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Brain Tumor Segmentation using FCM in MRI Images

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Abstract

Tumor segmentation is a major process in medical image processing. It can be divided as primary and secondary type of tumor. Primary level tumors do not affect the surrounding cells, whereas secondary level tumours affect surrounding tissues and also day activities. Segmenting this type of tumor is important in early stage itself. It is just a process of partitioning image into several non-overlapping regions which are in understandable format. Generally, segmentation of brain MRI consists of GM, WM, Cerebrospinal fluid (CSF) as normal brain tissues and tumor tissues as (solid or active tumor, edema, or necrosis). FCM (fuzzy C- Means) is used in segmentation for incorporating the local spatial information with that of function. It is an automatic and unsupervised method which makes use of priori information given by radiology experts. Manual segmentation of brain MRI is possible but it is time consuming and results are varying of between medical experts. Automatic or Semi-automatic segmentation is done which produce more accurate segmentation comprised of tumor volume, size, location of tumor, grade, edema enhancement, growth. In medical diagnosis, these types of segmenting brain MRI are very helpful for clinicians to discover tissues of tumor from normal brain tissues. This paper gives overview of different methods of FCM used in tumor segmentation.

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Keywords: Fuzzy C- Means, Priori Information, Brain MRI, Tumor Segmentation, Medical Image Processing.

1. Introduction

In the segmentation of tumor cells, Magnetic Resonance Imaging (MRI) is used instead of CT images as it is more accurate and do not contain any radiation in it. This type of MRI images provide an anatomical structure and abnormal tissues can be identified easily. It allows the clinical experts to effectively identify the tumor tissues in faster way and to monitor the patients. Segmentation is a process by which an image can be divided in to several non-overlapping regions so that every region is homogeneous and their union is heterogeneous. The time consumption for segmenting an image depends on the size of the image. If the size of image is large, then the

segmenting time will be high. If the size is small, the it takes less time. Tumor tissues such as solid or active tumor, edema, or necrosis are present. There are two types of tumor persists which is primary brain tumors (which begin in glial tissue) and secondary brain tumour (caused by the cancer cells).

1.1 Brain Structure

The major parts of brain are divided in to three types:

- Cerebrum
- Cerebellum
- Brain stem

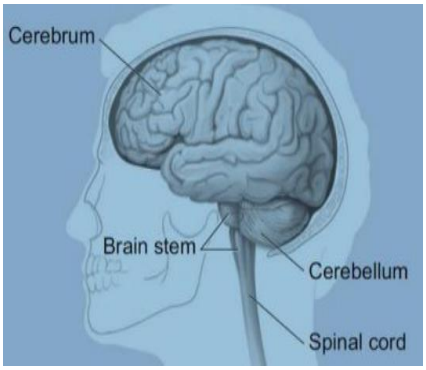

Figure 1 Brain Structure

Cerebrum is the major parts which allow learning, speak, and think, emotion, read, write and control entire functionalities. This is divided in to two parts as right and left hemispheres. Right side of hemisphere controls the left side on the other hand left side of muscles controlled by right side. Second part of the brain is cerebellum which controls day to day activities such as standing, walking and other difficult actions. Brain stem connects with that of spinal cord for breathing, controlling blood pressure, temperature of body, and some other basic functions.

1.2. MR Image of Brain

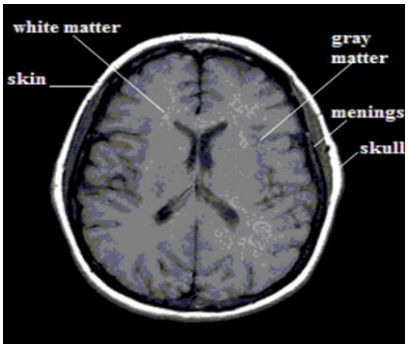

Figure 2 Brain MR Image

MR images are more accurate than that of CT images so that abnormal tissues can easily be segmented. These images do not produce radiation and so it is safer to human body. It uses computer to create images of brain.

Tumors are widely classified as two types such as benign, malignant. Primary level tumors do not affect the other region of body but it affect cancerous cells whereas secondary tumors affect and spread throughout the body. Therefore, these tumors have to be detected in earlier stage itself through segmentation otherwise it affects brain activity.

Manual Segmentation is also possible but it is not accurate and a time consuming one. This also leads to variations in report between two observers for a same image. Therefore, automatic segmentation of cells is done by experts to avoid inaccuracy. It is an interesting factor to do automatic segmentation because there will be no human intervention and it involves things such as tumor location, volume detection, size, similar patterns of growth, extent edema. An automatic segmentation includes soft computing methods such as fuzzy computing.

1.3 Segmentation

It is just a process of dividing an image in to more understandable format. Complex images are partitioned to several simple images thereby each pixel is assigned with a label. These processes generally capture every part in an image and convert them to computer required manner. There are two ways of segmenting an image. First method is that, discontinuities are detected where the intensity levels are checked according to which the images are segmented. Similarities in given image detected based on prior rules of information.

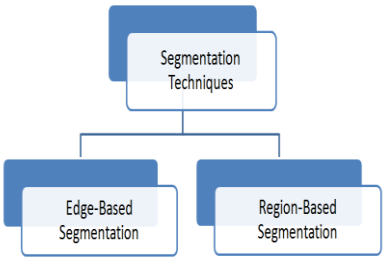

Figure 3 Segmentation Methods

1.4. Segmentation Based On Edges

Intensity level discontinuities are considered and abrupt changes in this value are noticed. Gray level values are recorded where changes in each level may lead to edge formation. Region of interest obtained, boundary between any two region form edges. An integrated method that segments edges into straight and curved edge segments for parts-based object recognition. Spatial masks used to find gray level at point, curve and line.

1.5. Segmentation Based On Region

This method is reverse concept of edges in which partition of images done by continuity. Cluster of regions which possess same gray level intensities formed into group as undetermined remaining pixels are segmented. Region growing is one of method in which overall image is splitted into similar sub region. In splitting & merging, given input is divided to several random regions and merged. Quad tree concept is used to segment it. Water shed is another way there a threshold value is set if gray level crosses that value of information, boundaries are drawn between them. Noise sensitivity is high in this type so that new concept is encountered to overcome disadvantages in it. Peer group which is non-linear filter applied to images reduce noise and smoothing.

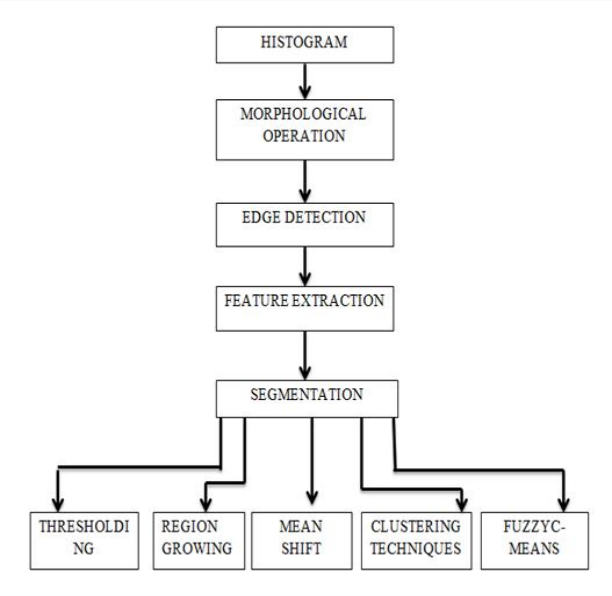

Figure 4 Steps in Segmentation

Above diagram shows evolution of steps in segmenting an image. Basically, thresholding is a factor through which limit or level is set. If a value of threshold is 1 then all pixels with the value less than 1 is clustered as one group of region and values with above 1 are grouped as another region. In region growing, same gray level value of pixels are combined. Initial process is to select a seed point among image where pixels are grouped relative to the seed point area. While this process is continued until all voxel are grouped with that value. Mean shift follows non- parametric clustering to which mean values identified, spherical widows containing r values are defined. Clustering is a common way of format for partitioning images. This provides all pixels having same values grouped as one cluster and remaining are combined as another one. On pixel can belong to only one cluster is known as exclusive clustering. That means, no single pixel cannot be allowed to present in many cluster. Another way clustering defines, single pixel can accommodate in many cluster are called as overlapping clustering.

2. Literature Review

2.1. Brain Tumor Tissue Segmentation Based On Fuzzy Information Framework

Fuzzy framework of information is used to segment cells of tumor in automatic segmentation. Prior knowledge about the tumor tissues are obtained from radiology experts to deal with different MRI images. In order to obtain accurate results, several multispectral images are compared with each other. Because single MRI cannot be able to provide detailed information about tumor. It comprises an algorithm with following steps:

- Multispectral images have to registered
- Characteristics of tumor has to be described by means of fuzzy
- Operators of fuzzy used in fusion

- Adjustment in region done with fuzzy connectors
- Compare between the results obtained and hand tracings

2.1.1Segmentation Procedure Overview

In common several types of tumor tissues are available such as glial, benign, and malignant. According to research, glial is very bright when compared to other methods. But it is darker in T1 images. Descriptions are given by experts relative to intensities of various MR data. The '+' symbol indicates high level of intensity which means hyper signal, '_' represents darker image means hypo signal, '+_' indicates darker than hyper signal, '_+' shows signal intensity is higher than hypo signal. '++' denotes intensity higher than hyper signal. In T1 weighted, it is neither dark nor bright.

Signal Intensity	TISSUES			
	GM	WM	CSF	TUMOR
T1	_ _	_	+ +	- +
T2	+ +	+	_ _	+ +
PD	+ -	+ +	_ _	+ +

Table 1 Intensity Levels Chart

2.1.2. Fuzzy Model Creation

Collection of objects with membership function is known as fuzzy set. A membership function represents a relationship between any two neighbour pixels [0, 1] in order to determine the degree of similar objects. Fuzzy set is obtained by several function provided by neighbourhood pixels. Many mathematical formulas are available such as trapezoidal, Gaussian likewise etc. The membership functions corresponding toT1, T2 and P Dare noted mFrT1, mFrT2 and mFrPD.

2.1.3 Fusion of Fuzzy Feature

Fuzzy is generally characterized as possibility or probability of occurrences. Presence of tumor can't be judged easily as region around data is non-similar(heterogeneous). Feature spaces are obtained from $\mu F_r T1$, $\mu F_r T2$, and $\mu F_r PD$ where it provides $F_r T1$, $F_r T2$, $F_r PD$ whose values defines possibility of presence of tumor.

2.2 Segmentation on 3-D MRI Images Based on Fuzzy classification

The major concept of 3-D image deals with, detecting abnormal cells in accordance with asymetric region thereby providing spatial relationship between ROI precise segmentation. Though there are many more methods available in medical diagnosis promising results of patients cannot be obtained due to the irregular process of segmentation. It is still a challenging one because of variation in size of tumor cells, location, shapes and difference in intensity levels. Learning based methods are used where they have two types. Supervised learning contains

trained datasets which prescribes a prior knowledge of information thereby decreasing risk of finding tumor cells are reduced. It includes k-means clustering, fuzzy and markov methods

2.2.1. Overview of Method

Initialization & refinement are the two basic steps going to be performed in first process. That means, histogram performed to improve intensity levels and morphological operations applied to deal with erosion, dilation. Assumption is done with specific gray levels and also according to shape of image. This detection provides the important steps performed in the second stage, through a parametric deformable model comprised by fuzzy spatial relations.

2.2.2. Segmentation of Brain

Symmetry analysis produces a plane formation of image therefore assuming area for presence of infected tissues in brain can be gathered by detailed prior knowledge which was given by radiologyexperts comprised with various intensity levels. While processing major step is to remove other unwanted parts in image such as skull, muscles etc.

3. Methodology

3.1. Fuzzy C-Means

It is an unsupervised method for analysis of data and do not force object belong one class itself. This allows that a data point can take membership between 0 and 1 and it belong to all group in cluster. Class Center is used in membership function for which data close to that class is having more relationship. The FCM makes use of priori information in segmentation.

3.2. Fast Generalized FCM

It is a combination two FCM which is fast FCM and enhanced FCM. This method overcomes the disadvantages in FCM such as lack of noise sensitivity, robustness, reduction in segmentation time. FGFCM can make use of both gray and spatial information and the time for segmenting an image is based only on gray levels.

3.3. Automatic Modified FCM

This method will be able to find number of clusters and provide good quality of segmentation. AMFCM combines spatial information with that of the membership function values. Neighbourhood pixels which are nearer to the class centers are combined together to obtain better segmentation.

3.4. Fuzzy Probabilistic c- Means Algorithm

It combines advantages of clustering and fuzzy c-means algorithm. Membership values are calculated with that of gray levels. Noise is major problem accounting in FCM whereas it is encountered and completely avoided in these methods. Each pixel can accommodate in one single cluster of region which states that no one pixel can be able to present in more than one group of cluster.

3.5. Bias Corrected FCM

Initial step of this method is dealing with in homogeneties in an image. It aims to label each pixel with

unique name thereby forming cluster also within that of neighbourhood pixels. The neighbourhood effect acts as a common factor for organizing similar pixels to form membership function; such an organizing function is used in equalizing intensity values.

4. Result

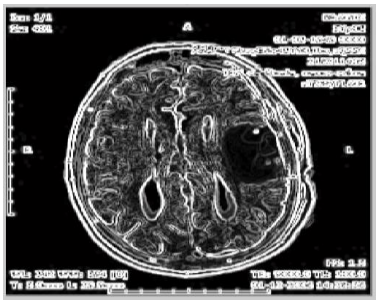

Figure 6 Tumor Edge Detection

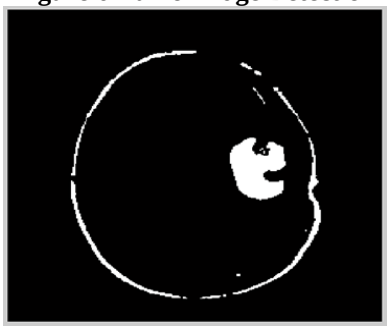

Figure 7 Segmented tumor

5. Conclusion

In general, segmenting tumor without manual intervention is a complex task. Besides several methods, FCM is an efficient way of tumor analysis so that experts make use of it for diagnosis process. This paper gives overview of about how FCM is used in tumor segmentation. In future, this FCM can be combined with several other methods to get more accuracy.

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