

# Brain Tumor Recognition from MRI Images using Multiple OTSU Thresholding and Cross Correlation

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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 a good and efficient strategy to detect and extract the brain tumor[4][5] from patient's brain MRI images. In this method an algorithm is developed, the primary part of this algorithm is to convert given MRI image into binary image (0 and 1) using segmentation technique[6] called multiple Otsu Thresholding[7], after which morphological operations[8] [9] has been applied. The obtained image is matched with the SRI24 database which is a MRI-based atlas of 24 normal adult human brain anatomies. The work is done and comprised by making a graphical user interface (GUI) in MATLAB. The algorithm results in good accuracy and better time for recognition of the brain tumor.

**Keywords-** Graphical User Interfacing (GUI), Image processing, brain tumor, Image segmentation, Magnetic resonance imaging (MRI)

## I. INTRODUCTION

The proposed work has been motivated and designed because of its vital importance in current situations. There are several ways and techniques to extract the information from a medical image to help doctors. Segmentation is a very prior part of it; there are many techniques for segmentation [10-20]. The recognition of brain tumor from MRI images is a crucial task, here total MRI images has been captured by MRI machine of one patient which takes images from different angles that creates views as axial, coronal and sagittal, and if any patient have tumor it is not visible in all the MRI images, it is recognizable in hardly one or two MRI images (normally dependent on size of tumor). It is highly possible that it can be ignored in some cases; hence proposed algorithm has come up with an accurate solution. The method uses multiple Otsu Thresholding which converts a grayscale image into a binary image [4]. Here in this work all the MRI images of brain has been taken in a variable form and first of all it gets compared with MRI images of normal brain (the normal brain MRI has been taken from CC-BY-SA licensed and IEEE standard database SRI24) [16]. If MRI image of patient do not match with normal brain MRI of database then there is a possibility of tumor in the taken MR image.

## II. METHODOLOGY

The tumor detection has been divided into two parts; the first one is preprocessing where the MRI image is preprocessed and second one is recognition. The preprocessing is done by using Otsu Thresholding [7] where the image had segmented followed by erosion and dilation [8]. The whole methodology is presented here in the diagram given below;

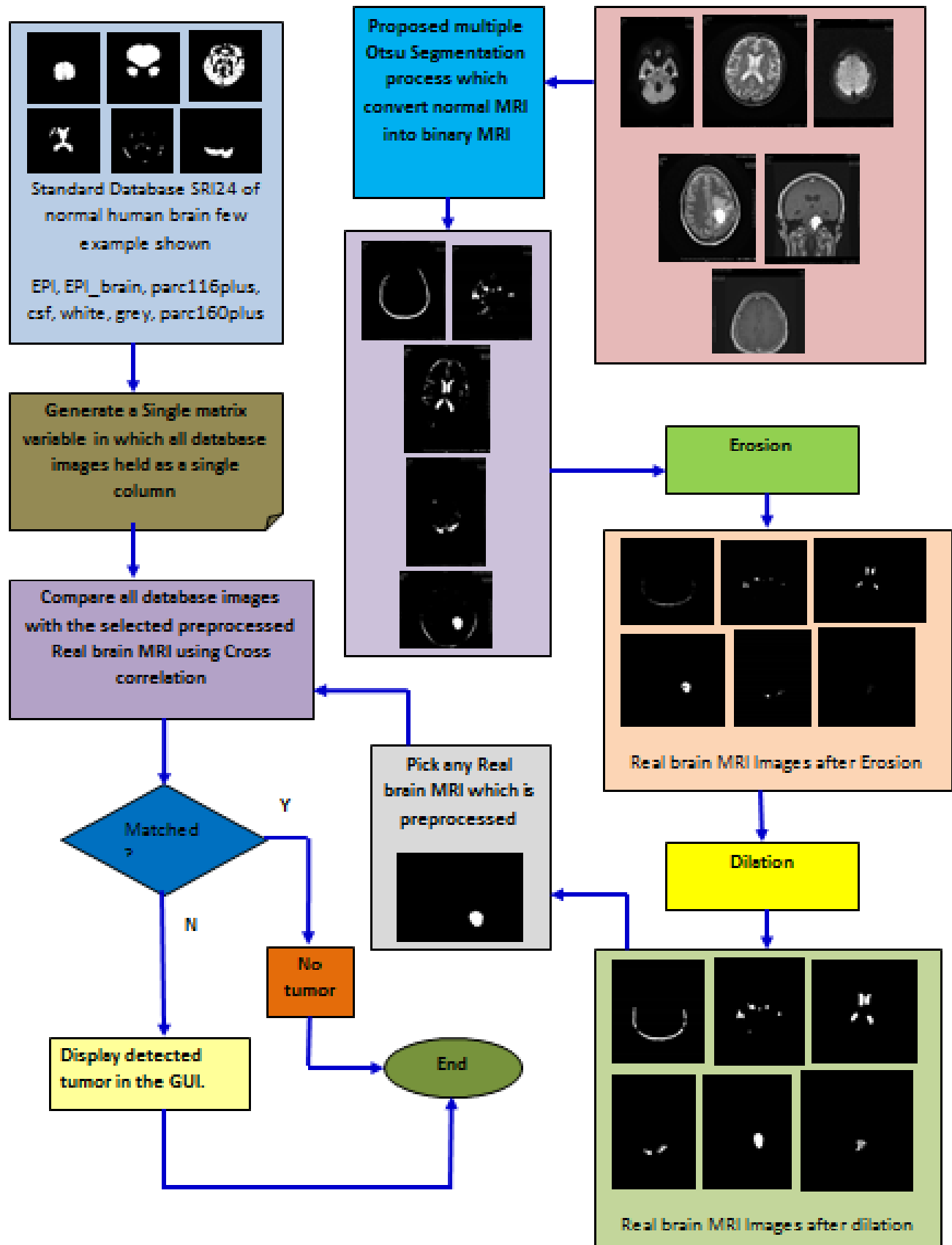


Fig. 1: working diagram of proposed method

### A. Preprocessing

Pre-processing is an important and required task has to be done in tumor recognition system. Pre-processing consists of two steps, Segmentation and Morphological filtering. Segmentation is done to convert gray scale image into binary image so that we can have only two areas in image one is foreground and other is background. Multiple Otsu algorithms [7] is used for segmentation purpose where 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 for that morphological filtering technique has been used. Morphological techniques [8] consists operations like dilation and erosion.

### B. Recognition

MRI matching is a one-to-many matching procedure that compares a test MRI image against all template MRI images in SRI24database [21].

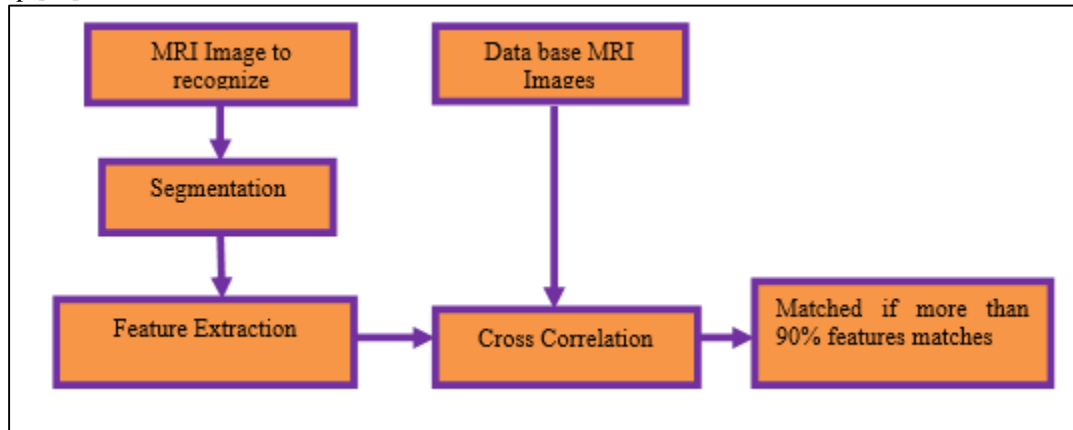


Fig. 2: Proposed Recognition method

## III. ALGORITHM ADOPTED

The tumor detection algorithm is developed here. The algorithm comprises Multiple Otsu Thresholding [7], morphological operations like erosion [8] and dilation [8], and calculation of dimensions of the tumor. A ‘contrast’ type MRI image of patient is taken and denoted as  $Y_{i,j}$ .

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

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

‘i’ and ‘j’ are the pixel positions. M is the row and N is the column.

A set of count values cnt1, cnt2, cnt3, cnt4, cnt5 has been assigned so we could know the quantity of pixel values that lies in a specific range.

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;

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

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

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

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

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

```

if(pcmt1 > 10)
    max = 255
elseif((pcmt1 + pcmt2) > 10)
    max = 200
elseif((pcmt1 + pcmt2 + pcmt3) > 10)
    max = 150
elseif((pcmt1 + pcmt2 + pcmt3 + pcmt4) > 10)
    max = 100
else
    max = 50

```

#### A. Thresholding

T is the Thresholding level which is 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  $Z_{i,j}$  = Image after Thresholding

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

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

#### B. 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  $v_t(a, b)$  = erosion in image,  $z(i, j)$  = central pixel,  $z(a, b)$  = pixels around the central pixel.  $n=M \times N/8$  and 't' repeats 'n' times

#### C. 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  $u_t(a, b)$  = dilation,  $v_t(i, j)$  = central pixel,  $v_t(a, b)$  = pixels around the central pixel  $n=M \times N/8$  and 't' repeats 'n' times

#### D. Resizing

It is to be done because the MRI standard size is 240x240 in database

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

Where  $D_{i,j}$  = Image after resizing

#### E. Matching Method

The standard database is SRI24 [21]. It is a MRI-based atlas of normal adult human brain anatomy, generated by template-free non rigid registration from MRI images of 24 normal control subjects

##### 1) Database Preparation

$SRI24_{240 \times 240}$  (m) = database

Where m is total number of MRI images in database (1240)

$$P_{57600 \times 1}(m) = [SRI24_{(240 \times 240, 1)}(1), SRI24_{(240 \times 240, 1)}(2), \dots \dots \dots SRI24_{(240 \times 240, 1)}(n)]$$

Where  $n = 1, 2, 3, \dots, 1240$ ,  $m$  is number of MRI's in database.

## 2) Cross Correlation Based Recognition

The cross correlation [23-24] in image processing has a very important significance. It is used for template matching

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

$r(n)$  = Autocorrelation in image  $D_{ij}$

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

$$r_m(n) = \sum_{k=0}^n D_{ij}(k) P_{ij}(k-n, m)$$

Where  $r_m(n)$  = Cross correlation between test image  $D_{ij}$ , and images of database  $P$ .

Sum of  $D_{ij}$  after autocorrelation,

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

Sum after cross correlation  $r_m(n)$ ,

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

The minimum of difference to get closest value

$$f_m = |S_m - S|$$

$$(Val1, K1) = Min(f_m)$$

Val1 = value of minimum

K1 = position of the minimum

## 3) Hard Thresholding

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

Hard Thresholding [22] uses the keep or kill rule. If the value matches with the given criteria, it is set to 1 and if does not then it is set to zero. Here if  $mch$  is '1' then no need for any further calculation because the MRI has been matched with any normal brain MRI significantly. But if  $mch$  is '0' then there is tumor.

## F. Detection

The detection is done to get the row and column values from which the tumor starts and ends. After all the required operation only the tumor part is left, so only the tumor part is enhanced and rest part of the image is zero or black, from the row where the tumor starts is considered to be minimum row, and where it ends is considered as maximum row. The same is followed for column operation. Below  $S_i$  is summation taken for row, it gives the number of minimum and maximum row of tumor. Where  $u_{i,j}$  is the image, after tumor recognition.  $S_j$  is the column operation to get minimum and maximum of the tumor from where it starts and ends.

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

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

Trl=Min(rw)

Tru=Max(rw)

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

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

Tcl=Min(cl)

Tcu=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, Tru is the row where the Tumor ends.

## IV. RESULTS

### A. Simulation Results

Figures given below shows the observed results after simulation of proposed work on MATLAB. These figures shows the original, segmented, eroded, dilated and finally detected tumor image.

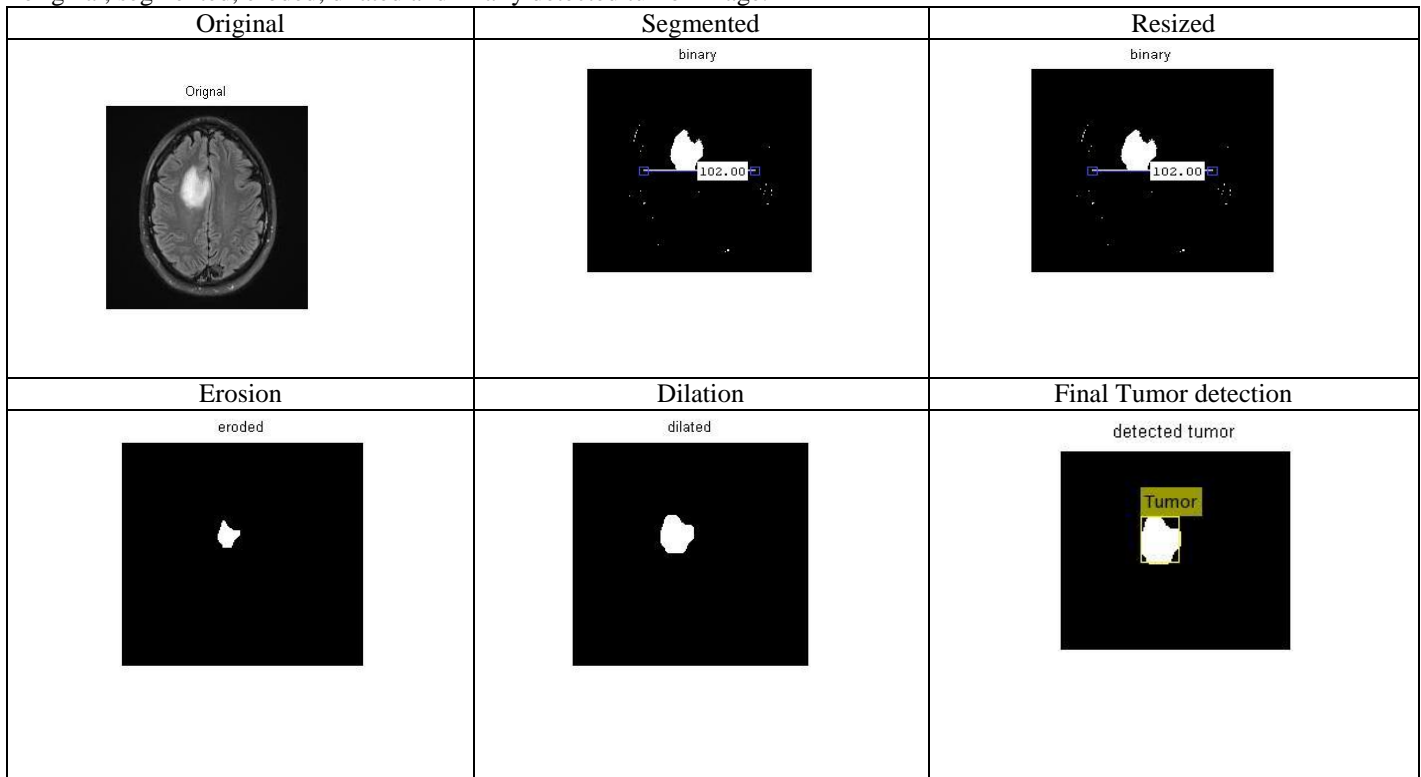


Fig. 3: Simulation results

### B. Accuracy

As shown in the figure below, it can be clearly observed that proposed work accuracy is found better as compare with available work

$$\text{Accuracy} = \frac{\text{Number of right results either matched or not matched with test MRI}}{\text{Total number of attempt}} * 100$$

100 times tested for different test images with or without tumors, 95 times proposed work shows correct matching.

$$\text{Accuracy} = \frac{95}{100} * 100 = 95$$

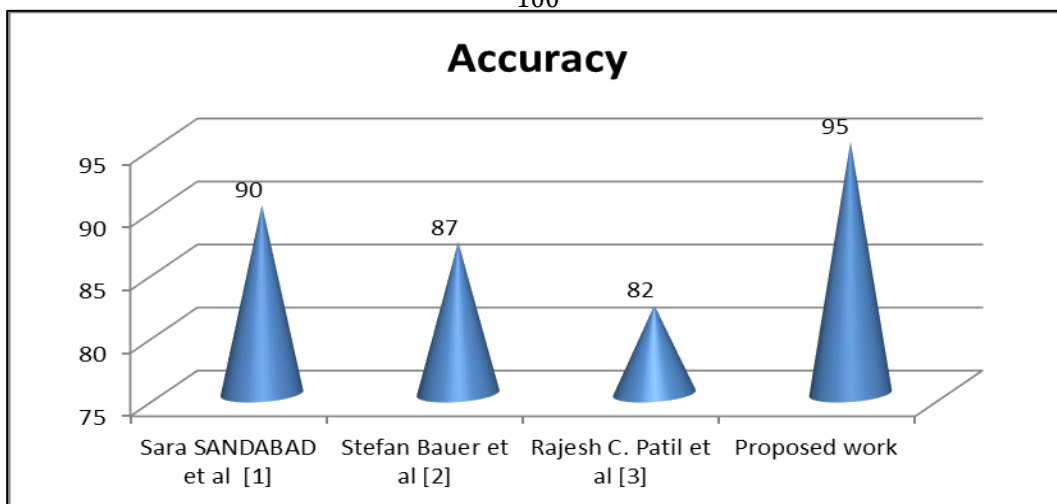


Fig. 4: Accuracy Results comparison

Matching requires threshold as in proposed work a hard Thresholding has been used, there are two possible error rates in Thresholding based matching algorithms FAR (False Accept Rate) and FRR (False Reject Rate). FAR is calculated as a fraction of impostor scores exceeding your threshold. FRR is calculated as a fraction of genuine scores falling below your threshold.

$$FAR = \frac{\text{wrong match above threshold}}{\text{all wrong match}}$$

$$FRR = \frac{\text{genuine match below threshold}}{\text{all genuine match}}$$

Proposed work total 1240 normal human MRI's available in SRI24 database, in simulations of 100 tumors MRI images only 2 tumors MRI's found as normal MRI and exceeds threshold and 98 does not exceeds threshold.

$$FAR = \frac{2}{98} = 0.020$$

Simulations of 100 normal MRI images only 4 normal brain MRI's could not exceeds threshold and detected as tumor MRI and 96 normal MRI's exceeds threshold successfully.

$$FRR = \frac{4}{96} = 0.040$$

### C. Simulation Time

As shown in the figure below, *proposed work* time to detect tumor is less as compare with available work

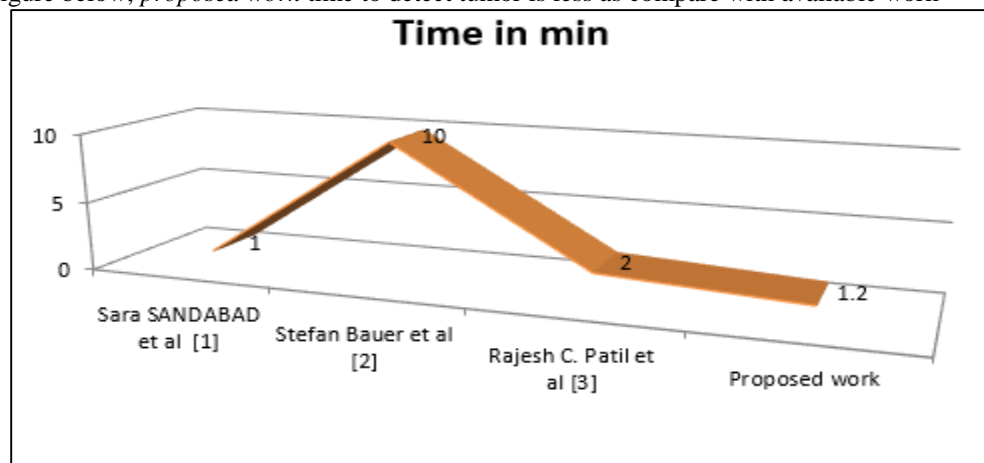


Fig. 5: Time delay Results comparison

### D. GUI Developed in MATLAB

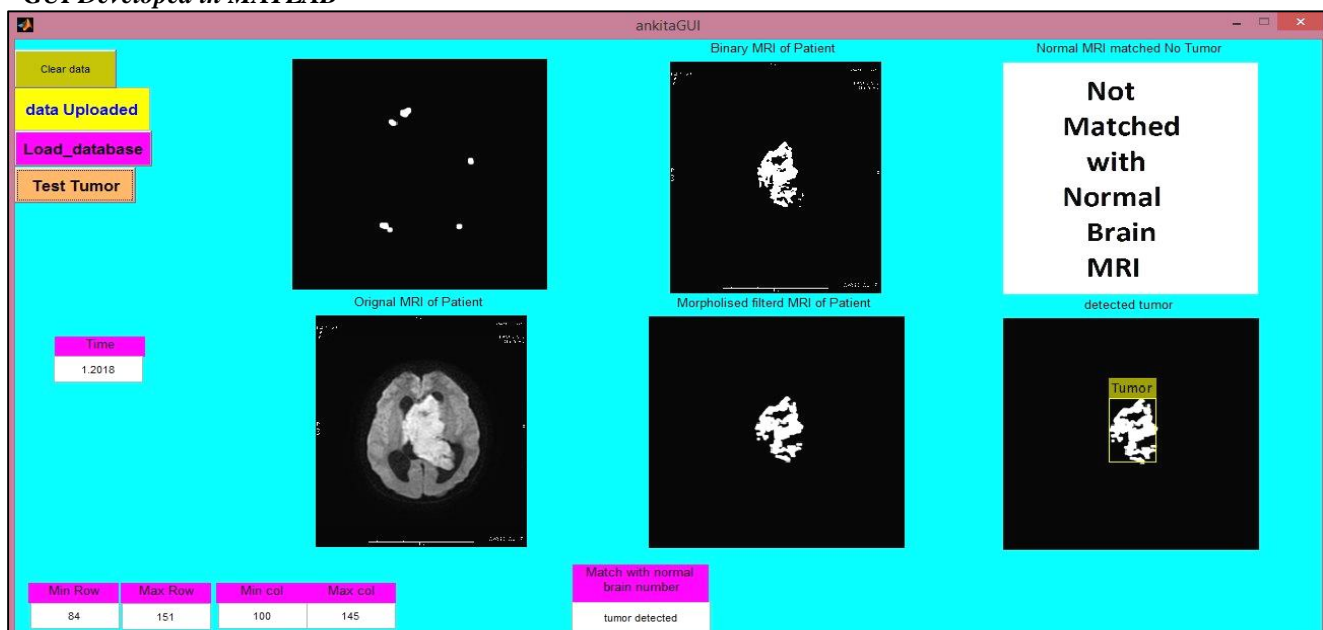


Fig. 6: GUI Developed for user interfacing for tumor detection in MRI image, when tumor detected

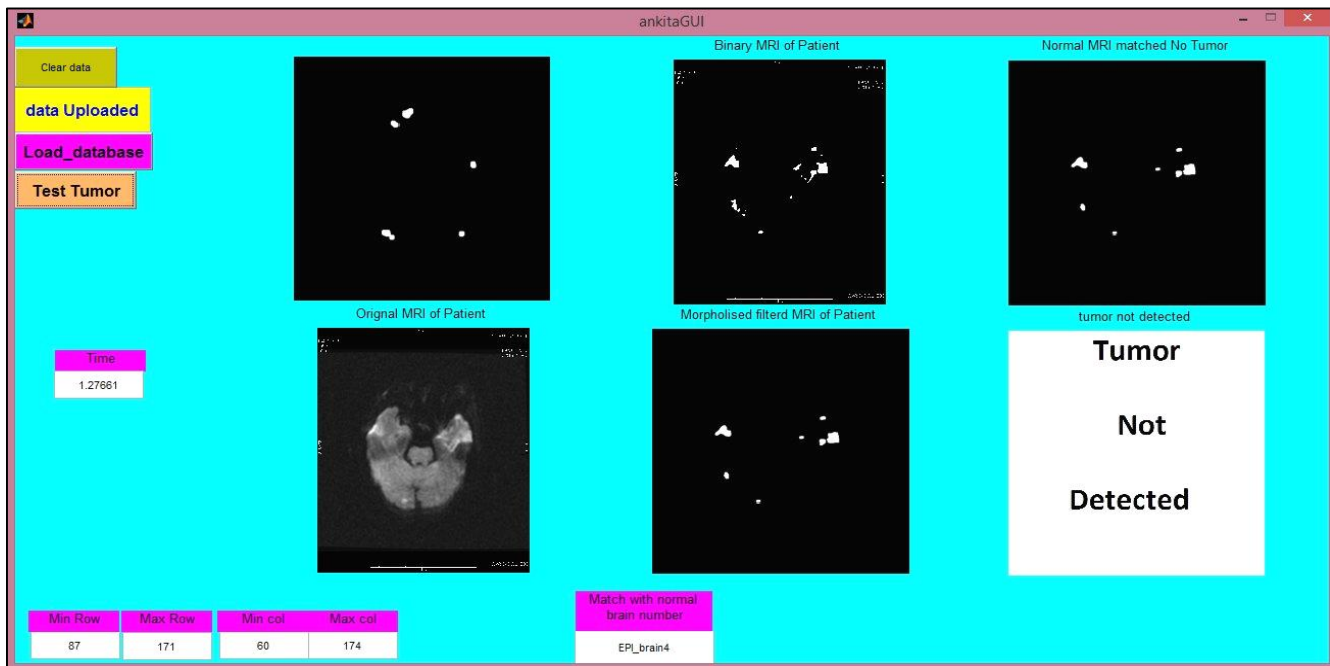


Fig. 7: GUI Developed for user interfacing for tumor detection in MRI image, when tumor not detected

In GUI database is taken first and then it takes the test image in which the tumor has to be recognized and when this test image is loaded, Thresholding and morphological filtering is performed on it. This processed image is then compared with the database templates. If the test image is matched with any of the images in database then there is no tumor in the test image and if the test image does not matched then there is a tumor in the test image.

## V. CONCLUSION

The proposed method for recognition of brain tumor in MRI images used multiple Otsu Thresholding and morphological filters which has given good segmentation results and MATLAB has been used to design the proposed system. To make the design user friendly a GUI has been developed. The results obtained are good in terms of accuracy and time delay. In the method real test MRI images has been collected. SRI24 (provided by International Medical Union) database has been used for matching test MRI image to ensure that the test image 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. Hence the application of proposed design is to identify tumor in MRI images of brain. In future, the proposed work can be used for recognition of tumor in other body parts.

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