Size Analysis of Brain Tumor from MRI Images Using MATLAB

G. Kanishka Reddy
Dept of Electronics and Communication Engineering
SRM University AP
Guntur, India
kanishka_reddy@srmap.edu.in

Bh.Akanksha Sahitya
Dept of Electronics and Communication Engineering
SRM University AP
Guntur, India
akanksha_sahitya@srmap.edu.in

Anirban Ghosh
Dept of Electronics and Communication Engineering
SRM University AP
Guntur, India
anirban.g@srmap.edu.in

***Abstract*— Medical image processing has gained a lot of relevance of late and is turning out to be a boon in different clinical aspects. One such emerging field is brain tumor detection from magnetic resonance images (MRI) of brain. Engineers are actively developing tools to process medical images and aid doctors in with their diagnosis. MRI images are clinical images which are obtained on a computer when a patient goes through MRI scanning done by a respective machine. A brain tumor is a cluster of an abnormal mass of tissue where cell growth is out of control due to an abnormality in the mechanisms that control normal cells. In this work, our main aim is to measure the size of a brain tumor in terms of its diameter and area from a patient's MRI imagery using MATLAB. The proposed method incorporates different layers of noise removal techniques to clean up the images as well as image segmentation and morphological operations for detection and extraction of tumors and determining their size. By measuring the size of the tumor in a patient's brain at regular intervals doctors can diagnose the severity of the tumor in a patient's brain and can administer suitable treatment before it gets malignant.**

***Keywords*— Tumor, MRI, segmentation, MATLAB, extraction**

I. INTRODUCTION

A brain tumor also known as neoplasm is an abnormal and excessive growth of cells that can have severe effects on the brain and its functionality. Brain tumors can be primary or metastatic, which are spread from other parts of the body to the brain [1]. It can be cancerous medically termed as malignant tumors or non-cancerous medically termed benign tumors [2]. Common symptoms of brain tumors are headache and nausea. Brain tumors are treatable and in non-cancerous cases can be completely cured, without causing serious health issues, if diagnosed in the early stages. Imaging and early detection of the severity of the lesion thus becomes crucial for doctors to diagnose and treat brain tumors.

The neoplasm in a suspected patient can be detected either by magnetic resonance imaging (MRI) or Computed Tomography (CT) [3]. In CT scan, the scanner captures several X-ray images taken from different angle and then combines them together to produce a cross-sectional image of the brain. In comparison MRI scanner produces high quality images using magnetic field and radio waves and is often preferred for anatomical analysis of brain development and its abnormality [4]. However, the MRI images of the brain depicts not only the tumor but also grey and white matter, cerebrospinal fluid, skull tissues present in the brain along with any noise associated during scanning [5].

In our current study, we thus use MRI images of the brain to extract and detect the size of lesion in a fast, effective, and accurate way by using different image processing techniques. In our proposed method we use the MATLAB image processing toolbox, to clean up the noisy image, use different segmentation method and perform different morphological operation to find out the diameter and area of the abnormal tissue growth which can serve as a crucial indicator of the severity of the neoplasm for the doctors.

The rest of the paper is arranged as follows – section II lists down the various related works, whereas section III describes the various stages in our proposed method. Section IV elaborates on the proposed algorithm and presents the result of our work as well. The paper is finally concluded in section V along with some future directions.

II. RELATED WORKS

Back in 2001, Sin *et al* [6], proposed an entropy based image segmentation technique for gray scale images by measuring the resemblance between an arbitrary template and the underlying true scene that gives rise to the actual image in terms of an index called the Gray – Scale Image Entropy (GIE). In recent times, researchers have proposed various such approaches in image segmentation for tumor extraction from MRI images of brain. In [7] the authors used different feature extraction and image segmentation techniques such as Canny edge detection and adaptive threshold approach for identification of tumor from a brain MRI and then uses neural network technique for image classification into benign and malignant based on an image set of only 102 clinical images. In [8] the authors used modified histogram equalization followed by morphological operation to extract tumor from MRI images more efficiently. A simple machine learning classifier was also used for image classification. In [9] k – means and fuzzy – c means clustering techniques were used for color based image segmentation and tumor detection. In [10] Yogita et al, also used k – means clustering method and watershed segmentation techniques to find the radius and area of the tumor but their implementation did not involve any noise removal stage which will be a crucial feature in our proposed method. In [1] – [2] and [11] – [12] authors have used a similar image processing structure of noise removal from image, image segmentation followed by morphological operation to detect or extract the tumor from an MRI image, but the size has not been calculated in any of mentioned work which could be instrumental in determining the severity of the lesion. In more recent works [13] – [15] the focus has been in classification of brain tumor using brain MRI. As is evident in most of the methods tumor

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extraction or classification has been the focus. In our proposed model we are not only proposing a tumor extraction technique but also means to determine it's size and area which to the best of our knowledge can prove to be instrumental in tracking the progress of the tumor or recuperation of a certain patient in case of early diagnosis. In the following section each of the image processing stages required for tumor extraction followed by size determination in our model are elaborated.

III. METHODOLOGY

The algorithm has three stages, the first being pre-processing of the MRI image followed by segmentation and performing morphological operations, finally finding the brain tumor's size from the extracted images. The steps of the algorithm are as follows[2]:-

1) MRI image of the brain given as input.
2) Conversion of MRI image into a grayscale image.
3) Application of high pass filter for noise removal followed by median filter for image enhancement.
4) Application of threshold segmentation for conversion to binary image.
5) Application of watershed segmentation to distuinguish between similar regions of interest.
6) Application of morphological operation for tumor extraction.
7) Analyse the size and area of the extracted tumor.

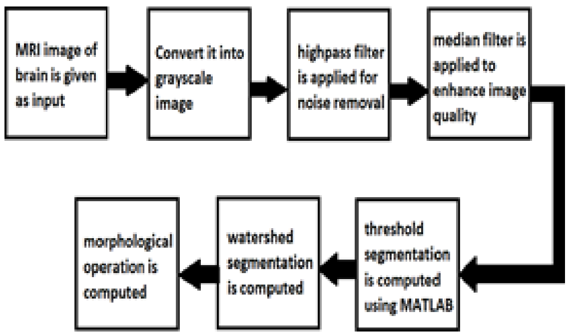


Fig 1. The workflow of the proposed method

A. *Converting to grayscale image*

The imported MRI image is given as input to the algorithm. Then it is converted into a grayscale image. Normally when MRI images are looked at through a computer they appear like black and white images. The illusion of gray shades in an image is created by presenting the image as a grid of black pixels in a sea of white ones or vice versa, where it is the size of the dots that determine the apparent intensity of gray in its neighbourhood. In general, the black dots are represented by R = G = B = 0 or 00000000, whereas the white ones by R = G = B = 255 or 11111111. As is known black signifies the darkest shade, occurring due to total absence of transmitted or reflected light while white results from the presence of transmitted or reflected light at all visible wavelengths and is considered as the lightest shade [2]. This is the justification for grayscale conversion.

B. *High pass filter and Median filter*

The grayscale image is next passed through a high pass filter. The purpose of the high pass filter is to allow the high frequency information of an image to pass while suppressing the low frequency portion. In comparison to low pass filter a high pass filter sharpens the image and reduces the noise by using different convolution kernel. The noise reduction by the kernel of a high pass filter is done by improving the brightness of the central pixels in comparison to its surrounding ones. In the subsequent step the high pass filtered image is passed through a median filter which is a nonlinear digital filter that can provide further reduction in noise. The main concept of applying a median filter is to scan through the incoming signal sequentially, replacing each element of the input signal with the median of the surrounding elements. The combined effect of the two filters improves the quality of the MRI images.

C. *Threshold Segmentation*

Then threshold segmentation is performed over the filtered image. This method is used to convert grayscale images to binary images. Segmentation is a method of dividing a digital image into multiple segments. Threshold segmentation mainly depends on the threshold value to segment an image. The key purpose of this segmentation is to modify an image representation into a simpler format such that it eases the analysis and further processing of the image. The major purpose of using image segmentation is to identify an objects or certain boundaries. The input to a thresholding operation is normally either a grayscale or a "A high speed parallel fuzzy c-mean algorithm for brain tumour segmentation"color image. In image segmentation pixels that are similar in color, intensity or texture are labeled as one for better visualization. In the simplest implementation, the output could be a binary image representing the segmentation. Black pixels correspond to the background while white pixels correspond to the foreground (or vice versa) [13] creating a segmented image. Conversion into black and white pixels results in isolation of the tumor.

D. *Watershed Segmentation*

Thresholding has a high speed of operation and is easy to implement. However, its performance is relatively limited since image pixels having the same gray level value will indefinitely be segmented into the same set [6]. Hence, in addition to threshold segmentation, watershed segmentation is necessary. Watershed segmentation is a region-based technique which utilizes image morphology. It is used for separating the different segments in the image, when two regions of interest are close to each other i.e., if their edges touch. A simple watershed transformation causes over segmentation without preprocessing of the image i.e., image enhancement and noise removal [14]. As preprocessing has already been done in the earlier steps, over segmentation issue can be avoided. For gray scale images Meyer's flooding Watershed Algorithm is used. It requires selection of at least one marker interior to each object of the image, where the flooding shall start. The markers are chosen by an operator or, are provided by an automatic procedure that considers the application-specific knowledge of the object [15]. Now, the pixels neighboring the markers are placed in a queue as per the priority of the gray levels of the pixel and are labeled accordingly.

E. Morphological Operations

Morphological operation is performed to get the final tumor region. These are especially used to generate a new binary image from the existing one by incorporating non – zero value in a pixel either by testing whether the pixel fits in a given neighborhood or it intersects the same. As morphological operations solely depend on the relative sequencing of pixel values and not on their absolute numerical values it is better suited to the processing of binary images. A small matrix of pixels consisting of zeros and ones represent a structuring element within the image. The dimension of such a matrix represents the scale of the structuring element whereas the pattern of ones and zeros in the matrix provides the shape of the structuring element. The origin of the structuring element is normally one of the pixels in the matrix but is often times found outside the structuring element as well. At the end, the tumor is extracted from the MRI image.

F. Size of extrcated tumor

Regionprops is used to measure properties of image regions in image processing. This function provides us with a tool 'MajorAxisLength' which can be used to measure the diameter of the tumor. To find the area, nnz matrix (number of non-zero matrix elements) is to be used which gives the area of the white region i.e., tumor region in terms of number of pixels. However, the size obtained would make more sense if it is expressed in terms of more traditional units such as millimeter. Finally, the size of the tumor region is obtained as the result. The pixeled values can be converted into our required units i.e., millimeters using spatial calibration technique. This technique uses a spatial calibration factor which is original pixels of the image per millimeter (pixelpermm). The size of image we get in pixels is divided with calibration factor as shown in eq. (1) to get the results in millimeters.

$$l_{mm} = \frac{l_{pix}}{\gamma} \tag{1}$$

where, l_{mm} is the length of the lesion in millimeter, l_{pix} is the length of the tumor in number of pixels and γ is the calibration factor.

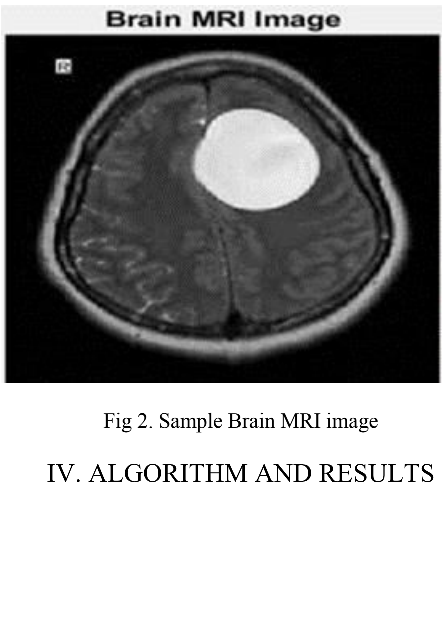


Fig 2. Sample Brain MRI image

IV. ALGORITHM AND RESULTS

The dataset in [16] is used for the implementation of the current work. The algorithm of the proposed method can be described as follows

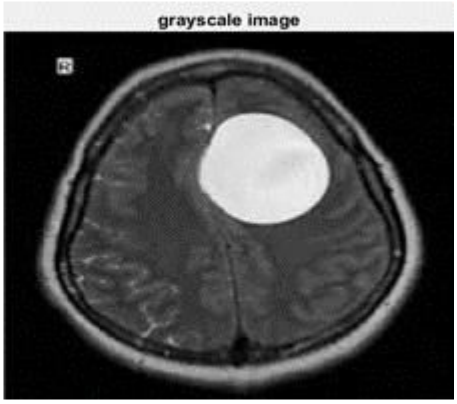


Fig 3. Gray scale image

Step I: MRI image as shown in fig. 2 is first imported into MATLAB.

Step II: The selected MRI image is converted to grayscale using im2gray() function as shown in fig. 3.

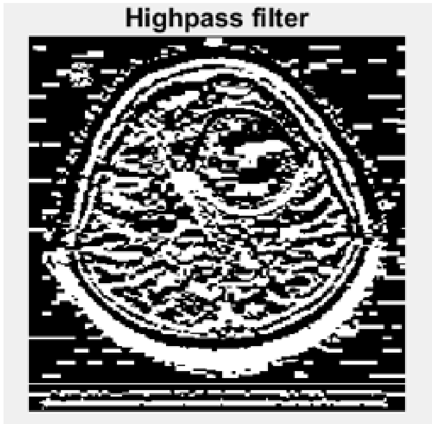


Fig 4. Image after passing through high pass filter

Step III: The gradient magnitude method is used for detecting the sharp edges which is used later for segmentation of image.

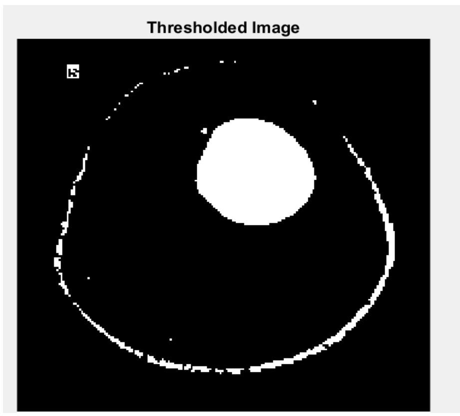


Fig 5. Image after Threshold Segmentation

Step IV: The pre – processed image is passed through a high pass filter to remove the noise. The image looks dull after passing through HPF as shown in fig. 4, so to improve the quality of the image a median filter is used. imshow() displays the binary image. For binary images, imshow() displays pixels with the value 0 (zero) as black and 1 as white.

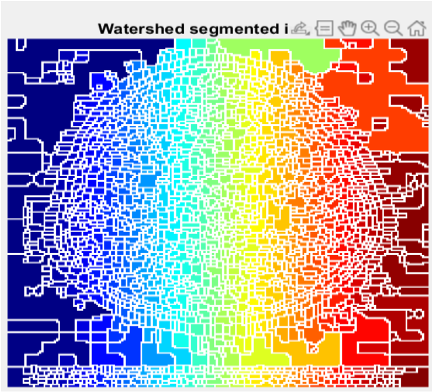


Fig 6. Image after Watershed Segmentation

Step V: Now a threshold value of 0.6 is used for threshold segmentation. We use the im2bw() function with the threshold value for threshold segmentation and output image is shown in fig. 5.

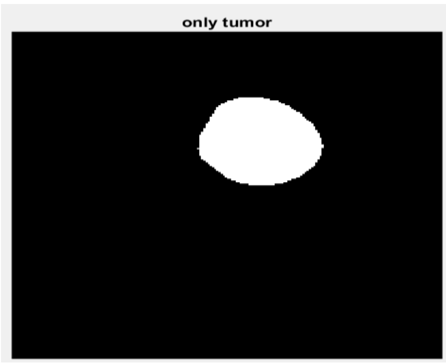


Fig 7. Image after Morphological Operation

Step VI: Next for segmenting the different parts of the image watershed segmentation is used. To do that, first

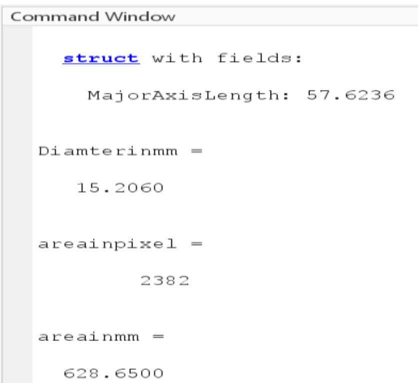


Fig 8. Snapshot showing area and diameter of tumor.

watershed ridge lines are needed and then the watershed transform is used for watershed segmentation. The label2rgb() function is further used to display a distinguished colored image as in fig. 6.

Step VII: The morphological operations are further performed on the watershed segmented image to reconstruct the pixels creating a clear boundary of the final tumor region as shown in fig. 7.

Step VIII: The size of the tumor is next measured in terms of pixels by using the different size analysis and measurement functions from the image processing toolbox as explained in section III.

Step IX: The final step is determining the area and diameter of the tumor in standard units (mm2 and mm respectively) from the pixelated image of fig. 7 using the proper calibration factor in eq. (1) as shown in command window snapshot for a particular image in fig. 8

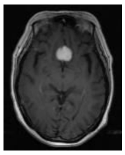
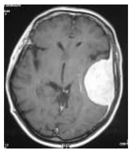
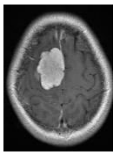
Input Image				
Diameter (in mm)	22.787	4.4	18.968	10.61
Area (in mm^2)	1185.386	43.297	797.561	495.8

Table 1. Comparison of MRIs with different sized tumors

As a validation for our proposed method some MRI scans with visually distinct sized tumors has been considered. The diameter and area of the tumors in the different scans are tabulated in table 1 for comparison and are calculated using the algorithm elaborated in this section. It can be clearly seen that smaller sized lesion in the second scan has smaller diameter and area as is intuitively expected compared to other samples.

V. CONCLUSION

An MRI dataset was collected, and different operations were performed in MATLAB using the Image processing toolbox. Different techniques have been used to enhance the image quality so that extraction of the tumor region and the results for size measurement of tumor are more efficient and accurate. Observing the results of this project it has been evident that it will be quite helpful to the doctors to get accurate size of the tumor in terms of both diameter and area. Knowing the size in two different parameters assures doctors to carry forward with the required treatment as soon as possible. Since it is a computer-aided method the results can be considered quite accurate, reducing the chance of human error. Thus, this technique can be considered significant for brain tumor detection, extraction, and size analysis. Due to paucity of data the current work is limited to determination of tumor size and area only. However, in future deliberations this method can be further extended in classifying the tumor stage by analyzing the area of the tumor and comparing it with pre-existing data of a particular patient. Moreover, an analysis on change in tumor size over time can also be done by plotting a graph using tumor affected patients MRI images and determining the rate of change. The detection of such a rate of change in addition to insights from the experts can prove to be a real boon in diagnosis and treatment of brain tumor.

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