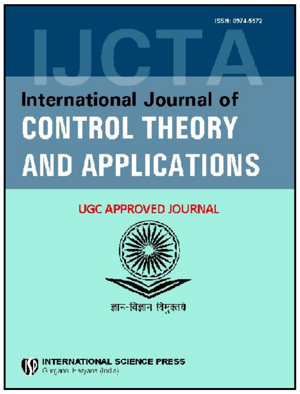

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A New Robust Approach to Brain Tumor Segmentation and its Area Calculation

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Abstract: Medical image processing continues to enable the biomedical technology revolution that we are experiencing today. With this actual development, the innovative approaches applying computer-aided techniques for segmenting brain tumor from MRI images are becoming more and more mature and coming closer to routine clinical applications. The overall objective of this research is to suggest a new robust approach for MRI brain segmentationby applying the improved Fuzzy C-means which incorporates spatial information (FCM_S) and also to get a better estimation of the clusters centers then the results obtained are considered as an initialization of the active contour for the Level set evolution. At the end of process, the tumor is extracted and its area: exact position and shapeare calculated.The experimental results clarify that this proposed approach improvesthe segmentation qualityand also give the high diagnosis accuracy.

Keywords: Magnetic Resonance Imaging (MRI), Brain Tumor, Segmentation, Modified Fuzzy C-Mean (FCM_S), Level Set, K-means,Image Processing.

1. INTRODUCTION

Magnetic resonance imaging (MRI)has become a vital component of a large number of biomedical applications. It is an important imaging technique for detecting abnormal changes in tissues and organs. However, Image processinghas the power to perform a good research in the field of medical sciences that it's one of the most highly challenging tasks.MRI images segmentation [8]is oneof the most difficult tasks holds an important position inimage processing which determine the quality of thefinal result such as in diagnosis, study of anatomical structure, the quantification of tissue volumes and localization of pathology, treatment planning and computer-integrated surgery.

Brain tumor segmentation helps the user to determine the precise size of the tumors.This paper is based on the research on Human Brain Tumor which uses the MRI imaging technique and image processing to create a newcooperative approach for automatedbrain tumor detectionby using the modified Fuzzy C-means (FCM_S) and level set algorithms.The processsystemhas four phases like pre-processing, segmentation,feature extraction and Tumor area calculation (approximate reasoning). Finally, the implementation, experimental results& discussions and their performance evaluation were described.

2. MRI IMAGES PROCESSING

MRI Image processing is an active researcharea which has potential applications in biomedical science. It helps to enhance an image or to extract hidden information from it.In this section we will talk aboutMRI image acquisition and differentmethods of image segmentation [2] used in our proposed work.

2.1. Image Acquisition

Images are obtained using MRI scan which is a modern imaging technique because it gives a more detailed image than CT scans and X-rays. MRI scans can uses a large magnet field, radio waves to take pictures of brain and other structure of the body. After the conversion, these scanned images are displayed in a two dimensional matrices (2D) having pixels as its elements. These matrices are stored in MATLAB and displayed as a gray scale image of size 256*256, their intensity is ranging from 0 to 255 where 0 resembles purely black color and 255 resemble purely white color. Any intermediate values between this rang vary in intensity from black to white. Figure 1: Shown the axial, coronal, and sagittal brain sections

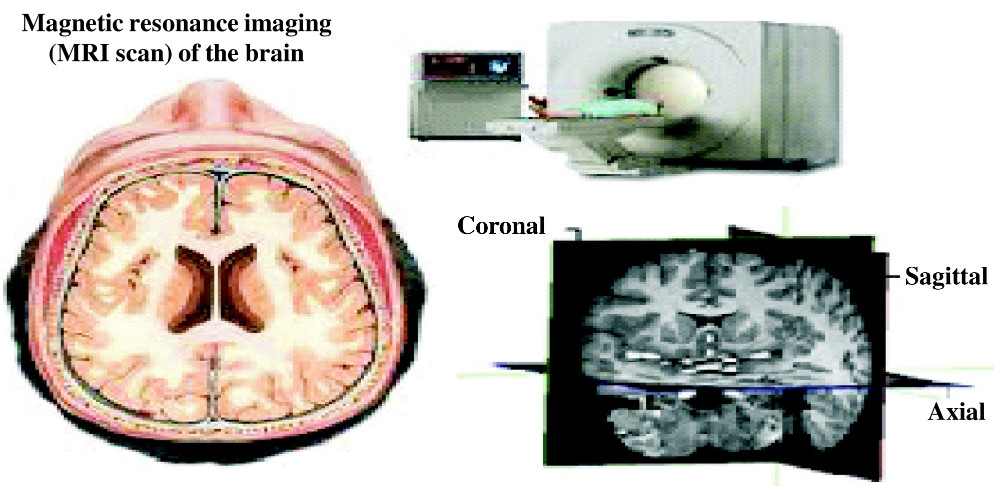


Figure 1: Brain MRI Image Sections

2.2. Existing Segmentation Methods

Image segmentation has various wide applications in the field of image processing. It can be defined as the partition of a digital image into similar regions or categories (sets of pixels,also calledsuper pixels) which correspond to different objects or parts of them. Every pixel in an image is allocated to one of a number of these categories. To define the segmentation: supposing the image is representedby W, denotes whole image region R_i (i=1, 2,.., k) are disjoint nonempty regions of W, consists of following conditions:

$$\bigcup_{i=1}^{k} R_i = W \tag{1}$$

$$\text{For All} \begin{cases} i, j \text{ and } i \neq j, \text{there exits } R_i \cap R_j = \emptyset \\ i = 1,2,..,k, \text{it must have } P(R_i) = \text{True} \\ i \neq j, \text{there exits } P(R_i \cup R_j) = \text{False} \\ i = 1,2,\ldots,k, R_i \text{ is connected component} \end{cases}$$

Image segmentation methods can be classified into three categories: Edge-based methods, region-based methods and pixel-based methods. The clustering and Edge methods are an important tool for a variety of applications.In this study, in order to detect the brain tumor from MRI images, we need to usesome combination between the following segmentation methods:

1. K-means clustering technique.
2. Fuzzy C-Means Method with the modification of their objective function: J_{FCM}.
3. Level Sets Edge-based method with the automatic initialization of their active contours.

3. PROPOSED SYSTEM

In this paper, we are going to propose a new cooperative approach which combines the modified fuzzy c-means [2] and level set method [8] without re-initialization. By using this approach we can obtain high accuracy images andthe overall efficiency of the system is enhanced. The proposed system has divided into four main parts. The output obtained from one part is taken as input to the next part. This can be represented by the following graphwork:

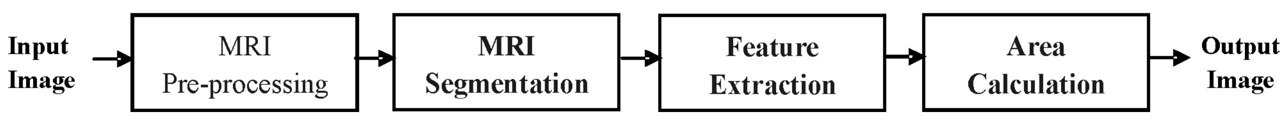


Figure 2: A Schematic Block Diagram of the Proposed System

3.1. MRI Pre-Processing

This is pre-processing part which is required to produce better results. So the gray scale imageis enhanced in the way that finer details and noise removal. Generally the possibilities of arrival of noise in modern MRI scan are very less but it may arrive due to the thermal effect. For that in our system we used gauss filter as noise filtering which helps us to procure the feasible results. Gauss filter is widely utilized in digital imageprocessing that he is proposed for improving the performance of brain MRI without high frequency noise and also without disturbing of the edges.

3.2. MRI Segmentation

Here, the performance of level set segmentation is subjected to appropriate initialization and optimal configuration of controlling parameters. The proposed algorithm has been developed to solve the problem of the initial parameters for the level set method such as the initial contours and its centers, for that reason it was used a technique called a modified FCM with spatial constraints denoted: FCM_S which allows us to act on image using global information and provides easily interpretable membership cards. Figure 3 shownthe differents methods used in MRI Segmentation part:

The main steps involved in the MRI segmentation part can be explained as follows:

Step 1: Obtain the first cluster centersfor FCM by applying K-means method.

Step 2: Calculate the mean filter (FCM_S1) or median filter (FCM_S2).

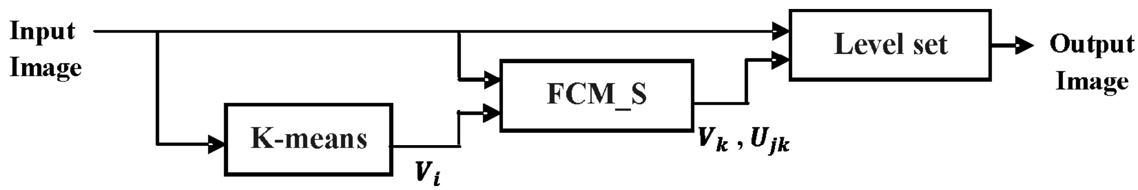


Figure 3: Block Diagram of MRI Segmentation

Regarding the standard FCM, Now the initialization of cluster centers is made by the K-means and for the statistical properties of neighboring pixels. By using the mean of neighboring pixels within a 3x3 mask will give the first variant of Spatial Fuzzy C-M (FCM_S1), also for the medianwill give the second variant that is FCM_S2.Where,m: degree of fuzziness equal to 2, C: number of the clusters,: pixel atlocation j.

Step 3: Startthe FCM_S algorithm in order to minimize the following objective function:

$$J_{FCM\_S} = \sum_{j=1}^{N}\sum_{k=1}^{C} U_{jk}^{m}\left\|y_j - v_k\right\|^2 + \sum_{j=1}^{N}\sum_{k=1}^{C} U_{jk}^{m}\left\|\bar{y}_j - v_k\right\|^2 \quad (2)$$

Step 4: Update the membership matrix using:

$$U_{jk} = \frac{\left(\left\|y_j - v_k\right\|^2 + \alpha\left\|\bar{y}_j - v_k\right\|^2\right)^{\frac{-1}{m-1}}}{\sum_{k=1}^{C}\left(\left\|y_j - v_k\right\|^2 + \alpha\left\|\bar{y}_j - v_k\right\|^2\right)^{\frac{-1}{m-1}}} \quad (3)$$

Step 5: Update the cluster centersby using the following equation:

$$v_k = \frac{\sum_{j=1}^{N} U_{jk}^{m}\left\|y_j - \alpha\, \bar{y}_j\right\|^2}{(1+\alpha)\sum_{j=1}^{N} U_{jk}^{m}} \quad (4)$$

Step 6: Reiterate Steps 4 and 5 until the convergence criterion: $\|v^{Old} - v^{New}\| < \varepsilon$

Step 7: Choose the fuzzy cluster to define initial contour for the level set method.

Step 8: Use the dynamic variational boundaries to approximate the evolution ofactive contoursl implicitly by tracking the zero level set Γ (t) with the following equation:

$$\begin{array}{c} \phi\ t,x,y\ <\ 0\ x,y\ is\ inside\ \Gamma\ (t) \\ \phi\ t,x,y\ =\ 0\ x,y\ is\ at\ \Gamma\ (t) \\ \phi\ t,x,y\ >\ 0\ x,y\ is\ outside\ \Gamma\ (t) \end{array} \quad (5)$$

3.3. Feature Extraction

This part consist feature extraction of the tumor area(region of interest)which shows the approximate reasoning. It was extracting the clusterby using an adaptive thresholding method[3] where each transform coefficient is compared with a threshold in threshold coding process. That entire image applies the binary mask value then the dark pixel becomes dark and the white pixel becomes brighter.

3.4. Area Calculation

Thebinarization method is used tocompute the tumor area of human brain [7]. It calculates the size of thetumor by calculating the number of white pixels (digit 0) inbinary image.That is the image havingonly two values either black (0) or white (1). Here256x256 is a maximum image size. Thebinary image can be represented as a summation oftotal number of white and black pixels.

Image, $I=\sum_{W=0}^{255}\sum_{H=0}^{255}[f(0)+f(1)]$

Pixels = Width (W) x Height (H) = 256X256;

f (0) = black pixel (digit 0), f (1) = white pixel (digit 1)

no_of_white_pixel, P = ΣΣ[f(0)]Where,P = number of white pixels (width*height)

1 Pixel = 0.264 mm, The area calculation formula isSize_of_tumor_is, S=[(“P)*0.264].

4. DESIGN AND IMPLEMENTATION

Once the proposed algorithm was developed, it was completely verified in Matlab software with multiple input images (MRI images). Then the in-built functions of MATLAB were replaced by user-defined functions in Matlab Simulink Model that we uses different Blocksets of “Video and Image Processing Blockset” library, here we present differents blocks used for this implementation as in table I:

Table I
Differents Simulink Blocksets Used

N°	*Blocks*	*Library*	*Quantity*
1	Image From File	Video and Image Processing Blockset> Sources	01
2	Gauss Filter	Video and Image Processing Blockset> Analysis & Enhancement	01
3	Video Viewer	Video and Image Processing Blockset> Sinks	03
4	Embedded MATLAB Function	Simulink> User-Defined Functions	06
5	Image data type conversion	Video and Image Processing Blockset> Conversions	02

The following section shows the proposed simulink model where various simulations have been carried out in MATLAB software. Figurenumber 4 represents the flowchart of proposed simulink model.

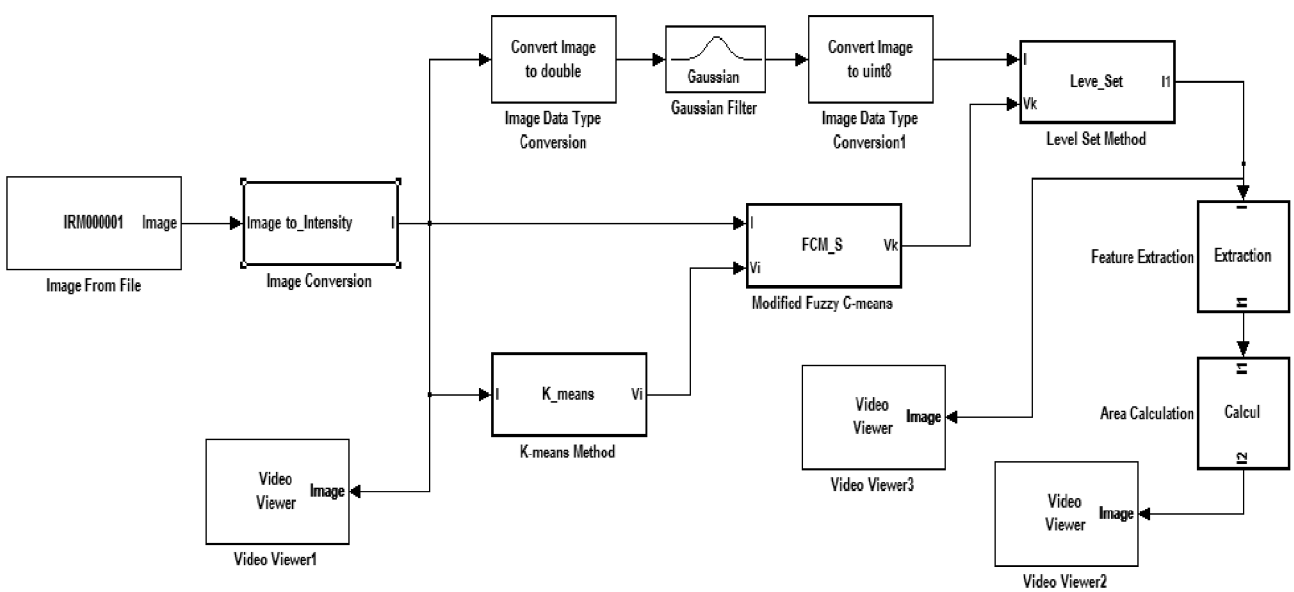


Figure 4: Flowchart of the Proposed Simulink Model

5. RESULTS AND DISCUSSION

The simulation results of the proposed work are presented in this section.The brain tumor location is found out by applying our proposed algorithm using MATLAB simulator version 8.3.0.532 (R2014a) installed under 64-bit,Windows 7 as Operating Systemand PCconfigurationwith i3 CPU. The Snap shot of the input image (original image) and it corresponding output image are summarized in Figure.5, 6 and 7.

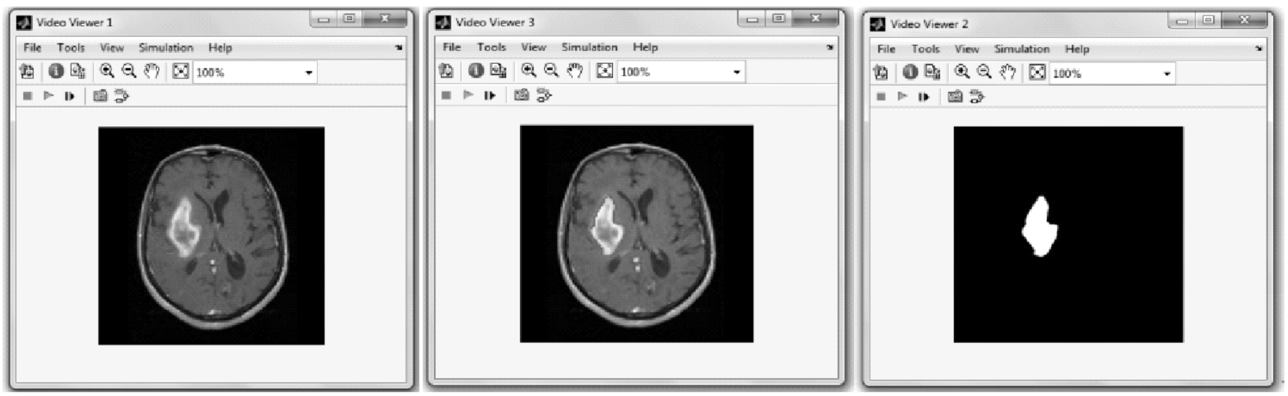
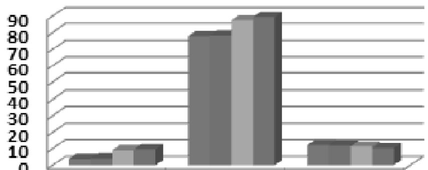


Figure 5: Axial Section: (a): Original image, (b): Level Set results, (c): Proposed Model output

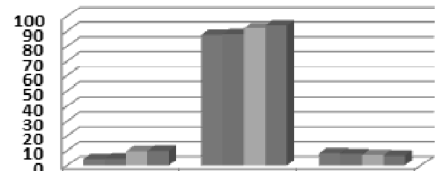
Figure 6: Coronal Section: (a): Original image, (b): Level Set results, (c): Proposed Model output

Figure 7: Sagittal Section: (a): Original image, (b): Level Set results, (c): Proposed Model output

To validate the results found, the evaluation were carried out including axial,coronal, sagittal sections. Theperformance comparison: Segmentation Accuracy, Tumor area and execution timewere calculated in order to confirm the good optimization. Theresults obtained are summarized in the following histogram:

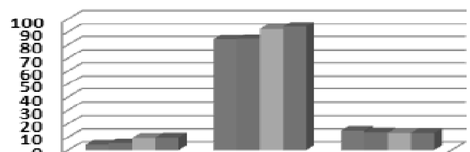


	Execution Time (sec)	Accuracy (%)	Tumor Area (mm²)
Standard FCM	3.906	77.82	12.05
FCM+K-means	4.283	78.25	11.83
FCM_S1+K-mean	9.035	87.42	11.34
FCM_S2+K-mean	9.547	89.36	10.22



	Execution Time (sec)	Accuracy (%)	Tumor Area (mm²)
Standard FCM	4.406	87.52	8.25
FCM+K-means	4.783	87.92	7.81
FCM_S1+K-mean	9.535	91.84	7.16
FCM_S2+K-mean	9.847	93.75	6.63

(a) (c) (b)



	Execution Time (sec)	Accuracy (%)	Tumor Area (mm²)
Standard FCM	3.996	84.12	14.79
FCM+K-means	5.362	84.63	13.54
FCM_S1+K-mean	9.611	92.19	13.22
FCM_S2+K-mean	9.874	94.02	13.04

Figure 8: Performance comparison: (a): Axial Section, (b): Coronal Section, (c): Sagittal Section

6. CONCLUSIONS AND FURTHER WORK

In this paper a simple and efficient segmentation method for detecting tumor in MRI images is proposed. According to the results obtained after the implementation, it is observed that combining between the modified fuzzy C-means and level set is a proper methodfor the segmentation of MRI images. The experimental results show that our proposed approach for brain tumor detection is able to improve the segmentation accuracy. Finally the approximate reasoning for calculatingtumor shape can be carried out.

Further work is ongoing to combine the FCM_S1 and FCM_S2 using also Pillar algorithm to have better results then we will implement itin the DSP processors of Texas Instrument (TMS320C6713 DSK).

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