

# A New Approach for Analyzing MRI Brain Images using Neuro Fuzzy Model

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## ABSTRACT

It is difficult to identify the abnormalities in brain specially in case of Magnetic Resonance Image brain image processing. Artificial neural networks employed for brain image classification are being computationally heavy and also do not guarantee high accuracy. The major drawback of ANN is that it requires a large training set to achieve high accuracy. On the other hand fuzzy logic technique is more accurate but it fully depends on expert knowledge, which may not always available. Fuzzy logic technique needs less convergence time but it depends on trial and error method in selecting either the fuzzy membership functions or the fuzzy rules. These problems are overcome by the hybrid model namely, neuro-fuzzy model. This system removes essential requirements since it includes the advantages of both the ANN and the fuzzy logic systems. In this paper the classification of different brain images using Adaptive neuro-fuzzy inference systems (ANFIS technology). Experimental results illustrate promising results in terms of classification accuracy and convergence rate.

## Keywords

Fuzzy logic, Neural network, ANFIS, Convergence rate

## 1. INTRODUCTION

With the growing age, there is advancement in each and every field. As far as the medical field is concerned, it also has everyday progress. The medical imaging field in particular, has grown substantially in recent years, and has generated additional interest in methods and tools for the management, analysis, communication of medical image data. Medical imaging technology facilitates the doctors to see the interior portions of the body for easy diagnosis. It also helped doctors to make keyhole surgeries for reaching the interior parts without really opening too much of the body. CT scanners, ultra sound and magnetic resonance imaging took over X-ray imaging by making the doctors to look at the body's elusive third dimension. MRI picks up signals from the body's magnetic particles spilling to its magnetic tune and with the help of its powerful computer, convert scanner data into revealing pictures of internal organs. MRI differs from CT scan as it does not use radiations.

MRI is a noninvasive medical test that helps physicians diagnose and treat medical conditions. It is a technique based on the measurement of magnetic field vectors generated after an appropriate excitation with strong magnetic fields and radio frequency pulses in the nuclei of hydrogen atoms present in water molecules of a patient's tissues. We know that the content of water differ for each tissue, by using this fact one can quantify the differences of radiated magnetic energy and have elements to identify each tissue. When we measure the specific magnetic vector components under controlled conditions, different images can be taken and we can obtain the information related to tissue contrast which reveals the details that can be missed in other

measurements [12]. Detailed MRI image allows the physicians to better evaluate various parts of the body and determine the presence of certain abnormalities that may not be accessed adequately with other imaging methods such as X-ray, CT scan, and ultra sound. Currently, MRI is the most sensitive imaging test of the head in routine clinical practice. MRI can detect a variety of conditions of the brain such as cysts, tumors, bleeding, swelling, developmental and structural abnormalities, infections, inflammatory conditions or problems with the blood vessels. MRI can provide clear images of parts of the brain that can not be seen as well with an X-ray, CAT scan, or ultrasound, making it particularly valuable for diagnosing problems with the pituitary gland and brain stem.



Figure 1.1: MRI machine

Applications of MRI segmentation include the diagnosis of brain trauma where a signature of brain injury, white matter lesions may be identified in moderate and mild cases. MRI segmentation methods are also useful in diagnosing multiple sclerosis, including the detection of lesions and the quantization of lesion volume using multispectral methods.[5]

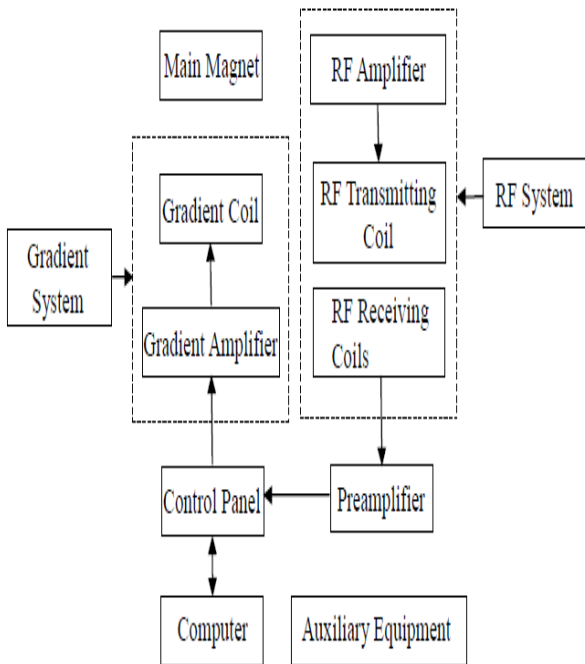


Figure 1.2: Schematic diagram of MRI machine

In MRI, water molecules give off radio signals which are converted into high resolution images that look like a picture shown in figure 1.3.

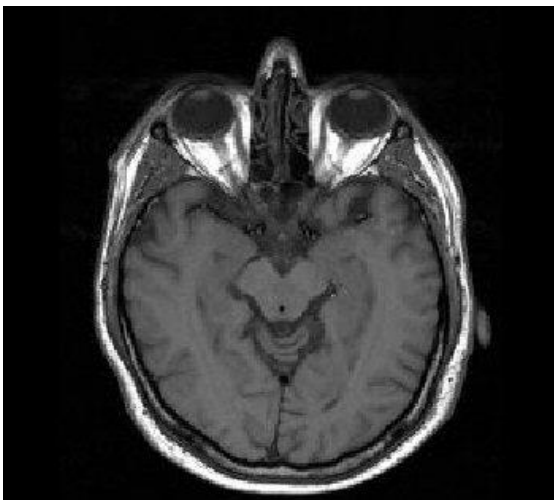


Figure 1.3: Brain MRI

## 2. METHODOLOGY

The work involves the feature extraction of MRI images of brain, dimensionality reduction and finally developing a suitable neuro fuzzy classifier to classify the normal and abnormal brain images. Images of brain are obtained from MRI and the textural features are extracted using principal component analysis (PCA) technique. These features are used to train the neuro fuzzy classifier. The neuro fuzzy classifier is used for classification is the Adaptive Network based Fuzzy Inference system (ANFIS). The developed neuro fuzzy classifier is tested for classification of different brain MRI samples. Thus, the proposed

work emphasizes on development of Neural Network and Fuzzy logic based method for the classification of MRI brain images. The block schematic diagram shown in figure 1 is the proposed architecture for classification of MRI brain images.

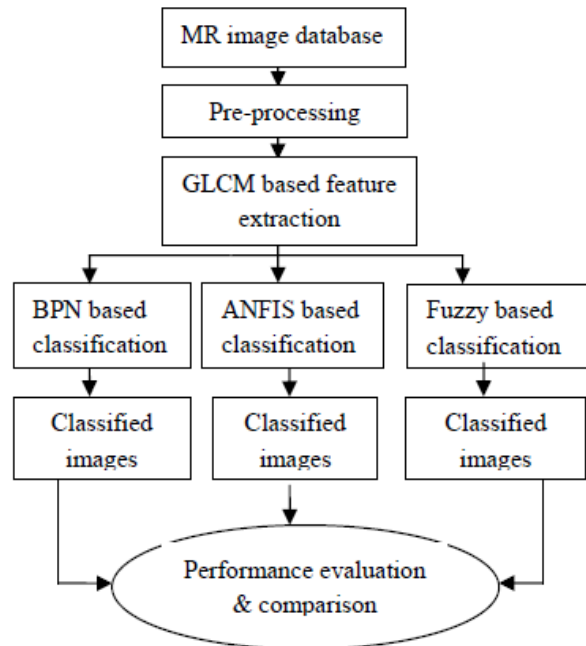


Figure 2.1: Proposed Methodology for Classification of MRI brain images

### A. MRI image data set

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

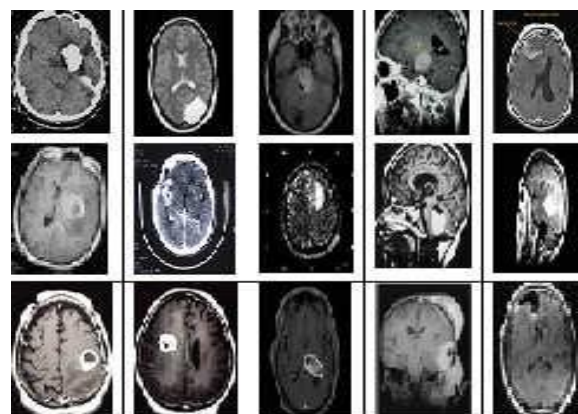


Figure 2.2: A typical example of the used MRI

### B. Feature Extraction

The feature extraction extracts the features of importance for image recognition. The feature extracted gives the property of the text character, which can be used for training the database. The obtained trained feature is compared with the test sample feature obtained and classified as one of the extracted character. [2] The

feature extraction is done using principal component analysis (PCA). This technique is mostly used for the image recognition and reduction. It reduces the large dimensionality of the data. The feature extraction of the test image is done. The memory of an MR image recognizer is generally simulated by a training set. The training database is a set of MR images. The task of MR image recognizer is to find the most similar feature vector among the training set image and test image. In the training phase, feature vectors are extracted for each image in the training set. Let  $I_1$  be a training image of image 1 which has a pixel resolution of  $M \times N$  ( $M$  rows,  $N$  columns). In order to extract PCA features of  $I_1$ , first convert the image into a pixel vector  $\Phi_1$  by concatenating each of  $M$  rows into a single vector. The length of the vector  $\Phi_1$  will be  $M \times N$ .

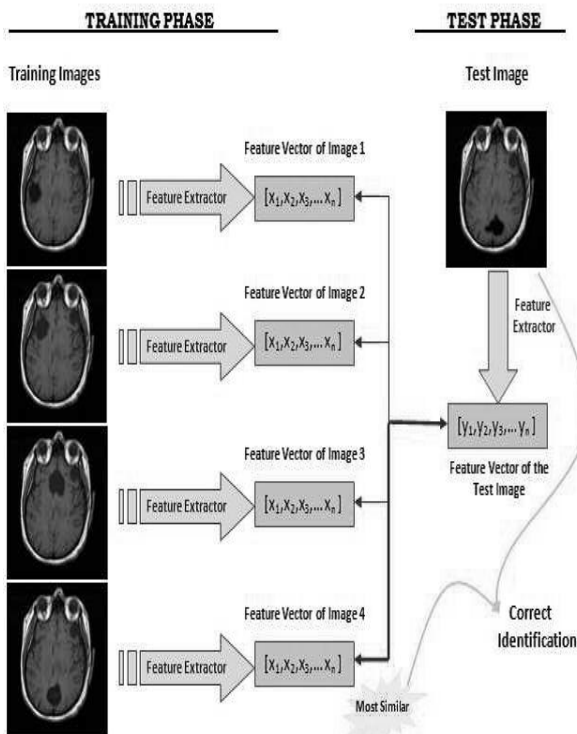


Figure 2.3: Schematic diagram of a MR image recognizer.

### C. Artificial Neural Network Classifier

An artificial neural network (ANN) is a computational model that attempts to account for the parallel nature of the human brain. An (ANN) is a network of highly interconnecting processing elements (neurons) operating in parallel. These elements are inspired by biological nervous systems. As in nature, the connections between elements largely determine the network function. A subgroup of processing element is called a layer in the network. The first layer is the input layer and the last layer is the output layer. Between the input and output layer, there may be additional layer(s) of units, called hidden layer(s). Fig.1 represents the typical neural network. You can train a neural network to perform a particular function by adjusting the values of the connections (weights) between elements.

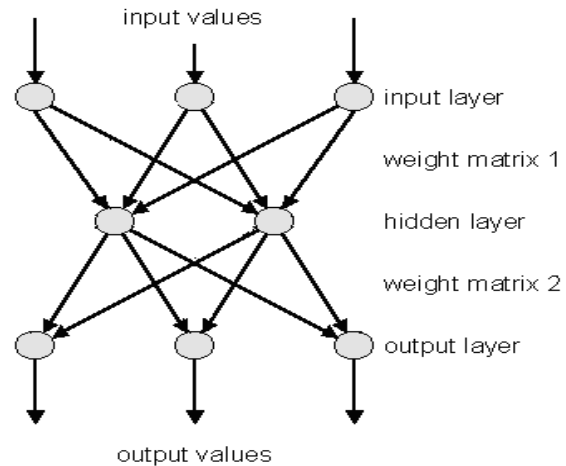


Figure 2.3: Architecture of a typical neural network

Medical Diagnosis using Artificial Neural Networks is currently a very active research area in medicine and it is believed that it will be more widely used in biomedical systems in the next few years. This is primarily because the solution is not restricted to linear form. Neural Networks are ideal in recognizing diseases using scans since there is no need to provide a specific algorithm on how to identify the disease. Neural networks learn by example so the details of how to recognize the disease is not needed [16]. Based on the way they learn, all artificial neural networks are divided into two learning categories: supervised and unsupervised. In supervised learning, the network is trained by providing it with input and output patterns. During this phase, the neural network is able to adjust the connection weights to match its output with the actual output in an iterative process until a desirable result is reached. An ANN of the unsupervised learning type, such as the self-organizing map, the neural network is provided only with inputs, there are no known answers. The network must develop its own representation of the input stimuli by calculating the acceptable connection weights. That is self-organization by clustering the input data and find features inherent to the problem.

#### Fuzzy Classifier

Fuzzy logic is relatively young theory. Major advantage of this theory is that it allows the natural description, in linguistic terms, of problems that should be solved rather than in terms of relationships between precise numerical values. This advantage, dealing with the complicated systems in simple way, is the main reason why fuzzy logic theory is widely applied in classification techniques.

Cluster analysis is based on partitioning data into a number of subgroups or clusters. The objects located within each cluster must show a degree of similarity. In hard clustering such a k-means, each point in the data is assigned to only one cluster. With the use of fuzzy clustering, each pixel has some degree of membership to each cluster. The degree of membership is an indication of how similar or close a pixel is to some criterion (Gath and Geva, 1989).

FCM is an iterative algorithm that aims to find cluster centers in an image that minimizes an objective function. A process called as fuzzy partitioning is employed which a data point can belong to all groups with different membership grades between 0 and 1 [17]. The objective function is the sum of squares distance between each pixel and the cluster centers and is weighted by its membership. FCM is defined by six parameters which are shown in Table 2.1.

Parameters	Description
n	number of data samples for whole images
c	number of clusters
xk	kth data sample (Pixel point value)
vi	ith cluster center
m	weighting exponent(constant greater than unity)
$\mu_{ki}$	membership of xk in ith cluster

Table 2.1: Various parameters for FCM

The advantage of the fuzzy c-means over other methods of segmentation such as classical and statistical methods, is that the algorithm does not require any prior knowledge of the data and it is fairly robust to noisy data.

#### D. Neuro-Fuzzy Classifier

A neuro-fuzzy classifier is used to detect the abnormalities in the MRI brain images. Generally the input layer consists of seven neurons corresponding to the seven features. The output layer consist of one neuron indicating whether the MRI is of a normal brain or abnormal and the hidden layer changes according to the number of rules that give best recognition rate for each group of features.[3]

Here the neuro-fuzzy classifier used is based on the ANFIS technique. An ANFIS system is a combination of neural network and fuzzy systems in which that neural network is used to determine the parameters of fuzzy system. ANFIS largely removes the requirement for manual optimization of parameters of fuzzy system. The neuro-fuzzy system with the learning capabilities of neural network and with the advantages of the rule-based fuzzy system can improve the performance significantly and neuro-fuzzy system can also provide a mechanism to incorporate past observations into the classification process. In neural network the training essentially builds the system. However, using a neuro-fuzzy technique, the system is built by fuzzy logic definitions and and it is then refined with the help of neural network training algorithms.

Some advantages of ANFIS systems are:

- It refines if-then rules to describe the behavior of a complex system.
- It does not require prior human expertise
- It uses membership functions plus desired dataset to approximate.
- It provides greater choice of membership functions to use.
- Very fast convergence time.[7]

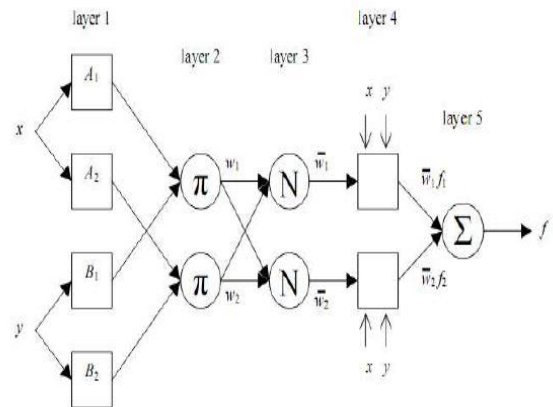


Figure 2.4: ANFIS architecture

#### E. ANFIS GUI

The ANFIS Editor GUI menu bar can be used to load a FIS training initialization, save the trained FIS, open a new Sugeno system or any of the other GUIs to interpret the trained FIS model. Any data set is loaded into the ANFIS Editor GUI, (or that is applied to the command-line function ANFIS) must be a matrix with the input data arranged as vectors in all but the last column. The output data must be in the last column. A sample of ANFIS Editor GUI with input is shown in Figure 2.5.

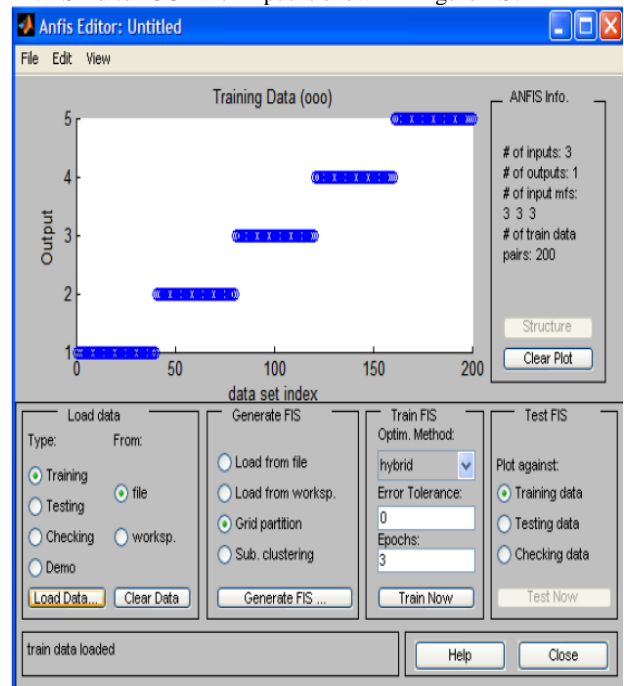


Figure 2.5: ANFIS Editor GUI

### 3. CONCLUSION

Neural networks are performing successfully where other methods do not. There are many areas viz. medicine, weather forecasting, classification, resource allocation, and stock market predication; where such decision support system can help in setting priorities and making effective and productive decisions. Since the traditional connectionist systems do not provide explicit fuzzy interface, the proposed hybrid systems have wider scope/acceptability and presents dual advantages of a type-2

fuzzy logic based decision support using ANN techniques. this technique increases accuracy.

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