International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

Brain Tumor Grade Detection by Using ANN

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Abstract:Brain tumor is death threatening disease, the early detection helps to extend the life time. Practically, the micro analysis of tissues only confirms the disease severity. Hence, a computer aided method is proposed to categorize brain tumors as benign and malignant by using Feed forward network. The existing works assign features as much of pixel counts. However, the proposed method eliminates the feature size by using significant features according to the tumor and brain anatomy. The network attains 96% of accuracy and compared against existing works.

Keywords: ANN, GLCM, Gober Filter, Morphology operator, MRI.

I. INTRODUCTION

Uncontrolled growth of brain cells is called brain tumor which is death threatening disease and in various types. Generally, brain tumor is categorized according to the tissue type as benign or malignant. The earlier stage of brain tumor is categorized as benign the later stage is named as malignant. Non-uniform structure and cancer cells acknowledge the malignant type of tumor. The both types of tumors are again classified into four grades by world health organization (WHO) and American brain tumor association [1]. Grade I and II tumors are benign and are curative where as grade III and IV are malignant. Radiotherapy, chemotherapy or surgical planning are only treatment to cure the malignant tumors [2]. Nowadays, no one automatic tool to analyze the tumor grade detection except biopsy [3]. The laboratory manual work increase the analysis time.

Pan et al. used machine learning network and fed images as input where as some self learned features extracted and segment the tumor. The work produced 18% better result than artificial neural network (ANN) network. Gray level co-occurrence matrix (GLCM) features were used to classify the Astrocytoma type of brain tumors by using Neuro Fuzzy classifier [4]. Zacharaki et al. investigated several classification methods support to classify the brain tumor types and grades.

Whereas intensity of pixels, tumor shape, and rotation variant texture features were taken as feature set. They achieved 96% of accuracy in the classification of high grade from low grade Neoplasm [5]. For the same work, GLCM and GLRM features and Fuzzy entropy measures were fed into Feed forward neural
network, back propagation neural network and multilayer perceptron were employed to classify the grade. They concluded that back propagation neural network resulted 96.7% of accuracy in classifying tumor grade [6]. Instead of back propagation, support vector machine classifier was used to classify the tumor images [7]. Evangelia et al. projected a method called machine learning scheme to classify the brain tumor and grade with the help of texture, shape and intensity based features. The method gave 85% of accuracy [8].

They have used ANN with certain features. The proposed method tries to classify the tumor by using Gabor filter features and GLCM features. Nowadays, Gabor filter plays a vital role in texture segmentation, document analysis, target detection and image coding and representation [9].

The remaining part of the paper is planned as three sections. The steps involved in the process are illustrated in the section 2, the obtained results are deeply discussed in section 3 and the conclusion regarding on the results are given in section 4.

II. PROPOSED METHOD

The proposed work deals the grade detection by four phases as given in Fig.1. The first phase deals the pre-processing, the second phase deals the segmentation, the third phase extracts features from MRI images and segmented image and fourth phase employ the ANN to classify the tumor grades.

Revised Manuscript Received on October 30, 2019.
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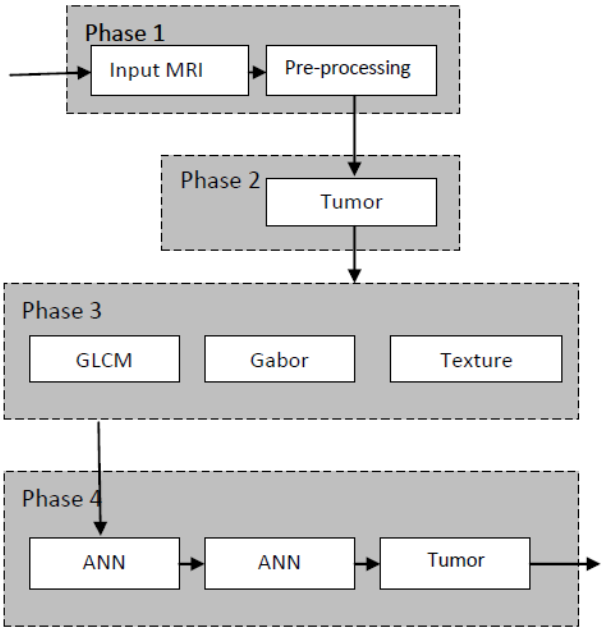

Fig. 1. Proposed Method

A. Pre-processing

Wavelet based method is employed to denoise an image. The denoising method uses six steps to denoise an image, commences from synthesis with the help of multi resolution analysis (MRA) method. Further, estimates the noise ratio in sub-band. Threshold value is estimated based on the noise level and shrink the noisy coefficients according to the threshold value. Finally compose the sub-bands and produce the denoised images.

B. Tumor Extraction

Tumor extraction is done by the Embanked watershed (E-WS). In this approach, morphological operator is used to embank the tumor boundary. Further, water shed algorithm employed to extract the tumor portion from brain MR image.

Feature Extraction

Features are representing the images in vector or scalar format. Neural network cannot analyze the image directly, instead of that several features like texture, statistical and second order features feed as input to the network. The proposed method extracts features by using Gabor filter, GLCM and statistical region based features. Some features are fed as input to ANN.

Gabor Features

Gabor Filter, short term Fourier transformation with Gaussian window was proposed to analyze the two dimensional signal of the spatial domain. Hence, the proposed method uses the filter to extract features,

The 2D Gabor filter is described at spatial index (x, y) as [10],

$$g_{\lambda,\theta,\sigma,\psi}(x,y) = exp\left(\frac{-x_\theta^2+\gamma^2 y_\theta^2}{2\sigma^2}\right) cos\left(\frac{2\pi}{\lambda} x_\theta + \psi\right) \quad (1)$$

where $x_\theta = xcos(\theta) + ysin(\theta)$ and $y_\theta = -xsin(\theta) + ycos(\theta)$, $\lambda = \frac{1}{f}$ represents wavelength, θ represents orientation and ϒ represents a special aspect ratio $\frac{\sigma}{\lambda}$ which determines the spatial frequency bandwidth.

The angle θ defines the orientation of the filter. By changing θ value different filters can be obtained. In each iteration, the theta value is increased 45° to obtain the texture features that are given in Fig. 2. The first image shows the filter of θ = 0° the subsequent images show the filters of θ = θ + 45°. The averages of the resulted images are taken as features of the proposed work.

C. Tumor Feature Extraction:

The benign and malignant tumors are differing in its texture. The malignant tumor consists of four sub regions such as necrosis, edema, enhanced and non-enhanced tumor [11]. The benign type of tumor is surrounded by a well defined border and contains two regions tumor and edema. So the statistical features are important to classify the tumor grades. The proposed method accounts the area, eccentricity, Euler number, Perimeter and convex area.

Eccentricity: it a shape based feature and determines ratio of the distance between the foci and the length of major axis. The value is between 0 and 1, 0 represents the circle and 1 represents line segment

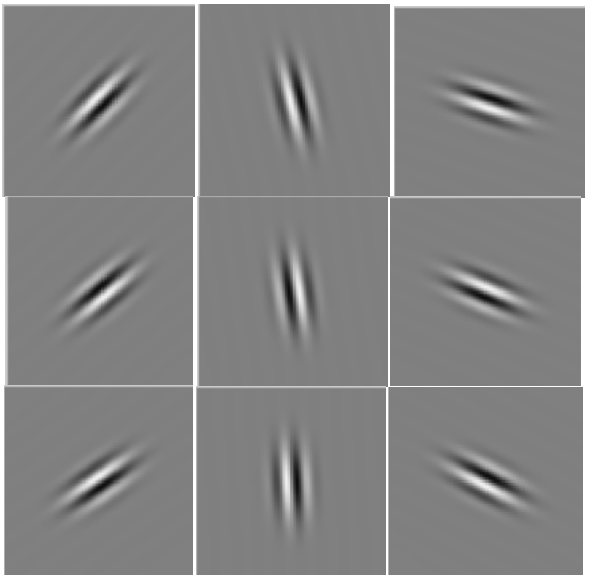

Fig. 2. Gabor Filters. The first filter is obtained by assigning θ = 0°, the subsequent images increased the θ = 45°,

Euler Number : it represents the number of holes in the objects
Perimeter : represents the length of the tumor border
Convex area : count of pixels in the convex hull

D. GLCM Feature Extraction:

GLCM creates a matrix by counting a pair of identical gray value presents in the image in adjacent.

Contrast – measures local variance in the GLCM and defined as

$$Contrast = \sum_{i,j=0}^{N-1} p_{ij}(i-j)^2 \quad (2)$$

where p_{ij} is the element of GLCM matrix

Correlation – measures the joint probability occurrence of the specified pixel pairs

$$Correlation = \sum_{i,j=0}^{N-1} p_{i,j} \frac{(i-\mu)(j-\mu)}{\sigma^2} \quad (3)$$

Energy – squares all elements then provides the summation value

$$Energy = \sum_{I,J=0}^{N-1} (p_{ij})^2 \quad (4)$$

Homogeneity - derives the closeness of the spatial distribution of members in the GLCM to the GLCM diagonal

$$Homogeneity = \sum_{i,j=0}^{N-1} \frac{p_{ij}}{1+(i-j)^2} \quad (5)$$

E. Classification

Recently neural network is widely used for all classification process. Feed forward (FF) neural network is employed for grade detection. FF network is a directed a cyclic graph, there are no feedback and loops. Input layer, hidden layer and output layer frame the network as given in Fig. 3, it take part in classification. Each layer contains many processing units called neurons or nodes whereas inputs are multiplied with a random number called weight. The summation value checks by some activation function in each iteration during training and unknown input values give to the network during testing.

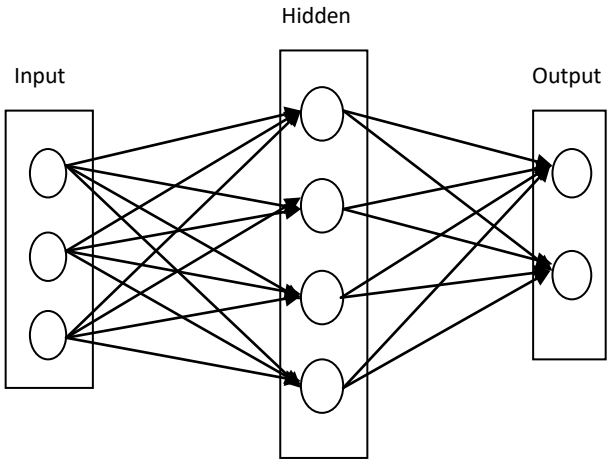

Fig. 3. Feed forward neural network's layers structure

Training

Number of hidden layers and nodes are determined by trail and error method. The number of hidden nodes should be between the input nodes and double of input nodes. The weights and biases are iteratively adjusted by using the momentum method, the network performance is improved by evaluated with mean square error between the network output and target output.

Testing

Unknown image features are given during testing. The trained net automatically classifies the tumor grade.

F. Evaluation Metrics

The performance of a classification method is verified by using sensitivity and specificity. Sensitivity measures the ability to identify the abnormal tumor pixels correctly. Specificity measures the ability to ignore the normal pixels in the result. Accuracy represents the accuracy of the result. The significant value for all is 1[12].

$$Sensitivity = \frac{T_P}{T_P + F_N} \quad (6)$$

$$Specificity = \frac{T_P}{T_N + F_P} \quad (7)$$

$$Accuracy = \frac{T_P + T_N}{T_P + F_N + T_N + F_P} \quad (8)$$

T_P is the count of tumor grad (malignant / beningn) which are truly as given grade . T_N is the count of normal image graded as normal. The count of malignant or benign tumor images classified and normal is considered as F_N and its contrary are considered as F_P.

III. RESULTS AND DISCUSSION

The entire method is coded by using Matlab 2013 in i3 processor to classify the tumor as high grade and low grade. The experiments carried over some MRI images obtained from web resource. Totaly 30 images were taken for the task, twenty high grade and ten low grade MRI tumor images were taken during the training process. Twenty five images were given during the testing period. Some complex images are given in Fig.4.

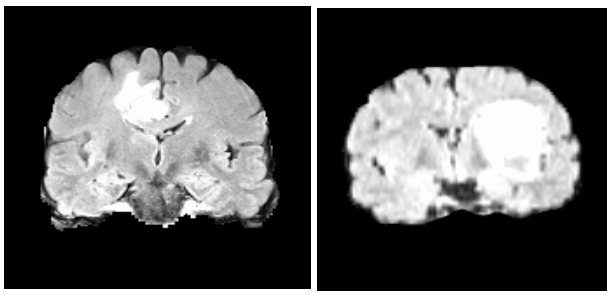

Fig. 4. Sample images

In Fig.4, the first image shows tumor in small size which is in bright pixels and the second image shows the tumor in large size. However, the first one is high grade tumor and second one is low grade tumor. They differ in its texture features. They were classified perfectly by the proposed method. The proposed network contains 10 hidden layers, trained with Levernberg-Marquardt method and the MSE error measure used to update the performance of the network. Initially, 1000 iterations given for the net but the training task completed at 10 iterations.

Table I. Evaluation metrics

	FP	FN	Sensitivity	Specificity
Malignant	0	1	96	100
Benign	1	0	100	96

Twenty five test images were taken to validate the performance of the proposed method. Among them, ten malignant, ten benign and 5 normal images were given for the experiment. The results are illustrated in the Table 1. The Table projects the proposed method gives sensitivity 100% for benign type of tumors. The specificity reflects that the proposed features perfectly fitted to detect malignant type of tumors. The proposed work compared with the existing methods and the results are illustrated in Fig. 5. In Fig. 5, the author names are given in x-axis and the achieved accuracy results are given in y-axis. The results ensure that the proposed feature combination and network formation yields good results than the existing methods.

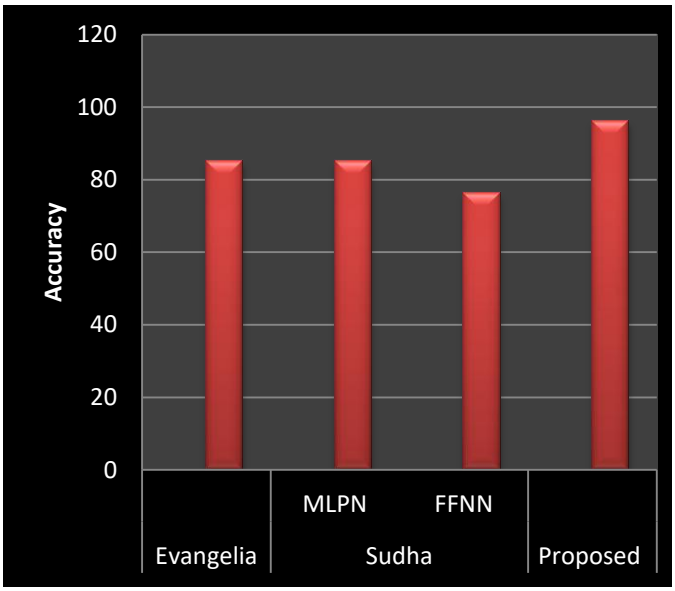

Figure 5. Comparison results with the existing methods

IV. CONCLUSION

The proposed work acquires some texture feature, shape based and region based features based on the brain and tumor anatomy. The method feeds Gabor features, GLCM features and some region based features as input to the Feed forward neural network. The proposed method obtains significant result with minimal number of features. The network attains 96% of accuracy and it outperforms the other methods.

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