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Stroke Lesion Detection in MR Images – A Survey Paper

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ABSTRACT

This is a survey paper which presents a comparison of segmentation methods used for detecting stroke lesions in brain from MR images obtained using diffusion-weighted imaging (DWI).Generally, CT scan or MRI are used to obtain images. These images are examined visually by the physician to detect and diagnose the presence of stroke lesions .This method of detection is time consuming and complicated, due to inaccurate determination of stages, area and location of lesion. Our objective is to determine after comparison, which of the segmentation algorithms provides the most accurate and quick result, which is vital for treating a patient affected with stroke.

Keywords: Lesion, MRI

1. INTRODUCTION

Stroke is one of the leading causes of death and permanent disability [1].Stroke occurs due to problems with the blood supply to the brain. The blood supply is either blocked or a blood vessel within the brain ruptures, causing brain tissue to die. Approximately 800,000 people have a stroke each year, which means every 40 seconds a person is affected by stroke [7]. Stroke can also be caused due to Brain tumors, which destroys the normal cells. These tumor cells affect the cerebrospinal fluid (CSF) which can cause a stroke [6].

There are three types of strokes:
(a) Ischemic strokes: This is caused by the blockages (or narrowing of the arteries that provide the blood to the brain.
(b) Hemorrhagic strokes: This is caused by arteries in the brain either by leaking or bursting.
(c) Transient ischemic attacks: This is similar to the ischemic strokes. Here, the flow of blood to the brain is only briefly interrupted.

The symptoms of strokes are confusion, headache, numbness and trouble in walking and seeing. Treatment is done through medications that dissolve the clot that is present or it can surgically be removed. This will require better understanding of the area and the volume of the clot.

In most cases MRI is used to detect and identify a stroke lesion in patients that show stroke symptoms. MRI uses a magnetic field; radio frequencies to capture the image inside the body. MRI will give a better contrast image than a CT image. DW-MRI is the only and best method to pick up stroke lesion and can pick up a stroke lesion within a few minutes of its occurrence. DW-MRI is based on the diffusion of water molecules, which is then mapped to get contrast images. The acquisition is non-invasive and there is no need for a contrast agent [3].

The MRI images are in DICOM format (Digital Imaging and Communications in Medicine). This is used for handling, storing, printing and transmitting information in medical imaging. DICOM enables the integration of medical imaging devices like scanners, servers, workstations, printers, network hardware.

Pre-processing is done and intensity levels are adjusted to make it noise free and segmentation is performed. Image segmentation is a fundamental step in image processing field. This gives a meaningful object from the input images. It becomes even more important while dealing with medical images where pre and post-surgery decisions are to be taken. The segmentation can be done manually, semi-automated and automatic. There are different segmentation techniques, a few of which we are discussed below.

2. THRESHOLDING

The thresholding technique is the simplest method used in the segmentation process. The process collects all the pixels with a certain threshold and rejects other pixels which have values less than the threshold. After the thresholding procedure is applied the stroke region will be isolated from the brain tissue. The stroke regions will be more clearly visible in the output images [16].

Threshold values can either be local or global. There can be multiple individual thresholds or multilevel thresholding segmentation. Global thresholding is the oldest and the simplest process amongst all methods but it cannot justify all variations in an image as threshold value is determined by considering properties of whole image. There can be variations within the object which can be diagnosed through local threshold method. This is an adaptive method which is used when threshold value is not determined from a part of an image.

Thresholding can be defined as an operation that involves tests against the function T,

$$T = T[(\vec{x}), p(\vec{x}), f(\vec{x})]$$

Where x is the spatial position of image point, p(x) is a local neighborhood property, f(x) is gray level intensity. [18]

Thresholding plays with region by including background unwanted pixels and ignoring required regional pixels and situation gets worse in case of noise. It is a well-defined method for images with homogeneous intensity and contrasting region of interest. Its results are questionable with large statistical variations. Hence cannot be used for defining an automatic segmentation method alone. [18]

3. REGION GROWING

The region growing is a step that groups the pixels or sub-regions into larger regions based on a predefined criteria for growth. A "Region" forms pixels growing with the same intensity level which is used to calculate the area of white mater for the skull [16]. The first step in region growing is to select a set of seed points. Seed point selection is based on some user criterion (for example, pixels in a certain gray-level range, pixels evenly spaced on a grid, etc.). The initial region begins as the exact location of these seeds. The regions are then grown from these seed points to adjacent points depending on a region membership criterion. Region growing methods can correctly separate the regions that have the same properties we define. And also they can provide the original images which have clear edges with good segmentation results.

The concept is simple. We only need a small numbers of seed point to represent the property we want, then grow the region. We can determine the seed point and the criteria we want to make and choose multiple criteria at the same time. It performs well with respect to noise.

However, the computation is consuming, no matter the time or power. Noise or variation of intensity may result in holes or over-segmentation. This method may not distinguish the shading of the real images. We can conquer the noise problem easily by using some mask to filter the holes or outlier. Therefore, the problem of noise actually does not exist. [17]

4. K MEANS CLUSTERING ALGORITHM

K-Means clustering is an unsupervised, numerical, non-deterministic and iterative learning algorithm for clusters. Clustering the image is grouping the pixels having the same characteristics, giving us primary segmentation. The clusters are non-hierarchical and they do not overlap.

There were many regions of similar intensities in an MR image of the brain, which might lead to over-segmentation, when done with primitive segmentation methods. Each member of a cluster is closer to its cluster than any other cluster. For initial clusters, the cluster centers are chosen in the first pass of data [9]. The dataset is partitioned into k clusters and data points are randomly assigned to the clusters. They take four clusters (k=4) to represent bone, soft tissue, fat and background [9]. The main idea is to define k centroids/cluster centers for each cluster. Place the centroids as far as possible [10]. For each data point we calculate the Euclidian distance from the data point to the mean of each cluster. After we have k centroids, a loop is generated. As a result of this loop we notice that k centroids change their location step by step until no more changes can be done [10]. K means algorithm is simple and has relatively less computational complexity. It works well when clusters are not well separated from each other, like in medical images.

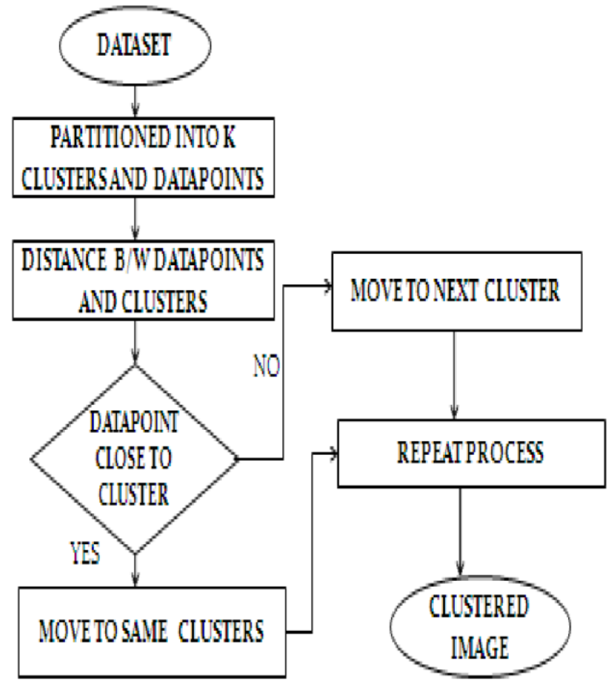

Figure1. Flow chart for K-Means Algorithm

5. FUZZY C MEANS CLUSTERING

Fuzzy c-means (FCM) is a data clustering technique in which a dataset is grouped into "n" clusters with every data point in the dataset belonging to every cluster to a certain degree.For example, a certain data point that lies close to the center of a cluster will have a high degree of belonging or membership to that cluster and another data point that lies far away from the center of a cluster will have a low degree of belonging or membership to that cluster.

FCM is an iterative process that allows data to belong to two or more clusters with different membership co-efficient. The initial fuzzy matrix is generated and then the initial fuzzy clusters are calculated. Iterations are based on two criteria i.e. membership degree and centre of cluster. The cluster centres and the membership grade point in each step of the iteration is updated, till the objective function is minimised to find the best position for the clusters. Process stops when the maximum number of iterations is reached or when the objective function improvement between two consecutive iterations is less than the minimum amount of improvement specified [11].One of the important characteristics of an image is that the neighbouring pixels possess similar feature values and the probability that they belong to the same cluster is great. This spatial relationship is important in clustering but it is not utilized in standard FCM algorithm, therefore we can use spatial FCM [12].Another proposed method is the hierarchical FCM algorithm which is based on template matching, but it suffers from a drawback of the requirement for an accurate template. Therefore, the efficiency of FCM can be improved by Silhouette method based cluster centre initialization instead of random initialization; it promises high speed processing [13].In this work, the FCM algorithm is implemented using the data compression technique without including the weight factor in the cluster centre updation criterion which further speeds up the process of segmentation which is a time consuming process. The modified FCM algorithm removes the drawbacks of manual segmentation.

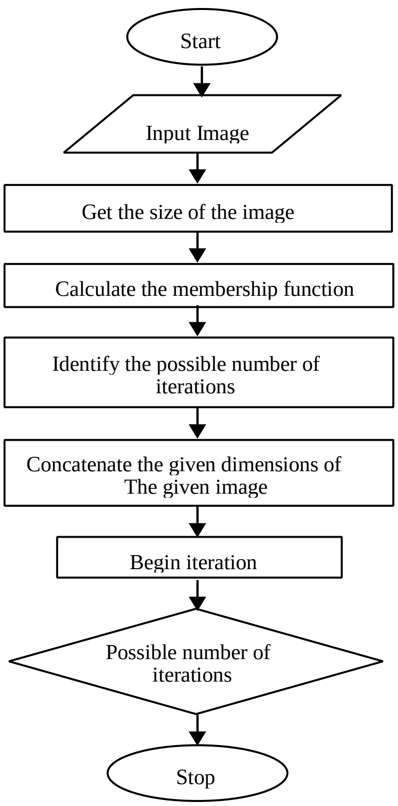

Fig: Fuzzy- C Means algorithm implementation

6. OTHER METHODS

ARTIFICIAL NEURAL NETWORK

Artificial Neural Network is a supervised clustering technique which consists of multiple nodes arranged in layers. Input layer is to receive input from real world. There are multiple hidden layers in which neurons are interconnected and output from one hidden neuron goes to another. There is output layer which outputs result which can be any character or an image. It is trained for the values of parameters to be used for mathematical operators to minimize error during output. ANN is complex method due to its large structure. [18]

WATERSHED TRANSFORM

Watershed method is a topography based method like a water drop flowing downhill after falling somewhere on landscape during rain till it reaches another water body like valley which is enclosed by catchment basin. Each point can belong to a single catchment basin which is differentiated from adjacent ones by topographical lines. Dams are built where water from different basins convene i.e. to define a boundary of ROI, this algorithm is interested in watershed lines. Thus, landscape is partitioned on areas where dams are built called watersheds. Practical use of this method has been seen more in case of tumor segmentation [19, 20,21] but less in stroke lesions.

It works on getting pixels with maximum gradient intensities and local minima. Hence, it leads to over segmentation and it requires additional processing to overcome this disadvantage and there are methods which can be used as pre-processing or post-processing steps with this model. [18,22].

7. CONCLUSION

Thresholding methods are based on intensity of gray levels of the pixels of the image and therefore, fail when in case of segments overlapping, due to noise or intensity variation. Therefore one or more threshold values cannot sharply define object boundaries.

Region Growing Based methods require human intervention for selection of seed points and Watershed algorithms need pre-processing and post processing to overcome its shortcomings.

Although Fuzzy set concepts can be useful in order to define sharp boundaries but it does not consider correlation of neighboring pixels which leads to increase in noise sensitivity [18].

The advantages and drawbacks of all the algorithms have been listed in the table below.

8. SUMMARY OF THE ALGORITMS

METHOD	ADVANTAGE	DRAWBACK
K-Means Clustering	It works well when clusters are not well separated from each other. It is fast.	In this, we have to specify the initial cluster. It does not guarantee to return a global optimum (in terms of performance).
Fuzzy C-Means Clustering	It defines sharp boundary for segmented region	It does not consider neighboring properties which may lead to noise. Iterative time consuming algorithm. Only passed on intensity. Sensitive to noise.
Thresholding	Easy to use	Limited capability to segment region sharply.
Region Growing	Computationally inexpensive	Requires human interference.
Watershed Method	Ability of completing contours in multiple segmented images	Pre and Post Processing are required.
Artificial Neural Network	Ability to model critical dependencies.	Slow learning phase.

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