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ANN Approach Based On Back Propagation Network and Probabilistic Neural Network to Classify Brain Cancer

Shweta Jain, Shubha Mishra

Abstract— 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 MRI images of different patients with Astrocytoma type of brain tumor. The image processing techniques have been developed for detection of the tumor in the 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.

Index Terms—Brain Cancer, MRI, Gray Level Co-occurrence Matrix, Texture Features, Back Propagation Network and Probabilistic Neural Network.

I. INTRODUCTION

A brain tumor is any intracranial tumor generated by abnormal and uncontrolled cell division, normally found anywhere in the brain. Benign brain tumors contain cells that look healthy, just like normal cells [1]. They have growth slowly, are not likely to spread, although these tumors may cause damage if they initiate to interfere with normal brain function. On the different, malignant brain tumors have irregular borders and made up of abnormally shaped cells [1]. The objective of this paper is to present a system as a diagnostic tool for identification of tumor / cancer appearing in brain. This paper 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. 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.

MRI is an imaging technique used primarily in medical settings to produce high quality images of the inside of the human body. MRI offers an unparalleled view inside the human body.

1.1 IMAGE PROCESSING TECHNIQUES

Image processing techniques are used to perform image segmentation on input image. The image processing techniques which is used in this system is shown in figure 1.

The image processing techniques are used in this system is to isolate the tumor region from the rest of the image or separate the tumor region.

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*****Correspondence Author(s)
Shweta Jain, M.Tech (I.T.)-4thSem LNCT Bhopal, India.
Shubha Mishra, Department Of I.T. LNCT Bhopal, India.

The first step is histogram equalization to perform on the MRI image.

The major problem in the process of detection of edge of tumor is that the tumor appears very dark on the image which is very confusing. To solve this problem, Histogram Equalization was performed. Segmentation subdivides an image into its constituent parts or objects. Thresholding has been used for segmentation as it is most appropriate for the present system in order to achieve a binarized image with gray level 1 representing the tumor and gray level 0 representing the background [2]. In simple implementations, the segmentation is determined by a single parameter known as the Intensity Threshold. For the binarization of equalized image a thresholding technique is used as shown below:

Binarized Image bi, j = 255 if e (i, j) > T

Else bi, j = 0

Where e (i, j) is the equalized MRI image and T is threshold resultant for the equalized image. Threshold described by following equation.

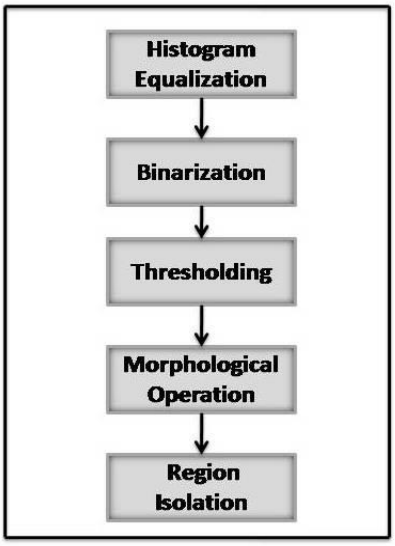

Fig-1 Image processing technique

$$T = \frac{\sum_{i=0}^{m-1}\sum_{j=0}^{n-1} ei,j * Ii,j}{\sum_{i=0}^{m-1}\sum_{j=0}^{n-1} Ii,j}$$

The fundamental enhancement needed is to increase the contrast between the whole brain and the tumor. Contrast between the brain and the tumor region may be present but below the threshold of human perception [2]. Morphological operation is used as an image processing tools for sharpening the regions and filling the gaps for binarized image [2]. The dilation operation is performed by “imdilate” command in “matlab”.

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This is applied for filling the broken gaps at the edges and to have continuities at the boundaries. A structuring element of 3x3 square matrix is applied to complete dilation operation. After filling operation on an image; centroids are calculated to localize the regions. The final extracted region is then logically operated for extraction of Massive region in given MRI image.

1.2 GRAY LEVEL CO_OCCURRENCE MATRIX

A statistical approach that can well describe second-order statistics of a texture image is a co-occurrence matrix. Gray level co-occurrence matrix (GLCM) was firstly introduced by Haralick. A gray-level co-occurrence matrix (GLCM) is essentially a two-dimensional histogram. The GLCM method considers the spatial relationship between pixels of different gray levels [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 [3]. A co-occurrence matrix is specified by the relative frequencies P (i, j, d, ϴ). A co-occurrence matrix is therefore a function of distance d, angle ϴ and grayscales i and j.

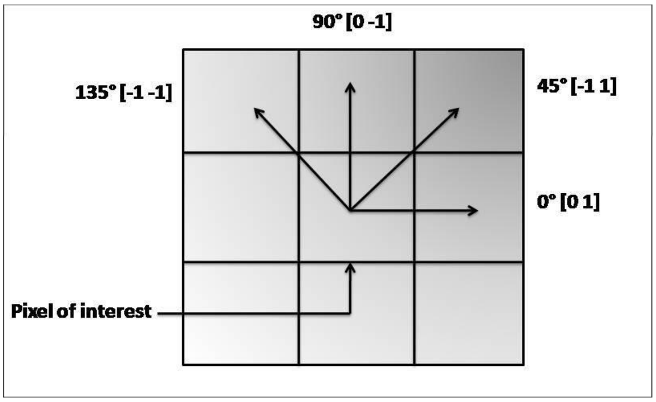

Fig-2 Direction for generation of GLCM

In our proposed system MRI image can be decomposed into patterns with regular textures. So we should be able to represent these regular texture regions by using co-occurrence matrices. To do so, we utilize the co-occurrence matrices in angles of 0°, 45°, 90°, and 135°.

1.3 TEXTURE FEATURES

Generally texture is a feature used in the analysis and interpretation of images. Texture is described by a set of local statistical properties of pixel intensities [3]. When the GLCM is generated, the textures feature could be computed from the GLCM. The seven common textures features discussed here are angular second moment (ASM) or energy, contrast, inverse difference moment (IDM) or homogeneity, dissimilarity, entropy, maximum probability and inverse. Energy is also known as uniformity of ASM (angular second moment) which is the sum of squared elements from the GLCM [4]. Contrast is used to measure the local variations. Homogeneity is to measure the distribution of elements in the GLCM with respect to the diagonal. Entropy measures the statistical randomness. The seven common textures features are shown in figure 3. All these features are extracted using GLCM methods at four directions (i.e. 0º, 45º, 90º and 135º) for every feature.

Energy	$F1 = \sum_{i,j=0}^{N-1} P_{i,j}^2$
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	$F4 = \sum_{i,j=0}^{N-1} P(i,i) * \lvert(i-j)\rvert$
Entropy	$F5 = \sum_{i,j=0}^{N-1} P(i,j) * \left[-\ln\left(P(i,j)\right)\right]$
Maximum Probability	$F6 = \max i,j\ P(i,j)$
Inverse	$F7 = \sum_{i,j=0}^{N-1} \frac{P(i,j)}{(i-j)^2}$

Fig-3 Computation of texture features [10]

1.4 BACK PROPAGATION ARTIFICIAL 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 [5, 6].

1.5 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 compete 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 [7].

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II. PROPOSED METHOD

The method used for MRI brain tumor image classification is shown in Figure 4.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 cooccurrence 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 binarization and thresholding) 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.

In this paper extracting the texture feature for unknown image sample and let the neural detect the type of this image or the type of brain cancer tumor using a neural network and the approach applied for different MRI images.

We propose a brain cancer classification method based on Gray level cooccurrence matrix (GLCM) with a neural network to recognize a certain class. The necessary points are allocated below.

- Image segmentation using image processing techniques 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.

The proposed system consists of two stages as below:

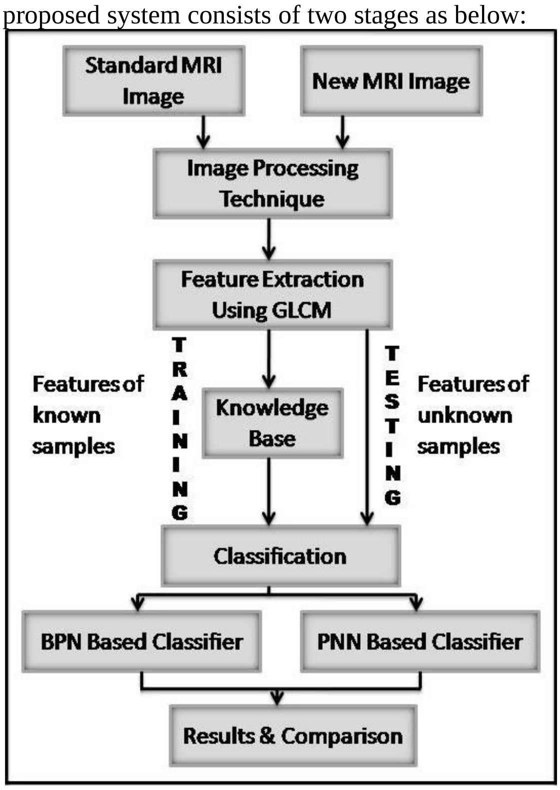

Fig-4 Proposed method

2.1 FIRST STAGE

The first stage in the system presented here is training and learning. 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 various image processing steps such as Histogram Equalization, Thresholding, and morphological operation etc. 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 homogenety, dissimilarity, entropy, maximum probability and inverse for each type of MRI image that was trained for the neural network is shown in table 1.

Table-1 feature extraction

Type	ASM	Contrast	IDM	Dissimilarity	Energy	Pr	Inverse
I	36308	913912	-968.112	179.8284	15016	84	7.904327
I	33374	1134920	-828.227	126.6727	17276	60	15.30695
I	33592	573452	-1040.98	262.8594	10800	92	2.063042
I	33458	973078	-866.955	140.1292	15970	74	17.18983
II	4746	1649184	-71.5462	44.94372	25900	5	27.27822
II	4166	2062032	-24.9533	28.70642	27356	2	2.678552
II	4396	1518546	-59.9776	44.69275	23462	4	0.637291
II	4142	2411008	-24.6135	29.90878	30104	3	6.457354
III	7428	396898	-200.463	100.4595	11890	10	0.270408
III	6378	639234	-129.659	55.78458	15214	4	0.111111
III	6532	427344	-157.524	72.94151	12032	5	0.005917
III	6410	699280	-107.478	49.49004	16176	4	4.963653
IV	5056	1240662	-111.914	67.20068	20414	6	4.697865
IV	4328	2283188	-62.7501	39.8359	28560	4	8.839943
IV	4384	1588562	-67.9284	46.80251	23526	4	0.027778
IV	4334	1858184	-64.4762	46.90367	25288	6	16.48894

2.2 SECOND STAGE

The second stage is testing and classification. 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 3. 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.

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III. EXPERIMENTAL RESULTS AND DISCUSSION

In this paper, an automatic brain tumor classifier was proposed. The proposed technique was implemented on MRI dataset (14 gradeI, 13 gradeII, 6 gradeIII and 7 gradeIV). The algorithm described in this paper is developed and successfully trained in Matlab version R2010a using a combination of image processing and neural network toolbox. For evaluate the proposed algorithm we used the classification accuracy which is shown in table 2 and 3. The overall accuracy of the proposed system is 77.56% in case of BPN based classifier and 98.07% in case of PNN classifier. The results of this proposed system are shown in figure 5, 6, 7, 8, 9, 10, 11, 12 and 13.

Table-2 Classification accuracy results for BPN based classifier

Class	Test Image	Correctly Classified Image	Incorrectly Classified Image	Classification Accuracy
GradeI	14	11	3	78.57%
GradeII	13	10	3	76.92%
GradeIII	6	5	1	83.33%
GradeIV	7	5	2	71.42%

Table-3 Classification accuracy results for PPN based classifier

Class	Test Image	Correctly Classified Image	Classification Accuracy
GradeI	14	14	100%
GradeII	13	12	92.3%
GradeIII	6	6	100%
GradeIV	7	7	100%

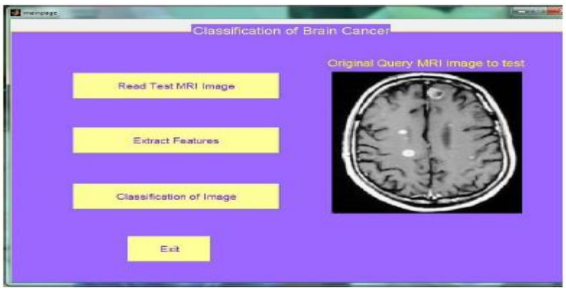

Fig-5 Input MRI Image

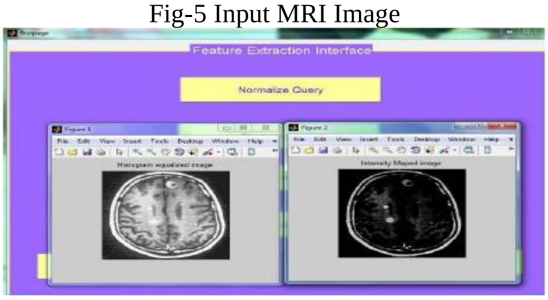

Fig-6 Normalize MRI Image

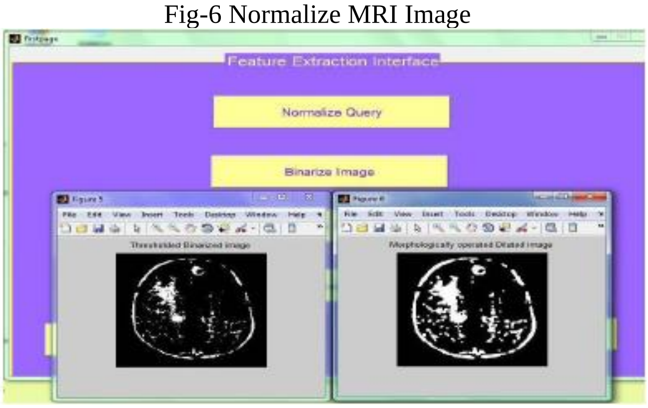

Fig-7 Thresholded binarized MRI Image

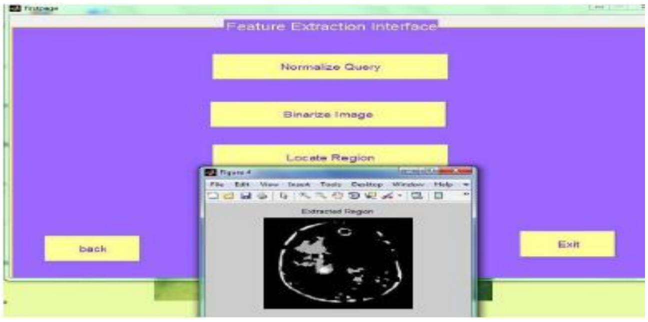

Fig-8 Extracted Region

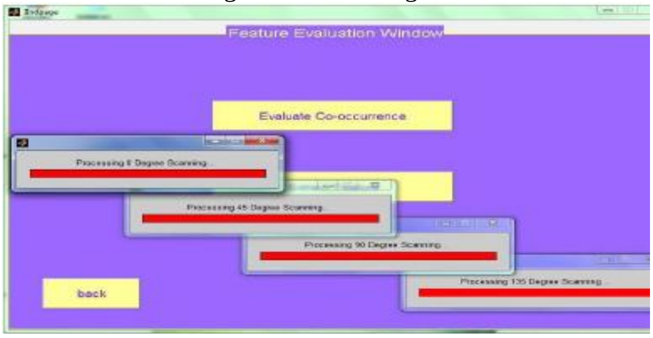

Fig-9 Evaluate co-occurrense matrix

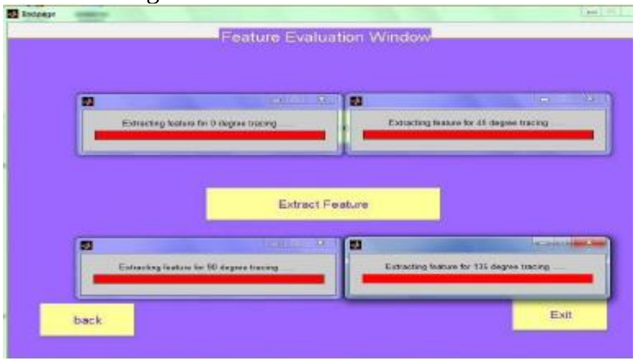

Fig-10 Extract Feature

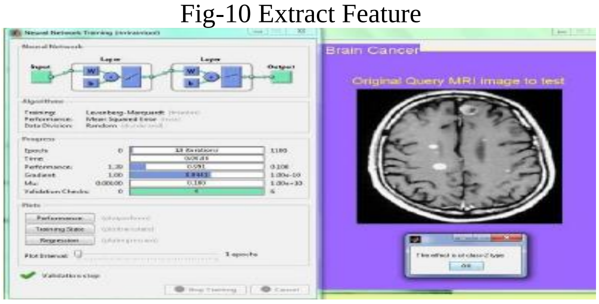

Fig-11 Training and classification using BPN

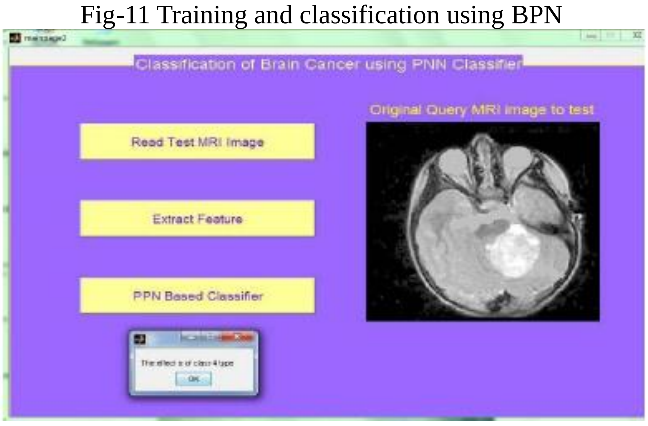

Fig-12 Classification based on PNN

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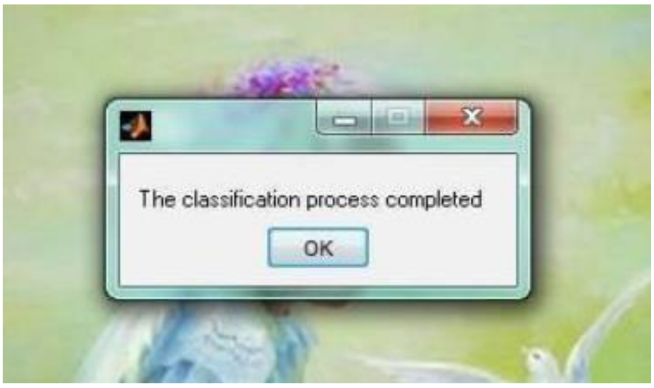

Fig-13 Process completed

IV.CONCLUSION

This article describes detection and Classification of Brain Cancer Using Artificial Neural Network approach namely, 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 histogram equalization, binarization, thresholding, morphological operation and region isolation are perform on Training/Learning. Texture features are used in the Training/Learning of the Artificial Neural Network. Cooccurrence 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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