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A Review - Various Segmentation Techniques for Brain Tumor Detection

Miss.Dipali B. Shah*, Mr.Nimit S. Modi
*M.E. Student of Computer Department, Sigma Institute of Engineering, Vadodara, India
Assist. Professor of Computer Department, Sigma Institute of Engineering, Vadodara, India

Abstract

In the analysis of medical images for computer-aided diagnosis and treatment, segmentation is required as a primary stage. Medical image segmentation is a complex and challenging task due to the intrinsic nature of the images. The brain has particularly complex structure and its precise segmentation is very useful for detecting tumors, edema, and necrotic tissues, in order to prescribe related therapy. Magnetic resonance imaging (MRI) is an important diagnostic imaging technique for the early detection of abnormal changes in tissues and organs. MRI Imaging forms one of the core methods to identify Brain Tumors, and access the existence, size and volume of the tumor. Clustering is one of the widely used image segmentation techniques which divide patterns in such a way that samples of the same group are more similar to one another than samples belonging to different groups. This paper presents review on some of segmentation methods based on clustering and Region Based with their advantages and disadvantages. Here, also include various measurements like Area, Volume, and Size of tumor

Keywords:. clustering, Region Based, segmentation method, brain tumor, MRI, Genetic algorithm

Introduction

The brain is the most important part of the central nervous system. The structure and function of the brain need to be studied noninvasively by doctors and researchers using MRI imaging techniques. The body is made up of many types of cells. Each type of cell has special functions. When cells lose the ability to control their growth, they divide too often and without any order. The extra cells form a mass of tissue called a tumor [1].A tumor may be primary or secondary. If it is the origin, then it is known as primary. If the part of the tumor spreads to another place and grows on its own, then it is known as secondary [2].

Segmentation is the important tool in medical image processing which helps to make a simple format of medical image which is easier and meaningful to analyse.Image segmentation may be defined as a technique, which partitions a given image into a finite number of nonoveriapping regions with respect to some characteristics, such as gray value distribution, texture distribution, etc [6].It is used in the medical images to identify the tissue or tumor, to measure the volume of tumor, for the radiation therapy and to locate the object and boundaries. Varieties of methods are available for the medical image Segmentation like thresholding, region growing, clustering, etc.

Even though the segmentation helps to identify the region of interest and for other Application, there may be lack of accuracy because of noisy and nonlinear characteristics of the medical images. These undesirable characteristics of the medical image will lead to partial volume effect, presence of artifacts, and Intensity in homogeneity, etc. It is not expected from the images so the pre-processing step is needed before the segmentation. Preprocessing before the segmentation is improving the performance growing is analyzed with and without pre-processing and compared the performance. General biological defects occurring in the brains are tumor [4]. Brain tumor segmentation means segregating tumor from non-tumor tissues. There are various types of malignant tumours such as astrocytoma, meningioma, glioma, medulloblastoma and metastatic, which vary greatly in appearance — shape, size and location. Many approaches are based on fuzzy logic, K means and Neural Networks [6]. This paper is structured in the following way: Section 1 gives introduction to image segmentation. Section 2 provides details on several image segmentation methods. Section 3 defines a set of image segmentation measurement. Section 4 provides conclusion.

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A. Magnetic Resonance Image

Magnetic resonance imaging (MRI), nuclear magnetic resonance imaging (NMRI), or magnetic resonance tomography (MRT) is medical imaging techniques used in radiology to visualize intemal structures of the body in detail.MRI is generally more useful for brain tumor detection because it provides more detailed information about its type, position and size.

MRI is of mainly 2 types:

T1-weighted MRI Spin-lattice relaxation time.

T2-weighted MRI Spin-spin relaxation time.

Another type of MRI is:

T*2-weighted MRI (Contrast Enhance).

Magnetic resonance (MR) sequences such as Tl-weighted, T2-weighted and contrast-enhanced T1-weighted scans provide different information about tumors. On these images, brain tumors appear either hypo intense (darker than brain tissue), or isointense (same intensity as brain tissue), or hyper intense (brighter than brain tissue) [3].

The extraction of brain from the T2-weighted data sets reduced the file size of The MRI and thus decreases the transmission time in a network application. Therefore, stripping the skull in MRI facilitates fast a access to an expert doctor even across hospitals in remote places.

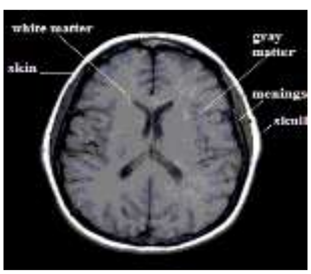


Fig. 1: Brain MR Image [5].

Image segmentation techniques

Now a day, image segmentation play vital role in medical image segmentations. The segmentation of brain tumor from magnetic resonance images is an important task. Manual segmentation is one of the techniques for finding tumor from the MRI. This method is time consuming but also generates errors. Segmentation by expert is variable [5]. Manually segmentation takes at least three hours to complete. Several automated technique have been developed for MRI segmentation. In this paper several automated segmentation techniques are discussed below.

Region growing

It is region based segmentation method. There are various Region growing methods:

Thresholding.

Seed region growing.

Neuro-fuzzy logic.

Thresholding

Threshloding is one of simple image segmentation technique. It is process of separating pixels in different classes depending on their pixels gray levels. A thresholding method determines an intensity value, called the threshold, which separate the desired classes. The segmentation is achieved by taking threshold value. Based on threshold value, pixels are grouping with intensity greater than the threshold into one class and remain pixels grouping into another class. In thresholding technique, image having only two values either black or white. MR image contains 0 to 255 grey values. So, thresholding of MR images ignores the tumor cells [5-2].

Steps required for thresholding:

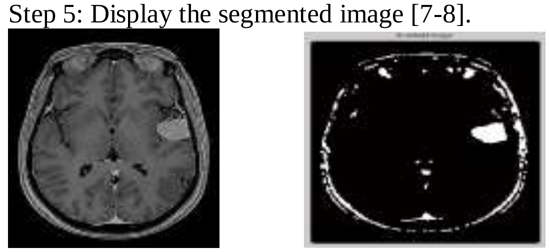
Step 1: Read the MRI image.

Step 2: Convert to read image to gray scale.

Step 3: Use the gray thresh function to obtain the level and effectiveness metric.

Step 4: Using the level value convert the input image to black and white.

Step 5: Display the segmented image [7-8].



(a) **(b)**

Figure 2: (a) Original Image (b) Image after threshold technique [8].

Seed region growing

This process is first requirement of manually select seed points. Selection of seed points is based on user criteria. It is also iteration based method, like clustering algorithms.The algorithm steps for region growing technique are below:

1. In the first step manually select seed points.
2. In the next steps pixels in the region of seeds are examined and added to the region accordance with the homogeneity criteria. This process is continued until all pixels belong to some region.
3. And in last step the object illustration is done by growing regions of pixels [5-4].

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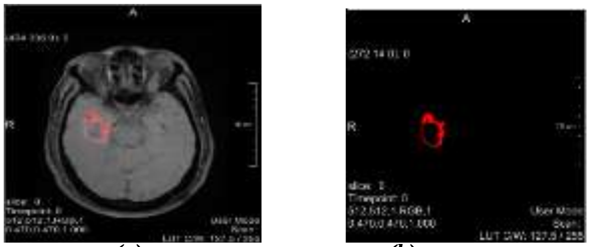

(a) (b)
Fig.3 region growing segmentation with pre-processing (a) seed point selection (b) segmented tumor [4].

Neuro-fuzzy logic

Fuzzy Neuro logic to detect various tissues like white matter, gray matter; cerebral spinal fluid and tumor for a given magnetic resonance image data set. A Neural Network is used in order to significantly reduce the computation time, and misclassification rate of the system.

Step 1: Read the given image, and convert it into a matrix form where each pixel value is in the range from 0-255.
Step 2: Apply median filtering to remove noise.
Step 3: Create fuzzy interference system.
Step 4: Decide the number and type of Membership functions for the input image by tuning the membership functions. The following fuzzy rules are used in the proposed algorithm for clustering.
1) If the mean value is low and the standard deviation value is low then it is not an edge pixel.
2) If the mean value is medium and the standard deviation value is low then it is an edge pixel.
3) If the mean value is high and the standard deviation value is low then it is not an edge pixel.
4) If the mean value is low and the standard deviation value is high then it is not an edge pixel.
5) If the mean value is medium and the standard deviation value is high then it is not an edge pixel.
6) If the mean value is high and the standard deviation value is high then it is not an edge pixel
Step 5: Apply Fuzzy classification using the rules developed above on the corresponding pixel Values of the input image which gives a fuzzy set represented by a membership function. Check the rules using rule viewer and surface viewer.
Step 6: Choose the cluster centers and extract the Features.
Step 7: Clustering is done based on similarity measures.
Step 8: Update the membership function and cluster centers.
Step 9: Calculate the cost function and update the weights.
Step 10: Test the stopping condition and convert the column form to matrix form and display the Segmented image [6].

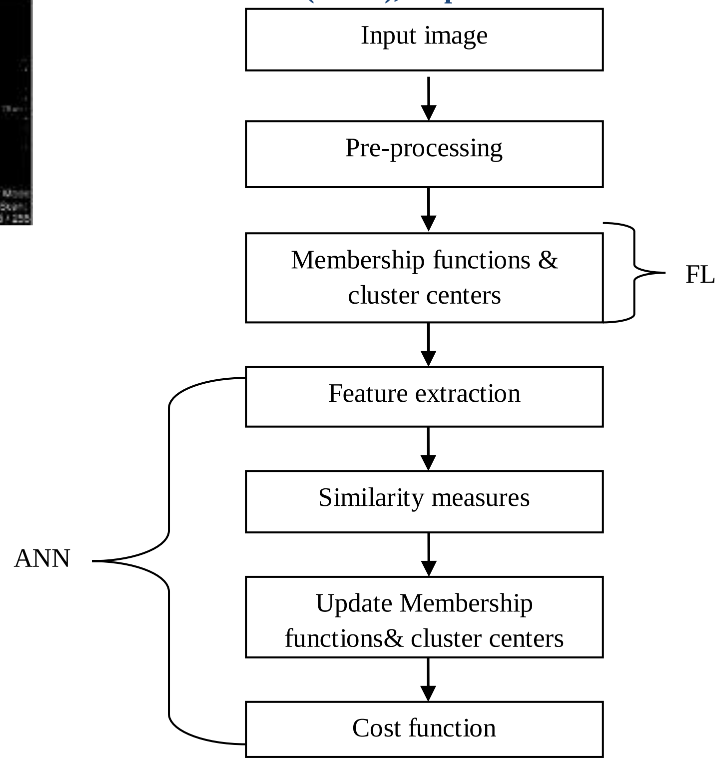

Figure 4: flow diagram [6].

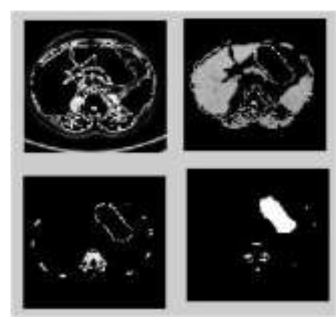

Figure 5: fuzzy-neuro logic [6].

Clustering based

Clustering the process of collection of objects which are similar between them and are dissimilar objects belonging to other clusters. Clustering is suitable in biomedical image segmentation when the number of cluster is known for particular clustering of human anatomy [5].

K-Mean clustering

K-means is one of the simplest unsupervised learning algorithms that solve the well known clustering problem [1-6].
A cluster is a collection of objects which are similar between them and are dissimilar to the objects belonging to other Clusters.

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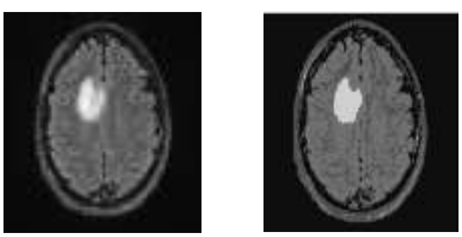
Clustering is an unsupervised learning method which deals with finding a structure in a collection of unlabelled data. A loose description of clustering could be the process of organizing objects into groups whose members are similar in some way.
K-means clustering is an algorithm to group objects based on attributes/features into k number of groups where k is a positive integer. The grouping (clustering) is done by minimizing the Euclidean distance between the data and the corresponding cluster centroid. Thus the function of k-means clustering is to cluster the data [1-2].
The procedure follows a simple and easy way to classify a given data set through a certain number of clusters.
Step1: choose K initial centers $z_1(1), z_2(2)$, which are arbitrary.
Step 2: At the k^{th} iterative step, distribute the sample $\{X\}$ the K Cluster Domain, using the
Relation $X \in s_j(k)$
If $\|X - z_j(k)\| < \| X - z_i(k) \|$, where $s_j(k)$ is set of sample whose cluster center is $z_j(k)$.
Step3: From the result of step 2, calculate the new clusters $z_j(k+1)$, where $j = 1,2, \ldots k$

$$z_j(k+1) = \frac{1}{n_j}\sum x, X \in s_j(k) \qquad \text{...... (1)}$$

Where n_j is the number of samples in $s_j(k)$and the cluster centers are sequentially updated.
Step4: If $z_j(k+1) = z_j(k)$ then the algorithm is said to have converged and the procedure is terminated, otherwise go to step 2[6].



(a) ***(b)***
Figure 6 :(a) MRI brain (b) Result image[1].

Fuzzy c-mean

Fuzzy C-means is an overlapping clustering technique. One pixel value depending on Two or more clusters centers. It is also called soft clustering method. One of the most widely used fuzzy clustering algorithms is the Fuzzy C-means (FCM) algorithm [5, 2].
I.FCM is an iterative algorithm. The aim of FCM is to find cluster centers (centroids) that minimize a dissimilarity function. The algorithm is defined by the following steps.

Step1. Randomly initialize the membership matrix U according to

$$\sum_{i=1}^{c} u_{ij} = 1, \forall j = 1, \ldots, n \qquad \text{...... (2)}$$

Step2. Calculate the centroid using

$$c_i = \frac{\sum_{j=1}^{n} u_{ij}^m x_j}{\sum_{j=1}^{n} u_{ij}^m} \qquad \text{...... (3)}$$

Step3. Compute dissimilarity between centroids and data points using

$$j(u, c_1, c_2, \ldots\ldots, c_c) = \sum_{i=1}^{c} j_i = \sum_{i=1}^{c}\sum_{j=1}^{n} u_{ij}^m d_{ij}^2 \qquad \text{...... (4)}$$

Where $u_{ij}$is between 0 and 1; c_i is the centroid of cluster i; $d_{ij}$is the Euclidian distance between i^{th} centroid(c_i) and j^{th}data point; and m $\epsilon[1,\infty]$ is a weighting exponent. Stop if its improvement over previous iteration is below a threshold [6].
Step4. Compute a new U using

$$\boldsymbol{u_{ij}} = \frac{1}{\sum_{k-1}^{c}\left(\frac{d_{ij}}{d_{kj}}\right)^{\frac{2}{m-1}}} \qquad \text{...... (5)}$$

By iteratively updating the cluster centers and the membership grades for each data point, FCM iteratively moves the cluster centers to the "right" location within a data set [6].

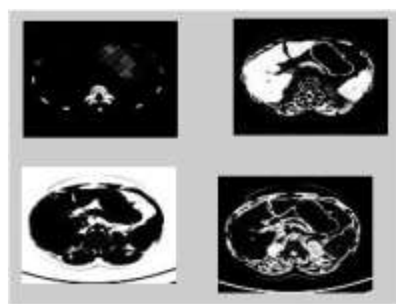


Figure: 7 Fuzzy C- Mean [6].

Fuzzy C-means is a popular method for medical image.

OPTICS

Ordering Points To Identify the Clustering Structure .OPTICS defines the core distance which is the shortest distance from the core that contains the minimum number of points. Those points within the radius of the core distance may contain points far from the core than all the other points located within the same core distance[9]. OPTICS algorithm is dealing with all slices of brain in parallel and it made the cluster by combining all the points which can be easily extracted.
Following are the steps for OPTICS:
Step 1. Specify ε and MinPts.
Step 2. Mark all the points in the dataset as unprocessed.

Step 3. For each unprocessed point, find its neighbors w.r.t parameters ε and MinPts. Mark the point p as processed.
Step 4. Set the core-distance for the point.
Step 5. Add the point to the order file.

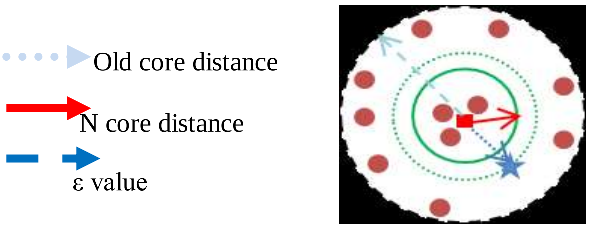


Figure 8: illustrated enhancement in core-distance [9].

Performance measures parameters

Volume measurement

Volume measurement of particular gland, tumor, and tissue using medical images are very important and also critical. the volume estimation is, sum all pixels in the region (Nr) and multiplies the summation value with the corresponding pixel area (A). The result is multiplied by the distance between medical image slices (D) and computing the region volume. This method is less complex and takes less time for the computation [4].

$$volume = \sum N_r \times A \times D \quad \text{..... (6)}$$

Neuro-fuzzy logic	It is used in order to significantly reduce the computation time, and misclassification rate of the system	Missclassification rate can be improved
K-Mean clustering	K-Means produce tighter clusters than hierarchical clustering, especially if the clusters are globular.	It does not work well with clusters (in the original data) of Different size and Different density Difficult to predict K-Value
Fuzzy c-mean	Fuzzy c-means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters.	FCM is not able to find abnormal tumor and it gives multiple solution which is not perfect. FCM algorithm takes huge computational time for convergence
OPTICS	OPTICS is able to detect the abnormal as well as irregular shape tumor. OPTICS is a Faster.	The value of ε might heavily influence the cost of the algorithma value too large might raise the cost of a neighborhood query to linear complexity.

Size measurement

It will measure tumor size. Here 256x256 JPEG image is a maximum image size. The binary image can be represented as a summation of total number of white and black pixels [2].

$$No\_of\_white\ pixel,\ p = \sum_{w=0}^{255} \sum_{H=0}^{255} [f(0)] \quad \text{... (7)}$$

Where, P = number of white pixels (width*height),1 Pixel = 0.264mm
F (0) =white pixel (digit 0)

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Area measurement

It will measure area of tumor.

Size_of_tumor,$s = \left[\left(\sqrt{p}\right) * 0.264\right] mm2.$ ..(8)

P = no of white pixels; W = width; H = height.

Table 9. Comparison table for segmentation method.

Image Segmentation Method	Advantage	Disadvantage
Thresholding	The simplest method of image segmentation. This method is based on a clip-level (or a threshold value) to turn a gray-scale image into a binary image.	Thresholding method ignored spatial characteristics which are important for malignant tumor detection.
Seed region growing	Region growing segmentation is a simple method which extracts the region of interest exactly.	Region based segmentation it needed more user interaction for the selection of seed.

Conclusion

From this paper we can show that Region growing segmentation is a simple method which extracts the region of interest exactly. Pre-processing which eliminate the noise and unwanted region which leaded to a better output. It is seen that the misclassification rate is less in fuzzy-Neuro. If there is any noise present in the MR image it is removed before the K-means process. The noise free image is given as input to the k-means and tumors are extracted from the MRI image. In fuzzy c-mean problem of over segmentation but it is popular method in medical segmentation. OPTICS less sensitive to the variant density data. Using OPTICS we can also have a actual real time information about dimensions of the Tumor.

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