Brain Tumor Detction and Segmentation Using Histogram Thresholding

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ABSTRACT - The knowledge of volume of a tumor plays an important in the treatment of malignant tumors. Manual segmentation of brain tumors from Magnetic Resonance images is a challenging and time consuming task. This paper presents a novel technique for the detection of tumor in brain using segmentation and histogram thresholding. The proposed method can be successfully applied to detect the contour of the tumor and its geometrical dimension. This technique can be proved to be handy tool for the practitioners especially the physicians engaged in this field.

INDEX: Histogram, MRI, Thresholding, Brain Tumor.

I.   INTRODUCTION

Brain cancer can be counted among the most deadly and intractable diseases. Tumors may be embedded in regions of the brain that are critical to orchestrating the body's vital functions, while they shed cells to invade other parts of the brain, forming more tumors too small to detect using conventional imaging techniques. Brain cancer's location and ability to spread quickly makes treatment with surgery or radiation like fighting an enemy hiding out among minefields and caves. A brain cancer is a disease in which cells grow uncontrollably in the brain. Brain tumors are of two main types: (i) Benign tumors (ii) Malignant tumors. Benign tumors are incapable of spreading beyond the brain itself. Benign tumors in the brain usually do not need to be treated and their growth is self limited. Sometimes they cause problems because of their location and surgery or radiation can be helpful. Malignant tumors are typically called brain cancer These tumors can spread outside of the brain. Malignant tumors of the brain are most harmful which may remain untreated and an aggressive approach is almost always warranted. Detection of Brain tumor is a serious issue in medical science. Brain tumor is one of the major causes for the increase in mortality among children and adults. Tumors can be benign or malignant. Imaging plays a central role in the diagnosis and treatment planning of brain tumor. Imaging of the tumors can be done by CT scan, Ultrasound and MRI etc. The MR imaging method is the best due to its higher resolution. But there are many problems in detection of brain tumor in MR imaging as well. An important step in most medical imaging analysis systems is to extract the boundary of an area we are interested in. Many of the methods are there for the MRI segmentation [1 – 7].Though till now histogram thresholding is used for preprocessing only in many of the segmentation methods this paper shows that it can be used as

a powerful tool for segmentation [8]. The image captured from a tumors brain shows the place of the infected portion of the brain. The image does not give the information about the numerical parameters such as area and volume of the infected portion of the brain. After preprocessing of the image, first image segmentation is done by using region growing segmentation. The segmented image shows the unhealthy portion clearly. From this image the infected portion (tumor) is selected by cropping the segmented image. From this cropped image, area is calculated [9 – 11].

II.   PROPOSED WORK

The concept behind the present work is based mainly on three points: (i) the symmetrical structure of the brain, (ii) pixel intensity of image and (ii) binary image conversion. It is a well known fact that human brain is symmetrical about its central axis and throughout this work it has been assumed that the tumor is either on the left or on the right side of the brain. MR image of the human brain can be divided into sub region such that white matter, gray matter, blood cells and cerebrospinal fluid can be easily detected. Tumor is nothing but the collection of blood cells at some specific point/s.

The image of a brain in MRI is represented through pixel intensity. In gray color images the intensity lies between 0-255 with 0 indicating for black and 255 is assigned for the white color. The blood cells (RED color in RGB) are represented by white color and 255 pixel intensity. All the gray matter is having a pixel intensity less than 255. First part of the present work addresses the problem of detecting the position of the tumor, i.e., whether the tumor is on the left or right side of the brain. This is achieved just with the knowledge of which part of the brain contains more numbers of the pixels having intensity around 255.

Based on the above idea and algorithm has been developed which has been implemented using MATLAB. The present work consists of following stages: (i) The brain is divided into two equal halves around its central axis and the histogram of each part drawn. This will detect the infectious side of the brain. (ii) The threshold point of the histograms is calculated based on a comparison technique made among the two histograms. (iii) The detected image is cropped along its contour to find out the physical dimension of the tumor.

III.   METHODOLOGY

The presented work is based upon histogram thresholding for brain image segmentation. The image of the brain is acquired through MRI technique. If the histograms of the images corresponding to the two halves of the brain are plotted, a symmetry between the two histograms should be

observed due to symmetrical nature of the brain along its central axis. On the other hand, if any asymmetry is observed, the presence of the tumor is detected. After detection of the presence of the tumor, thresholding can be done for segmentation of the image. Segmentation is done by calculating the threshold point. The differences of the two histograms are plotted and the peak of the difference is chosen as the threshold point. Using this threshold point, the whole image is converted into binary image providing with the boundary of the tumor. The binary image is now cropped along the contour of the tumor to calculate the physical dimension of the tumor. The whole of the work has been implemented using MATLAB R 2010. The flowchart below depicts the stages of the work reported in the present communication.
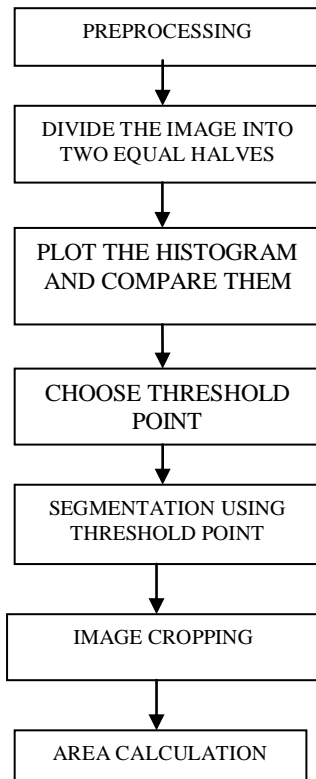
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┌─────────────────────────────┐
│        PREPROCESSING        │
└─────────────────────────────┘
              │
              ▼
┌─────────────────────────────┐
│   DIVIDE THE IMAGE INTO     │
│      TWO EQUAL HALVES       │
└─────────────────────────────┘
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              ▼
┌─────────────────────────────┐
│   PLOT THE HISTOGRAM        │
│   AND COMPARE THEM          │
└─────────────────────────────┘
              │
              ▼
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│   CHOOSE THRESHOLD          │
│        POINT                │
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│   SEGMENTATION USING        │
│     THRESHOLD POINT         │
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│      IMAGE CROPPING         │
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│     AREA CALCULATION        │
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Fig 1.1 Flow chart of the method used

In a neuroscience perspective, the concepts of symmetry and asymmetry are closely tied to the two hemispheres of the human brain (Fig.1.2), and the mirror symmetrical organization of the body along the vertical body axis produces two mirror body halves. Two objects may show mirror symmetry with regard to shape and structure, although the functions of the two are clearly asymmetrical.

Fig. 1.2 symmetrical structure of the brain

A. Preprocessing

The image of the brain obtained through MRI is loaded by using the command *'imread' in MATLAB.* The image is then converted into gray color image, i.e., 2D image. The gray color image consists of pixel intensity between 0-255 where 0 represents black and 255 is used for white.

B. Division the image

After converting the image into gray color image, it is divided into two equal halves along its central axis. The following algorithm is applied to achieve this:
The image pixels are stored as a variable (say P) where P shows the values of the pixels in a 2D matrix (row – column) form.
Number of rows and columns are assigned some other variables (say Q and R)
The column value is divided by 2 and assigned another variable name (say S)
Form new matrix using *for loop* by rows from 0:1:Q as outer loop and columns from 0:1:S as inner loop.
Using the command *'imshow',* the image is constructed based on the new matrix. This image will be the halves of the original image.
For the other half of the image, the column value from S:1:R is considered as the inner loop.

C. Plot the histogram and compare them

Histogram is a plot between number of pixel and pixel intensity. To plot the histogram, bar graph can be used. The histogram code operates by first reading the grayscale value at the first entry and coming up with pixel intensity between 0 and 255. It increments the total number of pixels and then it will move on to the next row or column entry until it finishes reading all the raster data. However, while it is reading each entry, if it picks up pixel intensity value more than once it will increment that particular value. MATLAB command used for this is *'bar()'*. Finally the two histograms are compared to detect the tumor and hence the tumor.

D. Choose threshold point

The difference of the two histograms is calculated and the resultant difference is plotted suing bar graph to select the threshold point.

E. Segmentation using threshold point

A zero matrix of same size of original image matrix (say 'c') is considered. Each pixel value of the image matrix is compared with the threshold point. If the value of pixel is greater than threshold, coordinate of c matrix is assigned a value 255 otherwise 0 is assigned to that. This process is repeated till all the pixel values are compared to threshold point. Matrix 'c' is then transformed into image using *'imshow'* command

F. Image cropping

Cropping is the process of selecting desired region from an image that is to be processed. The image shows the desired

tumor portion. This cropped image is used to calculate the tumor area.

G. Area calculation

Area of an image is the total number of the 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. To calculate the number of pixels in the cropped image the function **Bwarea()** is used. This function calculates the number pixels present in the image.

A right click on the image and exploring the detail property will provide the following detail of the image:

- Size of image, e.g., 600X400
- Horizontal resolution, e.g., 96 dpi.
- Vertical resolution, e.g., 96 dpi

From the horizontal and vertical resolution one can find the dimension of a single pixel. The algorithm used is follows:

There are 96 pixels in one inch. Hence vertical dimension of a pixel is 1/96 inch. Similarly horizontal dimension of a single pixel is 1/96 inch.

Area of single pixel is equal to (1/96)*(1/96) square inch.

$$A = (1/96)*(1/96)$$

*Area of the tumor = A*total*

IV. RESULTS

In order to taste the algorithm developed, an image of brain having tumor has been considered. The outputs of the program resulted the following graphs and images:

- Two halves of the original image and their respective histogram.
- Difference of the two histogram.
- Original and segmented image.
- Cropped image and area of the tumor in command window of the MATLAB.

Results, graphs and parameter obtained after the simulation are shown in the next sections.
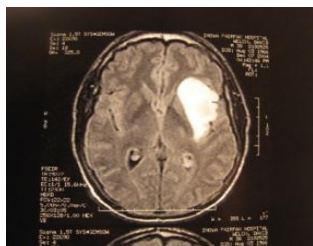
A. INPUT IMAGE

Fig.1.3 (a) MRI image of brain has medium size tumor

B. Histogram plot for each side of brain

From the figure it is clear that the histogram plotted for two sides are not symmetrical. Thus there may be tumor. In this graph horizontal axis shows intensity of pixels and vertical axis show number of pixels.
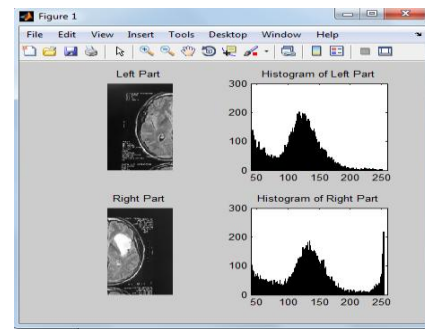

Fig.1.3 (b) separation of image and Histogram of two sides

From Fig. 1.3 (b) it is evident that the right part has more variation around 250 as compared to left part also number of pixels are very large above 240 in right part. So there is a chance of presence of tumor on right part of the brain.

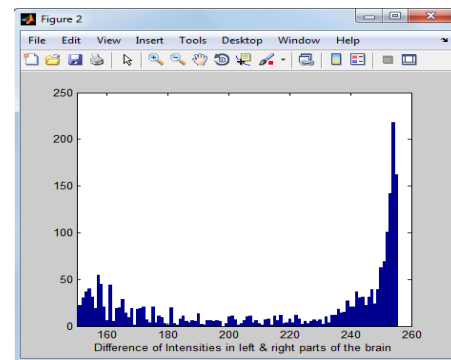### C. Difference in the intensity of the two side of brain

Fig.1.3(c) Difference in the intensities of two sides

From Fig 1.3(c) it is clear that there are peaks around 255. Hence this value is chosen as the threshold point.
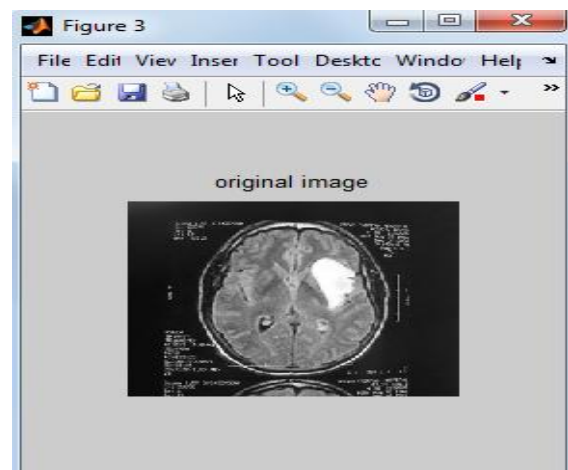
D. Original and segmented image
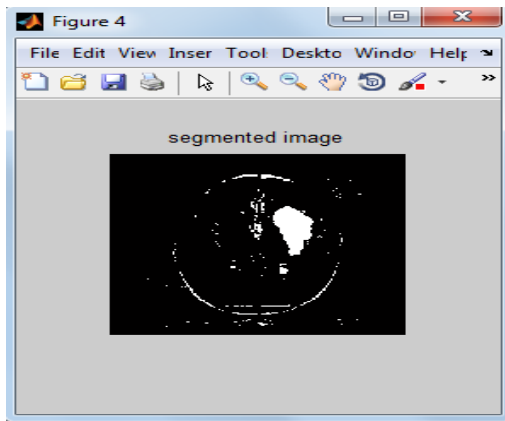

Fig.1.3 (d) Original image

Fig.1.3 (e) Segmented image

Fig. 1.3 (d) shows the original image but in gray scale and Fig. 1.3 (e) the segmented form of original image. As is clear from Fig. 1.3 (d) the segmented image shows the boundary of tumor.
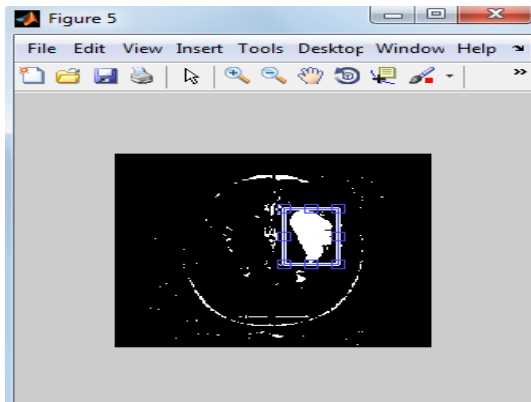
E. Cropped image

Fig 1.3 (f) Cropping of the boundary of the tumor for area calculation.

F. Area calculation in MATLAB command window

Fig.1.3 (g) Area calculation in command window

Here variable **'total'** represents the total number of white pixels in the segmented cropped image whereas the variable **'area'** represents the area of tumor in length unit. Thus there is no tumor the value of *total* and *area* is zero. Summary of the results has been placed in a tabular form in the following table.

Table 1.2 analysis of input image 1.3(a)

Symmetry in two histograms	No
Tumor detected	Yes
Side of brain in which tumor is present	Right
Total number of on pixel in cropped image	1401
Dimension of single pixel	0.0007 c.m.^{2}
Area of tumor	1.02 c.m.^{2}

V. CONCLUSION

In this study a technique to detect presence of brain based on thresholding technique has been developed. The segmentation of the brain is also being done while detecting the presence of the tumor. The physical dimension of the tumor which is of utmost importance to the physicians can also be calculated using the present technique.

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