Detection of Brain Tumor using Fuzzy Cluster Means and Neuro Fuzzy Technique

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Abstract—In human beings, brain is considered to be the central part of the nervous system. Brain is responsible for performing some of the higher functions like speech, hearing, emotions, intelligence etc. Thus we can say that any harm to the brain might result in people leading a life with disability. As per biological rules, the cells in brain divide and grow in self restrained manner to produce new cells. When these cells grow uncontrollably, they lead to the formation of a mass of tissue called as tumor. These tumors can either be cancerous (malignant) or non cancerous (benign) in nature. Despite many modern technologies available in the field of image processing for medical images, it has always been a tedious task to carry out manual segmentation of tumor and provide information about it. Due to the increase in population, there is tremendous need for the development of automatic tools for segmentation for increasing number of brain tumor patients. Motivated by the present scenario, this paper discusses about fuzzy c-means unsupervised clustering algorithm and a supervised neural network based ANFIS model for brain tumor segmentation. The results are presented on images of selected patients with brain tumors. The ANFIS based segmentation techniques provides good results and the algorithm is visually observed to show better segmentation.

Index Terms— *ANFIS, Brain Tumor, MRI Images, FCM.*

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I. INTRODUCTION

Brain tumor is one of the major root causes for increased mortality rate among children and adults in today's scenario. Thus, brain being the most sensitive and important part of our body must be treated very carefully by using efficient techniques if it is affected by any disease. Therefore the motivation for this project work is to overcome the difficulties faced by the surgeons in tumor detection using Image analysis techniques.

In India, about 80,271 people are affected by different types of tumor. Similarly, all over the world according to

The National Brain Tumor Foundation (NBTF) many people lose their lives every year after having diagnosed with primary brain tumors.In order to make the tumor detection task easierthere are some techniques using Artificial Neural Networks and some computerized techniques.Nowadays the popularity of Artificial Intelligence has been increasing in the field of research. However, this area of understanding an image (Image Analysis) is not very developed and still in its beginning stages in terms of research and development. The advancement in this field of AI is quite slower that what is expected. It can be said that the area of understanding the image (Image analysis) lies between image processing and computer vision.

There are various techniques available to detect brain tumor. Some of them that are generally used are Ultrasound, Computer Tomography (CT scan) and Magnetic Resonance Imaging (MRI) scan. The medical reports that are obtained from these techniques further need some detailed study and analysis for treatment. Hence, the area of computer vision plays an important role for the detailed study of these reports. Further there are fields such as computer vision whose major goal is to make the machine (computer) capable enough to understand and extract information from the available sequence medical images. However, branch ofArtificialIntelligence whose ultimategoal is to emulate human intelligence is in its earliest stages of research and development.

It is not surprising to say that images (either black or gray or color) play the most important role in human perception as it is always believed that vision is the most advanced of human senses. The field of science that deals with digital image processing refers to processing images with the help of a digital computer. One of the most important characteristic required for the design of image processing system is the significant level of experimentation and testing before arriving at an acceptable solution.For arriving at a viable system implementation, prototyping candidate solution plays an important role in cost and time reduction of the system.

The main objective of this work is to develop and design an automated tool for brain tumor quantification using MRI image data sets. After completion, the proposed whole system will be able to visualize the inside of a human body, and make surgeons and experts' able to perform operations on a patient without any open surgery. More specifically, the main aim for this work is to be able to segment a tumor in a brain. This will make the experts to be able to identify the tumor to make the treatment easy.The technique used in this project is Magnetic Resonance Imaging (MRI). Three dimensional approaches for image segmentation is a reliable source to achieve a proper estimation of tumor volume.

Brain tumors occur when there is abnormal growth of cells within a location in the brain. They can be categorized into benign (non cancerous) ormalignant(cancerous), based on the tissues and cells involved and placement of the tumor in brain.

A. Benign brain tumor

Benign as the word indicates are generally not very harmful in nature. Benign brain tumors do not consistof cancerous cells and can be removed with propertreatment. They have

an obvious border or edge and do not spread to the adjacent cells or parts in the human body. Even though they do not spread to other parts of the body, they can sometimes cause seriousheath problems if left untreated.

B. *Malignant brain tumor*

Unlike benign brain tumors, these types of cells are fast growing in nature and can affect surrounding healthy cells. The cells are cancerous in nature and hence are also called as brain cancer. Malignant brain tumors are threat for life and need to be treated at an earlier stage. Depending on the type of cells of the tumor and the location, medical experts have grouped brain tumors into four grades as grade I to grade IV. Cells from low-grade tumors i.e. grades I and II look more normal, less harmful and generally grow slower than cells from high-grade tumors i.e. grades III and IV respectively.

II. FCM & ANFIS TECHNIQUES

In our research work,we have used fuzzy logic & Neuro fuzzy technique to segment brain tumor and to calculate its volume. There are many performancemeasures available. Here, on the basis of Dice Scoremeasure, best technique is observed.

A. *K-Means Clustering*

K-means clustering belongs to the category of unsupervised cluster analysis algorithms. It is one of the hard clustering algorithms. In case when 'n' number of readings is given,this algorithm classifies these observationsinto different groups called clusters. The collection of data that are supposed to belongto same group or cluster are found to be alike in nature whereas those part of distinct group or clusters are not very much same in nature. However, the number of clusters 'k' is presumed to be fixed. Each group or cluster has a principal value or converging point which is called as 'centroid'. Cluster centroidsare then initialized with indiscriminate values. The Euclidean distance between observation and cluster centroid is minimized iteratively. The mean of all objects is then computed again till we achieve convergence.

B. *Fuzzy C-Means Clustering*

Fuzzy C-means clustering is considered to be one of the soft clustering techniques which allow the concept of partial association of pixels into distinct clusters [15]. These biased associations of the pixels can be calculated using a concept known as membership functions grades. It is observed that the values of membership functions of all data points ranges from 0 to 1 but the sum of all these value must be equal to on one. They have better application in segmentation when compared to hard clustering techniques. They involve a concept of minimizing the objective function. The algorithm finds 'c' clusters by minimizing the objective function given by equation

$$J_{FCM} = \sum_{k=1}^{n} \sum_{i=1}^{c} (u_{i,k})^q \, d^2(x_k u_i) \qquad (1)$$

where,x_k= { x_1, x_2 ……. x_3 } are thedata points, n is the number of data items, c represents the number of clusters, the degree of membership of x_k in the i^{th} cluster is represented as u_{ik}, q is the weighting exponent on each fuzzy membership, v_i represents the center of cluster i, $d_2(x_k, v_i)$ is the distance between data point x_k and cluster center v_i.

C. *ANFIS Technique*

An Adaptive neuro fuzzysystem is a combination of both neural networks and fuzzy systems in a single framework. They integrate the principles of both artificial neural networks and fuzzy logics. One of the most important aspects of the ANFIS is that the system should be able to interpret itself in terms of the inference rules also called fuzzy if-then rules, because it is based on vague knowledge presented by the fuzzy inference system.

Sugeno type Fuzzy Inference System is used along withback propagation learning algorithm to train the system. As the name suggests ANFIS techniques are adaptive in nature and use their self learning capabilities for determining the parameters of fuzzy inference system.

III. PROPOSED METHODOLOGIES

In our research work, the proposed system introducesa mechanism by which brain tumor could bedetected and segmented with maximum perfection. Apart from achieving accuracy, the proposed system is believed to overcome the drawbacks of the existing system. It is said to consist of mainly four modules:

- Pre-processingand Feature extraction.
- Neural networkclassification
- Segmentation
- Tumor size calculation

A. *Pre-processing and Feature Extraction*

Pre-processingis considered to be the initialstep which provides the input image (in the required format) for the next stage. Several pre-processing algorithmsare applied to MR images of the brain for intensity normalization and enhancement, background removal. This step also performs filtering of noise andother artifacts in the image and sharpens the edges which make the task of edge detection easier in the image required for segmentation.

Preprocessing is followed by featureextraction. Here, the features of the trained images like intensity, co-variance, entropy etc. are extracted and stored in the database. The images used in the following steps of extraction are 256*256 gray level images with intensity value ranges from (0 to 255). Therefore, the MR images obtained are normalized to gray level values from (0 to 1) using normalization techniques. Sincenormalization reducesthe dynamic range of the intensity values, segmentation step and the process of feature extraction are made much simpler. Any type of unwanted background noise present in the image is removed at this stage.

B. *Neural Network Classification*

The preprocessed input image is then used by the artificial neural network to classify whether the image is tumorous or non-tumorous. The Neural network like architecture is trained using learning algorithms efficiently.

C. Segmentation and tumor size calculation

Brain tumor segmentation process deals with the separation of tumor regions from the medical images of brain obtained from MRI scan. Here, we propose two algorithms: K-meansclustering algorithm and Fuzzy-C Means algorithmfor better accuracy of the system. K-means is efficient in classifying large data sets and Fuzzy-C-Means algorithm considers thefuzziness of the data and thereforeproduces amuch more natural representation of the tissues. Next is the process of extracting the cluster of data which depicts the predicted tumor region, by applying morphological operations. And finally, the area and volume of tumor is calculated in the final step, using mathematical equations.
The following figure gives an idea of the flowchart for the proposed algorithm:

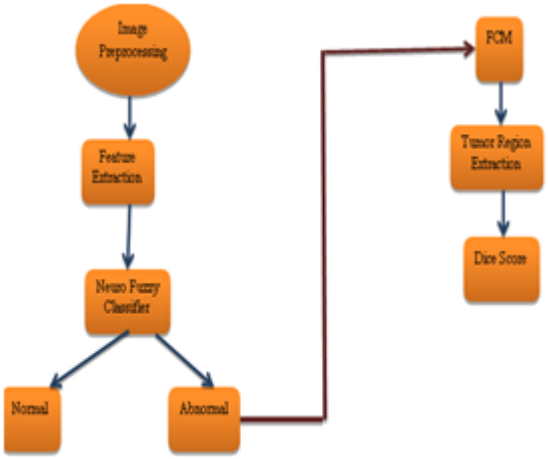

Fig. 1. Flowchart of proposed algorithm

The performance of neural and Neuro fuzzy is measured using some standard measures like Jacard score, Precision rate, recall rate and dice score. For each of the tumor regions we obtained a binary map with algorithmic predictions and the experts'consensus truth T, and we calculated the well-known Dice score as follows:

$$\text{Dice (P,T)} = \frac{|P_1 \cap T_1|}{(|P_1 + |T_1||)/2} \quad (2)$$

where ^ is the logical AND operator and P1 and T1 represent the set of voxels where P = 1 and T = 1, respectively. The Dice score normalizes the number of true positives to the average size of the two segmented areas. It is not very different from the Jacard Score and can be calculated easily. It is identical to the F score (the harmonic mean of the precision recall curve) and can be transformed monotonously to the Jacard score. Given the Dice Score S, the Jacard score J can be calculated using equation

$$J = S/(2 - S) \quad (3)$$

Recall Rate measure how many of the positives does the model. It is the proportion of positive cases that were correctly identified, calculated as

$$Recall = A/(A + B) \quad (4)$$

Precision Rate is how many of the returned documents are correct P is the proportion of thepredicted positive cases that were correct & calculate as

$$Precision = A/(A + C) \quad (5)$$

IV. Simulation & Result

In our work we have used 12 samples of multimodal MRI Scans of patients with brain tumor which are a part of multimodal Brain Tumor Segmentation (BRATS) 2015 challenge from the Virtual Skeleton Database (VSD). The proposed work is carried out on these 12 samples and the results are compared to that of the ground truth.

In our research, we have to take images from database, then analyze with fuzzy logic & Neuro fuzzy techniques. The resulted images are given below.

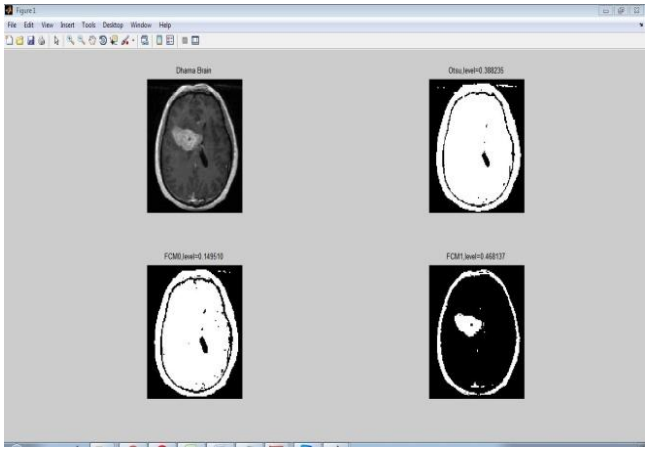

Fig 2 Detection of Tumor Image ID 1 using Fuzzy Logic

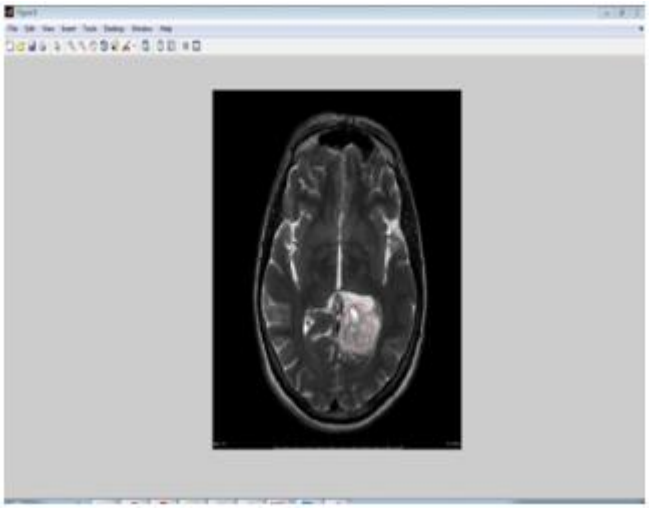

Fig 3 Detection of Tumor of Image ID 1 person using Neuro Fuzzy

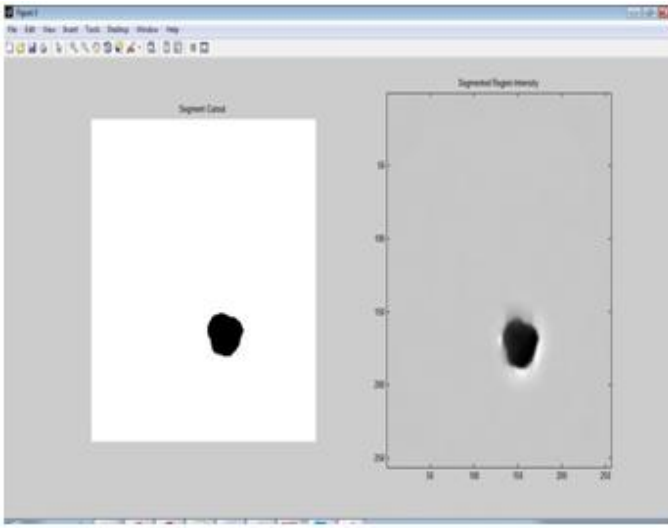

Fig 4 Detection of Segmented of 40yrs (Image ID 1) person using Neuro Fuzzye not italicized).

A general IEEE styleguide is available at www.ieee.org/authortools.

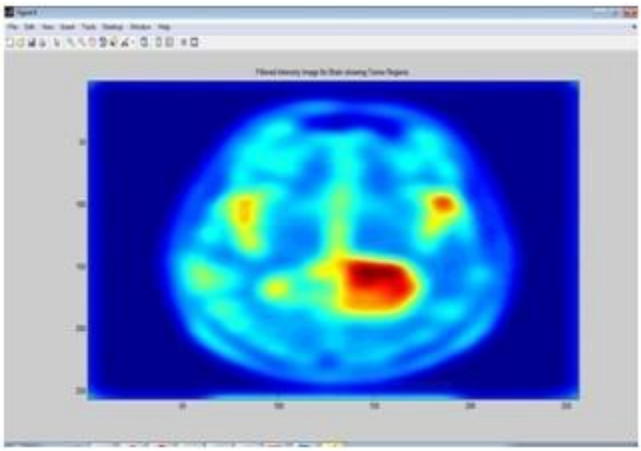

Fig 5 Detection of Filtered Intensity Tumor of 40yrs person using Neuro Fuzzy

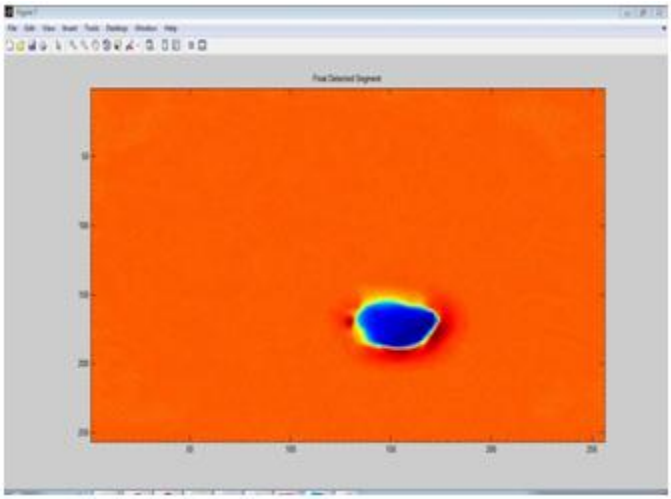

Fig 6 Final Detection of Tumor of 40yrs person using Neuro Fuzzy

V. Conclusion

Nowadays due to the growing cases of brain tumor among the population medical imaging techniques have gained much importance in the field of medical science. Computer aided diagnosis techniques improves the chances of information that are available for medical images for the treatment of brain tumors. Brain tumors can be not harmful or malignant in nature. The cells of malignant tumors are unusual and split up numerously, causing irreparable damage to nearby. It becomes very difficult to segment the benign and malignant tumor cells using automated methods. Existing methods for segmentation medical images include primitive operations. However, more, an advanced technique makes it easier to segment MRI images to distinguish the normal from abnormal tissues.

In this work we have focused on an ANFIS based segmentation algorithm using fuzzy c-means (FCM) clustering approach and Neural Networks. Where FCM is a fuzzy unsupervised clustering method and Neural Networks are supervised training algorithm. The results how that the improved ANFIS based segmentation can easily segment brain tissues in MR images of the brain having tumor. conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

TABLE I
Comparison of FCM & ANFIS Techniques

Technique	Jaccard Score (%)	Dice Score (%)
ANFSI	77.55	80.99

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