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An Amalgam Method To Detect And Classify Brain Tumor Using MRI Images By Fuzzy C Means, Discrete Wavelet Transform and Artificial Neural Network

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Abstract— Brain tumor is a group of abnormal cells that grows inside of the brain or around the brain and can directly destroy all healthy brain cells. Brain tumor segmentation consists of separating the different tumor tissues from normal brain tissues. In brain tumor diagnosis, clinicians integrate their medical knowledge and brain magnetic resonance imaging(MRI) scans to obtain the nature and pathological characteristics of brain tumors and decide on treatment options. In our approach, an automatic brain tumor detection and classification framework that consists of techniques based on Fuzzy C means clustering, Discrete Wavelet Transforms and Artificial neural network is used.

Keywords— Image pre-processing, Fuzzy C Means, Discrete Wavelet Transform, Artificial Neural Network

I. INTRODUCTION

A computer-vision paradigm submits the input image to a series of processes: Pre-Processing, Feature extraction, Segmentation, and Classification. Pre-processing improves the quality of the input images by accurate registration, correction of field inhomogeneities and noise filtering. Image segmentation refers to the decomposition of an image into regions, while classification is the step that labels each of these regions by tissue type. This association is most commonly performed by the operator or interpreted by the physician.

There are several ways to diagnose brain tumors, for example use MRI images. In MRI technique, brain is imaged on the basis of density of water in soft tissue which is higher compared to other tissues such as bone. Through the MRI images, the radiologist can see the brain anatomy without performing the surgery.

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This paper concerns segmentation algorithm based on fuzzy c-means clustering approach an unsupervised pixel classification technique based on iterative approximation to local minima of global objective functions. The statistical test data for the brain MRI image is used for the classification of any brain tumor categories the region growing algorithm introduced in [1]. The Fuzzy C- means algorithm is introduced in [2]-[3] performs segmentation, and then introduces an expert system with defined membership and clustered centroid to locate a landmark tissue by matching them with a prior model. FCM of Kannana et al [2] has limitation of noise sensitivity and imperfection to the abnormality of brain e.g. tumor, edema, and cyst. Feature extraction of the ground truth image and MRI image using Discrete Wavelet Transform, further classifying the image into tumor or non-tumor tissue with Artificial Neural Network. The most used technique for classification of brain MRI image is Artificial Neural Network (ANN). An ANN technique offered by Lugina et al [4] has shown good results with large data with the changing of some characteristics parameter for training and test of the network.

II. METHODOLOGY

Fig.1 shows the methodology used in the project. First the input MRI image is obtained from the database that contains MRI images of both tumorous and non-tumorous brain which is then compared with the ground truth images of the tumor. The entire process involves by taking one of the MRI image from the database which goes through the image enhancement block where the image is resized, filtered from noise. Then the enhanced image is sent to the segmentation block where the tumor part of the image is highlighted using Fuzzy C means clustering method.

First order features are skewness, variance, kurtosis. Region based property features are Energy, homogeneity etc. Next step is to classify the brain image as to whether it contains a tumor or not. This is done using Artificial Neural network. Feed forward network is used such that the features propagate in the forward direction through the neural network. To classify the image, two variables are required i.e. Feature vector database and Target vector table. A database of feature vectors for all the images in the MRI database is created and this is stored in a variable.

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Each column in the database contains all the features of one image. These features are known by performing image enhancement, segmentation, feature extraction on each and every image of the database.

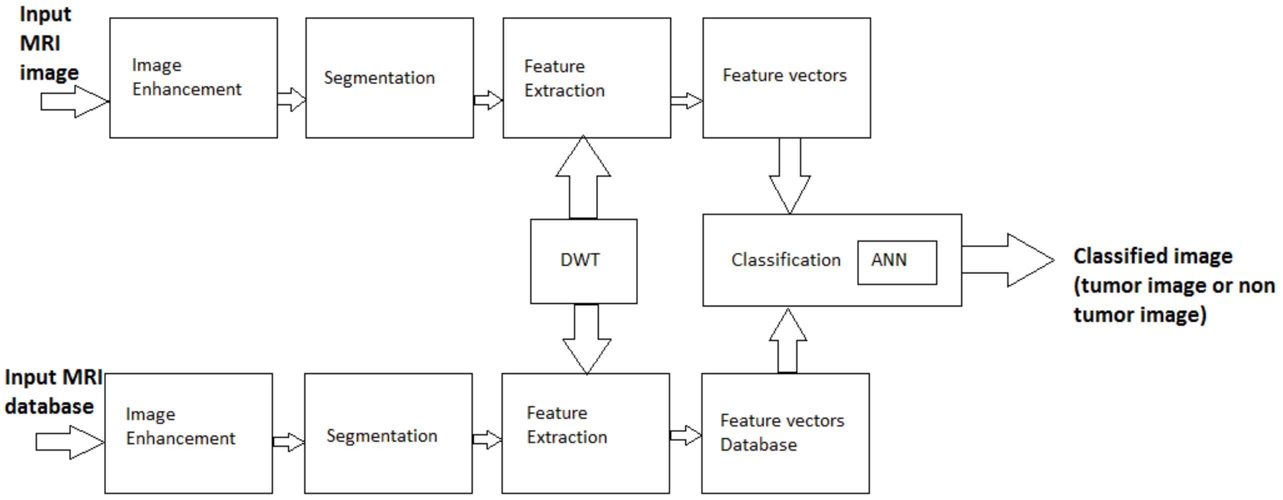

Fig.1 Methodology

The target vector table is created which contains information about whether the image is a tumorous or not. This information is entered such that the column in which it is entered matches the column entries in the image feature database, i.e. if an image is tumorous then the column number which contains the feature vectors of the image is noted and the information regarding whether it is tumorous or not is entered in the same column number in the target vector table.

Fig.2 shows the flowchart for the methodlogy.

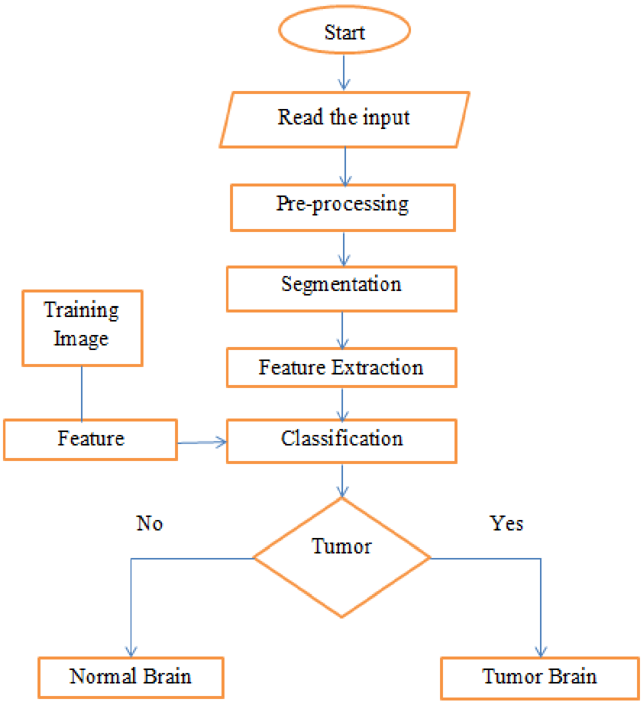

Fig.2 Flowchart

A. Image Pre-processing

Brain MRIs are degraded during the process of imaging due to image transmission and image digitization by noise and existence of extra-cranial tissues in MRI such as Skull, bone, skin, air, muscles, and fat. Pre-processing is a procedure to eliminate these noises and extra-cranial tissues from the Brain MRI and alters the heterogeneous image into homogeneous image. Though there are lots of filters which have been used for filtering the images, some of them corrupt the miniature details of the image and some conventional filters will process the image incessantly (smoothing) and consequently harden the edges of the image.

Steps followed in pre-processing:

1. Image is converted to grayscale.
2. Apply Gaussian Filtering.
3. Perform Otsu thresholding which can be used later for further processing after segmentation.

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B. Segmentation

Segmentation can be defined as the operation of dividing images into constituent sub regions. It is used to separate the image foreground from its background. Fig.3 shows the flowchart for FCM algorithm.

The approach used in the methodology is as follows:

1. Arrange the gray level matrix of the image in a single column which is called as data points.
2. FCM algorithm is used where the no of clusters in specified and the cluster centers are found using the equation for centroid as explained before.
3. Update the degree of membership of each data points which ranges from 0 (no membership) to 1 (full membership).
4. The cluster centers are compared with previously calculated centers. If they have changed loop back to updating the degree of membership or exit the loop.
5. Now we get the cluster centers and the membership values of each datapoint in 2 matrices.
6. The cluster centers are sorted in ascending order and we assign an index to it which is the position of the cluster center in the matrix before sorting.
7. Take the transpose of the membership matrix.
8. Arrange the columns of the membership matrix in an order, according to the center index numbers.

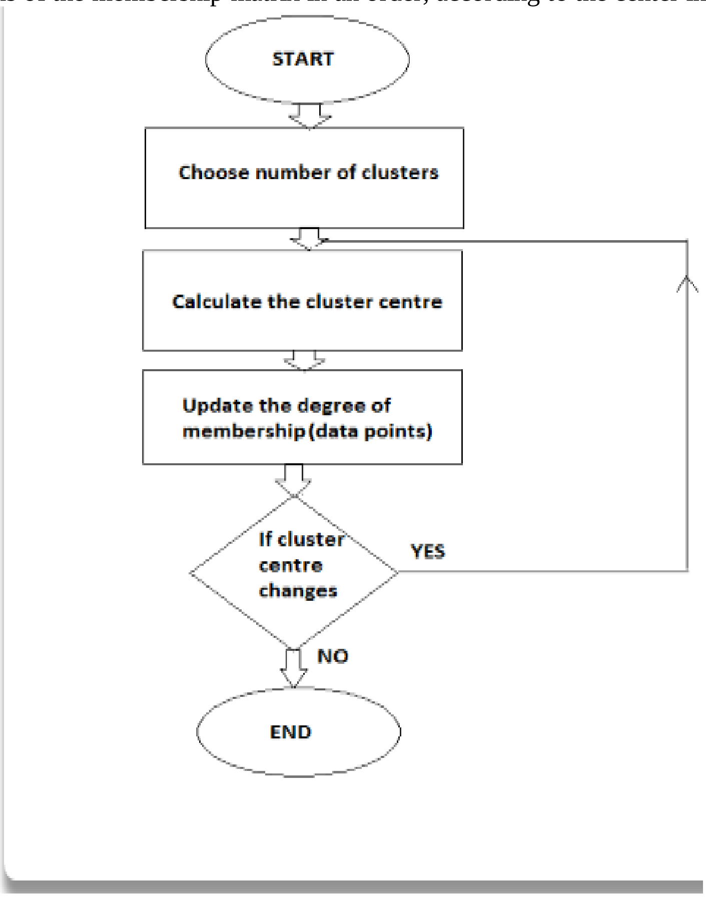

Fig .3 FCM algorithm

9. Find the maximum value in each row of the membership matrix and store it in a new variable max member at the corresponding row. Assign a label which contains the column number where the maximum value was found.
10. We then add the maximum value in the max member variable with label 2, and the minimum value in the max member with label 3, then divide it by 2 which gives the level for thresholding.
11. This Threshold level is used to generate a binary image.

C. Feature Extraction using DWT

Features that are required are extracted using discrete wavelet transform. Wavelets are often used to denoise two dimensional signals, such as images. The first step is to choose a wavelet type, and a level N of decomposition. Here Haar wavelet is used with 3 levels of decomposition. After applying the 3 levels of DWT the feature components such as horizontal, vertical, diagonal and approximation components are combined to give the features. Then through PCA and GLCM we can obtain the first order and the region property based features. It is used to further reduce the feature matrix. 13 parameters are obtained from after performing feature extraction which are used as an input for Artificial Neural Network.

D. Classification

Next step is to classify the brain image as to whether it contains a tumor or not. This is done using Artificial Neural Network. The Feed Forward Neural Network is used in this method where the outputs are propagated from input nodes to the output nodes Segmentation is applied to all the images in the MRI database and the 13 features are extracted from it. The features for the first image is saved in the first column of the table and so on.

These features are applied to the input node and the values at the hidden nodes are calculated by weighted sum of all the input nodes that are linked to that input node. The logistic function is applied to get the transformed value. The same procedure is followed for the output node and the value is transformed using logistic function. Fig.4 shows the classification using ANN.

A pattern, presented at the inputs, will be transformed from layer to layer until it reaches the output layer. Now classification can occur by computing the weighted sum and continuing the process that is used while training the network. At the output node the value is transformed using logistic function. This value is ranging from 0-1.

The algorithm used for increasing the accuracy for classification is as follows.

1. Train the ANN.
2. Provide the feature vectors of the segmented input image to the input nodes.

Calculate the value at the output node of the ANN.

3. Round up the output values. Since the output of ANN will be in the range 0-1.
4. If the value is equal to 1 then tumor is present.
5. Else tumor is absent.

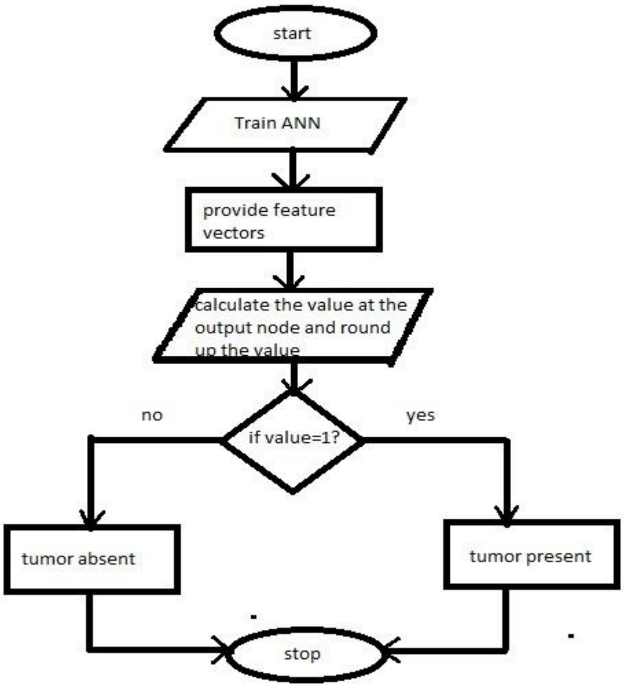

Fig.4 Classification using ANN

III. EXPERIMENTAL RESULTS AND PERFORMANCE ANALYSIS

Despite of the fact that there are varieties of segmentation, feature extraction and classification techniques stated in related works, we have utilised a combination of Fuzzy C Means for segmentation of the tumor, extraction of features from the segmented image through Discrete Wavelet Transforms and further classifying the presence and absence of the tumor by Artificial Neural Network to produce an efficient hybrid system which will help the medical community to diagnose the tumour in the earlier stage and give treatment respectively. Results are shown in Fig.5.

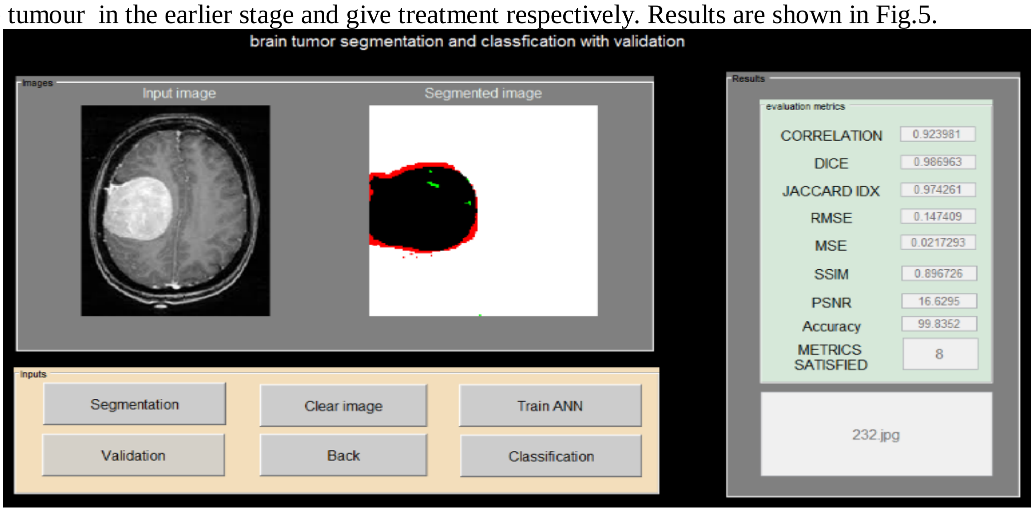

Fig.5 Segmentation results

FCM has robust characteristics for ambiguity and can retain much more information than hard segmentation methods. Although the conventional FCM algorithm works well on most noise-free images. It allows gradual memberships of data points to clusters measured as degrees in [0,1]. This gives the flexibility to express that data points can belong to more than one cluster.

To get better feature vectors DWT function is applied thrice for every approximated image which results in the extraction of feature components (horizontal, vertical, diagonal, approximated) and further feature vectors. Fig.6 shows the Feature components obtained.

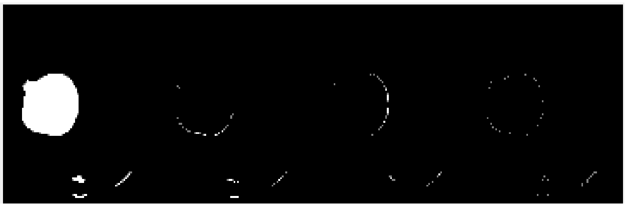

Fig.6 Feature components

Neural Network Pattern Recognition Tool is used for designing Neural Networks for classification, pattern recognition and decision problems. Here we have used npr tool for classification of the MRI image into tumor image or non-tumor image. Accuracy can be increased by increasing the number of inputs.

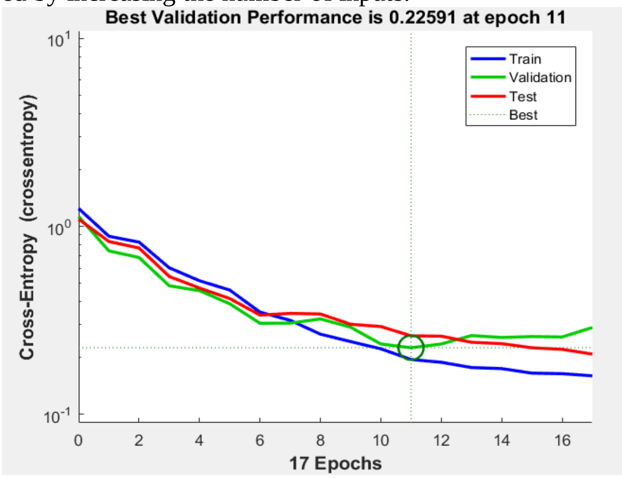

Fig.7 Performance plot

Fig.7 is a line graph that describes the training, validation and testing process which shows that the best performance is carried at the 11th iteration.

A confusion matrix is a table that is often used to describe the performance of a classification model (or "classifier") on a set of test data for which the true values are known.

The diagonal cells in the matrix shows the number of cases that are correctly classified, off diagonal cells give the number of cases that are miss-classified. Cells in red give error percentage whereas the cell in blue gives the overall accuracy percentage. Fig.8 shows the confusion matrix.

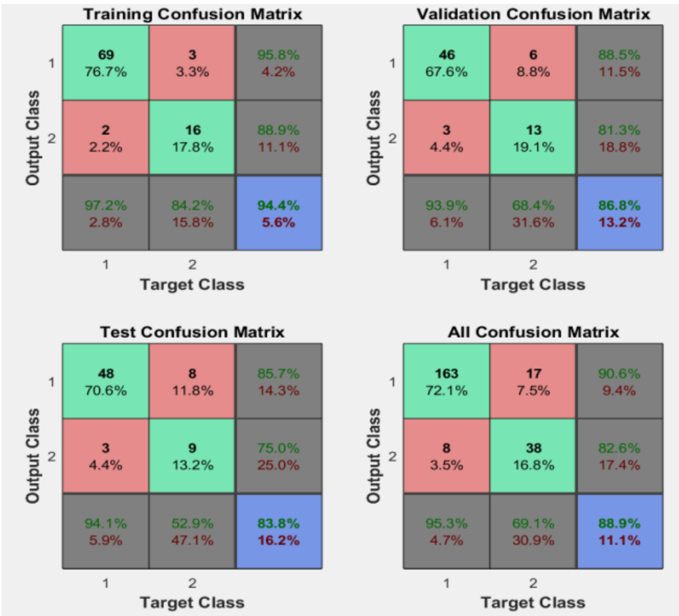

Fig 8- ANN Confusion matrix

Validation is performed to verify the segmentation results and evaluate it based on some predefined metrics. In this work we choose 8 evaluation metrics for comparison. We take a ground truth image which is an MRI image where the tumor is manually segmented by the radiologist. This is compared with our segmentation results. Fig.9 shows the ground truth image.

Fig.9 Ground Truth Image

Comparison with other algorithms in shown in the table below.

Algorithm	**Sensitivity (%)**	**Accuracy (%)**	**BER**
Thresholding	85	81.3	0.175
Region growing	88.46	86.47	0.812
FCM	86.95	99.83	0.136
K means	75	83.7	0.160
ANN	95.42	95.07	0.022
SVM	96.2	90.44	0.0234

From the above table, it is clear that FCM provides better segmentation results and ANN provides better classification compared to other algorithms. All the results shown in the above table are obtained by the image that provided highest values for the parameters mentioned above, and under the conditions that the ANN provided best validation performance while training. Program is written in MATLAB R2016a, image size 256x256, Processor- AMD FX4100, RAM 4GB, windows 10.

IV. CONCLUSIONS & FUTURE SCOPE

The abnormality of the tissues is needed to be identified or classified for the betterment of the human body. In this paper, the incorporated FCM and ANN based classification technique is proposed. The processed brain MRI images are firstly segmented using FCM algorithm in which the k value and updated membership are different from conventional process. There are two kind of features have been extracted from segmented images for the purpose of isolating and classifying tumor. The first kind of statistical features are used for the classifying normal and abnormal brain MRI image using FCM. The tumor categories and malignant tumor stages are classified through ANN back propagation algorithm. The results show that this method is better than others like region growing, thresholding and K-means in point of every parameter of comparison.

A novel algorithm for the segmentation and classification brain tumors is described in this research work. Results and analysis show that the proposed approach is a valuable diagnosing technique for the physicians to detect the 170 brain tumors. But, in final segmentation, a few other tissues also segmented in addition to tumors. Therefore, in order to improve the accuracy in the segmentation, it is necessary to include additional knowledge for discarding other tissues. In future work, it would be interesting to include additional feature information. Besides the energy, correlation, contrast and homogeneity add more information to the feature extraction in order to make the system more sensitive; information from the textures or location. It should be clear that many factors influence the appearance of tumors on images, and although there are some common features of malignancies, there is also a great deal of variation that depends on the tissue and the tumor type. Characteristic features are more likely to be found in large tumors. Small tumors may not have many of the features of malignancy and may even manifest themselves only by secondary effects such as architectural distortion.

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