

Efficient Brain Tumor Detection Using Image Processing Techniques

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Abstract— The paper covers designing of an algorithm that describes the efficient framework for the extraction of brain tumor from the MR images. The first phase of the Algorithm is Gaussian and Median Filters implemented to enhance the image quality. A couple of morphological operations are applied to calculate the morphological gradient. The filtered image and the morphological gradient image are added to enhance the intensity of the image to make it suitable for further operations. After the enhancement process, the threshold value is calculated using the mean and standard deviation of the image. This threshold value is used to binarize the image followed by the morphological operations. After this tumor area is made visible while rest of the image is darkened to differentiate between the affected and the unaffected area of the brain.

Index Terms—Gradient, Morphological Operations, Threshold, Mean, Standard Deviation, Area

INTRODUCTION

BRAIN tumor is abnormal growth of cells classified as Primary and Secondary Tumor. Primary tumors originates from brain and do not spread to other parts of body and are called benign while secondary tumors come to brain through other parts of body and can also spread to other parts of body and are called malignant. Both of the types cause serious threats to life.

Brain tumor can be of any shape, size, location and intensity, therefore it is very difficult to detect tumor and diagnose it.

There are two general approaches to detect brain tumor:

1. Computed Tomography Scan.
2. Magnetic Resonance Imaging.

Magnetic Resonance Imaging (MRI) is widely used to detect tumor in brain although it is very difficult to detect tumor because of various abnormalities, noise and intensities. MRI is usually more useful because it provides more detailed information about tumor type, position and size^[1]. It is an advanced medical imaging technique used to produce high resonance images of all parts of body. These high resolution images are used to detect abnormalities. Brain tumor segmentation has been the area in focus for the past years as it is required for the purpose of undertaking difficult tasks in a fully automated manner. MRI is a computerized technique so human error and many other issues can easily be overcome. A lot of work has been done to make the process fully automated but still it's not a part of the current medical system. Brain tumor detection is still not adoptable because of the fact that it is difficult to design an optimum algorithm that can

tackle the varying size of the tumor and also the location that is changing in almost every new image.

Image Segmentation refers to a method of getting desired portion from an image. Different methods and techniques are used for extraction of brain tumors. Some of them are watershed segmentation, region growing method, edge detection, clustering and fuzzy logic^[2].

Watershed has drawback of over-segmentation although it is vastly used for segmentation^[3]. Region growing method is also a useful technique for tumor extraction but it requires a seed value by user in start. Therefore, it is not an automatic technique. Also, there is a chance of selecting wrong seed value and it also has high time complexity^{[4],[6]}. Edge detection is used for high intensity images only because it has low gradient value for low intensity images^[5]. Clustering methods although have high speed but differ in producing same result on every run.

An algorithm should be designed which can detect tumor efficiently but can also calculate its area. This paper presents an algorithm which can detect brain tumor efficiently but also calculates area of the tumor. This paper is divided into four sections. Section 1 provides an introduction. Section 2 describes proposed method of detection, extraction and area calculation through morphological operations. Section 3 shows experimental results along with the original images and Section 4 describes analysis and conclusion.

PROPOSED METHOD

Extraction of tumor from different MR Images is very difficult

task to be done. Therefore, an easy method is being proposed to tackle this task without any difficulty. The proposed method has capability to detect and extract tumor easily.

The flow chart of designed algorithm is shown below:

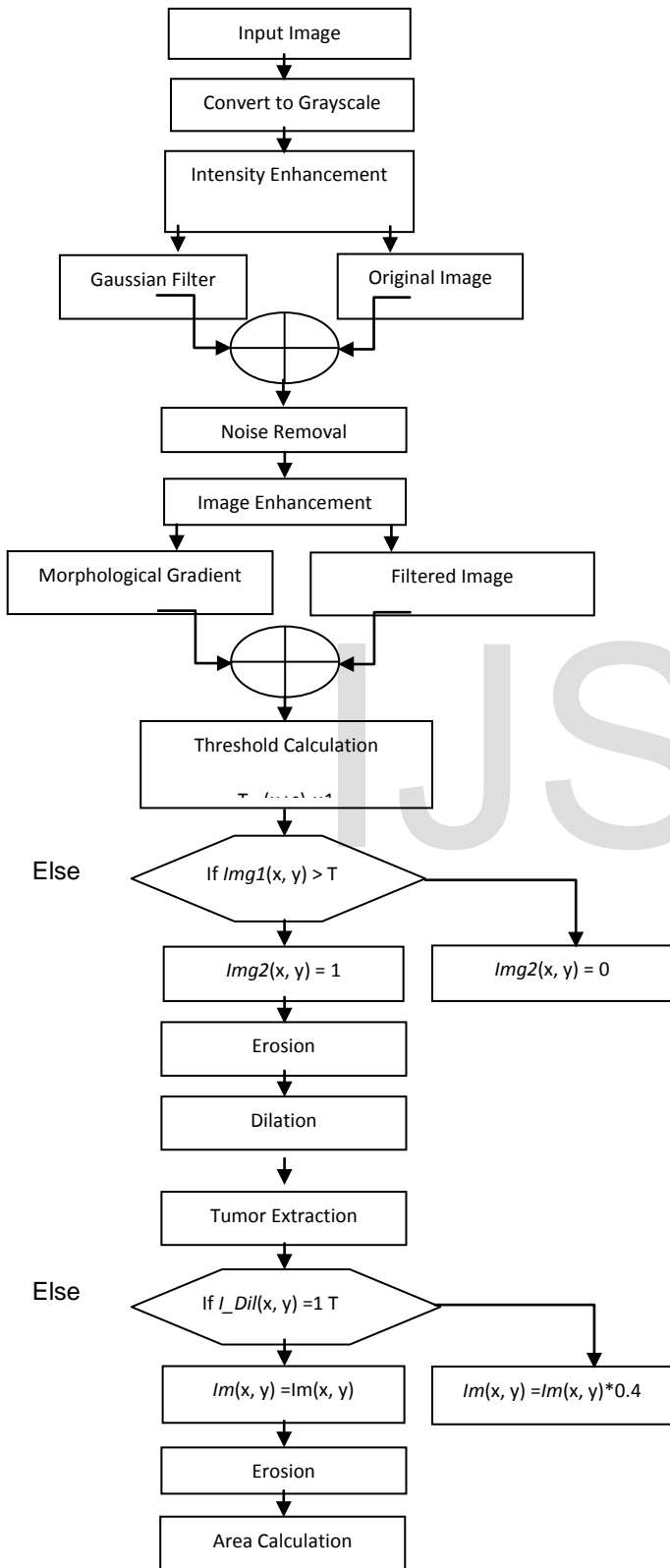


Fig.1. Flowchart of Designed Algorithm

Intensity Enhancement

In the first step, MR Images which are given as an input are converted in grayscale image because operations are easy to perform on grayscale images. The MR Images are taken from different MRI machines which cannot produce images of same intensity. Sometimes we have high intensity MRI and sometimes the intensity is low. To extract tumor from any intensity image first it is necessary to enhance the intensity of image so that tumor is clearly visible. To enhance the intensity of image, Gaussian low pass filter is used, which will blur the image but then it is added to original image. The original image and enhanced image are shown in Fig. 2:

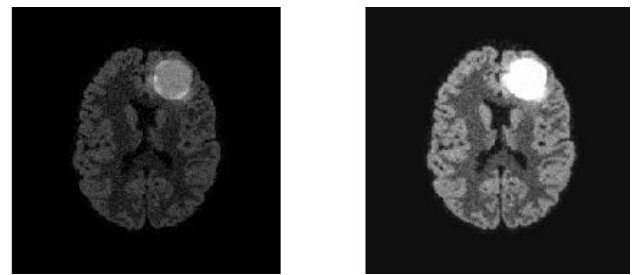


Fig.2. (a) Original Image. (b) Enhanced Image.

Noise Removal

Almost all MR Images have lots of noises, dust etc. which make extraction of tumor very difficult. Median filter is used for noise removal because it preserves the edges of image. The enhanced image and filtered image are shown in Fig. 3:

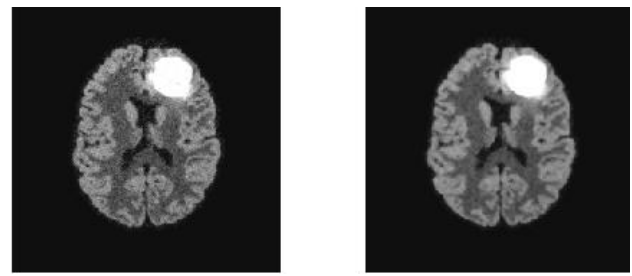


Fig.3. (a) Intensity Enhanced Image. (b) Image after Noise Removal.

Image Enhancement

Morphological gradient is computed from morphological operations like dilation and erosion [7]. Dilation is defined as maxima of pixels neighborhood where maximum is taken on group of pixel neighbors which are given by the shape of D_b . The equation for the dilation is given below:

$$(f \oplus b)(x, y) = \max \{ f(x-x'), y-y' \} \mid (x', y') \in D_b \quad (1)$$

Where f is the image after noise removal; D_b is domain of b and $f(x, y)$. $(x - x')$ and $(y - y')$ should be in the domain of f and x' and y' should be in the domain of b .

Erosion is defined as minima of pixels neighborhood where minimum is taken on group of pixel neighbors which are given by the shape of D_b . The equation for the erosion is given below:

$$(f \ominus b)(x,y) = \min \{ (f(x+x'), y+y') \mid (x', y') \in D_b \} \tag{2}$$

Where f is the image after noise removal; D_b is domain of b and $f(x, y)$. $(x+x')$ and $(y+y')$ should be in the domain of f and x' and y' should be in the domain of b .

The morphological gradient of image is calculated by the equation given below.

$$Mor_gra = \{ (f \oplus b)(x,y) - (f \ominus b)(x,y) \} \tag{3}$$

The filtered image and morphological gradient image is shown in Fig. 4:

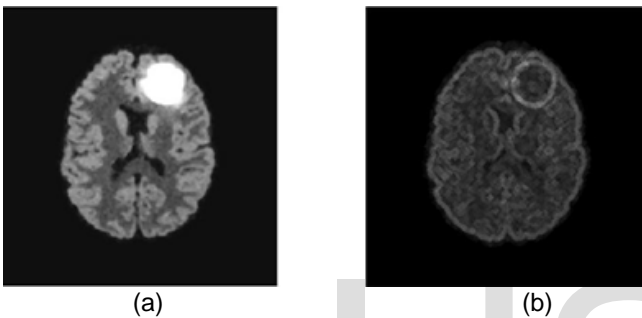


Fig.4 (a) Filtered Image. (b) Morphological Gradient Image.

To enhance the image, it is proposed to add morphological gradient image and filtered image.

$$IMG1 = Mor_gra + Fil_image, \tag{4}$$

Where Mor_gra is the morphological gradient image and Fil_image is the image after noise removal. $IMG1$ is the resultant image after the addition of morphological gradient image and filtered image and is shown in Fig. 5:

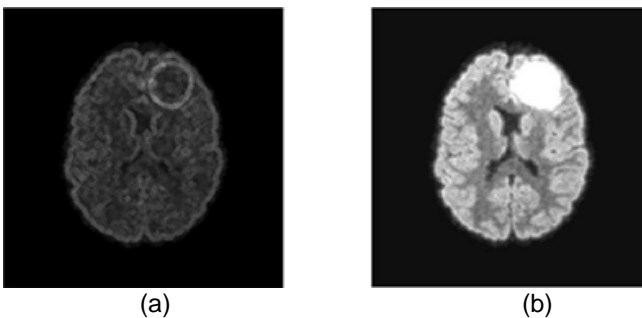


Fig.5. (a) Morphological Gradient Image. (b) Enhanced Image.

Threshold Calculation and Image Binarization

Threshold value of any image is of very important because image is binarized through threshold value. In our algorithm, through mean, standard deviation and mean of filtered image threshold value is calculated. The equations for mean, standard deviation and mean of filtered image are given below.

$$\mu = \max \left\{ \frac{1}{X \times Y} \sum_{x=0}^{X-1} \sum_{y=0}^{Y-1} I1(x,y) \right\},$$

$$\sigma = \frac{1}{X \times Y} \sum_{x=0}^{X-1} \sum_{y=0}^{Y-1} (I1(x,y) - \mu),$$

In these equations, μ and σ are mean and standard deviation of image $IMG1$. In the equation mean of every column of image $IMG1$ is calculated and then maximum mean value is picked up.

The mean value is again calculated from filtered image as given below.

$$\mu1 = \sqrt{\min \left\{ \frac{1}{X \times Y} \sum_{x=0}^{X-1} \sum_{y=0}^{Y-1} Fil_image(x,y) \right\}},$$

In this equation, $\mu1$ is the square root of minimum mean value of filtered image Fil_image .

Threshold value of image is calculated by using the equation given below.

$$T = (\mu + \sigma) - \mu1,$$

Where μ and σ are mean and standard deviation of image $IMG1$, and $\mu1$ is the square root of minimum mean value of filtered image Fil_image .

The image can be now be binarized. Binarization can be done by comparing threshold value with every pixel value of image. The equation for image binarization using this threshold value is given below.

$$IMG2(x,y) = \begin{cases} 1, & I1(x,y) > T \\ 0, & I1(x,y) < T \end{cases}$$

In this equation T is threshold value and $IMG2(x,y)$ is the resultant binarized image. Figure 6 shows the enhanced image and binarized image.

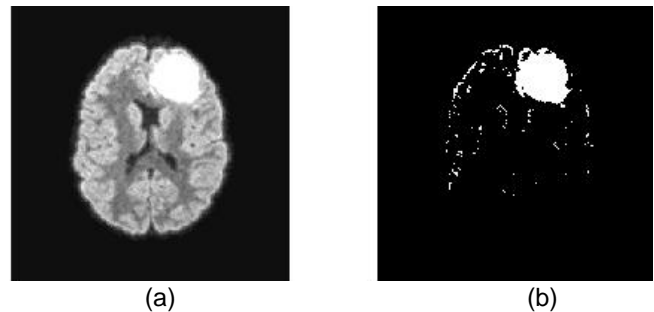


Fig.6. (a) Enhanced Image. (b) Binarized Image.

Erosion

Morphological operation erosion is usually used for thinning the image as it shrinks the pixels. In other words erosion is like zoom out. It is set operation in mathematics. The equation for erosion is given below.

$$IMG2_B = \{z|(B)z \cap IMG2^c \neq \phi\}$$

In above equation ϕ is an empty set and $IMG2$ is binarized image. The resultant image after erosion is assigned as I_Ero and is shown in Fig. 7 with binarized image.



(a)

(b)

Fig.7. (a) Binarized Image. (b) Image after erosion.

Dilation

The erosion operator shrinks the image and by doing erosion on binary image some part of tumor is also removed.

So to get removed part of tumor back, dilation is done on the image after erosion. Due to dilation, the removed part of tumor will grow up again. Dilation is also a set operation.

Mathematically, it is defined as

$$I_Ero = \{z|(\hat{B})z \cap I_Ero\}$$

In above equation B is the structuring element. Dilation operation is being performed on resultant image of erosion. The resultant image after dilation is assigned as I_Dil and further processing of designed algorithm will be done on this image. Dilated Image is shown in Fig. 8 with eroded image.



(a)

(b)

Fig.8. (a) Eroded Image. (b) Dilated Image.

Tumor Extraction

The next step is to extract that tumor in its original form as in dilated image it is in binary form. It is very important to extract tumor in its original form because the intensity of tumor in various pixels differ.

By proposed algorithm, tumor can be extracted by comparing original image with dilated image. If pixel of dilated image has value 1 then corresponding pixel of original image remains as it is and if pixel of dilated image has value 0 then corresponding pixel of original image becomes dull. By applying this algorithm tumor visible and all other portion of image becomes dull.

Mathematical equation of tumor extraction is given below.

$$Im(x, y) = \begin{cases} Im(x, y) & I_Dil == 1 \\ Im(x, y) \times 0.4 & I_Dil == 0 \end{cases}$$

In above equation, $Im(x, y)$ is resultant image after tumor extraction and I_Dil is the dilated image. Dilated image and tumor extracted image is shown in Fig. 9.



(a)

(b)

Fig.9. (a) Dilated Image. (b) Image after Tumor Extraction.

Erosion

After tumor is extracted once again erosion is done so that any noise remained in image gets shrunk and result is only extracted tumor.

Mathematical equation for erosion is given below.

$$Im_B = \{z|(B)z \cap Im^c \neq \phi\},$$

In above equation I_m is the image after tumor extraction and ϕ is the empty set.

The image after erosion and tumor extracted image is shown in Fig. 10.

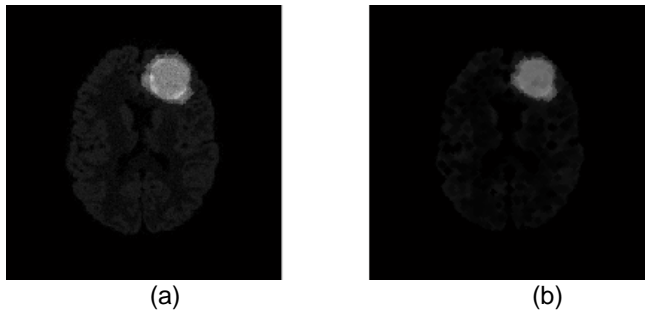


Fig.10. (a) Image after tumor extraction. (b) Image after erosion.

Area Calculation

Area of tumor can help the doctor in deciding the stage of tumor.

To calculate area through designed algorithm, pixels having value 1 will be counted. Mathematical equation to count pixels is given below.

$$Count = \begin{cases} Count + 1 & I_{Dil} == 1 \\ Count + 0 & I_{Dil} == 0 \end{cases}$$

Now this count of pixel will be converted into mm^2 . Mathematical equation for this is given below.

$$Area = \frac{Area}{8.045}$$

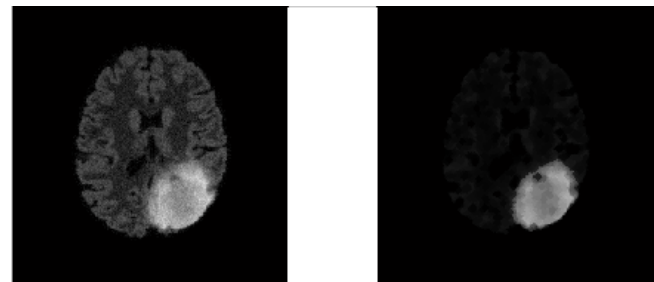
As $1mm^2$ is equals to 8.045 pixels. So $Area$ will be the area of tumor in mm^2 .

EXPERIMENTAL RESULTS

The designed algorithm was tested on a Dataset different MR Images. These images contained tumors of different types, shapes, size and intensity. Some MR Images of Dataset didn't have tumor and was successfully pointed out by algorithm.

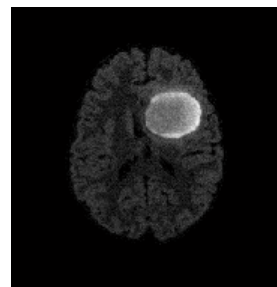
The experimental results show that our designed algorithm is fully automatic, easy and very successful in detection and extraction of tumor form MR Images. The designed algorithm was tested on MATLAB R2012b.

Our experimental results are shown below.



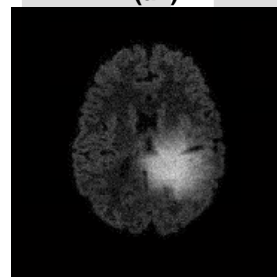
(a1)

(b1)



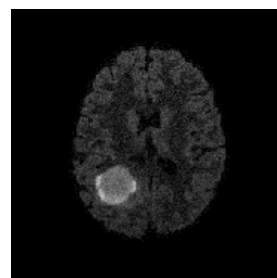
(a2)

(b2)



(a3)

(b3)



(a4)

(b4)

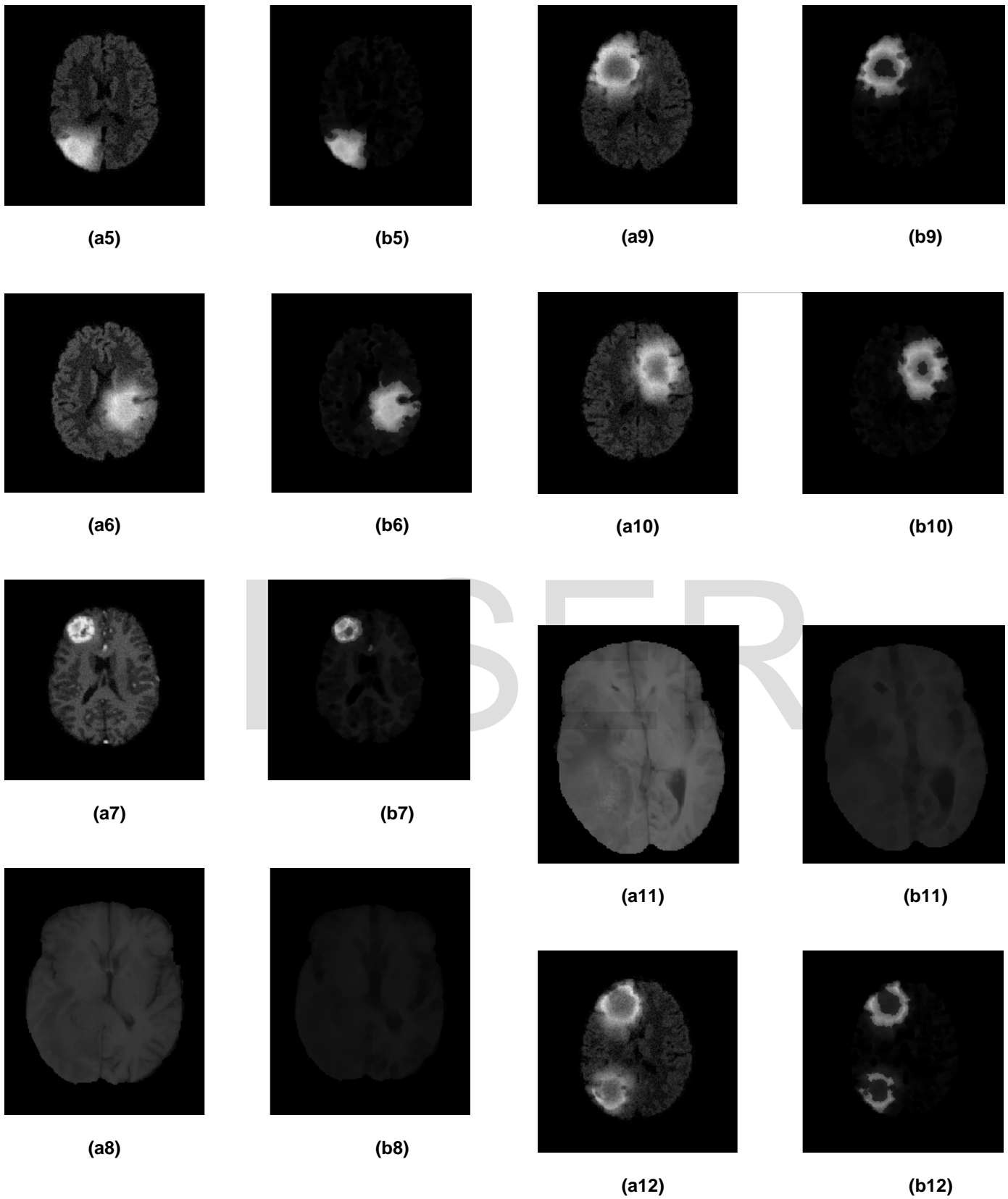


Fig.11.
(a1),(a2),(a3),(a4),(a5),(a6),(a7),(a8),(a9),(a10),(a11),(a12)

are Original Images.

(b1),(b2),(b3),(b4),(b5),(b6),(b7),(b8),(b9),(b10),(b11),(b12)

are the Images with Tumor extracted.

TABLE I
VALUES OF DIFFERENT PARAMETERS USED IN TUMOR EXTRACTION

S.No	Image	Mean Value (μ)	St.Deviation (σ)	Threshold (T)	Area
1	Fig.11.(a1)	131.4102	106.7599	238.1701	423.741
2	Fig.11.(a2)	111.6558	95.2530	206.9288	292.3555
3	Fig.11.(a3)	131.2734	101.6627	232.9361	331.0131
4	Fig.11.(a4)	106.0352	90.0553	196.0904	164.0771
5	Fig.11.(a5)	119.6797	95.7021	215.3818	311.0006
6	Fig.11.(a6)	139.3047	109.0334	248.3381	441.6408
7	Fig.11.(a7)	131.3008	90.6562	230.9569	194.4065
8	Fig.11.(a8)	90.4167	71.3749	161.7195	0
9	Fig.11.(a9)	121.9766	105.8658	227.8423	508.1417
10	Fig.11.(a10)	123.7617	109.4528	233.2145	533.2505
11	Fig.11.(a11)	164.6435	107.8247	272.4682	0
12	Fig.11.(a12)	141.3242	111.5528	252.8770	467.7439

The above table gives the different values of different parameters which have been used while Tumor Extraction.

In the whole procedure, the structuring element used for morphological operations like erosion and dilation is diamond shape with the value 3.

CONCLUSION

In this paper, an easy, fully automatic and efficient algorithm for extraction of brain tumor has been introduced. Morphological operation like erosion and dilation along with morphological gradient and threshold are used. Morphological gradient is used for calculating threshold. Threshold is used to binarize the image which results an image having tumor and some noise with it. Erosion is used for thinning the image as it shrinks the image and helps to reduce noise or unwanted small objects. Dilation is being used after erosion so that to get removed tumor portion back which was being removed by erosion.

The designed algorithm can detect and extract tumor of any shape, intensity, size and location. Experimental results show that our designed algorithm can efficiently enhance and retains the original shape of tumor.

Even though our algorithm is very easy and efficient in extracting any type of tumor but the decision and diagnoses depends upon expert doctor.

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