National Conference on Emerging Trends in Computer, Electrical & Electronics (ETCEE-2015)
International Journal of Advance Engineering and Research Development (IJAERD)
e-ISSN: 2348 - 4470 , print-ISSN:2348-6406,Impact Factor:3.134

Brain Tumor Segmentation Methods: A Review

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***Abstract*— Brain tumour is an abnormal growth of the cells inside the brain. Detecting Brain tumour takes special skills and techniques because they are difficult to detect – especially in early stages. The boundary of the tumour (i.e. the abnormality in brain) in an MRI or different medical image can be traced using image processing techniques. Segmentation is often essential as a preliminary step for medical image analysis for diagnosis and study of abnormality. The input image to the system is taken either from the available data base or the real time image, So that the presence of tumour in input image can be detected and the area of the tumour can also be analysed. The paper is based on the survey of different brain tumor detection techniques.**

***Keywords* - Brain tumor, enhancement, MRI, Edge based & Pixel based segmentation, Histogram Thresholding**

I. INTRODUCTION

Brain tumors are composed of cells that exhibit uncontrolled growth in the brain. These cancerous cells that are present in brain can be counted in the most deadly and intractable diseases. Detection of brain tumor is a serious issue in medical science. Brain tumor is one of the main causes for the increase in mortality among children and adults. Before the proper treatment of patient, diagnosis and analysis of tumor is important and necessary [9].

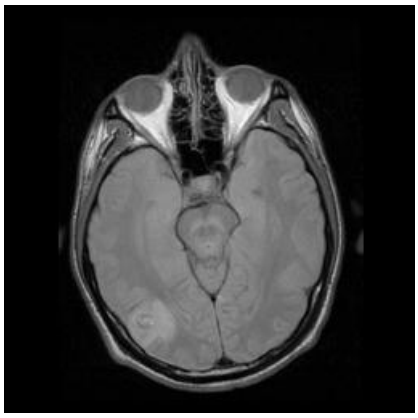


Fig 1: Tumor view inside brain
(Brain MRI)

1. *Diagnosis*

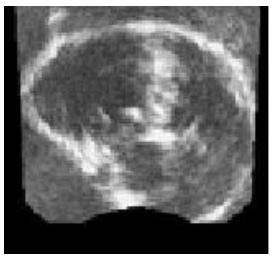
For the diagnosis and treatment of tumor, imaging of the brain has a vital role. Imaging of the tumors can be done by CT scan, Ultrasound, biopsy and MRI.[5]

MRI (Magnetic Resonance Imaging) is a scanning technique in which the device uses magnetic fields and computers to capture images of the brain. It provides pictures from various planes, which helps doctors to create a three-dimensional image of the tumor.[4]

CT or CAT scan (Computed Tomography) combines sophisticated x-ray and computer technology. It shows a combination of soft tissue, bone, and blood vessels [5]. CT images can determine some types of tumors, as well as help detect swelling, bleeding, and bone and tissue calcification [4].

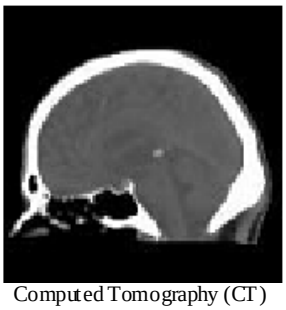
A biopsy is a surgical process where a sample of tissue is taken from the tumor spot and examined under a microscope. The purpose of a biopsy is to discover the type and grade of a tumor. A biopsy is the most accurate method of obtaining a diagnosis [4].

Ultrasound is an imaging modality that utilizes high-frequency sound waves to provide cross-sectional images of the body. Ultrasound imaging modality is used to visualize the anatomy and pathology of the liver and gallbladder, spleen, kidneys, retroperitoneal, abdominal vascular structures, lymph nodes.
After the diagnosis the next step will be its analysis.[3]



Ultrasound (US)

Magnetic Resonance Imaging



Computed Tomography (CT)

Fig 2: Slices of the brain by different imaging techniques

2. Analysis

For the proper accurate analysis of the tumor, segmentation techniques will be used [18]. The main aim for the medical image segmentation is (i) Study the anatomical structure (ii) identify Region of Interest (locate tumor and abnormalities); (iii) Measure tissue volume for the measurement of growth of tumor (also decrease in size of tumor with treatment) (iv) and Help in treatment planning, prior to radiation therapy; in medication dose calculation[5].

II. PRE-PROCESSING OF MRI IMAGES

After scanning of brain, detection of the Brain tumor from the brain scanned images (MRI Scan) is performed. Before the presentation of the brain tumor segmentation methods, the MRI pre-processing operations are introduced because it is directly related to the qualities of the segmentation results. In general, the raw MRI images need to be pre-processed to realize the segmentation purposes. These pre-processing operations include de-noising, skull-stripping, intensity normalization, etc, and have direct impact on the results of brain tumor segmentation.

Image de-noising is a standard pre-processing task for MRI. Many denoising methods for MRI image have been proposed, such as Anisotropic Diffusion Filtering (ADF)[23, 24], wavelets[25, 26], Non-Local Means (NLM)[27-28], and Independent Component Analysis (ICA)[14, 15]. ADF is the current most popular method for the de-noising of brain tumor MRI images.

Histogram equalization is a spatial domain image enhancement technique that modifies the distribution of the pixels to become more evenly distributed over the available pixel range [8].

In histogram processing, the distribution of the pixel intensity values is obtained from histogram. It also shows the probability density function (PDF) for a continuous function. An image that has a uniform PDF will have pixel values at all valid intensities. Therefore, it will show a high contrast image.

Histogram equalization creates a uniform PDF or histogram [8].

Skull stripping is an important pre-processing step for the analysis of MRI image. Skull stripping is the process of delineation and removal of non cerebral tissue region such as skull, scalp, and meninges from the brain soft tissues. It has been considered as an essential step for brain tumor segmentation. The precision in this process has impacts in the efficiency in detecting tumor. Removal of the skull region reduces the chances of misclassifying diseased tissues. The process of skull stripping is faced with many challenges due to the complexity of the human brain, variability in the parameters of MR scanners, and individual characteristics. Poor quality and low contrast images also contribute to difficulties in segmenting the images precisely. Many of robust skull stripping algorithms have been proposed to reduce these influences. After the pre processing of the image, segmentation techniques are applied to it.[33]

III. BRAIN TUMOR SEGMENTATION METHODS

Segmentation is the most important method to obtain the useful information from the MRI image of the scanned brain after the pre processing of the image which is done through histogram equalization.[3]

For manual brain tumor segmentation, the experts of brain tumor must master the information presented in the brain tumor images and some additional knowledge such as anatomy because manual brain tumor segmentation aims to manually draw the boundaries of the brain tumor and paint the regions of anatomic structures with different labels[31]. To date, manual segmentation is widely applied to clinical trial. In the clinic, since many of brain tumor images are emerging, the manual segmentation of the different regions of brain tumor will become an error-prone and time-consuming task for the experts and yield poor results in a way. Therefore, more advanced segmentation methods such as semi-automatic and fully automatic segmentation methods are required to address this problem.

The semi-automatic and fully automatic segmentation of tumor brain images are faced with great challenges due to usually exhibiting unclear and irregular boundaries with discontinuities and partial-volume effects for brain tumor images. This paper divides the current MRI-based brain tumor segmentation methods into three major categories: conventional methods, classification and clustering methods, and deformable model methods. Few segmentation techniques are described that are used to detect brain tumor from two-dimensional MR images

For fully automatic brain tumor segmentation, the computer determines the segmentation of brain tumor without any human interaction. In general, a fully automatic segmentation algorithm combines artificial intelligence and prior knowledge. With the development of machine learning algorithms that can simulate the intelligence of humans to learn effectively, the study of fully automatic brain tumor segmentation has become a popular research issue.[30]

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

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

1.1 Edge-based Segmentation

Edge based segmentation is the most common method based on detection of edges i.e. boundaries which separate distinct regions. Edge detection method is based on marking of discontinuities in gray level, color etc. This method divides an image on the basis of boundaries. Numbers of edge detecting operators based on gradient (derivative) function are available. For brain tumor detection various edge detection operators are used which are sobel edge detection, prewitt edge detection operator and canny edge detection operator.[16]

A. Sobel Operator

The Sobel operator performs a 2-D spatial gradient measurement on an image. It is used to find the approximate absolute gradient magnitude at each point in an input greyscale image [12]. The operator consists of a 3×3 masks and are shown in Fig 2. One mask is simply the other rotated by 90° [8][11]

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

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

Fig.3: Sobel mask

The magnitude of the gradient operator is calculated by:

$$|G|= (Gx2+Gy2)^{1/2}$$

B. Prewitt operator

The Prewitt operator as similar to the Sobel measures two components. The vertical edge component is calculated with kernel Gx and the horizontal edge component is calculated with kernel Gy

Fig 4: Prewitt operator mask

The magnitude of the gradient operator is calculated by:

$$|G|= (GX^2+GY^2)^{1/2}$$

C. Canny Operator

The Canny edge detection algorithm is known as an optimal edge detector. It is based on a set of principles that discovers the edges by minimizing the error rate. This is carried out by marking edges as closely as attainable to the actual edges. It maximizes localization, and marking edges only once, at the point when a single edge is found for the least response [10]. Smoothing of the image is carried out in the initial stage; by convolving it with a Gaussian filter. Then computation of the gradient of the image is done by giving the smooth image through a convolution operation with the derivative of the Gaussian in both the vertical and horizontal directions.

D. Laplacian Operator

The Laplacian is applied to image that has first been smoothened with something approximating a Gaussian smoothing filter in order to reduce its sensitivity to noise and also highlights regions of rapid intensity change[8]

$$L(x,y) = \frac{d^2I}{dx^2} + \frac{d^2I}{dy^2}$$

-1	2	-1
2	-4	2
-1	2	-1

1	1	1
1	-8	1
1	1	1

0	1	0
1	-4	1
0	1	0

Fig 5: Laplacian operator mask

1.2 Pixel-Based Segmentation

There are mainly two techniques in pixel based segmentation:

(i) Clustering Method and (ii) Region growing method [16]

A. Segmentation Using Region Growing Method

The seeded region growing method is the first region-growing method. This method [6] takes input as seeds and the image. Each of the objects to be segmented is marked by the seeds. The regions are iteratively grown. All unallocated neighbouring pixels are compared to the regions [13]. The difference between a pixel's intensity value and the region's mean is used as a measure of similarity. The pixel with the smallest difference calculated this way is allocated to that particular area. At the end of the process all pixels are allocated to a region [6].

The primary drawback of region growing method is the partial volume effect [33]. It limits the precision of MR brain image segmentation. Partial volume effect blurs the intensity distinction between different tissue classes at the border of the two tissues types, [32]. Some segmentation methods incorporate the region growing process as a refinement step [32]. A fuzzy information fusion framework was proposed for the automatic segmentation of brain tumor using MRI [33]. The registration of multispectral images was the initial step for the creation of this framework. That includes a priori knowledge, fuzzy feature fusion, and an modification by fuzzy region growing.

B. Segmentation Using Clustering Method

The K-means algorithm is used to partition an image into K clusters. It is an iterative technique. The basic algorithm is: (1). Pick K cluster centres, either randomly or based on some heuristic; (2). The cluster is assigned all the pixels of the image, so that the distance between the pixel and the cluster centre can be minimized; (3). Re-compute the cluster centres 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).[1,6]

Here, Pixel color, intensity level, texture, and location are the factor that determines the difference. K can be selected manually, randomly, or by a heuristic.[1,6]

1.3 Segmentation Using Histogram Thresholding

The image of the brain is acquired through MRI technique. If the histograms of the images corresponding to the two halves of the brain are plotted, symmetry between the two histograms should be observed due to symmetrical nature of the brain along its central axis. On the other hand, if any asymmetry is observed, the presence of the tumor is detected. After detection of the presence of the tumor, thresholding can be done for segmentation of the image [2]

IV. CONCLUSIONS AND OUTLOOK

This paper has provided a comprehensive overview of the state of the art MRI-based brain tumor segmentation methods. Most of brain tumor segmentation algorithms have relatively good results in the field of medical image analysis; there is a certain distance in clinical applications. Because of lack of communication between researchers and clinicians, clinicians still rely on manual segmentation for brain tumor in several cases. The existence of many tools aims to do pure research and is hardly useful for clinicians. Therefore, embedding the developed tools into more user friendly environments will become inevitable in the future.

In “The Edge Detection of Brain Tumor” Xie Mei, Zhen Zheng, Wu Bingrong, Li Guo have detected the edge of tumor by very less time by Canny edge detection Algorithm and 8-connected labelling is also used[17]

In “Survey on Brain Tumor Segmentation Methods” Hongzhe Yang, Lihui Zhao , Songyuan Tang, Yongtian Wang says clustering and classification technique are sensitive with the initial parameters. Some clustering methods are a point operation, and do not preserve the connectivity among regions. The training data and the appearance of the tumor strongly affect the results of the atlas-based segmentation. Edge-based deformable contour model is suffered from the initialization of the evaluating curve and noise

Riries Rulaningtyas and Khusnul A in [19] have detected edge of tumor by using Robert, Prewitt, Sobel method and have concluded that Sobel method is very much suitable for edge detection of brain tumor than others

In [2] Manoj K Kowar and Sourabh Yadav have studied a technique to detect presence of brain based on thresholding technique has been developed. The segmentation of the brain is also being done while detecting the presence of the tumor

Jaskirat Kaur, Sunil Agrawal & Renu Vig.'s paper presented thresholding and edge detection are one of the important aspects of segmentation, that comes prior to feature extraction and image recognition system for analysing images. And it helps in extracting the basic shape of an image, overlooking the minute unnecessary details. In this paper using image segmentation (thresholding and edge detection) techniques different geo satellite images, medical images and architectural images are analysed. [20].

In [21] Catalin Amza said that that segmentation of image is plays an important role. The literature is very rich in segmentation techniques and neural-network based methods have been applied successfully due to their signal-to-noise independency, their ability to achieve real-time results and the ease of implementing them with massive VLSI processors [21]

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