- K-means clustering algorithm and
- Fuzzy C-means algorithm

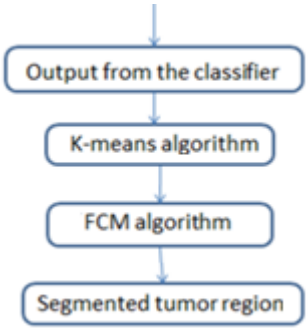

Figure 3.4: Schematic diagram of segmentation process

3.4.1 K-Means Clustering Technique

The K-means algorithm is well known for its efficiency in clustering large data sets. It is an unsupervised learning algorithm. Clustering the image is the process of grouping the pixels according to some characteristics, like intensity, texture etc. In the K-means algorithm, initially we have to define the number of clusters k or it could be set to a predefined number.

K-means clustering aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean.

Given a set of observations (**x** 1, **x** 2, …, **x** *n*), where each observation is a *d*-dimensional real vector, *k*-meansclustering aims to partition the *n* observations into *k* sets ($k \leq n$) **S** = {*S*1, *S*2,..*Sk*}

$$arg_s min \sum_{i=1}^{k} \sum_{x_{j \in S_i}} \left\| x_{j-\mu_i} \right\|^2$$

where $\mu_i$is the mean of points in *Si*.
Given an initial set of *k* means $m1^{(1)},\ldots,mk^{(1)}$ the algorithm proceeds by alternating between two steps:
Assignment step: Assign each observation to the cluster whose mean yields the least within-cluster sum of squares (WCSS). Since the sum of squares is the squared Euclidean distance, this is intuitively the nearest mean.

$$S_i^{(t)} = \{x_p : \|x_p - m_i^{(t)}\|^2 \leq \|x_p - m_j^{(t)}\|^2 \ \forall j, 1 \leq j \leq k\},$$

where each x_p is assigned to exactly one $S^{(t)}$even if it could be is assigned to two or more of them.
Update step: Calculate the new means to be the centroids of the observations in the new clusters.

$$m_i^{(t+1)} = \frac{1}{|S_i^{(t)}|} \sum_{x_j \in S_i^{(t)}} x_j$$

The generalized algorithm initiates k cluster centroids by randomly selecting k feature vectors from X. Later, the feature vectors are grouped into k clusters using a selected distance measure such as Euclidean. The clustering procedure stops only when all cluster centroids tend to converge. Similarity is measured by distance and defined by an N dimensional feature space. Feature distance calculation is based on features such as color or intensity and texture while spatial distance calculation is based on x, y (width, height) coordinates.

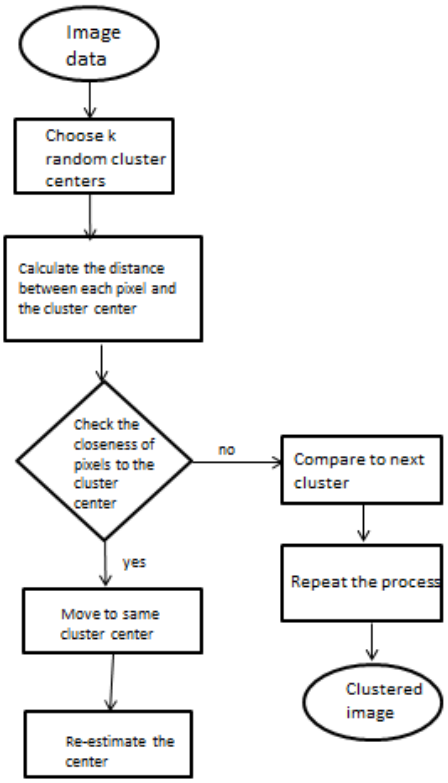

Figure 3.4.1: Flowchart of the algorithm

Even though K-means is an efficient clustering algorithm, it has certain disadvantages like becoming sensitive to outliers, finding only spherical clusters and it often becomes a bottleneck when clusters have different sizes. Also, working only on numeric values prohibits it from being used to cluster real world data containing categorical values To overcome these defects, the clustered image is passed through Fuzzy C-means algorithm.

3.4.2 Fuzzy C-Means Algorithm

The fuzzy logic is a way to processing the data by giving the partial membership value to each pixel in the image. The Fuzzy C-Means (FCM) algorithm uses fuzzy logic where each data point is specified by a membership grade between 0 and 1. The membership function defines the fuzziness of an image and also to define the information contained in the image.
It provides a fuzzy partition of the image by giving each pixel a degree of belonging to a given region. In the process of segmentation, cells which share common intensity values are grouped together. A representative membership value is chosen from each group. Moreover, it gives the natural representation of the behaviour of genes. Fuzzy logic is thus becoming a milestone in medical diagnosis.

Algorithm

1. Initialize $M=[M_{ij}]$ matrix, $M^{(0)}$)
2. At k-step: calculate the centres vectors $R(k)=[R_j]$ with $M^{(k)}$

$$R_j = \frac{\sum_{i=1}^{N} x_i . M_{ij}^{m}}{\sum_{i=1}^{N} M_{ij}^{m}}$$

where m is the fuzzy parameter and N is the number of data points

3. Update $M^{(k)}$, $M^{(k+1)}$

$$M_{ij} = \frac{1}{\sum_{K=1}^{C} \left(\frac{\|x_i - c_j\|}{\|x_i - c_j\|} \right)^{\frac{2}{m-1}}}$$

4. if II $M^{(k+1)} - M^{(k)}$) II $< \delta$
then STOP; otherwise return to step 2.
k = no: iteration steps
δ = termination value = constant between 0 and 1 = membership cut off value

Finally, morphological operations like erosion and dilation are applied over the clustered image to obtain the segmented region accurately.

3.5 Tumor Size Calculation

For the accurate diagnosis of the disease, the exact tumor size should be known. In this step, the tumor area is calculated using the binarization method. The image is considered to have only two values either black or white (0 or 1). Here, 256x256 jpeg image is a maximum image size.

$$image\ , I = \sum_{W=0}^{255} \sum_{H=0}^{255} [f(0) + f(1)]$$

Pixels = Width (W) x Height (H) = 256 x 256
f(0) = black pixel digit (0)
f(1) = white pixel digit (1)

$$\text{No: of white pixel, } P = \sum_{W=0}^{255} \sum_{H=0}^{255} [f(1)]$$

P = no: of white pixels (width x height)
1 Pixel = 0.264 mm

$$\text{Size of tumor, } S = \left[\left(\sqrt{P} \right) 0.264 \right] mm^2$$

P = no: of white pixels
W = width
H = height
Using the above equations, the size of the tumor region could be obtained and it could play an important role in future diagnosis of the patient.

4. Results

In the initial preprocessing step we use median filter to remove the noise in the input image. The filtered image is then given for neural network classification and the segmentation process relays on its result. In the segmentation process clustering techniques are used. And finally, area of the segmented tumor region is calculated. The results of the proposed method could be best illustrated by the screenshots below:

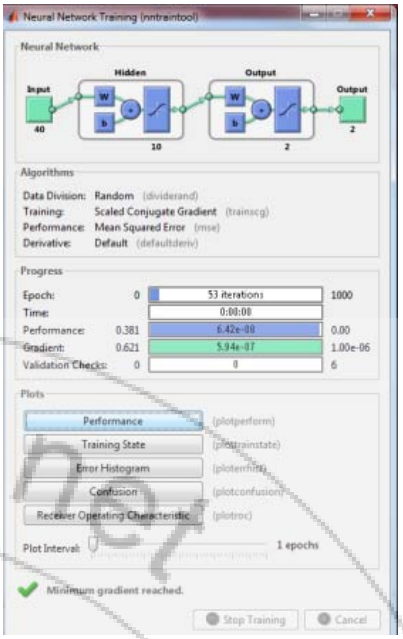

Figure 4.1: Neural network training

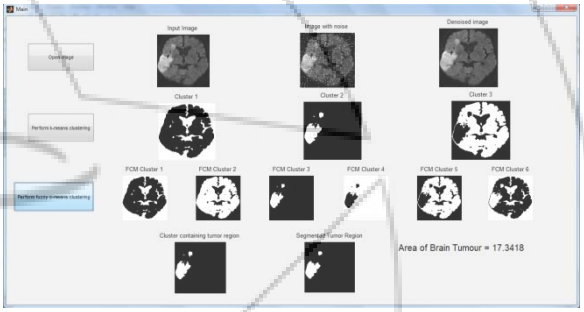

Figure 2: Entire process of tumor detection

5. Conclusion

In this paper, an efficient method for the brain tumor dection is presented. It provides fast and robust results compared to the existing system. The input image chosen should be (preferably) taken from an MRI scan. The neuro-fuzzy approach overcomes the drawbacks of the neural network and fuzzy logic, which occurs when used alone. After the pre-processing stage, the features of the image are extracted using the GLCM technique. The images in the database are trained by the implemented artificial neural network classifier. The fuzzy logic models attempt to mimic human reasoning and the capability of handling uncertainty. Fuzzy logic gives the natural representation of the behaviour of genes, since fuzzy logic does not stick on crisp boundaries.

The proposed method is computationally feasible in case of time and large data sets. Its approach is simple and easy to understand since the pixel-based segmentation methods are simple and the computational complexity is relatively low and accuracy is high compared with other region-based or edge-based methods, the application is more practicable.

6. Future Scope

In future, the system could be redone with 4-D technologies and upcoming segmentation methods.

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