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A Review on Automatic Brain Tumor Detection

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Abstract:
Detection and segmentation of brain tumor is very important because it provides anatomical information of normal and abnormal tissues which helps in treatment planning and patient follow up. Medical image segmentation is a method of extracting the desired parts and features from the input medical image data. Image segmentation locates objects and boundaries within images and the segmentation process is stopped when region of interest is separated from the input image. There are number of techniques for image segmentation. This paper emphasis on a comparison between two segmentation algorithms for segmenting brain tumors from MRI images. The tumor area is identified by using K-Means and Fuzzy C- Means algorithms and a comparative study of these methods is done using execution time and PSNR. Tumor classification is done using Feed Forward Neural Network. A GUI is developed to make the system more users interactive.

Keywords: *Image segmentation, K-Means, Fuzzy C-Means, Peak Signal to Noise Ratio (PSNR), Feed Forward Network (FFN), and Graphical User Interface (GUI)*

1. Introduction

Tumor segmentation from MRI data is an important but time consuming manual task performed by medical experts. Brain tumors may be benign or malignant. Due to the complex structure of brain tissues such as white matter (WM), gray matter (GM) and cerebrospinal fluid (CSF) in the brain images, extracting of useful feature is a fundamental task. Manual segmentation is a method for segmenting an MRI image. These methods are time consuming. It takes at least three hours to complete. Segmentation by experts is variable. Therefore, there is a strong need to have an efficient computer based system that accurately examine the boundaries of brain tissues along with less interaction of user interface. Segmentation of images holds an important position in the area of image processing. There are lots of methods for automatic and semiautomatic classification, most of them fail due to the presence of random noise, poor image contrast and boundaries that are usual in medical images. The existing method is based on the thresholding and region growing. The thresholding method ignores spatial characteristics. Normally spatial characteristics are important for the malignant tumor detection. Sometimes it ignores the tumor cells also. The region growing based segmentation needs more user interaction for the selection of seed. And also it will not provide the acceptable result in our feature extraction for all the images. The proposed system has mainly three modules; preprocessing, segmentation and feature extraction. Segmentation is carried out by K-Means and FCM clustering algorithms. An image obtained after segmentation is used for neural network classification. Neural Network classification is done using 'nntool' of Matlab. A two layer FFN with an adaptive learning rate is used for classifying the tumor. Also a GUI was created to make it more user friendly.

2. Methodology

2.1. K-Means Clustering

Clustering is a process of partitioning or grouping a given sector unlabeled pattern into a number of clusters such that similar patterns are assigned to a group, which is considered as a cluster. In this study, a new approach has been discussed to detect the area of tumour, by applying K-Means clustering algorithm. It is an unsupervised learning algorithm that classifies the input data points into multiple classes based on their intrinsic distance from each other.

The brain consists of four regions, i.e. gray matter, white matter, cerebrospinal fluid and background. The four regions can be defined as four different classes. So an input image is to be divided into four classes. In order to avoid chances of misclassification, skull stripping is done using Canny edge detection technique. This algorithm initiates K clusters centroids by randomly selecting K feature vectors from input X. Later the feature vectors are grouped into K clusters using a selected distance measure such as Euclidean.

The next is to recompute the cluster centroids based on their group members and then regroup the feature vectors according to the new cluster centroids. The clustering process terminates only when all cluster centroids tend to converge. Similar features are measured by distance and defined by an N-dimensional feature space. Feature distance and spatial distance calculations are entirely different. Feature distance calculation is based on features such as color or intensity and texture while the spatial distance calculation is based on width and height coordinates. The main objective of clustering is to minimize total intra cluster variance or the squared error function.

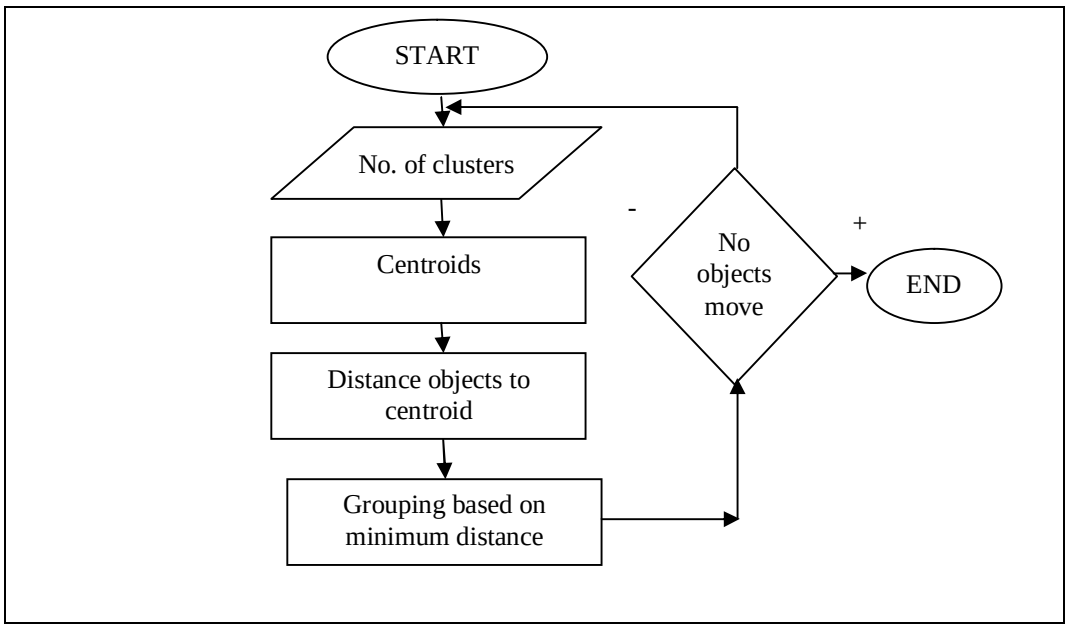

Figure 1: Flow chart of K-Means clustering

Steps for K-Means:

1. Give the number of cluster value as K.
2. Randomly choose the K cluster centre.
3. Calculate mean or centre of the cluster.
4. Calculate the distance between each pixel to each cluster centre.
5. If the distance is near to the centre, then move to that cluster.
6. Otherwise, move to next cluster.
7. Re-estimate the centre.
8. Repeat the process until the centre doesn't move.

2.2. Fuzzy C Means

Fuzzy C Means (FCM) algorithm is a unsupervised iterative algorithm mainly applied for feature analysis and clustering. Fuzzy clustering divides the input pixels into clusters on the basis of some similarity criteria, such that similar pixels belong to the same cluster. In this paper a 3-Class FCM algorithm with thresholding is used. The proposed 3-Class FCM clustering algorithm is sequentially given as follows:

1. Define the number of clusters and initialize the initial fuzzy partition matrix Ui, and also define its *Exp.*
2. Find initial estimate of Fuzzy membership functions.
3. Square Euclidean distance is calculated.
4. Compute the new membership function
5. Calculate the objective cost function for FCM.

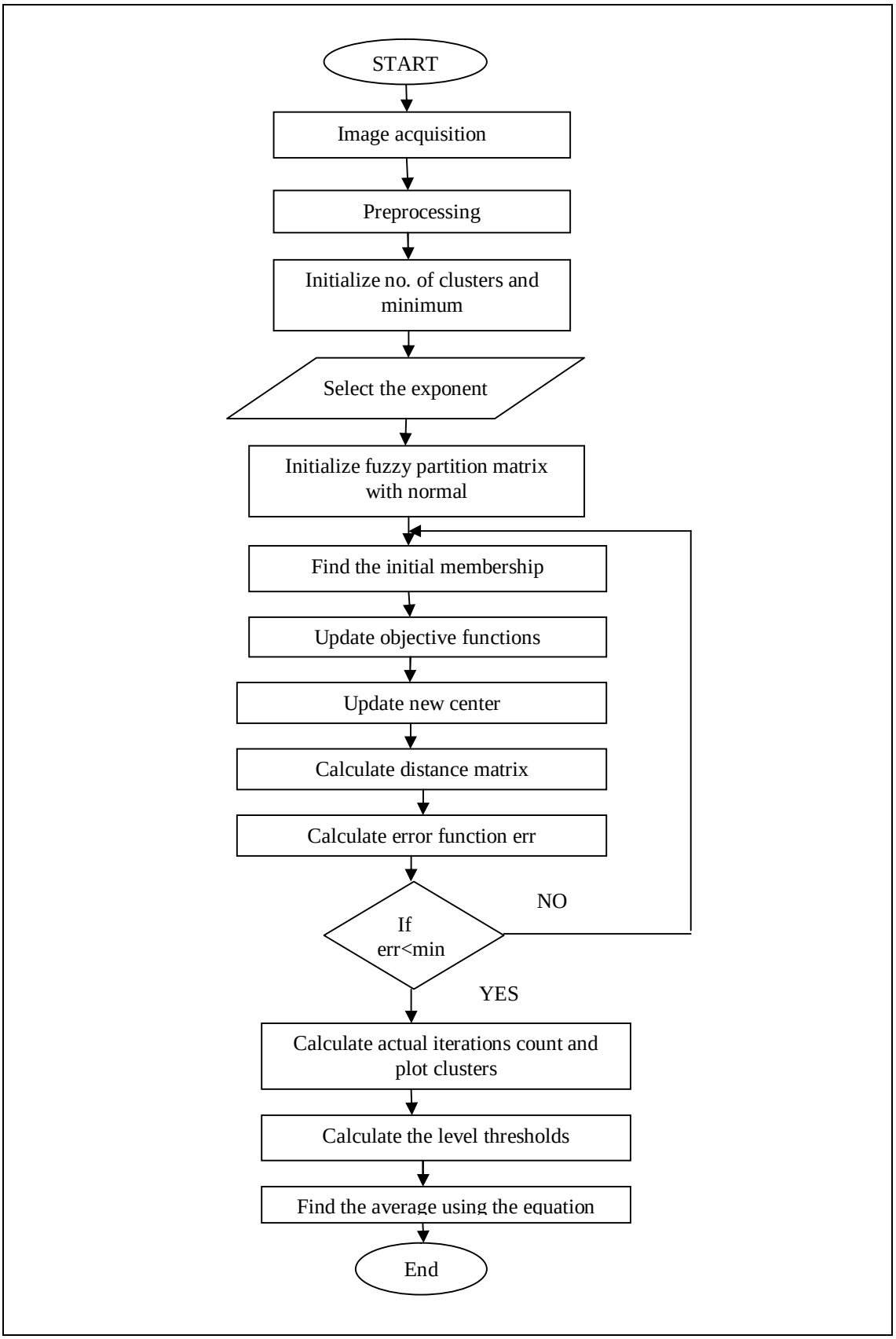

Figure 2: Flowchart of Fuzzy C Means Algorithm

5. In this paper proposed 3-Class method uses a hyperbox Fuzzy set concept. The hyperboxes are defined by a pair of min-max points and a membership function is defined with respect to these points. The membership function for each hyperbox Fuzzy set must describe a degree to which the pattern fits within a hyperbox.

3. Comparative Study

The proposed contains a comparative study of signal segmentation algorithms using time elapsed for execution and PSNR. Peak signal to noise ratio is the ratio between maximum possible power of a signal and power of corrupting noise that affects fidelity of its representation. It is most easily defined via means square error (MSE). Given a noise free m x n image I and its noisy approximation, MSE can be defined as

$MSE=1/mn \sum_{i=0.....m-1} \sum_{j=0..n-1} [I(I,j)-K(I,j)]^2$ ……1

$PSNR=10\log(MAX_i^2/MSE)$……...2

MAX_i-maximum pixel value of the input image

4. Tumor Classification Using Neural Network

The two layer FFN is trained with back propagation adaptive learning method. Standard back propagation method is gradient descent method. The neural network system is designed in two phases.

1) Learning/ Training
2) Recognize/Testing

The training process consists of 4 stages

1) Assemble the training data
2) Create the two layer FFN
3) Training the network
4) Simulate the network

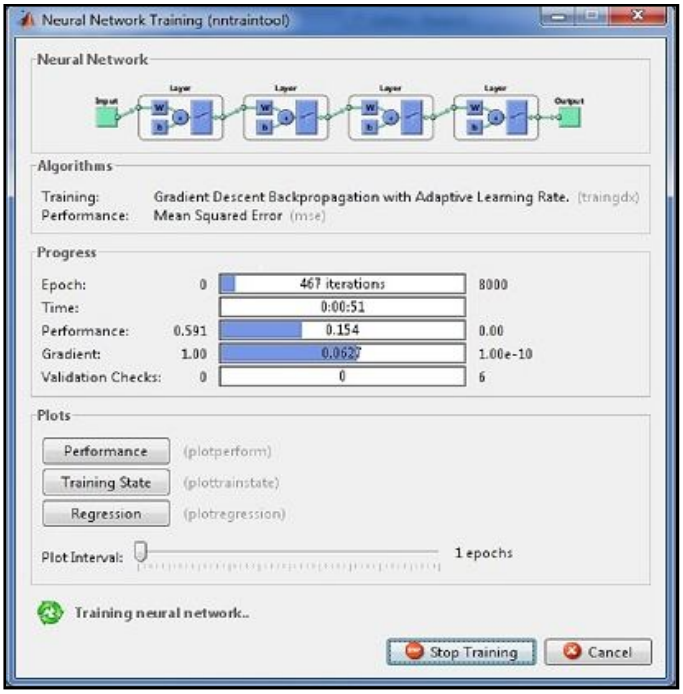

Figure 3: Training phase in neural network

The known samples are applied to the two layer FFN is trained with back propagation algorithm. Training/Learning means changing the weights of the network. By changing the weights till it gives the proper result. After training the neural network the network parameters are fixed. In the second stage i.e. in recognize/testing the unknown samples are applied to the trained network. The input sample image is compared with trained data set, if it matches output is 1 else output obtained is 0.

In the two layer FFN two log sigmoid transfer function are used. If the sum of multiplication of weights and input values are greater than log sigmoid function, then output value becomes '1', otherwise the output value become '0'.

5. Result

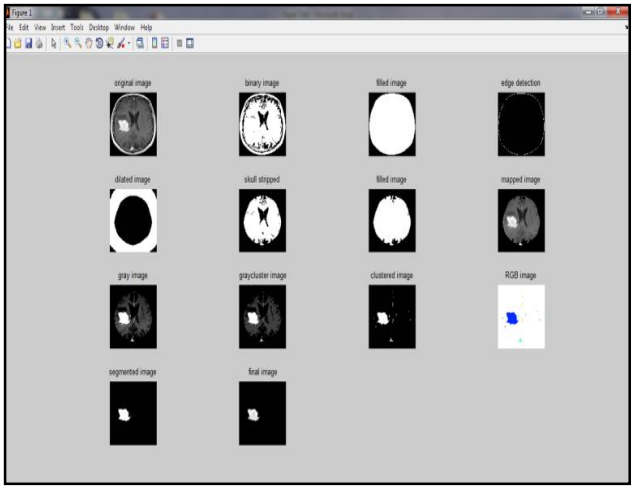

Figure 4: Output obtained after K Means clustering

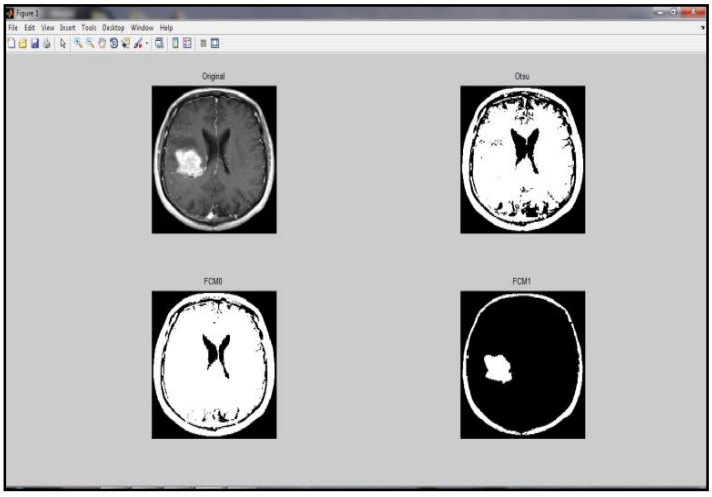

Figure 5: Output obtained after Fuzzy C Means clustering

6. Conclusions

In this paper, automatic detection of brain tumor is carried out by segmentation through K-Means and Fuzzy C-Means (FCM) algorithms. After segmentation the brain tumor was detected and its exact location was identified. This method also calculates the size of tumor by measuring the number of white pixels in the binary image. Output images obtained after segmentation through K- Means and FCM techniques are as shown in Figure3 and 4 respectively.

The main advantages of the system are than, it requires no prior information on images to segment, computational simplicity and less execution time. The proposed segmentation techniques have been implemented using Matlab 7.6.0.Time elapsed for execution and PSNR are used to compare these segmentation methods. The execution time of K-Means algorithm is lesser, also have a greater PSNR value. This makes K-Means more efficient than Fuzzy C Means algorithm for automatic detection of brain tumor from MRI images. The segmented tumor was classified using Feed Forward Network and GUI was implemented.

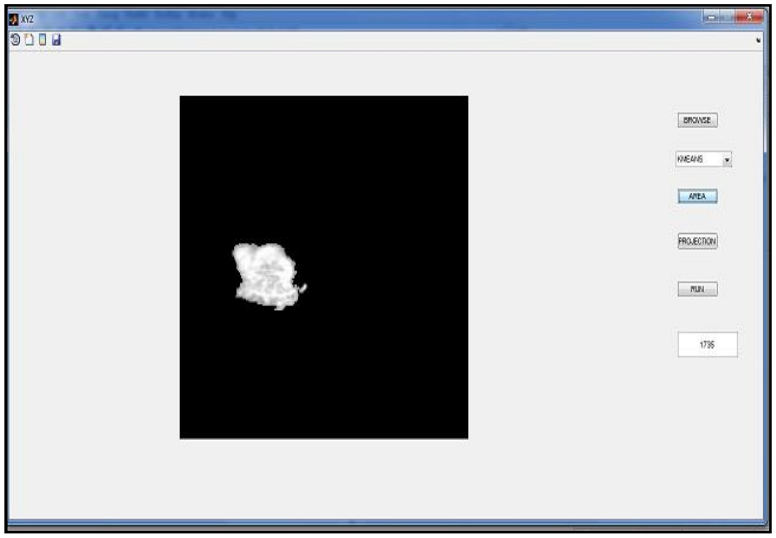

Figure.6.GUI implementation

Parameter	K- Means	Fuzzy C Means
1.PSNR	7.0083	5.2653
2.Time elapsed	0.038813s	0.8677s

Table 1: Performance analysis of K Means and Fuzzy C Means segmentation methods

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