Implementation of PNN Based on Extraction of DCT features for Brain Tumor Classification

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Abstract: Accurate detection, segmentation and classification of Brain tumor is a challenging task in medical field. This paper proposes a method for brain tumor classification using Probabilistic Neural Network based on textural feature extraction of Magnetic Resonance Images (MRI). The proposed scheme consist of several stages including image acquisition, segmentation of tumor part, feature extraction and classification. This project include clustering algorithm for segmentation of MRI to detect brain tumor. Discrete cosine transform (DCT) is used for the dimensionality reduction and feature extraction. PNN will be useful to classify the stages of brain tumor that is Normal, Benign or Malignant. This can be performed in two stages : 1) Gray level co-occurrence matrix and 2) Classification using PNN based function. Detection and extraction of tumor from MRI scan images of the brain is done by using MATLAB software. Evaluation was performed on image database of 90 MRI of brain.

Keywords: Discrete Cosine Transform(DCT), Gray level co-occurrence matrix(GLCM), MATLAB, K-means Clustering, Magnetic Resonance Images(MRI), Probabilistic Neural Network.

I. INTRODUCTION

Brain tumors are caused by an abnormal & uncontrolled growth of cells or cell division. Brain tumors may also spread from cancers primarily located in the other organs also known as secondary brain tumors. Tumor is mass of tissues that grows out of control. It interfaces with normal functioning of brain. Tumor shifts the brain towards skull & increases the pressure on the brain. Detection of tumor is first step in treatment. The MRI brain image is acquired from patient's database, internet and then Image acquisition, image segmentation is performed for brain tumor detection. Because of many types brain tumors, classification becomes very complicated. So classification of brain tumor is very important part. A good classification process leads to the right decision and provide proper treatment.

Brain tumors are classified based on the type of tissue involved, size of tumor, the location of the tumor, whether it is normal, benign or malignant.

Normal Brain: If there is not any unwanted growth of cells then it is non cancerous brain. It does not consist cancer cell. So it is Normal brain[4].

Benign brain tumor: This type of tumor generally do not consist cancer cells and can be removed. Benign brain tumors usually have an obvious border or edge[4]. They don't spread to other parts of the body. However, benign tumors can cause serious health problems.

Malignant brain tumor: This consists of cancer cells and hence also called as brain cancer. They are likely to grow rapidly and can affect nearby healthy brain tissues. This type of tumor can be a threat for life[4]. Malignant brain tumors do not have an specific border or edge.

II. PROPOSED METHODOLOGY

The concept of Probabilistic Neural Network is used for the effective and accurate classification. Decision making was performed in two stages: feature extraction using Discrete Cosine transform (DCT) and the Probabilistic Neural Network (PNN)[1]. This project classifies a brain tumor if it is a benign tumor, a malignant tumor or normal one. Probabilistic Neural Network gives fast and accurate classification and is a promising tool for classification of the tumors.

A. Image acquisition :

Maximum MRI Images of brain are collected form possible resources like Radiologists, Internet, and Hospitals etc. Images are obtained using MRI scan & displayed in 2D having pixels as its elements. MRI scan were stored in database of images in JPEG image formats. These images are displayed as a gray scale images. The entries of gray scale images are ranging from 0 to 255, where o indicates total black color and 255 represents total white colour.

B. Segmentation using Clustering:

In this paper segmentation is performed by using clustering method and morphological operations.

1) *K-means clustering & its algorithm :*

K clusters K-means is one of the simplest unsupervised learning algorithms that solve the well known clustering problem by making partitions in an image. Assume k number of clusters to classify the database by defining k centroids one for each cluster. The next step is to take each point belonging to a given data set and associate it to the nearest centroid[2].

Algorithm is as follows :
Step1. Choose the number K of clusters either manually, randomly or based on some heuristic.

Step2. Generate K clusters and determine the cluster's center.

Step3. Assign each pixel in the image to the cluster that minimizes the variance between the pixel and the cluster center

Step4. Re-compute cluster centers by averaging all of the pixels in the cluster.

Step5. Repeat steps 3 and 4 until some convergence criterion is met[2].

2) *Morphological operations:*

In this paper morphological operators are used for the tumor region extraction and to further remove the non tumor regions[6]. In tumor regions, vertical edges, horizontal edges, and diagonal edges are mingled together while they are distributed separately in non tumor regions[6]. The dilation operator is used for filling the broken gaps at the edges and to have continuities at the boundaries.

C. Feature Extraction :

The extraction of texture features in the detected tumor has been achieved by using Gray Level Co-occurrence Matrix (GLCM)[4][3]. The method calculates a GLCM by calculating how often a pixel with a certain intensity i occurs in relation with another pixel j at a certain distance d and orientation θ. Co-occurrence matrices are calculated for four directions: 0°, 45°, 90° and 135°degrees. The eight Haralick texture descriptors are extracted from each co-occurrence matrices which are computed in each of four angles.

Five features extracted in this paper are explained below.

(i) Contrast:

Contrast is defined as the separation between the darkest and brightest area.

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

(ii)Correlation:

Correlation is computed into what is known as the correlation coefficient, which ranges between -1 and +1.

$$Correlation = \sum_{i,j=0}^{n-1} P_{ij}\,\frac{(i-\mu)(j-\mu)}{\sigma^2}$$

(iii)Homogeneity:

Homogeneity is defined as the quality or state of being homogeneous.

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

(iv)Entropy :

Entropy is a measure of the uncertainty in a random variable.

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

(v)Energy :

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

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

D. Discrete Cosine Transform :

In the proposed technique DCT features of an images are extracted as an initial step. On the basis of these features brain MR images are classified as normal or abnormal. DCT operates on a function at finite number of discrete data points[1]. The DCT has the property that, for a typical image, most of the visually significant information is concentrated in just a few coefficients[1].

The DCT of an M x N gray scale matrix of the image f(x, y) is defined as follows:

$$T(u,v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y)\,\alpha(u)\,\alpha(v) \times$$

$$\cos\left[\frac{(2x+1)u\pi}{2M}\right] \cos\left[\frac{(2y+1)v\pi}{2N}\right] \quad (1)$$

$$\text{Where} \quad \alpha(u) = \sqrt{\frac{1}{M}} \quad \text{for} \quad u = o$$

$$= \sqrt{\frac{2}{M}} \quad \text{for} \quad u = 1,2,...,M\text{-}1 \quad (2)$$

The values T (u, v) are the DCT coefficients.

E. Training and Testing:

In the training phase, feature vectors are extracted for each image in the training set. Features are extracted through GLCM. Set of extracted features for each image is known as feature vector. Feature vectors for every image is computed as [x1 x2 x3...xn].

In the testing phase, the feature vector [y1 y2 y3..yn] of the test image is computed using DCT. In order to identify the test image, the similarities between test image and all of the feature vectors in the training set are computed. The similarity between feature vectors is computed using Euclidean distance. The identity of the most similar image is the output of the image recognizer. If feature vector of test image matches with feature vector of image in training set then test image has correctly identified.

F. Probabilistic Neural Network :

A probabilistic neural network (PNN) is a feed forward neural network, which was derived from the Bayesian network and a statistical algorithm called Kernel Fisher discriminate analysis. It was introduced by D.F. Specht in the early 1990s. In a PNN, the operations are organized into a multilayered feed forward network with four layers:

· Input layer
· Hidden layer
· Pattern layer/Summation layer
· Output layer

In 1990, Donald F. Specht proposed a method to formulate the weighted-neighbour method in the form of a neural network. He called this a "*Probabilistic Neural Network*". Following is a diagrammatic representation of a PNN network :
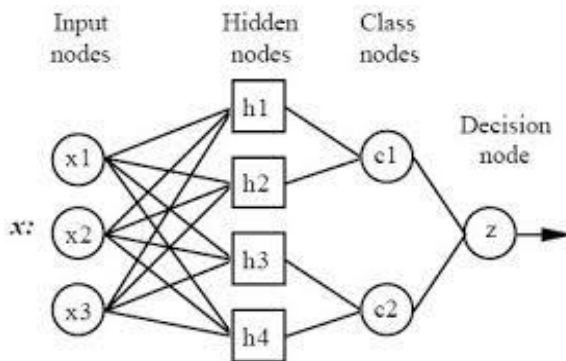

Fig 1. Architecture of Probabilistic Neural Network

PNN is often used in classification problems. When an input is present, the first layer computes the distance from the input vector to the training input vectors[3]. This produces a vector where its elements indicate how close the input is to the training input[4]. The second layer sums the contribution for each class of inputs and produces its net output as a vector of probabilities.

Finally, a complete transfer function on the output of the second layer picks the maximum of these probabilities, and produces a 1 (positive identification) for that class and a 0 (negative identification) for non-targeted classes[4]. Layers of PNN are as shown in the following figure :
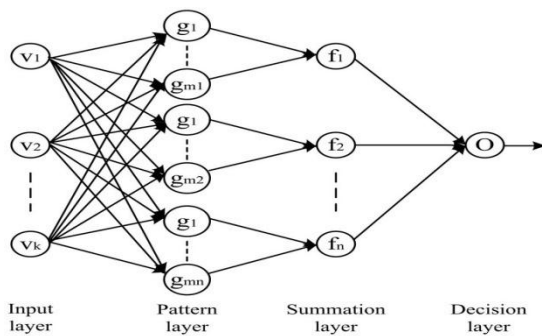

Fig 2. Layers of PNN

Input layer:

Each neuron in the input layer represents a predictor variable. In categorical variables, *N-1* neurons are used when there are *N* number of categories. It standardizes the range of the values by subtracting the median and dividing by the interquartile range. Then the input neurons feed the values to each of the neurons in the hidden layer.

Pattern layer:

This layer contains one neuron for each case in the training data set. It stores the values of the predictor variables for the case along with the target value. A hidden neuron computes the Euclidean distance of the test case from the neuron's center point and then applies the RBF kernel function using the sigma values.

Summation layer:

For PNN networks there is one pattern neuron for each category of the target variable. The actual target category of each training case is stored with each hidden neuron; the weighted value coming out of a hidden neuron is fed only to the pattern neuron that corresponds to the hidden neuron's category. The pattern neurons add the values for the class they represent.

Output layer:

The output layer compares the weighted votes for each target category accumulated in the pattern layer and uses the largest vote to predict the target category.

III. EXPERIMENTAL RESULTS AND ACCURACY ANALYSIS

Data base consist of MRI of brain. In this method different images from different patients have been considered, analyzed and classified. Here results for 3 test images are shown out of 7 test images. Following table shows input image, segmentation of tumor and assigned class.
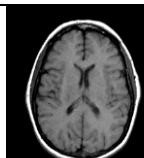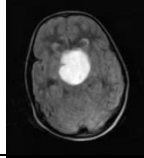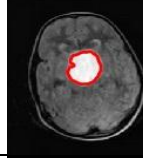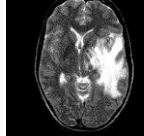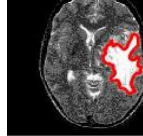
Sr. No	Input Image for Testing	Output Image	Assigned Class
1			Normal
2			Benign
3			Malignant

Table 1. Result for classification

A .Accuracy Analysis :

Sr. No	Test Image	Original Class	Classified Class	Accuracy
1	Image1	Normal	Normal	99.5716
2	Image2	Benign	Benign	98.4429
3	Image3	Benign	Benign	98.1795
4	Image4	Benign	Benign	98.5279
5	Image5	Malignant	Malignant	99.5292
6	Image6	Malignant	Malignant	99.4431
7	Image7	Malignant	Malignant	99.4562

Table 2. Accuracy Analysis for assigned classes

B. Extracted features :

Sr. No	Energy	Contrast	Correlation	Homogeneity	Entropy
1	0.0757	921.9987	0.2527	0.3809	7.0493
2	0.1350	246.8799	0.3335	0.5617	4.9761
3	0.1264	209.6587	0.3881	0.5434	5.0023
4	0.1343	261.3241	0.4410	0.5536	5.2635
5	0.0858	837.8144	0.3113	0.4075	6.9350
6	0.0644	706.6521	0.1481	0.3546	7.0025
7	0.0823	724.5247	0.2556	0.4322	6.2865

Table 3. Extracted features for 7 test image
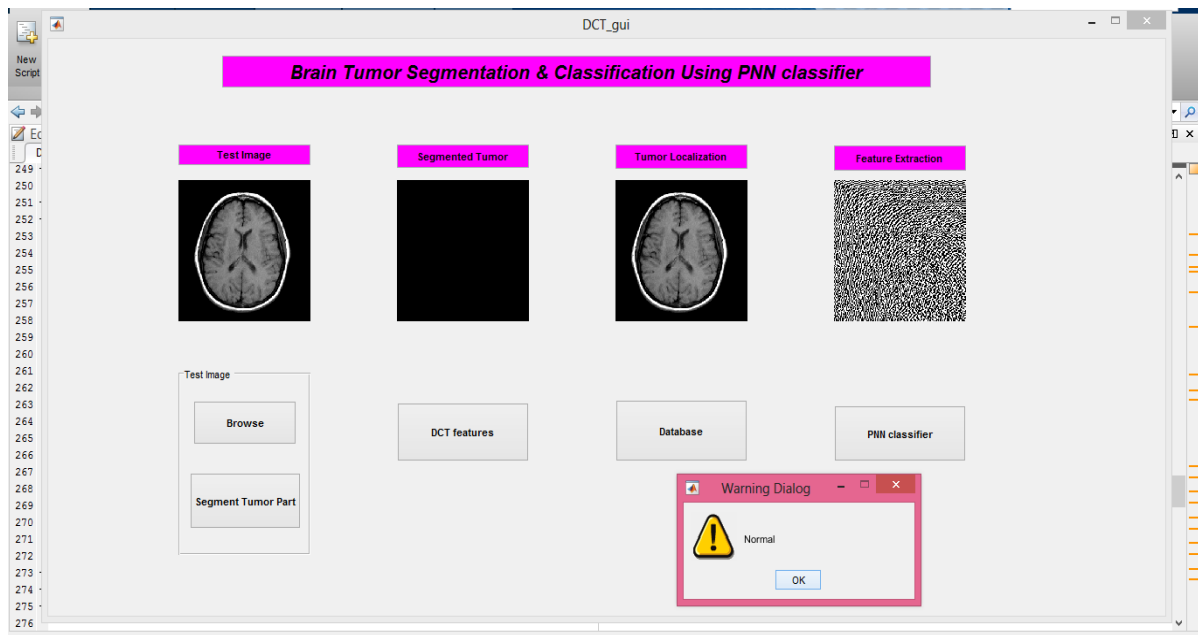
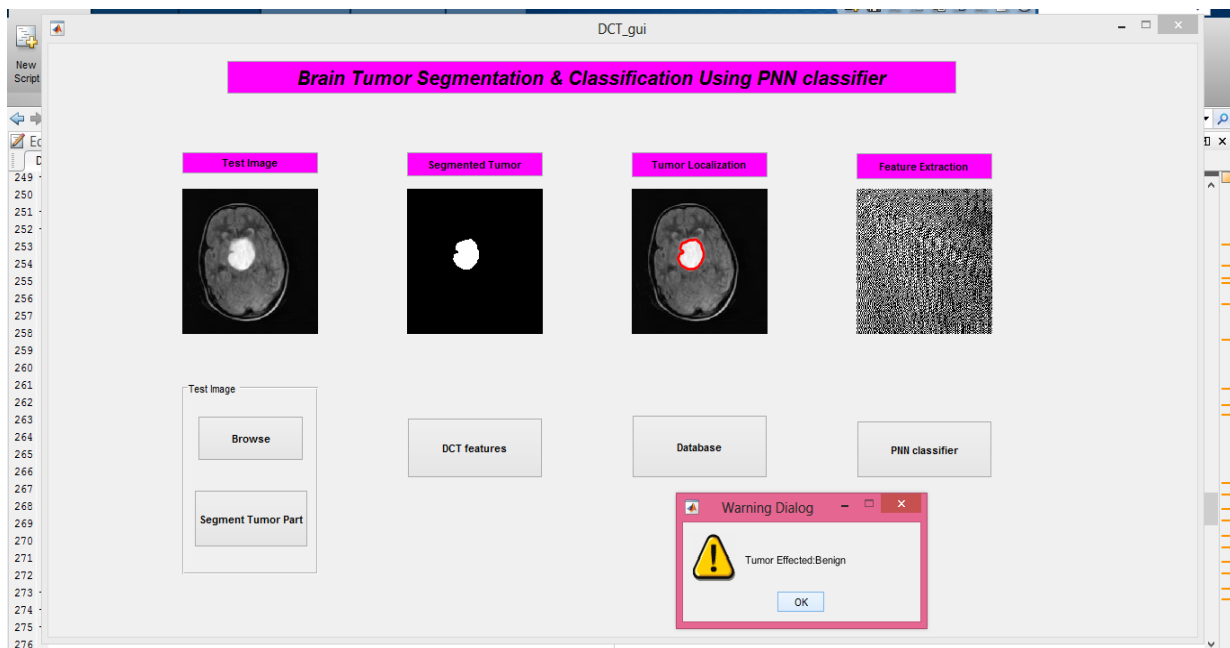## C. Simulation Results :

Fig.3 Result for Normal Brain

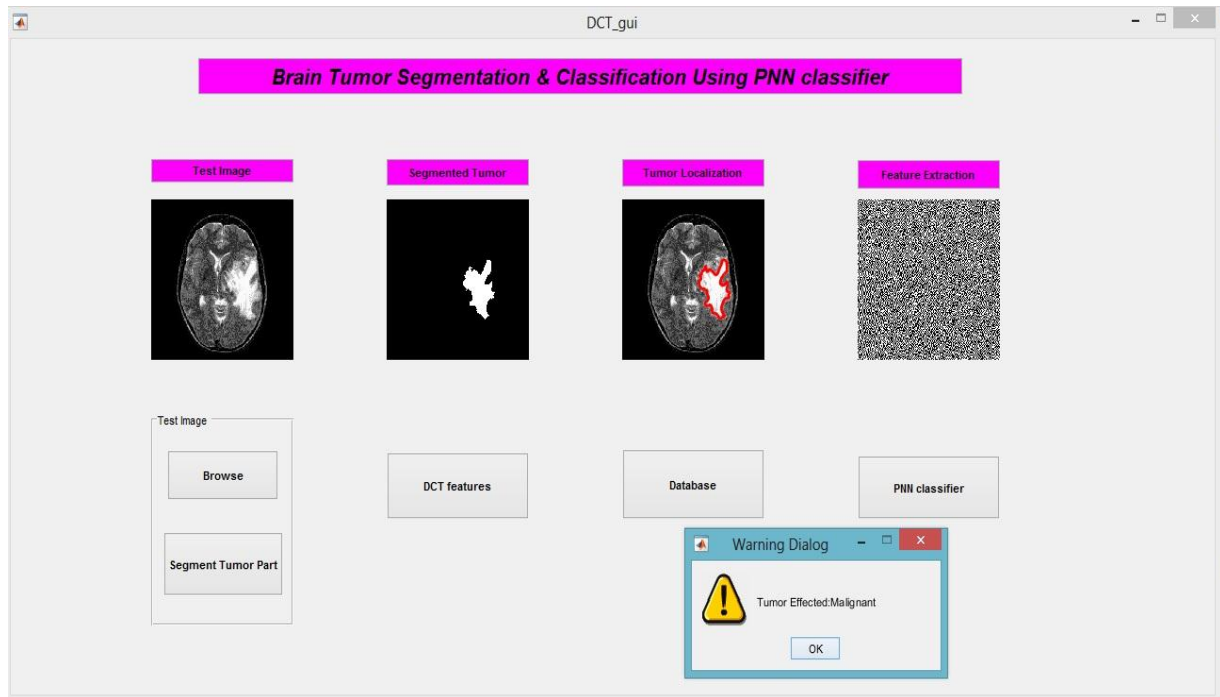Fig.4 Result for Benign type of Tumor

Fig.5 Result for Malignant type of Tumor

IV. CONCLUSION

Probabilistic Neural Network is used for classification of MRI of brain. It gives accurate results. By using clustering, segmentation is performed accurately. Classification is performed on the basis of DCT feature extraction. On an average this implementation gives 99.99% of accuracy which will be helpful for diagnosis of brain tumor in early stages.

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