A Comparative Analysis of K-means, Thresholding and Region Growing Algorithms for Segmentation of Brain Tumor of MRI Images

Muhammad Sheraz Arshad Malik[1], Samreen Shabir[2], Ghulam Asiya[3], Hurya Zafar[4]

[1,2]Technology, Government College University, Faisalabad, Pakistan
[3,4]Department of CS&IT, University of Sargodha, Sargodha, Pakistan

Abstract
Brain tumor is an irregular development of tissues in human brain. When this tumor turns into cancer, it can be threatened to human life. That's why the detection of exact location and size of tumor is necessary. Segmentation of MRI plays an important role for locating tumor in magnetic resonance image (MRI). This research surveys on different segmentation techniques which are applied to MR Images for the detection of tumor in human brain. It also includes the comparison of the different image segmentation techniques based on the accuracy of results of the techniques and time consumed by each technique.

Key words:
brain tumor segmentation, image processing, k-Mean segmentation, Thresholding Algorithms, Region growing

1. Introduction

A brain tumor is a development of irregular growth of cells in human brain. Our brain is enclose in skull which is very rigid. Any growth inside such a restricted space can cause problems. Brain tumors can be cancerous (malignant) or non-cancerous (benign). Image Segmentation used to separate the segment of interest from the entire image. In other words, image segmentation used to separate the foreground from background. It is use to change the representation of an image into another image that is more meaningful and easier to analyze. Brain tumor segmentation is the process of finding the tumor segment from the MRI images using image-processing algorithms. If tumor does not exist in MRI, the algorithm should not segment any region in image.

Segmentation of brain tumor from MRI (magnetic resonance imaging) data is a vital but time consuming manual task performed by medical experts. The automation this process to detect brain tumor is a challenging task because of the high diversity in the appearance of tumor tissues among different patients and in many cases similarity with the normal tissues. There are many segmentation methods to segment a brain tumor from MRI images. We will implement different techniques (i.e K-mean Clustering, Thresholding, Region growing) to find out their advantages and disadvantages by comparing their results and accuracy.

2. Literature Review

Brain tumor segmentation is a complex problem. And it contains many uncertainties that lead wrong results. Brain tumor detection is a health care problem therefore there is no chance of any mistake. To improve the result efficiency amount of work have been done in this direction. Researchers have successfully applied different techniques from the fields of computer sciences [1]. In 2014 Eman Abdel Maksouda,, Mohammed Elmogyb, , Rashid Al Awadi Proposed technique that is the combination of K means and fuzzy C means algorithms. That named as Navol segmentation technique. K means help in clustering image segmentation in minimal computational time, and Fuzzy C means help in accuracy in result. Algorithm based on two properties of image that is discontinuity and similarity of image intensity values. It has following stages pre-processing, clustering, tumor extraction and contouring, and validation that bring improvement in accuracy, computing time and performance time [2]. T. Logeswari and M. Karnan done the segmentation based on soft computing and implement SOM (self-organizing map) to separate the doubtful region in the Segmentation of MRI Brain tumor .In this paper, weight vector used in which neuron is input and winning neuron is output. This implementation gives more information about brain tumor. And it detects tumor pixels in the image [3]. In 2012 Tehseen Fatima, Ali Javed and AnamMustaqeem used threshold segmentation, watershed segmentation and morphological operators for segmentation of tumor. All procedures divided into two stages first one is preprocessing stage and second is post processing. Preprocessing stage is to access the MRI image, store it as gray scale image, sharpened image, remove noise and enhanced the image. Post processing consists of threshold segmentation, watershed transformation and then applies Morphological operations and at the end displays the result processing [4]. Malathi R and Dr. Nadirabanu Kamal A R

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implemented K MEANS clustering technique that is used for segmentation. This technique detects the object boundaries of noisily images, and it is a successful technique for finding abnormal behavior of objects or pixels in image, that may help in segmentation. This technique detects the tumor efficiently [5]. M.Murugeswari and M .Gayathr modified the Fuzzy C MEANS algorithm to improve the segmentation results. Although fuzzy C means (FCM) algorithm work well on most noise free images, but it fails to segment noise corrupted images. Proposed technique enhance the FCM and used the segmentation method that give the additional iteration and clustering, map the best matching then segmented image is mapped with database. It removes the noise by using the median filter. It preserves the edge while removing the noise [6]. Gauri P. Anandgaonkar1, Ganesh.S.Sable2 implemented the Fuzzy C Means That detects the brain tumor and then calculates the area of tumor. Input the image and then apply the preprocessing in which the edges sharpened by removing the noise and then extract the features and at the end calculate the area that finds out the type of brain tumor. This technique is efficient for limited data [7]. Rajesh C. Patil, Dr. A. S. Bhalchandra. Propose an algorithms that detect & extract brain tumor from patient's MRI scan images. The algorithm first take MRI image of brain as input. It will then convert it to gray scale image. After that, image become as an input to high pass filter. After that median filter is use to remove the noise and to increase image quality. Then threshold Segmentation computed. Meyer's flooding Watershed Algorithm is use in this research [8]. Vipin Y. Borole, Sunil S. Nimbhore, Dr. Seema S. Kawthekar implemented algorithms to find brain tumor stroke and other Kinds of abnormalities in human brain using MR Images. In this paper, edge detection technique is used. Morphological operation are also used for shape and Active contour method, Watersheds Method, Threshold Method, Seed region growing, Marker based Watershed are also related to this research [9]. A new Artificial Neural Network Approach was proposed for Brain Tumor Detection. This approach gave the edge pattern and segment of brain and brain tumor itself. [10]. AmanpreetKaur, Gagandeep Jindal described the overview for tumor detection in medical images using genetic algorithm. In this paper, fuzzy C means clustering is used. This approach takes the input image in jpg, bmp or any other valid medical image format. And convert it into normal image itself. This approach separates the tumor part of image [11]. Mr. Shital S. Agrawal, Prof. Dr. S. R. Gupta proposed a technique. The main objective of this technique is to detect the position and boundary of tumors automatically based on the symmetry information of MRI. The processes of this approach includes Image analysis for detecting brain diseases by applying segmented method, Comparative analysis of different segmentation technique and last step is Implementation of Prototype for Image Analysis and Identify best technique in different scenario for disease detection [12]. Pratibha Sharma, ManojDiwakar, SangamChoudhary proposed the technique. Objective of this technique is to provide an efficient algorithm for detecting the edges of brain tumor. Different stages are involved in proposed algorithm, the region that contain tumor has higher intensity value, and through this technique, we can easily detect that part [13]. Jin Liu, Min Li, have worked on imaging modalities of brain tumors. They performed preprocessing operations and the state of the art methods of MRI-based brain tumor segmentation is introduced and also discussed assessment and authentication of the results of MRI-based brain tumor segmentation . An objective valuation has presented and future progresses have addressed for MRI-based brain tumor segmentation methods [14]. NorainiSulaiman, NorelianiAwang Non, IzaSazanita Isa, NorhazimiHamzah used Adaptive Fuzzy K-means as a tool to cluster the three regions that are white matter, grey matter and cerebrospinal fluid spaces and results are compared with fuzzy C-means clustering. They performed the data analysis of MRI brain image and then performed analysis comparison of fuzzy C-means and adaptive fuzzy K-means clustering algorithm. They have proved that segmentation can be sharper and clearer in MRI brain image by using Adaptive Fuzzy K-means .Also the comparison detail of qualitative and quantitative discussed in the paper [15]. Mr. Ajaj Khan , Ms. Nikhat Ali Syed used method about the brain tumor detection and gives two steps that are implemented throughout the whole procedure to detect tumor from MRI of brain. They projected an approach of classification using Support Vectors Machine Classifier. They have worked on two phases first one is feature extraction and second is classification. They extract the features, take the extracted features to SVM classifier as an input, and prove that SVM is effective in high-level dimensions and effective where number of dimensions is greater than the number of samples.

Techniques used in the system based on image processing and image analysis. Image processing is a process through which we apply different operations on images by using any form of signal processing. For which input is an image or series of images and output may be either an image or a set of characteristics or parameters related to the image. Most of the image processing techniques involve treating an image as 2D array and applying some image processing techniques on it. Image analysis is the extraction of meaningful information from images, mainly from digital images by means of digital image processing.

3. Modules

3.1 Image Loading

This is the first step of the process. In this step, the system will load the MRI images from the system selected by the user. This is necessary step to perform any further image-processing task. The input image can be of any format from ".jpg" ,".png", ".bmp" image formats.

3.2 Image PreProcessing

The basic objective of the pre-processing step is to improve the pictorial appearance of the images and to improve the manipulation of datasets. The operations which are required before the main data analysis and extraction of information are called the pre-processing of image. Image pre-processing is also called image restoration. Image preprocessing is used for correction of distortion, degradation, and noise introduced during the imaging process. Several filter operations which intensify or reduce certain image details enable an easier or faster evaluation. Image adjustment done by converting the input image into gray scale image and then with the help of medium filter. Medium filter reduce the noise from the input image. First, if the image is not a gray scale image, it is converted to gray scale image. As gray scale image carries only intensity information so it is easy to process gray scale image as compared to process three components R (red), G (green), B (blue). The values between 0 to 255 assign to represent the brightness of the pixel. 0 represents black and 255 represent white. For brain tumor detection, RGB color image converted into the gray scale images as color information is not useful in this brain tumor segmentation process. Furthermore it reduces the computational cost. After gray scale conversion, medium filter is used to reduce noise from input image. Medium filter de-noise input image that helps to perform MRI image segmentation techniques efficiently.

3.3 Image Segmentation

Image segmentation is the main task of our project. Image Segmentation used to separate the segment of interest from the entire image. In other words, image segmentation used to separate the foreground from background. In our project tumor segment is the foreground and the remaining image is the background image. We have represents foreground or tumor with intensity value 1 and background with intensity value 0 of a binary image. We have applied three image segmentation techniques on our MRI image dataset to find an efficient and more accurate technique for our "brain tumor segmentation of MRI images using image processing algorithms" project. We have implemented K-Mean clustering image segmentation technique, global thresholding technique and region growing image segmentation technique. The procedures for these techniques are as followed:

3.3.1 K-Mean Cluster Segmentation

K-Means Cluster Segmentation is a technique in which n observations divided into k clusters. Each pixel belongs to the clusters. The objective function is minimized in such a way that within cluster sum of squares is get minimized. The process starts with initial K cluster centers. On the basis of similarity between the observations and cluster center, the observations reassigns to clusters. As the degree of gray-level similarity in the image is very high that's why automation of recognition and segmentation of brain tumors in MRI images is a very challenging task. We actually need two clusters from which one will be tumor and second will be background but results produced with k=2 are not suitable because the pixels of non-tumor region will also become part of the tumor and tumor will not be extracted accurately. So we start the K-mean algorithms with k=3. The resultant image has three clusters with only three gray levels. The first cluster has intensity values 1 and is of black color. The second cluster has intensity value 2 and is of gray color. The third cluster has intensity value 3 and is of white color. Since the tumor's color is white so, we are interested in the third cluster.

3.3.2 ThreSholding Segmentation

Thresholding segmentation is a technique that segments the input image on the basis of intensity value range. It extracts the part of image or the pixels whose intensity value exceed through a specified threshold. In this way, the result is only tumor part that whose pixel values exceed through threshold. All the remaining part will become black through this technique. So, the resultant image of threshold segmentation is binary image. Therefore, by using this technique, the tumor part of an image can be extract because tumor part gray levels are distinct from normal brain gray levels. Threshold value selection is a difficult task in threshold segmentation and has significant effect on the results.

3.3.3 Region-Growing Segmentation

Region growing technique is a simple region based image segmentation method. It based on the fact that the neighbors of the pixels have values that are more similar. The algorithm starts with a single pixel as initial seed point. In this approach of segmentation, the neighboring pixel of initial seed point examine and determine that the pixel neighbors should added to the region or not. The basic goal of this technique is to divide an image into different sections. Growth of cluster increase as pixels added with

seed pixel based on some similarity measures. When the growth of one region is stop then another seed point is selected and the process is repeated to detect another region. In our proposed system, there are three criteria's for selection of seed points. We have obtained three regions for all the images and the region, which satisfied the tumor constraints, selected as tumor region and displayed in results. If no region satisfies the constraints, the system will display the message of tumor not found.

3.4 Post Processing

Post-processing is a set of operations applied on segmented image resulted from each segmentation technique. In this step, our system will check some conditions before displaying results. Such that, tumor size and solidity constraints are check in this step. As in mostly MRI images there are more than one areas that are segmented as tumor but most of these are not part of the tumor, post-processing is applied to find maximum solid area from the binary image. The size constraints also checked in this step. Skull stripping also performed in this step. Since skull area has mostly similar gray levels as tumor regions, it may segmented as tumor in segmentation results, so skull is removed in this step to detect the brain tumor accurately.

3.5 Result

The final step is of results, that is the output of implementation. At this step, resultant image along with some information extracted from the given image displayed to the user. It the final output of the segmentation results. The output can be of the single segmentation technique specified by the user. The user may also see the output of all the segmentation techniques at the same time in a single window. The information about the resultant image of each segmentation techniques will contain size of the tumor, and the time elapsed to perform a particular segmentation technique. This information will be visible to the user along the image. The user also sees the graphical view of the information extracted from the image, for example pie charts and histogram of the image.

4. Experimantal Result

4.1 Dataset

We have data set of 155 MRI reports of different patients. From this, 105 images contain tumor and remaining 50 do not have tumor. Each MRI image is analyzes by using three image segmentation techniques (K-mean segmentation, threshold segmentation and region growing segmentation). The dataset used downloaded from oasis-brain site and from data set of previous researches.

4.2 Gray Scale Conversion

The images get from different resources may be an RGB colored images. It is first converted into gray scale. As gray scale image carries only intensity information so it is easy to process gray scale image as compared to process three components R (red), G (green), B (blue). The image is represented as matrix and the value assigned to the pixel is corresponding to its brightness/darkness at corresponding position. The gray scale image is an 8-bit image and to represent the brightness of pixel has gray levels from 0 to 255. Pixel value 0 represent black color and 255 represent white and remaining range represents gray levels. We convert RGB image into gray scale because RGB colors are not require for processing. It also reduces the computational cost.

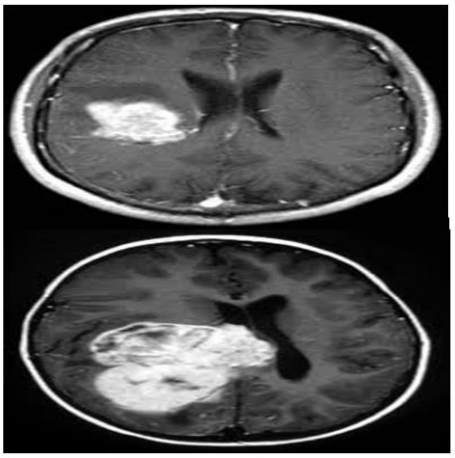

Fig. 1 gray scale conversion

4.3 Segmentation

Image segmentation methods divide an input image into significant sections with respect to specific application. Segmentation techniques used to separate the region of interest from an image. MRI image, consist of background and foreground. The tumor part is the foreground of the MRI image and the normal brain considered as background. Segmentation separates this foreground from background. In proposed system, three segmentation techniques used to segment the image on different similarity criteria.

1. K-Means segments the image into k clusters. 'K' represents the number of clusters. Each pixel belongs to a cluster in such a way that intra cluster similarity maximized and inter-cluster distances maximized or in

other words, intra-cluster distances minimized. Actually, we require only two clusters. The first part is tumor effected and other is normal brain part of the MRI image. But if we take k=2 then non tumor parts also becomes the tumor part because MRI is gray scale and almost pixels with intensity 0 to 128 will become part of first cluster and the pixels with intensities between 129 to 255 will become part of second cluster. Since the tumor has higher intensity values usually greater than 200 therefore we take k=3 to best segment the input image. First cluster has set of pixels, where all pixels have value 0 and represent as black color cluster. The second cluster has set of pixels with value 1 and represent as gray color cluster. The third cluster has set of pixels with value 3 and represent as white color cluster. Since tumor, area is of high intensities so we are interested in third cluster.

2. Second technique is threshold segmentation that segments the input image on the bases of intensity value range. It extracts the part of image or the pixels whose intensity value exceed through a specified threshold. In this way, the result is only tumor part that whose pixel values exceed through threshold. All the remaining part will become black through this technique. So, the resultant image of threshold segmentation is binary image. Threshold value selection is a difficult task in threshold segmentation and has significant effect on the results. We have implemented global threshold technique and the threshold selected is 173 because it produces better results on more of the input images in the data set.

3. Third region growing technique is the simple region based image segmentation method. It based on the fact that the neighbors of the pixels have values that are more similar. The algorithm starts with a single pixel as initial seed point. In this approach of segmentation, the neighboring pixel of initial seed point examine and determine that the pixel neighbors should added to the region or not. Therefore, by repeating this process, the region grows and stops when pixels stop to add in the region. When new neighbors added the mean of the region changed. Mostly applications of region growing technique are not fully automated instead these are semi-automated. User usually gives the seed point at run time. In our system, we automate this technique in selecting three different seed points where one cluster returned as tumor region by each technique. We have added the resultant regions of each seed point into a new image and select the true tumor segment by applying some constraints.

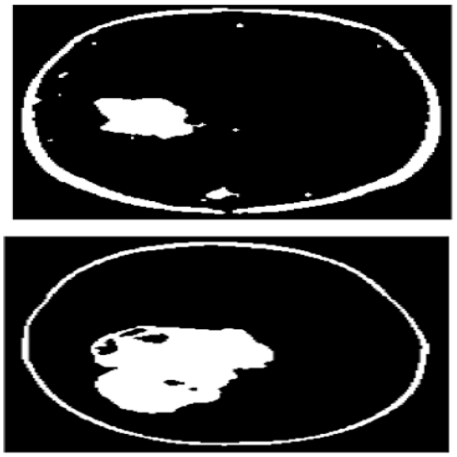

Fig. 2(a) Results of k-mean segmentation

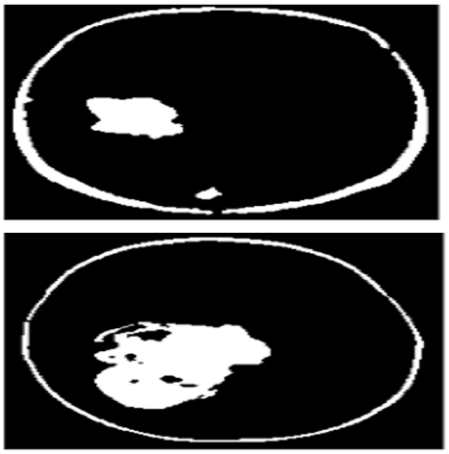

Fig. 2(b) Results of threshold segmentation

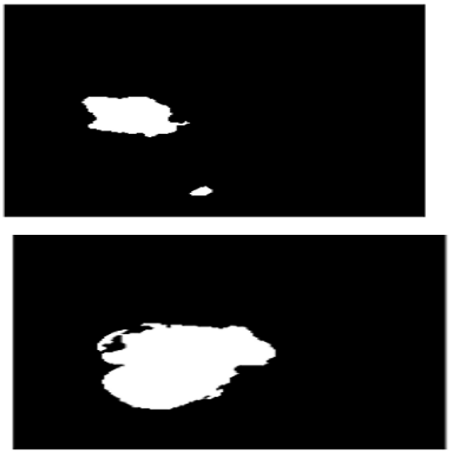

Fig. 2(c) Results of region growing segmentation

4.4 Candidate Region Extraction

Segmentation approaches segment the input image into different regions. The region of interest extracted on the bases of some conditions. First constraint is solidity, interested cluster or region is the high solidity region that is the tumor. Through this condition it will done skull stripping that removes the boundary area of image that creates uncertainty in results and a single region extracted as tumor region. The second condition is size of the region. The size of the tumor cannot be too large and cannot be too small. Therefore to extract the candidate region from the segmented image, this size constraint also tested. The results of implemented techniques after candidate region extraction are:

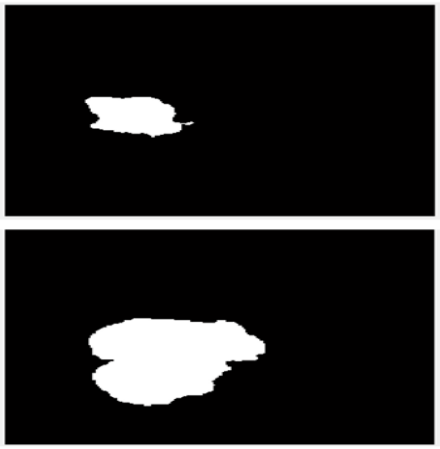

Fig. 3(a) candidate region extraction by k-means

Fig. 3(b) candidate region extraction by thresholding

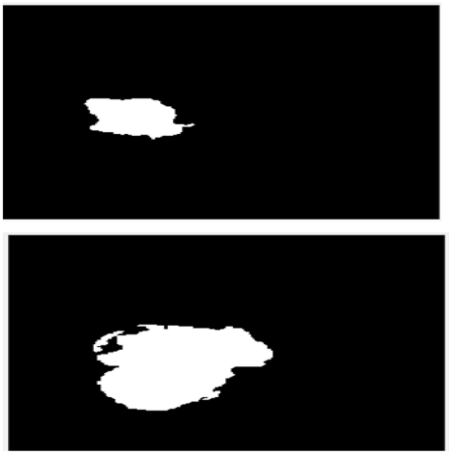

Fig. 3(c) candidate region extraction by region growing

4.5 Performance Evaluation

During performance evaluation, there exist some performance evaluation cases for each implemented technique. These cases have described below:

4.5.1 True Positive (TP)

If one detect the condition when condition present there, the test result is called true positive. As here segmentation technique correctly detect tumor when tumor present in MRI.

4.5.2 True Negative (TN)

If one does not detect the condition when condition is not present there, the test result is called true negative. As here segmentation technique do not detect tumor when tumor is not present in MRI.

4.5.3 False Positive (FP)

If one does not detect the condition when condition is present there, the test result is called false positive. As here segmentation technique do not detect the tumor when tumor exist in MRI.

4.5.4 False Negative (FN)

If one detects the condition when condition is not present there, the test result is called false negative. As here proposed technique detect the tumor when tumor does not exist in MRI.

4.5.5 False Positive-Positive (FPP)

If one detects the condition when condition is present there but do not detect it correctly, then the test result is called

false positive-positive. Segmentation technique detect tumor when tumor present but not correct location and size.

4.5.6 Accuracy

Accuracy mostly defined as the level of measurement without inherent limitations. It can be said that it is free of systematic errors. The ISO definition of accuracy is that accuracy is the degree of measurement that produce true (without any systematic errors) and consistent (without any random errors) results.
Accuracy is also used for statistical measurements. It measures that how well a binary classification test correctly recognizes and eliminates a condition.
That is Accuracy is proportional to the true results among the total number of cases tested.
Accuracy= ((TP+TN)*100)/(total length of dataset)

4.6 Result

The performance of the system depends upon each segmentation technique. Accuracy of results varies from technique to technique. By comparison, of implemented techniques accuracy of thresholding technique on this specified dataset is higher than other two techniques. The time duration for tumor detection is different for different MRI images and varies from technique to technique for each image and time consumed by thresholding technique is less than other techniques. Accuracy of thresholding segmentation is 95%, accuracy of k-means segmentation is 93%, and accuracy of region growing is 83% for this specified dataset.
The results obtained from all three techniques are as follows:

Techniques	K-means	Thresholding	Region growing
No. of images having tumor but not detected(FP)	1	1	12
No. of images without tumor but detected(FN)	12	4	5
No. of images having tumor but detected falsely(FPP)	4	2	9
No. of images correctly segmented (TP+TN)	140	148	129
Accuracy of the technique	90%	95%	83%
Average time consumed	0.175 sec	0.029 sec	0.252 sec

5. Conclusion and future work

The main objective of research and development of this project is to make easy and quick detection of tumor and comparison of results of different segmentation techniques. Proposed system applies three image segmentation techniques (Threshold segmentation, k-mean segmentation and region growing segmentation) to segment MRI images. The results of all techniques compared with each other on the bases of speed and accuracy. Our experiments show that this is low cost machine for detection and comparison of tumor results. Proposed system detect different shape and size of tumor that show that system working efficientlyExplore with the research community the challenges of research and innovation to develop trust and ability and establish quantum computing and simulation technologies.
In future, this work can be extends to classify the types of tumor (i.e. benign or malignant) and this work will be extended by developing the system that detects tumor from the images of x-ray and CT-Scan also.

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