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Classification of Brain Tumors Using Fuzzy Neural Networks

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Abstract: -- **The vital system of a human being is brain, such important part may be affected by unwanted tissue growth i.e tumor. Which is a critical problem in medical science for both diagnosis and treatment. In this paper we are concern about the diagnosis of tumor by analyzing MRI Images. The composite view of MRI images such as high intensive, divergent nature and Improper boundaries is difficult task for physician's interpretation. So, an automated tumor segmentation methodology is demanded. To confer a solution to this issue, tumor segmentation method by K means clustering and Fuzzy C means clustering is implemented in this paper. After segmentation The features are extracted to classify as tumorous or non-tumorous. The feature extraction form MRI Image are implemented by using Intensity, Intensity Histogram and GLCM Methods. GLCM (Gray Level Co-Occurrence) feature extracting method yields better results when compared with other methods. The Accuracy of the segmented data is evaluated by confusion matrix that is created from the extracted features. All the implementation are performed against BRATS dataset.**

Keywords: **MRI, GLCM, K-Means clustering, Fuzzy C means clustering, confusion matrix, MATLAB..**

I. INTRODUCTION

An automated system for classifying and detecting tumours in Bio-medical images is demanded. Detecting and classifying is a critical issue. Which requires a higher amount of accuracy. In this paper we used BRATS data set of Brain MRI images for classifying purpose. The motivation of this paper is to extract different intensity based features for brain tumour and project the result as one of the technique for the brain tumour classification. In the proposed implementation we extract several features from the MRI medical images [4],but we focus on the textural features [5]. Alteration , variation on the surface of an image is defined as a texture. We can cite that texture is distribution of gray levels neighbourhoods. Medical images of non-tumour and tumour type can be classified quickly by the physician through analysing intensity based features of the medical images. In recent days, brain tumours are common, due to day to day habitual behaviours of humans. Detecting tumours at earlier stage is a crucial issue, by detecting we can arrest the next stringent mutation of tumour by proper treatment. In general there are 2 types of tumours.

1. Benign Tumour --- Tumour which does not affect neighbouring healthy cells.
2. Malignant Tumour ---Tumour in which affects neighbouring healthy cells results in death of affected person.

The proposed Implementation is an efficient system for detection and classification of the tumour at early stages for the given set of BRATS data set MRI images to a normal tumour affected image.

II. IMAGE SEGMENTATION METHODS

K means segmentation

k-means clustering is a method of vector quantization, originally from signal processing, that is popular for cluster analysis in data mining. k-means clustering aims to partition n observations into k clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster.

The algorithm has a loose relationship to the k-nearest neighbor classifier, a popular machine learning technique for classification that is often confused with k-means because of the k in the name. One can apply the 1-nearest neighbor classifier on the cluster centers obtained by k-means to classify new data into the existing clusters. This is known as nearest centroid classifier.

K-Means Algorithm is as follows:

1. Number of cluster is taken as K.
2. Selection of cluster is random.
3. Calculate mean or center of the cluster.
4. The distance between each pixel to each cluster center is calculated.
5. Calculate the mean and update the new cluster center.

6. Repeat the process from step 3 until the center does not move.

Fuzzy C means Algorithm(soft clustering)

Fuzzy c-means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters.. This method is suitable for overlapping clusters. It is based on minimization of the objective function.

$$Y_m = \sum_{i=1}^{N}\sum_{j=1}^{c} M_{ij}^{m}\left\|x_i - c_j\right\|^2 \qquad 1)$$

Where m-real number above 1,
M_{ij} – Degree of membership of x_i in the cluster j,
x_i – D-dimensional data measure,
R_j – D-dimensional cluster center,
The update of membership $M_{ij}$and the cluster centers R_j are given by

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

$$R_j = \frac{\sum_{i=1}^{N} x_i - M_{ij}^{m}}{\sum_{i=1}^{N} M_{ij}^{m}} \qquad 3)$$

The process ends when

$$Max_i \left|M_{ij}^{k+1} - M_{ij}^{k}\right| < \delta \qquad 4)$$

Where
δ= termination value or constant between 0 and 1
K= Number of iteration steps
Fuzzy C-Means Algorithm is as follows:

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

$$R_j = \frac{\sum_{i=1}^{N} x_i - M_{ij}^{m}}{\sum_{i=1}^{N} M_{ij}^{m}} \qquad 5)$$

3. Update $U^{(k)}$ and $U^{(k+1)}$

$$M_{ij} = \frac{1}{\sum_{k=1}^{c}\left(\frac{\|x_i - c_j\|}{\|x_i - c_j\|}\right)^{\frac{2}{m-1}}} \qquad 6)$$

4. If $M_{ij}^{k+1} - M_{ij}^{k}| < \delta$ then STOP; otherwise return to step 2

$$M_{ij} = \frac{1}{\sum_{k=1}^{c}\left(\frac{\|x_i - c_j\|}{\|x_i - c_j\|}\right)^{\frac{2}{m-1}}} \qquad 7)$$

III. FEATURE EXTRACTION

In a Bio-Medical MRI images Extracting the visual contents are accomplished by feature extraction techniques, to preserve the raw image in its normalized form. Texture features of MRI image can be extracted by using co-occurrence matrix. The extracted set of features allows the Probabilistic Fuzzy Neural classifier to differentiate normal and abnormal patterns.

GLCM* (Gray Level Co-occurrence Matrix)*Feature Extraction Method.

Textural features of a medical image [13], which always focus on the pixel intensity level of the neighboring pixel [6] is defined by Five co-occurrence matrix in four spatial orientations horizontal, right diagonal, vertical and left diagonal (0^0,45^0,$90^0$and 135^0) and fifth matrix is defined [9] on the mean of preceding four matrices. The features are given by

CONTRAST:

Contrast is the separation between the darkest and brightest area in an image and is defined by following equation.

$$\sum_{i,j=0}^{n-1} P_{i,j}\,(i-j)^2$$

CLUSTER SHADE:

Cluster shade is given as a measure of skewness

$$\sum_{i,j=0}^{n-1} \left(i + j - \sigma_i - \sigma_j\right)^3 P(i,j)$$

ENERGY:

It provides the sum of squared elements in the GLCM. It is also known as uniformity or the angular second moment.

$$\sum_{i,j=0}^{N-1} (P_{i,j})^2$$

SUM OF SQUARE VARIANCE:

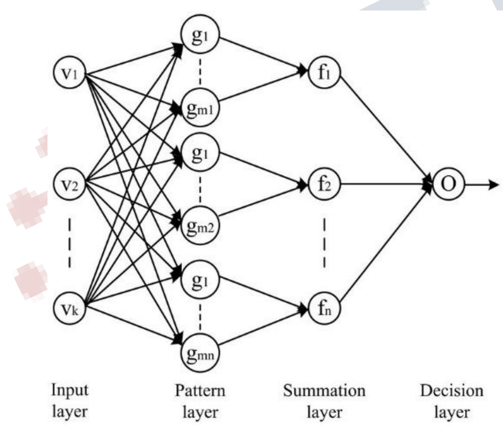
It gives higher weight that differs from the average value of P(i,j).

$$\sum_{i,j=0}^{N-1}(P_{i,j})(1-\mu)^2$$

In Intensity histogram [8] the features that are calculated for our statistics are smoothness, third moment, entropy and uniformity. The histogram is plotted on extracted values, which discriminates classes of brain tumour images one benign and other is malign. For the purpose of the pattern matching and pattern recognition the simplest available element is pixel which follow the first order statistics elements. The features are mean, median, mode and standard deviation.

probabilistic fuzzy neural network classifier

A neural network classifier is used to Differentiate circumscribed tumour. The number of neurons at the input layer side are indicates the number of images in the database and the output layer of each neuron indicates whether the MRI image have tumour or not and the hidden layer changes according to the number of rules that give the best recognition rate for each group of features.



Probabilistic Neural network

In the implemented model the feed forward supervised neural network is considered which is a Fuzzy Probabilistic Neural Network Classifier. Combining two techniques Fuzzy cluster means and the Probabilistic neural network algorithm. which contains Input layer, Hidden layer, pattern layer/summation layer and output layer. Pattern layer performs the classification. The probability density function used here is approximated by parsen estimator and the classification accuracy increase as number of training samples increases.

Here for each of the input vector, aranking level is enervated and the highest rank holdingvector is classified as winner. The pattern layer classifies the input vector only if there is a highest degree of match between the input vector and the training vector. This networks uses the bayesian theory .which is based on compromise fact that it is worst to misclassify an input vector that belongs to class A than to misclassify thevector that belongs to class B.

$$P_A C_A f_A(x) > P_B C_B f_B(x) \qquad 8)$$

Where P_A =Prior probability of occurrence of pattern in class

C_A= cost associate with classifying vectors.

$$f_A(x) = \frac{1}{(2\pi)^{\frac{\pi}{2}}\sigma^n m_n}\sum_{i=1}^{m} exp\frac{-2(x-x_A)^r(x-x_{Ai})}{\sigma^2} \qquad 9)$$

Where x_{Ai} = i[th] Training Pattern from Class A

n- Dimension of input vector

σ= smoothing parameter (corresponding to standard deviation of Gaussian distribution)

IV. SYSTEM DESIGN

The System Design involves the process of segmentation of the tumour MRI Images and sequence of steps are shown in Fig.2., which involves in 5 steps and it is described as follows.

1. Acquire the Bio-medical MRI Image, which is .mha file format from the BRATS dataset.
2. Pre-Process the Loaded Bio-medical image to improve the visual quality.In general we use Gaussian filter for this purpose.
3. After Pre-Processing the image is segmented by using Fuzzy C-Clustering algorithm
4. The visual information from the Segmented image is captured by GLCM method.
5. Now in this step we are giving the extracted features from the GLCM Method Neural Fuzzy Classifier which classifies type of tumour.

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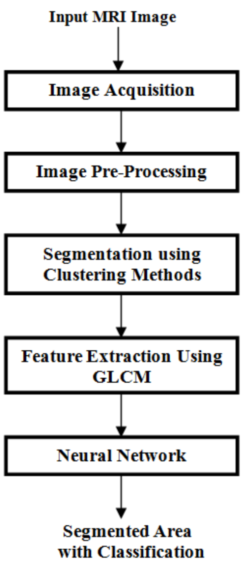

Fig.1: Functional Flow of Tumour –classification

V. PERFORMANCE EVALUATION RESULTS

For performance evaluation several types of metrics are used in the proposed method. It includes Analysis accuracy (AC) and Mathews Correlation coefficient (MCC) which are evaluated from the are calculated from the confusion matrix Actual and predicted classes can also be described by the confusion matrix. MCC is used to measure the quality of binary classification. It returns a value from -1(inversion prediction) to +1(perfect prediction)

science writers is [9].

$$AC = \frac{(TP+TN)}{(TP+FP+TN+FN)} \quad --------(10)$$

$$MCC = \frac{(TPXTN - FPXFN)}{\sqrt{(TP+FP)(TP+FN)(TN+FP)(TN+FN)}} \quad --------(11)$$

Where TP=True Positive
TN= True Negative
FP= False positive
FN= False Negative

VI. EXPERIMENTAL RESULTS

In the proposed implementation the MRI image Loaded as shown in the Fig.5 and is pre-processed using Gaussian filter for removal of noise and it is as shown in the Fig 6. The segmentation image is done through Fuzzy C means clustering as shown in Fig.7 and Fig.8 the data does not fully belong to an individual cluster and the degree of belongingness of a data point to a particular cluster is given by the degree of membership, which is very important tool for the classification of malignant tumor.

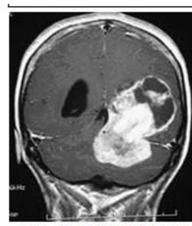

Fig 5: original image

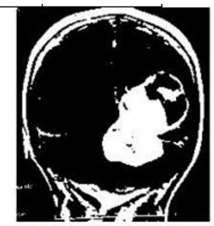

Fig 6: Threshold Image

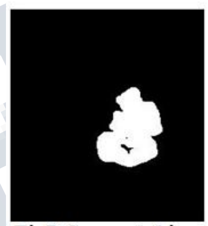

Fig7: Segmented image

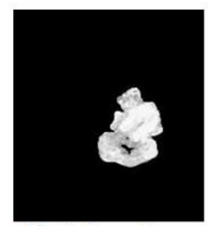

Fig 8: Fuzzy C means

The GUI of the proposed model for along with the features extracted is also calculated. The GUI shows the Accuracy of the proposed model. From the BRATS dataset (24 out of 300) images are taken and the segmentation along with the accuracy calculation is obtained. The neural network tool is used to train the extracted features using FPNN classifier. The neural network tool is given in the figure below.

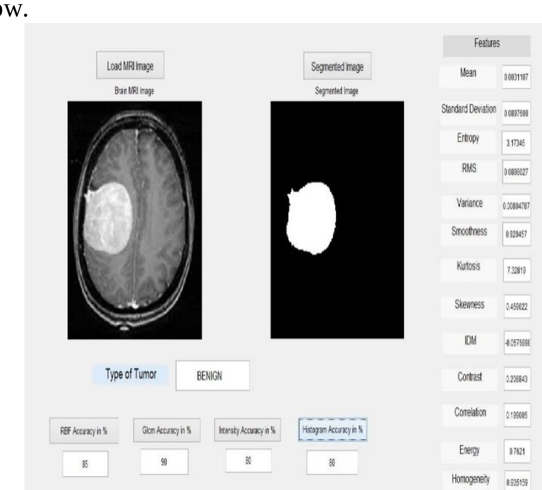

Figure 9 : GUI OF proposed Model

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Fig. 9 shows the GUI of the proposed implementation along with cluster image, extracted features value, tumour part. The accuracy is calculate from the confusion matrix. The featured wise confusion matrix is give in the tabular for with the true positive, true negative, false positive and false negative.

Table1: Confusion matrix based on GLCM Features

Actual	Predicted	
	Cancer (positive)	Normal (negative)
Cancer(Positive)	17	2
Cancer(Negative)	0	5

The above proposed method is also compared with the WEKA tool, intensity based, intensity histogram based which shows that the GLCM Feature extraction tool have the highest accuracy. This can be shown in figure 10

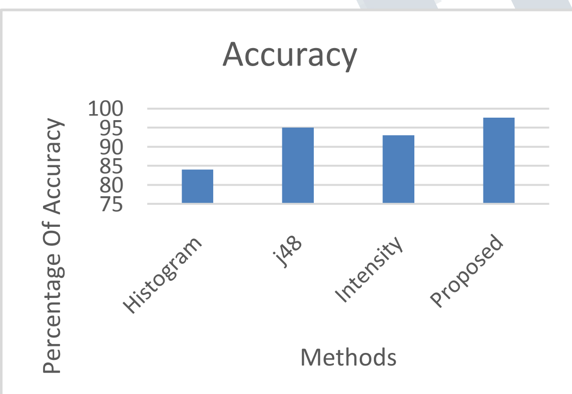

Fig.10 Accuracy Measurement of Different of Feature Extraction Method

VII. CONCLUSION

The proposed Implementation is used for the diagnosing tumors from magnetic resonance images brain. Diagnosing is done in many phases. Fuzzy c means clustering method used for segmentation of the MR image which given high degree of accuracy in terms of classification of images, compared with other techniques. The texture features are extracted from the Segmented image by using GLCM method, these extracted features are given as input Probabilistic Neural network for classifying MR image.

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