COMPARITIVE STUDY OF BRAIN TUMOR DETECTION USING MORPHOLOGICAL OPERATORS

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Abstract

Segmentation divides an image into foreground object and the background object. In our case foreground object is brain tumor and background is CSF, white matter, and grey matter. Aim of our study is to detect the tumor and remove the background completely and compare the morphological operations that can be used for this purpose. Segmentation remains a challenging area for researchers since many segmentation methods results in over segmentation or under segmentation and hence, leads to the false interpretation of the results. The proposed work is the comparative study of the morphological segmentation methods for segmenting brain tumor from MRI images. Before segmentation, filtration process is carried out using two method, Non Local mean filter and median filter and their results are compared using MSE and PSNR. NL mean filter preserves sharp edges and fine details in an image hence, preferred over median filter. Also tumor location is identified, to get an approximate idea about the position of the tumor in the brain i.e. in which part the brain tumor is located. The tumor is identified by using different algorithms which are based on morphology such as watershed segmentation, morphological erosion, and hole filling algorithm and comparison between them is carried out based on parameters like accuracy, sensitivity and elapsed time. Each of the segmentation results are compared with the tumor obtained using interactive tool present in MATLAB R2013b.

Keywords: *Brain tumor, MRI images, Image segmentation, Morphology, Erosion, Thresholding, Hole filling, Watershed segmentation*

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1. INTRODUCTION

Brain tumor or intracranial neoplasm occurs when abnormal cells grow within the brain. Diagnosis is usually done by CT (computed tomography) scan or MRI (magnetic resonance imaging) which is confirmed by biopsy. Size of the tumor and its location effects signs and symptoms of a brain tumor. The prime remediating objective of surgery is to remove as many tumor cells as possible. The identification of the tumor is the primary aim before removing it from the brain, the identification being the most vital step since tumor should be removed without harming other parts of the brain, it include the segmentation step. Segmentation is done to separate the foreground objects from background objects. The most basic form of segmentation being the histogram thresholding method which roughly separates tumor from other parts, it separates them according to the intensity values of the tumor and the brain. This paper deals with various methods of segmentation that are based on morphology. Which include thresholding, morphological erosion, hole filling algorithm and watershed transformation. The comparison between these methods was carried out on the basis of different factors such as accuracy, sensitivity and time taken to obtain the segmented tumor region. The reference segmented tumor from which these results are compared is obtained by using active contour method, which is an interactive segmentation method. This paper is organized into 6 sections. Section 2 discusses the filtration process. Section 3 discusses the tumor location identification to roughly get the idea about the location of the tumor. In section 4 the segmentation of tumor using morphological operations is discussed in detail. In section 5 comparison is carried out for the obtained results, and section 6 discusses conclusion.

2. FILTRATION

Although resolution signal-to-noise ratio and acquisition speed of MRI machine has been increased to greater extent, many MR images are contaminated due to noise. In order to do proper diagnosis of the patient, the MR images must undergo filtration process[1,2,8]. In this work filtration method discusses and compares two filters, the median and NL means filter. Median filter is a type of order-static filter, these filters are based on certain ordering of the pixel values. In the median filtering a certain mask i.e. median mask is rotated around the pixels of the image. The median mask returns the median or middle value among all the pixels. Other types of order-static filter is min filter and the max filter. Min filter returns the minimum value among all the pixels and max filter returns the maximum value among all the pixels. This type of order-static filter works best for salt and pepper noise. Hence, it has the disadvantage of returning only those values that are already present in the image. Thus, median mask ends up blurring the image, which is undesirable in the case MRI images. Segmentation requires identification of sharp boundaries hence, we employ NL means filter in our work. Non-Local means filter has the advantage of preserving the sharp details in the image. It takes into account the non-local pixel values to

calculate the value of the noisy pixel in a location. And it is based on the principle of self similarity. Self-similarity principle means only those pixels having same value are considered, such as intensity or grey value. The results of filtration is compared by calculating the MSE and the PSNR value of the two filters, it was found that the value of PSNR for NL means filter is more as compared to the median filter.

MSE : For an m*n image the MSE(mean square error) can be calculated as

$$\frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j)-K(i,j)]^2 \quad (1)$$

Where I(i,j) is input image and K(i,j) is output image. The value of PSNR, should be more than MSE.

PSNR: The PSNR can be calculated as:

$$20.\log_{10}(MAX_I) - 10.\log_{10}(MSE) \quad (2)$$

The higher is the value of PSNR the better is the quality of image.

3. TUMOR LOCATION IDENTIFICATION

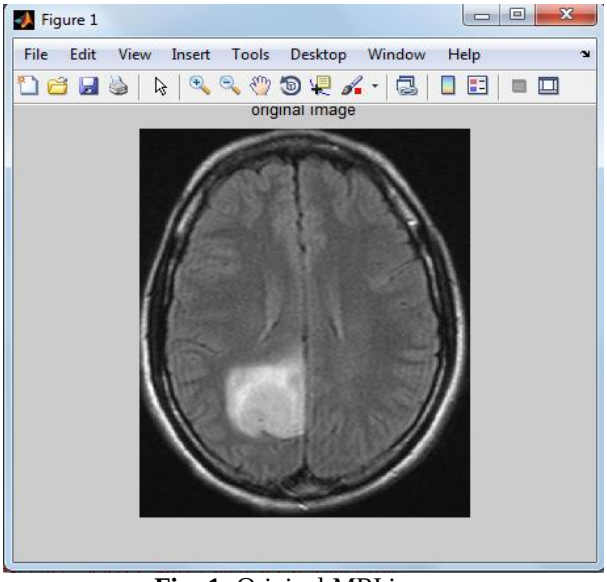

Fig -1: Original MRI image

The data base of MRI images was collected from SAHYADRI hospital Pune, the set of images were T-2 weighted axial slices of the brain tumor as shown in figure 1.Before segmentation step we will try to get the location of the tumor [6], i.e. to know in which part of the brain the tumor is located with respect to the central axis of the brain. For this we first divide the brain image into two parts, the left and the right hemisphere respectively then calculate the no. of pixels in each part, the part of brain that has more number of pixels has the tumor in it.This is depicted step by step in figure 2.

Step 1: Read the image in memory.
Step 2: Divide the image in two parts about the central axis of the brain.
Step 3: Plot the histogram of each part.
Step 4: Calculate number of pixels in each part, the part having more number of pixels has the tumor in it.
Step 5: Calculate the difference of the two histogram plots.
Step 6: If the number of pixels are equal in the two parts then no tumor is present.

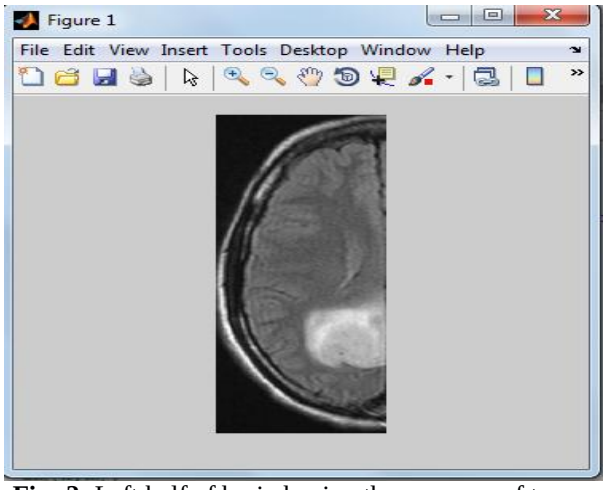

Fig -2: Left half of brain having the presence of tumor

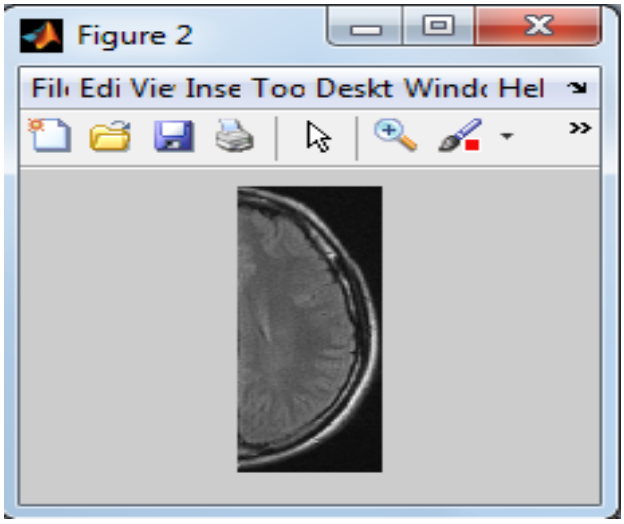

Fig -2: Right half of the brain

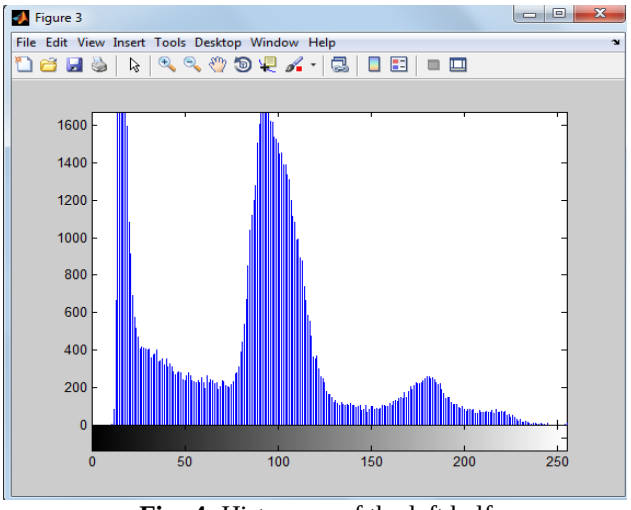

Fig -4: Histogram of the left half

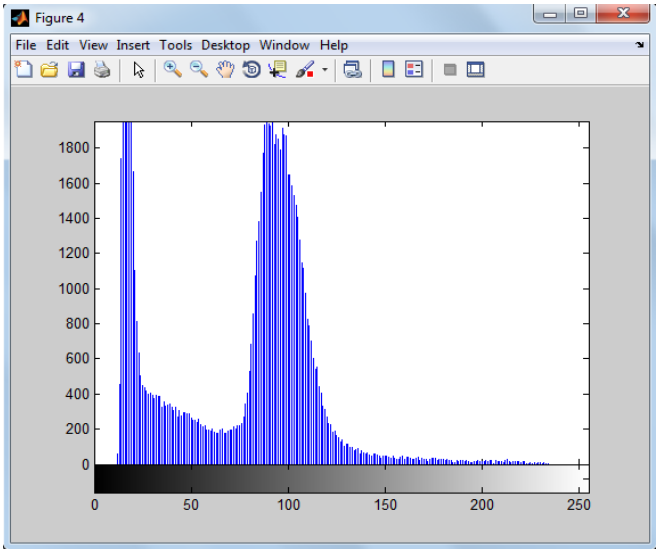

Fig -5: Histogram of the right half

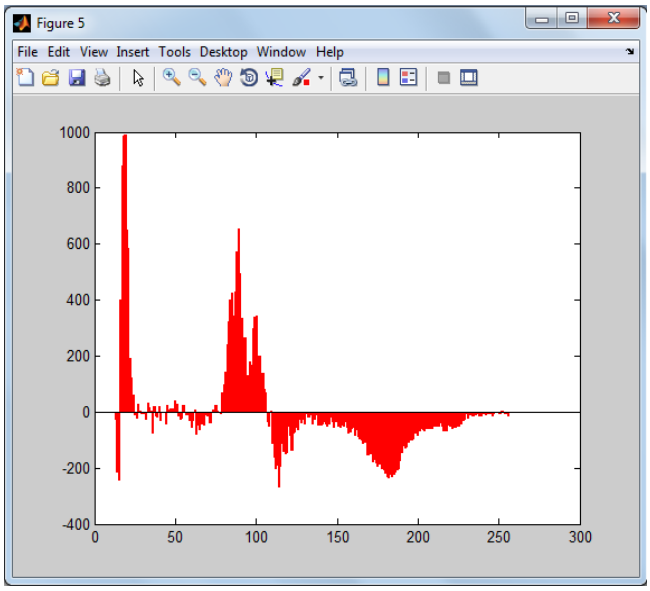

Fig -6: Difference between histograms of left and right half

4. IMAGE SEGMENTATION TECHNIQUES

Segmentation is a fundamental operation on images that partitions the image into homogeneous segments or regions to ease the analysis of images[9,10]. It is the process of grouping pixels together, with each group having at least one or more features in common. The features may be brightness, color, motion, texture etc. Segmentation can be represented as clustering problem in statistics and can be used for 3D reconstruction of objects when applied to a stack of images such as in Medical Imaging.

4.1. Thresholding Operation

In this process the tumor is extracted from the brain MRI image. A threshold is assigned to the image, and the threshold is computed from the histogram [3]. It was found that the pixel values of the tumor range from the interval 140 – 250, hence all the pixels that falls in this range are assigned value 1 and appear white in the output, and rest all appear black and are assigned 0 value. This type of the thresholding operation is called as multiple thresholding, and this method separates roughly the tumor part from rest of the brain parts.

4.2. Hole Fill Algorithm

To remove the non tumor regions of the brain image after the threshold operation hole fill algorithm was carried out[3]. The hole filling or the region filling algorithm works by filling a region A given its boundary β (A). $X = X_0$ is known and inside β (A).

$$X_K = X_{K-1} \oplus B \bigcap A\text{^}2, \quad K = 1,2,3 \qquad (3)$$

continue the process until $X_k = X_{k-1}$.

4.3. Erosion Operation

Morphological operations describe the interaction of an image with a structuring element S [3,6]. The structuring element is very small relative to the image. In the case of digital images, we typically use simple binary structuring elements like a cross or a square, the erosion ε(X) of a set X by a structuring element S is defined by

$$\varepsilon(X) = \{x | \forall s \in S, x + s \in X\}. \qquad (4)$$

4.4. Watershed Algorithm

It is a gradient-based segmentation technique and segments the image as a dam. Segmented regions are called catchment basins. Watershed segmentation is suitable for the images that have higher intensity value [5,6,7,8]. To control over segmentation, marker controlled watershed segmentation is used, in which sobel operator is used to distinct the edge of the object

5. RESULTS AND DISCUSSIONS

The results of filtration are depicted below

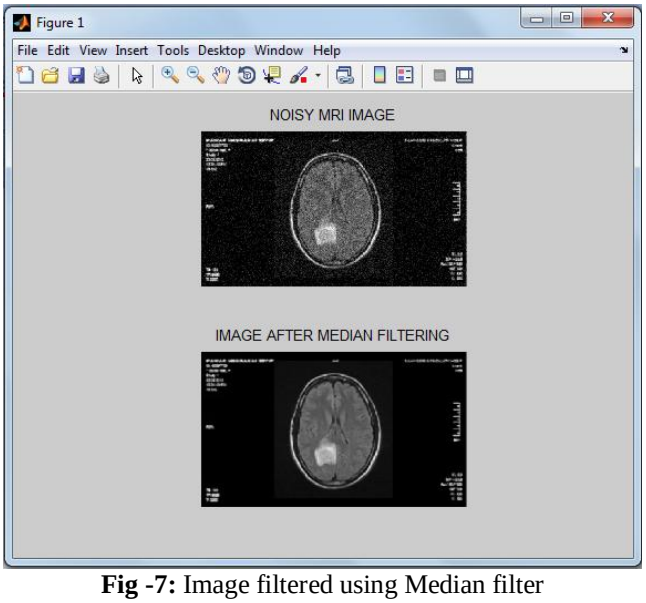

Fig -7: Image filtered using Median filter

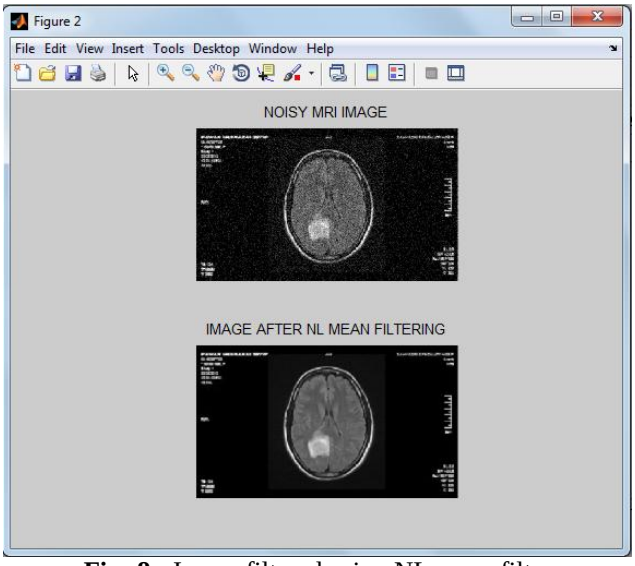

Fig -8: Image filtered using NL mean filter

Table -1: Comparison between median filter and NL mean filter

Filter	MSE	PSNR
Median	12.00	37.33
Non Local Mean	4.58	42.030

The above segmentation techniques were carried out on a brain MRI image having the presence of tumor the original image of the brain tumor is shown in figure 9. And result of each segmentation technique is shown in figure 9 – 13.

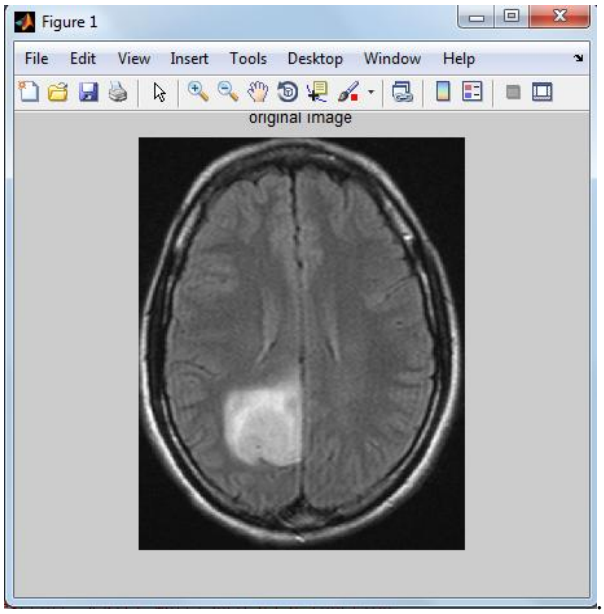

Fig -9: Original MRI image

Fig -10: Thresholding method

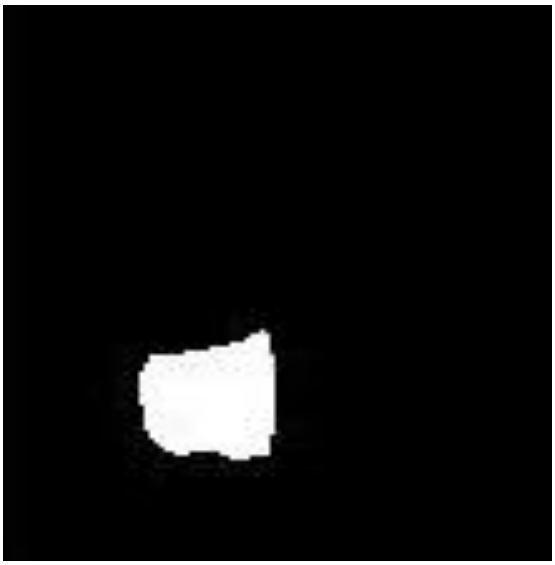

Fig -11: Hole fill algorithm

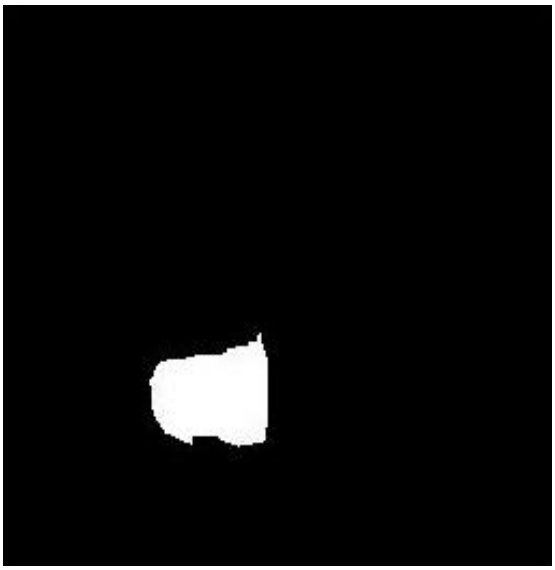

Fig -12: Erosion

Fig -13: Watershed segmentation

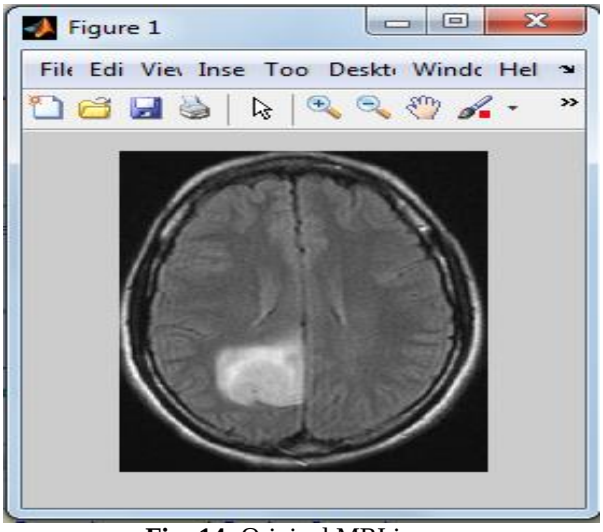

Fig -14: Original MRI image

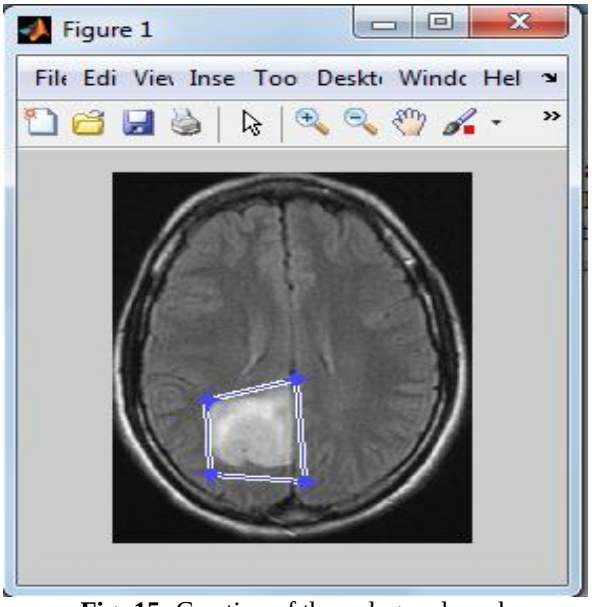

Fig -15: Creation of the polygonal mask

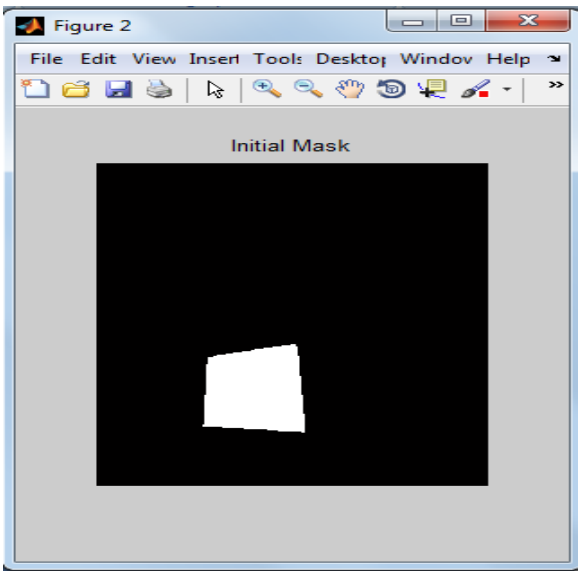

Fig -16: Initial mask

5.1 Performance Analysis of Segmentation Techniques

To know the efficiency of the above methods we have used the parameters such as accuracy, sensitivity and time [4].

Accuracy: In numerical analysis, accuracy is the nearness of a calculation to the true value. Accuracy is typically defined by the number of decimal or binary digits.

Accuracy is the addition of number of true positives and number of true negative divided by the additions of number of true positives, false positives false negetives and true negetives. An accuracy of 100% means that the measured values are exactly the same as the given values.

Sensitivity: Sensitivity is a measure of the proportion of actual positives which are correctly identified as such, and is complementary to the false negative rate.

$$\text{Sensitivity} = \frac{\text{true positives}}{\text{true positives} + \text{false negatives}} \quad (5)$$

Elapsed Time: It is the time taken to retrieve the segmented area from the input image. This is calculated by the option present in MATLAB R2013a named time and run.

The results of segmentation were compared with the output of an interactive based segmentation technique, which is obtained using MATLAB R2013a. The segmentation result obtained using the active contour method gives accurate result, the figure below shows the reference image which is obtained with the help of MATLAB R2013a. Using this method we segment an image by specifying a polygonal mask which is created interactively and then double click on point where mask is complete we get the output as segmented image as shown below.

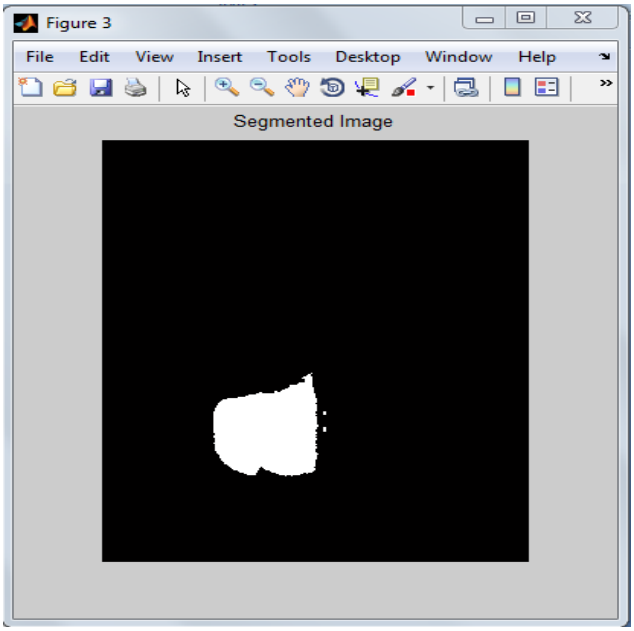

Fig -17: Segmented tumor.

The above comparison shows the qualitative result parameters when compared to various segmentation methods. Greater the accuracy value more efficient the segmentation process. Elapsed time gives us how much time it takes for a segmentation method to generate the output.

Table -2: Comparision of performance between different segmentation methods

Segmentation method	Accuracy	Sensitivity	Time (in secs)
Thresholding	0.9878	0.9868	2.380
Hole-fill	0.9703	NaN	3.874
Erosion	0.9961	0.8544	3.259
Watershed	0.9993	0.9811	4.860

6. CONCLUSION

In this work filtration process was carried out using NL mean filter as it shows the advantage of preserving fine details of the MRI image, also location of brain tumor is identified using histogram method. From table 2. we can conclude that watershed segmentation gives the most accurate results and is comparatively sensitive to other methods too, watershed segmentation method is an efficient method for brain tumor detection when compared to other methods. Apart from watershed, erosion also gives accurate result but its sensitivity is very poor as compared to watershed segmentation and thresholding. Thresholding method provide best result in terms of accuracy Sensitivity and time, but the major drawback of it is it includes the parts of background whose threshold value is similar to foreground, which is undesirable, since the output of segmentation step consists of non tumor parts too. Hence the most suitable segmentation method is Watershed segmentation. The only flaw with watershed segmentation is elapsed time which can be compensated if segmentation is accurate.

REFERENCES

[1]. A. buades, B. coll, and J.M. morel, “a review of image denoising algorithms, with a new one”, SIAM Journal on Multiscale Modeling and Simulation, 2005, pages 490-530.
[2]. J. Mohana,V. Krishnavenib, Yanhui Guoca, “A survey on the magnetic resonance image denoising methods", Biomedical Signal Processing and Control, Vol 9,2014, pages 56-69.
[3]. K Narayanan 1, Yogesh Karunakar2, “3-D Reconstruction of Tumors in MRI Images”, International Journal of Research and Reviews in Signal Acquisition and Processing,Vol 1, June 2011, pages 24-29.
[4]. D. Manju, Dr M. Seetha, Dr. K. Venugopala Rao, “Comparison study of segmentation techniques for brain tumor detection”, International journal of computer science and mobile computing, Vol. 2, Issue 11, November 2013, pages 261-269.
[5]. M. C Jobin Christ, R.M.S. Paravathi, “Segmentation of Medical Image using Clustering and Watershed Algorithms”, American Journal of Applied Sciences, Volume 8, Issue 2, 2011
[6]. Swe zin oo, aung soe khaing, “Brain tumor detection and segmentation using watershed segmentation and morphological operation”, International Journal of Research in Engineering and Technology, Volume 03 Issue 03 , March 2014, pages 367-374.
[7]. Sudipta Roy, Samir K. Bandyopadhyay ,“Detection and Quantification of Brain Tumor from MRI of Brain and it’s Symmetric Analysis”, International Journal of Information and Communication Technology Research , Volume 2, Issue No. 6, June 2012, pages 477-483.
[8]. Rajesh C. Patil, Dr. A. S. Bhalchandra, “Brain Tumour Extraction from MRI Images Using MATLAB”, International Journal of Electronics, Communication & Soft Computing Science and Engineering, Volume 2, Issue 1, pages 1-4.
[9].Geoff Dougherty, “Digital image processing for medical applications”, 2009, pages 271-335.
[10]. Naveen kumar R., Sanjay S., “Morphological Image Processing Approach for 2D to 3D Reconstruction of MRI Brain Tumor from MRI Images”, The International Journal Of Science and Technoledge, Vol 2, May 2014, pages 133-137.

BIOGRAPHIES

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