Computer Aided System for Brain Tumor Detection and Segmentation

M. Usman Akram[1], Anam Usman[2]
[1]Department of Computer and Software Engineering, Bahria University, Islamabad, Pakistan
[2]Department of Software Engineering, Fatima Jinnah Women University, Rawalpindi, Pakistan
usman@bahria.edu.pk, anam.tariq86@gmail.com

Abstract—**Magnetic resonance (MR) images are a very useful tool to detect the tumor growth in brain but precise brain image segmentation is a difficult and time consuming process. In this paper we propose a method for automatic brain tumor diagnostic system from MR images. The system consists of three stages to detect and segment a brain tumor. In the first stage, MR image of brain is acquired and preprocessing is done to remove the noise and to sharpen the image. In the second stage, global threshold segmentation is done on the sharpened image to segment the brain tumor. In the third stage, the segmented image is post processed by morphological operations and tumor masking in order to remove the false segmented pixels. Results and experiments show that our propose technique accurately identifies and segments the brain tumor in MR images.**

Keywords-**brain tumor detection, segmentation, CAD**

I. INTRODUCTION

Brain tumor segmentation in MR images has been recent area of research in the field of automated medical diagnosis as the death rate is higher among humans due to brain tumor [1]. In automated medical diagnostic systems, MRI (magnetic resonance imaging) gives better results than computed tomography (CT) as MRI provides greater contrast between different soft tissues of human body. Hence MRI is much more effective in brain and cancer imaging [2].

Detection of brain tumor requires brain image segmentation Manual brain MR images segmentation is a difficult task. It requires plenty of time, non-repeatable task, non-Uniform Segmentation and also segmentation results may vary from expert to expert. So computer aided system is useful in this context. An automated brain tumor detection system should take less time and should classify the brain MR image as normal or tumorous accurately It should be consistent and should provide a system to radiologist which is self explanatory and easy to operate.

Automatic brain tumor detection and segmentation faces many issues and challenges. It is a difficult task to segment brain tumor in an automatic computerized system as it involves pathology, physics related to MRI along with intensity and shape analysis of MRI image. The major issue with brain tumor segmentation is that the tumor varies in form of shape, size, location and image intensities. Manual segmentation of brain tumor requires human experts and it takes a lot of time, which makes a computer aided system for brain tumor detection and segmentation a desirable method.

Different approaches for brain tumor detection and segmentation have been proposed. Hierarchical self-organizing map based multiscale image segmentation was suggested by Suchendra et al. [4]. Murugavalli et al. used high speed parallel fuzzy c-mean and neuro fuzzy algorithm for brain tumor segmentation [5-6]. 3D variational segmentation based method was proposed by Chunyan et al. [7] and they tested it on tumor tissues from various patients. Clark et al. and Fletcher-Heath et al. [8,9] used artificial intelligence techniques for automated tumor segmentation. Statistical pattern recognition based method was proposed by Kaus et al. [10]. Gering et al. proposed a method that detects deviations from normal brains using a multi-layer Markov random field framework [11]. Cuadra et al. presented highdimensional warping to study deformation of brain Tissue due to tumor growth [12].

An automated diagnosis system for brain tumor detection should consist of multiple phases including noise removal, brain image segmentation and brain tumor extraction. This paper presents a computer aided system for brain tumor detection. Our systems extracts tumor by using three phases, pre processing, global thresholding and post processing.

This paper is arranged in four parts. Part II explains the proposed method and presents the step by step techniques required for automated brain tumor detection and segmentation. Experimental results of tests on the images and their analysis are given in Part III followed by conclusion in Part IV.

II. PROPOSED METHOD

Given a brain MRI image, the first step enhances the image, the second step segments the brain tumor image and in the third step post processing using morphological operations and windowing technique takes place. As a result of these steps, we get a final brain tumor detected image. Figure 1 shows a systematic overview of the proposed technique.

A. Preprocessing

Preprocessing of brain MR image is the first step in our proposed technique. Preprocessing of an image is done to reduce the noise and to enhance the brain MR image for further processing. The purpose of these steps is basically to improve the image and the image quality

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to get more surety and ease in detecting the tumor. Steps for preprocessing are as follows:

1) Image is converted to gray scale.
2) A 3x3 median filter is applied on brain MR image using equation 1 in order to remove the noise.

$$\bar{f}(x,y) = median_{(s,t)\epsilon Sxy}\{g(s,t)\} \quad (1)$$

3) The obtained image is then passed through a high pass filter to detect edges. The high pass filter mask is given in equation 2.

$$\begin{bmatrix} -1 & 2 & -1 \\ 0 & 0 & 0 \\ 1 & -2 & 1 \end{bmatrix} \quad (2)$$

4) The edge detected image is added to the original image in order to obtain the enhanced image.

Figure 2 shows the original brain MR image and preprocessed image.

B. Brain Tumor Segmentation

After enhancing the brain MR image, the next step of our proposed technique is to segment the brain tumor MR image. Segmentation is done to separate the image foreground from its background. Segmenting an image also saves the processing time for further operations which has to be applied to the image. We have used segmentation using a global threshold in order to segment the tumor image. The basic steps for global threshold segmentation are as follows:

1) Select a threshold value for the image.
2) Apply the threshold value to enhanced image to convert the image to binary.
3) If a particular pixel value is above the threshold value it is considered as foreground otherwise background.

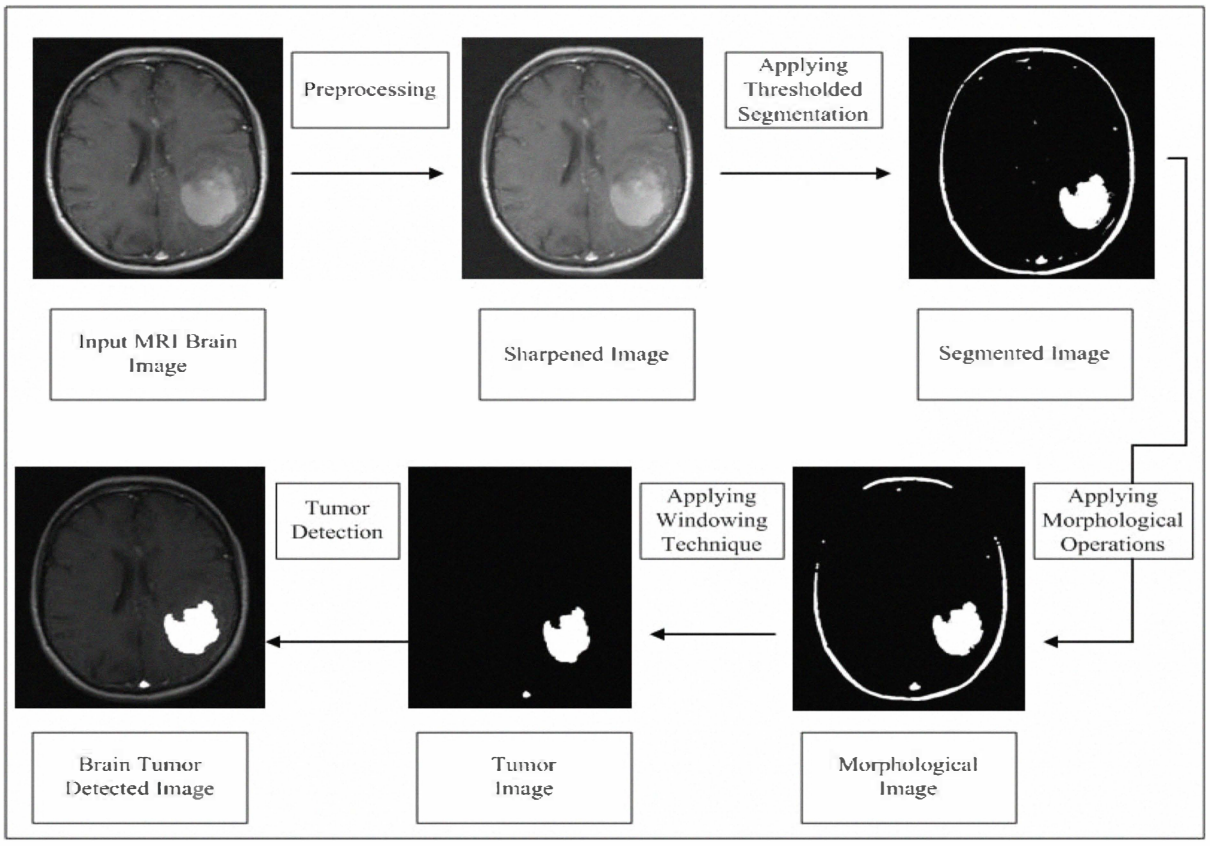

Fig.1 Flowchart of brain tumor detection

Figure 3 shows the enhanced image after preprocessing and a segmented image.

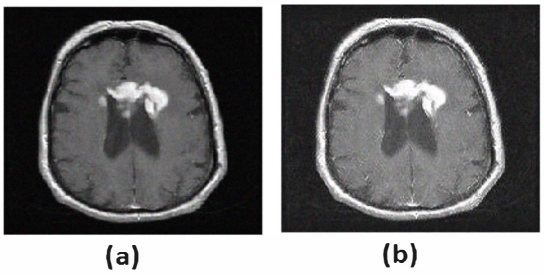

Fig.2. Preprocessing: a) Original image, b) Enhanced Image

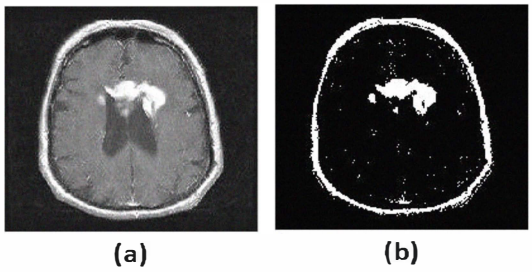

Fig.3. Segmentation: a) Enhanced Image, b) Segmentation

C. *Postprocessing*

After segmenting the brain MR image, several postprocessing operations are applied on the image to clearly locate the tumor part in the brain. The basic purpose of the operations is to show only that part of the image which has the tumor that is the part of the image having more intensity and more area. These postprocessing operations include morphological operations and windowing technique. The basic steps of postprocessing are as follows:

1) The morphological erosion is applied on the segmented brain MR image with 3x3 structuring element using the equation 3.

$$A \ominus B = \{z|(B)_z \subseteq A\} \tag{3}$$

2) The morphological dilation is applied on the eroded brain MR image with 3x3 structuring element using the equation 4.

$$A \oplus B = \{z|(\bar{B})_z \cap A \neq \Phi\} \tag{4}$$

3) Binary tumor masked window is created to segment out the tumor region from the image. Tumor tissue has basically more intensity than the other surrounding tissues of the brain MR image.
4) The final brain tumor detected image is obtained by applying the tumor mask on dilated brain MR image.

Figure 4 shows the output images of postprocessing phase. These images show that how accurately false segmented pixels are removed from segmented image.

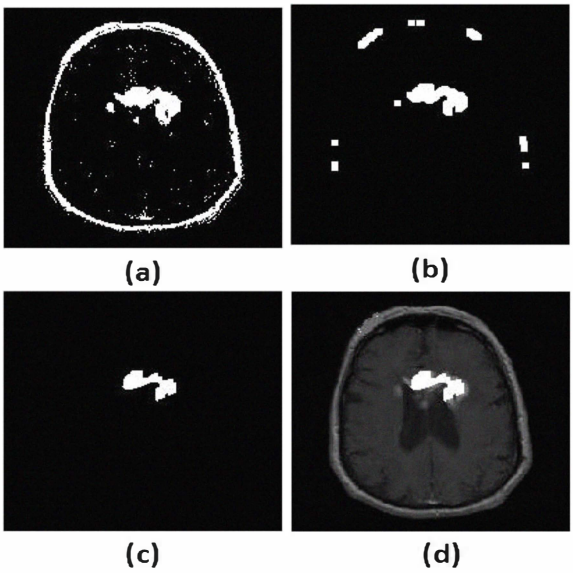

Fig.4. Postprocessing: a) Segmented Image, b) Output of morphological operation, c) Output of windowing, d)Tumor extracted Image

III. Experimental Results

The tests of proposed technique are performed with respect to the brain tumor segmentation accuracy using 100 MR images of different patients. The images used for testing are of size 676x624 pixels, eight bits per color channel. Images that we have used for testing contain brain tumor of different size, shape and intensity. In order to check the accuracy of automated segmented tumor area, tumor from all images is segmented manually by the ophthalmologist. The manually segmented images are used as ground truth. The true positive rate is the ratio of number of true positives (pixels that actually belong to tumor) and total number of tumor pixels in the MR image. False positive rate is the ratio of false positives (pixels that don't belong to tumor) by total number of non tumor pixels in the MR image.

Figure 5 shows the experimental results for different MR images containing tumor of different shape and size. It shows that proposed method have extracted the brain tumor accurately.

The results of tumor segmentation for MR images are summarized in table-I. It shows the results in terms of average accuracy and their standard deviation as compared with ground truth. Average accuracy is computed by counting the total number of pixels correctly classified.

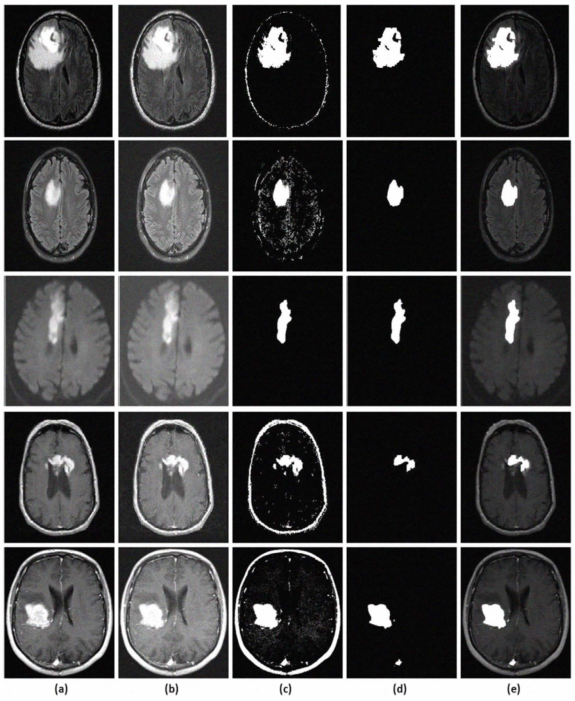

Fig.5. Experimental Results: a) Original MR images, b)Preprocessed Images, c)Segmented Images, d)Post processed Images, e)Tumor extracted Images

TABLE I
BRAIN TUMOR SEGMENTATION RESULTS

Parameter	Value
Average Accuracy	0.97%
Standard Deviation	0.0013
Accurately Segmented	97%
Poorly Segmented	3%

IV. CONCLUSION

In this paper brain tumor segmentation and detection is done using MR images. The proposed method enhanced the MR image and segments the tumor using global thresholding. False segmented pixels are the removed using morphological operations and applying windowing technique. The proposed method is invariant in terms of size, shape and intensity of brain tumor. Experimental results show that our method performs well in enhancing, segmenting and extracting the brain tumor from MR images.

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