i = 1,2, \ldots, c; j = 1,2, \ldots, n,$

Where u_{ij} denotes the grade of j^{th} object which belongs to center v_i .

The lists of steps that are followed in the FCM algorithm are:

Step 1: Given a positive integer c which can be decided by some rules. Initialize the membership matrix U by random uniform numbers in interval [0,1].

Step 2: Now Calculate the cluster center C

$$v^i = \frac{\sum_{j=1}^{n} u_{ij}^m x_j}{\sum_{j=1}^{n} u_{ij}^m}, 1 \le i \le C$$

And new membership matrix

$$u_{ij} = \left[\sum_{k=1}^{c} \left(\frac{\|x_j - v_i\|^2}{\|x_j - v_k\|^2} \right)^{\frac{1}{m-1}} \right]^{-1} \quad (m > 1)$$

And update the initialized fuzzy membership matrix $U = (u_{ij})$.

Step 3: Compute the objective function

$$J = \sum_{i=1}^{c} \sum_{j=1}^{n} u_{ij}^{m} \left\| x_j - v_i \right\|^2.$$

Step 4: Given $\varepsilon < 0$, if $\left| J^{(n)} - J^{(n-1)} \right| < \varepsilon$, the procedure end, else go to step 2.

IV. K-Means clustering

The K-Means clustering algorithm is the method of cluster analysis whose aim is to partition N observations into K clusters in which each observation belongs to the cluster with the nearest mean. For the partitioning of the clusters we use K-means criterion,

Based on the knowledge of clusters $D_1, D_2, \dots, D_n$, we can compute the mean vectors. Conversely, based on the knowledge of mean vectors, we can compute the clusters. The criterion function J is a function of the partition of the discrete set D. The algorithm to minimize the criterion is termed as the k-means algorithm. The basic principle is to compute the mean vectors based on the current clustering, re-classify the feature vectors based on updated mean vectors and repeat these two steps until the clustering does not change anymore.

The K-Means or ISODATA clustering algorithm is the most popular example of an algorithm that performs iterative adjustments of c (k in the original algorithm version) cluster centroids.

The central idea of the algorithm is to minimize an overall within-cluster distance from the patterns to the centroids. Usually, except in the case of a quite small number of patterns, an exhaustive search in all partitions of n patterns in c clusters us prohibitive. Instead a local minimum of the overall within-cluster distance is searched by iteratively adjusting c cluster centroids,m_j, and by assigning each pattern to the closest centroid

A. K-Means criterion

Let n_i be the number of feature vectors in class D_i. Let us define the similarity of D_i as

$$S(D_i) = -\sum_{x \in D_i} \|x - \mu_i\|^2$$

Where $\mu_i = \frac{1}{n_i} \sum_{x \in D_i} x$ We solve the unknown mean vectors by maximizing the sum of similarities of all classes. Equivalently, we can maximize the negative of this sum:

$$J(D_1, D_2, \dots, D_c) = \sum_{i=1}^{c} \sum_{x \in D_1} \|x - \mu_i\|^2$$

This is the k-means criterion. Also, it is a measure for the intra cluster variance or square-error criterion.

B. K-Means Algorithm

Based on the knowledge of clusters $D_1, D_2, \dots, D_c$, we can compute the mean vectors. Conversely, based on the knowledge of mean vectors, we can compute the clusters. This observation is important when minimizing the criterion.

The criterion function J is a function of the partition of the discrete set D. The algorithm minimize the criterion is termed as the k-means algorithm. The basic principle is to compute the mean vectors based on the current clustering, re-classify the feature vectors based on updated mean vectors and repeat these two steps until the clustering does not change anymore.

$$\arg\min_{s} \sum_{i=1}^{c} \sum_{x \in D_1} \|x - \mu_i\|^2$$

Where μ is the mean of points in D.

V. Conclusion

In this research we used Fuzzy c-means (FCM) clustering algorithm and k-means algorithm to get the better results of the image segmentation in the Magnetic Resonance Imaging (MRI) for medical diagnosis. By using the output of the FCM clustering algorithm as the input for k-means algorithm it can improve the segmentation accuracy of the MRI than the result that just uses FCM clustering algorithm.

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