

Brain Tumor Detection in MRI Images With New Multiple Thresholding

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Abstract – Medical image processing is the most challenging and emerging field now a day. Processing of MRI images is one of the parts of this field. This paper work describes the proposed strategy to detect & extraction of brain tumor from patient's MRI scan images of the brain. Proposed method incorporates with MRI Image preprocessing based on multiple Otsu Thresholding and morphological operations (Erosion and dilation) and also comparison of patient's brain MRI image with normal human brain MRI database SRI24. Proposed work finds tumor location and dimension from MRI scan images. The process done by using MATLAB software, to make the design user friendly a GUI has been developed for front end user. The GUI runs a background code in which proposed algorithm works, the results found are very good in terms of accuracy and time delay.

Index Terms – Graphical User Interfacing (GUI), Image processing, brain tumor, Image segmentation, Magnetic resonance imaging (MRI).

1. INTRODUCTION

The proposed work has been motivated and designed because of its vital importance in current situations. To recognize tumor in human brain peoples still dependent on doctor's observation of tumor in MRI images. To recognize tumor total 155 MRI images captures by doctor form four different angles top, left, right back and front, and if any patient have tumor it does not reflects in all the MRI images it hardly shows in one or two MRI images (normally dependent on size of tumor), and it is highly possible that it can be ignored in some cases, hence proposed design has come up with an accurate solutions in which all the MRI images of brain taken in a variable and then compared with MRI images of normal brain (the normal brain MRI is been taken from CC-BY-SA license and IEEE standard database SRI24). If MRI of patient does not matched with any MRI of SRI24, then there is a possibility of tumor in the MRI image which further detected through proposed multi level Otsu Thresholding and detection of size after morphological filtering (erosion and dilation).

2. METHODOLOGY

Figure1 shown below is the proposed work flow diagram; here the whole work has been separated in three major tasks

- Preprocessing
- Recognition
- Identification and calculation

The block shows few original MRI images and their preprocessed MRI after segmentation and morphological filtering and also shows few MRI of normal human brain database

Preprocessing: Pre-processing is an important required task to be done in tumor recognition system design. Pre-processing consist two steps, Segmentation and Morphological filtering.

Segmentation is done to convert gray scale image into binary image so that we can have only two object in MRI image one white blood circulation and other is black part where no blood flows. Multiple Otsu algorithm [3] is used for segmentation purpose and real brain MRI images are converted into binary image. After converting gray scale image into binary image it must be ensure that there is no noise and undesired elements in image so uses morphological filter technique. Morphological technique consist operations: dilation, erosion.

Segmentation: A good segmentation is needed to select an adequate threshold for gray level in order to extract blood circulation (white area). In general, selection of an appropriate segmentation algorithm depends largely on type for images and application areas. Otsu segmentation algorithm [3] was tested and found good segmentation results in order to MRI images, therefore, selected. Otsu algorithm is nonparametric and unsupervised procedure for automatic threshold selection. Converting a greyscale image (or into) monochrome is a common image processing task. Otsu's method, named after its inventor Nobuyuki Otsu, is one of many binarization algorithms. Otsu's Thresh holding method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels each side of the threshold, i.e. the pixels that either fall in foreground or background. The aim is to find the threshold value where the sum of foreground and background spreads is at its minimum. The algorithm will be demonstrated using the simple 6x6 image

shown below. The histogram for the image is shown next to it. To simplify the explanation, only 6 greyscale levels are used.

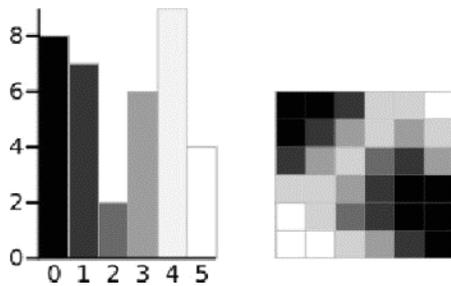


Figure 2: A 6-level greyscale image and its histogram

The calculations for finding the foreground and background variances (the measure of spread) for a single threshold are now shown. In this case the threshold value is 3.

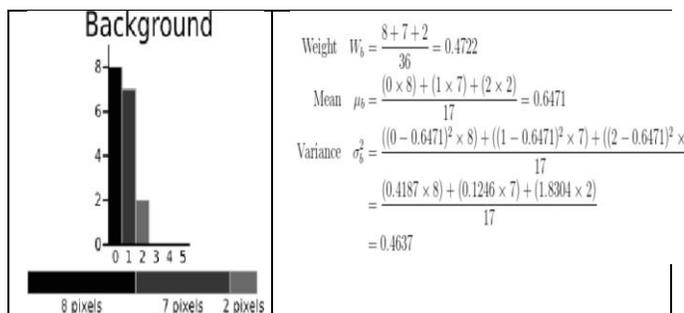


Figure 3 Background after Otsu and its calculations

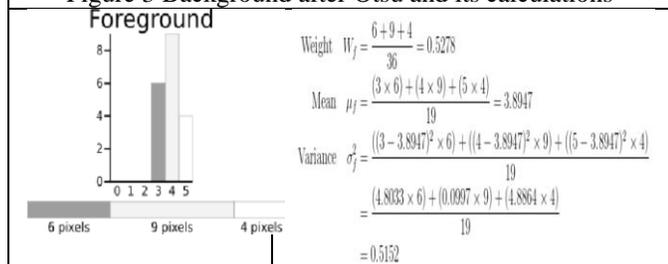


Figure 4 Foreground after Otsu and its calculations (formula should be written ,its in image)

Morphological Filtering: If we take(A) close look to segmented image after applying Otsu algorithm on original gray scale image we find that segmentation is not perfectly done.(sentence is inappropriate) Background may have some 1's which is known as background noise and MRI image may have some 0's that is known is MRI tissue noise. These errors can lead to a problem in detection in MRI image so we need to remove these errors. A morphological filtering [4] approach has been applied using sequence for dilation and erosion to obtain a smooth.

In morphological dilation and erosion we apply a rule on a binary image. Value for any given pixel for any given pixel in output image is obtained by allying set for rules on neighbors

input image. Dilation and erosion operation on a binary image A and with a structuring element B defined as follow.

Dilation : If A and B are sets in 2-D integer space Z^2 , $x = (x_1, 2)$ and \emptyset is empty set, then, dilation for A by B is $A \oplus B = \{x | (\hat{B})x \cap A \neq \emptyset\}$

Where \hat{B} is reflection for B. In dilation procedure first we obtain reflection for B about its origin and then we shift reflection by x. Condition for dilation for A by B is set for all x condition is such that in order to dilation for A by B is set off all x displacement such that \hat{B} and A overlap at least one nonzero element. Set B is commonly referred to as structuring element. Value for output pixel is maximum value for all pixels input pixel's neighborhoods. In any for pixels is set to value 1, output pixel is set to 1.

Erosion: erosion for A by B is

$$A \otimes B = \{x | (B)x \subseteq A\}$$

Erosion for A by B is set for all point x such that B, translated by A, is contained in A. Thus value for output pixel is minimum value for all pixels input pixel's neighborhood. In binary image, if any for pixels is set to 0, output pixel is set to 0.

Recognition: MRI matching is a one-to-many matching procedure that compares a test MRI image against all template MRI images in SRI24 database to determine identity in order to test MRI. Identification in order to test image is done by locating image in database that has highest similarity with test image. Identification procedure is a 'closed' test, which means sensor takes an observation in order to an individual that is known to be in database. Test subject's (normalized) features are compared to other features in system's database and a similarity score is found in order to each comparison. These similarity scores are then numerically ranked in a descending order.

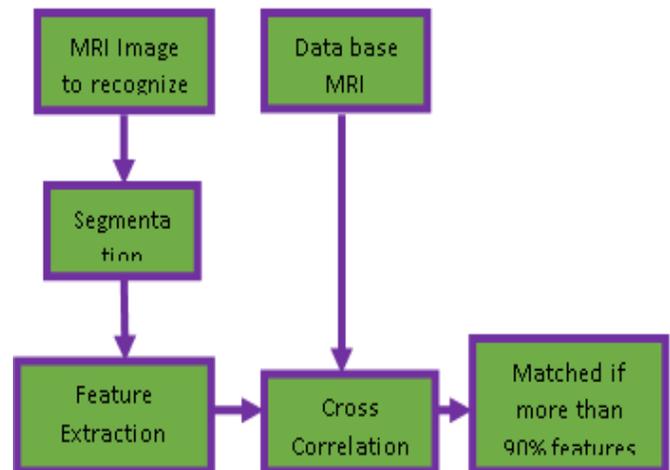


Figure 5: Proposed Recognition method

Percentage in order to times that highest similarity score is correct match in order to all individuals is referred to as 'top match score.' If any of top r similarity scores corresponds to test subject, it is considered as a correct match in terms of cumulative match. Percentage of times one of those similarity scores is correct match of all individuals is referred to as 'Cumulative Match Score', it is a curve is rank versus percentage of correct identification, where rank n is number of top similarity scores reported.

3. ALGORITHM ADOPTED

Proposed work is basically multi Otsu Thresholding for Extraction.

Presentably identification of 'Contrast' type tumors in brain MRI

$Y_{i,j}$ is MRI image of test human brain with $M \times N$ size,

$i=1, 2, 3, \dots, M$

$j=1, 2, 3, \dots, N$

'j' and 'i' are the pixel position

cnt1, cnt2, cnt3, cnt4 and cnt5 are the count values that are been assigned to get the count value so we could know the quantity of pixel values that lies in the specific range

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if( $Y_{i,j} > 0$   $Y_{i,j} < 51$ )
    cnt5 = cnt5 + 1;
elseif( $Y_{i,j} > 50$   $Y_{i,j} < 101$ )
    cnt4 = cnt4 + 1;
elseif( $Y_{i,j} > 100$   $Y_{i,j} < 151$ )
    cnt3 = cnt3 + 1;
elseif( $Y_{i,j} > 150$   $Y_{i,j} < 201$ )
    cnt2 = cnt2 + 1;
elseif( $Y_{i,j} > 200$   $Y_{i,j} < 255$ )
    cnt1 = cnt1 + 1;
    
```

$$Pcnt1 = \frac{cnt1 * 100}{cnt1 + cnt2 + cnt3 + cnt4 + cnt5}$$

$$Pcnt2 = \frac{cnt2 * 100}{cnt1 + cnt2 + cnt3 + cnt4 + cnt5}$$

$$Pcnt3 = \frac{cnt3 * 100}{cnt1 + cnt2 + cnt3 + cnt4 + cnt5}$$

$$Pcnt4 = \frac{cnt4 * 100}{cnt1 + cnt2 + cnt3 + cnt4 + cnt5}$$

$$Pcnt5 = \frac{cnt5 * 100}{cnt1 + cnt2 + cnt3 + cnt4 + cnt5}$$

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if( $pcnt1 > 10$ )
    max = 255
elseif( $(pcnt1 + pcnt2) > 10$ )
    max = 200
elseif( $(pcnt1 + pcnt2 + pcnt3) > 10$ )
    max = 150
elseif( $(pcnt1 + pcnt2 + pcnt3 + pcnt4) > 10$ )
    max = 100
else
    max = 50
    
```

Thresholding: T is the Thresholding level which decided according to Otsu Thresholding method

$$T = 50 * \sqrt{2 * \log(\text{Max})}$$

$$Z_{i,j} = \begin{cases} 255 |Y_{i,j}| \geq T \\ 255 * \text{sgn}(Y_{i,j}) * \frac{|Y_{i,j}|^\gamma}{T^{\gamma-1}} |Y_{i,j}| < T \end{cases}$$

Where $\gamma = \sigma \sqrt{2 * \ln(N)}$

And $\sigma = \text{mean}(Y_{i,j})$

Erosion: $v_t(a, b) = z(i, j) \& z_t(a, b)$

When $t=1, a=i+1, b=j,$

When $t=2, a=i-1, b=j,$

When $t=3, a=i, b=j+1,$

When $t=4, a=i, b=j-1,$

When $t=5, a=i+1, b=j+1,$

When $t=6, a=i+1, b=j-1,$

When $t=7, a=i-1, b=j+1,$

When $t=8, a=i-1, b=j-1$

Where $n=M \times N/8$ and 't' repeats 'n' times

Dilation: $u_t(a, b) = v(i, j) \wedge v_t(a, b)$

When $t=1, a=i+1, b=j,$

When $t=2, a=i-1, b=j,$

When $t=3, a=i, b=j+1,$

When $t=4, a=i, b=j-1,$

When $t=5, a=i+1, b=j+1,$

When $t=6, a=i+1, b=j-1,$

When $t=7, a=i-1, b=j+1,$

When $t=8, a=i-1, b=j-1$

Where $n=M \times N/8$ and 't' repeats 'n' times

Resizing: it is to be done because the MRI standard size is 240x240 in database

$$D_{i,j} = \text{imresize}(u_{i,j}, 240, 240)$$

Matching Method: The standard database is SRI24 it is an MRI-based atlas of normal adult human brain anatomy, generated by template-free nonrigid registration from images of 24 normal control subjects.

Database Preparation: Total SRI24_{240x240}(m) where m is 1,2,3....1240 MRI image of normal human brain of 240x240 pixels

Cross Correlation based recognition:

$$r(n) = \sum_{k=0}^n D_{ij}(k) D_{ij}(k-n)$$

'n' is the any sample position out of total 57600 samples of D_{ij}

$$r_m(n) = \sum_{k=0}^n D(k) P(k-n, m)$$

$$S = \sum_{n=0}^{57600} r(n)$$

$$S_m = \sum_{n=0}^{57600} r_m(n)$$

$$f_m = |S_m - S_1|$$

$$(Val1, K1) = \text{Min}(f_m)$$

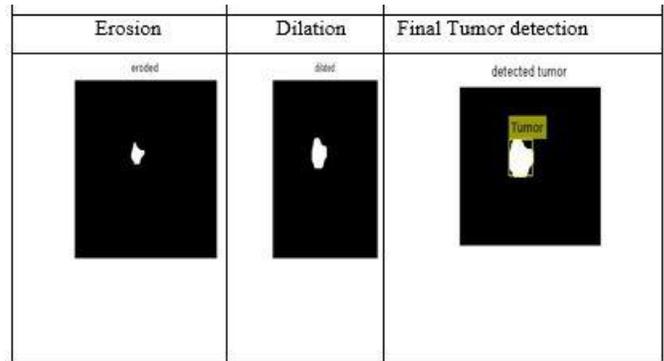
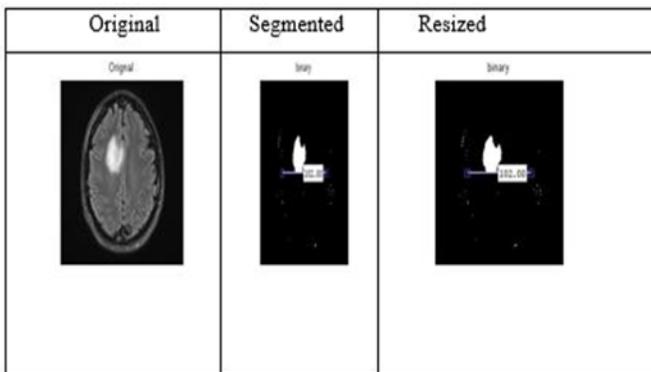
Hard Thresholding

$$mch = \begin{cases} 1 & \text{if } val1 < 10 \\ 0 & \text{otherwise} \end{cases}$$

If mch is '1' then no need for any further calculation because the MRI is been matched with any normal brain MRI (significantly write more accurately)

But if mch is '0' then there is tumor

Detection algorithm: write and define s_i , and s_j



$$S_i = \sum_{j=1}^{240} u_{i,j}$$

$$rw = [rw, i] \quad \text{if } (S_i \geq 255)$$

$$\text{Trl} = \text{Min}(rw)$$

$$\text{Tru} = \text{Max}(rw)$$

$$S_j = \sum_{i=1}^{240} mu_{i,j}$$

$$cl = [cl, j] \quad \text{if } (S_j \geq 255)$$

$$\text{Tcl} = \text{Min}(cl)$$

$$\text{Tcu} = \text{Max}(cl)$$

Tcl is the column where the Tumor starts

Tcu is the column where the Tumor ends

Trl is the row where the Tumor starts

	Accuracy	Time in min
Sara Sandabad et al [1]	90	1
Stefan Bauer et al [2]	87	10
Rajesh C. Patil et al [3]	82	2
Proposed work	95	1.2

Tru is the row where the Tumor ends

4. RESULTS

Simulation results: figures below shows the observe results after simulation of proposed work on MATLAB. This figure shows original, segmented, eroded, dilated and final detected

Figure 6 Simulation results

Table 1 Results observation and Comparison

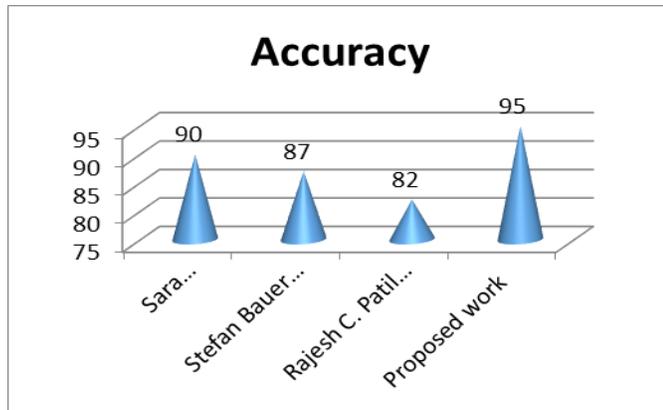


Figure 7: Accuracy Results comparison

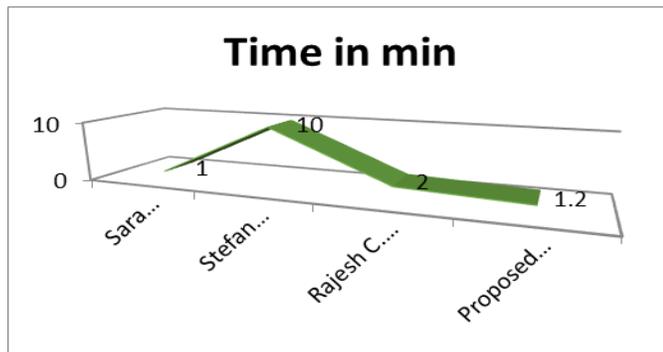


Figure 8: Time delay Results comparison

From the results above it can be clearly observed that proposed work accuracy is found better as compare with available work and it can also be seen that proposed work time to detect tumor is less as compare with available work. Figure shown below is the GUI developed with the help of MATLAB

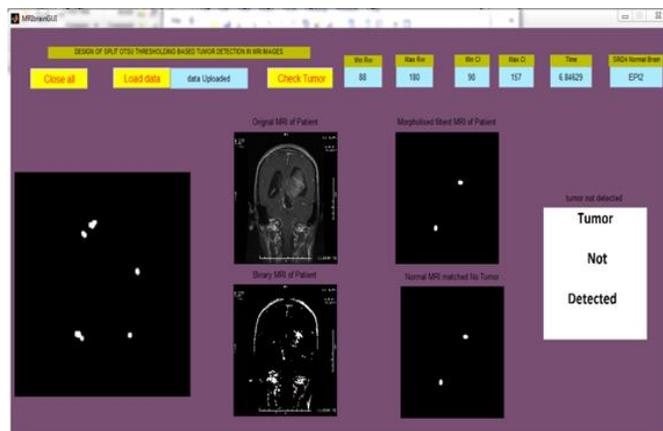


Figure 9 GUI Developed for user interfacing for tumor detection in MRI image when tumor not detected

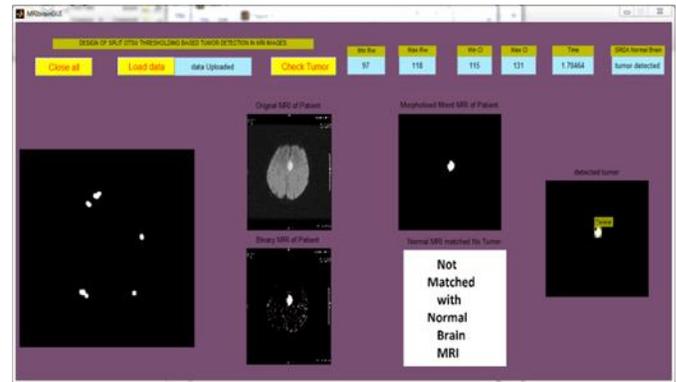


Figure 10 GUI Developed for user interfacing for tumor detection in MRI image when tumor detected

5. CONCLUSION

Proposed procedure for detection of brain tumor from MRI images and MATLAB is been used for the design the proposed system, to make the design user friendly a GUI is been developed, the results found are very good in terms of accuracy and time delay. SRI24 (provided by International Medical Union) database is been used for matching test MRI image to ensure that it is not matched with any normal brain MRI image. The major application of the proposed design is to recognize the tumor out of multiple MRI images taken for any patient, for accurate detection and exact dimension of tumor is highly requires in field of medical. Hence the only application of proposed design is to identify Tumor in MRI images of brain. In near future the proposed work can be used for recognition of other body parts MRI and it and be used for detection of other disease, as the proposed work is successfully recognizing circulation of blood.

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