Brain Tumor Detection by using Artificial Neural Network

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Abstract—**Brain tumor is one of the most dangerous diseases which require early and accurately detection methods, now most detection and diagnosis methods depend on decision of neurospecialists, and radiologist for image evaluation which possible to human errors and time consuming. This study reviews and describe the processes and techniques used in detection brain tumor based on magnetic resonance imaging (MRI) and artificial neural networks (ANN) techniques, Which executed in the different steps of Computer Aided Detection System (CAD) after collected the image data (MRI); first stage is pre-processing and post-processing of MRI images to enhancement it and make it more suitable to analysis then used threshold to segment the MRI images by applied mean gray level method. In the second stage was used the statistical feature analysis to extract features from images; the features computed from equations of Haralick's features based on the spatial gray level dependency matrix (SGLD) of images. Then selected the suitable and best features to detect the tumor localization. In the third stage the artificial neural networks were designed; the feed-forward back propagation neural network with supervised learning were apply as automatic method to classify the images under investigation into tumor or none tumor . the network performances was evaluated successfully tested and achieved the best results with accuracy of 99%, and sensitivity 97.9%.**

Keywords —Brain tumor, MRI image, , Texture Analysis, Haralick Texure features. Artificial Neural Networks .

I. INTRODUCTION

Abnormal and an uncontrolled growth of cells in the brain called Brain tumors which segmented into two types Benign and malignant tumors. Malignant tumor is basically termed as brain cancer. Benign tumors generally have a slower growth rate than malignant tumors[1]. The National Brain Tumor Foundation (NBTF) for research in United States estimates that 29,000 people in the U.S are diagnosed with primary brain tumors each year, and nearly 13,000 people die. In the UK, over 4,200 people are diagnosed with a brain tumor every year (2007 estimates). There are about 200 other types of tumors diagnosed in UK each year. [2] In India, totally 80,271 people are affected by various types of tumor (2007 estimates).[3] the diagnosis and treatment depends on a mixture of factors like the type of tumor, its size, its location and its state of development. Research shows that people affected by brain tumors die due to their inaccurate detection [4]. the tumor is heterogeneous, and the border is difficult to localize, it require accurate diagnosis which is needed for an early and successful treatment. if the tumor diagnosed at the early stage, the disorders can be treated and can be prevented from further complications. MRI is one of the best technologies currently being used for diagnosing brain tumor and it create more detailed pictures. Automatic detects detection in MRI is quite useful in several diagnostic and therapeutic applications [5][6]. MR images come in three standard flavors; T1-Weighted, T2-Weighted and PD- weighted images. to improve the radiologist diagnostics used automatic method such as CAD system and Artificial Neural Networks which depend on digital image processing include filtering image, segmentation and feature extraction.[7] Feature extraction is the techniques or method that used to measure of difference characteristics of image segments also its process to represent raw image in its reduced form to facilitate decision making such as pattern classification. Each segmented region in a scene may be described by a set of such features In this work used texture analysis method; The Spatial Gray Level Dependency matrix(SGLD) matrix generator, which decomposes the input image into texture features(Haralick's features)[14].for successful surgery of medical treatment require specific information about edge of the tumor; A neural network is a powerful computational data model that is able to capture and represent complex input/output relationships[8]. And also it is provides powerful tool to help doctors to analyze, model and make sense of complex clinical data across a broad range of medical image applications. Most applications of ANNs in medicine are classification problems such as pattern recognition; that is, the task is on the basis of the measured features to assign the patient to one of a small set of classes [9][10]. In this project used back propagation network which one of Artificial neural networks types. after create the network the training processing come by transfer functions which calculate a layer's output from its net input by using training Algorithm. The type of back propagation network training is supervised learning which it best method for simples that has nonlinear transformation like sigmoid transfer function[15].

II. METHODOLOGY

The proposed methods (fig.1)that were used for this study were summarized in three phases: First phase is pre-processing of MRI images Second phase is post processing of images like segmentation, morphological operations, feature extraction, etc. final phase is implement the feature of images for pattern recognition to detect the tumor.

A. Database

In this proposed system used digital magnetic resonance image database which were obtained from Whole Brain Atlas website that collected from the Harvard University, medical educational school and various sources [11]. The MRI brain images are taken from person with age above 20 years old group as there are no significant changes observed in image pattern after 18 years of age. Database consists of images of

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both male and female. In this database, every image is 256× 256 pixels and 8-bit gray level scale. It consists of 239 images which belong to normal and abnormal (with and without tumor) brain image. This data downloaded in gif format but wear changed to png format before used it.

B. Preprocessing steps

The preprocess steps include sharpening and smoothing filters. Sharpening filter is used to enhancement the images in sharpening and highlight fine detail in an image or to enhance detail that has been blurred, Smoothing Filter is used to remove or reduce the noise.

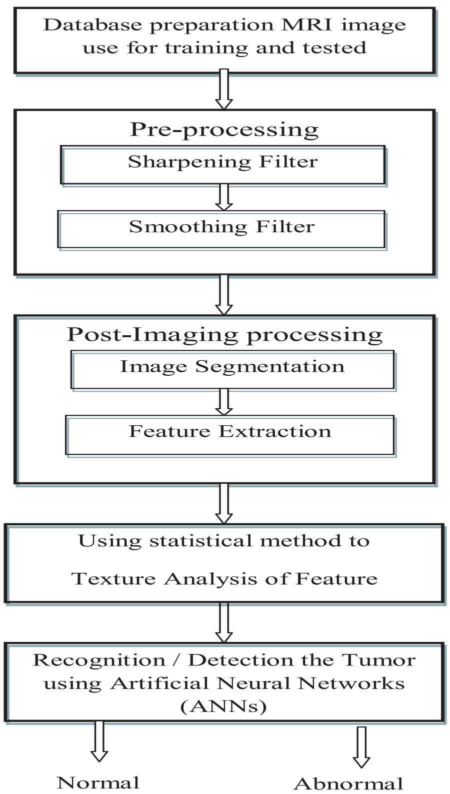

Figure 1 flow chart of proposed method

C. *Image Segmentation*

In post processing step which used threshold method to segment the MRI image gray level to binary image; tumor with gray level 1 and background with 0 Eq.1.

$$f_S(x,y) = \begin{cases} 255 \Rightarrow f(x,y) \geq Z \\ 0 \Rightarrow f(x,y) < Z \end{cases} \quad (1)$$

Where *f(x,y)* is gray level of MRI image, Z is threshold value and $f_s(x,y)$ is thresholding image or binary image.

D. *Morphological Operations*

The morphological operations used in this proposed are erosion and dilation by *imerode* and *imdilate* function respectively in MATLAB.

E. *Feature Extraction*

in this study texture analysis Haralick's features method was used by SGLD matrix, which decomposes the input image into texture features. The SGLD matrix calculated between two pixels one of a certain intensity ***i*** occurs in relation with another pixel ***j*** separated by distance ***d*** along the direction of angle θ . The SGLD matrix is describe by the relative frequencies *p(i, j, d, θ).* Un normalized frequencies of SGLD matrix for the distance *d* and orientation 0°, 45°, 90° and 135°.

It is observed that SGLD matrix is symmetrical because *p* (*i, j, d, θ*) = *p* (*j, i, d, θ*). Then used SGLD matrix in angles of 0°, 45°, 90°, and 135° and d=1 to calculate texture feature of specific MRI image by Haralick's Features is the statistical method used in identifying objects or regions of interest in an image[13], there are fourteen features which are : Energy(EG), Entropy(EN), Inertia(IN), Correlation(CO), Inverse Difference Moment (IDM), Variance(VA), Sum Average (SA), Sum Entropy (SE), Sum Variance (SV), Difference Entropy (DE), Difference Average (DA), Difference Variance (DV), information measures of correlation 1(IC-1) and information measures of correlation 2(IC-2). After calculated all fourteen parameter by haralick equations, choose eight parameter that has best performance in neural networks training process : Energy, Inertia, Entropy, Inverse Difference Moment, Sum Variance, Sum Entropy, Difference Variance and Difference Entropy.

E. Back propagation Network

In this study was used back propagation network were used for MRI image analysis, the feed forward neural network to demonstrate the capability of ANNs to classify the MRI images into normal or abnormal. First the BP network was created with three layers input , hidden and output layer. and training With sigmoid transfer function. The weights in an ANN express the relative strengths (or mathematical values) of the various connections that transfer data from layer to layer. in supervised learning initializes the weights and biases of the network it can be automatically. the BPN for one iteration is obtained by Eq.2 to adjust the weights values.

$$x_{k+1} = x_k - g_k \alpha_k \quad (2)$$

Where: x_k is a vector of current weights and biases, g_k is the current gradient and α_k is learning rate.

III. RESULTS

This section present the results of all a logarithm method which successfully applied in Matlab .

A. Results of Haralick's Features

After calculate all the Haralick's features, plot the characteristics curve for each one ; to choose the best parameter which have good performance and gives the true result to detect the tumor. that show in figures from fig.2 to fig.14

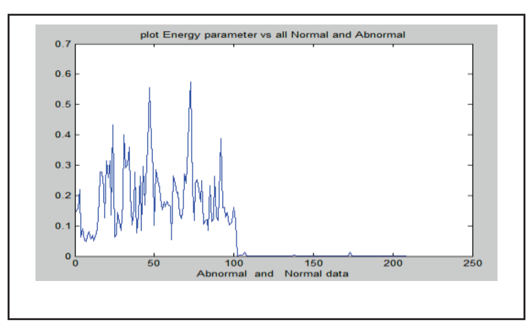

Figure 2: Energy's feature for 101 abnormal and 102 normal.

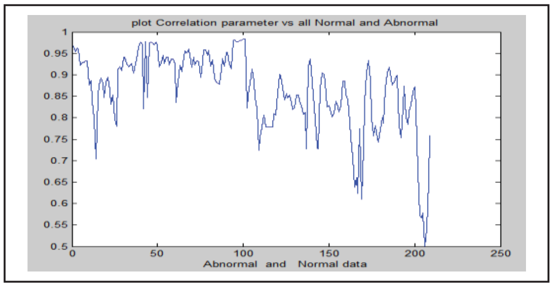

Figure 3: correlation's feature for 101 abnormal and 102 normal.

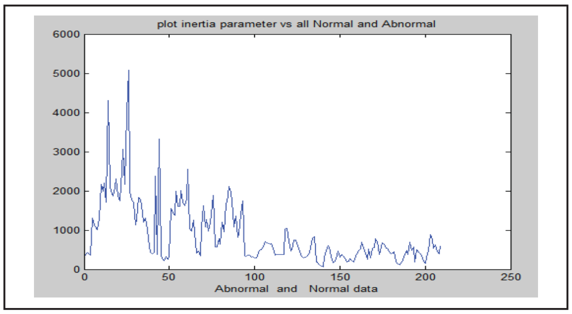

Figure 4: Inertia's feature for 101 abnormal and 102 normal.

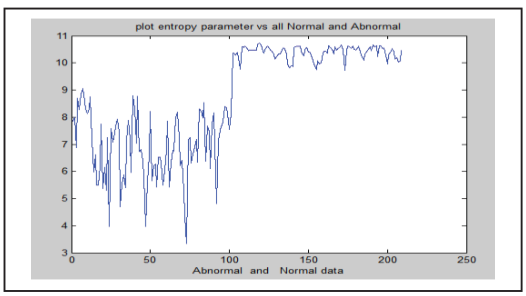

Figure 5: Entropy's feature for 101 abnormal and 102 normal.

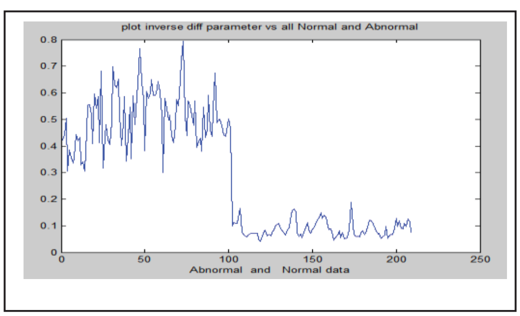

Figure 6: Inverse Difference Moment's feature for 101 abnormal and 102 normal.

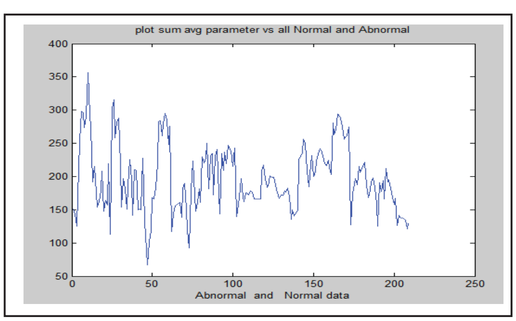

Figure 7: Sum Average's feature for 101 abnormal and 102 normal.

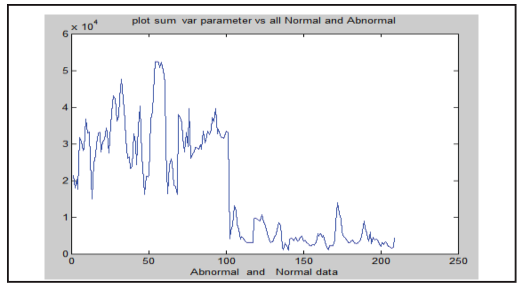

Figure 8: Sum Variance's feature for 101 abnormal and 102 normal.

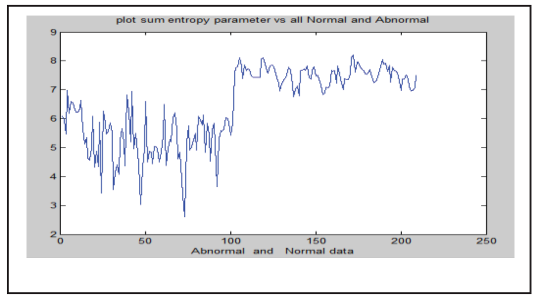

Figure 9: Sum Entropy's feature for 101 abnormal and 102 normal.

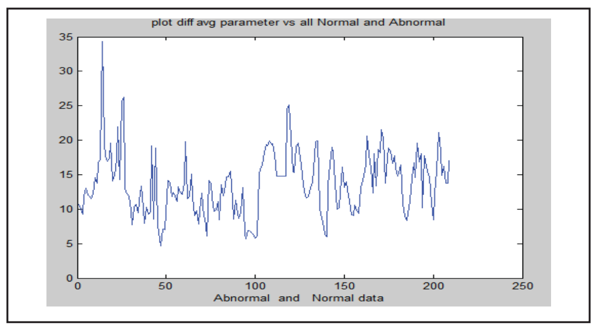

Figure 10: Diff-Average's feature for 101 abnormal and 102 normal.

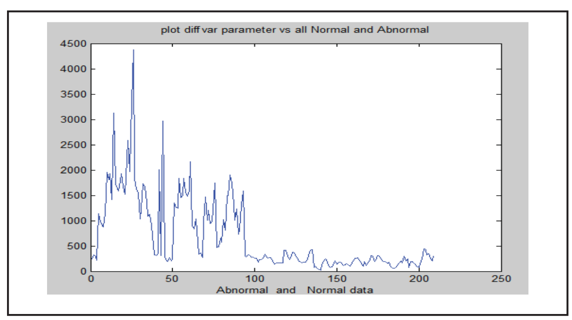

Figure 11: Diff- Variance's feature for 101 abnormal and 102 normal.

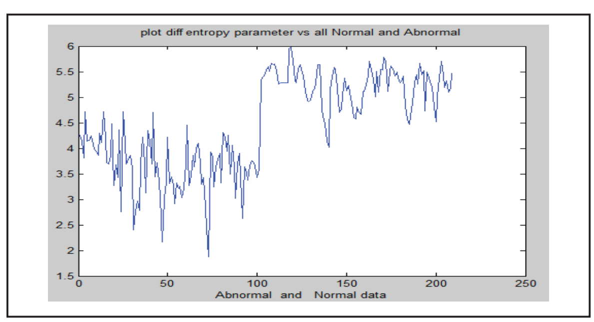

Figure 12: Diff- Entropy's feature for 101 abnormal and 102 normal.

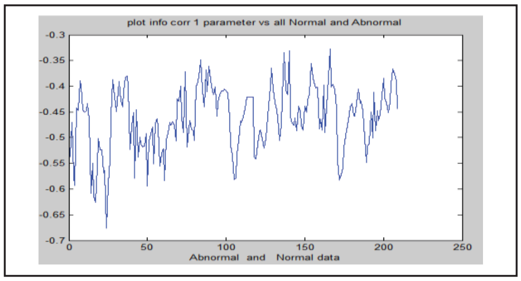

Figure 13: Info-correlation-1 feature for 101 abnormal and 102 normal.

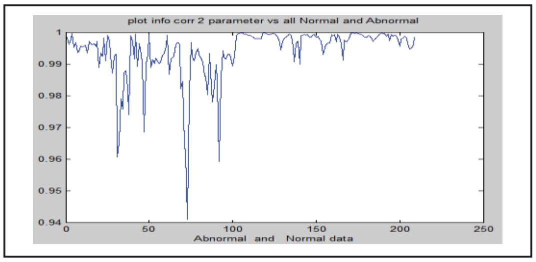

Figure 14: Info-correlation-2 feature for 101 abnormal and 102 normal.

From above figures was selected the best eight feature and used as input to Artificial neural network.

B. Results of Artificial Neural Networks Training:

- Result of random parameter:

First ,choose eight random parameter from thirteen Haralick's features to test the performance of ANNs ,the parameter are: EG, CO, IN, EN, SA, DA, IC-1 and IC-2 and their performance to detect the tumor is show in fig(15) in confusion matrix of networks. And then choose another eight features; SA, SV, SE, DA, DV, DE, Information IC-1 and IC-2 and their performance to detect the tumor is show in fig(16) in confusion matrix of networks. Finally, choose another eight parameter EG, CO, IN, EN, SV, SE, IC-1 and IC-2 and their performance to detect the tumor is show in fig(17) in confusion matrix of networks.

- Result of best parameters:

This is the results of the best eight parameter (features) which used to detect the tumor in this project, the parameter are: EG, IN, EN, IDM, SV, SE, DV and DE. The effect of these feature for training process of networks show in fig(18) .

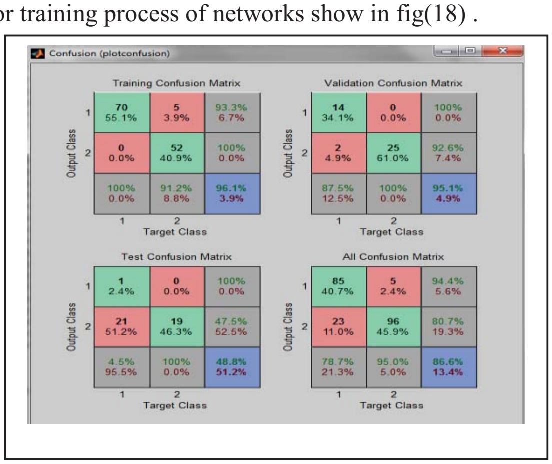

Figure 15: confusion matrix of (Energy, Correlation, Inertia, Entropy, Sum Average, Difference Average, Information measure of correlation 1 and Information measure of correlation

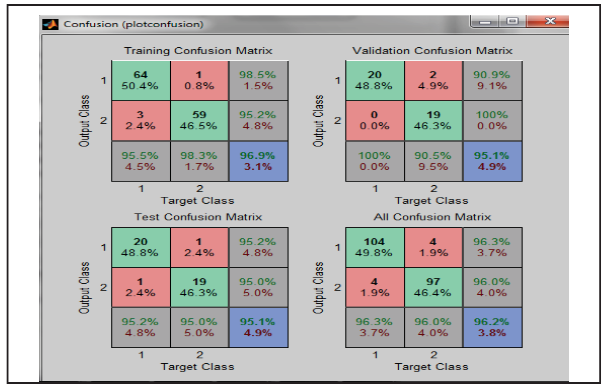

Figure 16: confusion matrix of (Sum Average, Sum Variance, Sum Entropy, Difference Average, Difference Variance, Difference Entropy, Information measure of correlation 1,Information measure of correlation 2)

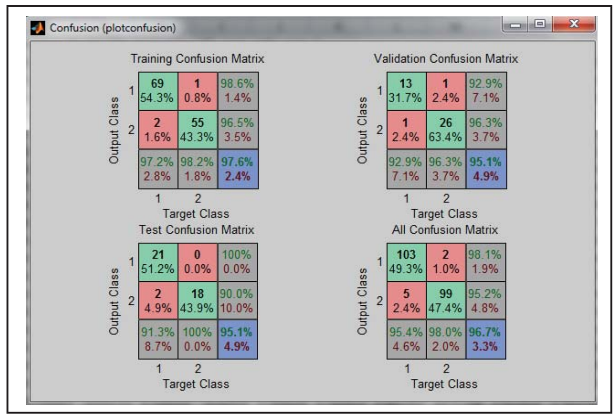

Figure 17: confusion matrix of (Energy, Correlation, Inertia, Entropy, Sum Variance, Sum Entropy, Information measure of correlation-1and Information measure of correlation-2)

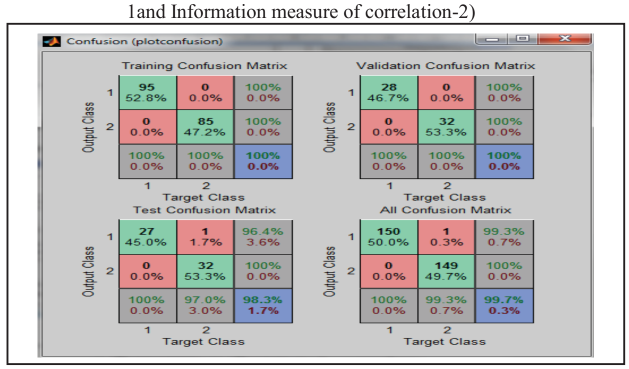

Figure 18: confusion matrix of best eight feature

- *Results of Graphic User Interface(GUI):*

this section presented result of Graphic User Interface(GUI) widow to describe all the proposed algorithm from load image to detect the tumor step-by-step

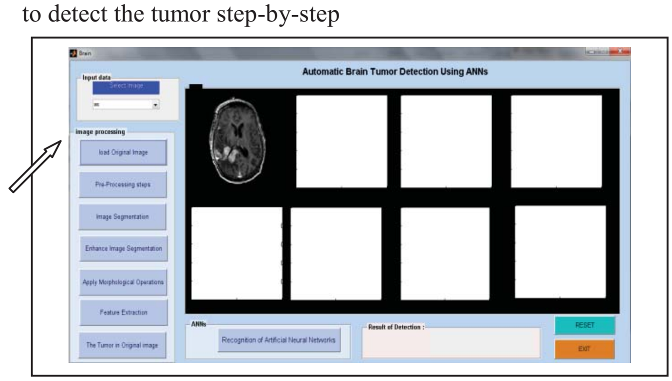

Figure 19: Image selector and load Original Image

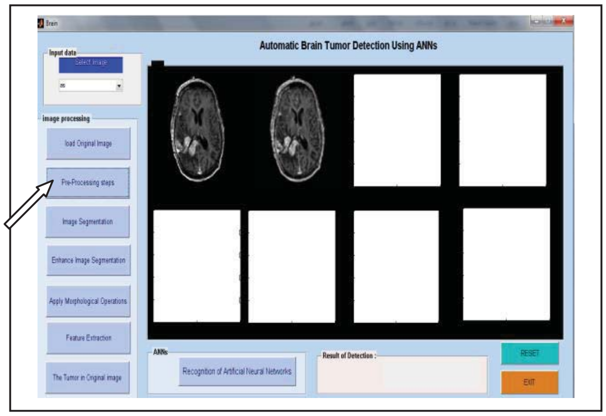

Figure 20: Pre- processing of Image

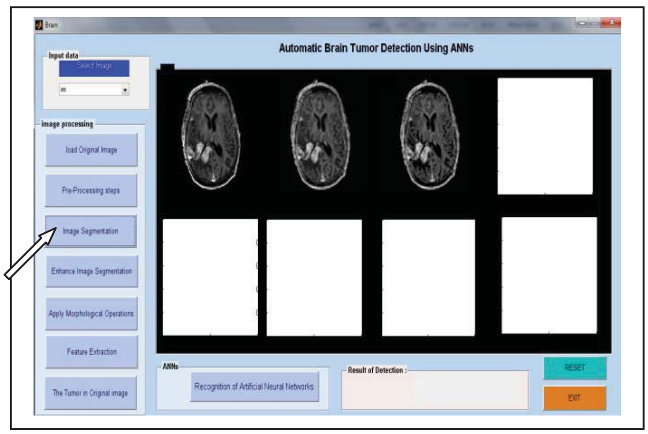

Figure 21: Image segmentation

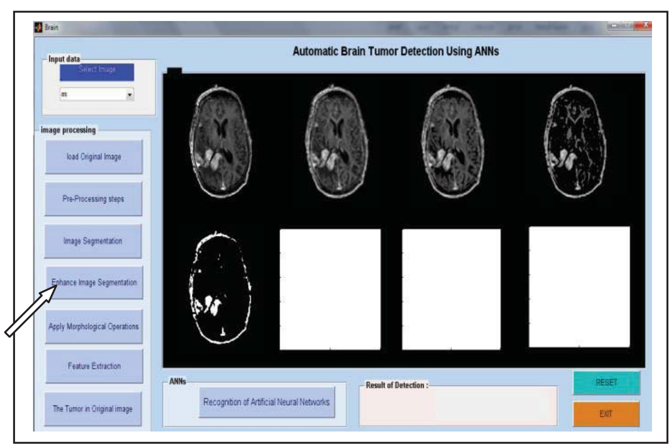

Figure 22: Enhance Image segmentation

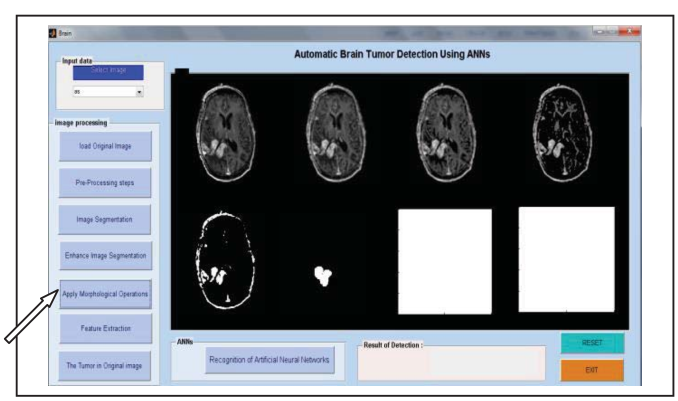

Figure 23: Apply Morphological Operation

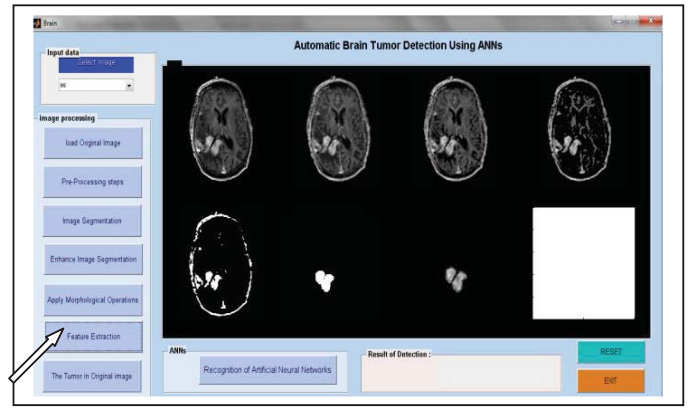

Figure 24: Feature Extraction

Figure 25: The Tumor in Original Image

Figure 26: The Recognition of ANNs and the Result of Detection

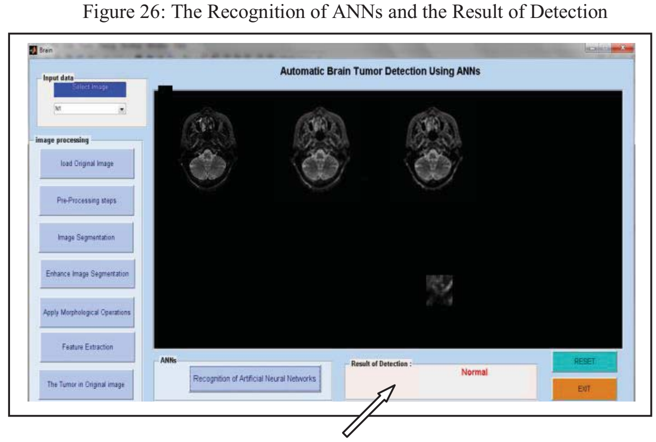

Figure 27: The Result of Detection

IV. DESCUSION

in the results of Haralick's features in plot figures exactly fig(2), fig(4) fig(5) fig(6) fig(8) fig(9) fig(11) and fig(12), their values versus the abnormal (form begging to 101in x axis) they have very variation .but in the normal cases(from 102 to 203in x axis) the values are homogeneity and have a little variation, that can very easily distinguish between normal and abnormal cases, and in the figures: fig(3), fig(7), fig(10), fig(13) and fig(14) it difficult distinguish between the normal and abnormal. So the eight feature were selected as the best and suitable features to detect the tumor. In result of ANNs, when the select eight feature randomly contains (just three from suitable features and five from unsuitable features) the performance of network in training state is equal 86.6%in confusion matrix see fig(15) and when choose another eight contains(four from suitable and four from unsuitable) the performance of network in training state is equal 96.2% see fig(16), and it equal 96.7% for (five from suitable and three from unsuitable) see fig(17); but when choose all the suitable eight feature the performance equal 99.7% see fig(18).

Finally evaluate the result by applied 100 cases(52 normal and 48 abnormal) in network after the training process. The proposed algorithm reaches accuracy about 99%, and sensitivity about 97.9% which calculated by predictive values: true positive value (TP), true negative value (TN), false positive value (FN) and false positive value (FP).

The sensitivity: This is the probability of positive result given that the subject has the disease.

$$\text{Sensitivity} = \frac{TP}{TP + FP} * 100 = \frac{47}{47 + 1} * 100 = 97.92\% \quad (3)$$

Accuracy: Accuracy is how close a measured value is to the actual (true) value.

$$\text{Accuracy} = \frac{\text{Numberofcorectdata}}{\text{Numberofalldata}} = \frac{99}{100} = 0.99 \quad (4)$$

V. CONCLUSIONS

This study aimed to design automatic algorithm to detect the brain tumor from MRI by Artificial neural networks. An algorithms has been successfully designed, implemented and tested with available brain tumor MRI. this paper proposed a set of image segmentation algorithms, feature extraction which gives a satisfactory result. The data collected and prepared to make it suitable to detect. The statistical feature analysis was used to extract features from images; the features computed from equations of Haralick's features based on the SGLD matrix of images. the feed-forward back propagation neural network with supervised learning was used to classify the images into with or without tumor. And all the best eight features were used as input parameters for BP. Finally; the proposed algorithm has been successfully tested and achieved the best results with accuracy 99%, and sensitivity 97.9% and all the results of this study step by step were presented in window of Graphic User Interface(GUI).

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