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A Comparative Study of Different Automated Segmentation Techniques for Brain Tumor Segmentation in MRI Scan of the Brain

A. NOREEN, N. MINALLAH, M. ASHFAQ

Department of Computer Systems Engineering, University of Engineering & Technology Peshawar, Pakistan

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Abstract:- Brain tumor detection is one of the challenging tasks in medical field and digital image processing. A tumor is the abnormal growth of cells in human brain. Such abnormal cell growth may cause a cancer in the human brain which according to a recent survey has been one of the most rapidly increasing reasons of deaths. With such an alarming number of cancer patients due to brain tumor, it is important to automate the diagnosis process for accurate and fast detection of tumors in the MRI scan of the patients. This research work thus discusses in detail the different automated segmentation techniques for detection and segmentation of tumor in MR images of brain. A brain tumor dataset of Surgical Planning Laboratory (SPL) and Department of Neurosurgery (NSG) is used which contains MRI brain tumor images of ten patients. The purpose of this research work is to compare different segmentation technique like threshold segmentation, histogram, watershed segmentation and k-means clustering and to find strategy which gives most accurate results. Segmentation techniques followed by morphological operations with optimum disk size of structuring element is used. The accuracy of Watershed technique using our segmentation strategy is 99.86% which is best of all other selected segmentation algorithms.

Keywords: Automated Segmentation Techniques Surgical Planning Laboratory and Department of Neurosurgery.

1. INTRODUCTION

In the field of medical image processing brain tumor identification and detection is one of the most challenging tasks. Images of brain tumor are complicated and can be understand by medical experts or physicians only. So in this paper brain tumor identification, detection and segmentation is achieved by the means of five automated segmentation techniques which are histogram, watershed, k-mean and threshold based segmentation by using brain MRI (medical resonance imaging) (Mahesh, 2013).

In this paper the MRI images of brain tumor dataset of Surgical Planning Laboratory (SPL) and Department of Neurosurgery (NSG) is used for tumor detection and segmentation process. The MRI images give better results as compare to computer tomograpgy (CT), X-ray and Ultrasound. MRI images are mostly used in the field of medical and radio imaging and give better results for diagnosis as compare to others. It doesn't use any radiation so it is not harmful to human body. This process is based on radio waves and magnetic field.

MRI is used to attain the structural details of chest, pelvis liver and brain of the body which helps in diagnosis or monitoring the treatment. Similarly the structure of human brain can easily be viewed with the help of MRI because it adopts a vibrant and dynamic image capturing mechanism (Mahesh, 2013). (Vipin *et al.*, 2015) Usually the cells of human body grow in controlled mechanism but tumor is a disorder of the tissues that grows in uncontrolled manner. In this way the new cells in the body replace the damaged and old cells. The tumor can either be primary or secondary. If the tumor is at the origin it is known as primary tumor but if it is spread and replicates to other areas, such tumor is known as secondary tumor (Rohini, 2015) (Rachana and Singh, 2013)

As shown in fig.1 there are different types of tumors the names are as follow, metastatic meningioma, medulloblastoma, astrocytoma and glioma. These tumors have various features in appearance i.e in size, shape and location. Different information about brain tumor is provided by different MRI sequences (Rachana and Singh, 2013).

Earlier many segmentation algorithms were made for brain tumor identification and segmentation but many of these had a drawback either in identification or segmentation. This problem is tried to solve in this paper by comparing different segmentation techniques and identifying the best segmentation technique which accurately detect and segment the brain tumor on MRI scan of brain.

A segmented image consists of two parts, one is ROI (region of interest) known as foreground and second part is other than region of interest known as background which is the extra or un required part of image.

++Corresponding Authors: E-mail: n.minallah@uetpeshawar.edu.pk

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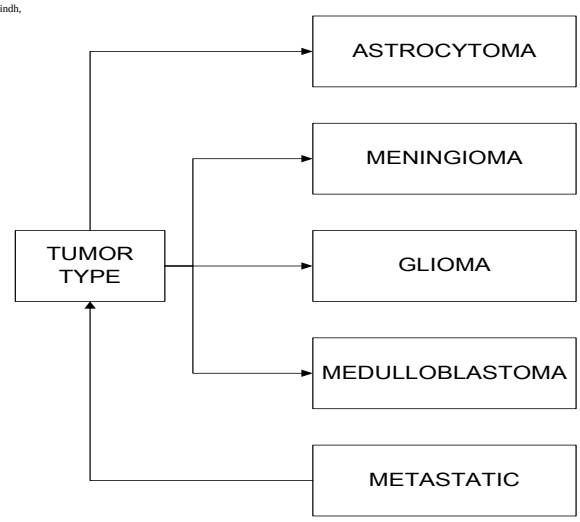


Fig 1: Brain tumor types

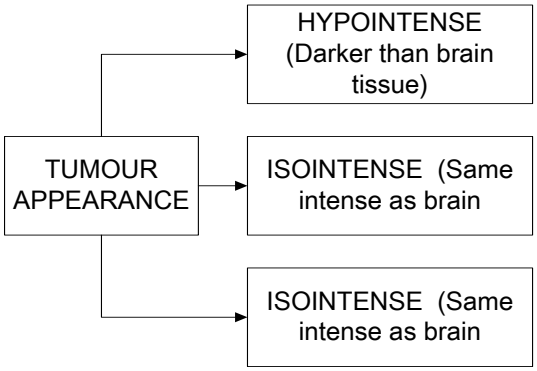


Fig 1: Appearance of tumor

Segmentation of an image deal with gray level values of image which needs to be segmented from rest of area. Segmentations techniques used in this research depends on the sudden and unusual change in the gray level values of the image. In MRI image tumor part has higher gray level values and the tissues are more concentrated so tumor can easily be detected in image.

In the past research, to overcome the problem of tumor identification and extraction in MRI scan a number of different segmentation methods has been proposed. In this paper, a comparative analysis is done on a single slice of 10 patients with manual segmentation (Ground Truth Data) by expert segmentation. Four segmentation techniques (Watershed, Histogram, K-mean, Threshold) are carried out for brain tumor detection and segmentation. This research would be helpful for medical purpose to figure out most efficient algorithm for tumor identification and its location (Rohini, 2015) (Rachana and Singh, 2013).

In **(Fig. 1 and 2)** a flow chart of brain tumor detection system is shown in which step by step working of the system is elaborated.

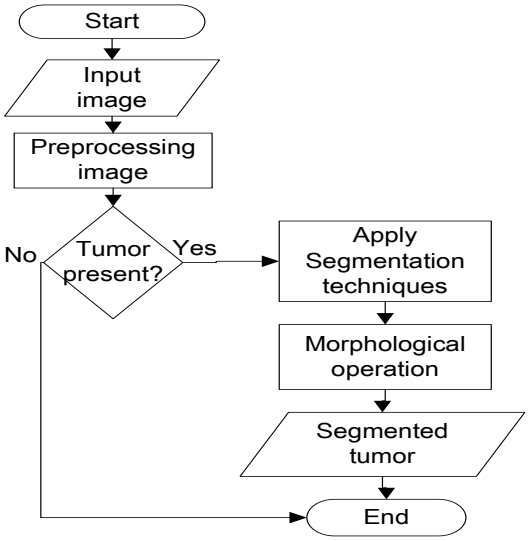


Fig 2: Brain tumor detection system

This paper is organized in the following sections: section 1 contains details about introduction of the paper, section 2 contains details about related literature review on the topic, section 3 deal with dataset description, section 4 deals with different segmentation techniques, section 5 deals with methodology, section 6 deals with comparative analysis and results, at the end in section 7 conclusion and future work are drawn.

2. RELATED RESEARCH ON BRAIN TUMOR SEGMENTATION TECHNIQUES.

In this section a brief survey of previous work on brain tumor detection and segmentation techniques are presented. It gives overview of important and latest literature pertaining to brain tumor detection using MRI scan of brain. The related literature work can be seen in the following cited paper.

A robust and efficient algorithm for detection of brain tumor on MRI scan using the technique of edge base detection is presented in (Mahesh, 2013). Similarly, two algorithms such that region based segmentation and fuzzy c-mean which resulted in automatic detection of accurate surface area of brain tumor on MR image is presented in (Deepak *et.al.,* 2015) presented efficient algorithms for tumor detection based on image segmentation methods of canny edge detection and fuzzy c-mean ,then to enhance the quality of scanned images morphological operators were applied to identify and segment the tumor area more precisely.

(Kailash *et. al.,* 2014) have presented optimized c-mean clustering technique using genetic algorithm for brain tumor detection in MRI scan of brain. This method showed better results than other optimized

clustering methods. (Sneha *et. al.,* 2015) presented a study of brain tumor detection by using the techniques of morphological operators like erosion, watershed segmentation and hole filing algorithms. The position of tumor was also identified in brain to know about the exact location of it.

Case No.	Slice No.	Tumor Type	Location
1	44	Meningioma	left frontal
2	58	Meningioma	left parasellar
3	78	Meningioma	right parietal
4	45	low grade gomia	left frontal
5	92	Astrocytoma	right frontal
6	81	low grade gomia	right frontal
7	92	Astrocytoma	right frontal
8	39	Astrocytoma	left temporal
9	31	astrocytoma	Left frontotemporal
10	35	low grade gomia	left temporal

(Dipali *et.al.,* 2016) presented a hybrid technique for prediction of brain tumor using a combination of two methods such that support vector machine (SVM) and fuzzy c-means (FCM), filters were used to remove the noise from image and then other morphological operations were applied for skull striping. (Swati *et.al.,* 2015) presented simple algorithm (c mean process, fuzzy c mean) for detection of position, shape and range of tumor with the assistance of MRI scan and 3D visualization was used to help users for better analysis of obtained results .

(Dipali *et .al.,* 2016) and (Nilesh *et.al.,* 2017) presented two techniques for brain tumor detection and extraction using Berkeley Wavelet Transformation (BWT) and Support Vector Machine (SVM). (Aboshgifa *et.al.,* 2015) presented a method that detect brain tumor from MRI images using watershed segmentation and contour of the image by filtering the image noise using sobel edge mask.

(Vrishali *et.al.,* 2015) presented an automatic brain tumor detection and localization framework that could easily detect and localize brain tumor in MR scan. The steps used in the method were pre-processing, smoothing, histogram equalization, erosion, dilation and at the end blob detection was applied to get better results. (Shubhangi *et. al.,* 2015) presented an efficient method for segmentation and detection of brain tumor in MRI scan which were comprised of three main steps such that preprocessing, segmentation and measurement of tumor area.

3. DATASET DESCRIPTION

In this paper to carry out research on brain tumor detection and segmentation Surgical Planning Laboratory [SPL] and Department of Neurosurgery [NSG] Database of brain tumor is used. Ten patients MRI images are manually segmented by four experts which will be considered as ground truth data for validation of results and finding accuracy of different segmentation algorithms. A specific slice out of 124 slices is taken out of each patient in which tumor is prominent. (Michael *et.al.,* 2001)

The following is the format of the used dataset:

Table 1: Case information

Image Parameter	Value
Resolution	256x256x124
Pixel size	0.9375 x 0.9375 mm
Slice thickness	1.5 mm
Slice gap	0.0 mm

The case information of the used dataset is shown in **(Table 1).**

4. IMAGE SEGMENTATION

The segmentation of an image is to divide and separate the image into similar region based on particular characteristics and features. The main aim of segmentation is to extract the important features from the given image for better analysis and understanding of an object (Sharma, 2015). Segmentation of image is usually used to locate the boundaries and objects in images. The segmentation algorithms has two main properties one is similarity of intensity values and other is discontinuity in intensity values in an image

4.1 SEGMENTATION TECHNIQUES FOR BRAIN TUMOUR DETECTION

For brain tumor detection and segmentation many algorithms and techniques have been used in the past such that KNN algorithm, merging methods, Fuzzy c-mean algorithm and region growing algorithms. Segmentation can also be performed using the method of clustering techniques. So in this research work aim is to find the best automated segmentation system among the available choices to identify and extract the tumor accurately. The following are the used automated segmentation techniques to carry out brain tumor segmentation.

4.1.1 K-Means Segmentation

K-Mean based segmentation comes under unsupervised learning. This algorithm is used to split the N observations into K clusters in which every observation belong to the nearest mean cluster. Initially in this algorithm the number of clusters is defined first. Then for centre selection any random k cluster is taken. After it the distance between center and each pixel is calculated. This process keeps on repeating until there remains no change. (Manju, *et. al.,* 2013).

4.1.2 Threshold based Segmentation

Threshold based segmentation is one of the simplest segmentation method, depending on gray level values the pixels are separated in different classes. This algorithm finds an intensity value that is called threshold value which is used to separate the respective classes. The process of segmentation is attained by using that particular threshold value. The values which are greater than threshold is grouped into one class and the others which are below it are grouped in another class. The disadvantage of this method is that it makes two classes only so it cannot be applied to multichannel images. In this method image can have only two values either black and white or 0 and 255 (Manju, *et. al.,* 2013).

4.1.3 Watershed segmentation

Watershed segmentation use the technique of edge based segmentation, in this algorithm first image acquisition is done and then gradient magnitude is performed on it. This method is preferred when it comes to separate the touching object in an image it can also segment non-homogenous tumors. This algorithm is effective to solve many segmentation problems.

Segmentation using watershed technique works good when the objects of foreground and location of background is identified perfectly. The following steps are taken for watershed segmentation. First of all the segmentation function is computed (this is the image in which darker regions are those objects which need to be segmented). In second step foreground markers are computed (these are connected blobs of pixels inside every objects). In third step background markers are computed (these are those pixels which are not part of any given object). In fourth step the segmentation function is modified (for the purpose that it has less values on the location of foreground and background markers. In step five background markers are computed (these are those pixels which are not part of any given object). In final step the segmented image is visualized.

4.1.4 Histogram Segmentation

Histogram based algorithm is based on symmetrical structure of brain. Histogram is plotted using bar graph. Between the number of gray level intensity and pixels values the histogram is plotted. In this method the image is sub divided into two equal half parts and histogram is taken, then histograms of both are compared to each other. Based on this comparison the threshold point is selected for histogram. After choosing the histogram threshold point the values is compared with every pixel in MR image. If threshold value is less than these values then it remained same but if the threshold value is greater than the pixel value, pixel is taken away from the MR image. After the process of the holding a binary image is achieved. This image has only two values in it which is either 0 or 1 while pixel values above the threshold point is 1.

In the final stage after applying segmentation techniques, morphological operators are applied on the segmented image to remove the unwanted information from it and it separates the tumor part from the segmented image.

5. METHODOLOGY

In this section, the results are presented which are obtained by applying different segmentation methods such that histogram, k-mean, thresholding and watershed techniques. The sensitivity, specificity and accuracy is calculated in the terms of true positive (TP), false negative (FN), true negative (TN) and false positive (FP).

A Surgical Planning Laboratory [SPL] and Department of Neurosurgery [NSG] Database of brain tumor is taken. This dataset contains 10 patient cases of brain tumor each with 124 slices. A specific slice from each patient is selected which contains brain tumor and was given to four experts for manual segmentation. In order to find accuracy of segmentation algorithms followed by morphological operations, we generated ground truth data from four experts' manual segmentation. The pixel is considered as tumor if more than two experts have labeled that pixel as tumor otherwise it is considered as healthy cell. In this way binary image of ground truth data is generated for each patient. Same slices of each patient are taken and segmentation algorithms followed by morphological operations are applied. A segmented image has imperfections like extrusions and intrusion so by applying the morphological operators such as erosion which makes object skeletal and results in reducing the object and dilation which thicken the object in an image by adding pixels to the boundaries of image. Fig.4 shows the effect of repeated erosion followed by dilation on the image having tumor using different radial dimension of disk as structuring element for morphological operation. After analysis of using different disk sizes for morphological operation disk size of 6 is found to be best for segmentation of brain tumor. Disk size of 6 removes noise from patient's image leaving behind tumor as segmented region.

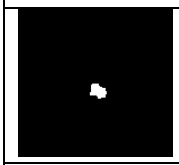
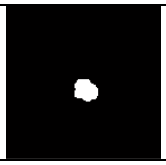
Eroded image	Dilated image
	
[disk,0]	[disk,0]
	
[disk,1]	[disk,1]
	
[disk,6]	[disk,6]

Fig 4: Erosion and Dilation

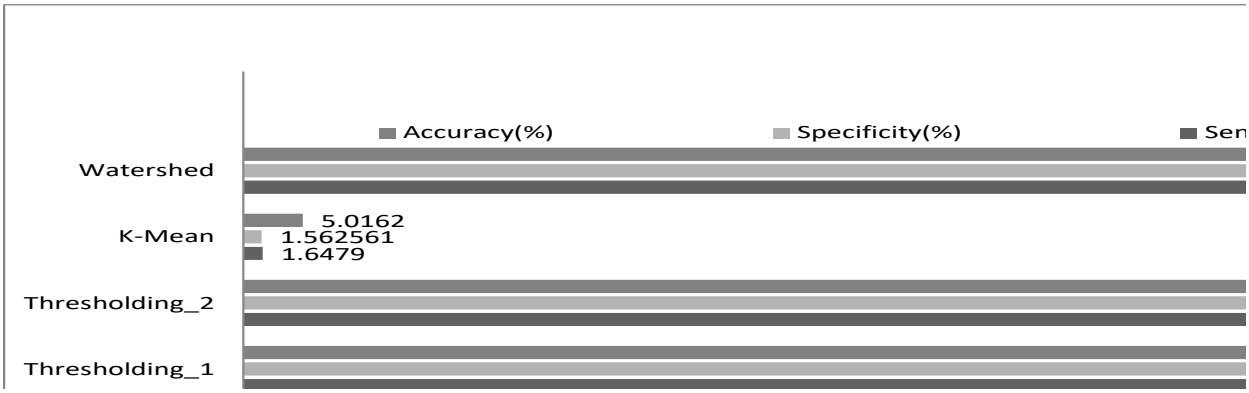


Fig 5: Comparative analysis of segmentation techniques

Table 2: Statistical analysis of comparative study

Sr.no	Segmentation Techniques	Sensitivity = TP/(TP+FN)*100	Specificity = TN/(TN+FP)*100	Accuracy =(TP+TN)/(TP+TN+FN+FP)*100	Elapsed time (seconds)
1	Histogram Algorithm-1	99%	100%	99.2%	2.406250
2	Thresholding With high pass filter Algorithm-2	97.6%	98.9%	98.5%	0.611298
3	Simple thresholding Algorithm-3	85%	99.2%	98.96%	1.686863
4	K-Mean Algorithm-4	1.65%	1.56%	5.02%	1.562561
5	Watershed Algorithm-5	96.98%	99.9%	99.86%	1.946375

Table 2 shows the detailed results pertaining to the statistical analysis. The sensitivity, specificity, accuracy and elapsed time are computed for each of given samples of brain tumor MRI. The given results will be of great importance in the medical image analysis pertaining to brain tumor detection and segmentation which is one of the challenging tasks.

The final segmented image obtained after applying segmentation techniques with optimum disk size of structuring element for morphological operation undergoes the process of validation with ground truth data. Sensitivity, specificity and accuracy is calculated for all segmentation techniques using following formulae.

- Sensitivity = TP/(TP+FN)*100
- Specificity = TN/(TN+FP)*100
- Accuracy = (TP+TN)/(TP+TN+FN+FP)*100

6. COMPARATIVE ANALYSIS OF DIFFERENT SEGMENTATION TECHNIQUES

Comparative study of different segmentation techniques is summarized in **(Fig.5, Table.2 and Table.3).** All the given five brain tumor segmentation techniques are compared on the basis of performance parameters such as sensitivity, specificity, and accuracy. In terms of accuracy, it is depicted that the performance of the algorithm 5 (Watershed) technique has significantly better results for tumor identification and segmentation as compared to other methods.

Table 3: Different Segmentation Techniques

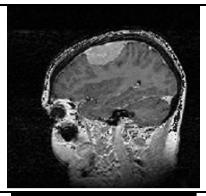
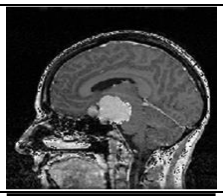
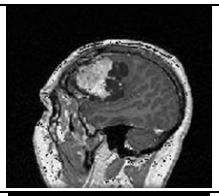
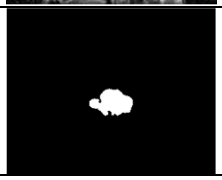
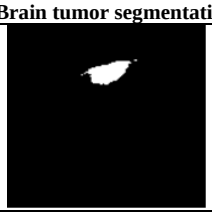
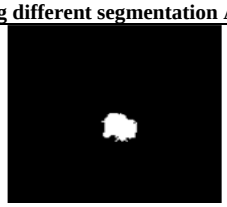
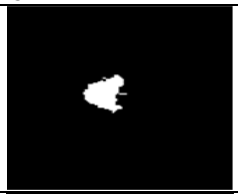
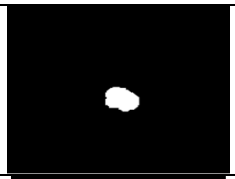
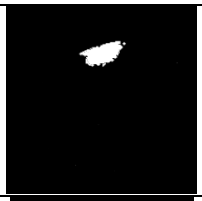
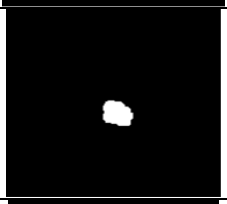
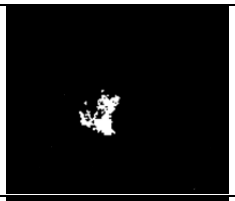
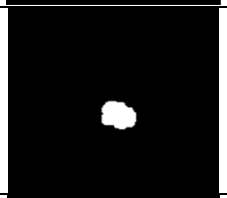
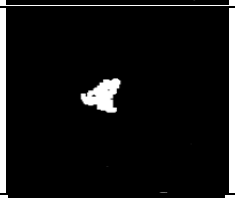
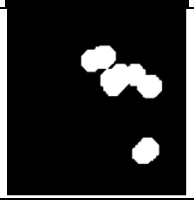
Brain Tumor Segmentation	**MRI_1 Case#1 Slice#44**	**MRI_2 Case#2 Slice#58**	**MRI_3 Case#9 Slice#31**
Tumor Type	meningioma	meningioma	astrocytoma
Location	left frontal	left parasellar	left frontotemporal
Brain Tumor MRI			
Expert Segmentation			
Brain tumor segmentation using different segmentation Algorithms			
Algorithm-1 (Watershed)			
Algorithm-2 (Histogram)			
Algorithm-3 (Thresholding using High pass Filter)			
Algorithm-4 (Simple Thresholding)			
Algorithm-5 (Kmean)			

Table.3 shows a single slice manual segmentation by a single expert segmentation and five other automated segmentation techniques.

7. CONCLUSION

In this paper a comparison between different segmentation techniques are carried out including Histogram, Thresholding, Watershed, K-mean segmentations. Results show that only segmentation algorithms are insufficient for segmenting brain tumor which may contain extra information of pixels from head, skull, skin, eyes and neck area. In order to remove extra information, we proposed a strategy in which segmentation algorithms are following by morphological operations. Different disk sizes as structuring element for morphological operations are analyzed and we found an optimum disk size which works best for all algorithms. The given techniques were compared on the basis of parameters like sensitivity, accuracy, specificity and elapsed time. The results of comparison show that watershed segmentation is the best segmentation technique for brain tumor segmentation since its accuracy is 99.86% when it is compared to other segmentation technique.

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