A Review of Segmentation Methods for Detection of Brain Tumor in MRI

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Abstract - **In addition to computed tomography (CT), magnetic resonance imaging (MRI) provides wide range of physiological and anatomical information. In the process of detection of tumor in MRI, segmentation plays vital role for partitioning an image into different subregion with homogeneous properties. In this paper various methods that have been used for segmentation in MRI are reviewed and a new approach by incorporating the advantages of Mean shift and Normalized cut (NCut) method is also included.**

Keywords - **Segmentation, Mean shift, Normalized cut (NCut), Tumor.**

I. INTRODUCTION

Human body is made up of many types of cells. Each type of cell has special functions. Most cells in the body grow and then divide in an orderly way to form new cells as they are needed to keep the body healthy and working properly. 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. Majority of the times children's as well as adults death are due to brain tumor, hence detecting of brain tumor at its early stage with its accurate diagnosis is very important. Identification of tumor involves test like CT and MRI. MRI plays vital role in identifying location, size and type of brain tumor.

Brain tumors can be cancerous (malignant) or non-cancerous (benign), however usually other types of cancerous or non-cancerous tumors in the body are defined differently from tumor located that in brain. Its treat level depends on the combination of factors like the type of tumor, its location, its size and its state of development. Because the brain is well protected by the skull, the early detection of a brain tumor only occurs when diagnostic tools are directed at the intracranial cavity. Usually detection occurs in advanced stages when the presence of the tumor has caused unexplained symptoms.

Densing of tissues is one of the symptoms of cancer. When tissues are caused with cancer they pulled the surrounding tissues towards them. Tumors are treated by examining them for location, shape, density, size, and edges. Mostly the nature of the benign tumors is circumscribed, compact and elliptical. Malignant tumors usually have faint boundary and appearance. Brain tissue and tumor segmentation in MR images is proven to be an important area of research in order to detect or extract the tumor from MR image. For analysis and understanding of an image, segmentation is an important process. In general segmentation is partitioning of an image into different sub regions having same label and similar properties. [5]

As the brain structure is very complex involving white matter (WM), gray matter (GM), and cerebrospinal fluid (CSF) this makes feature extraction of brain images as a basic work. Recently MR images are handled manually for the diagnosis of brain tumor which involves errors and consumed time as due to large variation of the various images indicating varied brain structure. 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 brief study of the segmentation techniques used in medical image analysis are discussed along with improved image segmentation algorithm which provides effective results that is less time consuming and also calculates the exact area of tumor.

II. SEGMENTATION TECHNIQUES

For the extraction of useful features from the complex brain structure Magnetic resonance imaging (MRI) is reliable. MRI is very important in order to improve the diagnosis and treatment of brain tumor, by detecting tumor at its early stage. Segmentation of medical images is first important step in their analysis, the segmentation gives organ detection and variation of growth of tissues as a output in medical images. In this paper several segmentation techniques are discussed as below.

A. Mean shift

Mean shift clustering is non-parametric clustering technique which does not require prior knowledge of the clusters. Mean shift algorithm clusters an n-dimensional data set. For each point mean shift computes its associated peak by first defining a spherical window at the data point of radius r and computing the mean of points that lie within the window. Algorithm then shifts the window to the mean and repeats until convergence. At each iteration the window will shift to a more densely populated portion of data set until peak is reached where data is equally distributed.

The procedure of situating maximum value of density function among the given isolated data sampled from that function. This is an iterative method, starting with an initial estimate d. Let K $(d_i - d)$ be a given Kernel function. . 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. $K(d) \neq 0$

The mean-shift algorithm now sets, $d \leftarrow m(d)$ and repeats the estimation until $m(d)$ converges.

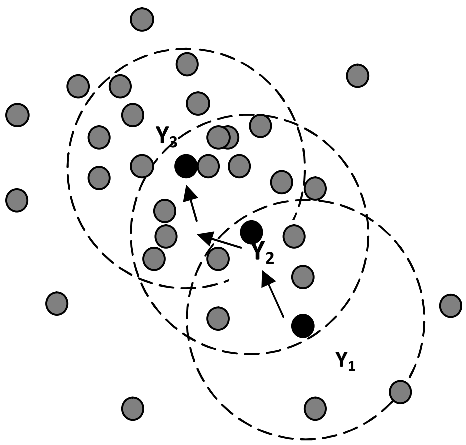


Figure: 1 Mean shift procedure

An example illustrating mean shift procedure is shown in Figure 1. The shaded and black dots denote the data points of an image and successive window centers respectively. Mean shift procedure starts at Point Y_1, 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. [3][6].

B. Histogram Thresholding

An image histogram is a type of histogram that acts as a graphical representation of the intensity distribution in an image. It plots the number of pixels for image intensity values. By looking at the histogram of image observer will be able to give the intensity distribution of an entire image. Histogram thresholding is most uncomplicated image segmentation process. Since thresholding is fast and economical in computation. For segmenting background and objects, a threshold is selected which is depend on the brightness of an image is used If Single threshold is defined for different elements in an image is known as local threshold whereas, if Single thresholds is defined for complete image is known as global threshold.

For determining the thresholds, threshold recognition approaches were used. Threshold recognition approaches are optimal thresholding, p-tile thresholding and histogram shape analysis. Optimal thresholding is used when there is closest gray level corresponding to maximum two or more intensity distributions present in an image. However this segmentation is less error prone. For color or multi band images multi-spectral thresholding is suitable.

Mathematically, a histogram is a function z_i that counts the number of pixels that fall into each of the different intensity levels Thus, if we let a be the total number of pixels and b be the total number of image intensities, the histogram z_i meets the following conditions,

If a Single threshold is defined for complete image is known as global thresholding. Figure 2 shows the histogram corresponds to an image $f(x,y)$, which consist of light object on a dark background and it is considered that object and background pixels intensity values are grouped into two dominant modes. Then by selecting the suitable threshold Thr the object can is extracted from the background such that point (x, y) by in the image where $f(x, y) > Thr$ determines the object point otherwise indicates background point. Mathematically, segmentated image $P(x, y)$ is given by.

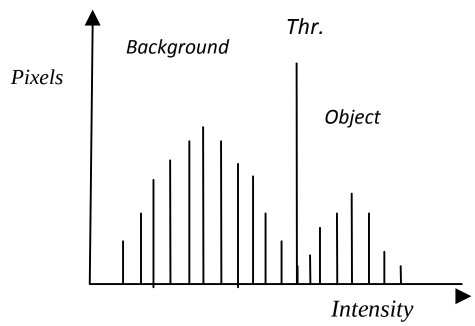


Figure 2: Intensity histogram that can be partitioned by single threshold to separate object from background.

C. Region Growing

As discussed in previous section the main objective of segmentation is to partition an image into regions. Segmentation is done with threshold based on distribution of the intensities of the pixels in an image. Region growing is a technique of segmentation in which pixels with similar intensities are grouped in order to find the regions directly. This group of pixels belonging to the region of focus is known as seeds. The similarity criteria of the pixels depend not only on the problem under consideration, but also on the type of image data available. The algorithm of region growing technique can be stated as follows. [1]

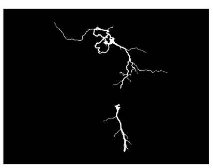
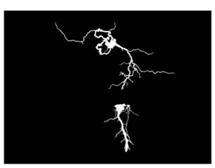
1. In the first step pixel or group of pixels which belongs to the region of interest called seeds are formed.
2. In the next step pixels in the region of interest are examined and added to the growing region in accordance with the homogeneity criteria. Until no more pixels can be adjoined to the growing regions, this step continues.

3. And in last step the object illustration is done by all added pixels to the growing regions.

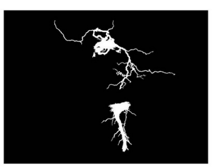
In the medical image segmentation field region growing technique can be applied in kidney segmentation, cardiac images, extraction of brain surface etc. The key advantage of region growing technique is, these methods can correctly separate the regions that have the same properties that are define. One of the drawbacks of this method is, noise or variation of intensity may result in over segmentation.

Figure 3 shows an example of region growing applied on the gray-scale lightning image the purpose of applying region growing on this image to mark the strongest lightning part. Figure 1 is the original gray-scale lightning image. The gray-scale value of this image is from 0 to 255. (b) Shows the selection of seed points, points having the highest gray-scale value which is 255 is the seed points. Purpose of region growing is to mark the strongest light in the image. Figure (c) is the region growing result by choosing the threshold between 225 and the value of seed points (which is 255). That means we have to mark out the points whose gray-scale values are above 225, which is shown in figure (c), and (d). From figure (c) to (e) the segmented result in this example are seed-oriented connected. There is still lot of points in the original image having the gray-scale value above 155 which are not marked in Figure (e).


(a) (b)

(c) (d)



(e)

Figure 3 An example showing region growing segmentation

D. Edge Based Segmentation

Edge detection approach is most frequently used for segmenting images based on local changes in intensity. In this method boundary or edge on an image is defined by the local pixel intensity gradient . The calculation of first order derivative of the image function is called a gradient. The gradient is denoted by $\nabla f(x,y)$ The magnitude of gradient for a given image $f(x,y)$ can be calculated as,

$$M(x,y)= mag(\nabla f) = \sqrt{gx^2+gy^2}$$

And The direction of vector is given by the angle

$$\alpha(x,y)= \quad —$$

The three fundamental steps used for edge detection are as follows:

1. In the first step image smoothing for reduction of noise is done.
2. Detection of edge points are the second step in which there is extraction of all the points in an image that have intensities to become edge points.
3. The last step of this method is Edge localization in this step there is a selection among the edge points that were selected in the previous step that are true members of the set of points that forms an edge.

Closed region boundaries are required to segment an object from an image. The desired edges are the boundaries between such objects. Xie Mei et al [10] in 2009 developed a method for edge detection of weak edges of brain by Canny algorithm, by labeling all the 8-connected edge with the different number and then they classify with that edge, for the size of all 8-connected edge circumference being different and then based on this information they plot the histogram according to the size of edge and lastly weak edge of the brain is detected by histogram segmentation.

E. Normalized Cut Algorithm

Normalized cut is a global criterion for partitioning the graph used for segmentation of image. 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.

……. (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. 4 illustrates one such case

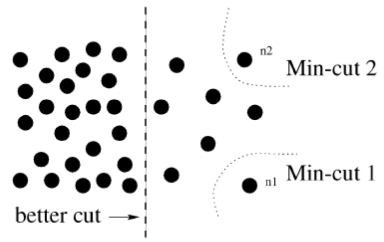


Fig.4 An example illustrating that minimum cut gives a bad partition.

From figure 3.3 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, [2] 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).

——— ———……….(2)

Where

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.

To overcome the limitations of Ncut algorithm by using the advantages of mean shift segmentation combination of both Mean shift and Normalized cut algorithms was done by Qiu-bo-Xi [4] on natural images. If this combination of two algorithms were used to detect the timorous region in MRI it can provide simplicity as well as speed for segmenting MR image. The MRI can be preprocessed before applying NCut method using Mean Shift algorithm. By using Mean shift algorithm image is first divided into the clusters and then each region node is considered instead of region. This number of regions is less than the image pixels, so when NCut is applied it provides fast processing and exact output as a tumors region.

III. Conclusion

Various segmentation methods for MR image have been discussed in this paper. However due to the complex structure of brain these method cannot produce effective results in constraints with the computational time and diseased area calculation. By combining the advantages of Mean shift and Normalized cut methods significant reduction in computational time and calculation of exact area of the tumor can be achieved.

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