



# International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol.2, Special Issue 5, October 2014

## A New Approach For an Improved Multiple Brain Lesion Segmentation

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**ABSTRACT:** Segmentation of human brain from MRI slices for identification of brain lesions has become one of the most active research areas in the field of medical image processing. Brain segmentation has various important applications in diagnosing a number of disorders. The main aim of this project work is to recognize lesions and its qualifications from a specific MRI scan of a brain image and compute the area of each lesion by thresholding. Thresholding approach segment scalar images by generating a binary partitioning of the image intensities. Otsu's technique is used to automatically carry out intensity based image thresholding. The quantitative analysis of MRI brain lesions allows obtaining useful key information about the lesions. Segmentation is done on basis of threshold, due to which whole image is converted into binary image.

**KEYWORDS:** Otsu thresholding, Lesion segmentation, MRI.

### I. INTRODUCTION

A lesion is an area of tissue that has been damaged through injury or disease. So a brain lesion is an area of injury or disease within the brain. While the definition sounds simple, understanding brain lesions can be complicated. That's because there are many types of brain lesions. They can range from small to large, from few to many, from relatively harmless to life-threatening. Brain lesions can be caused by injury, infection, exposure to certain chemicals, problems with the immune system, and more. Many times the cause is not known.

(1) The past few years had witnessed a rapid and multi directional increase in the applications of image processing. In today's digital era, capturing, storing and analysis of medical image had been digitized. (2) The proposed system enables Automatic detection of the brain lesions through MRI image processing. Segmentation describes separation of suspicious region from background MRI images. The critical problem is finding lesions. An important factor in detecting tumor from healthy tissues is the difference in the intensity levels. The aim of this work is to design an automated tool for effective brain lesions detection in a MRI.

The system works based on the concept of isolating the region of the brain in which the lesion is present by fragmentation, and then apply the segmentation method called Otsu Thresholding to find the lesion location automatically and later finding its length and area. The aim is to find the details of all such lesions, and print the range of the areas of the lesions.

### II. LITERATURE SURVEY

The authors A.Jeevitha P.Narendran [1] in their paper on BTS (Brain Tumor Segmentation) based on Otsu Thresholding suggest in their research work implement a method of Otsu Thresholding to perform tumor segmentation however this method suffered from over and under segmentation. Authors M. Stella Atkins and Blair T. Mackiewicz [2] performed a fully automatic segmentation of Brain in MRI using arthroscopic filters and "snakes" contouring techniques. From the Allied Publishers the authors K. Somasundaram and T. Kalaiselvi [3] from the Gandhigram Rural Institute also introduced an automatic detection method using Maxima transforms. Author Tao Wang,[4] Dept. of Computer Science University of Alberta, used a fully automated brain tumor segmentation using a normalized Gaussian Bayesian Classifier and 3D Fluid Vector Flow. Modern approaches use fuzzy logic to perform segmentation of multiple sclerosis lesions as suggested by the authors Admasu, Institute for

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simulation and Graphics, Al Zubi and Otto-von-Guericke [5] university of Magdeburg. A Semi-Automated segmentation of multiple sclerosis lesions in brain MRI using texture analysis was suggested by Ghazel. M[6] Columbia University, Vancouver BC.

## III. METHODOLOGY

The parts of the image containing the lesions normally have more intensity than the other portion and we can assume the area and length of the tumor in the image. We have used these basic conditions to detect the lesions in our code and the code goes through the following steps. In preprocessing some basic image enhancement techniques are implemented. Apart from that a method to manually remove the skull portion in the MRI image is also used. The purpose of these steps is basically to improve the image and its quality to get more surety and ease in detecting the lesion. Image is converted to gray scale image in first step. The obtained image is then passed through a method to remove the skull to ensure accuracy. Then the image is subjected to fragmentation this is done to isolate the lesions before they can be processed to ensure quality. Segmentation is done on basis of a threshold, due to which the image is converted into binary image. Basic matlab commands for threshold are used for this segmentation. This is the best method to segment an image to separate the lesions but it suffers from over and under segmentation, due to which the user must carefully choose the threshold values.

The major part of the work is image fragmentation after converting into gray scale format. The basic purpose of these operations is to isolate only that part of the image which contains the lesions, while the remaining parts are ignored to eliminate unnecessary processing. The algorithm is given below.

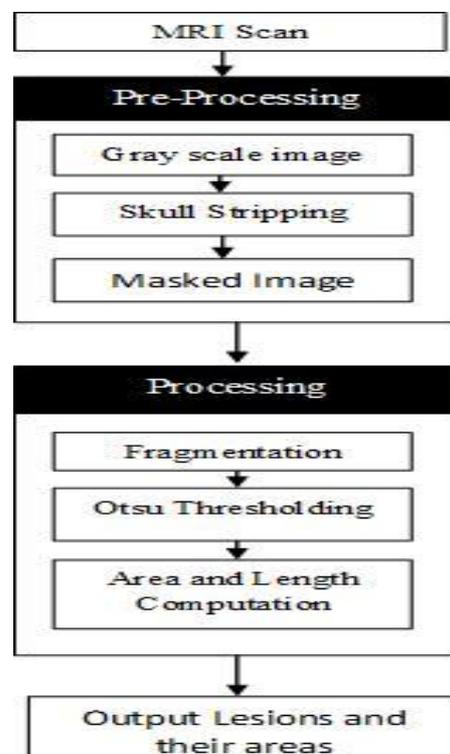


Figure 1: Proposed Methodology Flow



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## Algorithm

*Input:* MRI image of Human Brain *Output:* Areas and lengths of lesions

Step1: Convert the MRI scan image into grayscale image.

Step2: Using the freehand tool and masking, remove the skull portion of the human brain. Step3: Fragment the image either horizontally, vertically or into quadrants. The choice is given by user.

Step4: Initial processing identifies the fragments of the image which contains the lesions while the rest are eliminated.

Step5: The fragments (identified in Step4) are converted in to binary image with threshold value using Otsu Threshold.

### Threshold processing

Thresholding technique segment scalar images by generating a binary partitioning of the image intensities. A thresholding technique tries to find an intensity value, called the threshold, which separates the desired classes.

The segmentation is then obtained by grouping all pixels with intensity greater than the threshold into one class, and all other pixels into another class. In this step, the region between the skull and the brain tissue will be determined and this region to be segmented has considerable different gray values with other tissues. This proposed approach uses Otsu thresholding technique. Otsu's technique is used to automatically carry out histogram shape-based image thresholding, or the lessening of gray-level image to a binary image.

Step6: Isolate the lesion(s) in the given quadrant. If some portion of the brain is still present after thresholding, crop only the lesion portion using the freehand tool.

Step7: Obtained image from the Step6 is subjected to method with determines the areas of the lesions and calculates their lengths.

## IV. DEFINITIONS AND ABBREVIATIONS

- **Brain Tumors:** A brain tumor occurs when cells grow uncontrollably in the brain. A tumor is an abnormal growth of cells. Normally, cells divide in a regulated manner. If cells keep dividing when new cells are not needed, a mass of tissue forms; this is called a tumor. There are two types of tumors benign and malignant
- **Benign tumor:** Benign tumors stay in one place, grow to a certain size, and then (as a general rule) stop.
- **Malignant tumor:** Malignant tumors do not stop growing, and pieces of them travel to other parts of the body, where they also continue to grow. Malignant tumors, called cancers, are nearly all fatal if not treated.
- **Brain Lesions:** A lesion is an area of tissue that has been damaged through injury or disease. So a brain lesion is an area of injury or disease within the brain.
- **Multiple sclerosis (MS):** With this condition, the immune system attacks and damages the nerve linings (myelin) in the brain and spinal cord. These lesions make it difficult for messages to be sent and received properly between the brain and the rest of the body.



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## A. Abbreviations and Acronyms

- MATLAB:** Matrix Laboratory
- MRI:** Magnetic Resonance Imaging
- CT:** Computed Tomography
- GUI:** Graphical User Interface.

## B. Units

- The Area of the lesions is displayed in unit – cm<sup>2</sup>(read as centimeter square)
- The Length of the lesions is displayed in the unit- cm(read as centimeter).

## C. Equations

In Otsu's method we exhaustively search for the threshold that minimizes the intra-class variance (the variance within the class), defined as a weighted sum of variances of the two classes:

$$(1) \quad \sigma_w^2(t) = \omega_1(t)\sigma_1^2(t) + \omega_2(t)\sigma_2^2(t)$$

Weights  $\omega_i$  are the probabilities of the two classes separated by a threshold  $t$  and  $\sigma_i^2$  variances of these classes.

Otsu shows that minimizing the intra-class variance is the same as maximizing inter-class variance:

$$(2) \quad \sigma_b^2(t) = \sigma^2 - \sigma_w^2(t) = \omega_1(t)\omega_2(t) [\mu_1(t) - \mu_2(t)]^2$$

which is expressed in terms of class probabilities  $\omega_i$  and class means  $\mu_i$ . The class probability  $\omega_1(t)$  is computed from the histogram as  $t$ :

$$(3) \quad \omega_1(t) = \sum_0^t p(i)$$

while the class mean  $\mu_1(t)$  is:

$$(4) \quad \mu_1(t) = \left[ \sum_0^t p(i) x(i) \right] / \omega_1$$

where  $x(i)$  is the value at the center of the  $i^{\text{th}}$  histogram bin. Similarly, you can

compute  $\omega_2(t)$  and  $\mu_2(t)$  on the right-hand side of the histogram for bins greater than  $t$ . The class probabilities and class means can be computed iteratively. This idea yields an effective algorithm.

## D. Some Common Mistakes

- Sometimes the user may not completely remove the skull in preprocessing this may cause the system to treat the skull also as a lesion and compute the area wrong.
- The range of values permitted for the thresholds is between 0 and 1, any values given lower or higher will cause the system to return an error.

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- It is mandatory for all the input MRI images to have Horizontal and Vertical values.

## V. EXPERIMENTAL RESULTS AND DISCUSSION

The work is mainly dependent on the extraction of the lesion from rest of the brain based on the intensity. Otsu Thresholding is responsible to automatically classify the lesions based on their pixel intensities. However this depends on the threshold values given by the user which is used for image segmentation. This process maybe illustrated using the following image.



Figure2: Thresholding operation.

```
FINAL LESIONS REPORT
Lesion# Area(cm^2) Length(cm)
1      0.3340      0.6521
2      0.1815      0.4807
3      0.3638      0.6806
Total no of lesions =3
The area of the 3 lesions range from 0.182 cm^2 to 0.364 cm^2
Time Elapsed=160.175789 sec
```

Figure3: Finalized Output

Software testing is a critical element of software quality assurance and represents the ultimate process to ensure the correctness of the product. The quality product always enhances the customer confidence in using the product thereby increases the business economics. In other words, good quality product means zero defects, which is derived from better quality process in testing.

## VI. CONCLUSION

In our work we input the MRI image for which operations are performed on, the areas and lengths of each lesions are displayed. These output values are compared against expected values which are derived clinically to check for accuracy.

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MRI Image	Fragmentation Style	Threshold value	Lesions	Areas (cm <sup>2</sup> )	Actual Areas (cm <sup>2</sup> )	Difference (cm <sup>2</sup> )
	Vertical Fragmentation	0.984	1	22.3	22.5	0.2
	Quadrants Fragmentation	0.795	2	a. 0.0566 b. 0.0085	a. 0.0710 b. 0.0082	a. 0.02 b. 0.0003
	Horizontal Fragmentation	No lesions	0	-	-	-

**Table 1: Structural Testing**

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