Brain Tumor Detection Based on Segmentation using MATLAB

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Abstract— **An unusual mass of tissue in which some cells multiplies and grows uncontrollably is called brain tumor. It starts growing inside the skull and interpose with the regular functioning of the brain. It needs to be detected at an early stage using MRI or CT scanned images when it is as small as possible because the tumor can possibly result to cancer [1]. This paper, mainly focuses on detecting and localizing the tumor region existing in the brain by proposed methodology using patient's MRI images. The proposed methodology consists of three stages i.e. pre-processing, edge detection and segmentation. Pre-processing stage involves converting original image into a grayscale image and removes noise if present or crept in. This is followed by edge detection using Sobel, Prewitt and Canny algorithms with image enhancement techniques. Next, segmentation is applied to clearly display the tumor affected region in the MRI images. Finally, the image is clustered using the k-means algorithm. Here we have used MATLAB for the development of the project.**

Keywords— Clustering; k-means; MRI; Segmentation; Tumor

I. INTRODUCTION

The occurrence of uncontrolled and abnormal growth of cells within the skull is specified as brain tumor. It is basically of two types non-cancerous or benign and cancerous or malignant. However, it would be inappropriate to call benign as non-cancerous because it could be fatal too. The tumor can either damage brain cells directly or even indirectly squeeze different areas of the brain as the tumor grows or swelling inside the brain causing severe pain [1]. It is classified by their location in the brain as well as the tissue they are composed of. Whether the tumor is benign or malignant, the reason for this tumor could be either hereditary or it could be developed before birth such as craniopharyngioma. The reason of brain tumor is not very prominent ultimately. Some of the general symptoms of having it are a headache, vomiting, personality or behavioral changes, intellectual decline, abnormalities of eyes or double vision weakness, lethargy, swallowing difficulty, hand tremor etc.

The rest of the paper is arranged as, existing techniques for detection of brain tumor in section II, survey of different methods used until now are quoted in section III, in section IV the proposed work is addressed and in section V the results are analyzed. Lastly, section VI discusses about the conclusion and future scope.

II. BRAIN TUMOR DETECTION

Diagnosis of brain tumor is done medically. Some of the ways of diagnosing brain tumor are MRI scan, CT scan and biopsy of the head etc. In CT scan technique image of the brain is taken from several angles and is studied altogether. MRI stands for magnetic resonance imaging. In this method, magnetic imaging techniques and the radio waves are utilized to locate as well as to obtain a digital image of tissues present in the brain [2]. A biopsy is a diagnosis technique where a physical portion of the brain or the tumor present inside the brain is extracted and then studied under a microscope. There are different types of biopsy such as needle biopsy, open biopsy etc. From the above-mentioned methods, we have used MRI scan technique in which the MRI images will be processed through MATLAB using our proposed algorithm to specify the tumor and then segment the image to clearly view the tumor [3].

III. LITERATURE SURVEY

A. Sivaramakrishnan et al. [4] Designed a method for productive detection of the brain tumor area obtained from cerebral image by using fuzzy c-means (FCM) and histogram analysis. The decomposition of images was done using principle component analysis which was used for reducing the dimensionality of the wavelet coefficient. The results obtained from the proposed algorithm accurately and successfully extracted the affected regions from brain MRI images.

Riries Rulaningtyas et al. [5] studied three edge detection algorithms i.e. Prewitt, Sobel and Robert. Among the above three methods, they found that Sobel method is preferable to use for detecting edges of brain tumor because it has a little mean and standard deviation value. A pair of 3x3 convolution masks are used for evaluating the gradient in x-direction and gradient in y-axis.

Jun Kong et al. [6] proposed the method to locate the tumor composing of four stages. In the initial stage, the noise available in the image is removed using wavelet filter.

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In second stage watershed algorithm is applied to MRI image pixels as an initial method for segmentation. Next, merging operation is implemented on the segmented area by using fuzzy clustering algorithm. At last, the re-segmentation process is applied to those regions which are not partitioned completely by using k-NN classifier.

Ed-Edily Mohd. Azhari et al. [7] proposed an effective approach that can localize and detect brain tumor in MRI images. This technique comprises of five steps i.e. acquisition of image, pre-processing, edge detection, histogram clustering, and morphological operations. The affected portions get detected by post morphological operations where tumor appeared as pure white color in the pure black background. The proposed system resulted 92% accuracy.

Jaskirat Kaur et al. [8] described a new clustering algorithm for image segmentation and did a study on diverse varieties of image segmentation methods. They also suggested a technique to quantify and classify various clustering process based on their consistency in different operations.

IV. PROPOSED METHODOLOGY

MRI image of the brain is processed for the detection of the tumor using MATLAB. The proposed methodology employed here comprises of three stages. Initially pre-processing of given MRI image is done then edge detection of brain is conducted and finally, segmentation displays the tumor region vividly [3]. K-means clustering algorithm has also been implemented as an alternative method of segmentation. K-means clustering displays other important tissues and edges along with the tumor region.
The steps of the algorithm are discussed as follows.

A. Proposed Algorithm for Detection of Brain Tumor

Step 1: Take MRI image of the brain as an input.

Step 2: Convert it into equivalent grayscale image.

Step 3: Apply filtering methods for removing noise.

Step 4: Apply image enhancement techniques.

Step 5: Perform edge detection using Sobel, Prewitt and Canny algorithms.

Step 6: Implement segmentation technique and clustering algorithm for proper detection of tumor region.

The above-mentioned steps are explained below in detail.

B. Pre-processing Stage

Image pre-processing aims in noise removal and to improve the clarity of image or altering the quality of image to suit a purpose [3][9]. The functions performed at the pre-processing stage are described as follows.

1) *RGB to Grayscale Conversion*: As the name indicates, the image may consist of shades of grey. A 'gray' color is one in which the red, green and blue elements have similar intensity in RGB space. A grayscale image contains the grayscale values but some MRI images consist of primary (RGB) content [10]. These images need to be converted into grayscale image which range from 0 to 255 pixel values where range 0 defines the pure black color and range 255 defines pure white color.

2) *Noise Removal using Median Filtering*: Filtering is a technique used for eliminating the noise present within an image. During the conversion of an image from RGB to gray some sort of noise creeps into the image. Thus, this noise needs to get removed using filtering. It is applied to eradicate the noises such as salt and pepper from the converted grayscale image [10]. It exchanges the value of the pixel in the centre with the median of the intensity values in the neighbouring pixels [11].

3) *Image Enhancement*: Acquired image may have defects such as poor contrast. These defects have huge impact on the contrast of an image. When contrast is poor, the contrast enhancement technique comes into play. In this case, the gray level of each pixel is scaled for improving the contrast. The visualization of the MRI image is improved through contrast enhancement technique [2].

C. Edge Detection Techniques

Edge detection is an image processing approach used for tracing the boundaries of an object within the image. The algorithm works by finding sudden rise or fall in each pixel intensity and displaying only those sudden changes in the pixels. This change in the pixel is passed through an adequate convolution masks and the outcome is represented as the edge of the image [2] [11].

1) *Sobel Edge Detection Technique:* Sobel operator is a gradient operator. The relative gradient magnitude can be obtained by applying this operator in every point of the input image. Setting convolution mask c=2, we get two Sobel operators M_X and M_Y by passing it through 3x3 convolution masks, shown in TABLE I. The process of appending individual element of the image to its local neighbours weighted by a kernel is called convolution.

TABLE I: M_x and M_y are the horizontal and vertical masks for Sobel operators respectively.

-1	0	1
-2	0	2
-1	0	1

M_X

-1	-2	-1
0	0	0
1	2	1

M_Y

2) *Canny Edge Detection Technique:* Canny edge detection approach first involves the smoothing of an image i.e. removal of noise from the image. The objective of this step is to convert the blurred or irregular edges of the image into sharp edges and obtain a continuous and regular edges. This is principally processed by conserving all local maxima present in the gradient image and erasing everything else. The algorithm is given below.

   Step 1: In order to erase the noise, apply a Gaussian filter to smoothen the image.
   Step 2: Find the intensity gradients of the image.
   Step 3: Implement non-maximum constraints to eliminate spurious reaction to edge detection.
   Step 4: Implement double threshold to figure out possible edges.
   Step 5: Finally to track edge by hysteresis, finalize the edge detection by suppressing all distinct edges which are relatively weak and are not connected to the strong edges.

The Gaussian filter is implemented for the removal of the Gaussian noise from the image because it is an essential part of the canny edge detection technique. Thus, it is explained below in detail. To sharpen the image a Gaussian filter is implemented. The noise on the edge detectors can be reduced by brightening the image by applying Gaussian filter [10]. Every pixel of the image is passed through a 5×5 Gaussian mask as given in (2). As all edge detection outputs are affected by noise, therefore it is necessary to eliminate the noise to avert false detection caused by noise. The Gaussian filter kernel of size $(2k+1)\times(2k+1)$ is provided in (1).

$$H_{ij} = (2\Pi\,\sigma^2)^{-1}\exp(-(i-(k+1))^2+(j-(k+1))^2)/2\,\sigma^2);1\leq i,\, j\leq(2k+1) \quad (1)$$

Here is an example of a 5×5 Gaussian filter which is used to create the adjacent image where A is the value of pixel currently being processed and B is the value obtained after passing it through Gaussian mask. Note that every pixel of the image has to be passed through the Gaussian mask given in (2).

$$\mathbf{B} = \frac{1}{159}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix} * \mathbf{A}. \quad (2)$$

It is necessary to judge that the choice of the size of the Gaussian kernel affects the detector's performance. The greater the mask's size, lesser is the detector's sensitivity in respect to noise. The blurring of the image increases with the increase in the Gaussian filter kernel size. A mask of matrix 5×5 is a pretty good size commonly considered for most of the cases, but this may vary depending on specific situations [12].

3) *Prewitt Edge Detection Technique*: To determine approximations, the derivatives of two kernels of matrix 3x3 are convoluted with the original image, one for the horizontal changes and another one for the vertical changes. Setting convolution mask c=1, we get two Prewitt operators M_x and M_y by passing it through 3x3 convolution masks that is given in TABLE II.

TABLE II: M_x and M_y are the horizontal and vertical masks for Prewitt operators respectively.

-1	-1	-1
0	0	0
1	1	1

M_x

-1	0	1
-1	0	1
-1	0	1

M_y

D. Segmentation

Image segmentation is the major step and the most vital task in image processing. Its purpose is to extract the details from an image. The automation of medical image segmentation has established various applications in diverse areas like verdict for patients, treatment management planning and computer-aided operation. Boundary approach (thresholding), edge-based approach and region-based approach are the three major techniques widely used in segmentation [9]. For this project, boundary approach has been used. Let's have a conception about this method in brief. In thresholding technique, pixels are assigned to arrange according to the range of values in which a pixel lies. This is the easiest and popular method used in segmentation. Here, g(x,y) is the location of the every individual pixel of the image and T is the threshold value. The threshold value T is predefined in this algorithm. If the value of the current pixel $f(x,y)\leq T$ then pixel g(x,y) is allotted the value 0. Otherwise, the pixel g(x,y) is allotted the value 1. When all the values of "g" are displayed then a segmented image will be obtained [11][13]. Determining on the intensity values of the pixels, they are partitioned. Segmentation by thresholding can be done in the following three ways i.e. global thresholding, variable thresholding and multiple thresholding. They are discussed as follows.

1) *Global Thresholding*: Here, only one threshold value is applied on all images. This method is put in use when the pixel value of the defected portion and the background are fairly consistent over the entire image. Global thresholding using an appropriate threshold value can be defined in (3) and (4).

$$T: g(x, y) = 1, \text{ if } f(x, y) > T \quad (3)$$
$$T: g(x, y) = 0, \text{ if } f(x, y) \leq T \quad (4)$$

2) *Variable Thresholding*: Here, in every image the threshold value of the image varies. There are two main varieties of this methods available which are discussed below.
   a) *Local or Regional Thresholding*: Here, a grayscale image is taken as input and gives a binary image as output. T depends on the neighbourhood of pixels at (x, y).
   b) *Adaptive Thresholding*: In this technique, the threshold value at each pixel location depends upon the neighbouring pixel intensities.

3) *Multiple Thresholding*: Here, multiple threshold values are calculated by applying this technique to the given image, the image is segmented into certain brightness regions corresponding to one background.

$$\text{a. } g(x,y) = p\ ,\ \text{if } f(x,y) > T_2 \tag{5}$$

$$\text{b. } g(x,y) = q\ ,\ \text{if } T_1 < f(x,y) \leq T_2 \tag{6}$$

$$\text{c. } g(x,y) = r\ ,\ \text{if } f(x,y) \leq T_1 \tag{7}$$

The value of T is allocated to that specific category as shown in (5), (6) and (7).

E. Clustering

Clustering is a process of representing the image into various divisions for easier analysis and detailed study of the meaningful portions of the image. The image is divided in such a manner that each segment of the image shares certain similar characteristics such as intensity, texture or colour. The collected set of segmented image builds up the entire image. In the proposed method, the k-means algorithm is implemented for accurate prediction of the brain tumor regions.

Steps involved in the algorithm are discussed below in details.

Step 1: Set k different points where k indicates total number of regions of the image.

Step 2: Assign each pixel to the k^{th} point that has the closest centroid as per their Euclidean distance.

Step 3: When each pixel of the image is assigned to a cluster then the k's position is recalculated.

Step 4: Repeat steps 2 and 3 until the centroid "k" does not change.

Step 5: Display each divided cluster separately to view k number of clusters.

V. RESULTS AND DISCUSSION

A. Load the MRI Image

To start the processing of an image, first run the application in MATLAB. The image is browsed and loaded into the application. The input and GUI are shown in Figure 1. Now, the loaded MRI image is ready for processing.

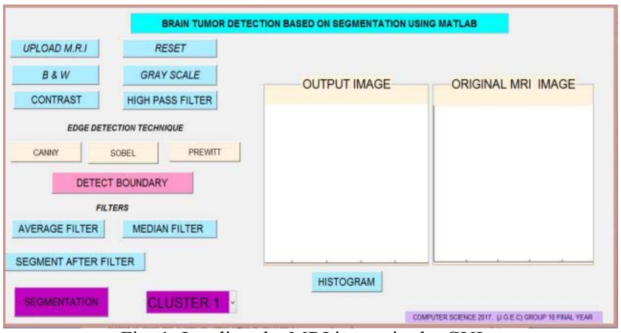

Fig. 1. Loading the MRI image in the GUI.

B. Convert Input MRI Image into Grayscale Image

Though all MRI images are not in grayscale hence it has to be converted into grayscale images. This conversion is shown in Figure 2.

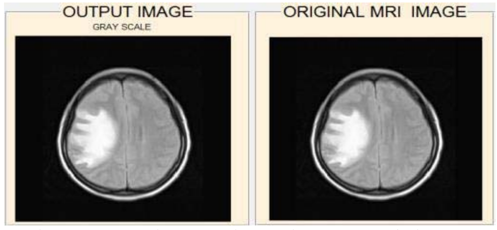

Fig. 2. Converting MRI image into grayscale image.

C. Image Enhancement

Normally the MRI image is filled with noise. To remove this, we have to increase the contrast of the image by applying high-pass filter [14]. Here two separate samples are shown, one for contrast enhancement and another for high-pass filtering. It has been shown in Figure 3 and Figure 4 respectively.

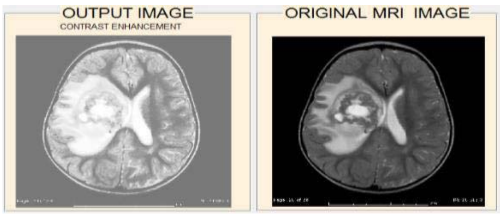

Fig. 3. Contrast enhancement of MRI image (sample 1).

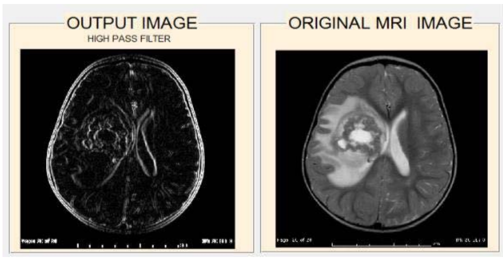

Fig. 4. Enhancement using high pass filter (sample 2).

D. Edge Detection

To separate the distinct regions of MRI brain image, edge detection techniques have been applied. Sobel, Canny and

Prewitt algorithms are implemented here. The edges of the brain image are clearly detected in each algorithm. Sobel and Prewitt algorithms detect only the boundaries of brain image whereas the Canny algorithm detects the edges of every region in the brain. Outputs of the above three algorithms are displayed in Figure 5, Figure 6 and Figure 7 respectively.

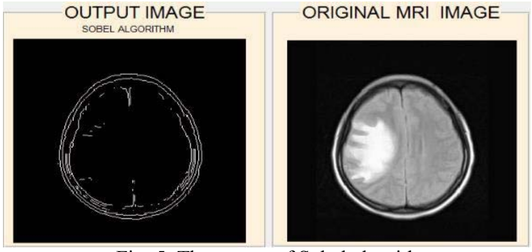

Fig. 5. The output of Sobel algorithm.

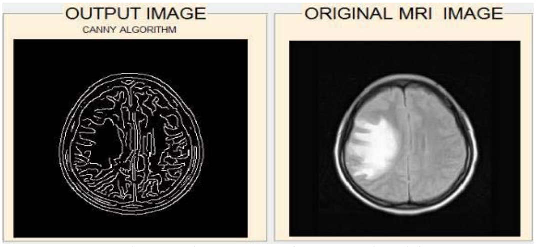

Fig. 6. The output of Canny algorithm.

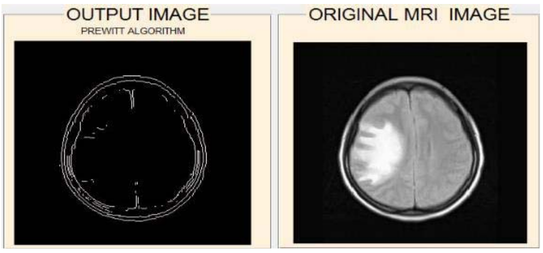

Fig. 7. The output of Prewitt algorithm.

E. *Median Filter to Remove Impulse Noise*

It may happen sometimes that the image gets affected with impulse noise i.e. salt and pepper noise. To remove impulse noise generated due to the conversion of MRI image into equivalent grayscale image, at first average filter is implemented to select the noises and then apply a median filter to remove this noise from the MRI image [11]. The results are shown in Figure 8 and Figure 9 respectively.

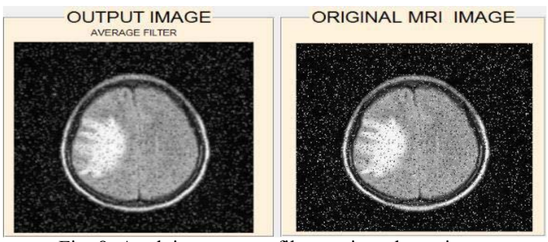

Fig. 8. Applying average filter on impulse noise.

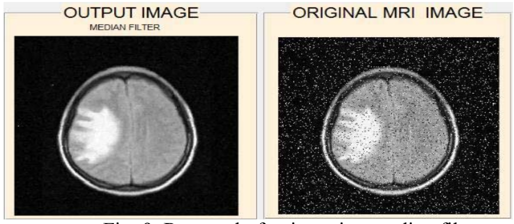

Fig. 9. Removal of noise using median filter.

The result of the median filter is then segmented separately and is displayed in Figure 10. The segmented image properly displays a noise free image which clearly shows the affected region. The segmentation is done here by the thresholding method.

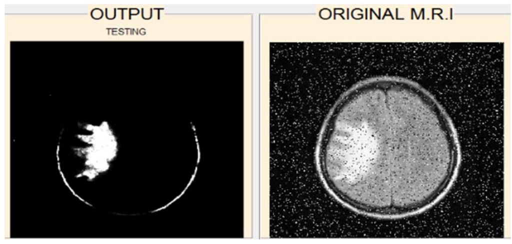

Fig. 10. Segmentation after Median filter.

F. *Segmentation using Thresholding Technique*

Threshold segmentation method is used here to segment the tumor regions from the image by which the brain tumor region is detectable [14]. The result is demonstrated in Figure 11.

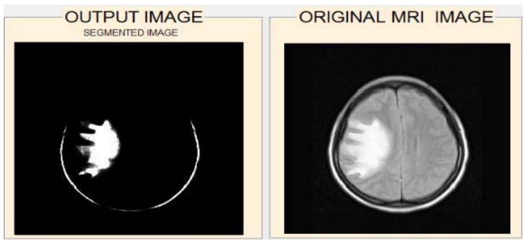

Fig. 11. Segmentation using thresholding method.

G. *Final Output*

The output image predicts only the tumor regions present in the MRI brain image. The region is identified as a tumor which exhibit a cluster of white pixels forming a lump and it is displayed in Figure 12.

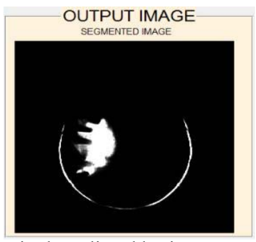

Fig. 12. Final predicted brain tumor region.

H. *Clustering*

Clustering is another important segmentation technique used widely in the image processing. Here segmentation is performed using the k-means algorithm. Taking the value of k as 4, four possible clustered regions are detected in the brain MRI image. The first two clusters show the boundary region and the last two clusters show the tumor region. It is shown in Figure 13.

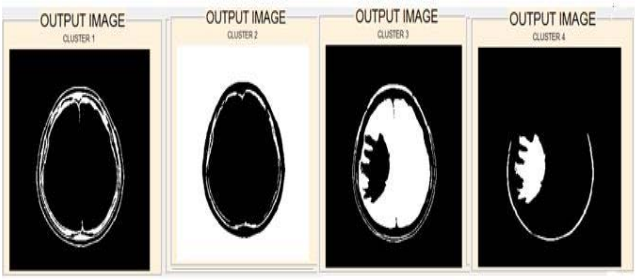

Fig. 13. The output of k-means clustering algorithm.

VI. Conclusion

MRI images are quite preferred for detecting the brain tumor. Here, we mainly analysed various image processing techniques and have discussed its requirements and properties in the context of brain tumor detection on MRI scanned images. The application of segmentation and edge detection is directly beneficial for medical diagnosis. To distinguish the tumor affected regions from various brain tissues we have employed the thresholding segmentation technique. Using the proposed algorithm, identification of the brain tumor regions is done efficiently. In future to detect the tumor regions more accurately, the algorithm can be improved using new segmentation techniques. Better efficiency can be obtained by applying advanced clustering algorithms as well as classification algorithms. The category of brain tumor identification i.e. malignant or benign can be done in near future.

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