



# INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X

Impact factor: 4.295

(Volume3, Issue3)

Available online at [www.ijariit.com](http://www.ijariit.com)

## Analysis of adaptive Neuro–Fuzzy based Expert System for Parkinson’s Disease Diagnosis

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**Abstract:** The real world Parkinson’s disease (PD) is a chronic progressive neurological disease that affects a small area of nerve cells called neurons in the area of the brain called the substantia nigra. Medical Expert System technique is a solution of this problem. This paper summarizes regarding the classification of Parkinson’s disease by using adaptive neuro-fuzzy inference engines. The learning focuses on the diagnosis of P.D. by using adaptive neuro-fuzzy inference system (ANFIS). The outcome obtained by fuzzy inference system is evaluated. MATLAB toolbox is designed for the simulation of the model. This also confirms that adaptive neuro is a better option in which we use the symptoms of the patient which is suffering from Parkinson’s disease and get a result.

**General Terms:** Expert system, fuzzy logic.

**Keywords:** Parkinson’s Disease; Expert System; diseases; ANFIS; Neuro Fuzzy.

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### 1. INTRODUCTION

The real world Parkinson’s disease (PD) is a chronic progressive neurological disease that affects a small area of nerve cells called neurons in the area of the brain called the substantia nigra. These cells normally produce dopamine, a chemical that transmits signals between areas in the brain that, when working normally, co- ordinate smooth and balanced muscle movement. P.D. causes these nerve cells to die and as a result, body communication. Parkinson’s involves the malfunction and death of vital nerve cells in the brain, called neurons. Parkinson’s primarily affects neurons in an area of the brain called the substantia nigra. Some of these dying neurons produce dopamine, a chemical that sends messages to the part of the brain that controls movement and coordination. As PD progresses, the amount of dopamine produced in the brain decreases, leaving a person unable to control movement normally. As symptoms get worse, people with the disease may have trouble walking, talking or doing simple tasks. Other symptoms may include depression and other emotional changes, difficulty in swallowing, chewing, skin problems and sleep disruptions [10]. The specific group of symptoms that an individual experience varies from person to person. Primary motor signs of Parkinson’s disease include the following.

- **Tremor** of the hands, arms, legs, jaw, and face
- **Bradykinesia** or slowness of movement
- **Rigidity** or stiffness of the limbs and trunk
- **Postural instability** or impaired balance and coordination

The chemical or genetic trigger that starts the cell death process in dopamine neurons is the subject of intense scientific study. Many believe that by understanding the sequence of events that leads to the loss of dopamine cells, scientists will be able to develop treatments to stop or reverse the disease. It is a combination of below factors-

- Genetic Factors
- Environmental factors

## **2. RELATED WORK**

In previous work, the author developed the clinical expert system for detection of Parkinson's disease. Author extracts the features of the system from voice recordings and considers an advanced statistical approach for pattern recognition. The significance of the previous work lies on the development and use of a novel subject based Bayesian approach to account for the dependent nature of the data in a replicated measure-based design. The ideas under in the previous approach are conceptually simple and easy to implement by using Gibbs sampling. In the previous model available information could be included in the prior distribution.

## **3. PROBLEM FORMULATION**

The real word Parkinsons Disease is a chronic progressive neurological disease that affects a small area of nerve cells called neurons in the area of the brain called substantial nigra. These nerve cells to die and as a result body communication. In proposed work, the classification of Parkinson's Disease by using adaptive neuro-fuzzy inference system. This inference system would be a gift for patients which is suffering from this disease and get a result at very early stage.

## **4. EXPERT SYSTEM**

**Expert System** is one of the most common applications of artificial intelligence. It is a computer program that simulates the decision and actions of a person or an association that has specialist facts and experience in a particular field. Normally, such a system contains a knowledge base containing accumulated experience and a set of rules for applying the knowledge base to each particular situation. The major features of the expert system are the user interface, data representation, inference, explanations etc. Advantages of an expert system are increased reliability, reduced errors, reduced cost, multiple expertise, intelligent database, reduced danger etc. Disadvantages of an expert system are the absence of common sense and no change with changing the environment.

Expert system development process can be explained in 4 factors which are as follow-

- Knowledge acquisition
- Knowledge modeling
- Knowledge representation
- Testing and evaluation

## **5. FUZZY LOGIC**

In recent years, the number and variety of applications of fuzzy logic have increased significantly. The applications range from consumer products such as cameras, camcorders, washing machines, and microwave ovens to industrial process control, medical instrumentation, decision-support systems, and portfolio selection.

To understand why the use of fuzzy logic has grown, you must first understand what is meant by fuzzy logic.[5]

Fuzzy logic has two different meanings. In a narrow sense, fuzzy logic is a logical system, which is an extension of multivalued logic. However, in a wider sense fuzzy logic (FL) is almost synonymous with the theory of fuzzy sets, a theory which relates to classes of objects with unsharp boundaries in which membership is a matter of degree. In this perspective, fuzzy logic in its narrow sense is a branch of FL. Even in its more narrow definition, fuzzy logic differs both in concept and substance from traditional multivalued logical systems. [9]

## **6. FUZZY SYSTEM**

A fuzzy system is a group of membership functions and rules. These functions and rules are used to reason about data. Fuzzy inference systems are oriented toward numerical processing. It takes numbers as input and then translates the input numbers into linguistic terms like Small, Medium and large. This translation is called fuzzification. Then the task of rules is to map the input linguistic terms onto similar linguistic terms describing the outcome. This task is done by the fuzzy inference engine. Finally, the translation of outcome linguistic terms into an outcome number is done. This translation is called defuzzification. All the fuzzy rules and linguistic variables are stored in the fuzzy knowledge base. Fuzzy inference systems have the ability to deal with imprecise information. Fuzzy system algorithm comprise of three main steps:[16]

### **A. Fuzzification**

Fuzzy system maps the input into fuzzy input by using membership function. There are different types of membership functions such as triangular, trapezoidal and Gaussian membership function.

### **B. Inference**

Fuzzy rules are constructed by using the fuzzy input and output variables. These fuzzy rules are used by inference procedure to obtain the output.

### **C. Defuzzification**

The fuzzy output is converted into crisp output by various defuzzification methods.

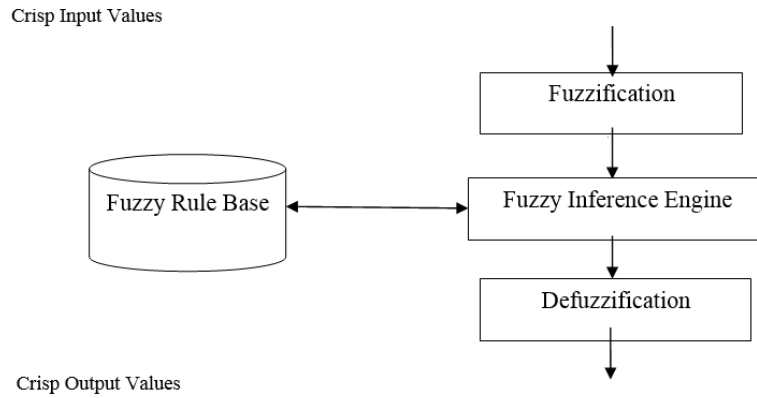


Figure 1: Structure of Fuzzy Inference System

## 7. NEURO-FUZZY EXPERT SYSTEM

ANFIS stands for Adaptive Neuro-Fuzzy Inference System. This inference system was developed in 1990. It is the combination of ANN (Artificial Neural Network) and FIS (Fuzzy Inference System). So ANFIS is considered as Universal Estimator. As ANFIS assist adaptation and learning corresponding to the fuzzy expert system so it is also known as a class of adaptive networks.[1]

## 8. NEURAL NETWORK

A **Neural network** (also called an ANN or an Artificial Neural Network) is an artificial system made up of virtual abstractions of neuron cells. Based on the human brain, neural networks are used to solve computational problems by imitating the way neurons are fired or activated in the brain. During a computation, many computing cells work in parallel to produce a result. This is usually seen as one of the possible ways artificial intelligence can work. Most neural networks can still operate if one or more of the processing cells fail. Neural networks can learn by themselves, an ability which sets them apart from normal computers. A subgroup of processing part is called a layer in the network. The primary layer is the input layer and the final layer is the output layer. Between the input and output layer, there may be extra layers, called hidden layers.

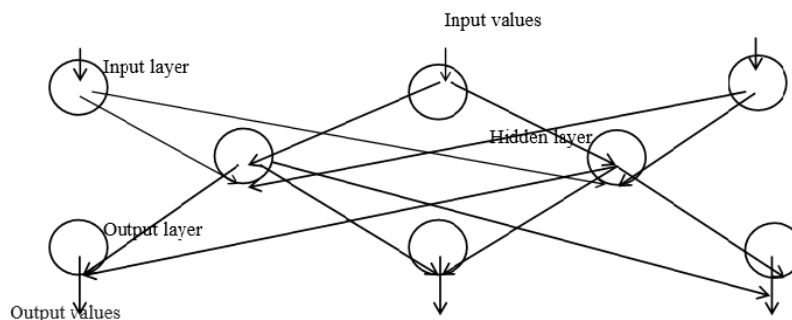


Figure 2:- A typical Neural Network

## 9. PRESENT WORK

### 9.1 Problem Formulation

The main problem of Parkinson's disease is the unawareness and carelessness among the people. So, the rate at which Parkinson's disease occur goes on increasing. The main reason is a lack of knowledge of symptoms of Parkinson's disease. The Parkinson's disease problem mainly caused due to tremor of hands, Brady kinesia, rigidity, postural instability. Patients come to know about their disease when they are at the last stage. So, Neuro-fuzzy medical expert system is required. As Neuro-fuzzy expert system would give the more accurate result as compared to rule-based and fuzzy systems. So, that the patients, diagnose their disease in the early stages. The number of doctors of Parkinson's disease is less. So, these medical expert systems are the blessings for the patients.

### 9.2 Objectives

1. To review and compile the literature so as to know the medical expert systems and the various techniques used in medical expert systems.
2. To gather knowledge from experts and doctors about the Parkinson's disease and its symptoms.
3. To develop the Adaptive Neuro fuzzy expert system for diagnosis of Parkinson's disease.  
To evaluate performance of the proposed expert system by achieving parameters such as accuracy, sensitivity, and specificity

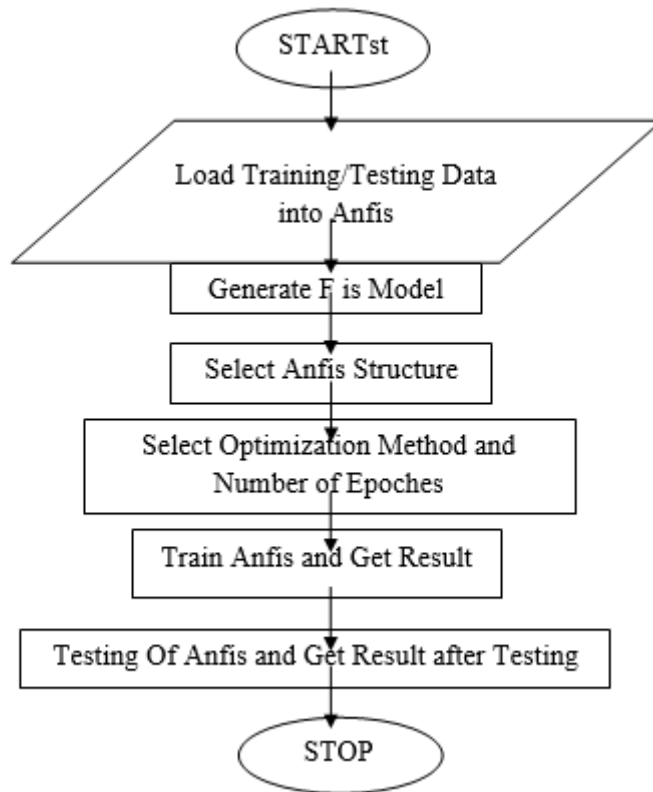


Figure 3:- Objectives of ANFIS

### 9.3 Methodology of Adaptive Neuro-fuzzy expert system

**Step 1.** Collect the data set from physicians.

**Step 2.** Make adaptive-Neuro fuzzy inference system by making calls to the function ANFIS.

- a) do
- b) Load the data set from workspace.
- c) Train the dataset using a hybrid method.
- d) Set the epochs to train the dataset.
- e) Repeat the steps for testing and checking.
- f) Draw the structure of ANFIS that consist of 5 layers.
- g) Layer 1 is used for the acceptance of fuzzy membership functions by using the formulae:

$$O_{1,i} = \mu_{A_i}(x) \quad \text{for } i = 1, 2$$

$$O_{1,i} = \mu_{B_{i-2}}(x) \quad \text{for } i = 3, 4$$

Where  $x$  is the input node  $i$  and  $A_i$  (or  $B_{i-2}$ ) is a linguistic label connected with the node.  $\mu$  is received weight corresponding to fuzzy membership function and  $O_{1,i}$  is the output of the  $i^{\text{th}}$  node of the layer 1.

- h) Layer 2 represents that the nodes are fixed nodes labeled as  $\Pi$ . Every node signifies the fire strength of the rule. In this layer AND operations are performed and it deals with T-norm operator. The output of layer 2 is the product of the incoming signals is represented as.

$$O_{2,i} = \mu_{A_i}(x) \cdot \mu_{B_i}(y), \quad i = 1, 2$$

- i) Third layer of ANFIS contains fixed nodes labeled as  $N$ . This layer does the normalization of the rules coming from the previous layer, known as normalized firing strengths. The results are represented by the following equation:

$$O_{3,i} = w_i = \frac{w_i}{w_1 + w_2} \quad i = 1, 2$$

- j) In the fourth layer every node  $i$  is an adaptive node. With a node function:

$$O_{4,i} = \bar{w}_i f_i = \bar{w}_i(p_i x + q_i y + r_i), \quad i=1,2$$

Where  $w_i$  is the normalized firing strength from layer 3 and  $\{p_i, q_i, r_i\}$  is the parameter set of this node referred to as consequent parameters.

- k) The fifth layer of ANFIS is a layer having fixed node labeled sum. This layer computes the overall output of all incoming signals with their summation as follows:

$$O_{5,i} = F = \sum_i \bar{w}_i f_i = \frac{\sum_i w_i f_i}{\sum_i w_i}$$

Until all inputs classified correctly.

**Step3.** Evaluate the accuracy, sensitivity, specificity and precision parameters are being chosen from the trained data

### 10. RESULT ANALYSIS

In this study different types of Parkinson’s disease are categorized by using Adaptive Neuro expert system and ANFIS that will be tested by the domain specialist categorize correctly and incorrectly by comparing systematic judgments with that of the domain specialist judgments reached on the same patient test cases. The performance of the system is usually estimated on the basis of the confusion matrix. The parameters calculated in this study are accuracy, sensitivity, specificity, and precision by using the formula.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

$$Sensitivity = \frac{TP}{TP + FN}$$

$$Specificity = \frac{TN}{TN + FP}$$

$$Precision = \frac{TP}{TP + FP}$$

TP (True Positive Rate) = It illustrates the records that are predicted as true as they are actually true.

TN (True Negative Rate) = It illustrates the records that are predicted as false as they are actually false.

FP (False Positive Rate) = It illustrates the records that are predicted as true as they are actually false.

FN (False Negative Rate) = It illustrates the records that are predicted as false as they are actually true.

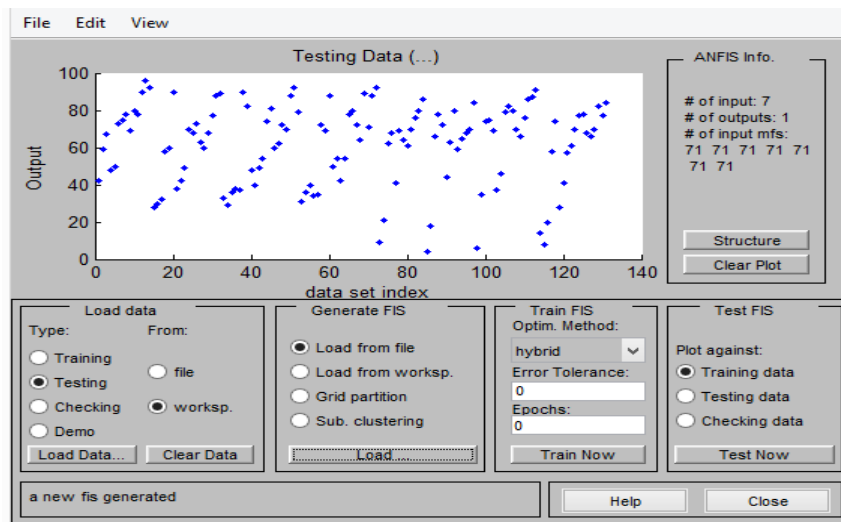


Figure 4: A new fis is generated

This figure shows how to generate fuzzy inference system from the file.

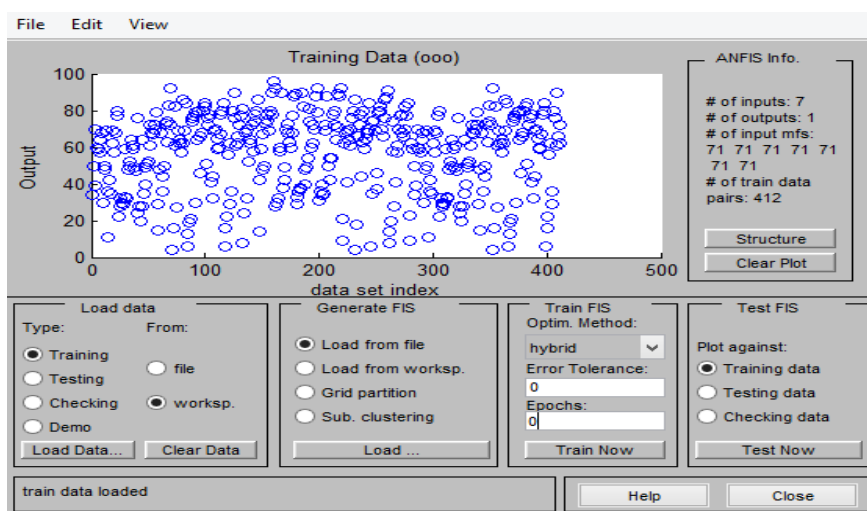


Figure 5: Train data loaded

This figure shows how to load data from type training.

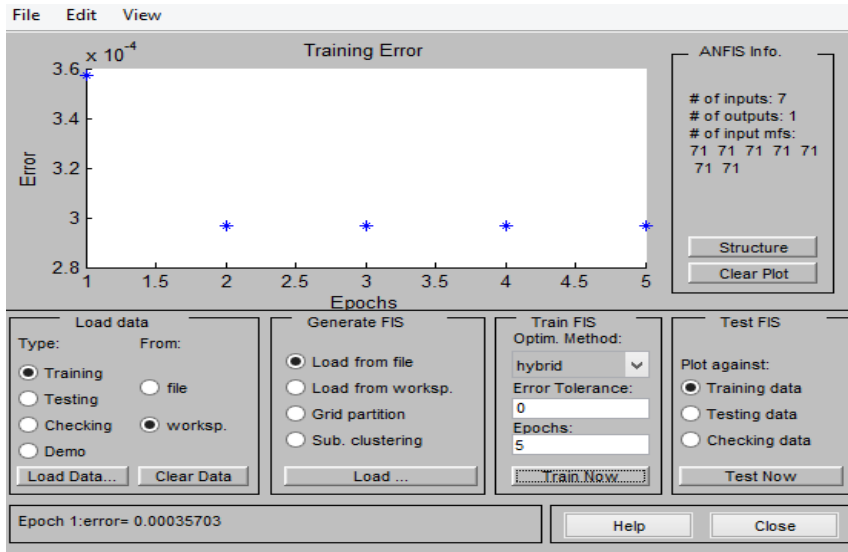


Figure 6: Training at epochs 5

This figure shows the training of data set at epochs 5 and the error rate is 0.00035703.

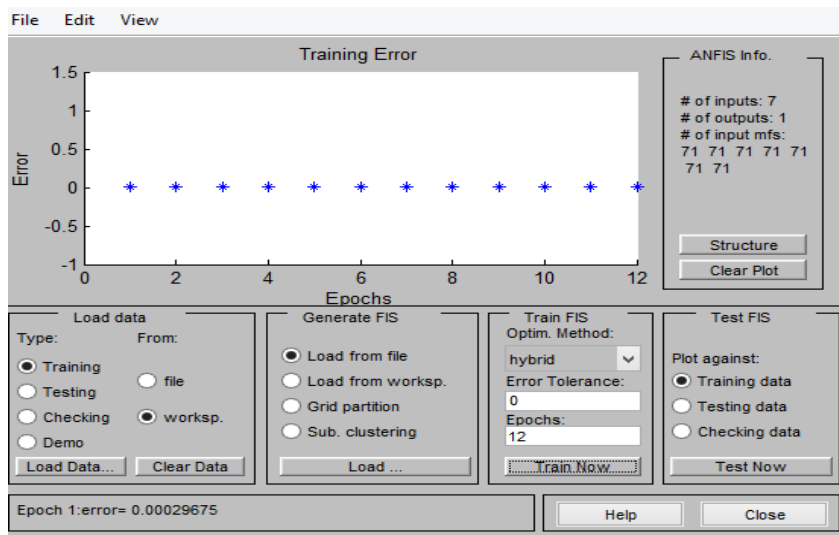


Figure 7: Training at epochs 12

This figure shows the training at epochs 12 and the error is 0.00029675.

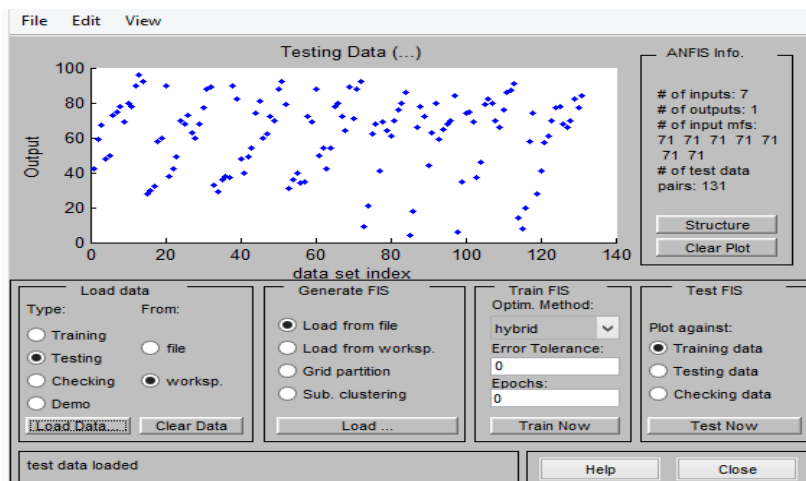


Figure 8: Test data loaded

This figure shows how to load the data from file type testing and from the workspace.

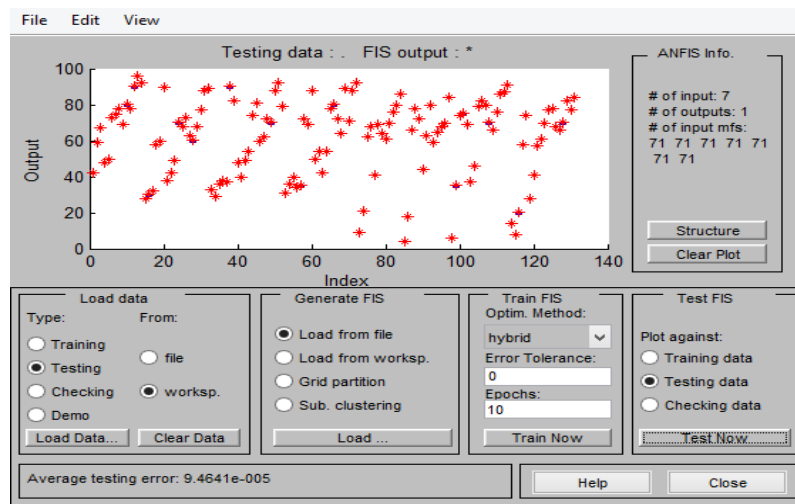


Figure 9: Testing at epochs 10

This figure shows testing of data set and the average testing error is 9.641e-005.

## 11. CONCLUSION AND FUTURE SCOPE

The community with the world's highest prevalence of Parkinson's disease is along the River Nile in Egypt amongst the rural illiterate Egyptians. The world's second highest prevalence of Parkinson's disease by far has been found among the amish community. This paper describes the P.D. using adaptive neuro-fuzzy technique some researchers work on this diseases by using rule-based, neural network or fuzzy system technique. They do not use adaptive neuro technique on Parkinson's Disease.

From the results, it is concluded that the accuracy of the adaptive neuro fuzzy expert system is quite more than a fuzzy expert system. Also, the other parameters such as sensitivity, specificity, and precision are better in the case of adaptive neuro fuzzy expert system rather than a fuzzy expert system.

In the future, there may be some more inputs which have better results with a diagnosis of Parkinson's Disease. These inputs may be added to the proposed system for more accurate results.

## 12. ACKNOWLEDGEMENTS

I would like to express a deep sense of gratitude to Principal **Dr. Naveen Dillon Ramgarhia** Institute of Engg. & Tech. Phagwara, **Er. Varinderjit Kaur** Asst Prof. (CSE Department), H.O.D.M.tech (CSE Department), **Er. Harshdeep Trehan** Asst. Prof. RIET Phagwara. I am also thankful to Chetna Sainifor guiding throughout the present research work and their sensible help and support. Last but not the least I am grateful to my parents for the interminable help, encouragement, support, and attention at every step.

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