An Approach to Medical Image Classification Using Neuro Fuzzy Logic and ANFIS Classifier

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Abstract- **It is a challenging task to analyze medical images because there are very minute variations & larger data set for analysis. It is a quite difficult to develop an automated recognition system which could process on a large information of patient and provide a correct estimation. The conventional method in medicine for brain MR images classification and tumor detection is by human inspection. Fuzzy logic technique is more accurate but it fully depends on expert knowledge, which may not always available. Here we extract the feature using PCA and after that training using the ANFIS tool. The performance of the ANFIS classifier was evaluated in terms of training performance and classification accuracy. Here the result confirmed that the proposed ANFIS classifier with accuracy greater than 90 percentage has potential in detecting the tumors. This paper describes the proposed strategy to medical image classification of patient's MRI scan images of the brain.**

Keywords- **ANFIS, Brain tumor, MRI images, Brain MRI, Neuro fuzzy logic, PCA.**

I. INTRODUCTION

An Automated classification and detection of tumors in different medical images demands high accuracy since it deals with human life. Different approaches that can produce medical images must be studied. Also, the technique that produces those images is very important in order to know what to apply to a certain medical image in order to get better results. A lot of methods have been proposed in the literature for CT (Computed Tomography), such as scans, different types of X-rays, MRI images and other radiological techniques. The problem is that it is not very easy to obtain such results. The idea is to reduce human error as much as possible by assisting physicians and radiologists with some software that could lead to better results. This is important since it involve saving human lives. Figure 1 shows the schematic of an MRI machine.

In this paper the automated classification of brain MRI [11] by using some prior knowledge like pixel intensity and some anatomical features is proposed. Since currently there are no widely accepted methods, therefore automatic and reliable methods for tumor detection are of great need and interest. The application of neuro fuzzy systems in the classification and detection of data for MR images problems are not fully utilized yet. These include the clustering and classification techniques especially for MR images problems with huge scale of data which consumes time and energy if done manually. Thus, classification or clustering techniques is essential to the developments of neuro fuzzy systems particularly in medical-related problems.

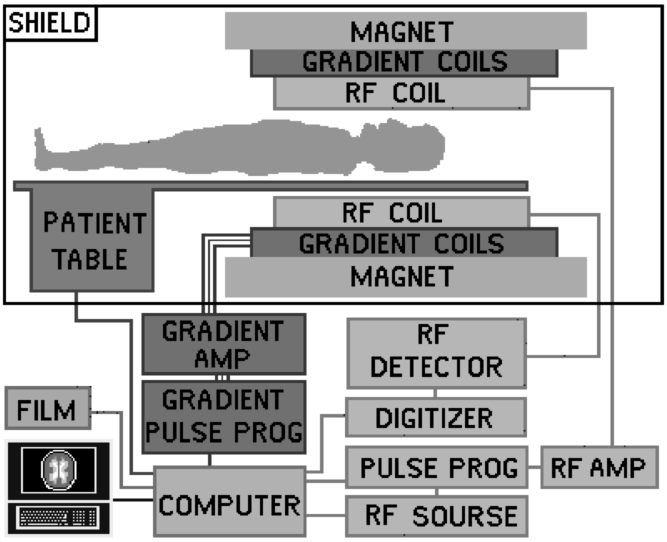

Figure 1. Schematic diagram of MRI machine

Fuzzy set theory plays an important role in deal with uncertainty when making decisions in medical applications [1]. Neuro fuzzy systems are fuzzy systems which use ANNs theory in order to determine their properties (fuzzy sets and fuzzy rules) by processing data samples. A specific approach in neuro fuzzy development is the adaptive neuro fuzzy inference system (ANFIS), which has shown significant results in modelling nonlinear functions. The ANFIS learns features in the data set and adjusts the system parameters according to a given error criterion [2]. Successful implementations of ANFIS in biomedical engineering have been reported, for classification [3] and data analysis [4].

The Self Organizing Feature Map (SOFM) ANN based algorithms [5] shows good results in the classification of brain tumor images. Learning vector quantization (LVQ) ANN show the potential of these architectures in the case of supervised classification. Hopfield neural networks (HNN) [6] prove to be efficient for unsupervised pattern classification of medical images Segmentation of images using neuro fuzzy model has been studied by Rami J. Oweis and Muna J. Sunna [7]. Image segmentation using neuro fuzzy tools are also implemented by Mausumi Acharyya [8].

N.Benamrane [9] has proposed an approach for detection and specification of anomalies present in medical images. The idea is to combine three metaphors: Neural Networks, Fuzzy Logic and Genetic Algorithms in a hybrid system. After applying the growing region algorithm to extract regions, the Fuzzy Neural Network detects the suspect regions, which are interpreted by the Fuzzy Neural Network of specification. Chin-Ming Hong [10] propose a novel neuro fuzzy network [17] which can efficiently reason fuzzy rules based on training data to solve the medical diagnosis problems.

II. METHODOLOGY

The methodology used for MR brain tumor image classification is shown in Figure 2. The first stage is the image processing system in which image acquisition and enhancement are necessary steps to be done. The proposed model requires converting the image into a format capable of being manipulated by the computer. The MR images are converted into matrices form by using MATLAB. Then, the neuro fuzzy model is developed. After the neuro fuzzy model is successfully developed, the classification of the MR images starts. Symptoms detection phase will follow once the output from the classification technique is done and lastly, performance based on the result will be analyzed at the end of the development phase.

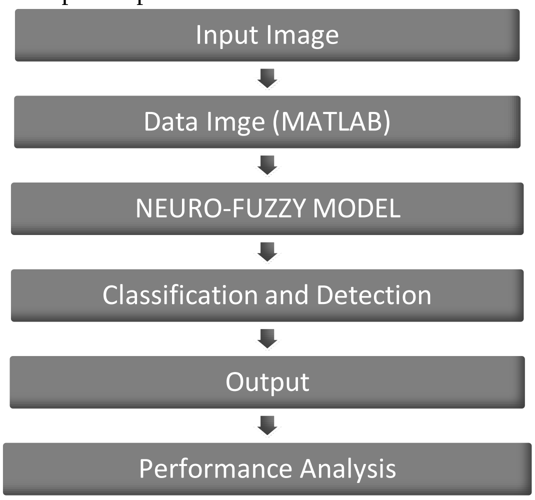

Figure 2. Stages in the Proposed Model

For the classification of normal and abnormal brain images a data set is collected from different sources. Our source is the Harvard medical school website. [http://www.med.harvard.edu/aanlib/home.html]. The various types of brain images include Axial, T2-weighted, 256-256 pixels MR brain images. The images are classified as normal and abnormal brain images.

The MR image will obtain and convert it to data form in MATLAB environment such as basic arithmetic operations and indexing, including logical indexing reshaping and reordering. MATLAB stores an intensity image as a single matrix, with each element of the matrix corresponding to one image pixel. The matrix can be of class double, uint 8, or uint l6. Normal brain image (prior image) and abnormal brain image (diagnostic image) are converted to matrix format automatically while the image being read in the MATLAB environment. Both images are converted to binary images. The region of interest [13][14] is determined by subtracting the normal brain image with abnormal image brain image as shown in Figure 3, 4 and 5.

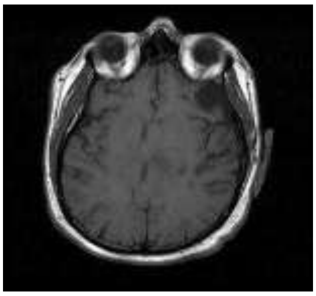

Figure 3. Normal Brain

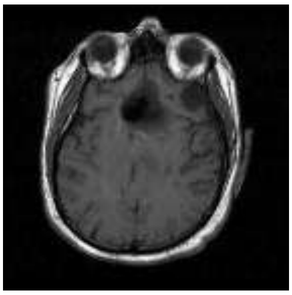

Figure 4. Abnormal Brain

Figure 5. Area of Interest (tumor)

The principal component analysis (PCA) [13][16] is used as a feature extraction algorithm. MR image recognition systems find the identity of a given test image according to their memory. In this paper, the training database consists of a set of MR images. Thus, the task of the MR image recognizer is to find the most similar feature vector among the training set to the feature vector of a given test image. The training and testing phase are shown in the Schematic diagram of a MR image recognizer as shown in Figure 6.

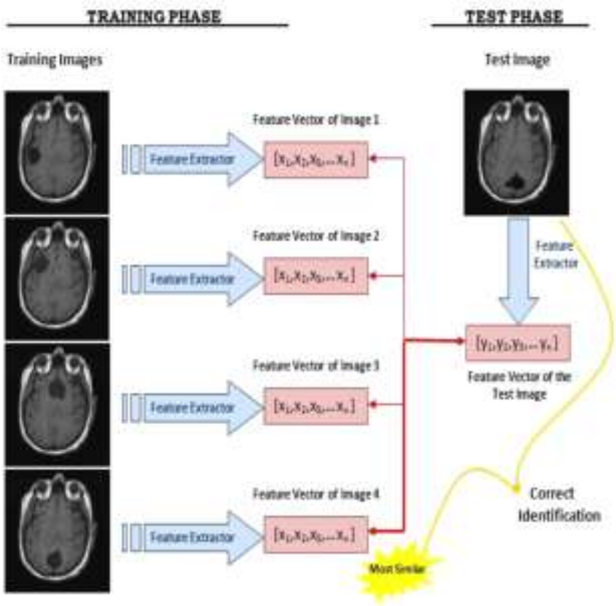

Figure 6. Schematic diagram of a MR image recognizer

The coordinated abnormal tissues which are in the matrix form are presented to ANFIS for training (estimating) membership function parameters. They fully represent the features of the data that the trained FIS intends to model in data modelling phase. Each row of the training data is a desired input/output pair of the target system to be modelled. Each row starts with an input vector and is followed by an output value. The data are provided from the transformation MR images into data form. The data is divided into 3 partition which are training, checking and application. In data mining there are 4 phases - input phase, classification and FIS phase, ANFIS phase, output phase (application and detection). There are some biomedical slides in Figure 7 which are used.

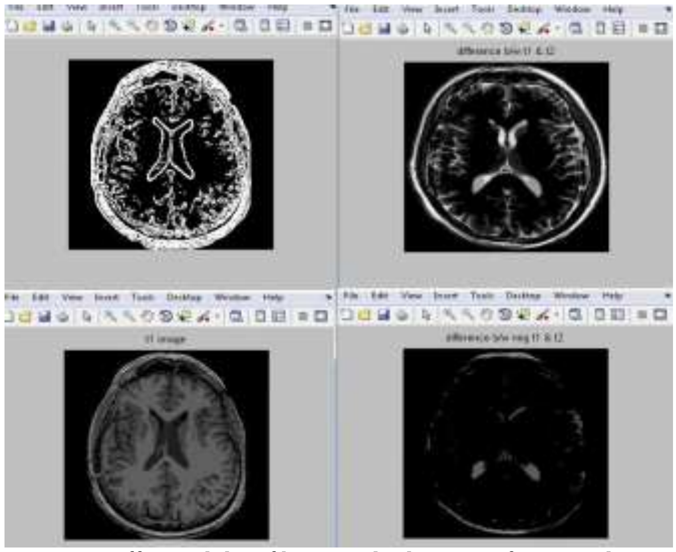

Figure 7. Different slides of brain medical images of various classes

III. NEURO-FUZZY MODELING AND IMPLEMETATION

An adaptive network is a multilayer feed forward network in which each node performs a particular function (node function) on incoming signals as well as asset of parameters pertaining to this node. Fuzzy inference systems are the fuzzy rule based systems which consists of a rule base, database, decision making unit, fuzzification interface and a defuzzification interface. By embedding the fuzzy inference system into the framework of adaptive networks, a new architecture namely Adaptive neuro fuzzy inference system (ANFIS)[18] is formed which combines the advantages of neural networks and fuzzy theoretic approaches.

ANFIS Architecture: The ANFIS is a fuzzy Sugeno model put in the framework of adaptive systems to facilitate learning and adaptation [12]. To present the ANFIS architecture, two fuzzy if-then rules based on a first order Sugeno model are considered.

Rule 1: If (x is A_1) and (y is B_1)

then ($f_1 = p_1x + q_1y + r_1$)

Rule 2: If (x is A_2) and (y is B_2)

then ($f_2 = p_2x + q_2y + r_2$)

where x and y are the inputs, A_i and B_i are the fuzzy sets, f_i are the outputs within the fuzzy region specified by the fuzzy rule, p_i, q_i and r_i are the design parameters that are determined during the training process.

The ANFIS architecture (5 layers) to implement these two rules is shown in Figure 8, in which a circle indicates a fixed node, whereas a square indicates an adaptive node. Different layer has different functions. After that the learning algorithms of ANFIS have been done.

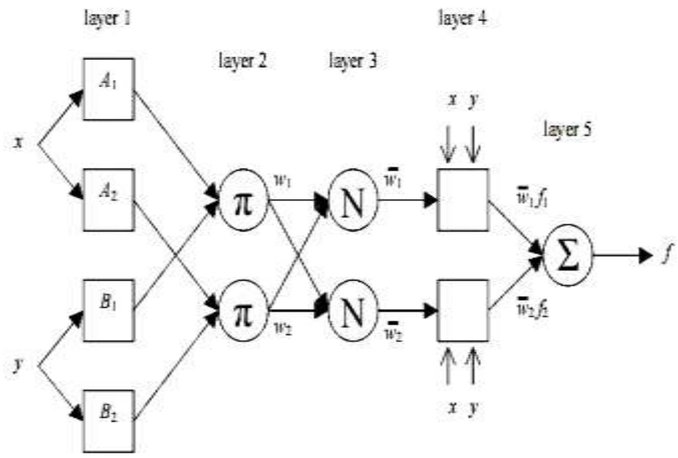

Figure 8. ANFIS Architecture

The proper selection of the number, the type and the parameter of the fuzzy membership functions and rules is crucial for achieving the desired performance and in most situations, it is difficult. These parameters are often chosen based on trial and error method. This fact highlights the significance of tuning the fuzzy system. The ultimate aim of training the ANFIS system is to determine the optimal premise and consequent parameters.

ANFIS Classifier: Gradient descent and Backpropagation algorithms are used to adjust the parameters of membership functions (fuzzy sets) and the weights of defuzzification (neural networks) for fuzzy neural networks. ANFIS applies two techniques in updating parameters. The ANFIS is a FIS implemented in the framework of an adaptive fuzzy neural network. It combines the explicit knowledge representation of a FIS with the learning power of ANNs. The objective of ANFIS is to integrate the best features of fuzzy systems and neural network.

There are five primary GUI tools for building, editing, and observing fuzzy inference systems in the Fuzzy Logic package:

1. Fuzzy Inference System (FIS) Editor
2. Membership Function Editor
3. Rule Editor
4. Rule Viewer
5. Surface Viewer

The modelling approach used by ANFIS is similar to many system identification techniques. First, a parameterized model structure (relating inputs to membership functions to rules to outputs to membership functions, and so on) is hypothesized. Next, input/output data is collected in a form that will be usable by ANFIS for training. ANFIS can then be used to train the FIS model to emulate the training data presented to it by modifying the membership function parameters according to a chosen error criterion. When the checking and training data are presented to ANFIS, the FIS model having parameters associated with the minimum checking data model error is then selected.

IV. RESULT AND DISCUSSION

Experiments were performed and the sizes of the training and testing sets were determined by taking into consideration the classification accuracies. The data set was divided into two separate data sets – the training data set and the testing data set. The training data set was used to train the ANFIS, whereas the testing data set was used to verify the accuracy and the effectiveness of the trained ANFIS model for the detection of brain tumors. There were a total of 27 fuzzy rules in the architecture of the ANFIS using a 3-type (generalized bell, triangular and pi) shaped membership function. Membership function of each input parameter was divided into three regions, namely, small, medium, and large.

The examination of initial and final membership functions indicates that there are considerable changes in the final membership functions but the change is very small due to less the number of data training. Figure 9 and Figure 10 shows the initial and final membership function before training and after training respectively.

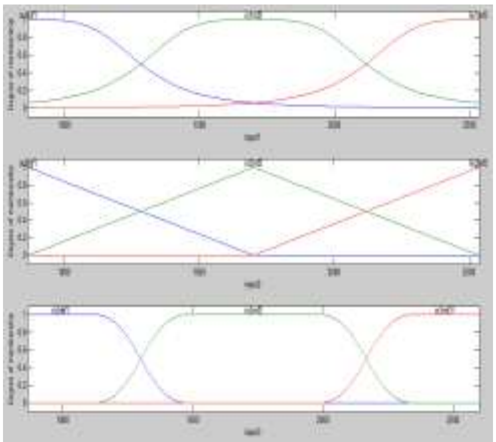

Figure 9. Membership function before training

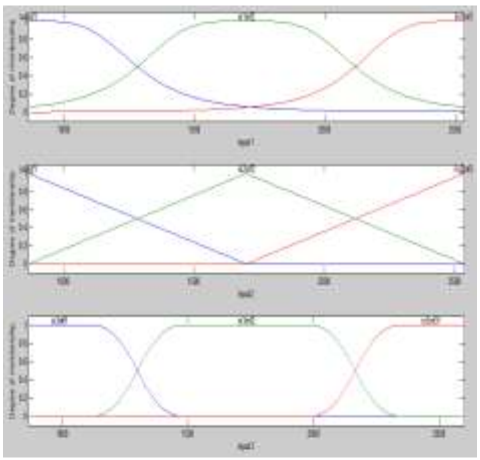

Figure 10. Membership function after training

The test performance of the ANFIS was determined by the computation of the statistical parameters such as specificity, sensitivity and accuracy. The values of these statistical parameters are given in Table 1. The different percentage of noise which is 1%, 2% and 3% are implemented to the testing data set to look the performance of the ANFIS classifier with noise consideration.

Statistical	Values
Specificity	93%
Sensitivity	96%
Accuracy	94%

Table 1. The Values of Statistical Parameters

Since the ANFIS classifier combines the merits of both the neural classifier and the fuzzy classifier, it yields superior results than the other classifiers. Performance from the PNN [15] and ANFIS method is compared and it is summarized that ANFIS has greater performance rating (more than 90%) than PNN (less than 90%) for same application data.

V. CONCLUSION

This paper presents an automated recognition system for the MRI image using the neuro fuzzy logic. Experimental result indicates that the technique is workable with accuracy greater than 90%. This technique is fast in execution, efficient in classification and easy in implementation. As an overall conclusion, this paper is successful as it met the objectives of the paper and successfully developed, run and optimized the performance of the classification technique.

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