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Implementation of Classification System for Brain Tumor using Probabilistic Neural Network

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Abstract: In this paper Brain cancer detection & classification system has been designed & developed for distinguishing different types of brain MRI into three classes such as Benign, Malignant and Normal. The image processing techniques such as image acquisition, image segmentation, morphological operations & feature Extraction have been developed for detection of brain tumor. In this project we have obtained the features related to the Discrete Cosine Transform as well as Discrete Wavelet Transform. For segmentation of tumor region K-means clustering is used. The extraction of texture features in the detected tumor has been achieved by using Gray level co-occurrence matrix (GLCM). Probabilistic Neural Network is employed to implement an automated brain tumor classification. The performance of the PNN classifier is evaluated in terms of training performance and classification accuracies. Tumor area is calculated. Finally there is comparison between accuracy analysis for Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) over 90 MRI of brain. Simulation is performed by MATLAB software.

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

I. INTRODUCTION

This paper is extended part of our previous paper. A brain tumor is an intracranial mass produced by an uncontrolled growth of cells either normally found in the brain such as neurons, lymphatic tissue, glial cells, blood vessels, pituitary and pineal gland, skull, or spread from cancers primarily located in other organs. World Health Organization (WHO) classification system to identify brain tumors. The WHO classifies brain tumors by cell origin and how the cells behave, from the least aggressive (benign) to the most aggressive (malignant). And also non tumorous image is classified as Normal Stage.
There are two common types of tumor:
[1] Benign tumor
[2] Malignant Tumor

[1] Benign Tumor: - A benign tumor is a tumor is the one that does not expand in an abrupt way; it doesn't affect its neighbouring healthy tissues and also does not expand to non-adjacent tissues.

[2] Malignant Tumor: - Malignancy is the type of tumor that grows worse with the passage of time and ultimately results in the death of a person. Malignant is basically medical term that describes a severe progressing disease. Malignant brain tumors do not have an specific border or edge.

[3] Normal: - 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.
There are many different types of brain tumors that make the decision very complicated. So classification of brain tumor is very important, in order to classify which type of brain tumor really suffered by patient. A good classification process leads to the right decision and provide good and right treatment.

II. PROPOSED METHODOLOGY

Proposed system includes following steps which is shown in figure below.

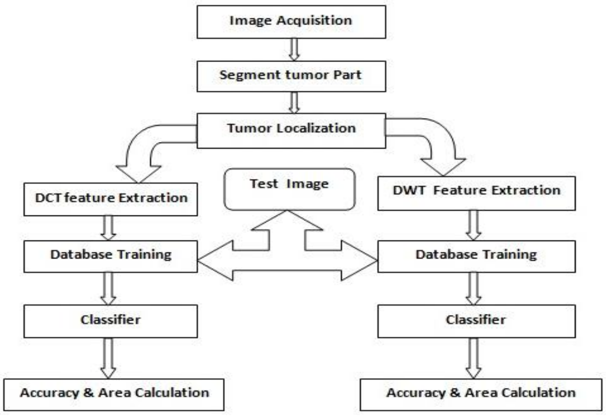

Fig.1 Block Diagram of Proposed Work

The above mentioned process is applied on a clustered database consisting of 90 distinct MRI images categorized into 3 classes.

A. Image Acquisition:

All MRI images are collected from Hospitals, Internet etc. MRI scan are stored in database of images in JPEG image formats. These images are displayed as a gray scale images.

B. Segmentation:

1) K-means clustering & its algorithm:
It is an iterative technique that is used to partition an image into K clusters. The K-means clustering technique is a pixel-based method [2]. K-means clustering is suitable for biomedical image segmentation as the number of clusters is usually known for images of particular regions

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of the human anatomy.

(i).STEPS FOR K-MEANS:
1. Give the no of cluster value as k.
2. Randomly choose k cluster centres
3. Calculate mean or centre of the cluster
4. Calculate the distance b/w each pixel to each cluster centre
5. If the distance is near to the centre then move to that cluster.
6. Otherwise move to next cluster.
7. Re-estimate centre.
8. Repeat the process until the centre doesn't move

2) Morphological operations:
In this paper morphological operators are used for the tumor region extraction and to further remove the non tumor regions. In tumor regions, vertical edges, horizontal edges, and diagonal edges are mingled together while they are distributed separately in non tumor regions [9]. The dilation operator is used for filling the broken gaps at the edges and to have continuities at the boundaries.

C. Feature Extraction:
Gray-level co-occurrence matrix (GLCM) is the statistical method of finding the textures that considers the spatial relationship of the pixels. The GLCM functions characterize the texture of an image by evaluating how frequently pairs of pixel with specific values and in a specified spatial relationship that present in an image, forms GLCM [3]. This makes the extraction of statistical measures from this matrix. It is the most widely used and more generally applied method because of its high accuracy and less computation time. A gray level co-occurrence matrix (GLCM) contains information about the positions of pixels having similar gray level values [10]. 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 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 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:

$$T(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\alpha(u)\alpha(v)\times \cos\left[\frac{(2x+1)u\pi}{2M}\right]\cos\left[\frac{(2y+1)v\pi}{2N}\right] \qquad (1)$$

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

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

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

E. Multi-Level Wavelet Decomposition with 4-level:
The proposed system uses the Discrete Wavelet Transform (DWT) coefficients as feature vector. The wavelet is a powerful mathematical tool for feature extraction, and has been used to extract the wavelet coefficient from MR images[4]. By applying multi-level wavelet decomposition with 4-level, we can get results in sub bands. For example in 2D level decomposition the image is displayed as an approximation and three detail images, representing the low and high frequency contents image correspondingly. LL1, LL2 represent the wavelet approximations at 1st and 2nd level respectively, and are low frequency part of the images. LH1, HL1, HH1, LH2, HL2, HH2 represent the details of horizontal, vertical and diagonal directions at 1st and 2nd level correspondingly and are high frequency part of the images[4][7]. The continuous wavelet transform of a signal x (t), Square-integrable function, relative to a real-valued wavelet, (t) is defined as:

$$w_{\psi}(a,b) = \int_{-\infty}^{\infty} f(x) * \psi_{ab}(t)dx$$

Where

$$\psi_{a,b}(t) = {}^{1}/_{\sqrt{|a|}}$$

Pyramidal 4-level decomposition of an image is as shown in the figure below.

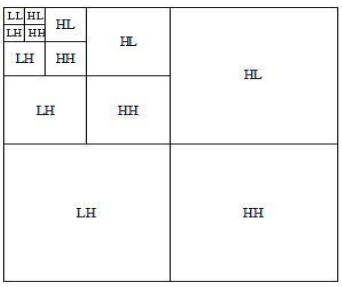

Fig.2 Pyramidal Decomposition of an image

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F. Database training & testing:
The classification gets closer as the number of training samples increases; the pattern layer consists of a processing element corresponding to each input vector in the training set.

All the output parameters in the pattern layer is tested and trained based on the Neural Network once. An element is trained to return a high output value when an input vector matches the training vector.

G. Probabilistic Neural Network:
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

Following is a diagrammatic representation of a PNN network:

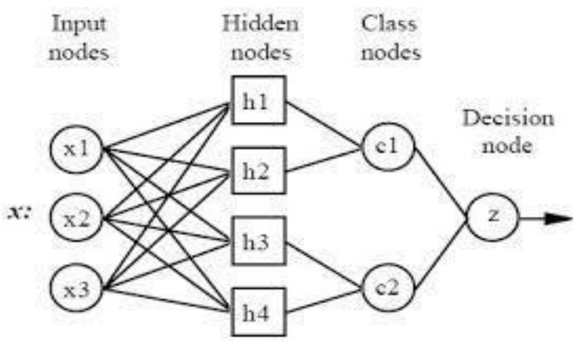


Fig.3 Architecture of Probabilistic Neural Network

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 [10]. 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 0 (negative identification) for non-targeted classes. Layers of PNN are as shown in the following figure:

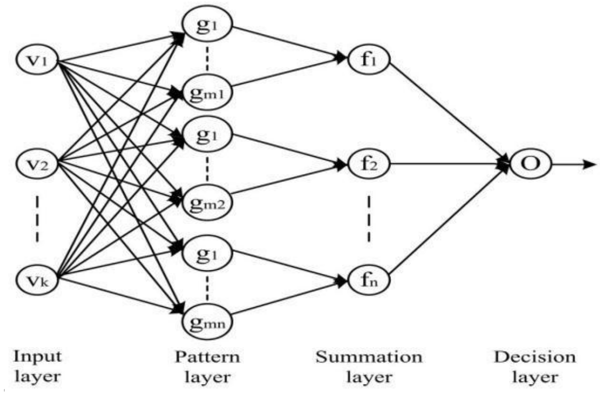


Fig.4 Layers in PNN

III.EXPERIMENTAL RESULTS & 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. Following are the results after applying feature extraction by using DCT & 4-level DWT.

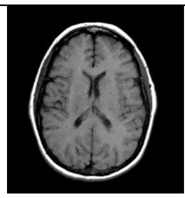
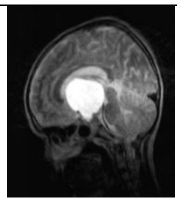
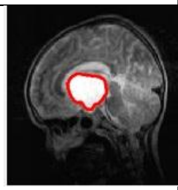
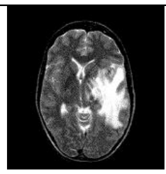
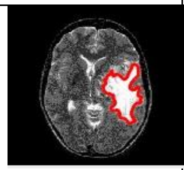
Sr. No	**Input Image for Testing**	**Output Image**	**Assigned Class**
1			Normal
2			Benign
3			Malignant

Table1. Results of classification

A. **Accuracy Analysis:**

Sr. No	Test Image	Original Class	Classified Class	Accuracy After DCT	Accuracy After DWT
1	Image1	Normal	Normal	99.5716	99.9919
2	Image2	Benign	Benign	98.4429	99.9664
3	Image3	Benign	Benign	98.1795	99.9631
4	Image4	Benign	Benign	98.5279	99.9750
5	Image5	Malignant	Malignant	99.5292	99.9942
6	Image6	Malignant	Malignant	99.4431	99.9864
7	Image7	Malignant	Malignant	99.4562	99.9919

Table2. Accuracy Analysis for assigned classes

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B. Simulation Results:

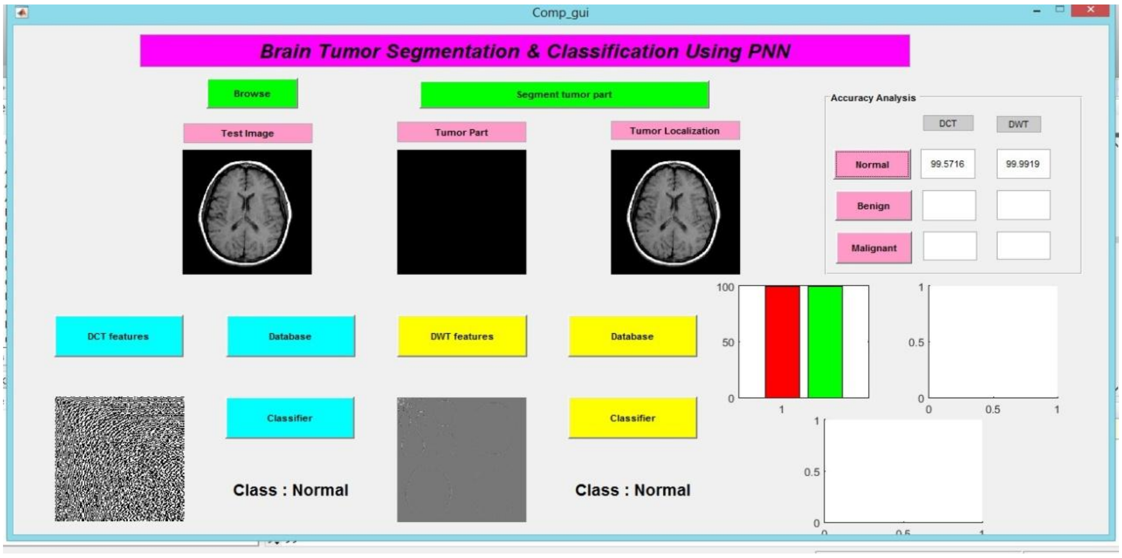

Fig.5 Result for Normal Brain

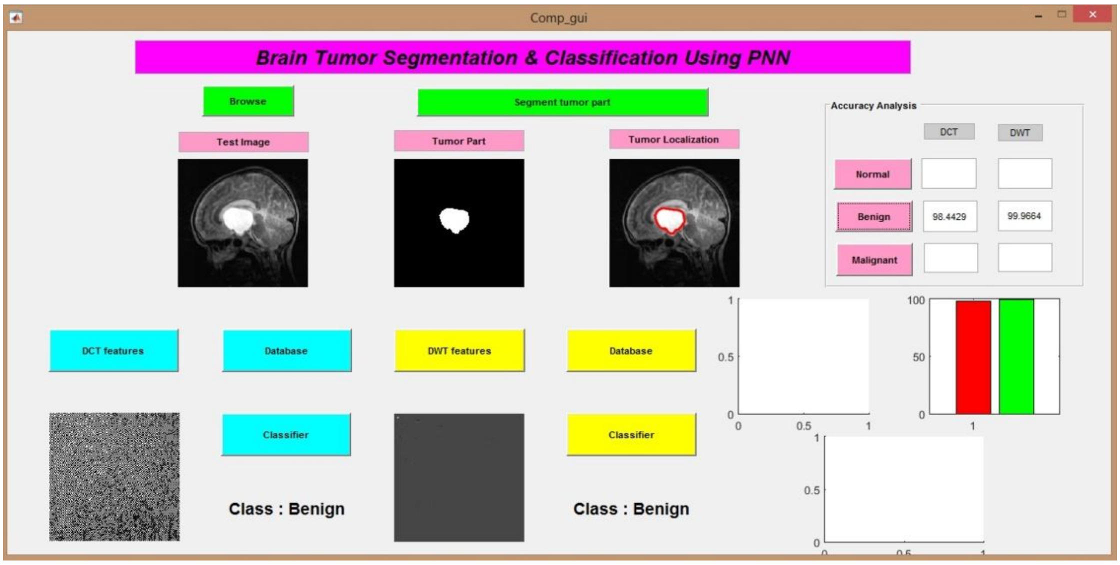

Fig.6 Result for Benign type of Tumor

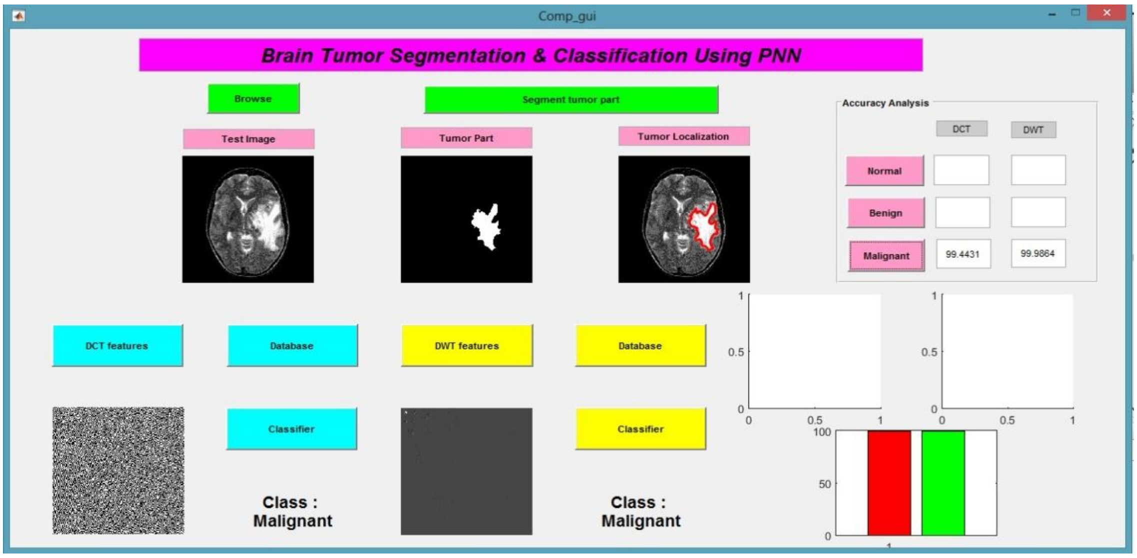

Fig.7 Result for Malignant type of Tumor

IV. CONCLUSION

Classification is performed on the basis of DCT & DWT feature extraction. The performance of DCT is almost similar to DWT at lower threshold values but for higher threshold DWT gives better visual image quality than DCT. Probabilistic Neural Network provides accurate classification. By comparing these two algorithms, we can conclude that we get nearly 100% accuracy for diagnosing and classifying the MRI of Brain.

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