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Detection and determination of Brain Tumor from MRI of Brain and its volume calculation

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Abstract

Brain tumor detection is one of the challenging tasks in medical image processing. The main purpose of this paper to design and implementation automatic system for brain tumor detection and its determination using MR images. The acquired MR images are processed using digital image processing techniques. These images are preprocessed and then segmented by threshold and watershed segmentation, after that, the morphological operations are used to extract only tumor in brain image automatic. Also, the region of interest algorithm (ROI) is used to extract tumor portion using a cursor, then compute the calculation volume of the tumor extracted automatically and compute the calculation volume of the tumor extracted by ROI to compare between these volumes. The location of tumor in brain is very important, so the proposed algorithm is to determine the location of tumor in MRI brain image. Results obtained were good compared with the review researches results. A detailed procedure using Matlab (R2010a) software is written to extract tumor region in MRI Scan Brain Image, MRI are used because MRI Scan has higher resolution and easier identification.

Keywords: Brain tumor, MRI(Magnetic Resonance Imaging), Segmentation, Morphological operations.

I. Introduction

Human beings have battled cancer since their existence, of which every year more than 200,000 people in US are diagnosed with a primary or metastatic brain tumor. Brain has a very complex structure and is considered as a kernel part from the body[1]. Nature has tightly safeguarded the brain inside a skull that hinders the study of its function as well as makes the diagnosis of its diseases more intricate. But, brain is not prone to diseases and can be affected by the abnormal growth of the cells in that changes it normal structure and behavior a disease generally known as a brain tumor[2]. Brain tumor is an abnormal mass of tissue in which some cells grow and multiply uncontrollably, apparently unregulated by the mechanisms that control normal cells. The growth of a tumor takes up space within the skull and interferes with normal brain activity. So the detection of the tumor is very important in earlier stages. Various techniques were developed for detection of tumor in brain[3,4].

Brain cancer may be considered among the most difficult cancers to treat, as it involves the organ which is not only in control of the body, but is also responsible

for the self-definition of the person. During surgery or any kind of treatment, eloquent areas must not be affected in order to minimize iatrogenic risks. Therefore good diagnosis and planning of treatment choices is essential[5].

Magnetic Resonance Imaging (MRI) is the state-of the-art medical imaging technology which allows cross sectional view of the body with unprecedented tissue contrast. MRI is an effective tool that provides detailed information about the targeted brain tumor anatomy, which in turn enables effective diagnosis, treatment and monitoring of the disease. Its techniques have been optimized to provide measures of change within and around primary and metastatic brain tumors, including edema, deformation of volume and anatomic features within tumors, etc[6]. Also, MRI provides a digital representation of tissue characteristic that can be obtained in any tissue plane. The images produced by an MRI scanner are best described as slices through the brain. MRI has the added advantage of being able to produce images which slice through the brain in both horizontal and vertical planes. This makes the MRI-scan images an ideal source for detecting; identifying and classifying the right infected regions of the brain[7,8].This paper is structured as follows: section-I gives a brief introduction of brain tumor. Existing brain tumor detection techniques have been discussed in the section-II, Section-III description the images used in this work, while explains the proposed methodology in the section-V. The experimental results discussed under section-VI. The conclusion and the scope for future improvement is given under section VII.

II. Related works

This section, presents review of the selected literature in image segmentation techniques and their usage. The key objective is to highlight key strengths and limitations to these techniques.

Zhang et al. in 2001 [9], suggest employing the Hidden Markov Random Field(HMRF) model for segmenting Brain MRI by using Expectation- Maximization algorithm. The study shows that HMRF can be merged with other techniques with ease. Marroquin et al. in 2002 [10] highlight the significance of 3D segmentation of brain MR scans. It uses separate parametric models for the intensity of each class. The brain atlas is employed with a robust registration procedure to find non-rigid transformation to map the standard brain to the specimen to be segmented. Tolba et al. in 2003 [11] in their paper presented a new algorithm proposed for MR brain image segmentation, which is based on EM algorithm and the multi-resolution analysis of images**.** Dibono et al. in 2008 [12] emphasized that a comprehensive methodology is required to explore the feasibility of the SVR kernel-based approach for extremely complex regression problem. The authors have addressed this problem by adopting a method modeled as a multiphase process, i.e. preprocessing phase and a prediction phase. Shi et al. in 2009 [13] employed neural networks for medical image processing, including the key features of medical image preprocessing, segmentation, and object detection and recognition. The study employed Hopfield and feed-forward neural networks. The feed-forward and Hopfield neural networks are simple to use and easy to implement. Yang et al. in 2010 [14] proposed an algorithm for medical image denoising by soft thresholding using wavelet transform followed by enhancement using non linear histogram equalization. besides enhancing the ROI, histogram equalization also enhances the noise contents of the image which is undesirable. Abhishek Raj in 2011 [1] we proposed an efficient algorithm for tumour detection based on segmentation and morphological operators. Finally the scanned image is enhanced and then morphological operators are applied to

detect the tumour. Padole and Chaudhari in 2012 [15] proposed an efficient method for brain tumor detection. Combination of two standard algorithm, *mean shift* and *normalized cut* is performed to detect the brain tumor surface area in MRI. Preprocessing step is first performed by using the mean shift algorithm in order to form segmented regions. then region nodes clustering are processed by *Ncut method*. Finally , the brain tumor is detected through component analysis.

III. Dataset description

Images of patients obtained from radiologists using MRI scan and scanned images are displayed in two dimensions matrices having pixels as its element. Three types of collections of MRI (TCGA-GBM,TCGA-LGG, REMBRANDT) are used. Images are stored as database as JPEG image format in Matlab. Images have information about 60 male and 40 female patients were examined. This database is download from MEDLINE.

V. Methodology

This section describes the method to extract tumor from brain MR images. The method is very simple to implement and computationally more efficient. The System design of the proposed method is shown in Figure1 in section B.5.

The proposed method has of the following two phases:

A- Preprocessing :- In this phase, we try to analysis the image which perform noise reduction and image enhancement techniques to enhance the image quality. The purpose of this phase is to make the image ready for further processing because the image may contain many noise need to apply filtering. This phase consist of the following steps:-

1- **Convert image to gray scale format**:- An MRI image is chosen from the database of brain images to be processed. This image is converted to gray-scale image of size 200*200. These images have shades of gray between 0 to 255, where 0 corresponds to black and 255 to white for instance.

2- **Enhancement and Smoothing** : There are different types of noise encountered by different techniques, depending on the noise nature and characteristics. In medical image processing, necessary to perform a high degree of noise reduction in an image before performing high-level processing steps, so we used two types of filters :-

a- **High Pass Filter**:- Noise presented in the image can reduce the capacity of region growing filter to grow large region or may result as a fault edges, so this gray scale image passes in to the filter. A high pass filter tends to retain the high frequency information within an image while reducing the low frequency information. So here, imfilter as high pass filter is used to replace each pixel of the image with weighted average of the surrounding.

b- **Median Filter** - Is nonlinear digital filter that is used to remove noise like salt and pepper, to smoothen and to preserve the edges of the image so it is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise because edges are of critical importance for the visual appearance of image. This technique calculates

the median of the surrounding pixels to determine the new (denoised) value of the pixel. A median is calculated by sorting all pixel values by their size, then selecting the median value as the new value for the pixel. The amount of pixels which should be used to calculate the median. Here , medfilt2 in matlab command is used to image enhancement to increase the quality of the image.

B- Processing :-In this phase, preprocessed image is used to segment it by using threshed and watershed segmentation then morphological operations are applied it to obtain only part of the tumor. Finally, we proposed two algorithms to calculate tumor volume and the location of tumor. This steps are described as follow:

1- **Segmentation**:-After the edge of MR image has been enhanced by preprocessing step, the segmentation of image is performed. Where, Image segmentation is the process of partitioning the medical image into multiple regions that can be associated with the properties of one or more criterion. So, the goal of the segmentation is to change the representation of an image into portions that is more meaningful and easier to analyze. Therefore we used two segmentation techniques:-

a- **Threshold Segmentation:**- The filtered image is converted into binary image by the thresholding method. It is useful in discriminating foreground from the background. By selecting an adequate threshold value T, the gray level image can be converted to binary image. The binary image should contain all of the essential information about the position and shape of the objects of interest (foreground). The main logic in this method is to select the threshold value. Several methods are used such as otsu's method ,entropy …ect. The global thresholding using graythresh function, which chooses the threshold to minimize the interclass variance of black and white pixels. So, we used otsu's method for computing threshold segmentation**.**

b- **Watershed Segmentation:-** The resultant image from thresholding segmentation is applied to watershed segmentation to segment it. The classical paradigm of watershed segmentation consists determining markers for each region of interest. The major idea of watershed segmentation is based on the concept of topographic representation of image intensity. So, controller watershed segmentation is used here for segment an MR image.

The result of the image segmentation is a set of segment that collectively cover the entire image. Each of the pixels in a region is similar with respect to some characteristic such as intensity, color or texture.

2- **Morphological Operation:-** After converting the image into binary form by choosing threshold value (depending on the image intensity), many morphological operations have been applied using structural element of 'diskshape', of 2-pixels diameter, where, the purpose of this operation is

to visualize only portion of brain tumor which appeared as white color because of this portion has high intensity than other regions of the image.

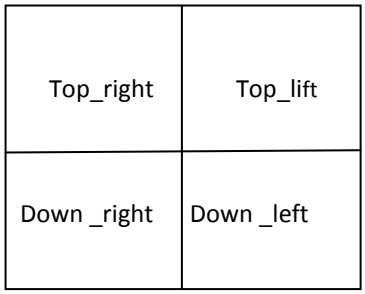
The public commands in matlab are used in morphological operations which are given below:

1- **strel** command which is used for creating more structural elements.
2- **imerode** command which is used to shrink (erode) an image.
3- **Imdilate** command which is used for dilating(filling expanding) an image.

4- **Edge Detection :-**Computes edge detection using sobel edge detection technique, and shows only tumor portion of the image by removing the small object area.

5- **Compute volume of tumor:-**in this phase, we calculate the volume of tumor by the extraction of connected components from a gray scale. The goal of this phase helps the doctor to determine the dangerous this tumor and to determine whether it is beginner or not.

6- **Determine location of tumor:-** Determining the location of the tumor in any part (top left, top right, bottom left, bottom right) is very important when doctors determine the degree of seriousness of the disease it is possible to eradicate it or not. Because in the human brain of each part is different mission for the other part, so the development of a new algorithm is used here to determine the tumor site as the show image of size(200*200).



B.1 Algorithm for Automatic Detecting Brain Tumor

Input: Brain MR image.
Output: Tumor portion.

Step1:- Read the input MRI brain image.
Step2:- Convert input image into grayscale image.
Step3:- Resize image (step2) into 200 × 200 image matrix.
Step4:- Grayscale image passes to high filter to remove noise from it.
Step5:- Add step2 and step4 images and pass it into a median filter to get the resultant enhanced image by removing salt & pepper noise from it .
Step6:- Compute a global threshold that can be used to convert an grayscale image to a binary image.
Step7:- Compute watershed segmentation on image of step6 by using controller based watershed in matlab.
Step8:-Compute the morphological operation on image of step7 by using three commands in matlab (strel, imerod, imdilate).
Step9:-Convert image of step8 from binary scale to gray scale by using the following steps:

Store the size of the step 8 image into size1 and size2
Each pixels in image(size1,size2) test the following step:-
If step8 image (i,j) == 1 then step2 image (i,j) = 255
Else step2 image (i,j) = step2 image (i,j) * 0.9

Step10:- Using sobel edge detection technique to compute edge detection.
Step11: Convert binary image of step10 into an RGB color image for the purpose of

visualizing labeled regions by using matlab command (`label2rgb`).

B.2 Algorithm for Volume Calculation of tumor extracted automatically

Input: Tumor portion.
Output: Volume of the tumor.
Step1:- Read the input image (output image from previous algorithm (**B.1**)).
Step2:- Convert image of step1 into grayscale image.
Step3:-Store the size of the step 2 image into array(A).
Step3:-Initialize a variable VT =0 .
Step4:- Each pixels in image A, test the following step:-
If A(i,j)==255 then go to the following step
Else increment VT
Step5:-Display the Volume of tumor (VT).

B.3 Algorithm for Detecting Brain Tumor using ROI and Volume Calculation of it.

Input: MRI of brain image.
Output1: Tumor portion of the image.
Output2: Volume of the tumor.
Step1:- Read the input MRI of brain image.
Step2:- Convert input image in to grayscale image.
Step3- Specify a polygonal region of interest by using matlab command (roipoly) ,where the cursor can be used to create a polygon.
Step4- Define the region of interest based on a color or intensity range by using matlab command (roicolor).
Step5- Create a binary mask by using Boolean indexing.
Step6- Apply edge detection using Sobel algorithm.
Step7- Subtract the output image of step6 from the original image of step2. This will give only the white area of portion tumor.
Step8:- Store output at (step7) into array B.
Step9:- Compute numbers of rows and column in pixels by [r c] = size (B)
Step10:- Initialize a variable VT =0
Step11:- For i=1:1: r
Step11:- For j=1:1: c
Step11:- If B(i,j)==1 then VT = VT +1
Step11:- Else VT = VT +0
Step11:- EndIF
Step11:- EndFor
Step11:- EndFor
Step12:-Display the Volume of tumor (VT).

B.4 Algorithm for Determine the location of Brain Tumor.

Input: Tumor portion of the image.
Output: Location of the tumor .
Step1:- Read the input gray image of the tumor (IM).
Step2:- Compute numbers of rows and column in pixels by [r c] = size (IM)
Step3:- For each pixels(r,c) in image (IM) tested
If IM (i,j) <> 255 then
If pixel (i,j) in the First quarter of image then increment n1
Else If pixel (i,j) in the second quarter of image then increment n2
Else If pixel (i,j) in the third quarter of image then increment n3
Else If pixel (i,j) in the Fourth quarter of image then increment n4
If n1 is the largest among (n2,n3,n4) then
Display ('The Location of Tumor is TOP_RIGHT')
else if If n2 is the largest among (n1,n3,n4) then
Display ('The Location of Tumor is TOP_LEFT')
If n3 is the largest among (n1,n2,n4) then
Display ('The Location of Tumor is DOWN_RIGHT')
else Display ('The Location of Tumor is DOWN_LIFT')

B.5: Flow Chart of our Proposed Method

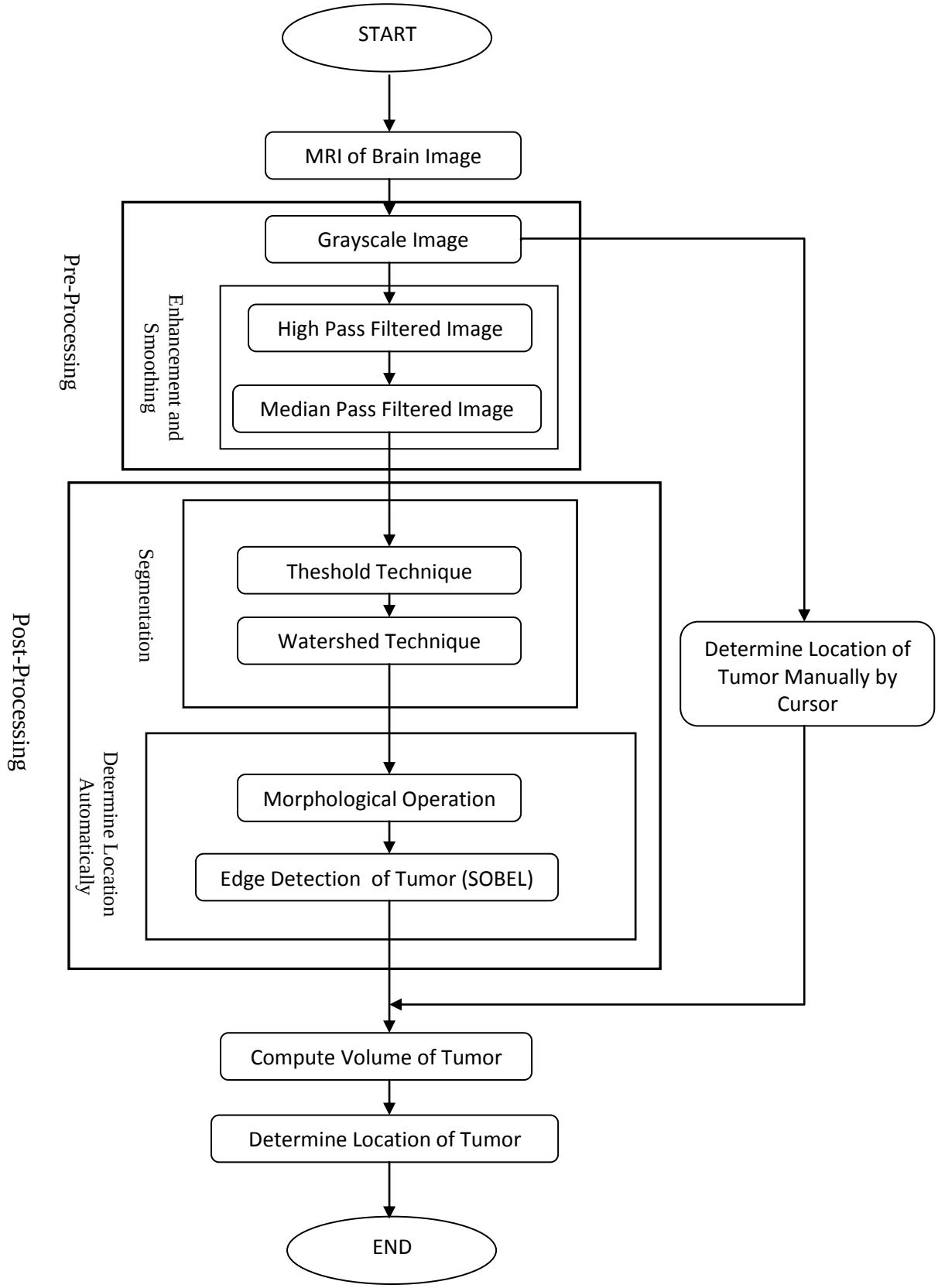


Figure 1:-steps of proposed system

VI. Results and Discussion

In this section, we presented some of the

results on MR images of brain. Codes are written in matlab, and the desired results are obtained.

a. The results are shown below:-
figure1 shows the original MRI scan image as an input, figure2 shows grayscale conversion of the image, figure3 shows the high pass filter, figure4 shows the resultant enhanced of image from figure3, figure5 shows threshold segmentation with threshold value 0.45, figure6 shows watershed segmentation, Figure7 shows apply morphological operations, figure8 shows edge detection with sobel technique, figure9 shows colored output tumor, finally Figure10 and figure11 shows the tumor detection using a cursor.

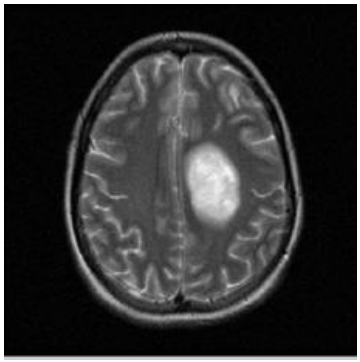


Figure1:- Original MRI Brain image

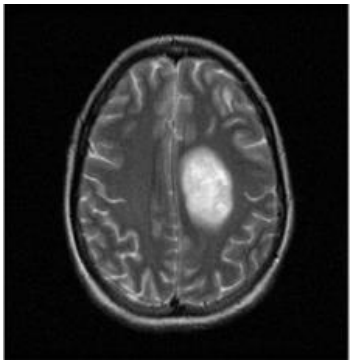


Figure2:- Grayscale image

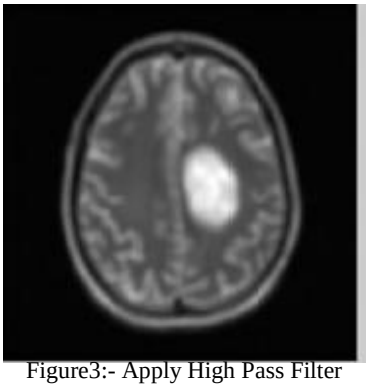


Figure3:- Apply High Pass Filter

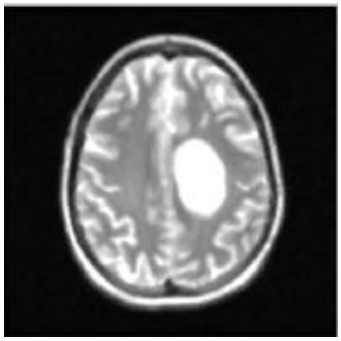


Figure4:- Apply Median Filter For Enhancement

Figure5:- Compute Threshold Segmentation

Figure6:- Compute Watershed Segmentation

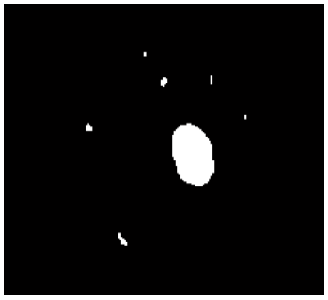


Figure7:- Calculate Morphological Operation

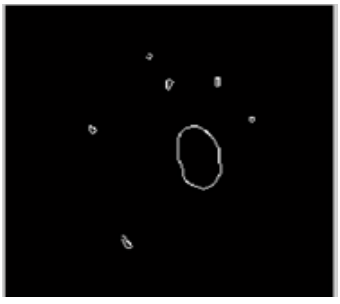


Figure8:- Sobel Detection

Figure9:- Tumor Colored

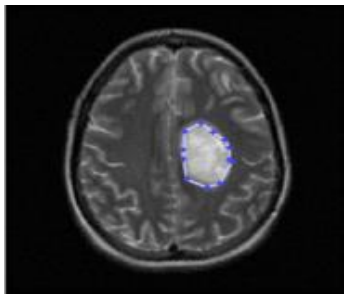


Figure10:- Tumor Detection Using a crosser

Figure11:- tumor portion extracted using a crosser

b. **Tabel1:** Contains image size with tumor volume in pixels when used automatically detection technique and tumor volume in pixels when used a cursor detection technique.

Image Name	Image Size	Tumor size in pixels	
		By a cursor	Automatically
Image1	200*200	1560	1566
Image2	200*200	311	326
Image3	200*200	1819	1206

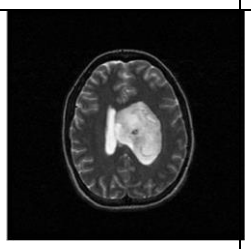
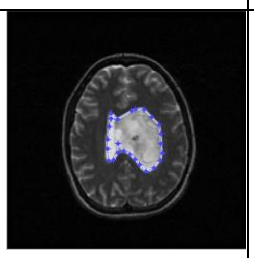
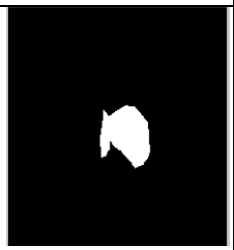
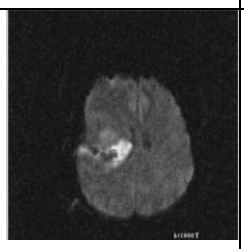
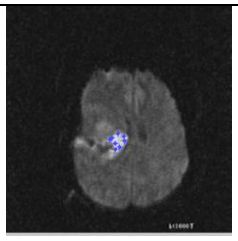
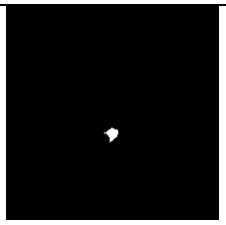
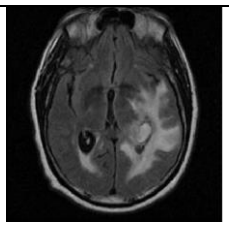
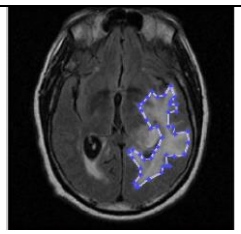
We noted in the Table1, the volume tumor extracted using automatically method is similar to the volume tumor when we used the a cursor method to extract it. This indicates the success of the proposed algorithm that is used for tumor detection and account volume. We also note that the automatic method to be more accurate than a cursor method, as we can be seen in the following examples:

1 – In image1, when we determined the tumor specifically a cursor note that the volume appeared to us like when we used the volume automatically method. (see Table2)

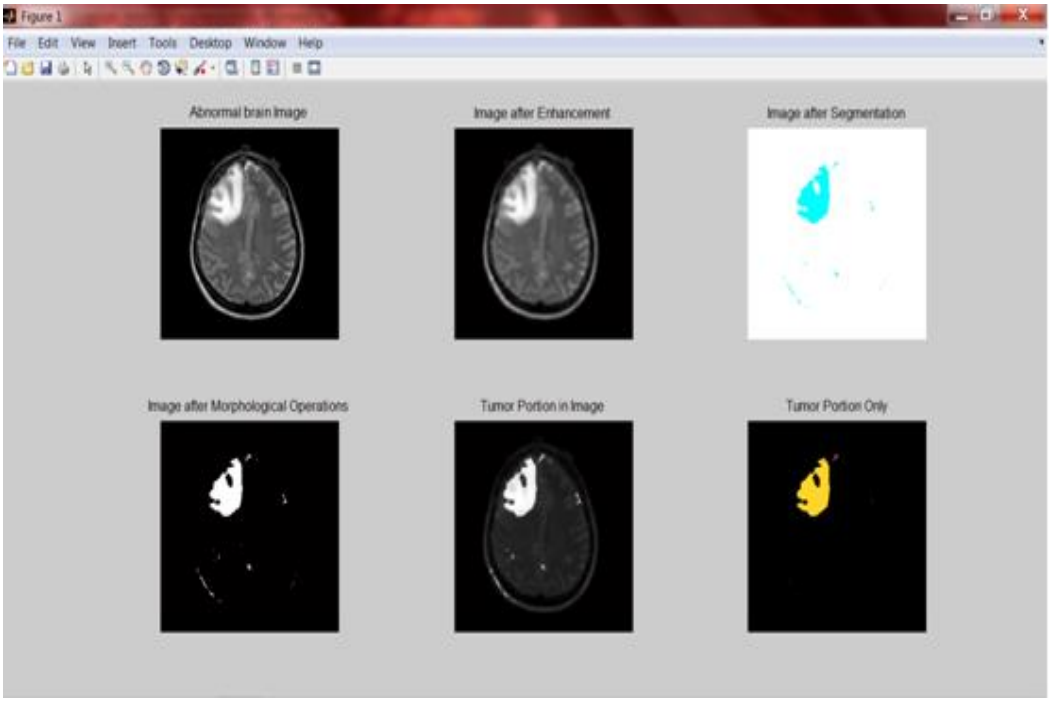
2 - In image2, when we determined the volume of the tumor using a cursor method is less than the real volume, appeared to us that the volume of the tumor cursor method is less than the volume of the tumor, in automatic method. This is normal case because when determined the tumor by a cursor didn't determine the all of tumor. (see Table2)

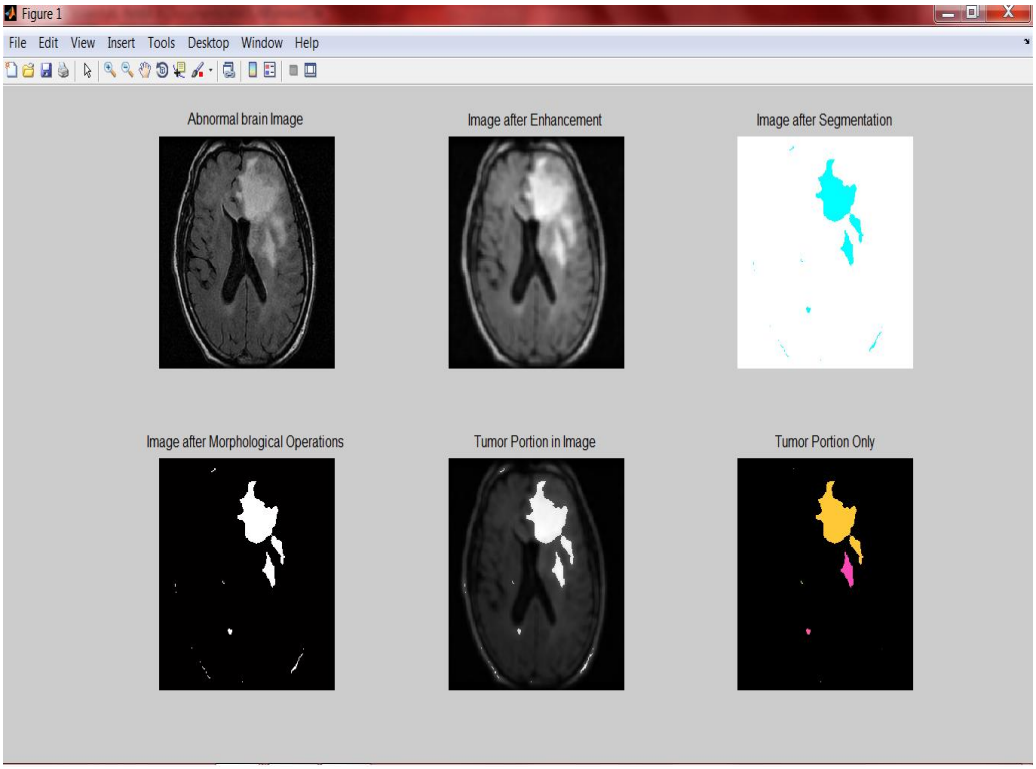
3 - In image3, when we determined the volume of the tumor using a cursor method is greater than the real volume of the tumor, appeared to us that there is a difference between them, where the value of the volume of the tumor extracted by a cursor is greater than the volume of the tumor which is extracted automatically.(see Table2)

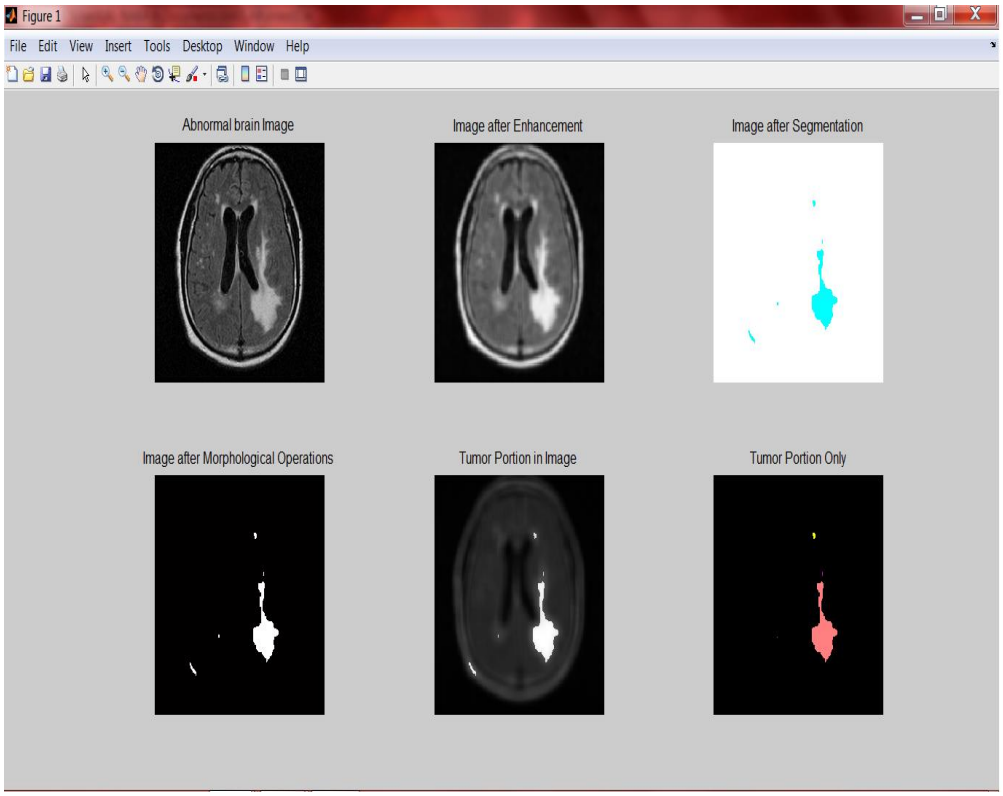
Tabel2: Contains original image with tumor when using automatically detection technique and tumor when using a cursor detection technique.

Image Name	Original image	Detection tumor By a cursor		Detection tumor Automatically
		Detection	Only tumor	
Image1				
Image2				
Image3				

c. Some other results are shown below for three different images with six steps for each image as explained in this figure:-







d. Tabel3: contains volume tumor and the location of its for three images are shown in section (c) which is presented above.

Image Name	Image Size	Tumor Size Extraction Automatically	Tumor Location In Brain MR Image
Image1	200*200	1293	TOP_RIGHT
Image2	200*200	1764	TOP_LEFT
Image3	200*200	1193	DOWN_LIFT

VII. Conclusion and Future works

During last years , brain tumor detection has become an emergent research area in field of medical imaging system. Because of the seriousness of brain tumor and the importance of treatment prematurely ,we present a new method to extract tumor from MRI brain . Also, we proposed new method to calculate the volume of tumor and its location, where calculating of the volume tumor helps a doctor to decision whether the patient needs surgery or not. In this work , we tried overcome the obstacles faced by previous researches by detecting brain tumor using two methods (automatically, manually) and the results of our system are very good when compared with review researches results . Our database contained different types of images with different tumors sizes, locations and intensities. Finally , our

system is being easy in the application and the execution that helps the uses to extract tumor accurately and efficiently .

In future works, we plan to develop the system by using statistical methods to detect and determine that type tumor is benign or malignant, also we can expand the system by using color images in three dimensions (3D images) , and finally we can make some adjustments to make it appropriate to use for the diagnosis of other tumors, like liver ,lung tumors and other.

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اكتشاف ورم الدماغ وتحديده من صور الرنين المغناطيسي للدماغ وحساب حجم الورم

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الخلاصة

يعد كشف ورم الدماغ من إحدى المهام الصعبة في مجال معالجة الصور الطبية. حيث ان الغرض الاساسي من هذا البحث هو تصميم نظام الي وتطبيقه لكشف ورم الدماغ وتحديده باستخدام صور الرنين المغناطيسي . تمت معالجة صور الرنين المغناطيسي التي تم الحصول عليها باستخدام تقنيات معالجة الصور الرقمية . عولجت الصور معالجة اولية لها ثم قسمت باستخدام تقنيتي التقسيم (التقسيم بالعتبة و التقسيم بالحد الفاصل), وبعد ذلك تم استخام العمليات التركيبية للحصول على جزء الورم أليا. كذلك استخدام خوارزمية (ROI) للحصول على جزء الورم يدويا باستخدام المؤشر ثم القيام بحساب حجم الورم المستخلص اليا وحجم الورم المستخلص يدويا لعمل مقارنة بين ألحجمين. كانت النتائج التي تم الحصول عليها كانت جيده مقارنه مع نتائج البحوث السابقه. تمت كتابة البرنامج بلغة ماتلاب نسخة (R2010a) وقد استخدمنا صور MRI نتيجة كون هذا النوع من الصور عالي الدقه وسهل التطبيق.

الكلمات المفتاحية :ورم الدماغ ، صور الرنين المغناطيسي ، التقطيع ، العمليات التشكيلية