An analysis of Brain Magnetic Resonance Images using Edge and Region based Segmentation Methods

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Abstract - Medical Image processing is a sequential combination of various computer based methods to extract medical data to identify diseases or disorders. The basic techniques include image pre-processing, thresholding, segmentation, feature extraction and pattern recognition. The recent researches show that association of machine learning and artificial intelligence paradigms with image processing create new dimensions. But the major part of this image processing is segmentation, the partition of image into segments based on gradient in the image properties such as intensity, color, or texture. The image segmentation has variety of techniques. This paper analyses the two major segmentation techniques i.e edge based and region based segmentations. The comparison has been made based on processing time and Jaccard Index (with the ground truth image). The images dataset taken for analysis is BRATS-2015 Brain Tumor Image Segmentation Challenge benchmark images.

Index Terms - Active Contour, Brain, Edge, MRI, Region Growing, Segmentation.

I. INTRODUCTION

Image segmentation is a process of clustering of same pixel gradient used for image feature extraction. This task is a way of classifying an image into different regions that possess similar properties such as intensity, texture, color etc. The major part of brain MR segmentation is to segment gray matter, white matter and cerebrospinal fluid. Segmentation is also used to find out the regions corresponding to lesions tumors, cyst, edema, and other pathologies and for this mostly T1- weighted images are used [4].

The task of identifying abnormal growth of lesions or tumour in the brain MRI is consist of a sequential steps which starts from various pre-processing stages like grayscale conversion, contrast stretching, background extraction and noise removal. In most cases median filtering done as noise reduction. Morphological operations such as dilation and erosion are two non-linear operations used to add features to the boundaries by adding or removing pixels.

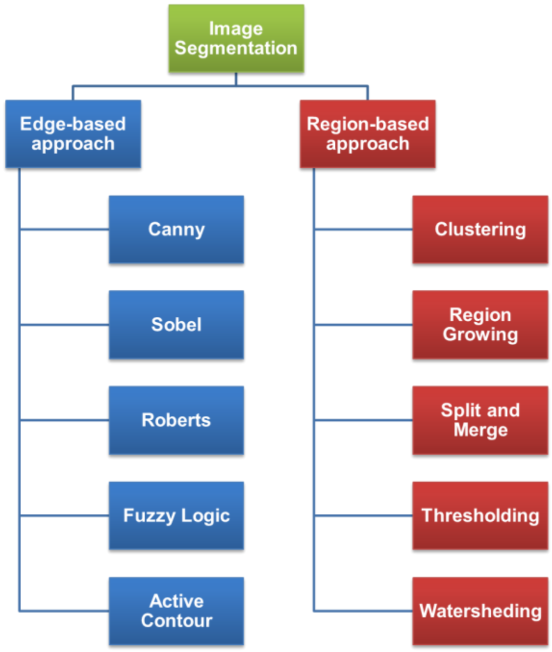


Figure 1: Various Image Segmentation methods

II. IMAGE SEGMENTATION TECHNIQUES

Images are segmented for identifying and grouping objects or regions which have same property. The role of segmentation is to partition the objects in an image; in case of medical image segmentation the aim is to study anatomical structure, locate tumor or lesion, measure growth or cure of tumor and assist in treatment. There are many methods available to segment an input image. They are Edge based, clustering based, region based, Histogram based, Model based, graph partitioning, watershed transformation, etc. But, widely used and most successful image segmentations for medical images are edge based and region based segmentations.

Automated and accurate classification of MR brain images is extremely important for medical analysis and interpretation. Over the last decade numerous methods have already been proposed [2].

The segmentation is classified in to many types based on it working methodology. Here, two major categories used, namely edge based segmentation and region based segmentation.

Table 1: Two segmentations comparison

Edge–based method	Region–based method
• Detects sharp contrast edge bounded objects	• Same pixel valued regions are well observed
• Works well in images with good contrast	• Works well even when the image has low contrast.
• It is more similar to the manual segmentation process of images.	• Very less sensitive to noise.

The table 1 indicates few differences between the selected two algorithms in this paper.

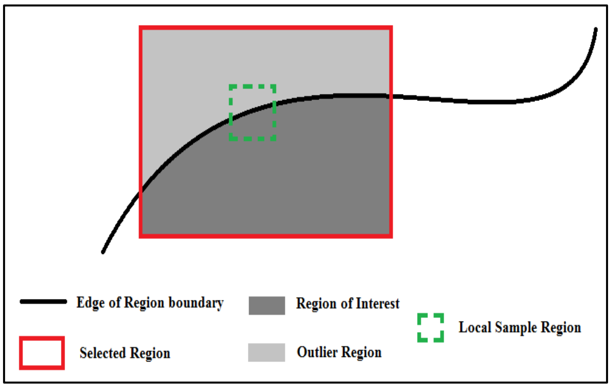


Figure 3: Segmentation process

The image segmentation process is combination of several sub tasks from noise removal till the feature extraction i.e object identification. The figure 3 depicts how an algorithm processes an image, which finds region of interest and outliers.

III. Edge-based Techniques

A. Algorithm for Edge detection

Input:	*Image*
Output:	*Contoured Image*
Step 1:	*Get input image*
Step 2:	*Pre-processing like smoothing, grayscale conversion.*
Step 3:	*Apply masking Gx and Gy to the input image.*
Step 4:	*Find gradient by process image with edge detection algorithm*
Step 5:	*Construct separate image for Gx and Gy*
Step 6:	*Results are combined to find the absolute magnitude of the gradient.*
Step 7:	*The final slope magnitude image is resultant image.*

First Order Derivative Edge Detection: The first order derivative operators are very sensitive to noise and produce denser edges.

Sobel: Detects edges are where the gradient magnitude is high. This property makes the Sobel edge detector more sensitive to diagonal edge than horizontal and vertical edges.

-1	0	1
-2	0	2
-1	0	-1

1	2	1
0	0	0
-1	-2	-1

Figure 3: X Component Y Component

The figure 3 shows the basic components for the sobel operator. Sobel and Prewitt methods are very effectively providing good edge maps[3].

Prewitt: This operator is a differentiation method which works similar to the Sobel edge detector, and it finds the gradient for the image intensity function. This algorithm also makes use of the maximum directional gradient. As compared to Sobel, the Prewitt masks are simpler to implement but the drawback is very sensitive to noise.

Roberts: diagonal edge gradients, susceptible to fluctuations. This Robert's operator not provide information about edge orientation and works best with binary images.

Frei-Chen method: Frei and Chen have adapted the Sobel's model. Frei-Chen method are accurate and better detection, low overhead, detect corners beside with edges and less sensitive to noise than other edge detector[7]. It creates the gradient for horizontal, vertical, and diagonal edges the same at the edge center. It works on a part of image with size 3*3 like the Sobel but instead of 2 masks, it uses 4 masks. This noise removed weighting method can take the refined edge detail very easy and give thinner edge lines, but it also increase the possibility of erroneously detect noise as real edge points.

2nd Order Derivative Edge Detection. In this second order method, the edge is detected if there is a significant spatial change in the second derivative. Second Order Derivative operators are more refined methods work towards automatized edge detection but it has the problem of sensitive to noise.

To avoid such noise due to the differentiation, it is recommended to smooth the image as a preprocessing before applying the Laplacians. The typical examples of 2nd order derivative edge detection are the Difference of Gaussian (DOG) and the Laplacian of Gaussian (LoG) Example: the Marr - Hildreth method.

B. Active contour model

Active contouring is developed for image segmentation based on the curve movement, arc and contour to find the exact target region or segment in the image. Contour models are used to process numerous images from diverse modalities. Active contours separate the regions of required pixel intensities based on the energy forces and conditions.

IV. REGION-BASED TECHNIQUES

The image segmentation is the process to partition an image into various regions. There are numerous methods are available to identify and classify specific regions. Each segmentation method follows its own way, for example thresholding method finds by looking for the boundaries between regions based on discontinuities in grayscale or color properties. The region-based method is a technique looks for regions directly to determine the different regions in the image. It is the clustering of an image into different regions, which is related to different objects in the image or parts of image objects. So each pixel in an image is united to one of the different clusters.

In region based segmentation, pixels in the same greyscale values are form a connected region upto the neighbouring pixels which have different intensity categories.

The following is the general formula for the region based segmentation algorithm.

$$\bigcup_{i=1}^{n} R_i = R \quad \text{---------------------------------} \quad (1)$$

$$R_i \cap R_j = \emptyset, i \neq j \quad \text{----------------------------------} \quad (2)$$

Where R_i is the region which is connected and $i = 1,2,3,\ldots,n$.

A. Region Growing

Region growing algorithm begins from a collection of pixels called seeds that belong to the structure of interest. Then it spreads across its neighbouring pixels and grows uniformly to make connected region from each seed. It compares the difference between the pixel intensity value and the mean intensity value over a region. The region growing methods results depend on the selection of the homogeneity criterion. If it is not properly chosen, the regions leak out into adjoining areas or merge with regions that do not belong to the structure of interest. Different starting points may not grow into identical regions[12].

B. Watershed Algorithm

The watershed algorithm is based on an immersion process analogy, in which the flooding of the water in the picture is efficiently simulated using a queue of pixels [10] [11]. It has been widely applied to a variety of medical image segmentation processes. In this algorithm, an image is regarded as a topographic landscape with ridges and valleys. The elevation values of the landscape are typically defined by the gray values of the respective pixels or their gradient magnitude. Inter-pixel implementation of the watershed method is introduced as nn enhancement to this algorithm [9].

V. LITERATURE REVIEW

Romesh Laishram et al. presented the two stage edge detection methodology. The input MRI image is performed image segmentation using Particle Swarm optimization incorporating Fuzzy C Means Clustering technique and canny edge detection. In this literature, it is claimed that technique yields better edge detected image of the human brain as compared to other edge detection methods. It provides good detection, good localization, and minimal response with less false edges[1].

Y. Zhang and L. Wu presented a method to classify MR brain image as normal or abnormal. The wavelet transform is applied to extract features from images, followed by Principle Component Analysis to reduce the dimensions of features. The features which are reduced sent to a Kernel Support Vector Machine (KSVM). Their work chosen seven common brain diseases i.e. glioma, meningioma, Alzheimer's disease, Alzheimer's disease plus visual agnosia, Pick's disease, sarcoma, and Huntington's disease[2].

Segmentation of image using a region-based active contour model could present difficulties when unknown noise distribution. A region-based model proposed for the segmentation of objects or structures in images by introducing a local similarity factor, which relies on the local spatial distance within a local region and local gradient difference to enhance the segmentation. By using this local similarity factor, their method extracts the object boundary while guaranteeing certain noise robustness. This algorithm avoidsthe pre-processing steps typical of region-based contour model segmentation, provides higher preservation of image details [5].

Yan li et.al proposed a dual-threshold method based on a strategic combination of RGB and HSV color space for white blood cell (WBC) segmentation. On that method consists of three main parts: pre-processing, threshold segmentation, and post processing. In the pre-processing two images received one contrast-stretched gray image and one H component image from transformed HSV color space. A dual-threshold method is introduced for improving the conventional single-threshold approaches and a golden section search method is used for determining the optimal thresholds. For the post processing part, mathematical morphology and median filtering are utilized to denoise and remove incomplete WBCs [6].

In [8], Gullanar M. Hadi and Nassir H. Salman used two techniques to achieve medical image segmentation. The first method is many ranges of pixels intensities of input gray image are defined depend upon the peaks in its histogram, this provide set of binary images represent these ranges, then combine all these images to get the segmented image. The second method was K-means algorithm used for the same images, and the result is a set of clusters that are entirely different clusters. Finally linear filtering was used to get image regions with their boundaries (segmented image regions).

VI. Methodology

This paper illustrates comparison of two major medical image segmentation methods. Two specific techniques taken from each method i.e. edge based Active contour model and Region growing method from region based segmentation. The image dataset taken for analysis is BRATS-2015 Brain Tumor Image Segmentation Challenge benchmark images. These images are converted as signed 16-bit integers.

VII. Results Analysis

Table 2: Analysis results of two segmentation methods

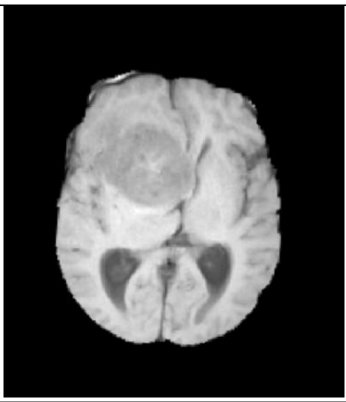
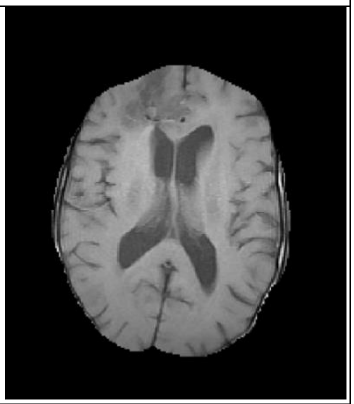
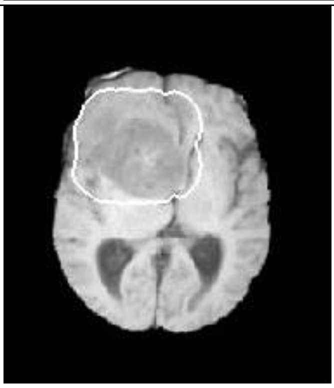
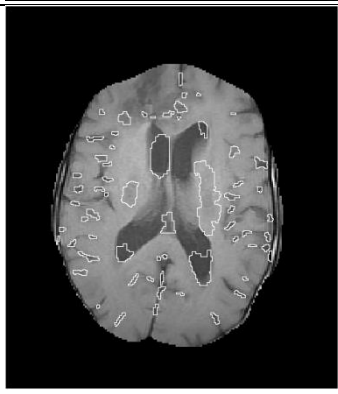
Image ID **(File name)**	**VSD.Brain.XX.O.MR_T1.54206**	**VSD.Brain.XX.O.MR_T1.54228**	**VSD.Brain.XX.O.MR_T1.40468**
Original Image			
Edge-based Segmentation Algoritm – Active Contour (EbSA-AC)			
Region-based Segmentation Algorithm – Region Growing (RbSA-RG)			

Table 3: Performance Time for the segmentation methods (in seconds)

Image ID	EbSA	RbSA
VSD.Brain.XX.O.MR_T1.54206	1.504	1.096
VSD.Brain.XX.O.MR_T1.54228	1.675	1.099
VSD.Brain.XX.O.MR_T1.40468	1.777	1.224

The table 3 shows the time taken for segmenting tumour for given three input images. The processing time is noted in seconds. The EbSA -AC (Edge based Segmentation Algorithm – Active Contouring) requires more time for processing than the RbSA – RG (Region based Segmentation Algorithm – Region Growing).

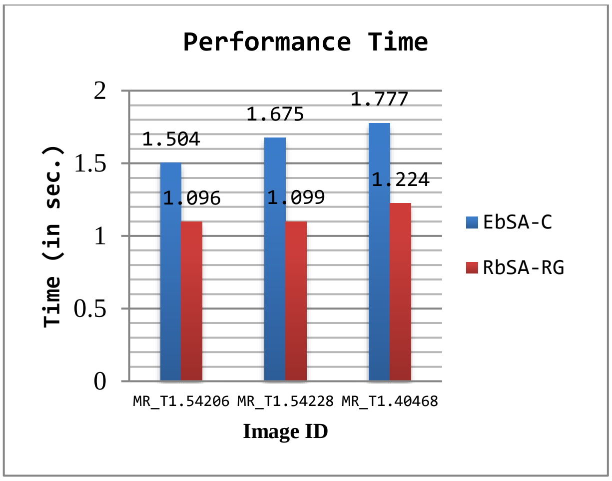


Figure 4: Performance time for algorithms

Table 4: Jaccard Distance

Image ID	EbSA	RbSA
VSD.Brain.XX.O.MR_T1.54206	0.1136	0.7090
VSD.Brain.XX.O.MR_T1.54228	0.1425	0.7076
VSD.Brain.XX.O.MR_T1.40468	0.1314	0.6893

Table 4: Jaccard Index

Image ID	EbSA	RbSA
VSD.Brain.XX.O.MR_T1.54206	0.8863	0.2909
VSD.Brain.XX.O.MR_T1.54228	0.8574	0.2923
VSD.Brain.XX.O.MR_T1.40468	0.8685	0.3106

The Table 3 and 4 show Jaccard distance and Jaccard index respectively, is a measure of how dissimilar two sets are. It is the complement of the Jaccard index and can be found by subtracting the Jaccard Index from 1. These measures compare two images to see difference between the original and segmented images. These measures are widely used for assessing the similarity among the two data sets. In segmentation, these indexes compares resultant image with the ground truth test images.

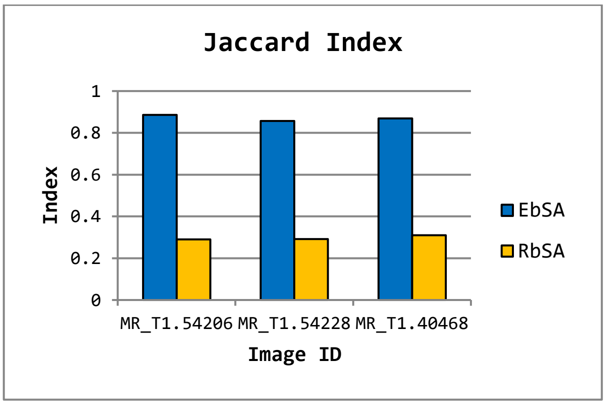


Figure 6: Jaccard Index of two segmentation methods

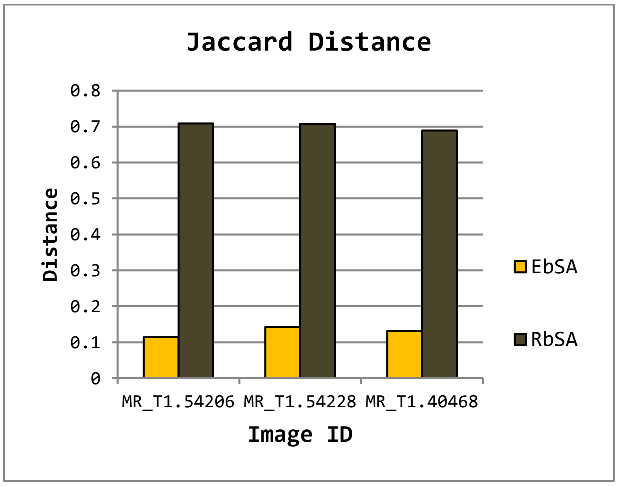


Figure 5: Jaccard Distance of Segmented images using two methods.

VIII. CONCLUSION

The medical image segmentation is the process of finding diseases or lesions in taken MR Images of patient's body. This results in identification of abnormal symptoms like tumour, bleeding or lesions. In this paper two segmentation algorithms used and compared to locate tumour on the brain MRI. The edge based active contour model and region growing method are used for analysis. Based on the results region growing method takes 66% less time than edge based contour model. But when discuss about Jaccard index, active contour model outperforms region growing about 42% as it produces false positive objects all over the image due to noise.

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