IJSEAS

International Journal of Scientific Engineering and Applied Science (IJSEAS) – Volume-2, Issue-5,May 2016
ISSN: 2395-3470
www.ijseas.com

Segmentation & Classification Of MR Images of Brain Tissue Using IFCM & K-NN Algorithm

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Abstract— In the analysis of medical images for computer-aided diagnosis and therapy, segmentation is often required as a preliminary stage. Medical image segmentation is a complex and challenging task due to the intrinsic nature of the images. The brain has a particularly complicated structure and its precise segmentation is very important for detecting tumors, edema, and necrotic tissues, in order to prescribe appropriate therapy. Magnetic resonance imaging (MRI) is an important diagnostic imaging technique for the early detection of abnormal changes in tissues and organs. Unfortunately, MR images always contain a significant amount of noise caused by operator performance, equipment, and the environment, which can lead to serious inaccuracies with segmentation. A robust & improved segmentation technique based on an extension to the traditional fuzzy c-means (FCM) clustering algorithm will be used here. . In this paper, we segmented the MR images by using K-Means clustering and Fuzzy C-Means clustering (FCM) algorithm. In K-means algorithm, number of cluster K is given as input. For testing purpose value of K is taken 6. This algorithm depends on initial set of clusters which are randomly assigned. To overcome this problem FCM algorithm is used. FCM clustering techniques are based on fuzzy behaviour and provide a natural technique for producing a clustering where membership weights have a natural interpretation. These two algorithms are implemented and their performance is analyzed based on their clustering result quality and compared to the K-means clustering .

Keywords-Magnetic resonance imaging (MRI), K-Means Clustering, Fuzzy C-Means Clustering(FCM).

I. INTRODUCTION

Curing the cancer has been a major goal of medical researchers for decades, but development of new treatments takes time and money. Science may yet find the root causes of all cancers and develop safer methods for shutting them down. Approximately 40 percent of all primary tumors successfully treated with surgery and, in some cases radiation. The number of malignant brain tumors appears to be increasing but for no clear reason. Reliable and fast detection and classification of brain cancer is of major technical and economical importance for the doctors. Common practices based on specialized technicians are slow, have low responsibility and possess a degree of subjectivity which is hard to quantify. Brain cancer is a complex disease, classified into 120 different types. So called non malignant (Benign) brain tumors can be just as life-threatening as malignant tumours, as they squeeze out normal brain tissue and disrupt function. Magnetic Resonance Imaging (MRI) has become a widely used method of high quality medical imaging, especially in brain imaging where MRI's soft tissue contrast and non-invasiveness is a clear advantage. MRI provides an unparalleled view inside the human body. The level of detail that can be seen is extraordinary compared with any other imaging modality. Therefore, the majority of research in medical image segmentation concerns MR images.

The distribution of tissue intensities in brain images is very complex, it leads to difficulties of threshold determination. Therefore, thresholding methods are generally restrictive and have to be combined with other methods. Region growing extends thresholding by combining it with connectivity conditions or region homogeneity criteria. Successful methods require precise anatomical information to locate single or multiple seed pixels for each region and together with their associated homogeneity [1]. Clustering could be the process of organizing objects into groups whose members are similar in some way. Cluster analysis is finding similarities between data according to the characteristics found in the data and grouping similar data objects into clusters. A cluster is therefore a collection of objects which are similar between them and are dissimilar to the objects belonging to other clusters. In this research work based on their clustering quality K-Means and Fuzzy C-Means clustering algorithms are examined .

II . K-MEANS CLUSTERING ALGORITHM

A . Description

K-Means is one of the simplest unsupervised learning algorithms that solve the well known clustering problem. The procedure follows a simple and easy way to classify a given image data through a certain number of clusters (assume k clusters) fixed a priori. The main idea is to define k centroids, one for each cluster. These centroids should be placed in a cunning way because of different location causes different result. So, the better choice is to place them as much as possible far away from each other. The next step is to take each point belonging to a given data set and associate it to the nearest centroid. When no point is pending, the first step is completed. At this point it is necessary to re-calculate k new centroids by averaging all of the pixels in the clusters resulting from the previous step. After obtaining these k new centroids, a new binding has to be done between the same data set points and the nearest new centroid. A loop has been generated. As a result of this loop, one may notice that the k centroids change their location step by step until no more changes are done. In other words centroids do not move any more. Finally, this algorithm aims at minimizing an objective function, in this case a squared error function. The objective function:[2]

The clusters are formed according to the distance between data points and cluster centres are formed for each cluster. The basic structure of the FCM algorithm is discussed below. The Algorithm Fuzzy C-Means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters[3].

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

Where $\left\| X_i^{(j)} - C_j \right\|^2$ is a chosen distance measure between a data point $X_i^{(j)}$ and the cluster centre *Cj*, is an indicator of the distance of the *n* data points from their respective cluster centers.

B. K-Means clustering algorithm

The algorithm is composed of the following steps:

1. Pick K cluster centers, either randomly or based on data.
2. Assign each pixel in the image to the cluster that minimizes the distance between the pixel and the cluster center.
3. Re-compute the cluster centers by averaging all of the pixels in the cluster.
4. Repeat steps 2 and 3 until convergence is attained (e.g. no pixels change clusters).

C . Disadvantages of K-Means Clustering

1. K-mean clustering is nothing but an iterative technique of partitioning the image. The quality of the solution depends on the initial set of clusters and the value of K.
2. K-Means clustering algorithm does not yield the same result with each run.

III .FUZZY C-MEANS CLUSTERING ALGORITHM

Fuzzy C-Mean (FCM) is an unsupervised clustering algorithm that has been applied to wide range of problems involving feature analysis, clustering and classifier design. FCM has a wide domain of applications such as agricultural engineering, astronomy, chemistry, geology, image analysis, medical diagnosis, shape analysis, and target recognition. With the developing of the fuzzy theory, the fuzzy c-means clustering algorithm based on Ruspini fuzzy clustering theory was proposed in 1980s. This algorithm is examined to analyze based on the distance between the various input data points.

A . Description

The FCM clustering algorithm introduced by Bezdek is an improvement of earlier clustering methods [4]. It is based on minimizing an objective function, with respect to fuzzy membership U, and set of cluster centroids V

$$J_m(U,V) = \sum_{j=1}^{N}\sum_{i=1}^{C} \mathbf{u}_{ij}^{m} d^2(\mathbf{x}_j, \mathbf{v}_i). \qquad (2)$$

In the above equation, $X = \{x_1, x_2, \ldots, x_j, \ldots, x_N\}$ is a p x N data matrix, where p represents the dimension of each x_j "feature" vector, and N represents the number of feature vectors (pixel numbers in the image). C is the number of clusters. $\mathbf{u}_{ij} \subseteq U(p \times N \times C)$ is the membership function of vector x_j to the i^{th} cluster, which satisfies $\mathbf{u}_{ij} \in [0, 1]$ and $\sum_{i=1}^{C} \mathbf{u}_{ij} = 1$, ($j$ = 1,2,…..N). The membership function is expressed as follows:

$$\mathbf{u}_{ij} = \frac{1}{\sum_{k=1}^{C}\left(\frac{d(\mathbf{x_j}, \mathbf{v}_i)}{d(\mathbf{x}_j, \mathbf{v}_k)}\right)^{2/(m-1)}}. \qquad (3)$$

$V = \{v_1, v_2, \ldots v_i, \ldots\ldots v_c\}$, which is a p x C matrix and denotes the cluster feature centre

$$\mathbf{v}_i = \frac{\sum_{j=1}^{N} (\mathbf{u}_{ij})^m \mathbf{x}_j}{\sum_{j=1}^{N} (\mathbf{u}_{ij})^m} \quad (i = 1, 2 \ldots C). \qquad (4)$$

$m \in (1, \infty)$ is a weighting exponent on each fuzzy membership, which controls the degree of fuzziness. $d^2(x_j, v_i)$ is a measurement of similarity between x_j and v_i

$$d^2(x_j, v_i) = \| x_j - v_i \|^2 \qquad (5)$$

$\|\cdot\|$ can be defined as either a straightforward Euclidean distance or its generalization such as the Mahalanobis distance. The feature vector X in MR images represents the pixel intensities, so $p = 1$. The FCM algorithm iteratively optimizes $J_m(U,V)$ with the continuous update of U and V, until $|U^{(l+1)} - U^{(l)}| \leq \varepsilon$ where l represents the number of iterations[1].

B . Fuzzy C-Means clustering algorithm

The algorithm is composed of the following steps:

1. Initialize $U = [u_{ij}]$ matrix, $U^{(0)}$
2. At l-step: calculate the centers vectors $C^{(l)} = [C_j]$ with $U^{(l)}$
3. Update $U^{(l)}$; $U^{(l+1)}$
4. If $\| U^{(l+1)} - U^{(l)} \| < \xi$ then STOP; otherwise return to step 2.

Here data are bound to each cluster by means of a Membership Function, which represents the fuzzy behaviour of the algorithm. To do that, the algorithm have to build an appropriate matrix named U whose factors are numbers between 0 and 1, and represent the degree of membership between data and centers of clusters. In general introducing the fuzzy logic in K-Means clustering algorithm is the Fuzzy C-Means algorithm. FCM clustering techniques are based on fuzzy behaviour and provide a natural technique for producing a clustering where membership weights have a natural interpretation.

RESULTS

MR images of brain are downloaded from Brain web [5].These MR images are segmented by using K-Means algorithm and FCM algorithm. Figure 1 shows the original and figure 2 shows segmented image obtained by K-Means clustering algorithm. In this algorithm number of cluster K is given as input. For testing purpose the value of K is taken 6. The image obtained after this algorithm has 6 clusters and 12 iterations are required to get this image. As the result of K-means depends upon the initial cluster set which are randomly assigned and value of K, it does not yield the same result with each run. To overcome this problem FCM algorithm is used. The core of a fuzzy set is its membership function. Membership function is a function which defines the relationship between a value in the sets domain and its degree of membership in the fuzzy set. The relationship is functional because it returns a single degree of membership for any value in the domain. Figure 3 shows segmented image obtained by FCM algorithm. The drawback of FCM for image segmentation is that the FCM membership function is sensitive to noise. If an MRI image contains noise or is affected by artefacts, their presence can change the pixel intensities, which will result in an incorrect membership and improper segmentation. These problems must be properly addressed to improve the robustness of the FCM algorithm. Therefore IFCM algorithm will be implemented.

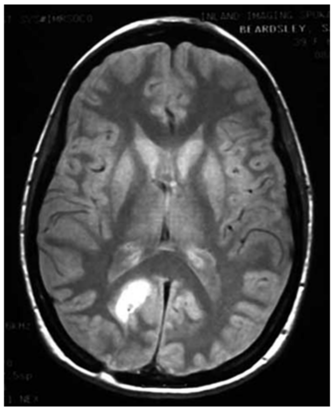

Figure 1.Input MR image.

Figure 2.Segmented image obtained by K-Means clustering.

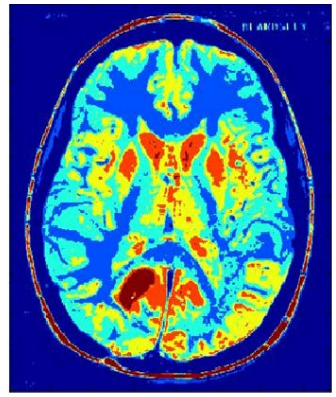

Figure 3.Segmented image obtained by Fuzzy C-Means Clustering

ACKNOWLEDGMENT

We would like to express sincere thanks to Principal and management of Abha Gaikwad Patil College of Engineering, Nagpur for providing the facilities for this research work.

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International Journal of Advanced Research in El ectrical, Electr and Instrumentation Engg. Vol. 3, Issue 12, pp. 13896-13903, December2014 .