Performance Analysis of Clustering Algorithms for 3d Medical Image Rendering and Its Volume Calculation

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Abstract
Three dimensional reconstructions of abnormal regions from MR brain images is an important operation as it helps the radiologist in the diagnosis, surgical planning and biological research. This paper evaluates and analyse the clustering algorithms involved in segmenting abnormal region from MR brain images. Volumetric calculation is also presented with the extracted region to assist the radiologist in estimating the stage of cancer.

Keywords: Clustering, Abnormal Region, MR brain image, Volume Calculation

Introduction
The brain is the most complex organ in human body and it is a part of the central nervous system. It is surrounded by the skull and consists of gray matter, white matter and cerebrospinal fluid (CSF). The CSF supplies the brain with nutrients and hormones. The gray matter consists of neuron cell bodies and the white matter consists of myelinated axons. The main structure of the brain is the cerebrum, which serves functions such as movement, sensory processing, communication or memory. It is divided in four lobes, which have specialized functions. The gray matter is surrounding the white matter on the cerebrum’s surface and comes partly below the white matter in the deep brain [1].

Magnetic resonance imaging (MRI) provides maps of anatomical structures with a high soft-tissue contrast. Basically the magnetic resonance of hydrogen (1H) nuclei in water and lipid is measured by an MRI scanner [2]. The signal values are 12-bit coded, so 4096 shades can be represented by a pixel. MR scanners require a magnetic field. They are available at 1.5 Tesla (T) or 3 T. In comparison with the earth’s magnetic field (~50 μT) the magnetic field of a 3 T MR scanner is approximately 60’000 times greater [3].

MR images are grids of pixels with ‘M’ rows and ‘N’ columns. Every pixel of an MR image corresponds to a voxel, a volume element, whose values represents the tissue and MR signal, respectively. The volume of a voxel depends on MR scan parameters, i.e. slice thickness and pixel spacing.

In this paper, at first the abnormal regions are extracted from the T1- weighted MR brain images using the clustering algorithm and later the volume is calculated. This paper is organized as below

Segmentation
The segmentation of an image entails the division or separation of the image into regions of similar attribute. The ultimate aim in a large number of image processing applications is to extract important features from the image data which a description, interpretation, or understanding of the scene can be provided by the machine. The segmentation of brain tumor from magnetic resonance images is an important task performed by medical experts or by the computer aided algorithm to extract the region of similar type. In this paper image processing based segmentation algorithms are employed. These are categorized as edge based and region based, in this paper region based clustering algorithms are used to extract the abnormal regions.

Clustering algorithms essentially perform the same function as classifier methods without the use of training data. Thus, they are termed unsupervised methods. To compensate for the lack of training data, clustering methods iteratively alternate between segmenting the image and characterizing the properties of each class. In a sense, clustering methods train themselves, using the available data. Clustering is useful in several exploratory pattern-analysis, grouping, decision-making, and machine-learning situations, including data mining, document retrieval, image segmentation, and pattern classification.

In this paper three clustering algorithms K-means [7], Fuzzy C-means [8] and Spatial C-means [9] algorithms are employed for segmentation. The results of segmentation performed by them are displayed in figure 1.
Proposed Approach
The following are the steps involved in the proposed approach

For region extraction
- Read a T1-weighted abnormal MR image [3]
- Apply Clustering algorithms for segmentation using [7] [8] [9]
- Calculate the performance of these algorithms

For Volume Calculation
- Merge the segmented portions of the images
- Render these images into a multi dimensional spatial data
- Apply Iso surface models to project the 3D rendered surface [10]
- Calculate the volume based on equation (1)

\[
\text{Tumour Volume} = (\text{Interslice gap} + \text{slice thickness}) \times \sum_{i=1}^{n} A_i
\]

Where ‘n’ indicates the total number of slices containing tumour and the ‘A’ is the area tumour on each slice which is given as

\[
A_i = \text{no of pixels in tumour region in slice } i
\]

*dimension of image

Experimental Results
The present work is carried on T1-weighted MR brain images consists of 67 slices of resolution 320x240. The segmented region of 25th slice is shown in figure 1. 3D surface images are displayed in figure 3 and the rendered slices are shown in figure 2

![Figure 1](image1.png)

![Figure 2](image2.png)

![Figure 3(a)](image3a.png)

![Figure 3(b)](image3b.png)

![Figure 3(c)](image3c.png)
Conclusion
This paper focused on extraction of abnormal region from MR images and calculates its 3D volume. The proposed approach is performed and evaluated with three algorithms and found that SFCM is appropriate. While it consumes 2.2 times more CPU processing time than K-means. However in medical diagnosis the accuracy is more preferable, so the approach with SFCM is more evitable for the present context.

References


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