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A Novel Approach to Brain Tumor Classification using Wavelet and Probabilistic Neural Network

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***Abstract*— Magnetic Resonance Imaging (MRI) brain tumor image classification is a difficult task due to the variance and complexity of tumors. This paper presents an efficient techniques for the classification of the magnetic resonance brain images. In this work we are taking MR images as input; MRI which is directed into internal cavity of brain and gives the complete image of the brain. The proposed technique consists of two stages.In the first stage, discrete wavelet transform is used for dimensionality reduction and feature extraction.In the second stage, classification is performed using the probabilistic neural network. The classifier have been used to classify real MR images as benign (non-cancerous) and Malignant (cancerous). Probabilistic neural network (PNN) with image and data processing technique is employed to implement an automated brain tumor classification. The use of artificial intelligent technique has shown great potential in this field.**

***Index Terms*— Brain tumors, Feature extraction,Classification, MRI, Probabilistic neural network, Dimensionality reduction, Discrete wavelet transform.**

I. INTRODUCTION

Brain tumor is one of the major cause for increase in mortality among children and adults.A tumor is a mass of tissue that have uncontrolled growth of cells.Magnetic resonance imaging (MRI) has become a widely employed high quality medical imaging now a days in the field of tumor detection.Brain tumor classification in MR images have become a vital area of discussion.For accurate image classification, some good features have to be extracted.

A good classification process leads to the right decision and provide good and right treatment.Treatments of various types of brain tumor are mostly depending on types of brain tumor[1].During the classification of MR brain images, variability in certain aspects such as tumor shape, location, size and intensity.In tumor classification,intensity feature plays a vital role in differentiating tumor from other brain soft tissues. The brain is comprised of different tissues such as the, white matter (WM), cerebrospinal fluid (CSF) and gray matter(GM).Brain tumors may have different types of symptoms ranging from headache to stroke,so symptoms will vary depending on tumor location.Magnetic Resonance Imaging(MRI) is widely used for the scanning purpose. MRI posses high image quality.The image quality plays a vital role in brain tumor classification. MRI will create detailed images of the organs and tissues within the body [2-4].It is efficient in the application of brain tumor detection,due to high contrast of soft issues, high spatial resolution and as it is a non-invasive method.Benign brain tumors are tumors that arise from cells in the brain or the covering of the brain.Malignant brain tumor occurs when cancers cells spread to the brain from a benign cancer to the other part of the body.

In today's digital era capturing,storing and analysis of medical image has been digitized.The challenge from the perspective of time and accuracy is the detailed interpretation of medical images [2].The challenges stand tall especially in regions with abnormal color and shape which needs to be identified by radiologists for further studies.MRI's create more detailed pictures than CT scans and are the preferred way to diagnose a brain tumor for early detection of abnormalities .

The image acquisition parametes can be adjusted in MRI for generating high contrast image with different gray levels of neuropathology.Brain cancer is one of the leading causes of death from cancer.Brain cancer is most treatable and curable if caught in the earliest stages of the tumor.The advanced brain cancer can only spread inward because the skull will not let the brain tumor expand further in outward regions,which puts excessive pressure on the brain and can cause permanently brain damage and eventually death.The diagnostic process will be completed through a physical and neurological exam.

A neurological exam helps in evaluating the brain and nervous system and sensation, movement, balance, alertness, coordination, vision, and hearing.

A diagnosis of brain cancer is generally made by a specialist called a neurologist or internist.Image testing that may be performed include MRI and/or CT scan which use computer technology to create detailed pictures of the brain.A procedure called angiography may also be done to illuminate blood vessels in the brain that feed blood to a brain tumor.The flowchart of the proposed technique is shown in figure 1.

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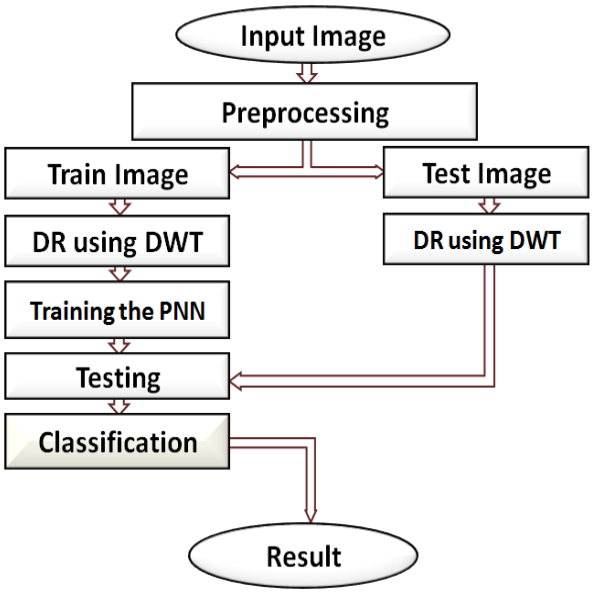

Fig. 1. Flowchart of the proposed technique

For the implementation of the proposed method of Brain tumor classification,Magnetic Resonance Images in DICOM format of T2 weighted axial plane were collected from the Sri Sai Krishna Neuro hospital, Hyderabad.The collected T2 weighted magnetic resonance images are categorized into two distinct classes with each as benign brain tumors and malignant brain tumors respectively.

II.DISCRETE WAVELET TRANSFORM

The wavelet is a powerful mathematical tool for feature extraction and has used to extract the wavelet coefficients from MR images.Wavelet transforms are multi-resolution image decomposition tool that provide a variety of channels representing the image feature by different frequency sub-band at multiscale.Discrete wavelet transform converts the image from the spatial domain to frequency domain[5].The image is divided by vertical and horizontal lines and the image can be separated with four parts those are LL, LH, HL and HH.

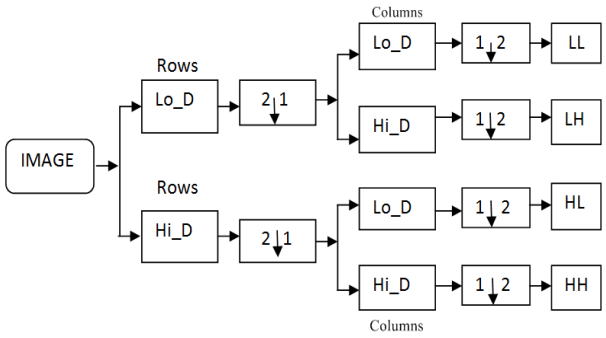

Fig 2. 2D Discrete wavelet transform

Where Lo_D – low pass filter;
Ho_D-high pass filter;
2↓1- Downsampling columns;
1 ↓ 2 – Downsampling rows;

The discrete wavelet transform can be evaluated by using ,

$$a_{j+1}[p]=\sum_{n=-\infty}^{\infty} l[n-2p]a_j[n] \qquad (1)$$

$$d_{j+1}[p]=\sum_{n=-\infty}^{\infty} h[n-2p]d_j[n] \qquad (2)$$

Where a j is used for next scale of the transform and d j is called wavelet coefficients, which determines output of the transform.The $l[n]$ and $h[n]$ are coefficients of low and high-pass filters respectively.we can assume that on scale $j+1$ there is only half from number of a and d elements on scale j.*wavelet* transform is an important method for image compression.

Wavelet based coding provides substantial improvement in picture quality for high compression ratios mainly due to better energy compaction property of wavelet transform [6].The haar DWT illustrates the desirable properties of wavelets.It captures not only a notion of the frequency content of input but also temporal content i.e, time at which these frequencies occur.

III.PROBABILISTIC NEURAL NETWORK

Probabilistic neural network is a radial basis neural network which provides a general solution to pattern classification problems by using an approach developed in statistics,called bayesian classifiers.Neural networks are frequently employed to classify patterns based on learning from examples[7].It is used to implement an automatic MR image classification of brain tumor into benign and malignant.

It is one of the most influential neural network Model which consists of several layers of Nodes[8].It consists of input layer, an output layer and a hidden layer, which include input node(s), output node(s) and hidden node(s) respectively.The second layer will sums these contributions for each class of inputs to produce a vector of probabilities as its net output.Finally, a complete transfer function on the output of the second layer picks the maximum of these probabilities and produces 1 for that class and 0 for the other class.

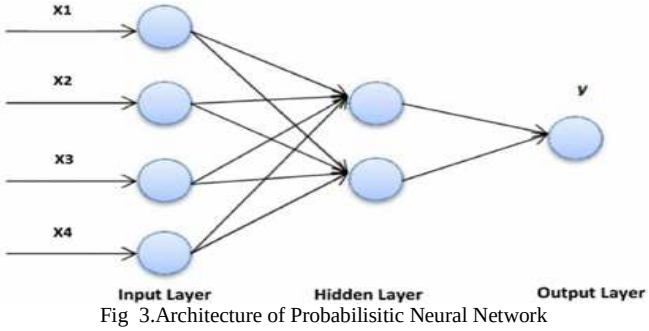

Fig 3.Architecture of Probabilisitic Neural Network

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The radial basis evaluates vector distance between input vector and row weight vectors in weight matrix.These distance are scaled by radial basis function non-linearity.Then the layer finds the shortest distance among them, and thus find the training pattern closest to the input pattern based on their distance.A training set is used to create a learning environment in the probabilistic neural network .The training set must be thoroughly representative of the actual data set for effective

classification.Adding and removing training samples simple involves adding or removing "neurons" in the hidden layer[9].As the training set increases in size,the probabilistic neural network asymptotically converges to bayes optimal classifier.A PNN is predominantly a classifier since it can map any input pattern to a number of classifications.The main advantages that discriminate PNN, are its fast training process, an inherently parallel structure guranteed to coverage, to an optimal classifier as the size of the representative training set increases and training samples can be added or removed without extensive retraining[7].It can be viewed as a supervised neural network that is capable of using it in a system classification and pattern recognition.An probabilistic neural network (PNN) is an information processing paradigm that is inspired by the way of biological nervous system,such as the brain and process information.The key element of paradigm is the novel structure of the information processing system.It composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. The probability can be estimated using the formula,

$$f(\mathrm{X}) = \frac{1}{(2\pi)^{p/2}\sigma^{p}} \frac{1}{m} \sum_{i=1}^{m} \exp\left[\frac{(\mathrm{X}-\mathrm{X}_i)^{t}(\mathrm{X}-\mathrm{X}_i)}{2\sigma^{2}} \right] \quad (3)$$

Where X *i* is i *th* training sample from category, σ is smoothing parameter, m is is number of training samples, P indicates the dimension of the pattern vector X. The input layer is fully interconnected with the hidden layer, which consists of the training set of PNN. The vector X serves as weight to the input layer.Finally,an output layer represents each of possible classes for which the input image can be classified.One other important element of PNN is the output layer and determination of the class for which the input layer fits.The output layer compares the weighted vectors for each target category accumulated in the hidden layer and uses the largest vector to predict the category.The hidden layer consists of a processing element corresponding to each input vector in the training set.Each output class should consist of equal number of processing elements otherwise it may lead to poor classification result.

Compared to the feed forward back propagation network,training of the probabilistic neural network is much simpler[1].Since PNN classify on the basis of bayesian theory, it is essential to classify the input vectors into one of the two classes in a bayesian optimal manner.The algorithm was implemented using MATLAB software package.

IV. CONCLUSION

This paper presents an efficient method for classifying MR images into benign and malignant tumor, using probabilistic neural network.The proposed method approach gives promising results in classifying MR images.Most of the existing methods can detect and classify MR brain images into normal and abnormal[10].Whereas, the proposed method with the help of discrete wavelet transform's output subands, is able to classify the brain tumor into benign and malignant. Based on the experimental results, PNN is considered to have major advantages over conventional neural networks, due to the fact that PNN learns from the training data instantaneously.This method of automatic early detection and classification of MR brain images into benign and malignant, not only replaces conventional invasive techniques,but also helps in reducing fatality rate.

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