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Brain Tumor Detection and Segmentation Using Conditional Random Field

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Abstract—Medical image processing is a highly challenging field. Medical imaging techniques are used to image the inner portions of the human body for medical diagnosis. MR images are widely used in the diagnosis of brain tumor. In this paper, we present an automated method to detect and segment the brain tumor regions. The proposed method consists of three main steps: initial segmentation, modeling of energy functions and optimize the energy function. To make our segmentation more reliable we use the information present in the T1 and FLAIR MRI images. We use Conditional random field (CRF) based framework to combined the information present in T1 and FLAIR in probabilistic domain. A main advantage of CRF based framework is we can model complex shapes easily and we incorporate the observations in energy function.

Keywords— Conditional random field (CRF), Fuzzy-C-Means algorithm, Fuzzy C Means Clustering Algorithm,

I. INTRODUCTION

Brain is the center of human Central nervous system. It contains 50-100 billion neurons forming a gigantic neural network. The brain is a complex organ as it made up of many cells. These cells have their own special function. Most of the cells in the body grow and divide to form a new cell for proper functioning of the human body. The tumor may be embedded in the brain region that makes the sensitive functioning of the body to be disabled. Because of its location and spreading capacity it is very complex and risky for treatment. This type of tumor affects healthy brain cells the scanning of brain can be done in different way by using different techniques like Magnetic Resonance Imaging (MRI) and Computer Tomography (CT) scan in horizontal as well as vertical section and at different depth levels. In this proposed algorithm used MRI image taken. Markov Random Fields (MRFs), is a popular classification technique that models such dependencies, have been used in many medical image segmentation tasks and have also been used in systems for brain tumor segmentation. However, generative MRFs often do not have the discriminative power of discriminative techniques such as SVMs. Conditional Random. Fields (CRFs) and their multi-dimensional extension, Discriminative Random Fields (DRFs), are discriminative alternatives to MRFs, which have outperformed MRFs for several tasks. Recently proposed Support Vector Random Field (SVRF) method, which combines the advantages of both SVMs and CRFs presents an evaluation of these techniques within a system for brain tumor segmentation that uses an extensive MR preprocessing pipeline and a setoff multi-scale image-based and alignment-based feature. In order to evaluate brain tumor different magnetic resonance image (MRI) techniques is used such as, T1-weighted, T2-fall the modality variants, T1-weighted and Fluid Attenuation Inversion Recovery(FLAIR) are the most sensitive for early stage tumor detection. Fluid attenuation inversion recovery (FLAIR) is a special in version recovery sequence with long T1 to remove the effects of fluid from the resulting images. The T1 time of the FLAIR pulse sequence is adjusted to the relaxation time of the component that should be suppressed. Primary brain tumors are tumors that originates in the brain, secondary tumor originated in other part of body and spread into the brain. The primary tumor can be cancerous or noncancerous type of tumor. The noncancerous brain tumor is known as benign whereas cancerous tumor is known as malignant tumor. The benign type of tumor grows slowly and it rarely spread to other areas of the body. This type of tumor can be removed completely by surgery and there are fewer chances to come back. Secondary type brain tumor begun in another part of the body such as in breast, in kidney etc. and that spreads to the brain. The scanning of brain can be done in different way by using different techniques like Magnetic Resonance Imaging (MRI) and Computer Tomography (CT) scan in horizontal as well as vertical section and at different depth levels.

Fig.1. Scanner at st George 's Radiology and Brain MRI image

II. LITERATURE SURVEY

In the implemented method Conditional Random Field (CRF) is commonly used of segmentation in this method have some issues are present to remove the noise present in edges of the images, to implemented the another method fuzzy c-means which is the most effective method in image segmentation, this method refer to image segmentation by using Histogram Equalization (HE) and Center Weighted Median (CWM) filter, this method face a problem of it considers only image intensity values to produces the un satisfactory results in noise images[1]. From the head brain images in every slice is acquired from several different MRI scanners, this method is implemented based on the integrated approach of image processing techniques based on the anisotropic filets is used. This method is works in the presence of the Radio Frequency (RF) in homogeneity so it is limited to RF rang pixel intensity values of the brain images. However, it does not work fully automatically on sagittal displayed 3-D T1- weighted images of accurate location [2],[3],[4],[5],[6],[7],[8] and [9]. In MRI image analysis the dedicated pre and post processing algorithms is used for analysis of brain images by using artificial neural network classifier including anisotropic and surface filtering methods is recommended for variations of correlation of the special intensity values, the main issue of the method is reasoning impairment in dementia has been reported that such a correlation does not exist [10] and [11]. The fuzzy c means (FCM) based on the clustering technique the clustering data points are formed with different membership degree, the main issue of this method is it does not fully utilize the spatial information in the image in fuzzy c means is limited to form the clusters in images [12]. MRI images on brain tumor segmentation to remove the noise present in the MRI images by using anisotropic diffusion filter for noise remove in image through the Fast Bounding Box (FBB). The 100 T2- weighted data base MRI images are used in this observation, this method have some limitations it is very difficult and time consuming task. The main aim of this method is remove of noise in the MRI images in the noise detection should not destroy the edges of the images and decrease the clarity and quality of the image [13]. An improved FCM watershed algorithm for image segmentation, in this method using decision based median filter for noise removal, and other one is fuzzy c-means is used for noise remove in image based on the cluster selection for modified watershed segmentation is used with integrated FCM. The main problem of watershed method is over segmentation, very sensitive to noise and high computational complexity [14]. In brain MRI image registration and data fusion adapted for the image segmentation is done by improved K-means algorithm with dual location method by using a negative of laplacian filter with parameters 'alpha' it controls the shape of the laplacian and must be in the range 0 to 1.0 the default values is 0.2, this method provides the computational speed is low [15] and [16]. Input MRI image skull stripping for rejecting the undesirable area form the image utilizing the modified FCM segmentation algorithm by using Gaussian filter for smoothing, through this filter to detect tumor portion of image the main issue of the filter is to set the huge sigma values only to identifies the blurring portion of the brain MRI images [17]. The main focused on clustering methods such as K- means and fuzzy c-means clustering algorithms by adding these two algorithms to from the new method is fuzzy K-C-means clustering algorithm. These algorithms are tested for human brain Magnetic Resonance Image (MRI) image, the operation is performed in these methods in images based on the clustering center values of the image the problem of the these methods is updated membership grade point [18]. Fish Image Segmentation (FIS) for brain image segmentation in special technique by using this method to found the tumor location of the brain image in FIS method is developed from the fuzzy rules method, to update the fuzzy rule method for different location in the brain image it identifies the tumor location of the human brain, the main issue of this method is there is no update in the fuzzy rules it does not gives the tumor detected portion of the brain image [19]. The Pattern Neural Network (PNN) tumor segmentation for MRI images by using this method to found the tumor area in the human brain image, it is a feed forward method for detection of tumor in the MRI image these method is works based on the kernels based on the kernels value filtering levels depends small kernels to avoid over filtering and large kernels over filtering is occurred [20],[22],[23]. In MRI images a novel tumor detection using K- means technique integrated with fuzzy C- means (FCM) clustering algorithm and Artificial Neural Networks (ANN) it allows a point to more than one cluster as per its membership values, the main problem of the Artificial Neural Network contains number of iteration steps is required for the detection of tumor area in the brain MRI images so it high computational complexity [21]. The K-means, FCM and watershed segmentation for brain tumor segmentation of MRI image, in this method median filter is used for removing the noise from the MRI images the problem of this method is the analysis of the too far distance of the data is not manual interpretation in MRI images [21,24]. The survey on the different segmentation techniques one of the author N. Friedland et.al is implemented Simulated annealing (SA) algorithm is used for detection of cavity boundaries with high speed in 2D echocardiograms the problem with is method is in expensive computational cost for satisfactory convergence of the segmentation of the image [25]. By observing the above literature survey they have some drawbacks in previous implemented methods so to overcome the above drawbacks to propose a novel method is Conditional Random Field (CRF) method to overcome the above problems in the literature survey. This method is gives better judgment to the above implemented methods.

This paper is divided into five sections: In section II about the literature survey, section III methodology of the brain tumor detection, section IV explains the present implemented method of the experimental results, section V finally conclusions are drawn.

III. METHODOLOGY

In this work to introduce the new method for brain tumor segmentation by using Fuzzy-C-Means algorithm, it is one of the most effective methods for MRI image segmentation the working mechanism of this algorithm is based on the clustering membership values, based on this membership values only image segmentation is done. To update the membership values in the Fuzzy-C-Means algorithm it make to identifies the tumor area of the brain MRI image by using clustering group of images of the pixel values. In this method to identifies the tumor area to follows some steps this steps are explains with help of the flow chat.

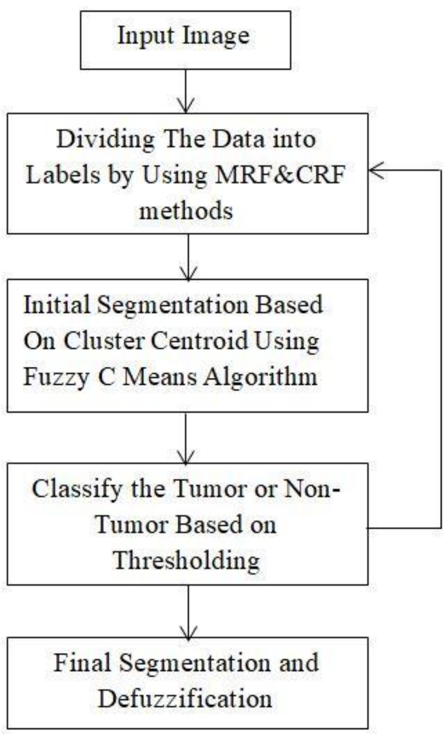


Fig.2. Flow Chart of Conditional Random Field (CRF)

The above flow chart explains what are the steps required detection of tumor in the brain MRI images based on the segmentation through novel method is CRF. In this method segmentation done based on the fuzzy c means algorithm of thresholding membership values. In this paper to consider the flair and T1-weighted images and detecting the tumor automatically using the combined information present in the flair and T1-weighted images . Conditional random fields (CRFs) are a class of statistical modeling method often applied in pattern recognition and machine leering and used for structured perdition. CRFs are a discriminative alternative to the traditionally generative Markov Random Fields (MRFs).This is important in the medical imaging applications, since anatomic structures can have complex shapes.

Fuzzy C-Means (FCM) algorithm: FCM is a clustering algorithm developed by Dunn, and later on improved by Bezdek. It is useful when the required number of clusters is pre-determined thus the algorithm tries to put each of the data points to one of the clusters. MRF is used to calculate the joint probabilities between the pixel values of the images. CRF is used to find directly the posterior distribution for labeling the given data. After distribution the labels of the data classified as two labels that is label-0,label-1Here,label-0 represents the tumor class and label-1 represents the non-tumor class. For modeling the energy function in CRF requires initial labeling. For initial labeling. use Fuzzy C-means algorithm (FCM). After that define the energy function using this initial labeling and optimize the energy function using graph cut approach.

Initial Segmentation: First remove the background of FLAIR image using the T1- weighted map (in ADC map background has zero value). For initial segmentation (labeling) used FCM algorithm on intensity features. FCM segments image into pre-specified number of clusters (k).
Thresholding: Thresholding applied in order to classify the non-tumor and tumor classes Segmenting the FLAIR image into tumor and non-tumor class applied FCM with k=2. Applied threshold on data matrix results probable tumor regions (with false positive) and non-tumor regions. Compare the tumor region with T1-weighted and remove the false regions.

Final Segmentation: The segmentation can be done by edge detection method, by Region growing or by thresholding segmentation technique. Otsu's thresholding method is one of the methods where the pixels that either falls in foreground or background are decided by iterating through all the possible threshold values. Otsu’s method measure of region homogeneity in terms of variance. It selects the threshold value by minimizing the within-class variance of the two groups of pixels separated by the thresholding value. Otsu’s method is minimum error method.

Fuzzy C Means Clustering Algorithm: The fuzzy C-means (FCM) algorithm follows the same principles as the K-means algorithm in that it compares the RGB value of every pixel with the value of the cluster center. The main difference is that instead of making a hard decision about which cluster the pixel should belong to, it assigns a value between 0 and 1 describing "how much this pixel belongs to that cluster" for each cluster. Fuzzy rule states that the sum of the membership value of a pixel to all clusters must be 1.

The FCM clustering is obtained by minimizing an objective function shown

$$J = \sum_{i=1}^{n}\sum_{k=1}^{c} \mu_{ik}^{m} \left|p_i - v_k\right|^2 \quad (1)$$

Where
J is objective function
n number of pixels in the image
c number of clusters
μFuzzy membership value from the table
m is fuzziness factor (>1)
p_i is ith pixel
v_k centroid of kth cluster
$\left|p_i - v_k\right|$ is Euclidean distance between p_i and v_k

$$\left|p_i - v_k\right| = \sqrt{\sum_{i=1}^{n}\left(p_i - v_k\right)^2}$$

Calculation of the centroid of the kth cluster is

$$v_k = \frac{\sum_{i=1}^{n} \mu_{ik}^{m} p_i}{\sum_{i=1}^{n} \mu_{ik}^{m}}$$

Fuzzy membership values from the fuzzy rule base table

$$\mu_{ik} = \frac{1}{\sum_{l=1}^{c}\left(\frac{\left|p_i - v_k\right|}{\left|p_i - v_l\right|}\right)^{\frac{2}{m-1}}}$$

Euclidean distance between the values of p_i and v_k is modified to incorporate the RGB colors.

$$\left|p_i - v_k\right| = \sqrt{\sum_{i=1}^{n}\left(p_{iR} - v_{kR}\right)^2 + \left(p_{iG} - v_{kG}\right)^2 + \left(p_{iB} - v_{kB}\right)^2}$$

Fuzzy C- Means Clustering:
Clustering is the process of grouping feature vectors into classes in the self-organizing mode. Let {x(q): q = 1,…,N} be a set of N feature vectors. Each feature vector x(q)= (x1(q), …, x_N (q)) has N components. The process of clustering is to assign the Q feature vectors into k clusters {c(k): k = 1, …, K}, usually by the minimum distance assignment principle. Choosing the representation of cluster centers is crucial to the clustering. Feature vectors that are farther away from the cluster center should not have as much weight to those are close. Finally Fuzzy C-Means clustering. Matrix's membership procedure is explain given below.

- Partition the data in to N stages $x_1, x_2, .., x_N, x_i \in R^d$
- Cluster c range is (1< c< N)
- Matrix's membership results $v_1, v_2, .., v_c, v_i \in R^d$

$$U = \begin{matrix} & X_1 & \dots & x_N \\ & \downarrow & & \downarrow \\ \begin{matrix} v_1 \rightarrow \\ \vdots \\ v_C \rightarrow \end{matrix} & \left[\begin{matrix} u_{11} \\ \vdots \\ u_{c1} \end{matrix}\right. & \begin{matrix} \cdots \\ \ddots \\ \vdots \end{matrix} & \left.\begin{matrix} u_{1N} \\ \vdots \\ u_{cN} \end{matrix}\right] \end{matrix}$$

- Objective function

$$U_{ik} \in [0,1] \sum_{i=1}^{c} \mu_{ik} = 1 \forall k$$

- Minimization

$$v_i = \frac{\sum_{k=1}^{N} \mu_{ik}^{m} x_k}{\sum_{k=1}^{N} \mu_{ik}^{m}}$$

$$\mu_{ik} = \left(\sum_{j=1}^{c} \frac{\left\|v_i - x_k\right\|}{\left\|v_j - x_k\right\|}\right)^{\frac{-2}{(m-1)}}$$

The above steps are Fuzzy C-Means Clustering algorithm of the matrix's membership function in this method divide the image in N number of number of stages clustering is based on the N clustering range is lies in between 1 to N.

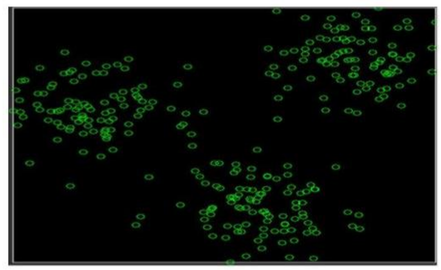


Fig.4. Initial Cluttering Process.

The above diagram shows the initial clustering stage of the fuzzy C Means cluttering algorithm based on the thresholding methods.

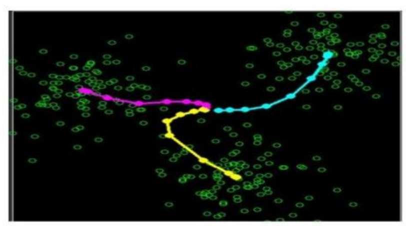
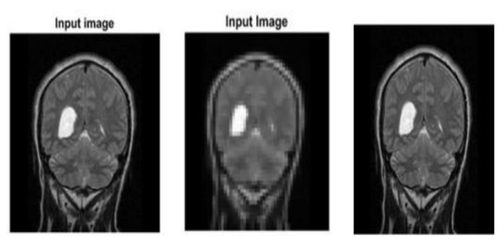


Fig.5. Final Stage Cluttering Process

IV. RESULTS AND DISCUSSION



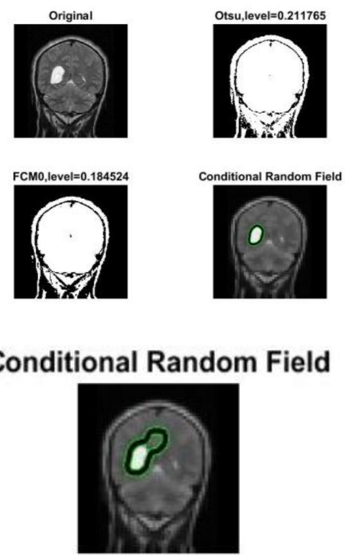


Fig.1. In first row input MRI human brain image, the input MRI image is divided into number of labels by using CRF and MRF method, and 3rd image is gray scale values of the weighted image, and second row describes filtered output images and final segmentation of images, the white matter image of otsu thresholding method and white matter of the FCM of filtered level of the image and finally tumor detection area of the brain MRI image by using CRF technique.

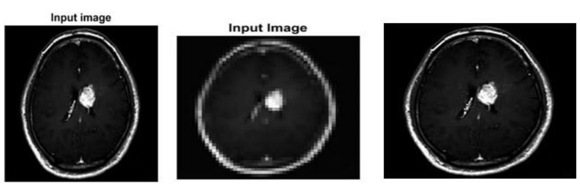


Fig.2. In above row input MRI human brain image, the input MRI image is divided into number of labels by using CRF and MRF method, and 3rd image is gray scale values of the weighted image.

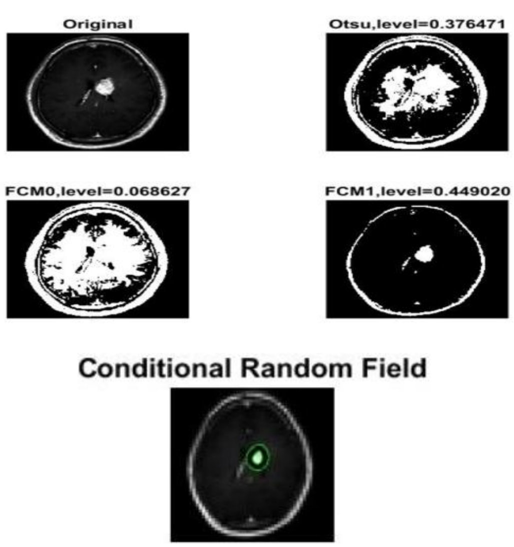


Fig.4. In the above row describes filtered output images and final segmentation of images, the white matter image of otsu thresholding method and white matter of the FCM of filtered level of the image and finally tumor detection area of the brain MRI image by using CRF technique.

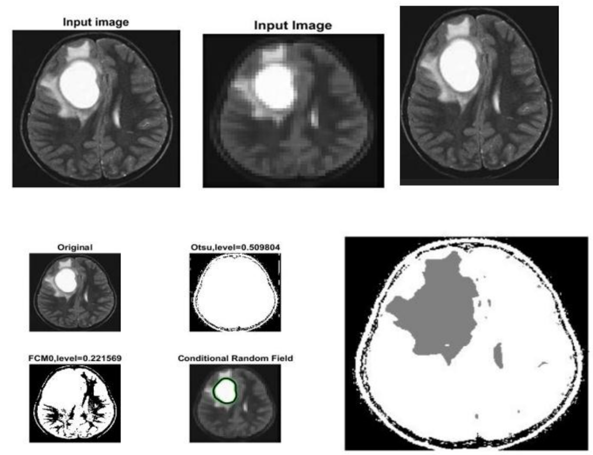


Fig.5. In first row input MRI human brain image, the input MRI image is divided into number of labels by using CRF and MRF method, and 3rd image is gray scale values of the weighted image, and second row describes filtered output images and final segmentation of images, the white matter image of otsu thresholding method and white matter of the FCM of filtered level of the image and finally tumor detection area of the brain MRI image of white matter by using CRF technique.

The above brain MRI medical images are executed in MATLAB for detection of tumor part in the brain images through the MRF and CRF methods. Detection of tumor area in the brain MRI images, in this work considers the three different types of MRI images. The tumor area is found in brain images through MATLAB software, first the input human brain MRI image is a applied to the MRF and CRF methods, then these methods divides the input brain image is divided in to number of labels this division of labels based on the formation of clusters in the given input image and this information is given to the fuzzy C Means algorithm. This algorithm is filtered the given input MRI image based on the fuzzy membership matrix’s values based on the membership matrix’s the image is filtered with different FCM levels. To filtered the each and every cluster area in the brain image to update the fuzzy C Means clustering matrix’s values. After completion of filtering process to identifies the tumor area in brain image for that one make the segmentation process to the brain image the segmentation process is done by different thresholding methods. This work in segmentation Otsu technique is used for tumor area based on the thresholding technique only to kwon the tumor area or non-tumor area this process is done iterative sequence for identification of tumor part in brain MRI image.

V. CONCLUSION

In this paper we proposed a automatic method for tumor detection and segmentation. This algorithm not takes any prior assumption of shape and size of tumor regions. This frame work incorporates local as well as global information. This method incorporates additional information present in T1- weighted, which makes performance better in presence of artifacts and help to improve the boundaries. Algorithm shows the promising results for detection and segmentation of tumor. In future we incorporate the preprocessing step to improve the contrast of tumor regions with background which helps to improve the performance of algorithm.

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