Detection and Classification of Brain cancer using BPNN and PNN

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Abstract— There are over 120 types of brain and central nervous system tumors. Brain tumor is one of the major causes of death among people. It is evident that the chances of survival can be increased if the tumor is detected and classified correctly at its early stage. Magnetic resonance (MR) imaging is currently an indispensable diagnostic imaging technique in the study of the human brain. A brain tumor is defined as an abnormal growth of cells within the brain or the central spinal canal. So tumor detection needs to be fast enough as the patient cannot recover if the damage is more than 50%. For detecting this tumor CT or MRI scan is done. This CT or MRI scan images are taken for this project to process it. This paper presents the artificial neural network approach namely Back propagation network (BPNs) and probabilistic neural network (PNN). It is used to classify the type of tumor in CT or MRI images of different patients with Astrocytoma type of brain tumor. K-means clustering method have been developed for detection of the tumor in the CT or MRI images. Gray Level Co-occurrence Matrix (GLCM) is used to achieve the feature extraction. The whole system worked in two modes firstly Training/Learning mode and secondly Testing/Recognition mode finally gets a classified output.

Key words: Brain tumor, MRI, Image segmentation, artificial neural network.

I. INTRODUCTION

The brain, its structure, and the role that each part plays in our everyday thoughts and behaviors is remarkable. These are some reasons why a tumor in the brain is so complex. There are 120 types of brain and central nervous system tumors. Tumor is an uncontrolled or abnormal growth tissue in any part of the body. These cells are look like healthy and normal cells. A brain tumor is an abnormal growth of tissue in the brain or central spine that can disrupt proper brain function. Doctors refer to a tumor based on where the tumor cells began, and whether they are cancerous (malignant) or not (benign).

Brain tumors may have different type's symptoms ranging from headache to stroke. So symptoms will very depending on tumor location. Different location of tumor causes different functioning disorder [2].

According to the World Health Organization, brain tumor can be classified into the following groups:

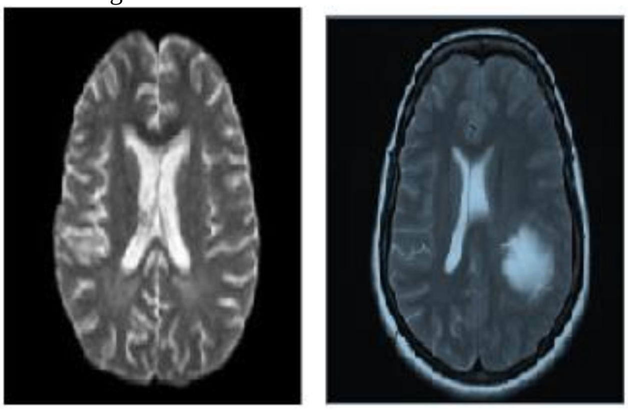
Grade I: Pilocytic or benign, slow growing, with well-defined borders.

Grade II: Astrocytoma, slow growing, rarely spreads with a well-defined border.

Grade III: Anaplastic Astrocytoma grows faster.

Grade IV: Glioblastoma Multiforme, malignant most invasive, spreads to nearby tissues and grows rapidly.

A scan is the first step to identify if a brain tumor is present, and to locate exactly where it is growing. A scan creates computerized images of the brain and spinal cord by examining it from different angles. Some scans use a contrast agent (or a dye) to allow the doctor to see the difference between normal and abnormal tissue which are shown in fig1.



a. normal b. abnormal

Fig. 1: Brain Images

Many diagnostic imaging techniques can be performed for the early detection of brain tumors such as Computed Tomography (CT), Positron Emission Tomography (PET) and Magnetic Resonance Imaging (MRI). Compared to all other imaging techniques, MRI is efficient in the application of brain tumor detection and identification, due to the high contrast of soft tissues, high spatial resolution and since it does not produce any harmful radiation, and is a non-invasive technique. Although MRI seems to be efficient in providing information regarding the location and size of tumors.

Many researchers have used different classification techniques for MRI data analysis, such as Baye's classifier-nearest classifier, artificial neural network (ANN) based approach, and support vector machines (SVMs) as a classification scheme. In these classification techniques designing the system is complex, time consumption is comparatively more and accuracy is low. Due to these reasons the K-means clustering method for image segmentation and artificial neural networks like back-propagation and probabilistic neural networks are used as classifier.

The objective of this paper is to present a system as a diagnostic tool for identification of tumor cancer appearing in brain. This project also proposed brain cancer / tumor classification from MRI data by means of texture analysis based on gray level co-occurrence matrix (GLCM) to train the artificial neural networks (back propagation neural network used here). For this first segment the input image using image processing techniques like clustering methods. In this we are using K-means clustering method. The segmented image will undergo feature extraction; this will further process in two stages of classifier. We describe the modes of this technique in two stages: the Training/Learning and Testing/Classification. Back propagation network (BPN) and probabilistic neural network (PNN) based classifier are used to classify the type of tumor in MRI image as normal or abnormal brain images which are shown in the fig.1(a) and(b).

II. IMAGE SEGMENTATION

The main idea of the image segmentation is to group pixels in homogeneous regions and usual approach to do this is by common feature. Features can be represented by the space of colour, texture and gray levels, each exploring similarities between pixels of a region. Segmentation [3] refers to the process of partitioning a digital image into multiple regions (sets of pixels).the goal of segmentation is to simplify and change the representation of an image into something that that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images.

There are many different methods to perform image segmentation, K-means clustering is satisfactory for bio-medical image segmentation as the number of clusters is usually known for images of particular regions of the human anatomy. It is an unsupervised clustering algorithm that classifies the input data points into multiple classes based on their built-in distance from each other.

The fig.2 shows steps in K-means clustering method. The most famous partitional clustering algorithm is k-means clustering. The steps of k-means clustering are as below.

Step1. Determine the number of clusters we want in the final classified result and set the number as N. Randomly select the N patterns in the complete data bases as the N centroids of N clusters.

Step2. Classify each pattern to the nearest cluster centroid. The closest usually indicate that the pixel value is similar, but it still consider other features.

Step3. Recompute the cluster centroids and then there have N centroids of N clusters as we do after Step1.

Step4. Repeat the iteration of Step 2 to 3 until a Convergence criterion is met. The typical convergence criteria are: no reassignment of any pattern from one cluster to another, or the minimal decrease in squared error.

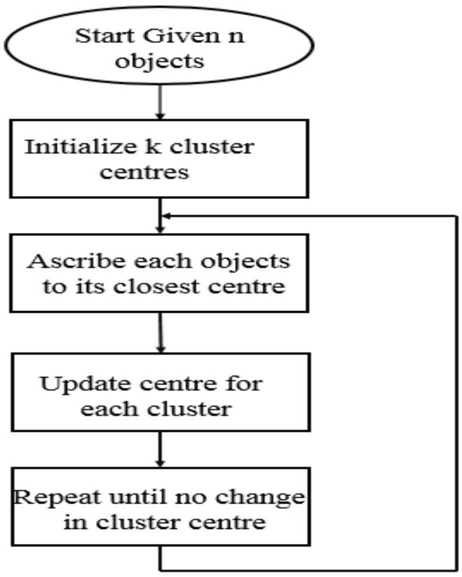


Fig. 2: K-means Clustering algorithm

Advantages:

(1) K-means algorithm is easy to implement.
(2) It is faster than the hierarchical clustering.

Disadvantage:

(1) The result is sensitive to the selection of the initial random centroids.
(2) We cannot show the clustering details as hierarchical clustering does.

III. METHODOLOGY

The method used for MRI brain tumor image classification is shown in Figure 3.This paper introduces a new approach of brain cancer classification for astrocytoma type brain cancer which is a part of image processing using Gray level co-occurrence matrix (GLCM). The easiest way in this paper is a classification of any MRI images of patients into patterns using adaptive segmentation (i.e. using image processing technique such as K-means clustering method) with the use of their textures features in different direction (i.e. 0º, 45º, 90º and 135º) of GLCM matrix to train the artificial neural networks (back propagation neural network and probabilistic neural network used here). This association obtains a good result. We propose a brain cancer classification method based on Gray level co-occurrence matrix (GLCM) with a neural network to recognize a certain class. The necessary steps are as follows.

– Input the sample brain MR images.
– Enhancement of input MR images.
– Image segmentation using image processing techniques (K-means clustering algorithm) perform for the input image.
– Texture Features extraction using GLCM Matrix in different Direction (i.e. at 0º, 45º, 90º and 135º).
– Train a neural network on different image samples for certain class (i.e. gradeI, gradeII, gradeIII and gradeIV).
– Test unknown image sample by calculate the texture features by GLCM and used a neural network to detect and classify it.

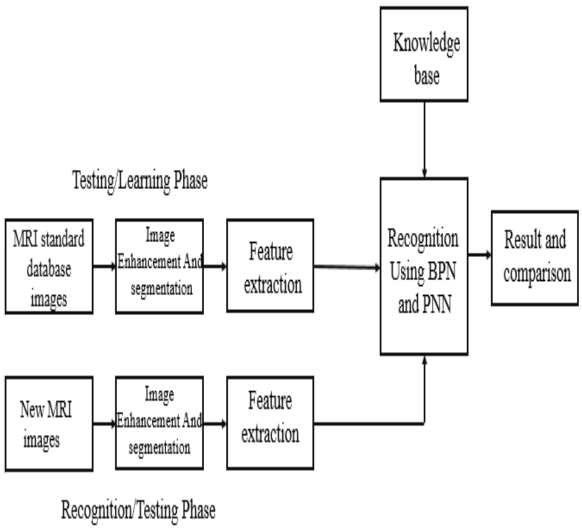


Fig. 3:. Proposed Methodology for classification of brain cancer

The proposed system consists of two stages as below:

(1) Learning/Training Phase

(2) Recognition/Testing Phase

A. Learning/Training Phase

In Learning/Training Phase the ANN is trained for recognition of different Astrocytoma types of brain cancer. The known MRI images are first processed through segmentation using pre-processing and various image processing steps such as K-means clustering method and then textural features are extracted using Gray Level Co-occurrence Matrix. The features extracted are used in the Knowledge Base which helps in successful classification of unknown Images. These features are normalized in the range -1 to 1 and given as an input to Back Propagation Neural Network (BPN) Based Classifier. In case of Probabilistic Neural Network these features are directly given as an input to PNN based classifier. The features such as angular second moment (ASM) or energy, contrast, inverse difference moment (IDM) or homogeneity, dissimilarity, entropy, maximum probability and inverse for each type of MRI image that was trained for the neural network is shown in table 1.

B. Recognition/Testing Phase

The second stage is recognition/testing phase. To test unknown MRI image sample and classify, two steps are performed, the first one is segmented the image and calculate the GLCM for each input MRI image. The obtained GLCM is used to extract features depending on equations which shown in figure 2. The second step is train the above features with the desired values of neural networks to determine the MRI image belong to which grade of astrocytoma type of brain cancer. The taken decision is made by back propagation neural network (BPN) based classifier and probabilistic neural network (PNN) based classifier.

C. Gray Level Co-occurrence Matrix

- It is introduced by Haralick.
- A statistical approach that can well describe second-order statistics of a texture image is a co-occurrence matrix.
- GLCM characteristics features are used with the patient’s MR image for training of neural network.
- 2-D histogram and represented by P(i , j , d, Ө) and use co-occurrence matrix in angles of 0°, 45°, 90°, and 135°.

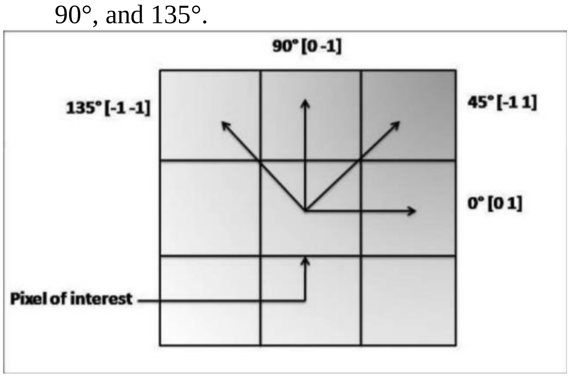


Fig. 4: Directions for generation of GLCM

D. Back Propagation Neural Network:

Back propagation is a supervised learning method. In supervised learning, each input vector needs a corresponding target vector. Input vector and target vector are presented in training of the network. The output vector (i.e. actual output) which is result of the network is compared with the target output vector then an error signal is generated by the network. This error signal is used for adjustment of weights until the actual output matches the target output. Algorithm stages for BPN are initialization of weights, feed forward, back propagation of Error and Updation of weights and biases [4, 5].

Energy	$F1 = \sum_{i,j=0}^{N-1} Pi,j2$
Contrast	$F2 = \sum_{i,j=0}^{N-1} P(i,j) * (i,j)2$
Homogeneity	$F3 = \sum_{i,j=0}^{N-1} \frac{P(i,j)}{1+(i-j)2}$
Dissimilarity	$F4 = \sum_{i,j=0}^{N-1} P(i,j) * \lvert(i,j)\rvert$
Entropy	$F5 = \sum_{i,j=0}^{N-1} P(i,j) * [-\ln(P(i,j))]$
Maximum probability	$F6 = \max i,j\ P(i,j)$
Inverse	$F7 = \sum_{i,j=0}^{N-1} \frac{P(i,j)}{(i-j)2}$

Table 1: Computation of texture feature

E. Probabilistic Neural Network

Probabilistic neural networks (PNN) are a kind of radial basis network suitable for classification problems. A PNN is primarily a classifier since it can map any input pattern to a number of classifications that is Probabilistic neural networks can be used for classification problems. When an input is presented, the first layer computes distances from the input vector to the training input vectors and produces a vector whose elements indicate how close the input is to a training input. The second layer sums these contributions for each class of inputs to produce as its net output a vector of probabilities. Finally, a complete transfer function on the output of the second layer picks the maximum of these probabilities. PNN is a fast training process and an inherently parallel structure that is guaranteed to converge to an optimal classifier as the size of the representative training set increases and training samples can be added or removed without extensive retraining [6].

IV. EXPERIMENTAL RESULTS

In this paper, an automatic brain cancer classifier was proposed. The proposed technique was implemented on MRI datasets. The algorithm is successfully trained in matlab version R2013a. For evaluate the proposed algorithm we used the classification accuracy. The overall accuracy of the proposed system is 77.56% in case of BPN and 98.07% in case of PNN based system. The results of this proposed system are shown in figure 5, 6, 7, 8, 9, 10.

Texture Features are shown in below

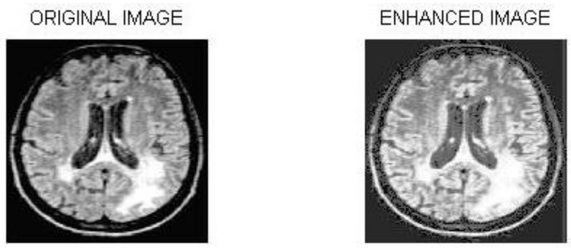


Fig. 5: Original image & Enhanced image

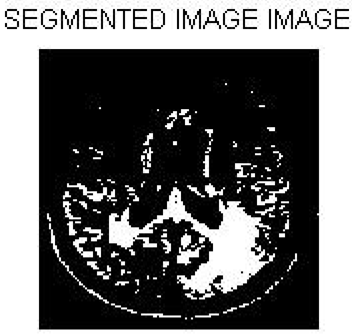


Fig. 6: Image Segmentation Process

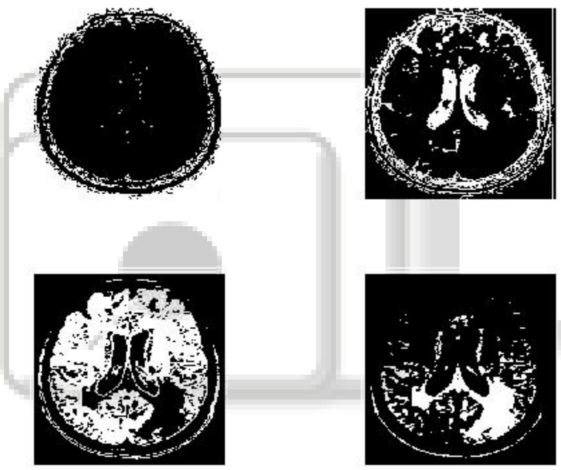


Fig. 7: K-means Clustering Process

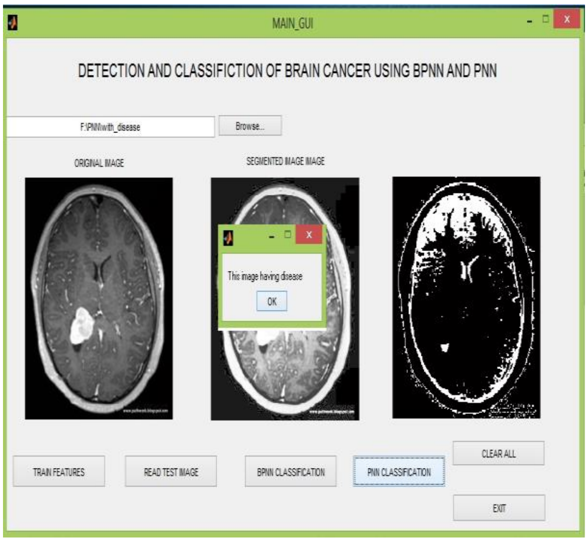


Fig. 8: Detection of The Brain Tumor

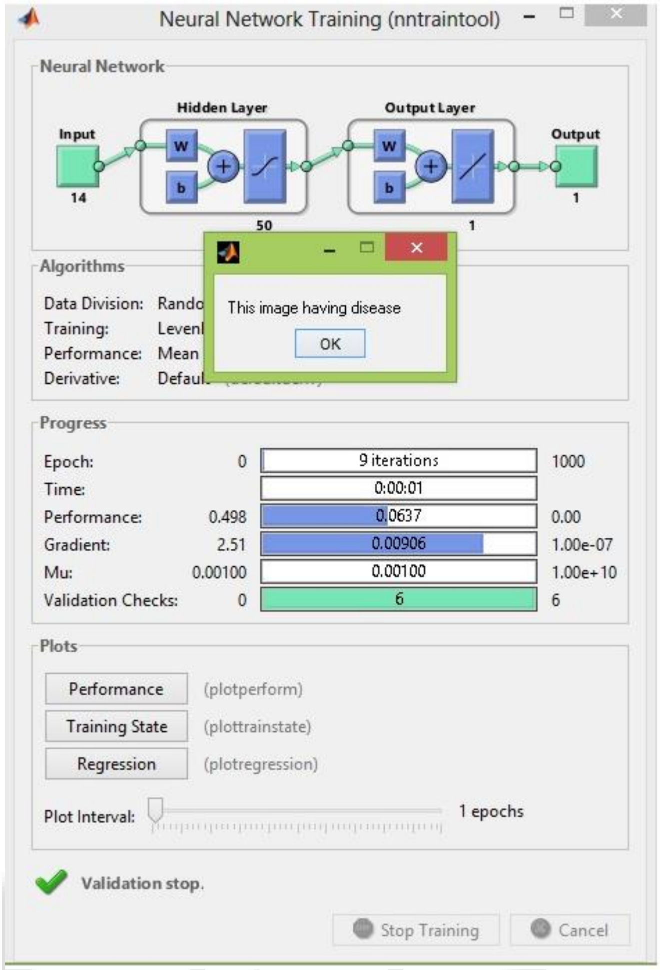


Fig. 9: BPNN Detection of the Brain Cancer

V. CONCLUSION

In this paper, the segmentation of MRI images is done by K-means clustering which has more efficiency compare to other clustering algorithm.

This article describes detection and Classification of Brain Cancer Using Back propagation network (BPNs) and Probabilistic neural network (PNN). The complete system worked in two stages firstly Training/Learning and secondly Testing/Recognition. The image processing tool such as K-means clustering is perform on Training/Learning. Texture features are used in the Training/Learning of the Artificial Neural Network. Co-occurrence matrices at 0º, 45º, 90º and 135º are calculated and Gray Level Co-occurrence Matrix (GLCM) features are extracted from the matrices. The above process efficiently classifies the tumor types in brain MRI images.

The system can be designed to classify other types of cancer. The further scope of the system is to improved ANN architecture by using other approach.

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