Classifying Alzheimer's Disease Using Adaptive Neuro Fuzzy Inference System

D.S. Gayathri , Nagarajan Munusamy

Abstract: Alzheimer's Disease (AD) may be a sort of dementia disease which is unpredictable with diagnose by understanding the clinical perception alone. Identifying Alzheimer'sdiseaseby scanning the brain using Magnetic Resonance Imaging (MRI) information is a Fundamental concern in the neurosciences. Universal evaluation of functional scan images regularly depends on Manual reorientation, visual reading and Furthermore, semi quantitative examination from certain specific segments of the cerebrum.This paper suggested the Adaptive Neuro methodology for robotized multiclass analysis of Dementia with the higher order reasoning about MRI Image of a human Brain. The Process begins with the pre-processing the MRI Images by disposing the noises present in them, like labels and X- Ray marks by using Tracking Algorithm. Feature Extraction process, eliminates the high frequency components using Discrete Wavelet Transform (DWT). Thus derived coefficients makeuse of primary couple of DWT coefficients for the preparation of classification in the means of Normal, Mild cognitive Influence; Alzheimer's disease using Adaptive Neuro Fuzzy Algorithm (ANFIS). The testresult consequence demonstrates that the proposed technique execution posses a better result than by comparing with different order methodologies.

Keywords: ANFIS, MRI Image, Alzheimer's Disease, DWT.

I. INTRODUCTION

With the aging of population in developed countries, the dementedness diseases become a serious drawback of public health. Alzheimer's disease (AD) is one amongst the most frequent pathologies and its early detection is extremely vital to realize delay in the disease progression. Since AD affects brain cells and causes their degeneration, advances and evolution of medical imaging techniques yield solution for finding structural changes in human brain and their relationship with clinical diagnosing of AD. In India, a total of 3.7 million people over the age of 60 are suffering from Alzheimer's disease and its related disorders [1]. An outright analysis will not be provided to the person reasonably at the early stage, but will be provided at the extreme cortex harm has occurred.

Due to a colossal increase of the range and the degree of medical specialty image collections and also the giant vary of image modalities obtaining accessible on these days, which pave the way, that there is a requirement for providing automatic tools to index medical information. Indexing of medical scan images using their visual content has shown its potency relative to textual approaches [2]. The methodologies such as Image content analysis and classification are currently additional as well as advanced process used for medical information mining and retrieval with the aim of Computer-Aided Diagnosing (CAD) [3].

Medical info from resonance Imaging (MRI) is employed for detecting structural abnormalities of the human brain. Specifically, structural MRI measurements facilitate in sleuthing and following the evolution of brain atrophy which is taken into account as a marker of AD method.

Timely detection and classification of Alzheimer disease based on their clinical report is very important nowadays. By using image processing techniques the Alzheimer disease region can be obtained by using a combination of de-noising, feature extraction and classification techniques. The proposed technique has the potential of assisting medical diagnosis.

A few analysts have suggested different techniques for identifying the Alzheimer disease which is discussed in the Literature review section. The Methodology used to classify the MRI Images is discussed in the Methodology section, in this section, the sample data used, pre-processing technique adopted, Feature Extraction techniques used and implementation of Adaptive Neuro Fuzzy Inference System (ANFIS) were discussed. Experimental Results section contains the comparative results of the work that done in this paper. Finally, the conclusion of this paper was discussed in the Conclusion section based on the results generated.

II. LITERATURE REVIEW

In Alzheimer's disease AD, the foremost common pronounced modification within the brain structure is that the reduction of the degree of the hippocampus [4]. Many works within the literature use extracted options from the hippocampus region of interest (ROI) for the aim of diagnosing [5]. MRI classification task plays a crucial role in medical image retrieval that may be a part of deciding and analyzing in medical image analysis. It involves grouping MRI image scans into predefined classes or finding of a category to that a subject matter belongs. There are many tries within the literature to automatically classify structural brain imaging as AD, MCI or NC.

Among of the foremost common strategies it's found that Voxel Based Morphometry (VBM) [6] which is assisted with an automatic tool. It allows a research of the variations in native concentration of SubstantiaGriseaand Nerve Tissue that present in the images. Tensor Based Morphometry (TBM) [7] was planned to spot native structural changes from the gradients of deformations fields.

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Object Based Morphometry (OBM) [8] was introduced to perform form analysis of anatomical structures and recently, Feature Based Morphometry(FBM) [9] was planned as a way for relevant brain options comparison by employing a probabilistic model on native image options in scale-space.

Another studies focused on activity morphological structure of a Region of Interest (ROI) illustrious to be plagued by AD on the hippocampus region. In an investigation that analyzes hippocampus atrophy, the subsequent image analysis schemes are known. In study by Toews et al. [10], the author involuntarily segments the hippocampus and uses its volume for the classification. In addition to volumetrical strategies, many surface-based form description approaches are planned to know the development of AD. In an exceedingly study done by Chupin et al. [11], shape details within the structure of Spherical Harmonics (SH) are utilized as options within the Support Vector Machine (SVM) classifier.

Just in case of analysis by Genrardin et al. [12], Statistical Shape Models (SSMs) are used for the purpose of modeling the variability within the hippocampus shapes among the population. Hence, the image-based diagnostic of AD depends in the main on analysis of hippocampus. With all, the overall volumetrical or form investigation of the hippocampus doesn't illustrate the native transformation of its structure that is useful for identification. ROI-based strategies are time intense and observer-dependent.

Moreover, most of the approaches cited on top of were planned for cluster analysis and can't be accustomed classify individual patients.

In order to beat of these limitations, laptop vision tools and visual image process techniques are developed to allow an automatic detection of atrophy within the ROI [13]. Recently, Content primarily based Visual info assortment strategies have been wide used for medical image analysis.

But, few are the works that address the visual content of brain scans to extract information relative to AD.

In Sakthivel et al. [14], the authors targeting and incorporating several styles of information, along with textual information, image visual characteristics extracted from scans additionally to direct user input.

In general, options will contain coefficients of a spectral transformation of image signal, e.g. Fourier or discrete Cosine transformation coefficients (DCT), statistics on image gradients etc. options accustomed describes brain pictures are local binary patterns (LBP) and DCT.

In a study by Agrawal et al. [15] uses visual image similarity to help early identification of Alzheimer. It proves the performance of user feedback for the aim of brain image classification.

III. METHODOLOGY

In this section, the overview of proposed methodology to classify the Alzheimer's disease using MRI Image is explained. Figure 1. Shows the overall architecture of the proposed methodology to classify the Alzheimer's disease using MRI scan images. It contains three phases, Pre-processing, Feature Extraction and Classification. Initially the MRIdata base, downloaded from the ADNI database [18] is pre-processed using Tracking Algorithm, which removes the film artifacts such aslabels and X-ray marks are removed from the MRI Scanned image. Then a further feature extraction technique is done by using Discrete Wavelet Transform (DWT). Then Adaptive Neuro Fuzzy Inference System is used to classify the images based on the features into three classes such as Normal, Mild Cognitive Impairment andAlzheimer's disease.

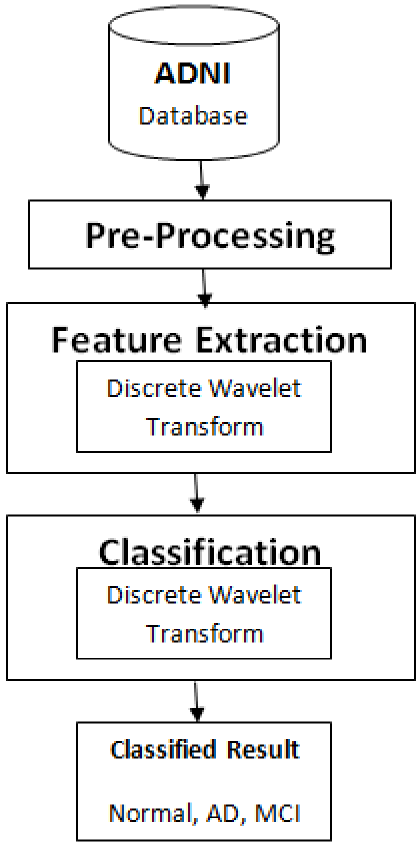

Figure 1: Overall Architecture of ANFIS Classification of Alzheimer's Disease

Pre-Processing

Pre-processing techniques is employed to boost the detection of the suspicious region from MRI Scan Image. The first step of pre-processing using Tracking algorithm, involve those operations that ar typically essential before the major information examination and extraction of details, and are commonly sorted as radiometric or geometric enhancements. MRI includes film artifacts or label on that, as an instance, patient name, age and marks. Film artifacts ar eliminated by suggests that of tracking algorithmic rule. At this time, starting from the first row and initial column, the intensity worth of the pixels is analyzed, consequently the threshold value of the film artifacts is found. It's to be noted that flag value and threshold value is extraordinarily more, then the threshold value will be eliminated from tomography. The high intensity worth of film artifacts are eliminated from MRI. At some purpose within the elimination of film artifacts, the image includes salt and pepper noise.

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ALGORITHM: Tracking algorithm

```
do
{
        Examine (MRI);
        Transform2D (MRI);
        Choose_Threshold(); // To eliminate white labels
        Flag= 255;
        Choose_pixel(MRI){
        if (intensity = Flag)
        {
                Flag=0;
        }
        Else
        {
        Pic=Get_Pixel();
        }
}
```

Adaptive Neuro Fuzzy Inference System

The Adaptive Neuro Fuzzy Inference System (ANFIS) is a data driven procedure representing a neural network approach for the solution of function approximation problems. Data driven procedures for the synthesis of ANFIS networks are generally supported based on clustering a training set of numerical samples of the unknown task to be approximated[16]. From the time when introduction, ANFIS networks have been successfully smeared to classification tasks, rule-based process control measures, pattern recognition and similar Issues. Here a fuzzy inference system comprises of the fuzzy model proposed by Takagi, Sugeno and Kang[17] to formalize a systematic approach to generate fuzzy rules from an input output data set.

ANFIS Structure

For simplicity, it is assumed that the Fuzzy Inference System (FIS) has two inputs and one output, under consideration. The rule base contains the fuzzy if-then rules of Takagi and Sugeno'stype as follows:

If x is A and y is B then z is f(x,y)

where A and B are the fuzzy sets in the antecedents and z = f (x, y) is a crisp function in the consequent. Usually f (x, y) is a polynomial for the input variables x and y. But it may also be the other process that mayalmost describe the output of the system within the fuzzy region as indicated by the antecedent[17].

When f(x,y) is a constant, a zero order SugenoFuzzy Model is formed which may be considered to be a special case of MamdaniFuzzy Inference System where each rule consequent is specified by a fuzzy singleton. If f(x,y) is taken to be a first order polynomial a first order Sugeno fuzzy model is formed. For a major order two rule SugenoFuzzy Inference System (FIS), the two rules could also be explicit as:

Rule 1: If x is A1 and y is B1 then f1 = p1x + q1y + r1

Rule 2: If x is A2 and y is B2 then f2 = p2x + q2y + r2

Here type-3 fuzzy inference system proposed by Takagi and Sugeno[18] is used. In this Fuzzy Inference System (FIS) the output of every rule could be a linear combination of the input variables accessorial by a persistent term. The final output is the weighted average of each rule's output. The corresponding equivalent ANFIS structure is shown in Figure 2.

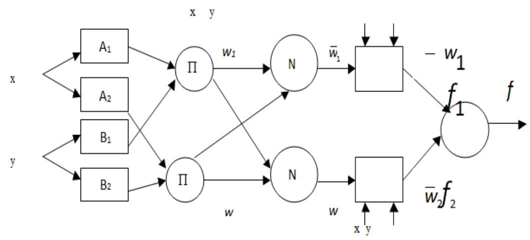

Figure 2: Type-3 ANFIS Structure

The individual layers of this ANFIS structure are described below:

In evaluating the rules, choose product for T-norm (logical and).

Layer 1: Every node i in this layer is adaptive with a node function

$$w_i = \mu_{A_i}(x)\mu_{B_i}(y),\ i=1,2.$$

Layer 2: Each node in this layer is a fixed node which calculates the firing strength w_i of a rule. The output of each node is the product of all the incoming signals to it and is given by,

$$f(x,y) = \frac{w_1(x,y)f_1(x,y)+w_2(x,y)f_2(x,y)}{w_1(x,y)+w_2(x,y)}.$$

Layer 3: Every node in this layer is a fixed node. Each i^{th} node calculates the ratio of the i^{th} rule's firing strength to the sum of firing strengths of all the rules. The output from the i^{th} node is the normalized firing strength given by,

$$f = \frac{w_1 f_1 + w_2 f_2}{w_1 + w_2}.$$

Layer 4: Every node in this layer is an adaptive node with a node function given by

$$\bar{w}_i = \frac{w_i}{w_1 + w_2}.$$

Layer 5: This layer comprises of only one fixed node that calculates the overall output as the summation of all incoming signals, i.e. Then f can be written as

$$f = w_1 f_1 + w_2 f_2.$$

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ALGORITHM: Adaptive Neuro Fuzzy Inference System

```
calculate_ANFIS(int counter, int recency){
        create_dataMatrix(counter, recency);
        create_outputMatrix();
        ANFIS_output=evaluate_ANFIS();
        free data and output Matrix;
        return ANFIS_output;
        }

if (hit)
{
        if (policy is ANFIS)
        {
        update counter;
        update recency;
        output_ANFIS=calculate_ANFIS(counter value, recency value);

        if output_ANFIS more than current output ANFIS value of the block
        pointed by replacement pointer
                assign replacement pointer to the new block
         else
                do not assign replacement pointer to the new block
        }
}
if (miss){
        if (policy is ANFIS)
        replace=pointer of block with ANFIS output equal to one;
}
```

IV. EXPERIMENTAL RESULTS

The Performance evaluation of the proposed system was discussed in this chapter. The proposed system was implemented in the MATLAB platform. The datasets used were downloaded from the ADNI database.

Data

ADNI (Alzheimer's DiseaseNeuro imaging Initiative) starting in 2004 could be a 7-year large effort to support analysis within the discovery and development of treatments that slow or stop the progression of Alzheimer's Disease. ADNI could be a multisite longitudinal clinical/imaging/genetic/bio specimen/biomarker study. Its goal is to see the characteristics of Alzheimer's disease because the pathology that evolves from traditional aging to gentle symptoms, to MCI, to insanity. ADNI is committed to establishing standardized strategies for imaging/biomarker assortment and analysis to be used in clinical trials. Relating the past, present and therefore the way forward for the ADNI MRI core, it starts with the "ADNI-1" for the primary five years (approximately, from 2005 to 2010).

Evaluation

The proposed system was compared with the Fuzzy Logic and Neural Networks, based on some performance measures like, Sensitivity, Specificity, Accuracy, Mean Square Error, Signal to Noise Ratio and Peak Signal to Noise Ratio. In this paper, Alzheimer's disease is taken as Issue thus, the performance measures will evaluate as:

Accuracy

Accuracy symbolizes the ability of the system to differentiate the normal and affected person correctly. To evaluate the accuracy of a system, one should calculate the proposition of True positive, True Negative, False Positive and False Negative.

$$Accuracy = \frac{TP+TN}{TP+TN+FN+FP} \quad (1)$$

Specificity

Specificity symbolizes the ability of the system to define the Normal Person correctly. To evaluate the specificity of a system, one should calculate the proportion of True Negative in Normal persons.

$$Specificity = \frac{TN}{TN+FP} \quad (2)$$

Sensitivity

Sensitivity symbolizes the ability of the system to define the Alzheimer's Disease affected person correctly. To evaluate the sensitivity of a system, one should calculate the proportion of True Positive in Alzheimer's disease affected persons.

$$Sensitivity = \frac{TP}{TP+FN} \quad (3)$$

Mean Square Error

Mean Square Error is used to measure the difference between the expected parameter and the perceived parameter, which paves the way for the researcher to make some decisions.

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \quad (4)$$

Peak Signal to Noise Ratio

Peak Signal to Noise Ratio is used to measure the ratio between the extreme possible power value of a signal and the power of garbling noise value that affects the quality of image representation.

$$MSE = 10log_{10}(MAX_i^2/MSE) \quad (5)$$

Figure 3 depicts the framework designed for the Alzheimer's Disease classification system using Mat lab guide environment. Figure 4 depicts the overall view of a sample MRI image downloaded from the ADNI database.

Figure 3: Framework for the Alzheimer's Disease Classification System

The performance evaluation metrics like Mean Square Error, Signal to Noise Ratio and Peak Signal to Noise Ratio are used to measure the perceptual quality of the MRI Image, after the noises are added to the MRI Bain Images, were mentioned in the Table 1. Based on the data present in the table, the performance of the system was concluded.

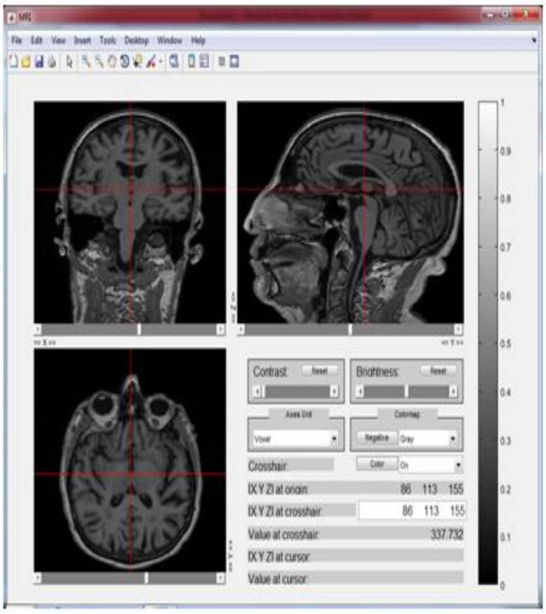

Figure 4: A Complete view of the MRI Image

Table 1: Experimental results for the classification methods using Mean Square Error, Signal to Noise Ratio and Peak Signal to Noise Ratio.

Classification Methods	Sample Images Used	MSE	SNR	PSNR
Fuzzy Logic	IMAGE 1	1.684	16.156	24.144
	IMAGE 2	1.668	16.352	24.356
	IMAGE 3	1.652	16.548	24.568
	IMAGE 4	1.636	16.744	24.78
	IMAGE 5	1.62	16.94	24.992
NEURAL NETWORK	IMAGE 1	1.604	17.136	25.204
	IMAGE 2	1.588	17.332	25.416
	IMAGE 3	1.572	17.528	25.628
	IMAGE 4	1.56	17.724	25.84
	IMAGE 5	1.556	17.92	26.052
ANFIS	IMAGE 1	1.54	18.2	26.32
	IMAGE 2	1.51	18.19	26.45
	IMAGE 3	1.49	18.5	26.66
	IMAGE 4	1.47	18.75	26.81
	IMAGE 5	1.43	18.9	27.2

Here the performance of the system proposed was compared with the system generated by Fuzzy Logic and Neural Networks. Figure 5 shows Mean Square Error comparison among the classification methods. Here Fuzzy Logic and Neural Networks shows greater error rate while comparing with the Adaptive Neuro Fuzzy Inference System.

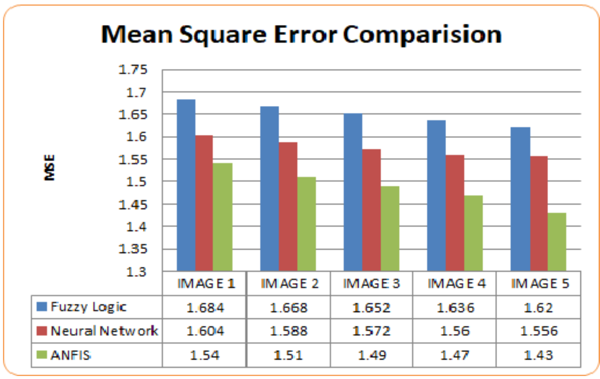

Figure 5: Comparing the Classification algorithms using Mean Square Error value

Figure 6 shows the Signal to Noise Ratio comparison among the classification methods. Here Fuzzy Logic and Neural Network show lesser ratio while comparing with the Adaptive Neuro Fuzzy Inference System.

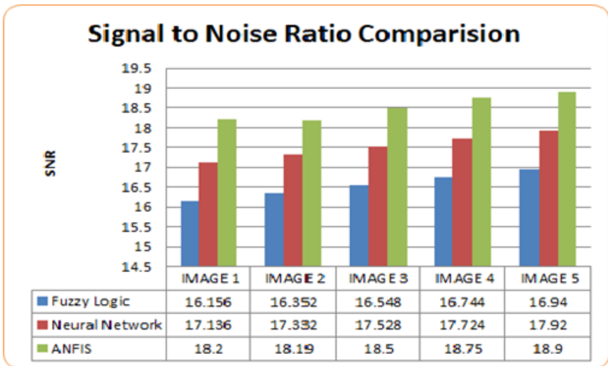

Figure 6: Comparing the Classification algorithms using SNR value

Figure 7 shows the Peak Signal to Noise Ratio comparison among the classification methods. Here Fuzzy Logic and Neural Network show lesser ratio while comparing with the Adaptive Neuro Fuzzy Inference System.

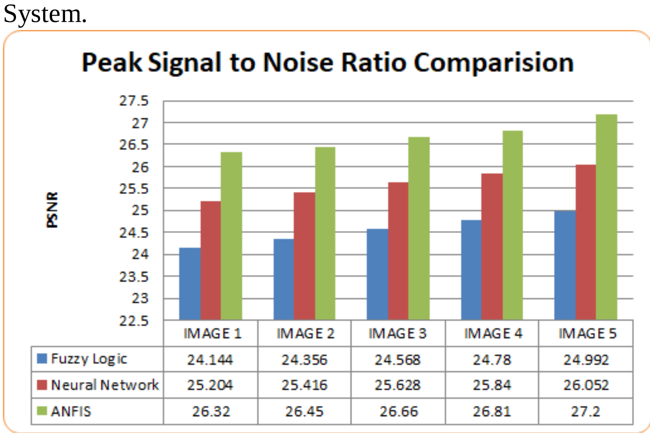

Figure 7: Comparingthe Classification algorithms using PSNR value

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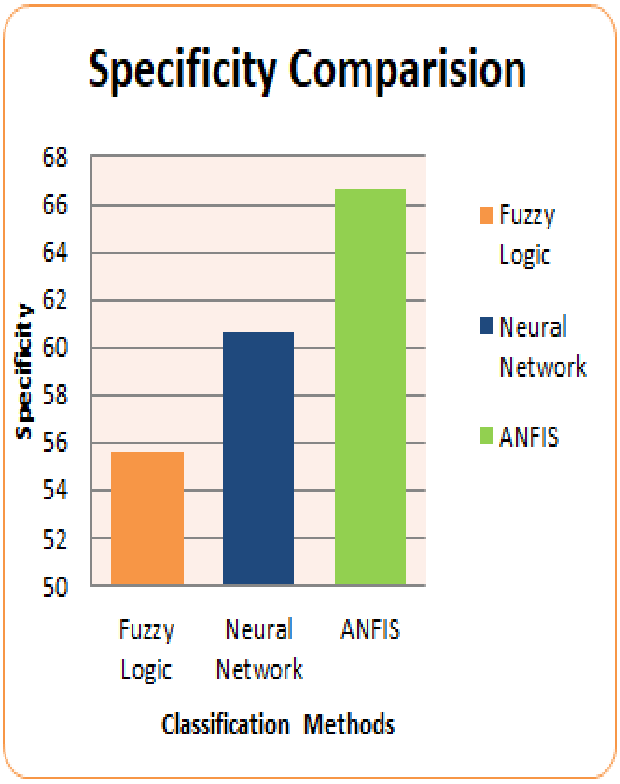
Table 2 shows the experimental result of the evaluation metrics like, Accuracy, Sensitivity and Specificity, comparison among the classification methods. Here Fuzzy Logic and Neural Network show lesser ratio while comparing with the Adaptive Neuro Fuzzy Inference System. The performance of the system was analyzed based on the data present in the table.

Table 2: Experimental results for the classification methods using Accuracy, Sensitivity and Specificity.

Classification Methods	Accuracy	Sensitivity	Specificity
Fuzzy Logic	82.5	90.32	55.56
Neural Network	90	95.81	60.61
ANFIS	95	97.3	66.67

Figure 8 shows the Specificity and Sensitivity comparison among the classification methods. Here the proposed methodology Adaptive Neuro Fuzzy Inference System shows greater Sensitivity and Specificity value while comparing with the Fuzzy Logic and Neural Network.



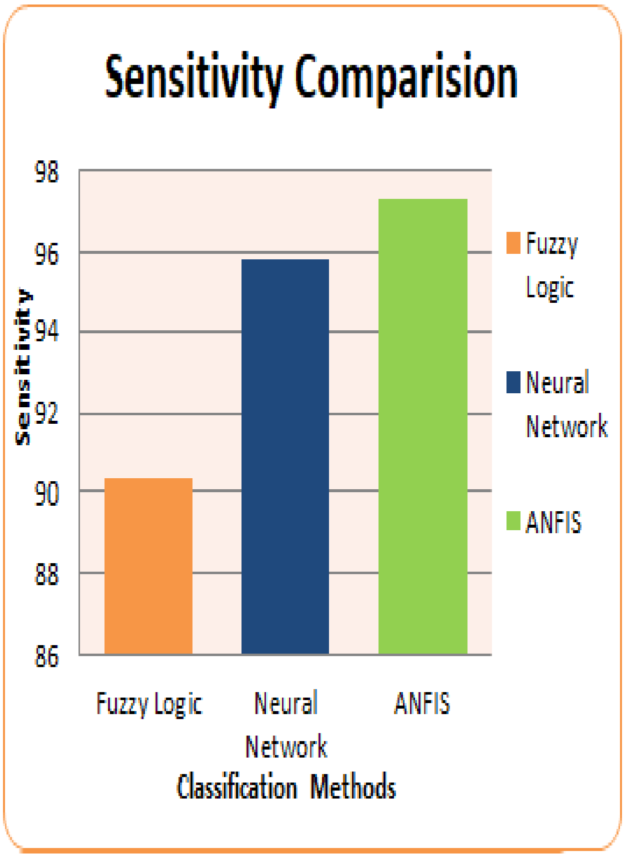


Figure 8: Specificity and Sensitivity Comparison among Classification Algorithms

Figure 9 shows the Accuracy comparison among the classification methods. Here the proposed methodology Adaptive Neuro Fuzzy Inference System shows greater Accuracy value while comparing with the Fuzzy Logic and Neural Network.

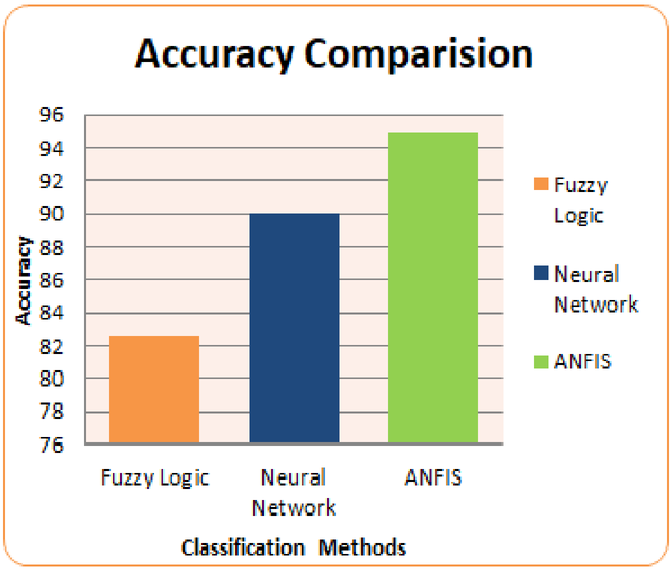


Figure 9: Accuracy Comparison among Classification Algorithms

Based on the experimental results discussed above the proposed methodology Adaptive Neuro Fuzzy Inference System provides better results while comparing with the previous volumetric methods.

V. CONCLUSION

This paper deals with the vital challenge of identification of Alzheimer's Disease (AD) and also the condition before dementia that is Mild Cognitive Impairment (MCI),by developing intelligent classifiers, that victimization the data of resonance imaging, which successfully classify different patients in line with their condition. In this paper after pre-processing, Discrete Wavelet Transformation (DWT) Algorithm has been used for feature extraction, and anadvanced methodology, such as Adaptive Neuro Fuzzy Inference System (ANFIS) was used for the classification purpose. This proposed methodology was compared with a Native Neural Network and Fuzzy Logic. The Experimental results shows the features derived are used for the intension of training the classification process. Thus the Adaptive Neuro Fuzzy Methodology provides higher classification accuracy when compared to different native methodologies like, Fuzzy Logic and Neural Network. At now it remains as future work, the study on the optimal slices to perform the classification, the utilization of alternative dimensionality reduction algorithms that may attain a reduction in time complexness for the matter, and also the study on other databases for Alzheimer's disease.

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