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MRI Image Segmentation Using Gradient Magnitude Based Fuzzy C Means Clustering In Level Set Method for a Medical Diagnosis System

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Abstract: **In medical image investigation, one of the essential problems is segmentation of structural sections. In the literature survey of problem over the internet it is found that, no work is done on the image segmentation of brain tumor by means of fuzzy C-means clustering in MATLAB environment. In this paper, we present a new concept of tumor detection and validated segmentation of 2D MRI Data. This method on the appropriate setting of parameters can segment the tumor. This method unlike others do not require any initialization in the tumor. In addition, the effectiveness of this approach is demonstrated by quantitative evaluations and visualization of the segmentation results. First, the work was carried over to calculate the area of the tumor with single slice of MRI data set and then it is extended to calculate the area of tumor from multiple image MRI data sets. The fuzzy c-means clustering algorithm along with self-organizing MAP neural network and thresholding and morphology is used for proper classification of medical data.**

Keywords: **Brain Tumor, Image Segmentation, Neural Network, MRI, Fuzzy C-means.**

I. Introduction

A cluster of abnormal cells coagulated in the brain is termed as brain tumor. According to this, brain tumor is classified in multi stages. The basic or primary brain tumor is the tendency of cells to multiply in brain and stay at their places. Metastatic brain tumor is the coagulation of cells that are migrated in brain but originated anywhere else in the body as cancer. Till now, over 120 varieties of brain tumors are classified. It is still un-predictable the cause of brain tumor. Malignant or Benign, primary or metastatic, most of the brain tumors are curable. Today many high-resolution techniques like Computed Tomography (CT-Scan), Magnetic Resonance Imaging (MRI-Scan), functional MRI (fMRI), Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT) are available to detect brain tumor. These techniques contain complicated anatomical structures that require precise and most accurate segmentation for clinical diagnosis.

One of the classical methods to detect the brain tumor is imaging method. The brain is scanned to take photographs of internal structure. The process is called scanning. A specific machine takes a scan in a way that is very similar to the digital photography. Using computer and various techniques the photograph taken from various angles are studied and a 3D image of tumor is synthesized. Some types of scan use contrast photography. It includes a ferromagnetic substance such as gadolinium. The material is injected in a vein, which flows into brain tissue. The damaged or diseased cells soak more dye than normal. The contrast agent allows the doctor to study the difference between abnormal and normal cell tissues [1].

MRI is more delicate for brain tumors than CT (Computerized Tomography), both in terms of detection as well as in showing more completely the level of the tumor. The major advantage of multi-planar imaging has been larger tumor localization, rather than increasing the recognition rate of lesions. MRI delivers significantly more information about intrinsic tissue classification and parallels judgments on gross pathology. The effects of necrosis on MRI are complex and varied but can often be

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identified with near-certainty. The association of cysts with certain neoplasms has long been utilized as an aid to differential diagnosis by neuro radiologists and MRI is very good at picking up cysts that are very abruptly delineated, overweight or ovoid masses. MRI uniquely depict shemorrhage, as of the paramagnetic properties of many of the blood-break down products. The signal strength pattern of intra-tumoral hemorrhage differs from benign intra cranial hematomas. Fat-containing neoplasms (e.g., teratoma, dermoid, lipoma) are easily recognized on MRI. The widened and enlarged blood vessels to the tumors may also be seen well on MRI and magnetic resonance angiography (MRA).

II. Literature Review

In [2] an efficient wavelet based algorithm is proposed for tumor detection. This method uses complementary and redundant information from CT-Scan and MRI-Scan. This algorithm provides a resultant fused image to increase efficiency of tumor detection. The authors also varied the fusion parameters like number of decompositions and type of wavelet used for decomposition to evaluate effectiveness of algorithm. In [3] an efficient method for detection of brain tumor from Magnetic Resonance Images (MRI) is proposed. In MRI detection, the segmentation process plays a vital role to partition an image into different sub-region with homogeneous properties. Two conventional methodologies i.e. Mean shift algorithm and Normalized cut (Ncut) Method are combined or automatic detection of exact surface are of brain tumor in MRI. By incorporating the advantages of the mean shift segmentation and Ncut method, Magnetic Resonance image (MRI) is pre-processed first by using the mean shift algorithm to form segmented regions, then Ncut method is used for region nodes clustering after this connect component extraction analysis is used to locate the exact tumorous area in MRI Images. In [4] a review of neural networks used in medical image processing is presented. It classify neural networks by its processing goals and the nature of medical images. Main advantages and drawbacks of the methods are mentioned in the paper. Problematic issues of neural network application for medical image processing and an outlook for the future research are also discussed. By this survey, authors try to answer the following important question: What the major strengths and weakness of applying neural networks for solving medical image processing tasks are. They believe that this would be very helpful for researchers who are involved in medical image processing with neural network techniques. In [5] a method is presented for three-level image segmentation through maximizing the fuzzy partition entropy of two-dimensional histogram. Two groups, each including three member functions, namely Z-function, Π-function and S-function, are used for fuzzy division of two-dimensional histogram to get nine fuzzy sets. The nine fuzzy sets are classified to three parts, corresponding to dark, gray and white part of the image, respectively, while a fuzzy partition is obtained for the two-dimensional space. Then fuzzy partition entropy is defined based on multi-dimensional fuzzy partition and entropy theory. The parameters of the six membership functions can be determined by maximizing fuzzy partition entropy of two-dimensional histogram and the procedure for finding the optimal combination of all the fuzzy parameters is implemented by quantum genetic algorithm with an appropriate coding method. The experiment results show that this method gives better performance than one dimensional

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three-level thresholding method under noise case. In [6] the author presents a novel method for CT head image automatic segmentation. The images obtained from patients have a spontaneous intra-cerebral brain hemorrhage (ICH). The results of the segmentation are images partitioned into five regions of interest corresponding to four tissue classes (skull, brain, calcifications and ICH) and background. Once the images are segmented it is possible to calculate various hemorrhage region parameters such as size, position, etc. The segmentation was performed in three major steps. In the first phase feature extraction and normalization was performed using a receptive field (RF). Experiments were performed to determine the optimal RF structure. Pixels were classified in the second phase using the radial basis function (RBF) artificial neural network. Experiments with different RBF network topologies were performed in order to determine the optimal basis functions, network size and a training algorithm. The segmentation results obtained using the RBF network were compared with results obtained by multi-layer perception neural network (MLP). In the third phase, the image regions obtained by the RBF network were labeled using an expert system. Experiments have shown that the proposed method successfully performs image segmentation.

III. Fuzzy C-Means

In fuzzy clustering, every point has a degree of belonging to clusters, as in fuzzy logic, rather than belonging completely to just one cluster. Thus, points on the edge of a cluster may be in the cluster to a lesser degree than points in the center of cluster. An overview and comparison of different fuzzy clustering algorithms is available.

Any point x has a set of coefficients giving the degree of being in the k^{th} cluster $w_k(x)$. With fuzzy c-means, the centroid of a cluster is the mean of all points, weighted by their degree of belonging to the cluster [14].

Fuzzy clustering is useful in handling unclear boundaries of clusters. One of the most widely used fuzzy clustering algorithms is the Fuzzy C-Means (FCM) Algorithm (Bezdek 1981) [7]. Fuzzy c-means has been a very important tool for image processing in clustering objects in an image.

Let $\{x_1, x_2, .., x_N\}$ be a set of N data objects represented by n-dimensional feature vectors.

$$x_k = [x_{1k}, \dots\dots, x_{nk}]^T \in \mathbb{R}^n$$

A set of N feature vectors is then represented as a $n \times N$ data matrix

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1N} \\ \vdots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nN} \end{bmatrix}$$

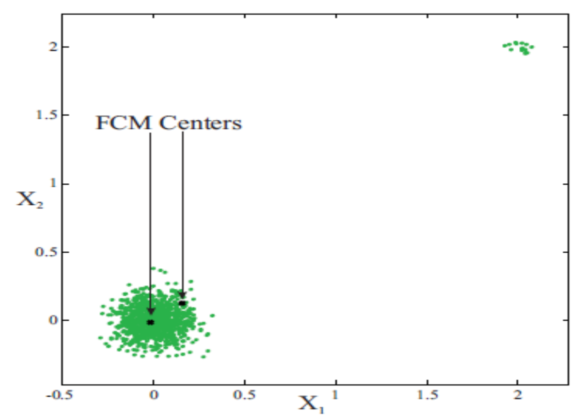

Figure.1: Cluster centers obtained with the FCM algorithm for data with two groups. The larger and the smaller groups have 1000 and 15 points, respectively.

IV. Proposed Methodology

Different algorithms that are based on a wide range of principles can perform the MRI segmentation.

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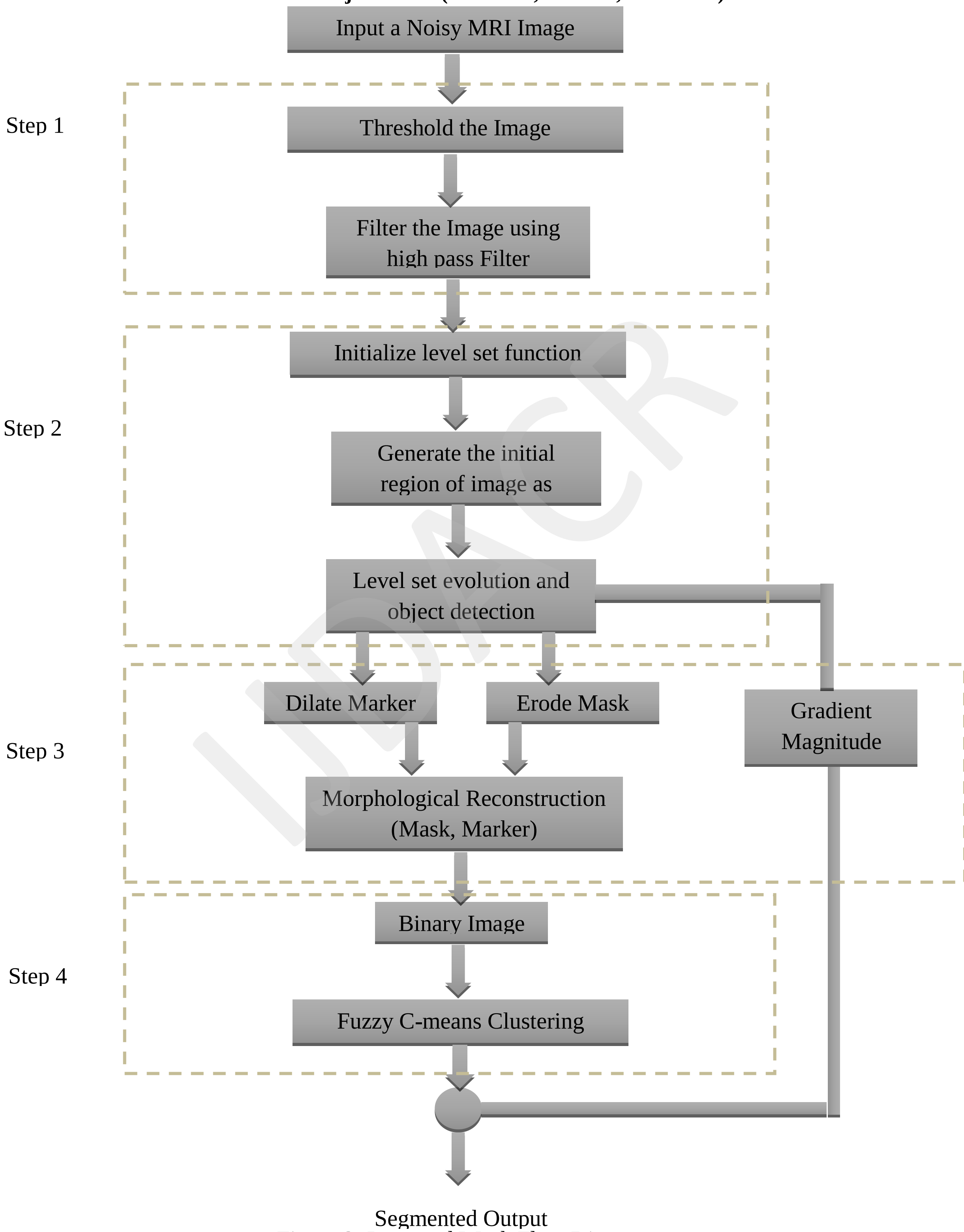

Figure 3: Proposed Work Flow Diagram

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The segmentation process can be accomplished with different levels of manual interaction. In case of a high manual interaction, the process is time consuming with high associated cost, as it is needed an import amount of time by well-trained professional to accomplish this task. In addition, it introduces a high intra-subject and inter-subject variability due to the personal subjectivity, which reaches discrepancies higher than 20%. On the other hand, highly automated methods require a deeper understanding of complex physical processes and mathematic modeling. This challenging approach tries to create a robust, objective and cost-time saving segmentation system.

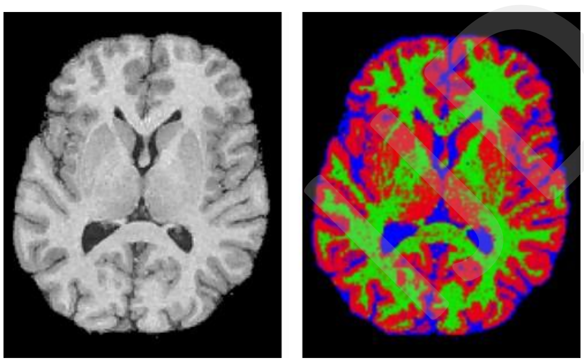

Figure 2: Figure with a brain segmentation of a T1 MR image. Left: Descalped MR image. Right: Segmented image. GM in red, WM in green and CSF in blue.

The advantage of the level set method is that one can perform numerical computations involving curves and surfaces on a fixed Cartesian grid without having to parameterize these objects. It has become popular in many disciplines, such as image processing, computer graphics, computational geometry, optimization, computational fluid dynamics. No doubt, in this digital world we have to implement a medical analysis system for complex medical image such as MRI image. Also, Fuzzy Clustering based segmentation became a popular tool for different applications that require image segmentation, such as machine inspection, aerial image understanding, medical image analysis, and video object segmentation. The Fuzzy C-means Clustering offers some advantages: it is a simple intuitive method, fast and can be parallelized and it produces a complete division of the image in separated regions, thus avoiding the need for any kind of contours joining. We are going to use gradient based Fuzzy C-means Clustering in level set method to increase the overall accuracy in terms of segmentation rate, the figure in next page shows a detailed flow of work model.

V. Results and Simulation

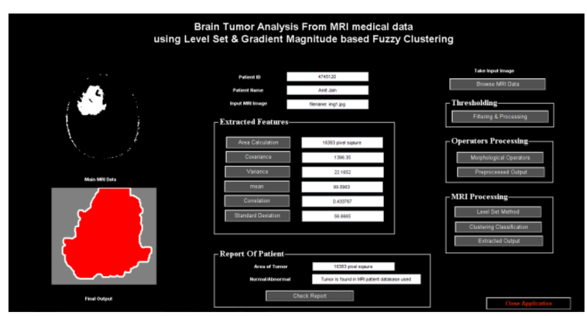

Figure 3: Main graphical user interface for proposed work, it consist of certain axes to show images and few buttons to perform desired operations.

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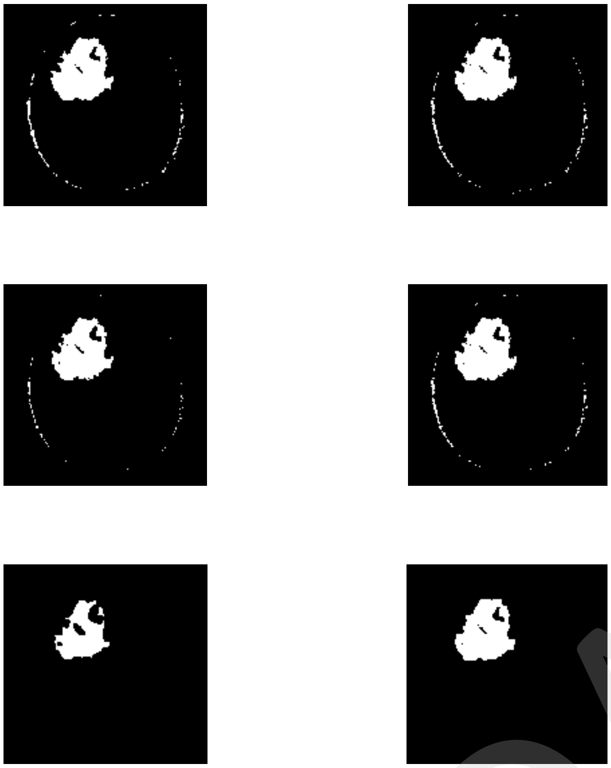

Figure 4: Morphological Operations perform sequentially on images (erosion after dilation in three steps)

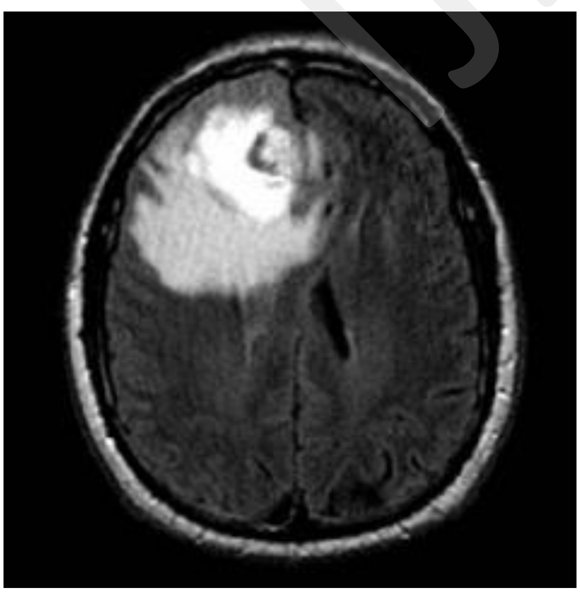

Figure 5 (a)

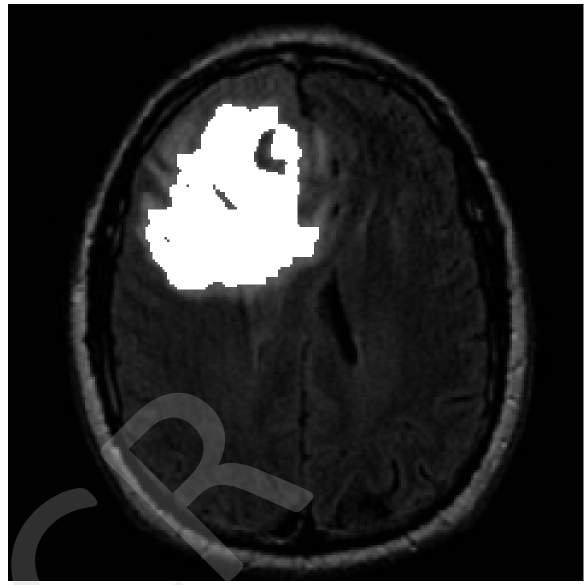

Figure 5 (b)

Figure 5 (a and b): Diffusion of extracted area from morphological operation performed image into original grayscale image with respect to input image

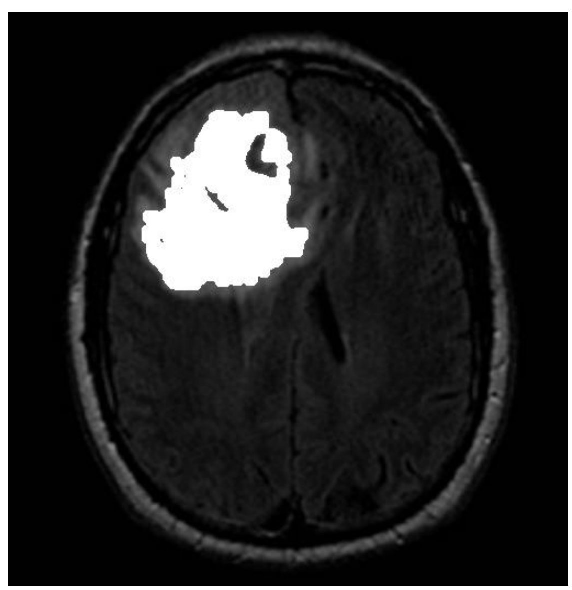

Figure 6: Diffusion of extracted area from morphological operation performed image into original grayscale image

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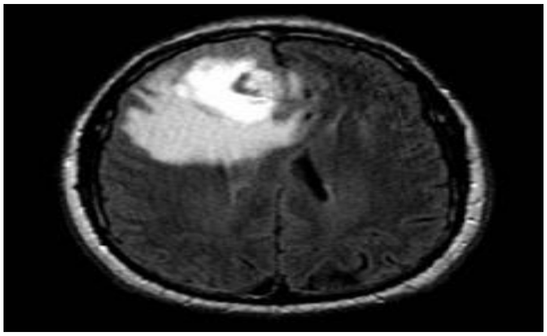

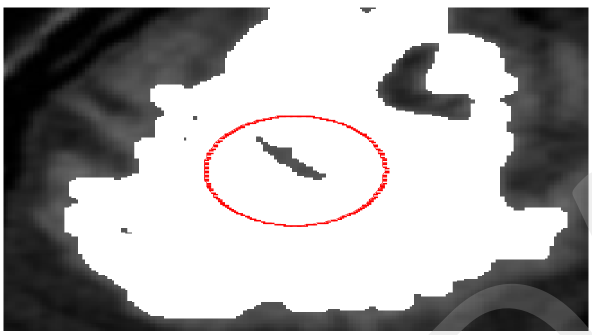

Figure 7: Initialization of level set method from center of image area

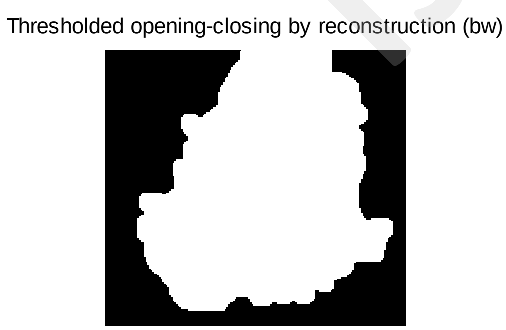

Figure 8: Type from heading

VI. Conclusion

In the classification of brain tumor, the approach of fuzzy c-means clustering in MATLAB environment gave a 2 dimensional figure of concerned section with clear outlines of tumor. The RGB to gray conversion simulated the performance of Morphological operations that outlines the tumor region. The fuzzy clustering rules then modify the results of morphological operations based on standard rules and improve the accuracy of proposed architecture. This image processing approach could further be modified to 3D; subjected to availability of resources. The research is limited to this point and further enhancement in this segment is due to algorithms that are more specific.

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