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Detection of Brain Tumor in MRI Images Using Mean Shift Algorithm and Normalized Cut Method

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Abstract—This paper introduces an efficient method for detection of brain tumor from Magnetic Resonance Images (MRI). In the process of detection of tumor from MRI, segmentation plays vital role for partitioning an image into different subregion with homogeneous properties. The methodology introduced here consist of combination of two conventional algorithms i.e. Mean shift algorithm and Normalized cut (Ncut) Method which provides automatic detection of exact surface area of brain tumor in MRI. By incorporating the advantages of the mean shift segmentation and Ncut method, Magnetic Resonance image (MRI) will be preprocessed first by using the mean shift algorithm to form segmented regions, then Ncut method will be used for region nodes clustering after this connect component extraction analysis is used to locate the exact tumorous area in MRI Images.

Index Terms— Mean shift, Normalized cut (NCut), tumor.

I. INTRODUCTION

A space within the skull is covered by the brain tumor which causes the disturbance of normal brain activity. It can increase pressure in the brain, shift the brain or push it against the skull, and/or invade and damage nerves and healthy brain tissue. The location of a brain tumor influences the type of symptoms that occur. Identifying the presence of a brain tumor is the first step in determining a course of treatment. Identification of a brain tumor generally involves a neurological examination, brain scans, and/or an analysis of the brain tissue. Doctors use the diagnostic information to classify the tumor from the least aggressive (benign) to the most aggressive (malignant). Identifying the type of tumor helps doctors determine the most appropriate course of treatment. There are number of techniques to segment an image into regions that are homogeneous. As the structure of MR image or any medical images is inaccurate and complex these techniques are not suitable for their analysis in order to extract the useful features, in this paper a improved technique to solve the problem of segmenting a complex MRI has been introduced which is combination of two conventional methods i.e., Mean shift clustering and Normalized cut (Ncut). If this combination of two algorithms were used to detect the tumor region in MRI it can provide simplicity as well as speed for segmenting MR image. Clustering plays crucial role while executing the task of organizing the objects into groups based on its properties. A cluster is therefore a set of objects which are "analogous" between them and are "dissimilar" to the objects belonging to other clusters.[8] The concept of mean shift estimating the probability density gradient function is discussed by Cheng Yizong [2] according to which Mean shift algorithm has been extensively applicable in the area of computer vision like tracking, image segmentation edge extraction, motion estimation, feature space analysis, filtering, video analysis and for other numerous tasks, on the other hand this algorithm cause failure because of its over segmentation phenomenon. Graph cut segmentation is the another development for solving the crucial task of image segmentation in which pixels are considered as nodes and unidirected weighted graph is used while segmenting an image by using Graph cut method. While partitioning the graph, deciding precise criterion for good partition and computation of such partition are the primary requirements. In order to resolve these requirements image segmentation approach based on Normalized cut (Ncut) has been proposed by Shi and Malik [1]. Ncut algorithm finds wide acceptance not only in the field of image processing but also in related fields like motion picture, medical imaging and vector field of segmentation. However this algorithm fails when there are more pixels in the image due to which more number of graph nodes are generated which causes complexity to solve the algorithm.

Based on above two algorithms an improved method is implemented in order to overcome the drawbacks of both algorithms. For verification of its improved performance it is applied on various MRI and its results in constraints with the computational time and diseased area calculation are verified.

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II. MEAN SHIFT ALGORITHM AND NORMALIZED CUT SEGMENTATION

A. Mean Shift algorithm

Mean shift clustering is non-parametric clustering technique which does not require prior knowledge of the clusters. This is an iterative method, starting with an initial estimate d. Let K (di − d) be a given Kernel function[6][2] . This function determines the weight of nearby points for re-calculation of the mean. Typically Gaussian kernel is,

$$m(d) = \frac{\sum_{d_i \in N(d)} K(d_i - d) d_i}{\sum_{d_i \in N(d)} K(d_i - d)}$$

used on the distance to the current estimate, $K(d_i - d) = e^{c\|d_i - d\|}$. The weighted mean of the density in the window determined by K is

$$m(d) = \frac{\sum_{d_i \in N(d)} K(d_i - d)d_i}{\sum_{d_i \in N(d)} K(d_i - d)}$$

where N (d) is the neighborhood of x, a set of points for which. K (d) ≠0

The mean-shift algorithm now sets, d ← m (d) and repeats the estimation until

m(d) converges.

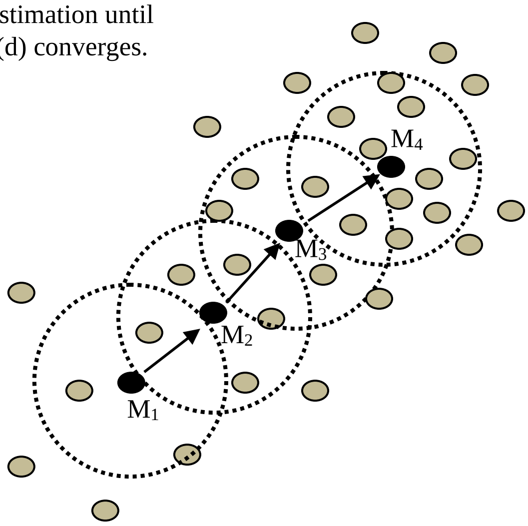

Fig.2.1 Mean shift procedure showing how densest region is calculated by estimating the mean of data points within the spherical window which is defined around M1 data point and shift the centre at the mean of this data points until densest region is reached which is area around M4 in this case.

An example illustrating mean shift procedure is shown in Fig.2.1 The shaded and black dots denote the data points of an image and successive window centers respectively. Mean shift procedure starts at Point M1, by defining spherical window of radius r around it, algorithm then calculates the mean of data points that lie within the window and shifts the window to the mean and iterates the same procedure until peak is reached. At each iteration window is shifted to the more densely populated region.[2]

B. Ncut Method for Segmentation

Normalized cut is a global criterion for partitioning the graph used for segmentation of image[1]. Normalized cut criterion measures both the total dissimilarity and similarity between different groups.

A graph G = (V, E) can be partitioned into two disjoint sets, A, B, A U B, =V, A intersection B= Ø by simply removing edges connecting the two parts. The degree of dissimilarity been removed. In graphical language, it is called the cut.[4]

$\text{cut}(A, B) = \sum_{\mu \epsilon A, \vartheta \epsilon B}^{n} W(\mu, \vartheta)$ ……. (1)

The successful bipartitioning of a graph is the done when it minimizes this cut value. Although there are a various number of such partitions, in the past lot of work was done for finding the minimum cut of a graph. Wu and Leahy [11] proposed a clustering method based on this minimum cut criterion. They partition a graph into k-sub graphs such that the maximum cut across the subgroups is minimized. By finding the minimum cut this problem can be efficiently solved by them. However the minimum cut criteria favors cutting small sets of individual nodes in the graph. Fig illustrates one such case

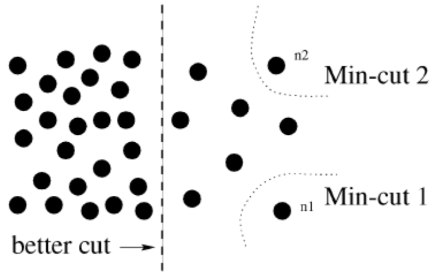

Fig 2.2.An Example Illustrating that Minimum Cut gives a Bad Partition.

From figure 2.2 any cut those partitions out individual nodes on the right half will definitely have smaller cut value than the cut that partitions the nodes into the left and right halves. To avoid this problem of partitioning small sets of points, [1] propose a new measure of finding cut between two groups. Instead of looking at the value of total edge weight connecting the two partitions, they computes the cut cost as a fraction of the total edge connections to all the nodes in the graph and call this disassociation measure the normalized cut (Ncut).[3]

$N\,\text{cut}(A, B) = \frac{\text{cut}(A,B)}{\text{assoc}(A,V)} + \frac{\text{cut}(A,B)}{\text{assoc}(B,V)}$……….(2)

Where

$\text{assoc}(A, V) = \sum_{\mu \epsilon A, t \epsilon V}^{n} W(u, t)$ is a total connection from nodes A to all nodes in the graph and assoc(B,V) is similarly defined. However if there are more pixels in the image, more graph of nodes will be generated and this will cause difficulties to solve this algorithm.

III. METHOD

A. Focused Images

In order to segment a complex and inaccurate MRI, various MRI scans of different patients containing tumors were examined for detection of tumor from it and calculation of its parameters i.e area, centroid, eccentricity, and bounding box was done.

B. Implementation

Proposed method is the combination of two conventional algorithms of segmentation i.e Mean shift algorithm and normalized cut method followed with connect component extraction analysis (CCE) for calculation of exact tumor area from magnetic resonance images (MRI). Fig. 3.1 shows block diagram of proposed method.

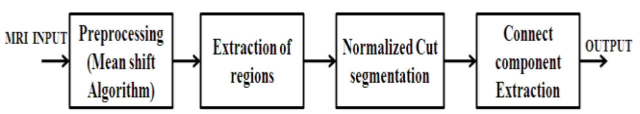

Fig.3.1 Block Diagram of Proposed Method involving Combination of Mean shift Algorithm and Ncut segmentation

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A image was preprocessed into multiple separated regions by using mean shift algorithm so each region will be extracted, and one region nodes will be used instead of one region. These region nodes produces an information about feature vector and spatial location. These region nodes are represented as a weighted unidirected graph which is input to the Ncut algorithm, and used for constructing the weight matrix W, and then used the Ncut method for region nodes clustering. After this connected component extraction analysis is applied (CCE) which extracts the regions which are not separated by boundary after region boundaries have been detected. Any set of pixels which is not separated by the boundary is called connected component, the set of connected components partition an image into segments. And finally area calculation of detected tumor is done.
Proposed Method consist of following steps

Step 1 Before applying the Ncut the data is preprocessed which is output from mean shift to find insignificant cluster to make it background and generate the input data for Normalized cut (Ncut).

Step 2 After this weight matrix is generated, weight between any two nodes is the Euclidean distance between the intensity vectors of pixel corresponding to the nodes, the Ncut is applied on this pixels or region nodes.

Step 3 According to the step 2, these region nodes are represented as a weighted undirected graph, the graph as the Ncut algorithm input, and use these region nodes to construct the weight matrix W, and then use the Normalized cut (Ncut) method for region nodes clustering.

Step 4 Finally the connected component extraction analysisis applied to the Ncut output image was applied, in which various properties of the region was calculated i.e area, centroid, bounding box, eccentricity. These properties were used to determine the shape of the region which are explained as follows.

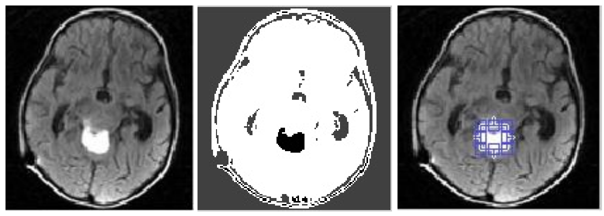
IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

When Normalized cut (Ncut) method is directly applied on MRI, it takes more time for segmenting MRI because of more number of graph nodes are generated . This problem can be overcomed by preprocessing an image using mean shift algorithm before applying an Ncut algorithm to get results in less time. In this work we provide a improved image segmentation method for determining the tumor in the magnetic resonance image (MRI) which calculates the exact tumor area, its centroid, eccentricity, and bounding box. For measuring the performance of improved image segmentation method, it is applied on various MR images and output of this algorithm at various stages is determined. Table 4.1 shows various calculated parameters of detected tumor in MRI.

Experiments were performed by taking a variety of magnetic resonance images from different planes and proposed image segmentation algorithm was applied on it. First experiment was performed by taking MRI from axial section having tumor in limbic lobe shown in fig 4.1, as an input and it was found that for this MRI input, tumor area was found to be 156 i.e 156 pixels were lie in the tumor. And eccentricity was 0.7759 and when it is equal to 1 it represents straight line so the tumor in this MRI was horizontally spreaded ellipse. The total time required for extraction of tumor was 18.27 seconds.

Fig 4.2 shows Magnetic resonance image in axial section having tumor present in the frontal lobe was processed by proposed algorithm in second experiment and at the output tumor area was found to be 435 i.e 435 pixels were lie in the tumor. And eccentricity was 0.39 and when it is equal to 0 it represents circle so the tumor in this image was closed to circular ellipse. The total time required for extraction of tumor was 9.55 seconds.

In third experiment MRI in sagittal section having tumor in occipiteal lobe as shown in fig 4.3 was considered as an input and area was found to be 843 i.e 843 pixels were lie in the tumor which is maximum amongst the previous two experiments . And eccentricity was 0.4401 and when it nearly equal to 0 so the tumor in image 4.3 was closed to the circular tumor. The total time required for extraction of tumor was 9.23 seconds which was less than the previous two inputs.

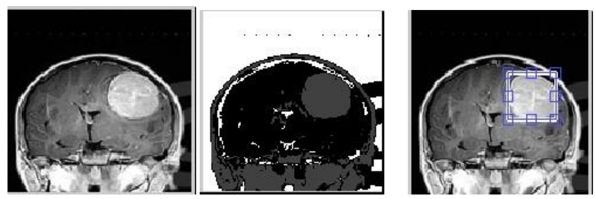


(a) (b) (c)

Fig 4.1 Magnetic resonance image of human brain showing axial section and having tumor in limbic lobe (a) Input Image (b) Resultant Image after Applying Mean-shift Algorithm (c) Result of Proposed Algorithm

(a) (b) (c)

Fig 4.2 Magnetic resonance image of human brain showing axial section and having tumor in frontal lobe (a) Input Image (b) Resultant Image after Applying Mean-shift Algorithm (C) Result of Proposed Algorithm



(a) (b) (c)

Fig 4.3 Magnetic resonance image of human brain showing sagittall section and having tumor in occipiteal lobe (a) Input Image (b) Resultant Image after Applying Meanshift Algorithm (c) Result of Proposed Algorithm

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Table 4.1 Various Calculated Parameters for Detected Tumor

INPUT	CALCULATED PARAMETERS			
	AREA	CENTROID	ECCENTRICITY	BOUNDING BOX
MRI 1	**156**	**[62.71 85.35]**	**0.77**	**[53.50 76.50 17 15]**
MRI 2	**435**	**[76.88 44.98]**	**0.39**	**[66.50 32.50 23 26]**
MRI 3	**843**	**[87.56 60.97]**	**0.44**	**[70.50 44.50 34 32]**

V.CONCLUSION

Mean shift algorithm is an efficient method of clustering, which segments the magnetic resonance image (MRI) into multiple separated regions having homogeneous properties. However on applying Ncut method on MRI it takes more time for segmentation because of more graph nodes are generated which causes the difficulties to solve this algorithm. In this paper a image segmentation algorithm has been implemented and it is based on the conventional mean shift algorithm and Ncut algorithm. The effectiveness of the proposed algorithm have verified by some experimental results to express its improved performance in detecting the shape and spread of tumor by calculating the parameters of tumor in magnetic resonance image.

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