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Tumor Identification in Brain MRI Images Using Fuzzy-C-Means Algorithm

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Abstract : *Human brain consists of different tissues namely white matter(WM), gray matter(GM), cerebrospinal fluid matter(CSF). The tumors may exist in any of these three matters, in the brain image it is difficult to demarcate them individually. This paper deals with the detection of the tumors in these three matters in a human brain. This includes two steps, in the first step, image segmentation is done by FCM (Fuzzy-C-Means) algorithm. Image segmentation is helpful in segmenting the different objects in an image. Here the Fuzzy C-Means algorithm is implemented for clustering of the brain image in an efficient way. The second step is to detect the edges in the resultant brain image of the first step. By this, curves will be generated for a specific matter of a human brain. This approach follows level setting technique and it makes easier in the visualization of the tumors. Level set method is one of the numerical method for tracing interfaces and shapes.*

Keywords : *Brain MRI, Clustering, FCM , Level set, Segmentation*

I. Introduction

The diagnostic tools in medical imaging namely magnetic resonance imaging (MRI), X-ray, positron emission tomography (PET) and computed tomography (CT), medical ultrasonography, single-photon emission computed tomography(SPECT) MRI is a very versatile imaging modality, which is used to acquire images of different body parts such as brain, heart, knee etc. The images generated by the MRI are interpreted visually and qualitatively by radiologists. But, quantitative information, such as the volume of WM, GM and CSF in brain and size of the various brain structures after a traumatic brain injury is required for diagnosis. It is necessary to take leverage of technology and develop a methodology for viewing and measuring various structures in order to provide quantitative information about brain from brain MRI images. Moreover the task is often made more difficult by the presence of noise and artifacts and patient movement. There is yet no universal algorithm for medical image segmentation. An algorithm's advantages and drawbacks often varying according to the problem under investigation.

Medical image analysis is an important bio medical application, which is highly computational in nature and requires the aid of the automated systems. Automated detection of the abnormalities in medical images is an important in medical diagnostics, planning and treatment. Doctors need to use their own knowledge and expertise to adjust the parameters related in many segmentation algorithms for an optimal performance. Due to non-homogeneous physiological tissues the brain MRI image segmentation is considered complex, most of the available methods are interactive or semi-automatic. The doctors initialize the segmentation and interrupt the process as and when required. Therefore such a methodology is subjective and labor intensive.

A tumor is an abnormal benign or malignant new growth of tissue (like swelling) that possesses no physiological function and arises from uncontrolled usually rapid cellular proliferation. It is not synonymous with cancer. It can be benign, pre-malignant whereas cancer is by definition malignant.

A benign tumor is a tumor that lacks all three of the malignant properties of a cancer. Thus, by definition, a benign tumor does not grow in an unlimited, aggressive manner, does not invade surrounding tissues, and does not spread to non-adjacent tissues (metastasize). Common examples of benign tumors include moles and uterine fibroids.

Malignancyis the tendency of a medical condition, especially tumors, to become progressively worse and to potentially result in death. Malignant is a corresponding adjectival medical term used to describe a severe and progressively worsening disease. The term is most familiar as a description of cancer. From the literature survey, it is observed that less work is done in the area of brain image segmentation. The available methods are semiautomatic and require intervention from the radiologist during segmentation. Hence, we are proposing a two-stage completely automatic method for brain MRI image segmentation. In the first stage, a modified FCM algorithm is used to get approximate boundary for WM, GM and CSF. In the second stage, level sets are used to get accurate boundary. This combined method requires less time to segment and also gives good segmentation quality.Image segmentation is the division of an image into regions or categories. Segmentation attempts to partition the pixels of an image into groups that strongly correlate with the objects in an image.

The paper is divided into four sections. The proposed methodology which includes FCM and segmentations is given in section two. Results and discussions are presented in section three. Conclusion of the work is given in section four.

II. Proposed Methodology

This methodology consists of two stages. In the first stage,image segmentation is done by modified FCM (MFCM).The results of 1^{st} stage are used in the 2^{nd} stage which comprises of level set segmentation.The MFCM also helps in estimating the controlling parameters which are required for the level set segmentation method.

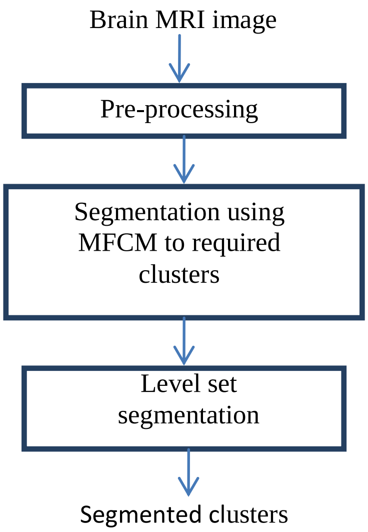

Fig 1. Steps used in the segmentation of brain MRI images

2.1.Preprocessing:

The images which are used in this paper are bmp gray scale format which are of size 200*250 pixels.sample input brain image is shown below. Different regions of tissues are marked.The presence of any degradation in the image can be reduced by using adaptive filter which is used to remove the noise. It is the low pass filter which processes the grayscale image degraded by constant power additive noise.

2.2.Segmentation using MFCM(Modified fuzzy-C-Means):

In this methodology, initially the FCM technique is applied on a brain MRI Image which results in three clusters namely, White Matter (WM), Gray Matter (GM) and Cerebro Spinal Fluid (CSF). These three Clusters act as input to the Level Set Algorithm. Through this algorithm, accurate boundaries are obtained for each Cluster. By evaluating the boundaries of these Clusters, Tumor can be easily detected.

The aim of this thesis is to detect Tumor present in a brain MRI Image through Segmentation. In this thesis work Segmentation is done using FCM algorithm and the output thus resulted is given as input to the level set block to locate the actual position of the Tumor. The new system is significantly improved in the following aspects. Firstly, Fuzzy Clustering incorporates spatial information during an adaptive optimization, which eliminates the intermediate morphological operations. Secondly, the controlling parameters of level set Segmentation are now derived from the results of Fuzzy Clustering directly. Thirdly, a new strategy directed by Fuzzy Clustering is proposed to regularize level set evolution, which is different from the existing methods.

Fuzzy C-Means is an overlapping Clustering technique. One pixel value depending on two or more Clusters centre's. It is also called soft Clustering method. One of the most widely used Fuzzy Clustering algorithms is the Fuzzy C-Means (FCM) algorithm. The FCM algorithm is partition of n element $X=\{x1\ldots x_n\}$ into a collection of C Fuzzy Clusters with respect to below given criteria.

The FCM is also known as Fuzzy C-Means nebulous because it uses Fuzzy Logic so that each instance is not associated with only one Cluster, but has a certain degree of membership for each of the existing Centers. For this, the algorithm creates a matrix U Associatively, where each term μ_{ij} represents the degree of membership of sample i to cluster j. In the FCM algorithm have a variable Fuzziness m such that $1.0 < m < \infty$, where m is a real number. The closer m is to infinity (∞), the greater the fuzziness of the solution and the closer to 1, the solution becomes increasingly similar to the clustering of binary K-Means.

Fuzzy-C-Means is a popular method for medical image segmentation but it only considers the image intensity thereby producing unsatisfactory results in noisy images. A bunch of algorithms are proposed to make FCM robust against noise and in homogeneity,but it,s still not effect.

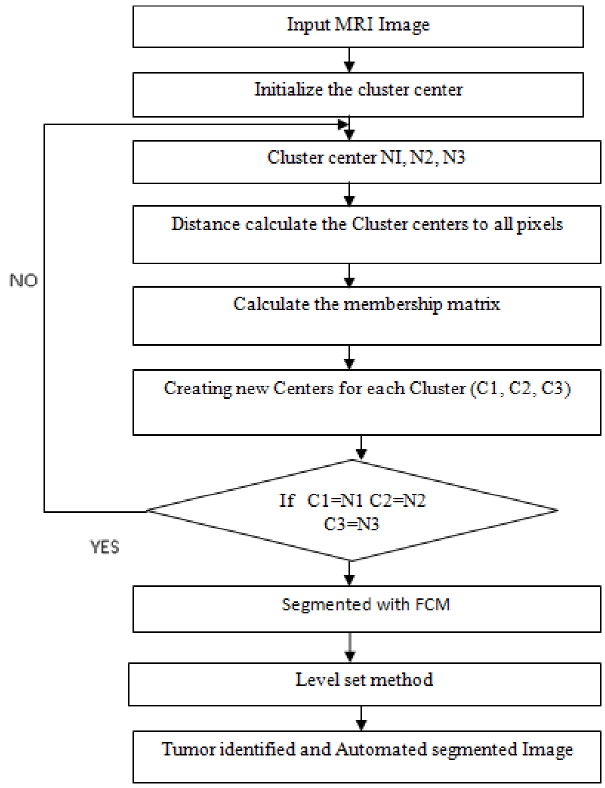

Fig 2. Flow chart for Proposed Algorithm

This method produces the idea of partial membership of belonging. As a soft Clustering method, Fuzzy Clustering has been extensively studied and successfully applied to Image Segmentation. One of the most important and widely used Fuzzy Clustering methods is the Fuzzy C-Means (FCM) algorithm. The main purpose of the FCM algorithm is to make the vector space of a sample point be divided into a number of sub-spaces in accordance with a distance measure.

In Fuzzy clustering the centroid and the scope of each subclass are estimated adaptively in order to minimize a pre-defined cost function.It is thereby appropriate to take fuzzy clustering as a kind od adpative thresholding.Fuzzy c-means(FCM) is one of most popular algorithms in fuzzy clustering,and has been widely appiled to medical problems.

The classical FCM algorithm originates from the K-means algorithm.In brief,the k-means algorithm seeks to assign N objects,based on their attributes,into k clusters(k≤N).For medical image segmentation,N equals the number of image pixels $N_x\times$ N.Thedesired results include the centroid of each cluster and the affiliations of N objects.Standard K-means clustering attempts to minimize the cost function.

The probability is dependent solely on the distance between the pixel and each indiviual cluster center in the feature domain using the FCM method. Let membership function μmn indicates the degree of membership of the nth object to the mth cluster. It is necessary to include the spatial information into an FCM because image noise and artifacts affect the FCM segmentation performance. Hence the FCM is modifued to include spatial information and is called modified FCM (MFCM). To include the spatial information into an FCM a spatial fuction is defined as $h_{ij}=\sum_{k\epsilon w(x_j)} u_{ik}$

Where $w(x_j)$ represents a small square window centered on pixel $x_j$in the spatial domain. The spatial function h_{ij}represents the probability that pixel $x_j$belongs to i_{th}cluster.

2.3.Level set segmentation:

In contrast to FCM using pixel classification,Level set methods utilize dynamic variational boundaries for image segmentation. Segmenting images by means of active contours is well known approach,but instead of parametric characterization of active contours,level set methods embed them into a time dependent.The idea behind the level set method is to imbed a curve within a surface. In our case, we imbed a two-dimensional curve within a three-dimensional surface. PDE function Ø(t,x,y).It is then possible to approximate the evolution of active contours,implicity by tracking the zero level set Γ(t).

Ø(t,x,y)<0 (x,y) is inside Γ(t).
Ø(t,x,y)=0 (x,y) is at Γ(t).
Ø(t,x,y)>0 (x,y) is outside Γ(t).
The implicit interface Γ may be comprised of a single or a series of zeros isocontours. The issue of an image segmentation is therefore converted to

$$\mathbf{U S_k U \Gamma = I}$$

Note that the inclusion of the time variable t leads to a higher dimensional level set functional, which incurrs an additional computation,but has many practical advantages.

Level Set method finds the curve in which the pixel values inside the curve having less intensity values when compare with its boundary value. The curve is having an intensity value which is an output of the FCM technique.

$$(x, y) = \begin{cases} S > d(x, y) \text{ inside the} r(t) \\ S = d(x, y) \text{ on the } r(t) \\ S < d(x, y) \text{ outside the} r(t) \end{cases}$$

Where

(x ,y) is resultant curve,

r (t) is the curve,
S is the segmented cluster intensity levels

We have used the level set directly with manual initialization. Then it is observed that it is not possible to identify W M, GM and CSF even after 1000 iterations using level set based approach. We have thought of combining FCM and Level set and carried out the same experiments. We get accurate results using only 100 iterations by the combined approach.

III. Results

The operating system used is Microsoft windows 7. The code is implemented in MATLAB version 7.12.0.635 (R2011a). Results obtained using combined MFCM and level set segmentation approaches are better than using individual FCM and level set segmentation methods.

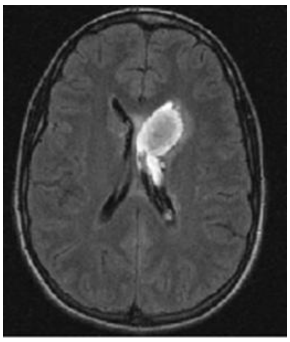

Fig 3. Input Brain MRI image and different tissues

Fig 4. Segmented clusters after applying MFCM (a)WM (b)CSF (c) GM

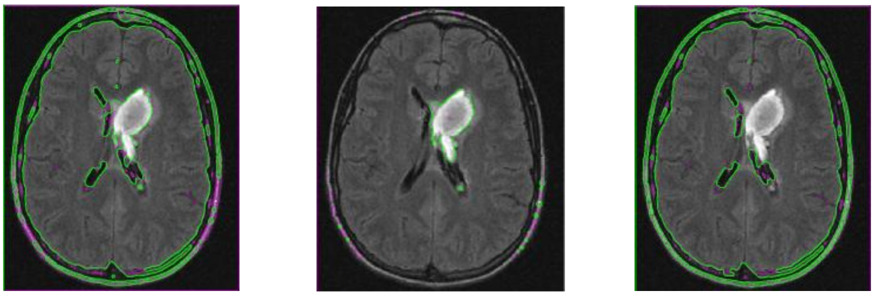

Fig 5. Segmented clusters after applying level set (a)WM (b)CSF (c)GM

IV. Conclusion And Future Scope

A new fuzzy level set segmentation algorithm has been proposed for automated medical image segmentation. It utilizes fuzzy clustering as initial level set function.The enhanced FCM algorithms with spatial information can approximate the boundaries of interest well.Therefore, level set evolution will start from a region close to the genuine boundaries. In addition, the new algorithm estimates the controlling parameters from fuzzy clustering automatically.

The proposed Fuzzy C-Means algorithm with level set method has given proper boundary for the tumor in the brain compared to the other methods. In this thesis a healthy brain image is taken as a reference and the algorithm was implemented on that reference image for extracting the required parameters. In the similar manner the tumor image or the image is to be tested is also processed by the corresponding algorithm and required parameters are calculated. These two parameters are compared and tumor location has been traced in the tested image.

FCM technique applications in other medical diagnostics like identification of faults in other human body parts like Heart, Lungs, Kidneys and Liver etc. can also be implemented.

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