Automatic detection of brain tumour from MRI brain image by histogram thresholding and segmenting it using Region growing algorithm

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Abstract

This paper presents an efficient method for automatic brain tumour segmentation for the extraction of tumour tissues from MR images. It combines morphological operators for skull stripping, 2D Gaussian convolution filter for enhancement, bimodal histogram for selecting seed pixels and region growing algorithm for segmenting abnormal tissue . The proposed method uses T1 weighted grey level intensity images. This proposed method can be used to detect the abnormal tissue and its geometrical dimension. This technique is simpler, faster and automatic. This method produces good result in noisy images also. The proposed method has been applied to a large number of MR images showing promising results for various image qualities, encouraging for future.

Keywords: Image segmentation, Skull stripping, MRI Image, Morphological operator, Tumour detection, Brain segmentation

I. Introduction

Magnetic resonance imaging is one of the advanced medical imaging technique mainly used in radiology to view the structure and produce high resolution images. MRI is used to visualize the anatomy and structure of a body organ for assistance in medical diagnostics of certain disease or conditions to evaluate a particular disease [5, 6, 7]. MRI imaging is often used in detecting brain tumours. These high resolution images are used to examine human brain development and discover abnormalities. Today there are several MRI segmentation approaches as follows: 1. Threshold techniques 2. Edge based methods and 3. Region based segmentation [13]. Despite the existence of many MRI segmentation frame works, brain MRI segmentation is still a subject requiring intensive exploration due to the numerous challenges [9, 10, 11, 12]. Even though several imaging techniques are available for classifying MR images, precise segmentation and classification of tumour are still a challenging and complicated task because of inherent noise, partial volume effect and image intensities of different types of tumour. Manual segmentation methods exhibit the problem of repeatability due to inter observer variance introduced over multiple trials of training. Further, supervised segmentation methods are time consuming and require domain experts. so, these limitations suggest the need for an automatic method for segmentation.

The automatic segmentation has great potential in clinical medicine. The main difficulties in the field of automatic tumour segmentation are related to the factor that the brain tumour are very heterogeneous in terms of shape, color, texture and position. The motivation of our proposed work is to recognize a tumour using digital image processing technique and compute the area of the tumour by fully automated process. In this paper, a simple automatic segmentation method is presented which can separate the brain tumour from normal tissues. An initial preprocessing is done based on morphological operators and thresholding technique that we have proposed in our previous research papers [1, 2]. Then, the 2D Gaussian convolution filter is used to smoothen

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the skull stripped brain image. later, histogram technique is used to select the threshold point. with this threshold point the tumour region is detected by region growing process.

The rest of this paper is organized as follows: section 2 presents the overview of the proposed method. section 3 gives the concept of histogram thresholding and region growing. Section 4 presents the detailed experimental results. Lastly, section 5 concludes the paper.

II. PROPOSED METHOD

The proposed method is composed of 4 major stages as shown in figure 1. In stage1, the input image is preprocessed, i.e., skull is removed using mathematical morphological operators as shown in figure 2(a) and 2(b). A 2D Gaussian filter is applied to the skull stripped image to smoothen it. The smoothened image is shown in figure 3. A two-dimensional Gaussian function is

$$f(x,y) = Aexp\left(-\left(\frac{(x-x_o)^2}{2\sigma_x^2} + \frac{(y-y_o)^2}{2\sigma_y^2}\right)\right) \quad (1)$$

Here the coefficient A is the amplitude, x_o, y_o is the centre and σ_x, σ_y are the x and y spread parameter . better image smoothing is implied through larger σ. In general, a 2 dimensional elliptical Gaussian function is expressed as [3]

$$f(x,y) = Aexp(-(a(x-x_o)^2 - 2b(x-x_o)(y-y_o) + c(y-y_o)^2)) \quad (2)$$

In Stage2, the smoothened image is partitioned into 2 halves and the histograms of both the images are subtracted to get the threshold values. In stage 3, the tumour is extracted using the threshold values and in the final stage, the area of the tumour is calculated.

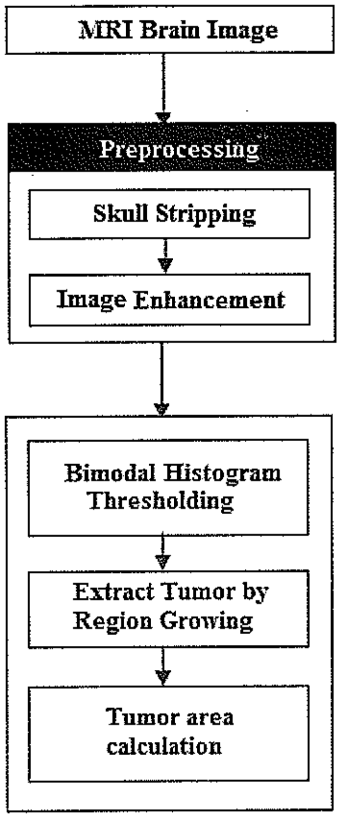


Figure 1. Proposed Method

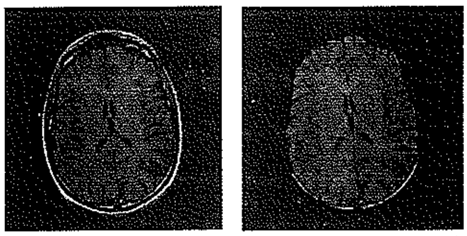


Figure 2 (a) Input Image (b) Skull Stripped Image

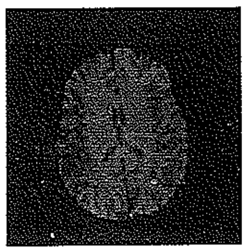


Figure 3 Smoothened Image

III. Bimodal Histogram Thresholding

Histogram is one of the most uncomplicated image segmentation process since thresholding is fast and economical in computation and they require only one pass through the pixels. The histogram of an image represents the relative frequency of occurrence of the various gray levels in the image. This is useful in setting a threshold value to detect the abnormal region. In this technique, a histogram is computed from all the pixels in the image. The peaks and valleys in the image are used to locate the clusters in the image. powerful tool in image processing. The histogram of an image represents the relative frequency of occurrence of the various gray levels in the image. This is useful in setting a threshold value to detect the abnormal region.

For segmenting background and objects, a threshold defined as brightness constant is used. Band thresholding, local thresholding, multi thresholding, bimodal thresholding are some of the modifications made in this technique. Single threshold can differ in image elements are known as local threshold where as single threshold that can be applied to the complete image are known as global threshold. In order to determine the threshold automatically, histogram shape is analyzed.

In our proposed method, after smoothening the skull stripped brain image, it is divided into 2 equal halves along its central axis. The histogram is plotted between the number of pixels and pixel intensity for both the halves. Finally the difference between the two histograms are taken and the resultant difference is plotted to select the threshold values.

The binary image, g(x,y) of the original image, f(x,y) using the double threshold values [8] can be defined as,

$$g(x,y) = \begin{cases} 1; T_1 \leq f(x,y) \leq T_2 \\ 0; else \end{cases} \quad (3)$$

Where, T_1 and T_2 are the lower and upper limit threshold values. In figure 8, the difference between intensity of the two sides of the brain is plotted. It shows that the intensity level lies between 110 to 205. So, the threshold value T1 and T2 are considered as 110 and 205 to segment to tumour.

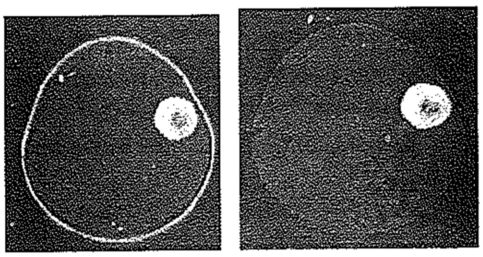
Each pixel value of the input image is compared with the threshold values. if the value of pixel lies between the threshold values then it is assigned a value 255 else the pixel value will be assigned as 0.The area of an image is the total number of pixels present in the area which can be calculated in the length units by multiplying the number of pixels with the dimension of one pixel [4]. In our proposed method, the size of the input image is 235x480. Therefore, the horizontal resolution is 1/235 inch and the vertical resolution is 1/480 inch. The area of single pixel is equal to (1/235)*(1/480) square inch.

A=(1/235)*(1/480)

Area of the tumour = A * total number of pixels

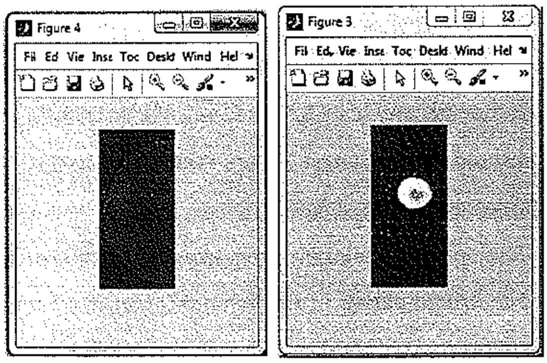
IV. Experimental results

We have presented a technique for segmentation and detection of pathological tissues (tumour) from magnetic resonance (MR) images of brain with the help of histogram thresholding and region growing. The proposed technique is designed for supporting the tumour detection in brain images with tumour and without tumour. The input image and skull stripped image is shown in figure 4(a) and 4(b).



(a) (b)

Figure 4. (a) Input Image,(b) Segmented Brain Image with tumour



(a) (b)

Figure 5. Partitioned image of Skull stripped brain image Input Image, (a) Left Part (b) Right Part

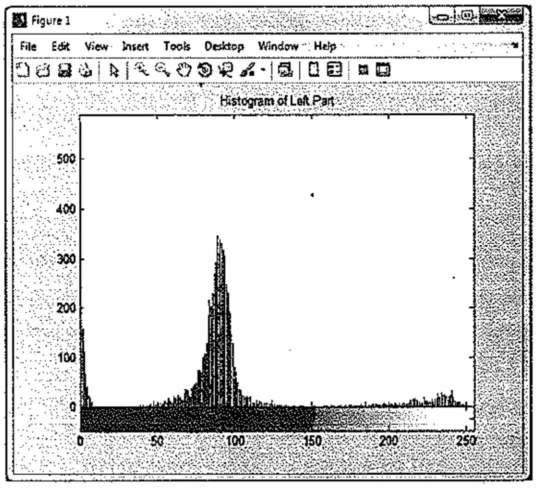


Figure 6. Histogram of left side of the brain

The skull stripped image shown in figure 4(b) is partitioned in to two equal halves. Histogram is constructed for the partitioned image shown in figure 5(a) and 5(b). When we compare the histogram plotted for both the sides (figure 6 and 7), they are not symmetrical. The histogram of the right side brain has more intensity when compared to left hand side because a difference exists between the histograms of both sides as shown in figure 8. This indicates that there may be a tumour on the right hand side of the brain. The difference between the histogram of both the sides are calculated to find the threshold value to detect the tumour.

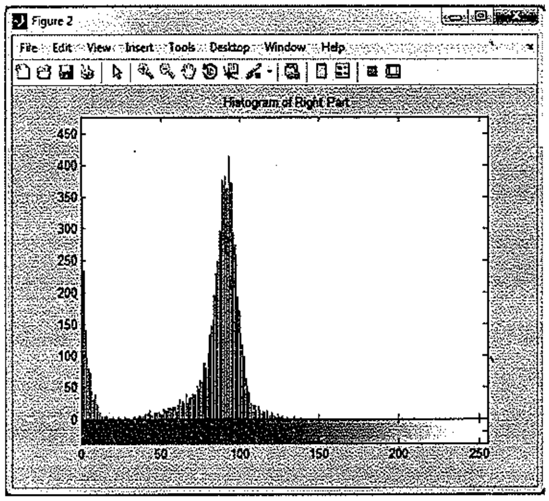


Figure 7. Histogram of Right side of the brain

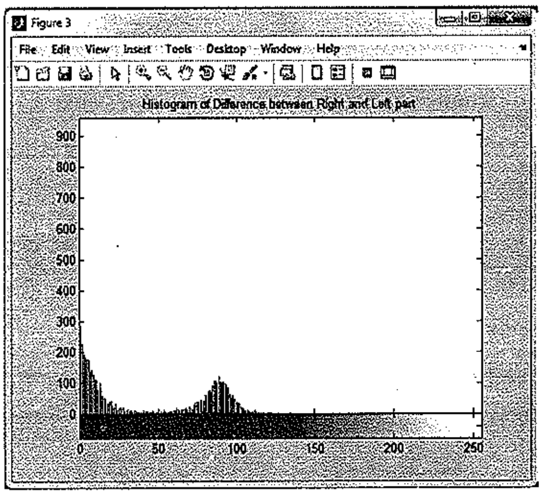
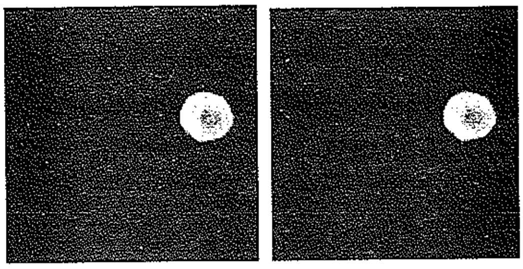


Figure 8. Histogram of Difference between intensities of two sides of the brain

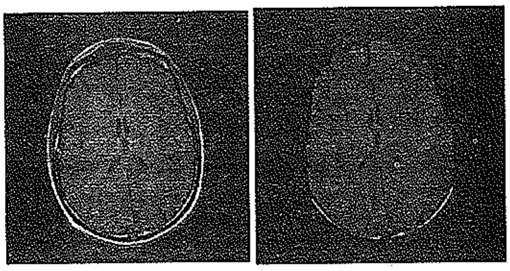
The figure 9(a) shows the tumour detected image using the threshold value. The noise present in the image during region growing is removed using morphological operators. The final tumour detected image is as shown in the figure 9(b). The dimension of the tumour is calculated and tabulated in table 1.

The proposed method is implemented even in normal brain image and the corresponding skull stripped image and the histogram charts for both the sides are shown in figure 10, 11, 12 and 13. The histogram difference chart (figure 14) shows that the difference between the two sides intensity is very less and this can be neglected. so, this difference shows that the brain is normal and the tumour is absent.



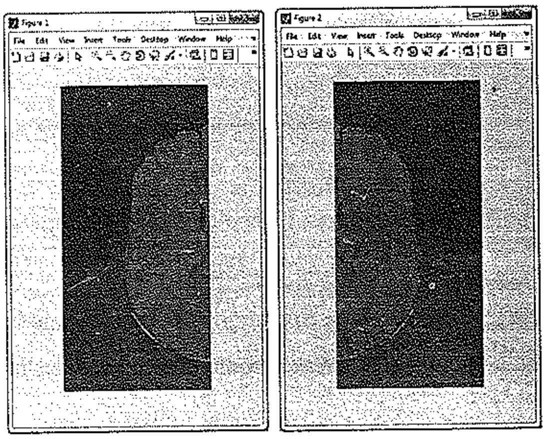
(a) (b)

Figure 9. Segmented Tumour



(a) (b)

Figure 10. (a) Input Image, (b) Segmented Brain Image without tumour



(a) (b)

Figure 11. (a) Input Image, (b) Segmented Brain Image

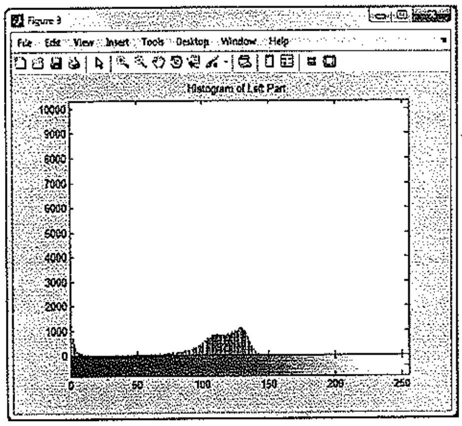


Figure 12. Histogram of left side of the brain

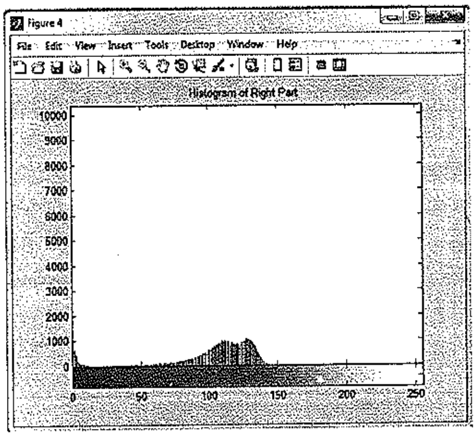


Figure 13. Histogram of Right side of the brain

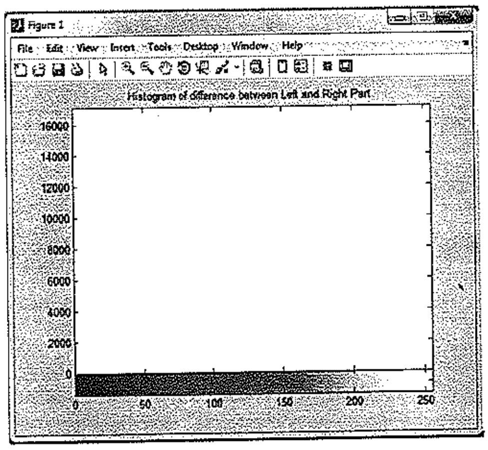
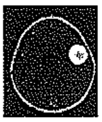
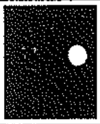
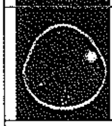
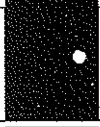
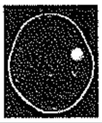
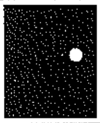
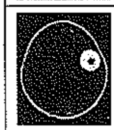
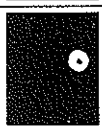


Figure 14. Histogram of Difference between intensities of two sides of the brain

V. Conclusion

The results show that the proposed method can detect the presence of tumour in brain images with tumour and without tumour. The method is unsupervised and can automatically detect the tumour. The area of the tumour is also calculated for various brain images are shown in table 1.

Table 1 Tumour area in pixels with different brain images

Input Image	*Image No*	*Tumour*	*Area of Tumor (Sq. inch)*
	AN1		0.009987
	AN2		0.011092
	AN3		0.00968
	AN4		0.00988
	AN5		0.01042

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