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A Survey on Segmentation Techniques Used For Brain Tumor Detection

Sanjuna Sabu[1], Jerin Thomas[2]
[1]P.G scholar, Department of CSE, Amal Jyothi College Of Engineering Kanjirappally , Kottayam, India
[2]Asst. Professor, Department Of CSE, Amal Jyothi College Of Engineering Kanjirappally , Kottayam, India

Abstract-In recent years Brain tumor is one of the most commonly found causes for death among children and adults. Early detection of tumor is a must in order to reduce the death rate. For tumor detection various image techniques can be used. In this paper we mainly concentrate on the images obtained from MRI scans. In MRI images, the tumor may appear clearly, but for further treatment the physician need to be a qualified and well experienced person. In order to help the radiologist in detection computer-aided diagnosis was developed. The generation of a CAD system consists of several processes and among them segmentation is considered to the most important process. Image Segmentation is a process of partitioning an image into multiple segments. The main objective of segmentation is to represent the image into a simplified form so as to increase the efficiency and accuracy of the system. Therefore the segmentation of brain tumor can be considered as an important role in the medical image process. Hence in this paper we concentrate on the recently used segmentation techniques for the detection of tumor using MRI images.

I. INTRODUCTION

The brain is a complex organ, which control our basic body functions such as sense, thoughts, memories, feelings etc. Brain tumor is one of the most frightening diseases with which a person can be diagnosed. [1] Tumor is a group of unwanted cell growing inside and around the brain. Brain tumor is of two types: Malignant (cancerous) and Benign (non-cancerous) tumor. Malignant tumor can be further classified into two: primary tumor and secondary tumor. Primary tumors are those that originate within the brain, this may arise due to loss of differentiation of cells, premature death of cells or due to uncontrollable division of cells. These causes may lead to Accumulation of unwanted cell within the brain and results in unwanted growth. Secondary tumors are metastatic tumor that originates in some other organ that propagate through blood vessels and invade into the brain.

A tumor can be identified based the certain symptoms. Also, they may occur when a tumor blocks the fluid that flows through and around the brain, or when the brain swells because of the fluid buildup.

Unfortunately brain tumor is not extremely rare. According to National Brain Tumor Society, in United States approximately nineteen out of every one hundred thousand people develop brain tumor. Metastatic brain tumor are most common than primary tumor and they occur in a 20% to 40% of cancer patient. Brain cancer is one of the most common types of cancer that causes death in people under the age of thirty five. [1]

Early detection of tumor is a must in order to provide better diagnosis. For tumor detection various image techniques such as CT scan, MRI scan, PET scan can be used. This paper mainly concentrates on the images obtained from MRI scans. Magnetic resonance imaging (MRI) is a medical imaging technique used in radiology to investigate the anatomy and physiology of the body. This technique uses strong magnetic fields and radio waves to form images of the body. MRI is more efficient in comparison with CT scan, due to its high contrast of soft tissues, high spatial resolution and the most important one does not produces any harmful radiation.

In the brain magnetic resonance imaging (MRI), the tumor may appear clearly, but for further treatment the Physician need to be a qualified and well experienced person. In order to help the radiologist in detection computer aided diagnosis was developed. This can provide a great help in analyzing the tumor area. Studies show that a CAD system can help to improve accuracy, lighten the burden of increasing workload, and reduce cancer Missed due to fatigue, over-loaded. In order to develop a CAD system, pattern recognition and machine learning system plays a vital role. Pattern recognition is the act of extracting features from objects and making decision based on obtained data.
Many different techniques are used for a creating a CAD system. Generally, to create a CAD system, various image processing techniques are to be integrated such as: image segmentation, feature extraction and selection and classification. In this paper we mainly concentrate only on the image segmentation techniques.

II. IMAGE PROCESSING

The development of automated tools can be of immense importance to help in diagnosis, prognosis and presurgical and post surgical procedure depending on whether the subject is a healthy one or is a pathological subjects, suffering from some brain disorder[4]. In order to enhance the diagnosis, detailed information about the brain MRI image is to be obtained, this can be done by performing certain operations on the input image, and these operations are known as image processing techniques.

Image processing is a methodology of processing an image. Image processing consists of four steps: image preprocessing, image segmentation, Feature extraction and classification. These steps are the basis for generation of a CAD system.

Here the MRI image is passed as an input to the system. Initially the image is preprocessed, that is, the removal of unwanted noise n variations within the images. These done using denoising techniques such as various segmentation techniques.

Mean Filtering, Median Filtering. Then the preprocessed image is segmented using various segmentation techniques which will be discussed in following sections.

These segmented images are passed as an input to next level which is feature extraction and dimensionality reduction. Here different features of the MRI are extracted using various techniques such as DWT, LDA, ICA, and PCA is used to reduce the extracted set into a confined set. .This is done to reduce the complexity of the classifier. Next this reduce features are set as an input to the classifier. The classifier classifies the brain image into a healthy or pathological brain. Classifications can be done using k-nn, ANN, SVM, FCM or SOM methods. Once the classification is done, a performance evaluation is carried out i.e., to evaluate the accuracy of the classification. After the evaluation the result is passed as an output to the radiologist. In the following subsections we discuss about the various techniques used in image segmentation. In this paper we compare the techniques and identify their strengths and weakness.

III. IMAGE SEGMENTATION

Image segmentation is the process of partitioning an image into multiple segments, so as to change the representation of an image into a form that is more easier to analyze. Segmentation is done based on two basic properties: 1) intensity values involving discontinuity that refers to sudden or abrupt changes in intensity as edges in image, 2) similarity that refers to partitioning a digital image into regions according to some predefined likeness criterion. [5] At the output, each object in the image represents a set of pixels which is isolated from the rest of the scene. Segmentation is of two types: a) Local Segmentation: considers only a small part of image. b) Global Segmentation: consider the entire image for segmentation.

There are several segmentation techniques to identify the cancerous region from the MRI image. Here we discuss some of the techniques used for segmentation.

Deformable Models

A deformable model based segmentation scheme, used in concert with image pre-processing, can over-come many of the limitations of manual slice editing and traditional image processing techniques. These connected and continuous geometric models consider an object boundary as a whole and can make use of a priori knowledge of object shape to constrain the segmentation problem. The inherent continuity and smoothness of the models can compensate for noise, gaps and other irregularities in object boundaries. Furthermore, the parametric representations of the models provide a compact, analytical description of object shape. [9]

Deformable models are the curves or surfaces de ne within an image domain. This can be moved under the influence of internal forces and external forces. The internal forces are designed to keep the model smooth during deformation. Similarly the external forces are de ne to move the model towards an object boundary or other desired feature within a image.[7]There are two types of deformable models : a) Para-metric Deformable models : Represents curves and surfaces explicitly in their parametric form. This al-lows direct interaction with the model. b) Geometric Deformable: Provides a solution for primary limitation of parametric model. It is based on the curve evolution theory level; set methods.

Level set Models

The level set method for capturing moving fronts was introduced by Osher and Sethian in 1987.The level set method is a numerical and theoretical too for interface propagation. The basic idea is to start with a closed curve in 2D or a surface in 3D and allow the curve to move perpendicular to itself at a prescribed speed. In image processing the level set method is most frequently used as a segmentation tool through propagation of a contour by using the properties of the image.

An interface C is represented implicitly as a level set of a function called level set function, of higher dimension. This level set function is defined as the distance function from the zeroth level set i.e., contour. The function is zero if the pixel lies on the curve itself; otherwise, it is the minimum distance from the pixel to the curve. The distance is regarded as negative for pixels outside C and positive for pixels inside C.

Livewire Models

Livewire is a segmentation technique in which a user can select the region of interest that is to be extracted. This is done using a simple mouse click i.e the user sets the starting point by clicking on an images pixel, (known as an anchor). Then, starts to move the mouse over other points, the smallest cost path are drawn from the anchor to the pixel where the mouse is over. It is also known as Intelligent Scissors.

Thresholding Method

Thersholding techniques are used in the case where pixel within segments has similar intensities. It is one of the popular techniques as it is very simple to implement. Threshold-based techniques are generally used for gray scaled images. [8]. Here the intensity of each pixel is compared with a threshold value.

For gray scale image f(x,y) , consider the image is divided into two parts : background and foreground. The foreground is defined as the region of interest and the background as the rest. Threshold value T is first calculated by analyzing all image pixels intensity. Any pixel (x,y) for which f(x,y) > T is called object point, otherwise, that point is called background point. Thus, intensity level is compared to the background image and a threshold value decides if the pixel differs enough to belong to the foreground or not.

In order to use this technique for color and synthetic images we must use additional tools.

Edge Detection Method

Edge detection is by far the most common approach for detecting meaningful discontinuities in gray level [8]. First and second order derivatives like gradient and laplacian are used for detection of edges in an image. Edge detection is a basic step for image segmentation process. It divides an image into object and its background. Edge detection is usually done with local linear gradient operators. These operators work well for images with sharp edges and low amount of noise. Gray histogram and Gradient are two main methods for edge detection for image segmentation.

An edge is a set of connection between two adjacent pixels provided they have same intensities. Edges in an image can generally be divided into two categories: intensity edges and texture edges. Intensity edges arise from abrupt changes in the intensity pro le of the image. Texture edges are boundaries of texture regions that are invariant to lighting conditions. Most of the edge detectors works on the measuring the intensity gradient at a point in the image.

Region-based techniques.

Region-based method can be classified into two: Region growing and Region splitting-merging procedures.

In region growing procedure it groups pixels or sub-regions into large regions based on certain predefined criteria. Initially set of seed points are created and from this point and remaining regions grows up if neighboring pixels have similar properties of that of `seed point. Selection of seed points is critical procedure for colored images if priori information is not available. Hence set of descriptors based on intensity levels and spatial properties are required to determine the pixel intensities.

In region splitting-merging, an image is subdivided into arbitrary, disjoint regions and then either merge and or split operation is performed to satisfy prerequisite constraints [2]. This algorithm is iterative. First split given image into four disjoint quadrants, then merge any adjacent regions which satisfy the prerequisite constrained. Repeat this splitting of regions and merging till no further merging or splitting is possible. Image regions are implemented with the help of quadtree.

Watershed Method

Watershed transformation is a powerful tool for image segmentation. It is more stable technique than those discussed earlier. The Watershed transformation considers the gradient magnitude of an image as a topographic surface. Pixels having the highest gradient magnitude intensities (GMIs) correspond

to watershed lines, which represent the region boundaries. The gray-level of the image represents the altitudes. Water placed on any pixel enclosed by a common watershed line flows downhill to a common local intensity minima (LMI).The region edges corresponds to higher watershed and low-gradient regions corresponds to catchment basins.[8]Watershed are defined as the lines Separating catchment basins which belong to different minima. The minima correspond to an object of interest.
Direct application of this segmentation algorithm generally leads to over segmentation due to noise and other local irregularities of the gradient. The problem of over segmentation can be solved with the help of markers. A marker is a connected component of an image. Marker can be defined as per requirement of problem definition.

Expectation maximization

The Expectation Maximization (EM) Algorithm is a statistical method. The EM algorithm produces Maximum Likelihood (ML) estimates of parameters. The EM Algorithm is used widely in the image segmentation field and it produces very good results especially with less noise distortion. The image is considered as a Gaussian mixture model. Each class is represented as a Gaussian model and the pixel intensity is assumed as an observed value. The EM is used for finding the unknown parameters of the mixture model [10].
The EM algorithm consists of two major steps: an expectation step (E-step), and a maximization step (M-step). The expectation step is to estimate a new mapping (pixel-class membership function) with respect to the unknown variables. The maximization step then provides a new estimate of the parameters. The EM Algorithm is used in different image segmentation problems, such as medical images, natural scene images, and texture images.

Markov Random Field

Markov Random Field (MRF) based segmentation is known as Model based segmentation. MRF is used for color segmentation. Components of the color pixel tuples are considered as independent random variables for further processing. MRF is combined with edge detection for identifying the edges accurately. MRF has spatial region smoothness constraint and there are correlations among the color components. The initial segmentation is performed at coarse resolution and then at finer resolution. The resolution based segmentation is done only to the part of the image [10].
The segmentation may also be done by using Gaussian Markov Random Field (GMRF) where the spatial dependencies between pixels are considered for the process.
Gaussian Markov Model (GMM) based segmentation is used for region growing. The extension of Gaussian Markov Model (GMM) that detects the region as well as edge within the framework. The feature space is also detected by using this technique.

K-means Clustering

K-means is a fast and simple clustering algorithm, which has been applied to many applications. For a brief review of conventional K-means algorithm, suppose observations are xi: i =1,,L. The goal of K-means algorithm is to partition the observations into K groups with means x1, x2........xk such that

$$D(k) = \min(X_i \ \ X_j)^2$$

is minimized. K is gradually increased and the algorithm stops when a criterion is met.

K-means clustering algorithm can be easily used in image segmentation [10]. However, the conventional K-means based image segmentation methods only cluster observation vectors in feature space. Considering the spatial constrains are essential attributes of images, combining K-means clustering with spatial
constrained region growing to obtain better segmentation.

Pulse Coupled Neural Network

The Pulse Coupled Neural Network (PCNN) is a biological model based on the mammalian visual cortex, proposed by Eckhorn [11]. The PCNN is advisable to solve tasks as the feature generation for image and pattern recognition image segmentation etc.

$L_{ij}[n]$-e ^{1} $L_{ij}[n\ \ 1]+v_{L\ \ kl}\ w_{ijkl}Y_{kl}[n\ \ 1]$

$U_{ij}[n]=S_{ij}[n](1+L_{ij}[n])$

$Y_{ij}[n]= 1, (U_{ij}[n] > \ _{ij}[n])$

$Y_{ij}[n]= 0,(U_{ij}[n]\ \ _{ij}[n])$

where S is the input signal, F is the feed, L is the link, U is the internal activity, Y is the pulse output, and is the dynamic threshold. The weight matrices M and W are local interconnections and are the linking constant. I is the inhibition term that is determined by the total activity of the network. The output values of all neurons are summed up, negated, and fed back to each neuron of the neural network.
Let the input image be a gray-scale image having of MN pixels. This image can be represented as a MN matrix having normalized intensity values. Then the array is fed at the MN inputs of PCNN. Initially all neurons are set to 0. The threshold of each neuron significantly increases when the neuron res, then the threshold value significantly decays with time. When the threshold value falls below the neurons potential (U), the neuron res again, and thus the threshold value increases again. Therefore this process continues and thus creates binary pulses for each neuron.
While this process goes on, neurons encourage their neighbors to re. The ring neurons begin to communicate with Their nearest neighbors, which in turn communicate with their neighbors. This result is an autowave that expands from active regions. Thus, if a group of neurons is close to firing, one neuron can trigger the entire group. Due to the interconnection between neurons, the pulsing activity of invoked neurons leads to the synchronization between groups of neurons corresponding to subregions of the image that have similar properties and produces a temporal series of binary images. This synchronization results in image segmentation.

APPROACH	ADVANTAGE	DISADVANTAGE
Deformable model	enable the contour to expand or con- tract over time,	Generates ill defined boundaries when applied to noisy images
Level Set	used in the case where the topology of the image changes	Uses functions to separate the image into two disjoint regions and define the boundary but in

		case of non-simple curves and multiple phases it becomes Complicated.
Threshold based	These thresh-old techniques are very much useful for image linearization and more efficient in gray scale image	This algorithms does not work properly for all type MRI of brain image, because of the intensity variation within the image
Region growing	Region growing methods separate the regions that have the same properties based on the criteria properties based on The criteria.	Local method: no global view of the problem. May lead to gradient problem. It is very much sensitive to noise
Watershed	the best methods to group pixels of an image based on their intensities	The main problem of watershed transform is its sensitivity to intensity variations, which results in over segmentation
MRF	Markov random field models (MRFs)are not deterministic, are best characterized by their statistical properties	only applicable to homogeneous tumor, therefore heterogeneous tumors and only allows the identification of tumor structures that have normal intensities
k-mean	simple to implement, fast and efficient	Output depends on the number of partitions used in the segmentation

PCNN	PCNN is the invariance of generated time signal to rotation, translation of images. It is advisable for the feature generation and pattern recognition in the classification tasks using Conventional neural networks.	Some algorithms require multiple PCNN parameters and a satisfactory result strongly depends on the parameters i.e. it is self iterative process, Therefore, no automatic procedure to stop the PCNN

Table 1: The advantages and disadvantages of the most used segmentation methods for human brain tumor through MRI

IV. CONCLUSION

In this survey, we discuss different traditional and popular image segmentation techniques. An outline of different techniques has been described in this paper. The advantages and disadvantages about the various techniques are discussed in short in the Table 1. Although several segmentation techniques are available and each segmentation has their own advantages and disadvantages, it is upto the developer to choose a suitable segmentation techniques based on their application.

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