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Semi Automatic Detection of Epilepsy from T2 Weighted MR Images by using Atlas based Segmentation of Brain Structure

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Abstract

Detection of epileptic area from T2 weighted image of MR Image was performed by calculating the volumes of the brain structures. Atlas based segmentation is used for the segmentation of brain structure. The volume of each part of brain is calculated, and the ratio of right hemisphere of the brain to the left hemisphere of the brain is determined. The ratio of normal brain will be equivalent to 1, but in case of epileptogenic areas the ratio will increase or decrease. The results obtained will be correlated with the original diagnosis result which was already available. The area marked by our method was correlated with the area marked by the original diagnosis. The conclusion was validated by the calculation of true positive, true negative, false positive and false negative point.

Keywords: T2 weighted image, Epilepsy, atlas based segmentation, true positive, false negative

1 Introduction

Epilepsy is a type of neurological disorder which is characterized by triggering of seizures. There are four steps in the diagnosis of epilepsy- Patient's history, Physical test, EEG (electroencephalograph) and MRI scan. When epilepsy is not getting cured by taking anti epileptic drugs, patient has to undergo surgical treatment. For surgical treatment planning, person has to undergo brain scan [1]. Brain structure segmentation of brain structure plays a vital role in the analysis of image. There are

various segmentation methods available such as novel approach, fuzzy clustering algorithm, semi automated method and automates method of segmentation of medical images, hybrid bloch equation and tissue template simulation [2-9]., the novel method follows four steps- wavelet based de noising, watershed algorithm, apply watershed algorithm, merging using Fuzzy C mean algorithm approach[2]. Nissen et. al. roughly grouped these method into three categories: classification based method, region based method and boundary based method[10]. The method in the first two categories are limited by difficulties due to intensity inhomogenity, partial volume effects and susceptibility artefacts and the last categories suffer from spurious edges. In a normal brain atlas the ratio of volume of right part and left part is equivalent to 1[11], although some range is there. In case of person suffering from epilepsy the ratio will be larger than or less than 1. There are many reasons which can cause epilepsy such as brain injury, brain tumour, due to brain stroke, etc. For this study, the data of epileptic patients are taken from Open epilepsy database [12] where the epileptic area is already found out with the algorithm applied on EEG signals. Jean et. al. segmented brain MR image using atlas based segmentation [13]. In our segmentation process we are using atlas based EM (Expectation Maximization) method. The result we obtained from atlas based segmentation method is correlated with the result available at open access epilepsy database. False positive, false negative, true positive and true negative points are calculated. In this study, 14 epileptic data and 14 normal data are used and the volumes are calculated.

2 Materials and methods

Atlas based segmentation is used for segmentation of brain structure and volume calculation. Atlas based segmentation is the type of segmentation which segments the MR data on the basis of an atlas to which the MR data is registered. We have used EM atlas based segmentation of brain. EM segmenter is fast and flexible, requires minimal amount of training effort and uses probabilistic atlas. In the beginning stage it undergoes pre processing techniques like atlas to target registration and smoothening of the target image and then finally it goes for segmentation. EM segmenter works step by step for the segmentation process. In first step it segments the cranial cavity, in second step it segments the tissues like cerebral spinal fluid, gray matter and white matter and finally it segments sub cortex and cortex. When the target MR image data is totally segmented, the volume is also calculated as all the slices of MR data are loaded together. The volume of each and every part is calculated after the segmentation of whole brain structure is done. The ratio of volume of right side structure and left side structure is then calculated. 14 epileptic data and 14 normal data were taken and the ratio was calculated. The true positive, true negative, false positive and false negative points were determined, accuracy and precision was calculated with reference of true positive and true negative points. The result obtained from our work was correlated with the ground truth.

Ground truth: The result which is given in open epilepsy database is considered as ground truth here. The result which is given in open epilepsy database is taken as reference point.

True positive: The area which is considered as affected area in the ground truth and we are also getting the same result in the epileptic data, we will consider that point as true positive.
True negative: The area which is not marked as effected region in the ground truth and we are getting that particular area as affected area in the epileptic data, we will consider that point as true negative.
False positive: When we are not any affected area in a normal MR data, we will consider that point as false positive point.
False negative: When we are getting an affected area in a normal MR data, we will consider that point as false negative point.

Table 1: Design of hypothesis

True Positive	False Positive
True Negative	False Negative

Accuracy:

$$\frac{\text{No. of True Positive + No. of True Negative}}{\text{No. of True Positive + False Positive + False Negative + True Negative}}$$

Precision:

$$\frac{\text{No. of True Positive}}{\text{No. of True Positive + No. of False Positive}}$$

The whole work was done in a software 3D Slicer

2.1 Flow Chart

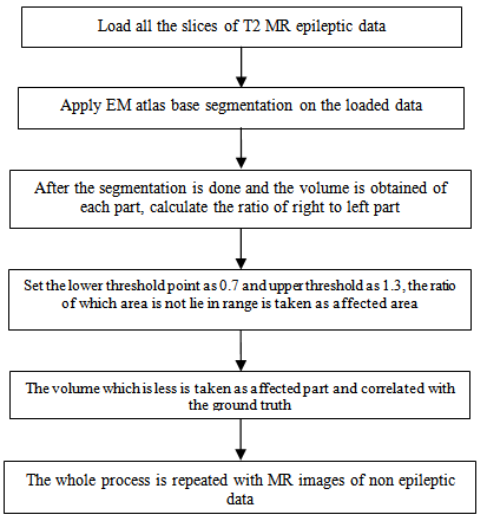

Figure 1: Flowchart of whole process

3 Results and Discussions

The range of ratio is kept between 0.7- 1.3, the ideal ratio is equivalent to 1[11]. It has been tried on normal MR data and the range of the ratio has been fixed. The range of ratio is decided after executing the process on normal brain MR data. Normal brain MR data was obtained from brain web database. Non epileptic data was obtained from OASIS (Open Access Series of Imaging Studies).

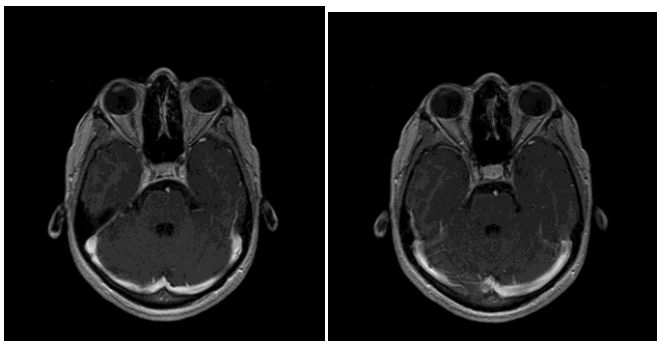

Figure 2: MR image before segmentation

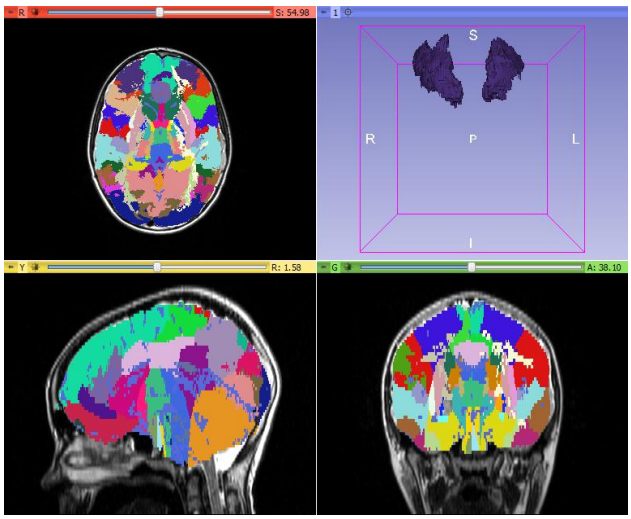

Figure 3: Segmentation of epileptic brain MR image

The above figure is segmentation of epileptic brain structure by EM atlas based segmentation, different colours are the different parts of brain.. It shows sagittal, axial and coronal view of brain. We can reconstruct a 3D model of any part of brain to see the volume difference.

Table 2: Volume of epileptic MR image data

Sl. No.	Part of brain	Volume of right part (a)(cc)	Volume of left part (b) (cc)	Ratio=a/b
1.	Middle frontal gyrus	25.887	18.773	1.37
2.	Superior frontal gyrus	51.023	49.011	1.04
3.	Triangular part of inferior frontal gyrus	8.468	7.257	1.16
4.	Opercular part of inferior frontal gyrus	11.468	13.915	0.83
5.	Superior temporal gyrus	31.003	30.027	1.02
6.	Middle temporal gyrus	14.370	18.992	0.75
7.	Lateral occipital gyrus	16.460	19.550	0.84
8.	superior parietal lobe	28.684	27.761	0.92

In the above table we can see that one value is exceeding 1.3, so we have considered as an abnormal value. All the other values are within 0.7-1.3, so they are considered as a normal value. In Table number 2 the red colour denotes that middle frontal gyrus is the affected area, we will be considering the left frontal lobe as effected area as the volume of the left part is less, the presence of tumour has compressed the volume of left frontal lobe. This method has only been implemented on lobe epilepsy, generalised epilepsy has not been tested by this method, as volume change in generalised epilepsy is not necessary. According to ground truth, in this case left frontal lobe is affected, so this is true positive point.

Table 3: volume of normal person brain MR image data

S.L.	**Parts of brain**	**Volume of right part (a)(cc)**	**Volume of left part (b)(cc)**	**Ratio = a/b**
1	Middle frontal gyrus	25.787	23.39	1.10
2	Superior frontal gyrus	37.361	39.682	0.94
3	Triangular part of inferior frontal gyrus	11.747	9.95	1.18
4	Opercular part of inferior frontal gyrus	9.37	10.687	0.85
5	superior temporal gyrus	25.058	20.487	1.22
6	Middle temporal gyrus	14.762	15.287	0.96
7	Lateral occipital gyrus	16.976	13.586	1.24
8	Superior parietal lobe	24.428	18.816	1.29

In table 3 there is no effected area, and this data belongs to non epileptic data, there is no effected area shown so it will be considered as true negative point.

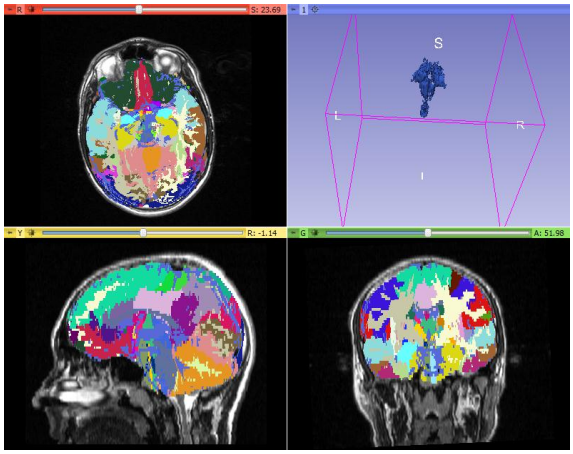

Figure 4: Segmentation of normal brain MR image data.

In figure 4, it is segmentation of normal person image data, different colours shows different parts of brain. It shows sagittal, axial and coronal view of brain. We can reconstruct a 3D model of any part of brain to see the volume difference.

Number of true positive point= 11
Number of true negative point=12
Number of false positive point=3
Number of false negative point=2
Accuracy = 0.8214 or 82.14%
Precision = 0.78 or 78%

4 Conclusion

We developed a method for localisation of epilepsy based on volume of brain structure. We found the results obtained from this method correlated well with the ground truth.

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