

Automated brain tumor detection application development using digital image processing

Vipin Y. Borole¹, Sonali B. Kulkarni²

¹Department of Computer Science & Information Technology,
Dr. Babasaheb Ambedkar Marathwada University, Aurangabad

²Department of Computer Science & Information Technology,
Dr. Babasaheb Ambedkar Marathwada University, Aurangabad

Abstract: Automated brain tumor detection and tumor area calculation is a challenging task due to the complex structure of brain. MRI images offer better difference concern of various soft tissues of human body. MRI Imaging play an important role in brain tumor for detection analysis, diagnosis and treatment planning. It helpful to doctor for detection of tumor and diagnosis of disease as well as treatment planning of brain tumor. Brain tumor is an abnormal growth of cell of brain. MRI Image provides better results than CT, Ultrasound, and X-ray. In this study, design and developed Matlab application using various preprocessing, post processing and methods like; (Filtering, contrast enhancement, Edge detection) and post processing techniques like; (Histogram, Threshold, Segmentation, Morphological operation) through image processing (IP) tool. The brain tumor segmentation carried manually from MRI images is very crucial and time consuming task. Therefore, to avoid that, it needs to use computer aided method for detection of brain tumor. In this application MRI image is taken as input and applied various image processing techniques step by step upto brain tumor is separated from MRI images and tumor area is calculated in MM2.

Keywords: Brain tumor, MRI-Images, Tumor area, image processing.

1. INTRODUCTION

Automated brain tumor detection helps in diagnosis of brain tumor and helps in quantitative analysis of MR images such as measuring accurate size and volume of extracted tumor. Manually segmentation and tumor detection methods are time consuming and it may give inaccurate results [1-3]. The proposed algorithm overcome these problem and give better results. Exact measurements of brain tumor are difficult because of different shapes and sizes of tumor as well as complex structure of brain [4-5]. The proposed methods are tested with different MRI Brain cancer images with the different intensity, shape and size. Proposed method was successful to competently extract the tumor part from the brain tumor images. In the first step a MRI image taken form system after that perform the preprocessing operation on that image because when MRI machine taking an image from scanner that time it occur

some noise. For noise removal median filter applied on that image which is very helpful to remove the noise from image. By applying logarithmic transform it will give the better enhanced output which is very helpful to recognize tumor part from image.

After complete preprocessing step then perform the segmentation (Post processing). In this step thresholding segmentation techniques for image segmentation is used. Here perform the threshold segmentation which is very helpful for to converting of grayscale to binary by applying this techniques the tumor part will be look separate. For a next step which is helpful to recognize the objects or tumor part of the MRI image feature extraction (region props) method is used. After the image segmentation the region props method is applied which is under the region of interest techniques for separation of tumor object from the segmented image.

The next step of proposed algorithm is morphological operation. Erosion and dilation method are used for dealing with shape of the brain tumor object. Sometime the line or edges are not connected with each other so connect that edges or to remove the unwanted edges from the image for that reason morphology operator used which is very helpful to connect the edges or to remove the unwanted edges for image. After the tumor separation it calculate the tumor area. The method was tested using MATLAB 2013a. Experimental results for the MRI brain cancer kinds of image are shown below in the Graphical User Interface (GUI).

2. DATABASE

In this research, online MRI Database from Frederick National Laboratory the cancer imaging archive research institute REMBIENT database is used. MRI brain images are used, these MRI scanned images are displayed in a two dimensional matrix which will have the number of pixels as its elements. In this database various 134 MRI brain images of different planes are used, these MRI scanned images are displayed in a two dimensional matrix which will have the number of pixels as its elements. The database size is 25 MB and the resolution of image is 256 X 256 (width X height) and these images are grayscale images. The values of the gray scale image would range from 0 to 255, where 0 represents total black color and 255 shows pure white

color. Anything in between shows a variety of values representing the intensities of gray color. By using proposed algorithm (method, techniques) for input images, the tumor is detected and separated. After the tumor separation it calculate the tumor area. The exact tumor area detection is helpful for tumor diagnosis and treatment planning.

3. APPLICATION DESIGN (SNAP SHOT)

The GUI is the Graphical User Interface. It is design for user friendly application and GUI design is based on proposed algorithm. GUI application is design in MATLAB 2013a software. This GUI is useful for better understanding and better visualization of step by step execution. GUI design for automated brain tumor detection using image processing shown in figure-1 to figure- 8 step by step.

Step 1: Starting Window –

To click on run button the GUI design window is executed and the design window is shown in the form of application program and it shown the starting window.

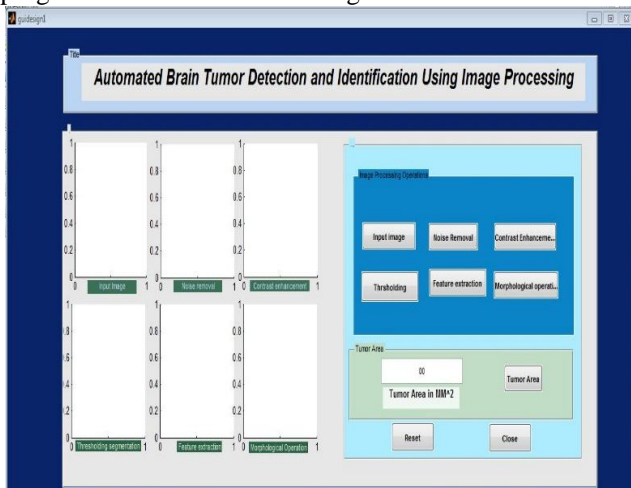


Figure 1: Starting window of GUI

Step 2: Browse input image-

To upload the input image to click on input image button then browse the image from specific location from the computer hard disk and select the brain tumor MRI image then upload the input image in input image axes.

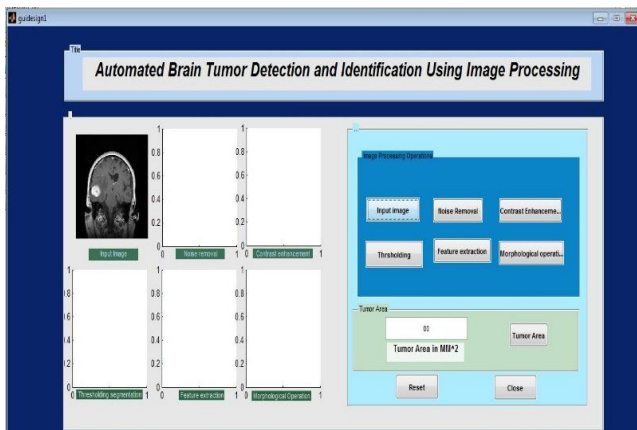


Figure 2 Read input image

Step 3: Noise removal technique applied-

To click on noise removal button the noise removal median filtering technique is applied on input image and the resulted image is shown noise removal axes.

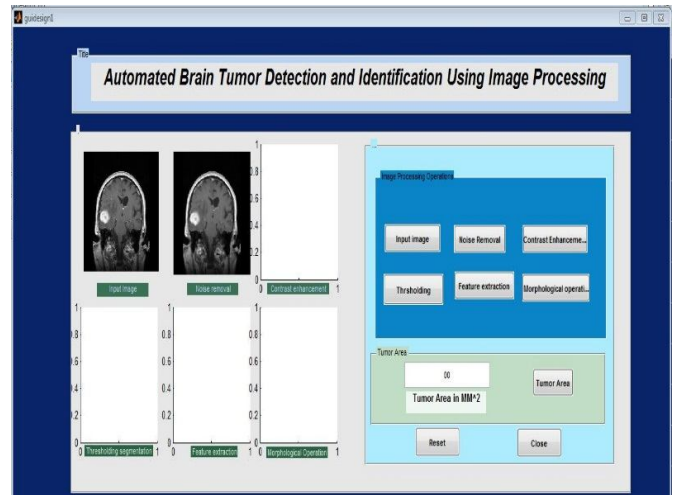


Figure 3 Result of noise removal

Step 4: Contrast enhancement-

To click on contrast enhancement button the contrast is enhanced and resulted image is shown in contrast enhancement axes.

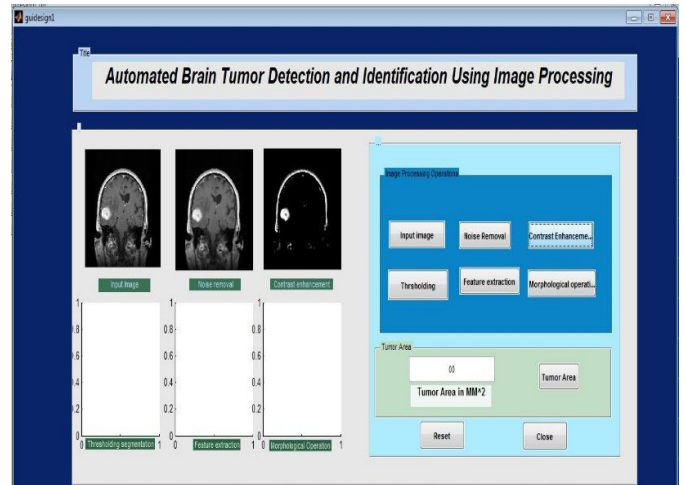


Figure 4 Result of Contrast Enhancement

Step 5: Thresholding segmentation-

To click on thresholding button it applied the thresholding segmentation on the preprocessed image perform the operation and reulted image is shown in thresholding segmentation axes.

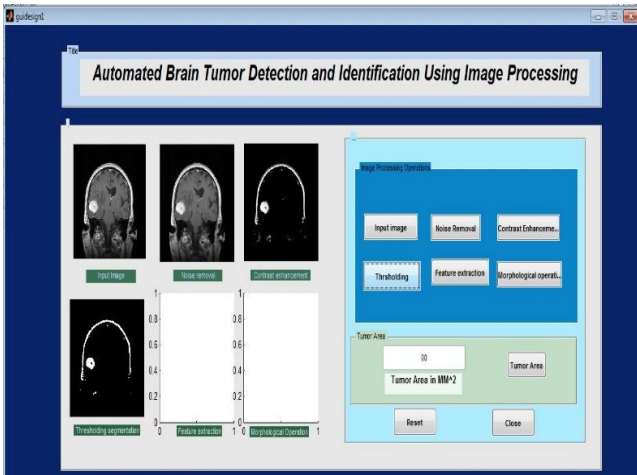


Figure 5 Result of Thresholding Segmentation

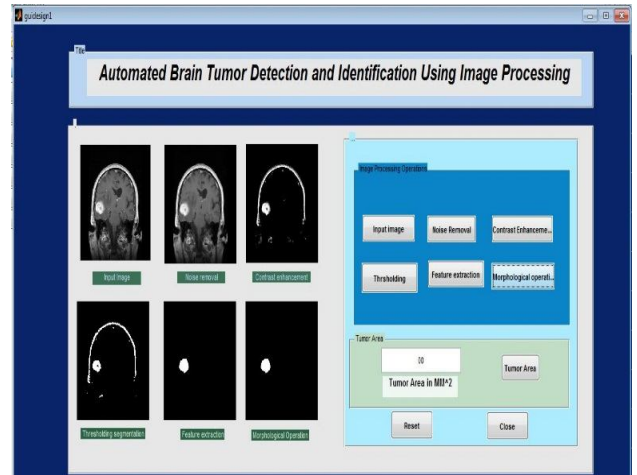


Figure 7 Result of Morphological Operation

Step 6: Feature Extraction method is applied –

To click on region props button it applied region props method for feature extraction. In feature extraction it separated the tumor area from the segmented image and separated tumor area is shown in region props axes.

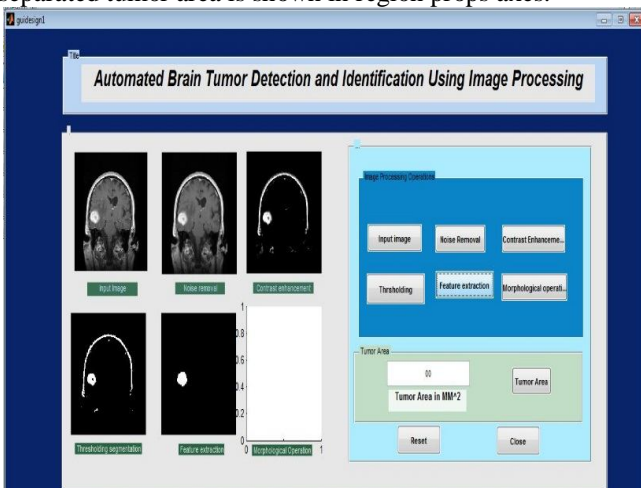


Figure 6 Result of Feature extraction

Step 8: Tumor area calculation-

To click on tumor area button it calculate the separated tumor area pixel then calculate the tumor area in millimeter square and the tumor area is shown in the textbox.

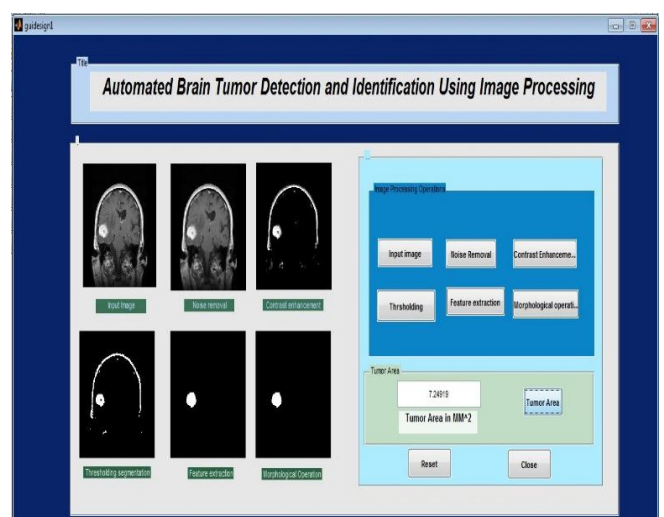


Figure 8 Result of Calculate tumor area

Step 7: Morphological Operation is applied-

To click on Morphological Operation button it applied the morphological operation on extracted tumor for enhance the shape of separated tumor. Then final resultant tumor is shown in morphological operation axes.

The proposed algorithm is tested on various brain tumor MRI images. Figure 1 to Figure 8 shows the process of tumor extraction from MRI images. Then the tumor portion of the MR image is visible, it shown in white color. This portion has the higher intensity than other region of the image. The above methods are successfully able to extract the brain tumor.

After to applying various methods of tumor separation from MRI brain images, it calculate the tumor affected area using tumor area calculation equation 4 and tumor area shown in mm². Same methods are applied for number of different MRI brain tumor images. Proposed algorithm is best suited for automated brain tumor detection and it gives good results as per the quality measurement and subjective knowledge.

4. TUMOR AREA CALCULATION

After the successfully tumor area separation from MRI brain images. The tumor area is shown in white color then first calculate the white pixel in the tumor area.

The binary image can be represented as a summation of total number of white and black pixels

The dimension of each image is 256×256 pixels Therefore; the pixel dimension is fixed to $1 \text{ mm} \times 1 \text{ mm}$.

An image (I) is given by

$$I = \sum_{W=0}^{255} \sum_{H=0}^{255} [f(0) + f(1)] \dots \dots \dots (1)$$

Where,

I= input image

Pixels = Width (W) X Height (H) = 256×256

W= (0 - 255) represent the intensity of pixel from 0 to 255

H= (0 - 255) represent the intensity of pixel from 0 to 255

$f(1)$ = white pixel (digit 1)

$f(0)$ = black pixel (digit 0)

$$\text{No_of_white pixel } P = \sum_{W=0}^{255} \sum_{H=0}^{255} [f(1)] \dots (2)$$

Where,

P = number of white pixels (width*height)

$$1 \text{ Pixel} = 0.264 \text{ mm} \dots \dots \dots (3)$$

The tumor area calculation formula is,

$$\text{Size_of_tumor, } S = [(\sqrt{P}) * 0.264] \text{mm}^2 \dots \dots \dots (4)$$

Where,

P= no-of white pixels

After finding the total number of white pixels by using equation (2) from the separated tumor region. Then calculate the tumor area using the equation (4) [1-3].

5. CLASSIFICATION

Classification techniques is used to classify the images of the medical test. In the given test the disease is present or absent whether to check the test is accurate or fail. In the classification of the brain tumor MRI image is there are different parameter is used. In the medical field sensitivity and specificity are used to evaluate the clinical test. For detection of sensitivity and specificity the classification of test image is necessary. TP, FN, TN, FP parameters are used to classification of test image [6].

TP = True Positive: There will be some cases with the disease correctly classified as positive

FN = False Negative: some cases with the disease will be classified negative

TN = True Negative: some cases without the disease will be correctly classified as negative

FP = False Positive: some cases without the disease will be classified as positive. For this study total 134 images are used, for representation of classification and experimental results. Classification of disease present or disease absent shown in Table 4. It shows the classification of TP, FN, TN, FP.

5.1. Sensitivity and Specificity

Sensitivity and specificity are terms used to evaluate a clinical test. Sensitivity and specificity are used for classification of MRI images; whether tumor is present or not. In general, the higher the sensitivity, the lower the specificity, and vice versa. The sensitivity of a clinical test refers to the ability of the test to correctly identify those

patients with the disease. The specificity of a clinical test refers to the ability of the test to correctly identify those patients without the disease [7,8]. By using the classification of brain tumor images, prepare the table 5 for analysis of sensitivity and specificity. In this table it shows the True positive, False Negative, False Positive, False Negative values as well as total number of images. To calculate the sensitivity, specificity and accuracy of the results by using the value of TP, FN, FP, TN form Table 1 is used.

Table 1 sensitivity and specificity analysis

Truth	Disease [number]	Non Disease [number]	Total [number]
Positive [number]	(True Positive) 116	(False Positive) 12	T Test Positive 128
Negative [number]	(False Negative) 3	(True negative) 3	T Test Negative 6
Test Results	T Disease 119	T Non Disease 15	Total 134

- Formula of Sensitivity, Specificity and Accuracy.

$$\text{Sensitivity} = \frac{TP}{TP + FN} \dots \dots \dots (7)$$

$$\text{Specificity} = \frac{TN}{TN + FP} \times 100 \dots \dots (8)$$

$$\text{Accuracy} = \frac{(TP+TN)}{(TP + FN+FP+TN)} \dots (9)$$

- Calculation of Sensitivity, specificity and accuracy equation 7, 8, and equation 9 are used respectively.

$$\text{Sensitivity} = \frac{116}{116 + 3} \times 100 = 97\%$$

$$\text{Specificity} = \frac{3}{3 + 12} \times 100 = 20\%$$

$$\text{Accuracy} = \frac{(116 + 12)}{(116 + 3 + 12 + 3)}$$

Sensitivity: probability that a test result will be positive when the disease is present.

Specificity: probability that a test result will be negative when the disease is not present [8].

After the classification of the MRI images, to analysis of TP, FN, FP, TN and calculate the sensitivity, specificity

and accuracy. It shows that sensitivity=97.47 %, Specificity= 20%, and Accuracy= 95.52%.

6. CONCLUSION

This paper illustrates the experimental Results of different MRI images. Various digital image processing methods are used for tumor detection. The proposed algorithm detects the tumor affected area and separated from the background area (MRI Image), then calculates the tumor area, and measure the quality of images. Whatever the proposed algorithm successfully extract the tumor from the MRI images and calculate the tumor area with good results. Sensitivity and specificity used for classification. For result analysis receiver operating characteristic curve (ROC) is also used and this algorithm achieves sensitivity up to 97.47 % and specificity equal to 20 % and accuracy is 95.52 %.

References

- [1] V. P. Ananthi, P. Balasubramaniam, T. Kalaiselvi, "A new fuzzy clustering algorithm for the segmentation of brain Tumor", Springer-Verlag Berlin Heidelberg 2015, 29 July 2015.
- [2] Ravi Kumar, Munish Rattan, "Analysis of Various Quality Metrics for Medical Image Processing", IJARCSSE, 2012 pp.137- 145, 2012.
- [3] Sivasundari .S, R. Siva Kumar, M.Karnan, "Performance analysis of image filtering algorithms for mri images", Volume: 03 Issue 05, pp. 438-441, May-2014.
- [4] Swathi P S, Deepa Devassy, Vince Paul, Sankaranarayanan P N, "Brain Tumor Detection and Classification Using Histogram Thresholding and ANN" International Journal of Computer Science and Information Technologies, Volume 6(1), pp.173-176, 2015.
- [5] Eman Abdel-Maksoud, Mohammed Elmogy, Rashid Al-Awadi, "Brain tumor segmentation based on a hybrid Clustering technique", Egyptian informatics journal (2015), pp.71-81, February 2015.
- [6] [Online Available] <https://dsp.stackexchange.com/questions/11326/difference-between-snr-and-psnr>
- [7] Vipin Y. Borole, Sunil S. Nimbhore, Seema S. Kawthekar, "Image Processing Techniques for Brain Tumor Detection: A Review", International Journal of Emerging Trends & Technology in Computer Science, Volume 4, Issue 5(2), page No.(28-32), September – October 2015
- [8] Vipin Y. Borole, Seema S. Kawthekar, "Study of various DIP Techniques used for Brain Tumor detection and tumor area calculation using MRI images", International Journal of Computer Sciences and Engineering, Volume-4, Issue-7, July 2016, Pg. 39-43
- [9] [Online Available] <http://gim.unmc.edu/dxtests/reviewof.htm>
- [10] [Online Available] <https://onlinecourses.science.psu.edu/stat507/node/71>
- [11] [Online Available] https://www.medcalc.org/calc/diagnostic_test.php
- [12] [Online Available] <https://www.medcalc.org/manual/roc-curves.php>