ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 5, May 2015

A REVIEW ON MRI IMAGE SEGMENTATION TECHNIQUES

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Abstract **Image processing is the most important achievements and commonly used engineering techniques in all the areas of science, including medical science that now a days severely has eclipsed diagnosis and treatment of many diseases Since MRI compared to other diagnostic modalities is safe and noninvasive and on the other hand reflects the true dimensions of the organ, its use in imaging of brain is widely considered. This paper presents a latest review of different technologies used in medical image segmentation like genetic algorithm & fuzzy control etc.**

KEYWORDS **Image Processing; C-means Fuzzy Clustering; Genetic Algorithm; MRI; Image Segmentation.**

I. INTRODUCTION

In clinical diagnosis, the segmentation of medical images is an important step [5]. Information is conveyed through images. Image processing is a process where input image is processed to get output also as an image. Main aim of all image processing techniques is to recognize the image or object under consideration easier visually [2]. All the images used in today's world are in the digital format. Medical images are images that show the physical attributes distribution. Medical imaging modalities as in MRI, CT scan mostly depend on computer technology to generate or display digital images of the internal organs of the human body which helps the doctors to visualize the inner portions of the body.

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Image processing is one the most important achievements and commonly used engineering techniques in all areas of science, including medical science that nowadays severely has eclipsed diagnosis and treatment of many diseases Since MRI compared to other diagnostic modalities (radiography, C T scan, etc.) is safe and noninvasive and on the other hand reflects the true dimensions of organ, its use in imaging of brain is widely considered [1].

Methods for performing segmentations vary widely depending on the specific application, imaging modality, and other factors. For example, the segmentation of brain tissue has different requirements from the segmentation of the liver. General imaging artifacts such as noise, partial volume effects, and motion can also have significant consequences on the performance of segmentation algorithms. Furthermore, each imaging modality has its own idiosyncrasies with which to contend.

Fully automatic brain tissue classification from magnetic resonance images (MRI) is of great importance for research and clinical study of much neurological pathology. The accurate segmentation of MR images into different tissue classes, especially gray matter (GM), white matter (WM) and cerebrospinal fluid (CSF), is an important task [8].

II. MAGNETIC RESONANCE IMAGING

Magnetic Resonance Imaging (MRI) is an imaging technique used primarily in medical settings to produce high quality images of the inside of the human body. In order to preview about MRI, in this section we give a brief description of the principles of MRI which are refered to [[6]. In MRI, the image is a map of the local transverse magnetization of the hydrogen nuclei. This transverse magnetization in turn depends on several intrinsic properties of the tissue. The MR phenomenon relies on the fundamental property that protons and neutrons that make up a nucleus possess an intrinsic angular momentum called spin. When protons and neutrons combine to form nucleus, they combine with oppositely oriented spins. Thus, nuclei with an even number of protons and neutrons have no net spin, whereas nuclei with an odd number of protons or neutrons possess a net spin. Hydrogen nuclei have an NMR signal since its nucleus is made up of only a single proton and possess a net spin. The human body is primarily fat and water, which have many hydrogen atoms. Medical MRI primarily images the MRI signal from the hydrogen nuclei in the body tissues [4].

III. IMAGING CHARACTERISTICS OF MRI SCANS

The images produced by MRI scans are usually gray images with intensity in the range 0-255. The GM of the brain consists of the cortex that lines the external surface of the brain and the gray nuclei deep inside of the brain, including the thalami and basal ganglia. WM is comprised of the neuronal axons that interconnect different regions of the brain and serve as the interface between the brain and the rest of the body. The watery fluid, CSF acts as a cushion for physical shocks. The WM constitutes a connected region that is bordered by GM and CSF as shown in Fig.1. In Fig.1, for the display purpose WM is shown in gray color, GM as white color and CSF as black color. In MRI of head scans, the picture of organ is usually surrounded by air particles, known as background (bck) in order to make a matrix representation. This bck is another major ROI in MRI of head scans [3].

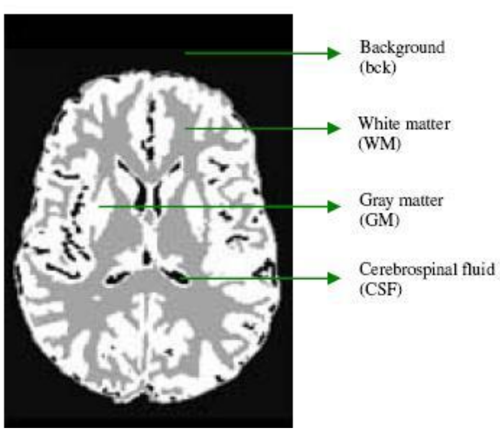

Fig 1.Segmentation results of MRI of axial head scan [3]

IV. IMAGE SEGMENTATION

Segmentation subdivides an image into its constituent regions or objects [4]. The level of detail to which the subdivision is carried depends on the problem being solved. That is, segmentation should stop when the objects or regions of interest in an application have been detected. Segmentation of nontrivial images is one of the most difficult tasks in image processing. Segmentation accuracy determines the eventual success or failure of computerized analysis procedures. For this reason, considerable care should be taken to improve the probability of accurate segmentation.

1. GENETIC ALGORITHM

A genetic algorithm is an iterative procedure that involves a population of individuals, each one represented by a finite string of symbols, known as the genome, encoding a possible solution in a given problem space. This space, referred to as the search space, comprises all possible solutions to the problem at hand. The standard genetic algorithm proceeds as follows: an initial population of individuals is generated at random or heuristically. Every evolutionary step, known as a generation, the individuals in the current population are decoded and evaluated according to some predefined quality criterion, referred to as the fitness, or fitness function. To form a new population, individuals are selected according to their fitness. Thus, high-fitness individuals stand a better chance of reproducing, while low-fitness ones are more likely to disappear. Then crossover is performed with the probability *pc* between two selected individuals, called parents, by exchanging parts of their genomes to form two new individuals, called offspring. Next, the mutation operator is introduced to prevent premature convergence to local optima by randomly sampling new points in the search space. Flipping bits at random carries it out; with some small probability *p*m. Genetic algorithms are stochastic iterative processes that are not guaranteed to converge. The Termination condition may be specified as some fixed maximal number of generations or as the attainment of an acceptable fitness level [7].

Basically, a genetic algorithm consists of three major operations: selection, crossover, and mutation. The

ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 5, May 2015

selection evaluates each individual and keeps only the fittest ones in the population. A genetic algorithm is based on the idea that natural evolution is a search process that optimizes the structures it generates. An interesting characteristic of GA is their high efficiency for difficult search problems without being stuck in local extremum. In a GA, a population of individuals, described by some chromosomes, is iteratively updated by applying operators of selection, mutation, and crossover to solve the problem. Each individual is evaluated by a fitness function that controls the population evolution in order to optimize it [10].

Many optimization techniques have been used to detect tumor more efficiently and accurately. In recent years, genetic algorithm has been used to extract features present in the image. The features of the image help in determining the information which is used for detecting tumors. The genetic algorithm (GA) is a search heuristic that mimics the process of natural evolution. This heuristic is routinely used to generate useful solutions to optimization and search problems. Genetic algorithms belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection and crossover [2].Genetic Algorithm is used as feature extraction and feature selection technique. Also at classification step different algorithms are presented. Classifiers are divided to supervised and unsupervised according to training methods. One of the popular classification methods is Support Vector Machine (SVM) .SVM is a supervised learning method which classifies points by assigning them to one of two disjoint half spaces. These half spaces are either in the original input space of the problem for linear classifiers, or in a higher dimensional feature space for nonlinear classifier [7].

A genetic algorithm is defined by considering five essential data [10]:
(1) *genotype*: the segmentation result of an image *I* is considered as an individual described by the class of each pixel.
(2) *initial population*: a set of individuals characterized by their genotypes. It is composed of the segmentation results to combine,
(3) *fitness function*: this function enables us to quantify the fitness of an individual to the environment by considering its genotype. The evaluation criteria described in the previous sections can be used as a fitness function in the unsupervised case or in and in the semi supervised cases,
(4) *operators on genotypes*: they define alterations on genotypes in order to make the population evolve during generations.
(5) *stopping criterion*: this criterion allows to stop the evolution of the population.

Given these five information, the execution of the genetic algorithm is carried out in four steps [10]:
(1) Definition of the initial population (segmentation results) and computation of the fitness function (evaluation criterion) of each individual,
(2) Mutation and crossing-over of individuals,
(3) Selection of individuals,
(4) Evaluation of individuals in the population,
(5) Back to Step 2 if the stopping criterion is not satisfied.

2. FUZZY C-MEANS SEGMENTATION

Clustering is a mathematical tool that groups the data with similar feature vector in to one group and dissimilar data in to different group. In hard clustering, a feature vector can be a part of only one cluster. Whereas, in Fuzzy clustering feature vector can belong to more than one cluster but have different membership degrees (between 0 and 1). Steps of Fuzzy C-means Algorithm: Let X = {x1, x2, x3 ..., xn} represents feature vector and V = {v1, v2, v3 ..., vc} represents set of centers of cluster.

FCM clustering is an unsupervised method for the data analysis. This algorithm assigns membership to each data point corresponding to each cluster centre on the basis of distance between the cluster centre and the data point. The data point near to the cluster centre has more membership towards the particular centre. Generally, the summation of membership of each data point should be equal to one. After, each iteration the membership and cluster centers are updated according to the formula [11].
1) Algorithmic steps for fuzzy C-means clustering [11]:
Let X = {x1, x2, x3, ...xn}be the set of data points and V = { v1, v2, v3, ...vc }be the set of cluster centres.
Step1: Randomly select ‘c’ cluster centres
Step2: Calculate the fuzzy membership ‘µij’using the equation

ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 5, May 2015

$$\mu_{ij} = \frac{1}{\sum_{k=1}^{c}\left(\frac{d_{ij}}{d_{ik}}\right)^{\left(\frac{2}{m-1}\right)}}$$

Step3: Compute the fuzzy centres 'vj'using

$$V_j = \frac{\left(\sum_{i=1}^{n}(\mu_{ij})^m x_i\right)}{\left(\sum_{i=1}^{n}(\mu_{ij})^m\right)}, \forall_j = 1,2....c$$

Step4: Repeat step2 and step3 until the minimum 'J' value is achieved or $\|U(k+1)-U(k)\| < \beta$
Where,
'k' is the iteration step
'β' is the termination criterion between [0,1]
'U=(µij)nc' is the fuzzy membership matrix
'J' is the objective function
The first loop of the algorithm calculates membership values for the data points in clusters and the second loop recalculates the cluster centre's using these membership values. When the cluster centre stabilizes the algorithm ends.

The FCM algorithm gives best result for overlapped data set and also gives better result than k-means algorithm. Here, the data point can belong to more than one cluster centre. The main drawback of FCM is

1) The sum of membership value of a data point xi in all the clusters must be one but the outlier points has more membership value. So, the algorithm has difficulty in handling outlier points.
2) Due to the influence of all the data members, the cluster centers tend to move towards the centre of all the data points. It only considers image intensity thereby producing unsatisfactory results in noisy images [11].

3. THRESHOLDING

Thresholding approaches segment scalar images by creating a binary partitioning of the image intensities. A thresholding procedure attempts to determine an intensity value, called the *threshold*, which separates the desired classes. The segmentation is then achieved by grouping all pixels with intensity greater than the threshold into one class, and all other pixels into another class. Determination of more than one threshold value is a process called multi thresholding [12].

Thresholding is a simple yet often effective means for obtaining the segmentation in images where different structures have contrasting intensities or other quantifiable features. The partition is usually generated interactively, although automated methods do exist [12]. For scalar images, interactive methods can be based on an operator's visual assessment of the resulting segmentation since the thresholding operation is implementable in real-time. Thresholding is often used as an initial step in a sequence of image processing operations. Its main limitations are that in its simplest form only two classes are generated and it can't be applied to multi-channel images. In addition, thresholding typically does not take into account the spatial characteristics of an image. This causes it to be sensitive to noise and intensity inhomogeneities, which can occur in magnetic resonance images.

V. RESULT

Sr. No.	Method	Merits	Demerits
	Genetic algorithm	used to generate useful solutions to optimization and search problems detect tumor more efficiently and accurately	Computation time is more More complex
	Fuzzy C-means	Effective for high resolution images	Depends on initial cluster center
	Thresholding	effective means for obtaining the segmentation in images where different structures have contrasting intensities or	It can't be applied to multi-channel images. sensitive to noise and intensity inhomogeneities

		other quantifiable features Thresholding operation is implementable in real-time.	

VI. CONCLUSION & FUTURE SCOPE

Segmentation is an important step in advance image analysis and computer vision and therefore is an ongoing research area although a dense literature is available. Many image segmentation methods have been developed in the past several decades for segmenting MRI brain images, but still it remains a challenging task. A segmentation method may perform well for one MRI brain image but not for the other images of same type.

Future research in the segmentation of medical images will strive towards improving the accuracy, precision, and computational speed of segmentation methods, as well as reducing the amount of manual interaction. Accuracy and precision can be improved by incorporating prior information from atlases and by combining discrete and continuous-based segmentation methods. For increasing computational efficiency, multi scale processing and parallelizable methods such as neural networks appear to be promising approaches. Computational efficiency will be particularly important in real-time processing applications.

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