Detection of Brain Tumor in MR images using hybrid Fuzzy C-mean clustering with graph cut segmentation technique

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Abstract: In the medical image processing field segmentation task is very important process in order to diagnose any diseases in medical images taken from different machine. Medical images from MRI, CT scan, X-rays, Ultrasound and PET have different features, so segmentation process is very challenging task. In this paper, the graph theoretical approaches are proposed because it has flexibility representing any complex structure. Before segmentation process, MR images are pre-processed using Region of Interest, Inverse method and Boundary detection method. In this method the segmentation of MRI brain images is performed using Fuzzy C-mean clustering with graph cut techniques. FCM algorithm is proved to be efficient in term of computational rate by improving cluster center and modified way to selection of seed points. Seed point selection is by using FCM clustering derives new technique called Fuzzy C-mean seed selection (FCMSS). Image segmentation is performed using obtained path in the graph applied on set of cluster region of interest on MR images to detect brain tumors.

Keywords: Graph theory, Magnetic resonance images, FCMSS, Edge Detection

1. Introduction

Image segmentation is a process, where images were analyzed from human perspective to get desire result. Segmentation of any images of the real word is defined as dividing an image into number of parts or classes related to various features. In medical image processing, segmentation of medical images is very essential procedure in order to find clinical solutions to various diseases and to find better treatment planning. During segmentation of medical images the pre-processing step is most challenging task because medical images have various noises, blurring, unwanted areas and intensity variations [1,2].

Segmentation plays an important role in pre-processing stage also to get the region of interest by dividing the image and extracting boundary line to form required shape or area of the given images. The main aim of segmentation is to partition the image into distinct homogeneous areas or to get interested field in the image. The obtained boundaries are expected to these equivalent regions and to be coincident with actual portion the objects. In medical image processing and machine vision applications, segmentation plays a very important role. This process influences the outcome of the remaining step of medical image analysis [3-5].

A good image segmentation method for medical images should have the following features:

1. Intensity, texture and shape should be uniform and homogeneous area in order to segment image to proper analysis.
2. Segmenting area should be simple, clear and without large difference in holes.
3. Border area is the adjacent to segmentation region significantly homogeneity feature.

Segmentation is crucial job because of complex structure of brain. In today's modern medicine, diagnosis of medical image plays a significant role. Including this detection and diagnosis of diseases at early stage is necessary for easier treatment with less cost. Human brain is one of the most complex and largest organs in the human body. Brain is formulated by many cells including gill cells and neurons. Brain contains seven varieties of tissues. The significant activities of the brain are thinking, voluntary movements, creative visualization, responsible for coordination and balance, executive planning, learning, memory and emotional responses. In nervous system brain is the center part any abnormalities in the brain may leads to collapse of the whole body functionalities.

Digital image processing is one the emerging research area used in various application areas to identify the particular pattern and person identification. Medical image processing is one increasing application area of digital image processing. In medical filed image processing used to identify and classify the different disease and classify its conditional stage i.e. either in initial stage or final stage, where it is necessary to identify the geographical structure and size of the identified tumor. Brain tumor is one of the severe diseases in human being which is increasing day by day. The number of deaths due to this brain tumor is also increasing. A brain tumor is a disease

where there is abnormal growth of the cells in brain. Image processing is one the field where scanned MRI brain images are analyzed to identify the tumor region of that particular person. Analyses of the MRI images is more efficient than other techniques because brain is one of the complex and most sensitive organ of the human being in which it is very challenging to identify the tumor within the tissue [6,7].

2. Research Objective

Brain is surrounded by fluid called cerebrospinal fluid because of fluid movement it is difficult to capture a moving image with high end precision. Brain is as well composed by many layers, identifying the complex structure and obtaining an accurate image is very challenging. Constructing the brain tumor by segmentation of medical images using graph models is an obstacle. In order to accomplish the above mentioned research aim, following research objectives are set.

1. To explore and understand the preliminary study of existing techniques from other image processing fields.
2. Brain tumor interactive segmentation using enhanced graph cut with FCM clustering method.
3. Comparative analysis of proposed method with other segmentation techniques.
4. To develop a building image guide surgery system for better treatment planning.

3. Research Methodology

The aim of the proposed research work is to offer a significant knowledge in implementation. The proposed method consists of the following steps for the completion of construction of Brain tumor by graph cut segmentation technique.

- Fixed Image: This image is constructed by the fixed images as such as MRI scanned images and then it is compared with the real patient problem and analyzed and basically diagnosis is done accordingly
- Pre-processing: The ability of the system to remove the noise and unnecessary distortions from the image, by using techniques such as Region of Interest, Inverse method and Boundary detection method.
- After perform the registration process, we obtain the registered moving image that matches with the MRI volume data, the next step is to perform a transformation over the labels maps that is based on intensity based registration.
- Segmentation is done using the graph cut method in order to generate the high precision data of brain tumors along the depth, location and width of the tumors.
- Graph cut segmentation: Graph partitioning methods can effectively be used for image segmentation.

3.1.Aim :

The primary aim of this paper of the study is to collect the MRI brain images then pre-processing of the images registering them in the database, and then segmentation by fuzzy c-mean clustering with graph cut methods of those images and training them in order to obtain exact identification of Brain tumors. Later evaluate the proposed research work based on the accuracy and benchmarking with the present techniques.

3.2.Problems to Be Addressed :

On the basis of literature survey made constructing exact brain tumor detection is highly impossible as there is continuous fluid movement in the brain, and also comprises of various tissue layers. Considering single T1 brain imaging it is easy to segment and register using suitable transformation techniques, but trying to transform T1 and T2 imaging together they arises the obstacle for segmentation and registration techniques. Hence image registration is vital part for this phase as transferring of the data sets into one co-ordinate system, as well as segmentation of the brain images using suitable methods need to be done, so that multiplying the original image along with the segmented image and obtaining the exact location of the brain tumor of the images.

3.3.Methodology to Be Adopted :

The methodology implemented is a novel approach. Our proposed architecture is as shown in Fig 1. The proposed system takes input images from BRATS 2018 data sets. The input brain MRI images are taken for pre-proposing after image registration process done for sample images. Applied pre-processing techniques are RoI, Inverse method and Edge detection for boundary from the image. Segmentation is process is performed using Fuzzy C mean algorithm with graph cut techniques. Seed point selection is by using FCM clustering derives new technique called Fuzzy C-mean seed selection (FCMSS).Image segmentation is performed using obtained path in a graph applied on set of cluster region of interest on MR images to detect brain tumors.

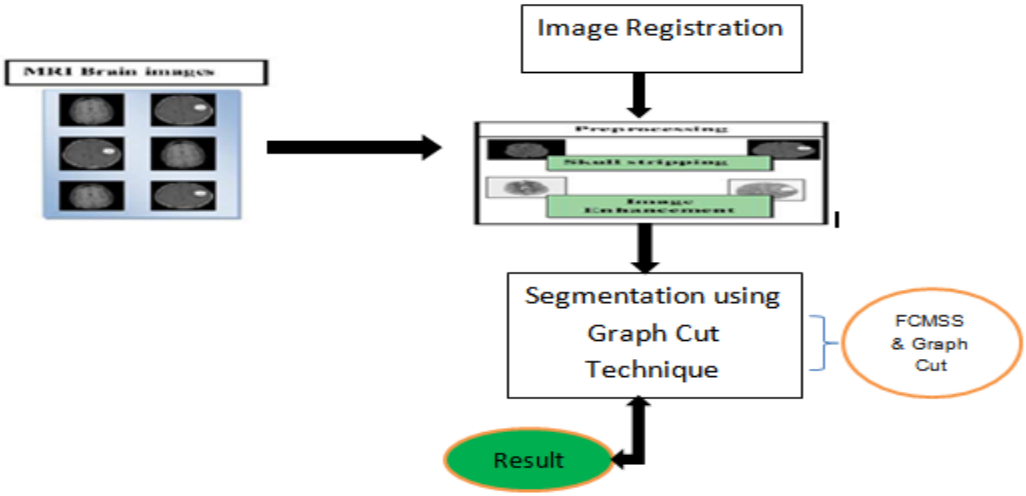

Fig 1: Block diagram of proposed system

4. Image Registration

Image registration is the method of aligning of two or more images which are taken from the similar scene in different times, from various view points and by different sensors. It aligns the two images i.e. sensed and reference image geometrically. Based on the various imaging conditions present difference between two images are introduced. Image registration is significant step in image analysis process. Image registration gives the final information from the integration of different source for example image fusion, multi-channel image restoration and change detection. In image registration similarity measurement between the two images based on intensity is one of the key components. Fig 2 shows the basic steps concerned in the image registration [8].

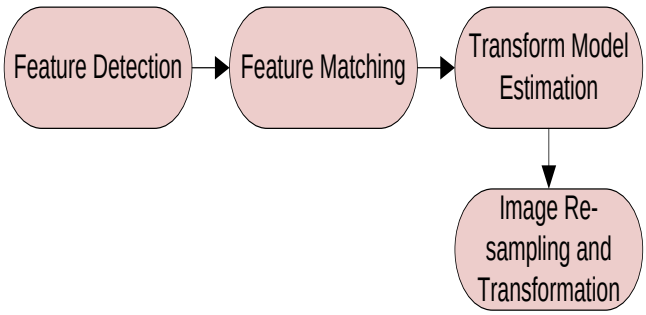

Fig 2: Steps involved in Image Registration

The image registration is divided in to four stages namely: Feature detection and Feature matching. Transform model estimation and image re sampling and transformation. Feature detection step is used to detect features based on image intensities or may be edges, corners etc. Feature matching matches the correspondences features between the images. Transform model estimation estimates the mapping functions and aligning the one sensed image with the other reference image. Image re-sampling and transformation step transforms the sensed image by means of the mapping functions.

In the proposed system intensity based registration is performed. It maps the certain pixel from each image to the same place based on relative intensity patterns. This approach eliminates the feature detection step. In this registration method by considering the geometric transformation based on image intensities observation similarity and dissimilarity metrics are defined. The steps involved in the proposed system registration method are presented in Figure 4. In the proposed system two input images that fixed T1 tumor MRI volume and moving T2 tumor MRI volume image are considered [9]. As presented in Fig 3, similarity measure is based on the pixel intensity and it is calculated in overlapped regions of the two input T1 tumor and T2 tumor MRI images. The optimizer gives the methodology for maximizing or minimizing the similarity metric. Transformation defines the 2D transformation type that brings misaligned image (i.e. moving T2 MRI image) into alignment with the fixed T1 tumor MRI image. The interpolator re-samples the pixel intensity into fresh co-ordinate system as per geometric transformation found.

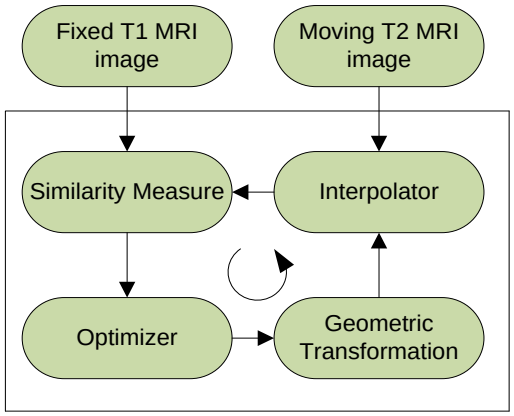

Fig 3: Intensity based Registration

4.1.Pre-Processing:

The prprocessing methods are divided into following categories data cleaning, data integration, data transformation and data reduction. The data pre-processing is progress of the image that overpowers irrelevant distortions or enhancing the image features important for further processing. The work is applying pre-processing techniques RoI, Inverse method and Edge detection for boundary from the image as shown in Fig 4.. The pre-processing of region of interest aids to detect the significant region. The inverse method support to identify the lower and upper boundary of the digital converted values and boundary detection assistances to determine and fix the contorting area of the cluster based on its digital density [10].

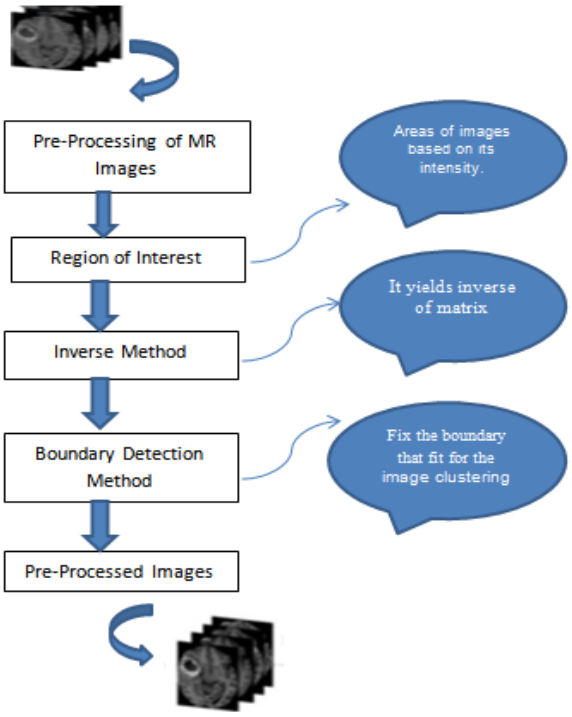

Fig 4: Block diagram of Pre-processing of input MR images

5. Tumor Segmentation

5.1.Graph-cut:

Graph cut method is used for segmentation of MR images by optimizing energy function [11]. In this research, energy function is derived for every clusters divided based on seed point selection. The modified energy function [12] by including region and boundary term with pixel intensity values gives equation as shown below:

$$E(L) = \gamma R(L) + B(L)$$

Where, L= {*l*1, *l*2, ...,*lp*}, is a matrix, which is the collection of intensity values for every pixel in the selected

cluster region.

$$L = \sum_{k=1}^{n} l(k)$$

For instance, *li* = 0 means this pixel *pi* belongs to background, and *lj*= 1 means this pixel *pj* belongs to object.

5.2.Region term:

Region term: Energy cost *R*(*L*) of regions between source and sink node is the sum of very pixels intensity value and region value associate with cluster centroid point. Region cost *R(L)* is generated between neighboring pixels around the region [12].

$$R(L) = \sum_{p \in P} R_p(L_p)$$

5.3.Boundary term:

Boundary term: Energy cost *B*(*L*) of boundary regions is sum of cost between the terminal nodes and pixels and intensity difference between two pixels near boundary region[13]. If intensity values between two pixels are same then add zero or add 1 to boundary term.

$$B(L) = \sum_{\{p,q\} \in N} B_{\{p,q\}} \cdot \delta(L_p, L_q) \qquad \delta(L_p, L_q) = \begin{cases} 1 \; if \;\; L_p \neq L_q \\ 0 \; otherwise \end{cases}$$

5.4.Fuzzy C-mean clustering

The Fuzzy C-Means (FCM) clustering algorithm was first introduced by Dunn [14] and later was extended by Bezdek [15]. Fuzzy C-mean clustering algorithm is most widely used method for brain tumor segmentation. This algorithm was proved to be more efficient method compared other clustering method with respect to segmentation to detect brain tumors because efficient selection of clusters based on pixel intensity value. The modified FCM method is based on data compression using iterative process. That divides the image into different cluster using two different compression techniques like quantization and aggregation of cluster.

The quantization of selected region of interest is performed based on centroid values for masking lower 'm' bits of pixel value. Centroid values selected from FCMSS technique in lesser time than feature vector. The aggregation process is used to group set of vectors with similar intensity values among selected clusters during quantization process. After the aggregation of cluster, the distance between clusters is used to find source and sink nodes to perform graph cut operation. Euclidean distance is calculated for every cluster grouped based on centroid points and its intensity similarity and dissimilarity with each point [16].

$$distance = \sqrt{\sum (p_k - q_k)^2}$$

FCMSS technique is developed in order to improve the time taken to select seed point accurately without any ambiguity with cluster region. This techniques select seed points to cluster in less time. FCMSS is employed to obtain effective centroid points for segmentation of MR images for brain tumor detection. The input T1 and T2 brain MR images pre-processed to remove unwanted region, further select the number seed pointer for clustering to perform quantization process. Increase in the value of centroid point results in selection of more clusters with similar intensity at boundary region. In this paper number of clusters are selected are based on feature value selected for centroid point. FCMSS technique selects seed points based on cluster regions towards boundary area of interest [17,18]. Then seed point selected clusters are separated using graph cut segmentation is performed.

5.5.Research Challenges

- Camera angle is important: The camera angle is important to know as it takes up continuous image and thus helps in determining the percentage of intensity of volumetric data
- Whether the captured image is fixed or moving: Determine whether the captured image is fixed or moving image, to enhance the reconstruction of the image

- Registration of image: If obtained image is in 2D, then its accuracy level will be poor so accurate registration techniques are used in order to generate a high efficient image for location of tumor
- Graph cut segmentation: This process of segmentation of images using graph cut methods to generate accurate analysis and obtain correct result.

6. Results and Discussions

Our proposed work is implemented using MATLAB tool, helps in creating the simulation of identifying the brain tumor much efficiently and accurately [19,20] which has shown in the figures from 5 to 12.

This work is completely depends on the fusion image information, which integrate both T1 and T2 tumor image information. Increase in the intensity value which enhances the segmentation operation and to detect the brain tumor using graph cut segmentations.

6.1.Research Outcomes

- When image is taken from MRI, CT scan or PET scan etc., the images are not always clear, hence diagnosis becomes challenging to doctors, to identify the exact location of brain tumors so our proposed work is telling the exact location of tumors along with depth and width.
- Improves the accuracy of the image from 2D construction to the best brain tumor construction Later, this can also be extended for using neuro-stimulator device for correct location during surgery. This can also enhance the medical field as there would be lot of successful operations.
- Compared to the existing techniques, image precision on the brain images is obtained from 2D to brain tumor imaging and graph cut mechanism.
- Brain tumor construction that ensure, it provides the clarity and acts as a guide system for doctors during operation.

6.2.Applications

- This application can be used in medical imaging which can act as guide to the surgeons to perform a neuro-stimulator operation.
- Reduces the time consumption in image interpretations by providing interactive multiple labeling and display.
- This is not just implemented in Brain images, but also in heart, lungs, kidney, or any organ for that matter and also segmentation of blood vessels.
- This application can be used in medical imaging which can act as guide to the surgeons to perform a neuro-stimulator operation.

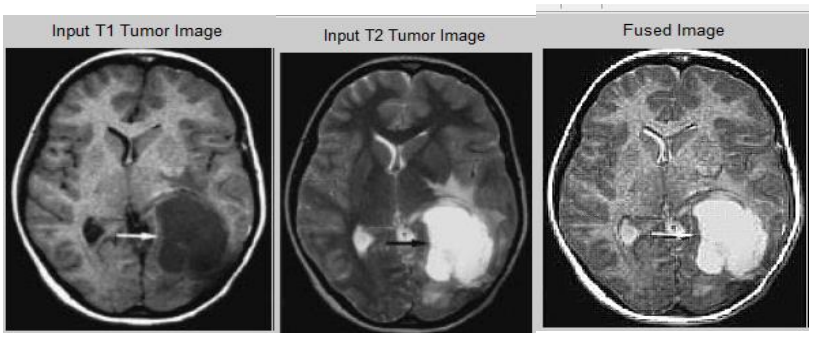

Fig 5. Input -T1 Image **Fig 6.** Input -T2 Image **Fig 7.** Fused Image

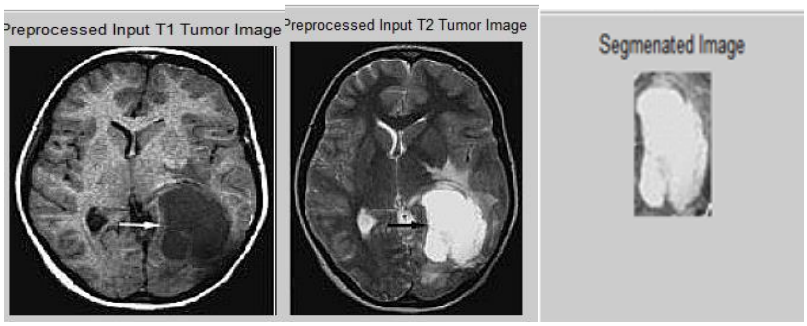

Fig 8. Pre-processed T1 Input Image **Fig 9.** Pre-processed T2 Input Image **Fig 10.** Segmented Image

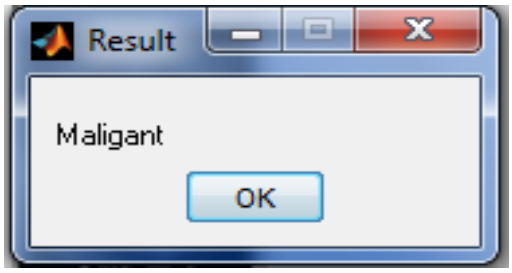

Fig 11. Result of Input-T1 Image

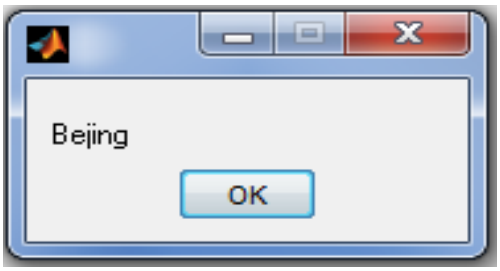

Fig 12. Result of Input-T2 Imag

7.Conclusion

In this work the main area of concentration was detection of brain tumors in T1 and T2 type of MR images using hybrid fuzzy C-mean and graph cut techniques. Accurate registration of T1, T2 brain tumor image registration & segmentation by making use of graph cut analysis. Registration using the brain tumor database and trying to transform with the layer 1 and layer 2 and obtaining an accurate result, and then generating an exact location of brain tumor segmentation and analysis of the depth, width and size as well as location in the brain region. Used Fuzzy C-mean seed selection (FCMSS) methods will improve the segmentation process in tumor detection of medical imaging. In the next phase the main work is to check with the feature extraction and classification process in different input images.

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