A Study of Different Segmentation Techniques to Detect Tumor from Brain MR Images

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Abstract— The brain is the frontal part of the central nervous system. Brain tumor is an irregular growth caused by cells reproducing themselves in an uncontrolled manner. Brain tumor is may be serious and critical because of space formed inside the skull. So detection of the tumor is very important in earlier stages. Brain tumor detection helps in finding the exact size and location of tumor. This paper is the review of different segmentation techniques used in detection of brain tumor. These segmentation techniques use the MRI Scanned Images to detect the tumor in the brain.

Keywords- *Brain Tumor; MRI; Morphological Operators; Segmentation;*

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I. INTRODUCTION

A tumor can be defined as a mass grows without any control. Real time diagnosis of tumors by using more reliable algorithms has been the main focus of the latest developments in medical imaging and detection of brain tumor in MR images and CT scan images has been an active research area. The main problems faced by most of the medical imagery diagnosis systems are the separation of the cells and their nuclei from the rest of the image content. The process of separation i.e. segmentation is most important in the construction of a robust and effective diagnosis system. Images Segmentation is performed on the input images. This enables easier analysis of the image thereby leading to better tumor detection efficiency. Hence image segmentation is the fundamental problem in tumor detection. A number of methods have been proposed in the past for brain tumor detection. In this paper we discuss watershed segmentation in conjunction with morphological operations.

A. *Structure of Brain*

Generally human brain consists three main parts which controls different activities.

1. Cerebrum

The cerebrum controls learning, thinking, emotions, speech, reading, writing, problem solving etc.

2. Cerebellum

The cerebellum controls movement, standing, balance, & complex actions.

3. Brain Stem

Brain stem joints the brain with spinal cord. It controls blood pressure, body temperature & breathing & also controls some basic functions. [2]

B. Types of Tumor

There are three general types of Tumor: 1. Benign
2. Pre-malignant 3. Malignant

1. Benign Tumor: A benign tumor is a tumor which does not expand in an abrupt way; it doesn't affect its neighbouring healthy tissues and also does not expand to non-adjacent tissues.

2. Pre-Malignant Tumor: Premalignant Tumor is a precancerous stage. It is considered as a disease, if not properly treated it may lead to cancer.

3. Malignant Tumor: Malignancy is the type of tumor, which grows worst with the passage of time and ultimately results in the death of a person. The term malignant tumor is typically used for the description of cancer. [7]

c. Diagnosis

MRI (Magnetic Resonance Imaging) & CT (Computed Tomography) are basically used in the biomedical to detect and visualize finer details in the internal structure of the body. CT uses ionizing radiation but MRI uses strong magnetic field to align the nuclear magnetization then radio frequencies changes the alignment of the magnetization which can be detected by the scanner. That signal can be further processed to create the extra information of the body.[7] MR image is safe as compared to CT scan image as it does not affect human body.[8]

II. IMAGE SEGMENTATION & ITS TECHNIQUES

Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, which are also called as super pixels). The main aim of segmentation is to simplify or to change the representation of an image into something which is more meaningful & easy to understand.

In medical field image segmentation is typically used to study anatomical structure, to identify Region of interest (i.e. to locate tumor & other abnormalities), used in treatment

planning etc. There are various techniques of image segmentation.

A. Thresholding

One of the simplest techniques of image segmentation is thresholding. It is the process of separating pixels of image in different classes depending on their pixels grey levels. This method determines an intensity value which is called as threshold, which separates the desired classes. By taking threshold value, desired segmentation is achieved.

Based on threshold value, pixels having intensity value greater than threshold are grouped into one class and remaining pixels are grouped into another class. In thresholding technique, image having only two values either black or white. Thresholding creates binary images from grey-level ones by turning all pixels below some threshold to zero and all pixels above that threshold to one. The main disadvantage of this technique is it cannot be applied to multichannel images. [2]

B. Compression-based methods

Compression based methods assume that the optimal segmentation is the one which minimizes, the coding length of the data and over all possible segmentation. The connection between these two things is that segmentation tries to find patterns in an image and any regularity in the image can be used to compress it. The method describes each segment by boundary shape and texture. [6]

C. Region Growing

Region growing is a region based segmentation method. It is a technique for extracting an image region which is connected based on some predefined technique. This criterion can be based on intensity information of image and edged in the image. Normally simple region growing requires a seed point which is selected by an operator and extracts all pixels connected to initial seed based on some predefined criterion. [4]

In medical field this technique is generally used for the extraction of brain surface, cardiac images, in kidney segmentation etc. The main disadvantage of this technique is, it is very time consuming process because it require user interface for selection of seed points. [2]

D. Edge Detection

Edge is nothing but boundary between two images. So for detection of these edges edge based segmentation is used. The edge detection technique is used for the identification and locating sharp discontinuities in the image. This method divides an image on the basis of boundaries. [3]

The basic edge detection operator shows a matri area gradient operation which determines the level of varience between different pixels of image. Based on Gradient (derivative) function number of edge detection operators are available like sobel edge detection operator, prewitt edge detection operator, Cannny edge detection operator, Laplacian of Gaussian edge detection operator. [5]

1. Sobel edge detection operator

The entire document should be in Times New Roman or Times font. Type 3 fonts must not be used. Other font types may be used if needed for special purposes. It is a gradient (first derivative) operator. Sobel operator performs 2-D spatial gradient measurement on an image. Normally it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. [5] Sobel operator uses a pair of 3x3 convolution masks, one finding gradient in the x-direction (columns) and the gradient in the y-direction (rows). Fig 1 shows the 3x3 area representing the gray levels of an image & the sobel convolution masks are shown in fig 2.

Z_1	Z_2	Z_3
Z_4	Z_5	Z_6
Z_7	Z_8	Z_9

Fig 1: Image neighborhood

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Fig 2: Sobel convolution masks

The detector uses the masks to compute the first order derivatives Gx and Gy, as shown in (1).

$$Gx = Z_7+2Z_8+Z_9$$

$$Gy = Z_1+2Z_2+Z_3 \quad (1)$$

2. Prewitt Edge Detection Operator

Prewitt operator uses two 3x3 kernels. The vertical edge component is calculated with kernel Gx and the horizontal edge component is calculated with kernel Gy as shown in (2).

$$Gx = (Z_7+Z_8+Z_9) – (Z_1+Z_2+Z_3)$$

$$Gx = (Z_3+Z_6+Z_9) – (Z_1+Z_4+Z_7) \quad (2)$$

The prewitt masks used to implement Gx and Gy are shown in fig 3.

-1	0	1
-1	0	1
-1	0	1

G_x

1	1	1
0	0	0
-1	-1	-1

G_y

Fig 3: Prewitt masks

3. Canny Edge Detection Operator

Canny edge detector algorithm first involves smoothing of image, means removal of noise from image. Then the gradient of the image is computed by feeding smoothed image through convolution operation with the derivative of Gaussian in both the vertical and horizontal directions. [5] After this non-maximum suppression is applied to this gradient to convert the blurred edges in the image to sharp edges. [3]

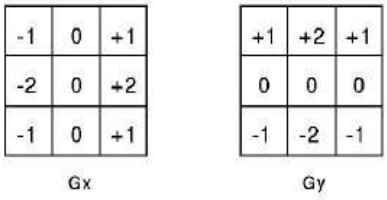

Fig 4: Canny convolution masks

4. Laplacian of Gaussian Operator

The Laplacian is a 2-D isotropic measure of the 2nd order derivative of an image. The Laplacian of an image highlights regions of quick intensity change, so it is often used for edge detection. The Laplacian is applied to an image which is first smoothed with Gaussian filter to reduce its sensitivity to noise. The operator takes a single gray level image as input and produces another gray level image as output.

The kernels mentioned in Fig 5 are used as discrete approximations to the Laplacian filter

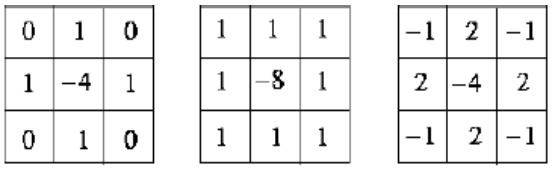

Fig 5: Laplacian of Gaussian kernels

E. Clustering Method

Clustering is a set of data with similar characteristics. [4] Clustering is suitable in biomedical image segmentation when the number of cluster is known for particular clustering of human structure.

Clustering algorithm has two types as:

- Exclusive clustering
- Overlapping clustering

In exclusive clustering, one pixel belongs to only one cluster and it does not belong to another cluster. The example of exclusive clustering is K- mean clustering. In overlapping clustering one pixel belong to two or more clusters. The example of overlapping clustering is fuzzy C-mean clustering.

1. K-mean Clustering

It is one of the most popular and widely used clustering algorithms. It performs pixel based segmentation of multi-band images. An image stack is considered as a set of bands corresponding to the same image. [4]

The procedure for k-mean clustering is simple and easy to segment an image using basic knowledge of cluster value. Initially define the number of clusters and arbitrarily select centre for each cluster. Secondly calculate distance between each pixel to chosen cluster centroid. Compare each pixel with k clusters cenroids and find distance using distance formula. If the pixel has shortest distance among all pixels, then it is moved to particular cluster. Repeat this procedure until all pixels compared to cluster centroids. This procedure continues until some convergence criteria are met. [2]

The main advantages of this algorithm are to its simplicity and minimum computational price. The main disadvantage of this algorithm is, it does not give same result each time the algorithm is executed. [4]

2. Fuzzy C-mean Clustering

Fuzzy C-means is the example of overlapping clustering technique. Here one pixel value depends on two or more clusters centers. One of the most widely used fuzzy clustering algorithms is the Fuzzy C-means (FCM) algorithm (Bezdek 1981). The FCM algorithm is partition of n element X={x1,…,xn} into a collection of c fuzzy clusters with respect to below given criteria.

It is based on minimization of the following objective function:

$$J=\sum_{i=1}^{N}\sum_{j=1}^{c} u_{ij}^{m} |x_i - y_i|^2$$

Where,

m = level of fuzziness and real number greater than 1.

uij= degree of membership of xi in the cluster cj

x = data value

Fuzzy C-means is a popular method for medical image Segmentation but it only considers image intensity and thus produce unacceptable results in noisy images. Lots of algorithms are planned to make FCM strong against noise and in homogeneity but it's still not perfect. [2]

F. Watershed Segmentation

It is one of the best methods to group pixels of an image on the basis of their intensities. Pixels falling under similar intensities are grouped together. It is a good segmentation technique for dividing an image to separate a tumor from the image. Watershed is a mathematical morphological operating tool.

It considers the gradient magnitude of an image as a topographic surface. Pixels which have highest gradient magnitude intensities (GMIs) are considered as watershed lines, which represent the region boundaries. Water placed on any pixel enclosed by a common watershed line flows downhill to a common local intensity minimum (LIM). Pixels draining to a common minimum form a catch basin, which represents a segment of that image. [1]

G. Conclusions

Image processing plays important role in today's world. It has important application in biomedical field. Medical image processing is most challenging field in the research area. Medical imaging techniques are used to image internal structure of human body for medical diagnosis. In medical

image processing, image segmentation plays vital role for the extraction of specified region from medical images. For detection of tumor from Brain MRI images, image segmentation is used. In this paper different segmentation techniques for brain tumor detection are studied.

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