

MATLAB Implementation of an Efficient Technique for Detection of Brain Tumor by using Watershed Segmentation and Morphological Operation

T. Maha Lakshmi

Assistant Professor

*Department of Electronic and Communication Engineering
P. V. P Siddhartha Institute Of Technology, Kanuru, A. P*

R. Swathi

Assistant Professor

*Department of Electrical & Electronics Engineering
P. V. P S.I.T, KANURU, A. P*

Dr. A. Srinivas

Associate Professor

*Department of Electronic and Communication Engineering
GITAM University, A.P*

Abstract

Medical imaging is placing a major role in diagnosing the diseases and in image guided surgery. There are various imaging modalities for different applications giving the anatomical and physiological conditions of the patient. Magnetic Resonance Image (MRI) are used to analyze the human organs without surgery. Detection of the tumor is the main objective of the system. Detection plays a critical role in biomedical imaging. Brain image segmentation is one of the most important tools and hence need by the clinicians. However an accurate segmentation is a significant task and crucial for exact diagnosis. In this paper, MRI brain image is used to tumor detection process. This system includes test the brain image process, image filtering, skull stripping, and segmentation by using OTSU and watershed, morphological operation, calculation of the tumor area and determination of the tumor location.

Keywords- Magnetic resonance image, skull stripping, segmentation, morphological operation, detection

I. INTRODUCTION

Radiation Oncologists and many other medical experts currently spend a substantial portion of their time segmenting medical images, and in particular, labeling brain tumors and associated edema in MRI. This labeling is especially important when planning radiation therapy, and new treatment techniques such as Intensity-Modulated Radiation Therapy will soon drastically increase the segmentation workload [1]. The introduction and acceptance of these types of new technology will thus depend on reducing the manual time associated with detecting and segmenting tumors. Over the past 15 years, an immense amount of research has focused on semi-automatic and fully automatic methods for detecting and/or segmentation brain tumors in MRI scans, but the tools used in practice still rely on significant manual interaction. There have been manually engineered automatic systems designed to perform this task, but even the most effective of these address simplified cases (such as the high-contrast 'enhancing' pixels [2]), do not achieve sufficiently accurate results for difficult cases [3], and depend highly on the local imaging hardware available to the designer. This is primarily due to the complex nature of the data, and the difficulty in translating complex anatomic knowledge into a series of operations that have good generalization properties. There has been significant exploration of this problem from a Machine Learning (ML) perspective, by formulating the problem as a pixel classification task (illustrated in Figure 1). A Machine Learning solution would remove dependencies on the specific imaging hardware used (as it could be trained on images produced by any system), and could potentially have better generalization properties than manually engineered systems for this task. However, Machine Learning approaches applied to this problem have had limited success. This is a result of the pixel intensities violating the 'independent and identically distributed' (iid) assumption within and between images, and of the observation that some normal pixels look very similar to some tumor pixels. The iid assumption is violated due to the spatial nature of the data, and the corruption of MRI intensities by inter-slice intensity variations, an intra-volume intensity bias field, and differences in the intensities recorded for identical tissues between volumes. The latter problem is the most severe, and proposed ML methods often require training data from the image to be segmented (termed patientspecific training) [4]. Some recent ML systems have incorporated techniques to correct (or reduce) these effects to allow inter-patient training [5, 6, 7], making the methods fully automatic. However, disambiguating normal and tumor regions with similar or identical intensity properties remains an unsolved problem. In the medical field, magnetic resonance image (MRI) is widely used in many research [1]. MRI techniques is a

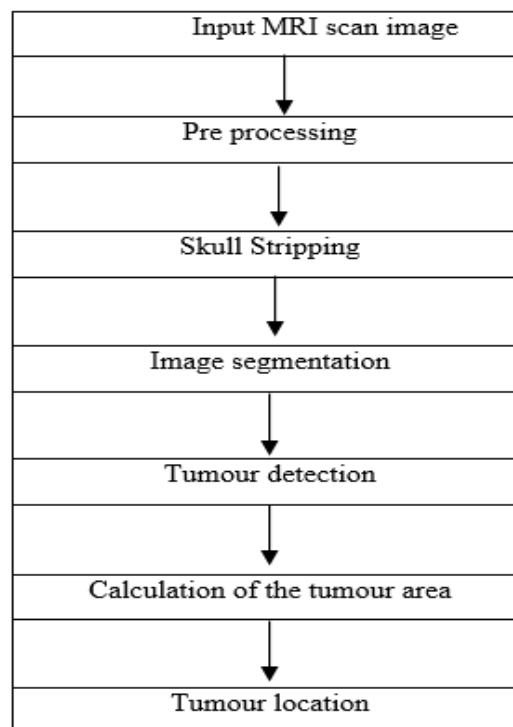
noninvasive method and uses powerful magnet and radio waves to create the picture of the body. It is suited for examining soft tissues of the human body such as Ligament and tendon injury, spinal cord injury and brain tumors, etc. [2]. The detail information of the human brain can be get using MRI techniques [1]. Brain, heart and lung etc. are the most important parts of the human body. And then, all parts of the body are controlled by the brain cells [3]. Therefore, brain is a vital organ of the body. Nowadays, brain tumor is a very serious disease among children and adults. The most deadly and intractable diseases are brain tumor [4]. Brain tumor's location and quickly spreading make a critical problem in treatment of tumor [5]. Thus, image segmentation and detection are vital method to solve the medical problem of the various diseases. Imaging of the brain tumor can be done by computer tomography (CT) scan, magnetic resonance image (MRI) scan, Ultrasound, etc. In this research, MRI scan is used to implement the system [2].

Several works for detection of the brain tumor have been reported in [1],[5] - [8]. Pratik P et al [1] proposed brain tumor detection method using connected component analysis. The method proposed by Manor K Kowari et al [5] requires to do image cropping so that the exact result of the tumor region is not obtained. M. Masroor Ahmed et al [6] proposed the method of the brain tumor detection using Kmeans Clustering. Nagalkar V J et al [7] proposed brain tumor detection using soft computing method. This method can cause false detection in seeing scan. Rajesh C. Patil et al [8] proposed the method of the brain tumor extraction from MRI images using MATLAB. Image segmentation can be done by various techniques: histogram thresholding, region growing, K-means Clustering and watershed segmentation [9]. Watershed segmentation is suitable for tumor region that have higher intensity values [10]. In this paper, marker controlled watershed segmentation is used to prevent over segmentation [11]. Preprocessing of the MRI image is the primary step which removes noise and smooth the image. To prevent misclassification of brain tissue and non-brain tissues, skull stripping is done [8]. And, image segmentation is carried out using marker controlled watershed segmentation [12]. Then, the tumor region is detected from the segmented image using morphological operation and calculated the tumor region [4]. Finally, the location of the tumor region is determined.

II. METHODS

In this paper, the system is implemented as shown in Fig-1. In this system, the input MRI brain image is used to implement the algorithms. MRI image gives the detailed information of the brain tissues than other scan of the brain. Firstly, the brain image is checked out as the brain image with tumor region or the brain image without tumor region. So, the tumor region is extracted from the brain image and the number of pixel for the tumor region is calculated. If the number of pixel for the tumor region is equal to zero, the system displays the brain image without tumor region. Otherwise, the system displays the brain image with tumor region. If the brain image has tumor region, this image is needed to do the following further steps. In the next step, the noise from the brain image is removed using filter. Several filters can be used to remove the noise. But, the MRI image does not contain a lot of noise. Measure the properties of a specified image region, such as the area, centre of mass, and bounding box.

III.FLOWCHART



A. Preprocessing

In this phase image is enhanced in the way that finer details are improved and noise is removed from the image. Most commonly used enhancement and noise reduction techniques are implemented that can give best possible results. Enhancement will result in more prominent edges and a sharpened image is obtained, noise will be reduced thus reducing the blurring effect from the image. In addition to enhancement, image segmentation will also be applied. This improved and enhanced image will help in detecting edges and improving the quality of the overall image. Edge detection will lead to finding the exact location of tumor.

Following steps will be followed in the preprocessing stage:

- 1) The acquired MRI scanned image, stored in database is converted to gray scale image of size 255*255;
- 2) Image is processed to remove any noise represent. Visual quality of noisy image will not be satisfactory;
- 3) The noiseless, high quality image is then operated by a high pass filter for sharpening and edge detection. ;
- 4) The obtained sharpened image is then added to original image for further enhancement.

1) Noise Removal

Many filters are used to remove the noise from the images. Linear filters can also serve the purpose like Gaussian, averaging filters. For example average filters are used to remove salt and pepper noise from the image. Because in this filter pixel's value is replaced with its neighborhood values. Median filter is also used to remove the noise like salt and pepper and weighted average filter is the variation of this filter and can be implemented easily and give good results. In the median filter value of pixel is determined by the median of the neighboring pixels. This filter is less sensitive than the outliers.

2) Image Sharpening

Sharpening of the image can be achieved by using different high pass filters. As now noise is been removed by using different low pass filters, we need to sharpen the image as we need the sharp edges because this will help us to detect the boundary of the tumor. Gaussian high pass filter is used to enhance the boundaries of the objects in the image. Gaussian filter gives very high rated results and used very widely to enhance the finer details of the objects.

B. Skull Stripping

Skull stripping is important process in biomedical image analysis. It is needed to make only in brain image but is not needed to make in other medical image analysis such as heart, lung, etc. It must be done before other image processing step. It is a process of eliminating all non-brain tissues from brain image. In skull stripping, it is removed extra cerebral tissues such as skull, fat, skin, etc. Skull stripping can be done by various methods. They are automatic skull stripping using image contour, skull stripping based on region growing and mathematical morphology, skull stripping based on histogram analysis, skull stripping based on resonance principle and skull stripping based on threshold value. Skull stripping based on threshold value is used to remove the skull tissues in this paper. In the skull stripping based on threshold value, the threshold value of the skull tissues and that of normal brain tissues are manually determined for every image.

A technique that is to be used must be effective, efficient, reliable and fully automated. Different techniques have been developed and every technique has its own pros and cons. Some techniques are effective but very inefficient and vice versa. But the morphological techniques is an effective and fully automated but inefficient way of stripping skull. Erosion and Dilation are two basic operators in the area of mathematical morphology. These typically applied to binary images, but there are versions that work on grayscale images. As erosion is a technique which uses background and the foreground for the processing. In Brain MRI there is a particular intensity of the back-ground that appears before brain image. Unfortunately in brain MRI, the same intensity is appeared as a part of the brain. And this appearance is a false background. So in this scenario that algorithm would be unable to distinguish between the original back ground and the false background. Eventually the area around the false background will also be eroded, which causes distortion in the brain tissues image [13] along with the skull.

1) Steps Involved In Skull Stripping

- 1) Step 1: Read the image.
- 2) Step 2: Convert it to grayscale.
- 3) Step 3: Convert it into binary image.
- 4) Step 4: Remove the noise from the image.
- 5) Step 5: Apply the Erosion operation.
- 6) Step 6: Stop the process.

C. Watershed Segmentation

Watershed segmentation is a gradient-based segmentation technique. It considers the gradient map of the image as a relief map. It segments the image as a dam. The segmented regions are called catchment basins. Watershed segmentation solves a variety of image segmentation problem. It is suitable for the images that have higher intensity value. Watershed segmentation is caused over segmentation. To control over segmentation, marker controlled watershed segmentation is used. Sobel operator is suitable for edge detection.

D. OTSU'S Method for Image Segmentation and Optimal Global Thresholding

Let the components of an image histogram be denoted by $P = nq/n$ $q=0,1,2,3,\dots,L-1$ Where n is the total number of pixels in the image nq , is the number of pixels that have intensity level q , and L is the total number of possible intensity levels in the image (remember. Intensity levels are integer values). Now suppose that a threshold k is chosen such that c_1 is the set of pixels with levels $[0, 1, 2, \dots, k]$ and c_2 is the set of pixels with levels $[k+1 \dots L-1]$. Otsu's method is optimum, in the sense that it chooses the threshold value k that maximizes the between-class σ , defined as: $\{0, 1, 2, \dots, L-1\}$, L means gray level intensity $M \times N$ is the total number of pixel, Denote the number of pixels with intensity q . We select C_1 a threshold and use it to classify: Intensity in the range C_1 and C_2

$$P_1(k) = \sum_{i=0}^k p_i \quad P_2(k) = \sum_{i=k+1}^{L-1} p_i = 1 - P_1(k)$$

; Apply this

$$P_1 m_1 + P_2 m_2 = m_G$$

After that

$$P_1 + P_2 = 1$$

$$\sigma_G^2 = \sum_{i=0}^{L-1} (i - m_G)^2 p_i$$

$$\sigma_B^2(k) = P_1 P_2 (m_1 - m_2)^2 = \frac{(m_G P_1(k) - m(k))^2}{P_1(k)(1 - P_1(k))}$$

Above regional process

$$\eta = \frac{\sigma_B^2(k)}{\sigma_G^2} \quad 0 \leq \eta(k^*) \leq 1$$

It is a measure of separability between classes onwards

$$g(x, y) = \begin{cases} 1 & \text{if } f(x, y) \geq k^* \\ 0 & \text{if } f(x, y) < k^* \end{cases}$$

For $x = 0, 1, 2, \dots, M-1$ and $y = 0, 1, 2, \dots, N-1$. Syntax for otsu method:- $[T, SM] = \text{graythresh}(f)$, Where f is input image. T is resulting threshold normalized to range $[0, 1]$. SM is separability measure. $\gg [T, SM] = \text{graythresh}(f)$ $T = 0.4902$, $SM = 0.9437$, $\gg T * 255$ $Ans = 125$ $G = \text{im2bw}(f, T/255); \text{imshow}(G);$

E. Morphological Operation

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. A morphological operation on a binary image creates a new binary image in which the pixel has a non-zero value. Morphological operations transform the image. In this paper, erosion is applied to detect the tumor [6]. The erosion of A by B is given by the expression: $A \ominus B = \{(i, j) : B(i, j)\}$ (4) Where, A = the binary image, B = the structuring element (i, j) = the center pixel of structuring element

F. Calculation of the Tumor Region

The area of the tumor region is calculated by the following equation: Tumor area = $A \times$ total number of pixel in the tumor region (5) $A = V \times H$ (6) Where, A = the area of each pixel H = horizontal dimension of the image V = vertical dimension of the image $H = 1/\text{horizontal resolution of the image}$ $V = 1/\text{vertical resolution of the image}$ ed watershed segmentation, sobel operator is used to distinct the edge of the object [10].

IV. IMPLEMENTATION

In this paper, the system is implemented as shown in Fig-1. In this system, the input MRI brain image is used to implement the algorithms. MRI image gives the detailed information of the brain tissues than other scan of the brain. Firstly, the brain image is checked out as the brain image with tumor region or the brain image without tumor region. So, the tumor region is extracted from the brain image and the number of pixel for the tumor region is calculated. If the number of pixel for the tumor region is equal to zero, the system displays the brain image without tumor region.

Otherwise, the system displays the brain image with tumor region. If the brain image has tumor region, this image is needed to do the following further steps. In the next step, the noise from the brain image is removed using filter. Several filters can be used to remove the noise. But, the MRI image does not contain a lot of noise. So the average filter is used to remove the noise from the brain image in this system. After preprocessing, the smoothed image is obtained and it is ready to use in the next step. The smoothed image is used to operate the next step quickly. In brain image, skull stripping is needed to do for avoiding misclassification. Skull stripping can be done by various method. In this paper, skull stripping based on threshold value is used to extract the skull tissues. In process, the brain tissues are firstly extracted from the brain image and the holes are filled the brain image. And then, the skull tissues are extracted from the filled image and are given the name, the skull image. The skull image is

converted into the binary image. The binary image and the inverse of the image that extract brain tissues image are combined to get the skull border. When the skull border in the brain image is given zero, the brain image without skull tissues is get. After the brain image without skull tissues had been obtained, segmentation process is done. In segmentation step, the brain image obtained from the skull stripping step is segmented using marker controlled watershed segmentation. This segmentation process uses the sobel operator to find the gradient image. Using the gradient image, the watershed transform is estimated. Next, the segmented image is divided into normal brain region and tumor region according to intensity value of the original image. Therefore, the final segmentation map is get. Then, the tumor region is detected from the final segmentation map using morphological operation. In this process, the image get from the segmentation step is eroded. And then, the gray matter and white matter are extracted from the brain image. The region properties of the image are defined and the values of the regions are calculated. And the region that has the maximum intensity value is found out.

Finally, the tumor region is efficiently detected from the brain image. After the tumor region had been detected from the brain image, the area of the tumor region is calculated. Firstly, the area of the pixel is calculated. Then, the total pixel of the tumor region is calculated. And then, the area of the tumor region is calculated. Next, the location of the tumor region is determined. The tumor image obtained from the detection process is divided into two parts. The right part of the image is defined as the left hemisphere of the brain and the left part of the image is the right hemisphere of the brain. Then the total number of pixel for each part is calculated and compared them. If the total number of pixel of each part is equal, the tumor is located in the center of the brain. Otherwise, the other two conditions are checked out. If the pixel value of the right part of the image is greater than that of the left part, the tumor is located in the left hemisphere of the brain and else the tumor is located in the right hemisphere of the brain.

A. Area

In this, after the tumor region is detected, the maximum intensity pixel value can be obtained .By using this intensity value, the pixels can be converted into square millimeters. We have to follow some sequential steps to calculate the result.

1) Algorithm

The algorithmic steps involved for brain tumour shape detection is as follows,

- 1) Step 1: Start the process.
- 2) Step 2: Get the MRI scan image input in JPEG format.
- 3) Step 3: Check whether the input image is in required format and move to step 4 if not display error message.
- 4) Step 4: If image is in RGB format covert it into gray scale else move to next step. . .
- 5) Step 5: Calculate the size of the tumour using the formula.
- 6) Step 6: Display the size and stage of tumour.
- 7) Step 7: Stop the program.

This algorithm scans the RGB or gray scale image, converts the image into binary image by binarization technique and detects the edge of tumour pixels in the binary image. The stage of tumour is based on the area of tumour. Here considered that, if the area is greater than 6.00mm^2 it will be the critical position. The stage of tumour is based on the area of tumour. Here considered that, if the area is greater than 6.00mm^2 it will be the critical position.

B. Location

The tumor image obtained from the detection process is divided into two parts. The right part of the image is defined as the left hemisphere of the brain and the left part of the image is the right hemisphere of the brain. Then the total number of pixel for each part is calculated and compared them. If the total number of pixel of each part is equal, the tumor is located in the center of the brain. Otherwise, the other two conditions are checked out. If the pixel value of the right part of the image is greater than that of the left part, the tumor is located in the left hemisphere of the brain and else the tumor is located in the right hemisphere of the brain.

1) Algorithm

- 1) Step 1: Start the process.
- 2) Step 2: Read image
- 3) Step 3: convert the image to gray scale image.
- 4) Step 4: calculate the no.of rows and no.of columns in an image.
- 5) Step 5: Divide the rows and columns into two half's.
- 6) Step 6: display the result as left hemisphere and right hemispre.
- 7) Step 7: Stop the process.

V. RESULTS

When the input image is loaded into the test image process, the process classifies as the image into two types: the brain image with tumor and the brain image without tumor. We have taken the image with tumor and we implemented using this. The MR image is referred in the (fig 4.1) for the input image.

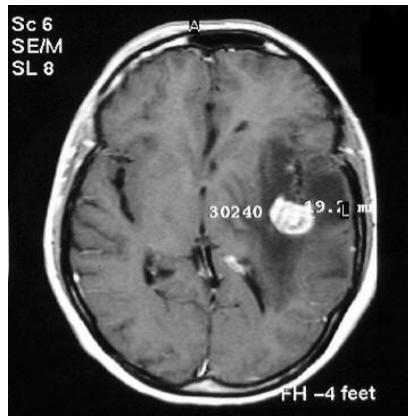


Fig. 4.1: Original Brain Image

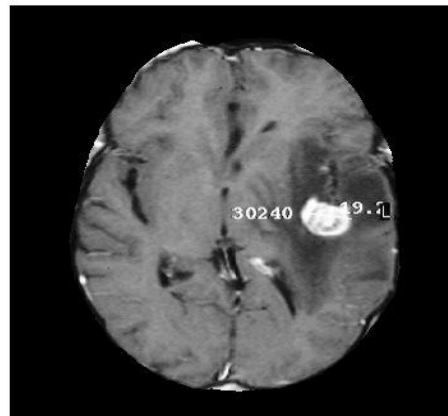


Fig. 4.2: Skull Stripping

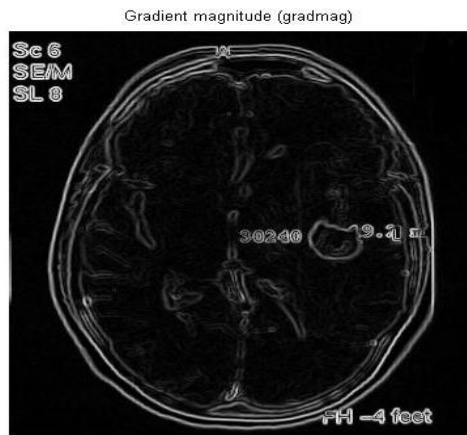


Fig. 4.3: Watershed Segmentation

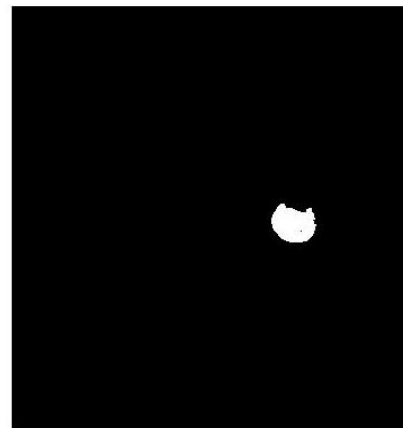


Fig. 4.4: Brain Tumor

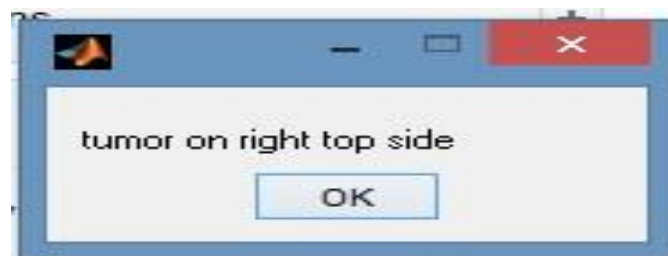


Fig. 4.5: Location

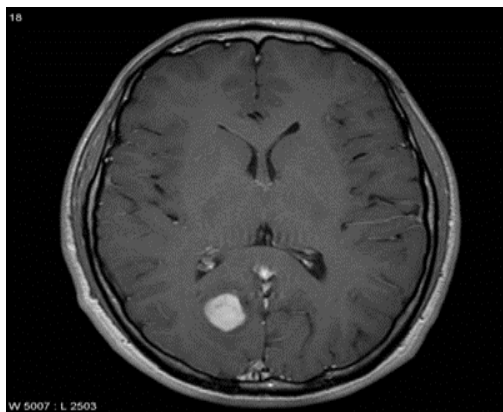


Fig. 4.6: Original Brain Image

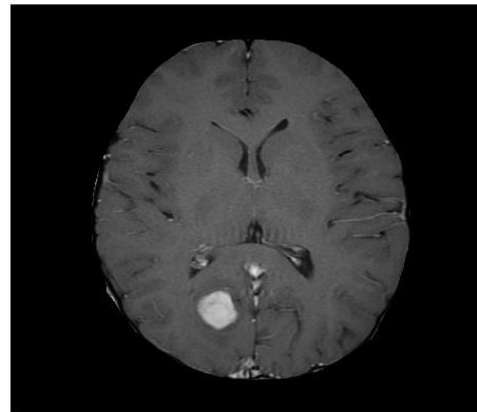


Fig. 4.7: Skull stripping



Fig. 4.8: Brain tumor



Fig. 4.9: Watershed Segmentation

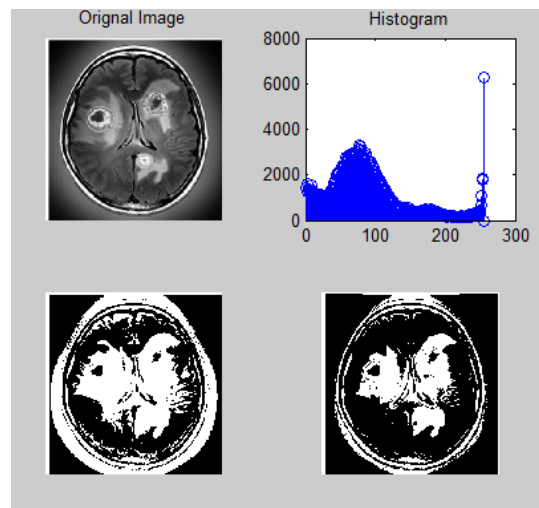


Fig. 4.10: OTSU method

VI. CONCLUSION

This Research is our continuous study and we will find the better results in highlighting the tumor in the segmented portion. Magnetic resonance image (MRI) is a critical part in many researches. So the MRI brain image is used to implement the system. And morphological operation is used to detect the tumor region. It is easy to implement and reasonably fast. In this work, the brain image testing process has been done. This method is given the reliable result for the brain image. If the brain image has the tumor region, the further processing steps are needed to be done. The preprocessing step is important to segment the brain image. After the preprocessing, the brain image is free from noise and this smoothed image is ready to be used in further processing. In this system, a skull stripping based on threshold value has been done. This method is able to remove the skull tissues from the brain image and give the suitable result. And then, marker controlled watershed segmentation has been done. Therefore, the intensity of normal brain tissues and that of tumor region is split up into groups. After segmentation, this resulted image is divided into the normal brain region and the tumor region to get the final segmentation map. After that, the tumor region is detected from the final segmentation map using morphological operation. And the tumor region is calculated according to the equation. Finally, the location of the tumor region has been determined based on the pixel value of the tumor region in this paper, the tumor region is extracted from the single MRI brain slice. Really, MRI scan take the picture of the brain in many slices. And the tumor region is not located in the single slice. Above the reason, the tumor volume is needed to calculate. The volume of the tumor is calculated to get the exact result of the tumor region. Therefore, the tumor volume is needed to calculate.

REFERENCES

- [1] “SweZin Oo1, AungSoe Khaing2” brain tumor detection and segmentation using watershed segmentation and morphological operation. IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308.
- [2] “Rohit S. Kabade” Segmentation of Brain Tumour and Its Area Calculation in Brain MR Images using K-Mean Clustering and Fuzzy CMean Algorithm. International Journal of Computer Science & Engineering Technology (IJCSSET).
- [3] “Mansa S Mane & Nikita J Kulkarni & Santosh N Randive” Review on Brain Tumor Detection and Segmentation Techniques. International Journal of Computer Applications (0975 – 8887) Volume 95– No.5, June 2014.
- [4] “R. Rajeswari 1, G. Gunasekaran 2” Tumor Detection and Segmentation Using Watershed and Hierarchical Clustering Algorithms. International Journal of Innovative Research in Computer and Communication Engineering (An ISO 3297: 2007 Certified Organization) Vol.2, Special Issue 5, October 2014.
- [5] “Geetika Gupta1, Rupinder Kaur2, Arun Bansal3, Munish Bansal” Analysis and Comparison of Brain Tumor Detection and Extraction Techniques from MRI Images. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 11, November 2014.
- [6] “B.K.Saptalakar& Miss. Rajeshwari.H” segmentation based detection of brain tumor B.K Saptalakar, et al International Journal of Computer and Electronics Research [Volume 2, Issue 1, February 2013].
- [7] “Ed-EdilyMohd. Azhari1, Muhd. MudzakkirMohd. Hattal1, ZawZaw Htike1&Shoon Lei Win2” Brain Tumor Detection and Localization in Magnetic Resonance Imaging. International Journal of Information Technology Convergence and Services (IJITCS) Vol.4, No.1, February 2014.
- [8] “Xiaopeng Wang, Shengyang Wan, Tao Lei” Brain Tumor Segmentation Based on Structuring Element Map Modification and Markercontrolled Watershed Transform. JOURNAL OF SOFTWARE, VOL. 9, NO. 11, NOVEMBER 2014.
- [9] “Rajeev Ratan1, Sanjay Sharma2 and S. K. Sharma3” Multiparameter segmentation and quantization of brain tumor from MRI images. Indian Journal of Science and Technology. Vol.2 No 2 (Feb. 2009) ISSN: 0974- 6846.
- [10] “A.Sindhu1, S.Meera2” A Survey on Detecting Brain Tumors in MRI Images Using Image Processing Techniques. International Journal of Innovative Research in Computer and Communication Engineering (An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 1, January 2015.
- [11] “AtulAnirudhaPadghan, &NarendraKashiramMarwadi” Review of Watershed segmentation used for Brain Tumor Detection from Digital MR Images. International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Recent Trends in Mobile & Cloud Computing (NCRMC- 08th & 09th October 2015).
- [12] “Roshan G. Selkar& M. N. Thakare” brain tumor detection and segmentation by using thresholding and watershed algorithm. ISSN 2348 – 9928 IJAICT Volume 1, Issue 3, July 2014 Doi:01.0401/ijaict.2014.03.08 Published Online 05 (08) 2014.
- [13] “Roopali R. Laddha1, Dr. Siddharth A. Ladhake2” Brain Tumor Detection Using Morphological And Watershed Operators. International Journal of Application or Innovation in Engineering & Management (IAIEM).Volume 3, Issue 3, March 2014 ISSN 2319 – 4847.
- [14] “K. Padmavathi1, Ms.C.Megala2” Detection of Brain Tumour with Filtering Techniques. International Journal of Advanced Research in Computer and Communication Engineering Vol. 4, Issue 7, July 2015.
- [15] “RoopaliR.Laddha, S.A.Ladhake” A Review on Brain Tumor Detection Using Segmentation And Threshold Operations. (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 5 (1), 2014, 607-611.
- [16] “Monika Jain1, Shivanky Jaiswal2, Sandeep Maurya3, Mayank Yadav4” A Novel Approach for the Detection & Analysis of Brain Tumor. International Journal of Emerging Technology and Advanced Engineering (Website: www.ijetae.com ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Issue 4, April 2015).
- [17] “AnamMustaqeem& Ali Javed&Tehseen Fatima” An Efficient Brain Tumor Detection Algorithm Using Watershed &Thresholding Based Segmentation. I.J. Image, Graphics and Signal Processing, 2012, 10, 34-39 Published Online September 2012 in MECS (<http://www.mecspress.org/>) DOI: 10.5815/ijgisp.2012.10.05.
- [18] “D.selvaraj&R.dhanasekaran”MRI brain image segmentation techniques - A REVIEW. D.Selvaraj et.al / Indian Journal of Computer Science and Engineering (IJCSE).
- [19] “R. G. Selkar 1, Prof. M. N. Thakare2, Prof. B. J. Chilke3” Review on Detection and segmentation of brain tumor using watershed and thresholding algorithm. IORD Journal of Science & Technology E-ISSN: 2348-0831 Volume 1, Issue II (JAN-FEB 2014) PP 11-14.
- [20] “Shubhangi S. Veer (Handore) 1, Dr. P.M. Patil”An efficient method for Segmentation and Detection of Brain Tumor in MRI images. International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 02 Issue: 09 | Dec-2015 www.irjet.net p-ISSN: 2395-0072.