Diagnosis of Hypertension using Adaptive Neuro-Fuzzy Inference System

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Abstract
This research paper presents Adaptive Neuro-fuzzy inference system (ANFIS) technique for diagnosis of hypertension. For training the ANFIS system, patient’s data set are collected under the supervision of physician in clinical trials on hypertension patients in hospital. This paper proposes the methodology of ANFIS was used to diagnose and presents the comparison of proposed system with existing fuzzy expert system on the basis of performance matrices i.e. Accuracy and Sensitivity. This paper proved that ANFIS system has better performance than existing model. We obtained that the accuracy and sensitivity of proposed model results is 94.63% and 97.50% resp.

Keywords
Adaptive Neuro-Fuzzy Inference System (ANFIS), Fuzzy Expert System, Hypertension, Medical Diagnosis.

I. Introduction
Nowadays the advancements in computer science giving new and progress into new technologies in the fields of medical area which can help a common people to simply diagnosis diseases itself. Recent advances in the pasture of artificial intelligence have lead to the appearance of expert systems for medical applications designed to diagnose the disease. Expert system such as rule-based, fuzzy expert system, Adaptive neuro-fuzzy inference system deliberate to improve the abilities of expert-doctors for making decisions regarding their patients also simulates a physician’s behavior for diagnosis of the disease. Adaptive neuro-fuzzy inference system (ANFIS) is multi-layer system proposed by Jang, enables to increase the performance by integrates the best features of Artificial Neural Networks and Fuzzy inference system into a single framework. It is a popular framework for solving complex problems. ANFIS system is very competent system for solving the distracted equations involving the automatic knowledge expressed only by the if-then rules. ANFIS has advantages over the fuzzy expert system are: automatic adapts the non-linear connections between inputs and outputs also it has more accurate performance shown by testing the results.

Hypertension is an unrelieved situation in which the continuing force of the blood adjacent to your artery walls is high an adequate amount that it might eventually cause many health problems such as heart disease, kidney failure, aneurysm, trouble with memory, etc. There are many risk factors for hypertension includes: Age, family history, stress, heart rate, diabetes, drinking too much alcohol, too little vitamin D and potassium in your diet, being obese or overweight, using tobacco or drugs, not being physically active, smoking. Some of the risk factors are used to implement the system in this paper that have more effects on risk of hypertension.

Hypertension is defined as having a blood pressure reading, occurs when too high pressure inside the blood vessels. When your heart pumps it sends blood towards the arteries. Your blood pushing adjacent to the walls of your arteries by force causes pressure. The additional blood pump by your heart and the narrower your arteries, the elevated your blood pressure.

In the paper described [1] the author proposed a Fuzzy Expert System to diagnose hypertension for different patients. Hypertension also called as high blood pressure and the input parameters used in this system are age, body mass index, blood pressure, heart rate, diabetes, physical activity and genetics. Fuzzy expert system input parameters divided into three crisp values like low, medium and high. Fuzzy expert system based on symptoms and rules.

In this paper, we have proposed an adaptive neuro-fuzzy inference system used for diagnosis of hypertension. Hypertension patients data has been collect from physician are age, blood pressure, body mass index, heart rate, diabetes, physical activities and genetics of the patients are used to determine the risk factor of hypertension developed. Then a proposed model result has been compared with existing Fuzzy expert system [1] techniques with the help of performance parameters: Accuracy and Sensitivity.

II. Medical Data
Hypertension patient’s record are used for training and testing purpose of the ANFIS model has been collected under the supervision of experienced physician in clinical trials on hypertension patients who were undergone diagnosis and presents their symptoms in Civil Hospital, Jagraon from March to June, 2015. In this study, 550 patient’s cases are considered with 7 patient’s health parameters. The health parameters taken in study are symptoms related with hypertension namely Age, Blood pressure, Body mass index, Heart rate, Diabetes, Physical activities and Genetics. Each record contains the patients symptoms used as system inputs parameter as well as the risk factor of hypertension diagnoses by physician used as system output parameter. In this research, the risk factor of hypertension has three classes classifiers are considered i.e. Low risk (L) factor, Medium risk (M) factor and High risk (H) factor hypertension patients. The low risk factor of hypertension patient’s are considered as normal patients or we can say that slightly suffer from disease and both medium and high risk factor of hypertension patients are considered as abnormal patients or we can say that patients suffer from disease. This hypertension patient’s risk factors classification given by physician. The patient’s data collected in form of table that contains the numerical values in which rows are represented by cases and columns are represented by symptoms.

III. Proposed Method
Fig. 1. shows the flow chart of proposed Adaptive Neuro-Fuzzy Inference System (ANFIS). The proposed method used for diagnosis of hypertension that needs input values of patient’s health symptoms that is collected under the supervision of physicians.
ANFIS is intelligent system that combines knowledge, techniques and methodologies from various sources also solution of function approximation problems. For designing of ANFIS model procedure is divided into 4 steps:

- Load data
- Generate FIS
- Train FIS
- Test FIS.

**A. Load data**

ANFIS modeling process starts by obtaining a data set and two different data types for loading to system that includes training and testing data sets. In this study, dataset contains the 550 records out of which 75% data set were used for the design of ANFIS structure’s training and remaining 25% data set used for testing accuracy of the trained system. The testing data set known as validation set used to test the output of trained FIS to ensure the accuracy and to check the total number of cases provided true results and having false results. Loading the training and testing dataset into ANFIS is shown in fig. 2.

**B. Generate FIS**

In Generate FIS step, system has three methods i.e. load the designed FIS, second is Grid Partition and third is Subtractive Clustering. This system uses Grid Partition method for generation of FIS. The main advantage of using the grid partition in FIS is block by dimensions curse, means when we increase the number of input variables then number of rules also increases. Assume an example, if there are n input variables having m MF of each input variable, then total number of rules is mn also presents the connection among inputs with output. Generate FIS presents a black box diagram contains three different interfaces: inputs (patient’s symptoms), fuzzy inference engine and output (diagnosis the risk of hypertension). In Generated FIS, there are seven inputs includes Age, Blood pressure(BP), Body mass index(BMI), Heart rate(HR), Diabetes(DBT), Physical Activities(PA), Genetics and one output .Each input having their different number of membership function (MF), two sets of MF defined having Linguistic values in this system. The first set, having three number of MF for inputs (Age, BP, BMI, HR, DBT and PA) also its Linguistic values defined as Low, Middle & High and the second set has two number of MF for last input (Genetics) also its Linguistic values defined as Yes or No. The type of MF for input variables is triangular and output variable is constant.

**C. Train FIS**

In this system, Generation of FIS from the data set whose MF adjusted by training algorithm and error plots is displayed. For
training, this steps has two optimization methods i.e. Hybrid learning and Back propagation. For training the generated FIS, Hybrid method is used that combines the Back propagation gradient descent and least-squares method.

Through the hybrid learning algorithm, training process is done by selecting the number of iterations. Different number of epochs in system performed in order to achieve the lower training error. This system, training is started with 10 epochs then epochs increases to 40 and 100 also error tolerance sets to zero. Training error occur during the training of ANFIS is 0.00090773 at 100 epochs. System training process is a stop when the error goal is achieved with maximum epoch number is reached.

D. Test FIS

After the training process of FIS, validate the model means test the FIS output to ensure the accuracy using a testing data set that is not the part of training data set. Also average training error is difference between the output value by training data and output of the FIS. In proposed ANFIS model, the average testing error of training data is 0.00090507 and average testing error of testing data is 0.913. Figure 5 and Figure 6 show the average testing error of training data and testing data respectively.

Table 1 shows the confusion matrix using proposed Adaptive Neuro-fuzzy inference system. The entries in the matrix has the meaning: total 205 diagnosed patient’s cases tested on the system, row first has 45 patient’s cases are categorized as hypertension risk factor is low out of which 42 cases truly categorized and 3 cases wrongly categorized as medium risk by the system which is closer to the physician judgments. The second row, total 70 diagnosed cases, 65 patient’s cases are truly categorized as medium risk factor of hypertension and 3 & 2 cases wrongly categorized as low & high risk resp. Similarly, third row, total 90 diagnosed cases, 87 cases are categorized as high risk and 1 & 2 cases wrongly categorized as low & medium risk resp.

Table 2 shows the comparison table of performance parameters for proposed Adaptive Neuro-Fuzzy Inference System (ANFIS) model and existing Fuzzy expert system (FIS) for diagnosis of hypertension. Figure 7 and Figure 8 shows the comparison graph of performance parameter Accuracy and Sensitivity resp. for proposed and existing model.

<table>
<thead>
<tr>
<th>Models</th>
<th>Accuracy</th>
<th>Sensitivity</th>
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<tbody>
<tr>
<td>Proposed ANFIS</td>
<td>94.63%</td>
<td>97.50%</td>
</tr>
<tr>
<td>FIS</td>
<td>90.24%</td>
<td>93.75%</td>
</tr>
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</table>
There are two performance parameters used to compare these models i.e. Accuracy and Sensitivity. In this research, proposed model shows the value of accuracy and sensitivity is higher from existing Fuzzy expert system for diagnose of hypertension. The Accuracy and Sensitivity of proposed model is 94.63% and 97.50%. So, it is proved that the proposed Adaptive Neuro-Fuzzy Inference System method has better performance than the existing Fuzzy Expert System.

![Accuracy Graph](image1)

*Fig. 7: Comparison Graph of Performance Parameter Accuracy*

![Sensitivity Graph](image2)

*Fig. 8: Comparison Graph of Performance Parameter Sensitivity*

**V. Conclusion**

It may be concluded from this research for diagnosis of hypertension give better results and diagnose the disease more accurately as compared to fuzzy expert system on the basis of performance matrix: Accuracy and Sensitivity. Hence, it is proved that proposed method give highest value of Accuracy and Sensitivity as compared to Fuzzy expert system.

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**References**


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