International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Review Article

MRI Brain Tumor Segmentation Methods- A Review

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Accepted 02 May 2016, Available online 05 May 2016, **Vol.6, No.3 (June 2016)**

Abstract

Medical image processing and its segmentation is an active and interesting area for researchers. It has reached at the tremendous place in diagnosing tumors after the discovery of CT and MRI. MRI is an useful tool to detect the brain tumor and segmentation is performed to carry out the useful portion from an image. The purpose of this paper is to provide an overview of different image segmentation methods like watershed algorithm, morphological operations, neutrosophic sets, thresholding, K-means clustering, fuzzy C-means etc using MR images.

Keywords: *Brain tumor, segmentation, MRI.*

Introduction

Tumors are the unwanted growth of brain tissues in the skull. Tumors are of different type and behave differently according to their size, shape and location. Tumors can be classified as: - 1. Benign 2. Pre-Malignant 3. Malignant. Benign means non-progressive. So these types of tumors cannot be spread and are non-cancerous. But these can have negative effect such some may press against nerves of blood vessels and can cause pain. Pre-Malignant tumors are the pre-cancerous stage of the tumor that is not yet malignant but is about to become so malignant brain tumors are cancerous and these become progressively worse and can cause death.

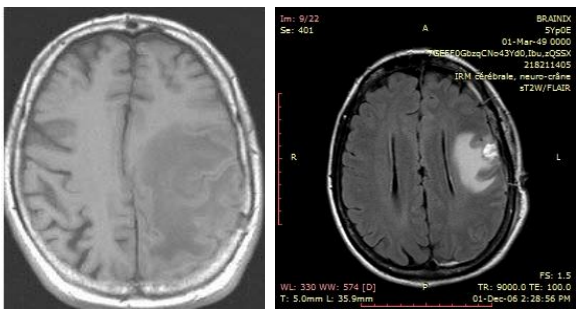

Fig 1.a) brain tumor image with no contrast b) with contrast

Moreover, Brain tumor is the abnormal growth of cells inside the brain. Brain tumors can be divided into two categories. 1. Primary brain tumor 2. Secondary brain tumor. Primary brain tumors are that which originates inside the brain and do not spread anywhere. These can be classified by the type of the tissue in which they arise. Secondary brain tumors are those which begin from another part of the body such as lung, breast, skin and kidney etc. and grow towards the brain. These can cause the death of the patient. According to WHO there are 120 types of brain tumor. They divided it into from least progressive (Benign) to more progressive (Malignant). It classifies brain tumors into grade I to IV under the microscope. In general, grade I and grade II are benign brain tumor (low-grade); grade III and grade IV are malignant brain tumor (high-grade). If low-grade brain tumor is not treated, it is likely to deteriorate to high-grade brain tumor. In Southern Asia i.e. in India, incidence rate of brain tumor is about 2 patients per 1, 00,000 population, while the molarity rate is less than 2 patients per 1,00,000 population. In 2006, at TATA Memorial Hospital in Mumbai 372 people diagnosed with brain and central nervous system problems. Among which 250(67%) were male and 122(33%) were female. In 2015, estimated deaths became 15,320 i.e. 67% among this 4000 were teens. In the United States 13,000 deaths are noticed per year.

Segmentation is the process of partitioning a digital image into segments i.e. into small number of pixels to simplify the representation of the image. There are several segmentation methods. Thresholding technique in which input gray scale image is converted into binary image based on some threshold value. Thersholding is of two types a) Global b) Local In watershed transformations pixels of an image are grouped on the basis of their intensities. Morphological operations are non-linear operations which are related to the shape and morphology of features in an image. K- means clustering is an algorithm which is used to group pixels based on attributes into k number of groups where k is a positive integer. Fuzzy c-means is a

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way of processing the data by giving the partial membership value to each pixel in the image. Genetic algorithm is based on heuristic method. It works in five stages i.e. 1. Initialization of population 2. Evaluation of fitness function 3. Selection 4. Crossover 5. Mutation and termination. In neutrosophic theory, every event has not only a certain degree of the truth, as well as a falsity degree and an indeterminacy degree that must be considered autonomously from one another. Region growing technique is pixel based image segmentation. In normal region growing method, only the intensity constrain is taken into account. Here, first a threshold value is set and a seed point is found out. The neighboring pixels, whose intensity difference between the seed point and corresponding neighbor pixel is below the particular threshold value, are grown to the region.

Literature Survey

A number of different research papers were studied for image segmentation methods. A report of literature survey is presented here

Ananita Fathi Kazerooni *et al,* 2011; introduced multi scaled vector flow based segmentation for tumor detection. The results show better accuracy and sensitivity than traditional vector flow and Bspline GVF.

P.Dhanalakshmi *et al,* 2013; used k-means clustering for automatic brain tumor segmentation and area calculation. The proposed algorithm shows the better accuracy and reproducibility.

G. Evelin Sujji *et al,* 2013; presented threshold based image segmentation. The outcome shows the proper detection of region of interest.

Divya Kaushik *et al*, 2014; introduced genetic algorithm based segmentation. The propsed algorithm describes the extraction of brain tumor regions from the corners as well.

Swe Zin Oo *et al*, 2014; proposed watershed segmentation and morphological operation based brain tumor segmentation. The results show the removal of skull tissues and location of tumor based on pixel value.

Alan Jose *et al,* 2014; introduced K-means clustering and fuzzy c-means algorithm. The algorithm shows the exact location and detection of tumor.

Rohini Paul Joseph *et al,* 2014; introduced MRI brain tumor detection and segmentation based on K-means clustering and morphological operations. The result shows detection of tumor location and avoids misclustered regions.

Roopali R.Laddha *et al,* 2014; introduced brain tumor image segmentation using threshold operations. Result shows the efficient end results of brain tumor segmentation.

Jin Liu *et al,* 2014; presented a review paper on different segmentation methods. The results of this paper show the comparison of different segmentation techniques.

Mohan J *et al,* 2015; introduced automated brain tumor segmentation based on neutrosophic sets. The result shows 98.37% accuracy and 99.52% high specificity.

G. Vishnuvarthanan *et al,* 2015; presented unsupervised learning method for tumor identification and tissue segmentation. The result shows the different types of tumors at different locations.

Segmentation Techniques

Nowadays, brain tumor segmentation techniques can be composed into different classes based on different principles. In the clinic, brain tumor segmentation methods are normally divided into three main categories including manual, semi-automatic, and fully automatic segmentations based on the degree of required human interaction [12].Various segmentation techniques are used in digital image processing. 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. 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. Some of the common techniques that are used for image segmentation are:-

Conventional methods

In this paper, conventional brain tumor segmentation methods mainly include the use of standard image processing methods such as threshold based methods and region-based methods. Threshold-based and region-based methods are commonly employed in two-dimensional image segmentation.

Threshold-based methods

Thresholding is used to convert gray scale image into binary image. This method of segmentation applies a single fixed criterion to all pixels in the image simultaneously.

Global Thresholding

Suppose the histogram of an image f (x, y) is composed of light objects on a dark background. Two dominant modes are used to group the pixel intensity levels of the object and the background. In global thresholding, a threshold value T is selected in such a way that it separates the object and the background.

Global thresholding technique will not produce the desired output when pixels from different segments overlap in terms of intensities. The overlapping of intensities may be caused due to (a) noise (b) variation in illumination across the image.

Local Thresholding

Global thresholding method is not suitable whenever the background illumination is uneven. In local thresholding technique, the threshold value T depends on gray levels of f(x, y) and some local image properties of neighboring pixels such as mean or variance.

Genetic Algorithm

Genetic algorithm is a natural inspired Meta heuristic algorithm. In GA each solution is constituted as chromosome and each chromosome is made up of genes. In the next iteration, the best generated solutions will be added while the bad solutions will be rejected. When its solutions are iterates by the algorithm, these solutions are produced better up to a point where a converge to near optimal solution is achieved.

In general, a GA has five stages: initialization of population, evaluation of fitness function, selection, crossover, mutation and termination. Initial population is created randomly, which can be done by setting genes to random values. After the initialization process, fitness function of each chromosome is evaluated.

Watershed Algorithm

Watershed segmentation is a gradient-based segmentation technique. It considers the gradient map of the image as a relief map. It segments the image as a dam. The segmented regions are called catchment basins. Watershed segmentation solves a variety of image segmentation problem. It is suitable for the images that have higher intensity value. Watershed segmentation is caused over segmentation. To control over segmentation, marker controlled watershed segmentation is used. Sobel operator is suitable for edge detection. In marker controlled watershed segmentation, sobel operator is used to distinct the edge of the object.

Morphological Operation

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. A morphological operation on a binary image creates a new binary image in which the pixel has a non-zero value. Two basic morphological operations are erosion and dilation. Erosion shrinks the image and dilation grows the image.

Fuzzy C-means Algorithm

Fuzzy C-means (FCM) algorithm is a clustering methodology introduced by Dunn, enhanced by Bezdek and further titivated by Matteo Matteucci and it groups the voxels (data) of the magnetic resonance (MR) brain images as 'n' number of clusters. The neigh-boring pixel of least mean distance from the centroid pixel are assigned with low membership grade value and are grown around the centroid value, hierarchically. The membership grade and the cluster centers are iteratively updated to reduce the objective function of grouping the voxels.

Self-Organizing Map

SOM is capable of projecting the prototypes either in two dimensional or three dimensional spaces. This representation occurs based on the dimension of the output layer. Initial level grouping of the prototypes is done using SOM. Prototypes which are quite similar in nature are placed closer to the output space. This placement of prototypes is usually performed based on Euclidean distance calculation. The location of the prototype son the output space tends to be a valuable source of information and can be utilized to cluster the SOM.. Based on the eigen-values and eigenvectors of the training data, linear initialization of the SOM prototypes is performed.

Neutrosophic sets

In neutrosophic theory, every event has not only a certain degree of the truth, as well as a falsity degree and an indeterminacy degree that must be considered autonomously from one another. This hypothesis considers each thought <A> together with its inverse <antiA> and with their range of neutralities <neutA> in the middle of them (i.e. thoughts or thoughts supporting neither <A> nor <antiA>). The <neutA> and <antiA> thoughts together are alluded to as <nonA>. In the neutrosophic sets let U be a universe of talk, and M a set incorporated into U. A component x from U is noted concerning the set M as x (T, I, F) and has a place with M in the accompanying way: it is t% valid in the set, i% uncertain in the set, and f% false, where t changes in T, i differs in I, f fluctuates in F. Statically T, I, F are subsets, however progressively T, I, F are capacities/administrators relying upon numerous known or obscure parameters.

Survey based on Algorithms

FCM algorithms

FCM is a clustering method which divides one group of data into two or more clusters. This method is used for pattern recognition. In this, membership value is assigned to each data point corresponding to each cluster center according to the distance between the data point and the cluster. On the basis of data nearer to cluster center the more possibility of its membership value towards the particular cluster center. In the study of brain tumor segmentation, brain tumor was segmented as active cells, necrotic core and edema using unsupervised FCM clustering algorithm.

Atlas-based algorithms

Firstly, the Atlas based algorithm was introduced to register the different images. After that it was widely

used as guidance for brain tumor segmentation. Atlases can be used for the restriction of tumor location and classification models. It includes three steps:

Step 1. An affine registration brings the atlas and the patient into global correspondence.
Step 2. The seeding of a synthetic tumor into the brain atlas provides a template for the brain tumor.
Step 3. The deformation of the seeded atlas by optical flow principles and brain tumor growth. Atlases are not only used to impose spatial constraints, but also to provide probabilistic tissue model for brain tumor detection.

MRF algorithms

MRF was proposed to integrate spatial information into the clustering or classification process. The possible problem of overlapping and the effect of noise on the result are reduced in the clustering technique. With strongly labeled region as tumor or non-tumor MRF determine if the neighbor region is same. Conditional Random Fields (CRF) were proposed to build probabilistic models to segment and label sequence data. The tumor growth model, formulated as a mesh-free MRF energy minimization problem, ensures correspondence between the atlas and the patient image, prior to the registration step. This method is non-parametric, simple, and fast compared to other approaches.

SVM algorithms

SVM was used as a parametrically kernel based method which deals with supervised classification problems. Basically, it is used in the field of brain tumor segmentation mainly due to classification property. There is one another method for image segmentation that is called one class SVM. It has the ability of learning the non-linear distribution of the image data without any kind of prior knowledge, by automatic procedures of SVM parameters. By this method not only healthy tissues are segmented but also sub-compartments of healthy and tumor tissues are segmented. Two steps are performed in this algorithm:-

Step 1. Classifying the tumor region using a multi kernel which performs on multi stage sources.
Step 2 Obtains relative multi-results and ameliorating the contour of the tumor region using both the distance and the maximum likelihood measures.

Some relatively good algorithms of MRI-based brain tumor segmentation.

Year of Publication	Author name	Method	Results
2015	G. Vishnuvarthanan *et al*	FKM+SOM	Different types of tumors at different locations.
2010	Mohan J *et al*	Neutrosophic sets	98.37% accuracy, 99.52% specificity
2013	P. Dhanalakshmi & T. Kanimozhi	K-means clustering and area calculation	Better accuracy, reproducibility
2013	G. Evelin Sujji *et al*	Thresholding	Proper detection of region of interest
2014	Divya Kaushik *et al*	Genetic algorithm	Tumor region is extracted from corners as well
2014	Swe Zin Oo *et al*	Watershed morphology	Tumor location determined
2014	Alan Jose *et al*	K-means+ fuzzy c-means	Tumor detection, exact location of tumor
2014	Rohini Paul Joseph *et al*	K-means+ morphological filtering	Avoids misunderstanding, detection of tumor location
2014	Roopali R.Laddha *et al*	Threshold operations+ watershed+ morphology	Efficient end results of tumor detection
2011	Anahita Fathi Kazerooni *et al*	Gradient vector flow	92.8% accuracy, 95.4% sensitivity

Conclusion

This paper has presented the different segmentation and algorithms for tumor detection and classification. Different techniques give different results in terms of accuracy, efficiency, sensitivity and location of brain tumor. Flower pollination algorithm (FPA), gravitation search algorithm (GSA), combination of gradient and morphology etc. are not used for tumor detection which can be used.

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