Detection and Extraction of Tumor Region from Brain MRI using Fuzzy C-Means Clustering and Seeded Region Growth

Harsimranjot Kaur, Dr. Reecha Sharma

Abstract— The detection of brain tumor is one of the most challenging tasks in the field of medical image processing, since brain images are very complicated and tumors can be analyzed efficiently only by the expert radiologists. Therefore, there is a significant need to automate this process. In this paper, a method for the automatic detection of the tumor from the brain magnetic resonance imaging (MRI) images has been proposed. For this, the region-based segmentation of the input MRI image is done. The wavelet-based decomposition of the input image is done and the input image is reconstructed on the basis of soft thresholding for the enhancement of the image. After that, fuzzy c-means clustering (FCM) followed by seeded region growing is applied to detect and segment the tumor from the brain MRI image and finally comparison with Sobel operator is done on the basis of accuracy, and sensitivity values for performance analysis. The results for the proposed technique are better than the results obtained by using Sobel operator.

Index Terms— Brain tumor segmentation, Edge detection, Fuzzy clustering, Region growing, Sobel operator, Wavelet decomposition.

1 Introduction

The brain tumor is a very common disease now-a-days which has devastated many lives and the count is still increasing. In the field of biomedical imaging, the segmentation of brain tumor from the MRI images has become an emergent area of research. The magnetic resonance imaging (MRI) scans produce detailed images of the internal structure of human brain and other parts of the body. The MRI scan is preferred over other techniques like computed tomography (CT) scan or ultrasound for brain tumor diagnosis as it provides more clear images of those parts of brain also which cannot be seen with other techniques. The accurate detection of the size and location of the tumor in the human brain plays a significant role in the diagnosis of the tumor. The segmentation of brain tumor from MRI scan is done manually by experts. The manual segmentation of brain tumor region is a very difficult and time-consuming task and the accuracy of the result depends on the experience of the physician. In this work, a method for automated detection of brain tumor from MRI scan is being presented. The system for automated detection of the brain tumor from the MRI helps in the extraction of region of interest from the MRI scans which of great significance to the physicians in the diagnostic and treatment process. Then the comparison of the proposed method is done with the Sobel operator and the performance analysis is done on the basis of accuracy, sensitivity, specificity and precision values.

2 Related Work

The segmentation of brain tumor from MRI images is a major topic of biomedical research and extensive work had been done in this area. A large number of different techniques are available for this purpose [1] [2]. The researchers have used edge based segmentation techniques, thresholding and region based segmentation techniques [3], fuzzy clustering and neuro-fuzzy techniques and have been able to segment tumor region [4] [5]. Asra Aslam et al. presented an improved edge detection algorithm for segmentation of brain tumor [6]. This algorithm is based on Sobel edge detection method. The brain tumors extracted from proposed method using Sobel method along with closed contour algorithm are better than the tumors detected using Sobel method only. Roy et al. proposed a completely automatic algorithm to detect tumors by utilizing symmetry analysis [7]. It produces great results in images with non-uniform intensity distributions also. S. Roy et al. explored a technique to distinguish tumor in brain MRI images [8]. It applied segmentation technique on the MRI image of brain tumor, converting it into binary image and then applied morphological operations on it. The results obtained by this technique were efficient. Malakooti et al. proposed a tumor segmentation technique which uses combined fuzzy logic and neural networks and extracts the boundary taking into account level set method [9]. The proposed technique gave better results as compared to other existing techniques. Deshmukh et al. presented an automated recognition system for the MRI image using the neuro-fuzzy logic [10]. It takes the idea that manual analysis of brain tumor is time annihilating and produces inaccurate results. This proposed method is quick in execution, proficient in arrangement and simple in implementation. In the proposed work segmentation of the input and performance analysis is done on the basis of accuracy and sensitivity values.

3 Proposed Technique For Brain Tumor Detection From Mri

In this work, the fundamental concept is to detect and extract the tumor region in brain MRI. For this, the region-based segmentation is applied on the input image. The proposed work uses wavelet based decomposition for image smoothing. After that fuzzy c-means clustering is

applied to cluster the input image into a number of clusters. This step segments the brain tumor into a significant cluster. Therefore it becomes easy to process that region which consists of the tumor. Then connected component analysis and seeded region growing are applied to extract the tumor region. The flowchart for the procedure is as given in fig.1.

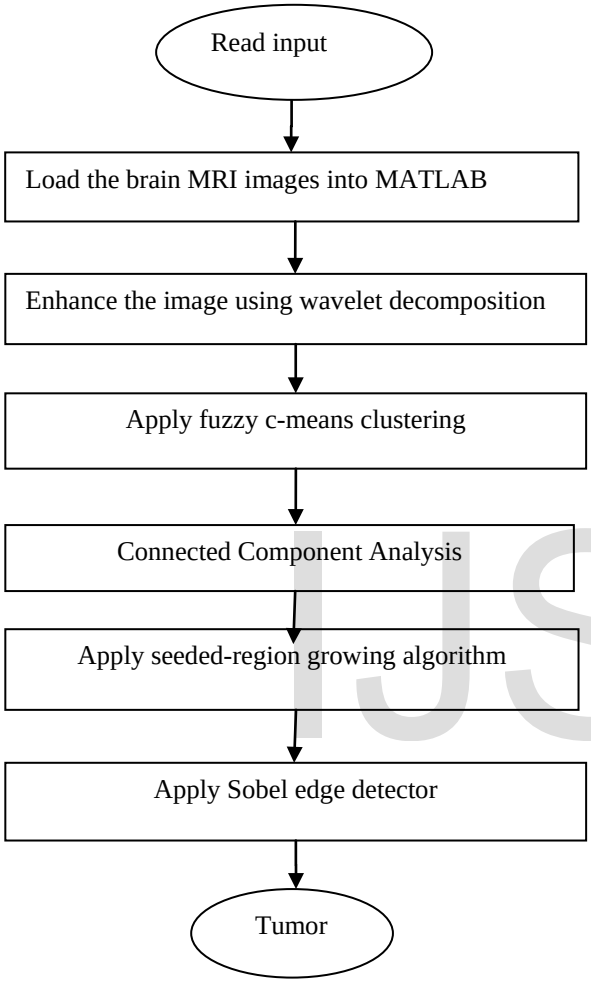


Fig.1: Flowchart for brain tumor extraction

STEP 1: Input the MRI image into MATLAB

Load the brain MRI image into MATLAB and convert it to grayscale image of 256*256 matrix. If the image is in RGB color format then it is converted into grayscale image.

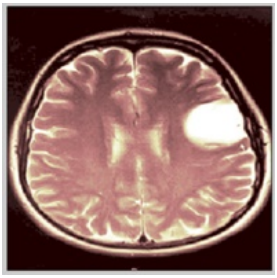


Fig.2: Input brain tumor image

STEP 2: Apply Wavelet Decomposition

After that, apply wavelet based decomposition for enhancing and de-noising the image. In the proposed work, 'bior 3.5' wavelet has been used to decompose the image up to four levels. The approximation and the detailed horizontal, vertical and diagonal coefficients of the image are extracted. Soft thresholding is applied before reconstruction of the decomposed image.

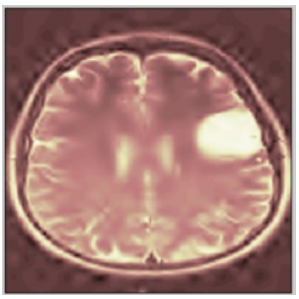


Fig.3: De-noised image using wavelets

STEP 3: Apply fuzzy c-means clustering

After smoothing the image, apply fuzzy c-means clustering (FCM) to get segmentation of image into four clusters. FCM clustering is an unsupervised technique for the analysis of given input image. The fcm clustering algorithm assigns membership function to each pixel in an image corresponding to each cluster center based on the distance of the cluster center from that pixel [11]. The pixels near to the cluster center have higher membership function towards that particular cluster.

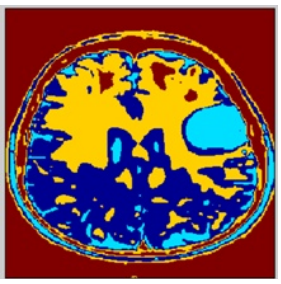


Fig.4: FCM clustered image

STEP 4: Connected component analysis

After that the connected component analysis of the output image is done. The pixels of the binary image obtained after applying FCM are labeled as 0 are the background object pixels. The pixels which are labeled as 1 make up one object; the pixels being labeled as 2 make up a second object and so on. In this paper, we used area and perimeter property of the regions and used them to eradicate unwanted objects in the binary image and found the object which contains maximum pixels of brain tumor in it. Further, the centroid of the final object is used as a seed point to get segmentation of tumor done using region growing algorithm.

Fig.5: Objects left after filtering using area of binary objects

STEP 5: Region growing algorithm for segmenting out tumor

The fundamental idea behind the technique of region growing is grouping the pixels with similar properties together to form a particular region. The seed point for the final object left after connected component analysis is calculated automatically and the neighboring pixels around the seed point pixels are analyzed by the pre-determined region growing formula. When all the neighboring pixels are included into the seed pixels domain, at that point the region is said to be grown and region growing stops.

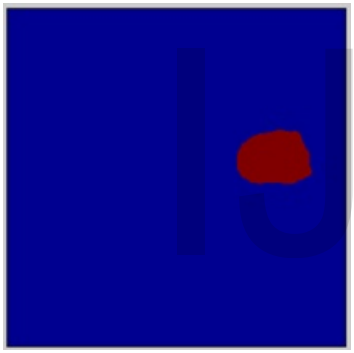


Fig.6: Tumor detected after region growing algorithm

STEP 6: Edge detection of tumor

After the region growing algorithm, edge detection of the tumor region is done using the Sobel operator.

Fig.7: Tumor edge detection using 'Sobel' filter

4 Experimental Results And Discussions

The results thus obtained by the proposed method are analyzed using various performance parameters [12]. The parameters being calculated include Accuracy and Sensitivity. The more the values of these parameters, the better is the performance of the system. These values can be defined on the basis of true positive (TP), false positive (FP), true negative (TN) and false negative (FN), where TP indicates the pixels of the region of interest that are correctly detected, FP indicates the background pixels wrongly detected as region of interest, TN indicates the background pixels that are correctly detected and FN indicates the region of interest wrongly detected as background pixels. The ground truth image is taken as reference for comparing the results so obtained.

1. Accuracy: It is a measure of the extent to which the region of interest is correctly identified in accordance with the ground-truth image. It can be defined as:

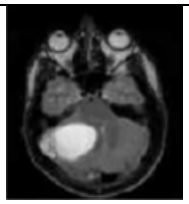
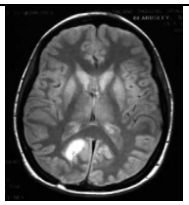
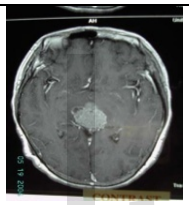
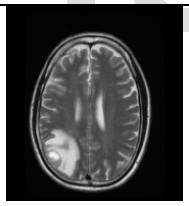
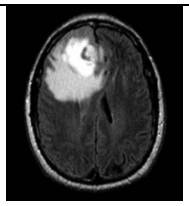
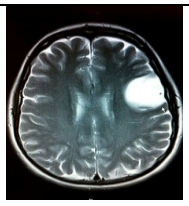
$$\text{Accuracy} = \frac{TP+TN}{TP+FP+TN+FN}$$

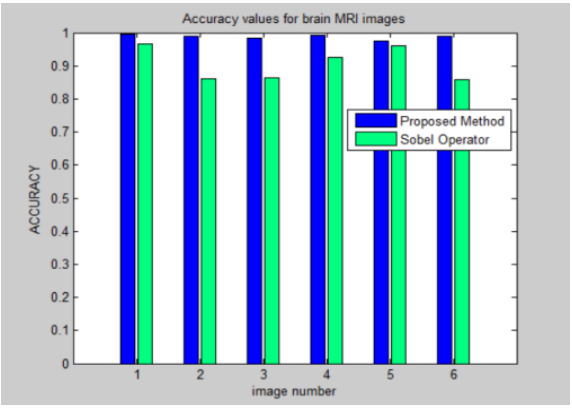
2. Sensitivity: It is a measure of the extent to which each pixel of the region of interest is correctly detected as foreground in the output. It can be defined as:

$$\text{Sensitivity} = \frac{TP}{TP+FN}$$

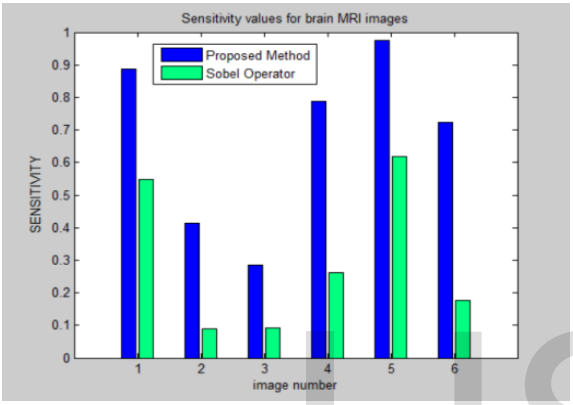
For performance analysis, the values obtained by using the proposed algorithm are being compared with the values being obtained by using Sobel operator. The values are tabulated as given below:

Table 1: Accuracy and Sensitivity values for the proposed method and Sobel operator

S.No.	Input Brain MRI Image	ACCURACY		SENSITIVITY	
		Proposed Method	Sobel Operator	Proposed Method	Sobel Operator
1.		0.9949	0.9672	0.8874	0.5488
2.		0.9888	0.8603	0.4134	0.0886
3.		0.9846	0.8636	0.2855	0.0932
4.		0.9936	0.9250	0.7893	0.2624
5.		0.9765	0.9603	0.9744	0.6186
6.		0.9902	0.8590	0.7223	0.1770



(a)



(b)

Fig. 8: Performance comparison in terms of (a) Accuracy; (b) Sensitivity

From the outcomes appeared above it has been found that the proposed algorithm has high Accuracy and sensitivity values than those obtained by using the Sobel operator. The results for a few pictures have been shown as depiction while we attempted the calculation on a number of distinct images.

5 Conclusion

In this work, we proposed a method which can help the radiologists in the automatic detection of the brain tumor from MRI images. For this, the region-based segmentation of the input brain MRI image is done. For image enhancement the wavelet based decomposition of the input image is done and after applying FCM and connected component analysis, region containing brain tumor is extracted from MRI images using the seeded region growing. At last, Sobel operator is applied to detect the edges of the brain tumor. The proposed algorithm gives excellent results for the input MRI images.

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