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Genetic Neuro Fuzzy System for Hypertension Diagnosis

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***Abstract*— Artificial Intelligence techniques have been successfully employed in disease diagnosis, disease risk evaluation, patient monitoring, robotic handling of surgeries and predicting effect of new medicines. This paper proposes and evaluates Genetic Neuro Fuzzy System for diagnosing Hypertension risk. Risk factors viz. Systolic and Diastolic Blood Pressure, Body Mass Index, Heart Rate, Cholesterol, Glucose, Blood Urea, Creatinine and Uric Acid have been taken as inputs to the system. The system classifies the input samples into Low, Medium and High risk samples. The results of proposed system have been compared with Neuro Fuzzy System in terms of Accuracy, Mean Square Error and Regression and found better.**

***Keywords*-- Hypertension Diagnosis, Neuro-Fuzzy System, Genetic Algorithm, Optimization of Back Propagation Network**

I. INTRODUCTION

Hypertension means elevation of arterial blood pressure likely to induce cardiovascular, renal and other problems. A High Blood Pressure reading in a patient may be transient due to aggressiveness, fear, recent diet etc. In order to correctly evaluate Risk of Permanent Hypertension, physicians consider several other medical factors along with blood pressure of the patient.

Researchers have been proposing Fuzzy Systems in order to evaluate hypertension risk using different input factors. Sujit Das, et.al. (2013) [1] have proved that a Neuro Fuzzy System confirms to the expert judgments better as compared to a Fuzzy System. Fig 1. shows block diagram of a Neuro Fuzzy System.

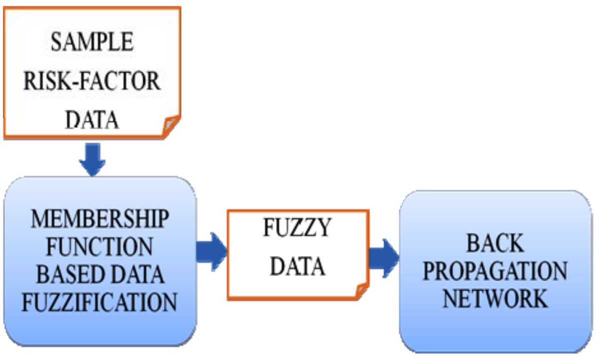

Fig. 1 Neuro Fuzzy System

This paper presents a Genetic Neuro Fuzzy System with nine input risk factors. Back Propagation Network is a feed forward network whose output depends on the network inputs and the weight matrix [2]. The Genetic Algorithm has been used in order to initialize the Neuro Fuzzy System with optimized weights and biases. Fig 2. depicts a block diagram of the proposed system. It includes three steps viz. Data Fuzzification, Optimization of back propagation network using Genetic Algorithm and Training and Testing of the back propagation network. These steps have been discussed in detail in proceeding sections.

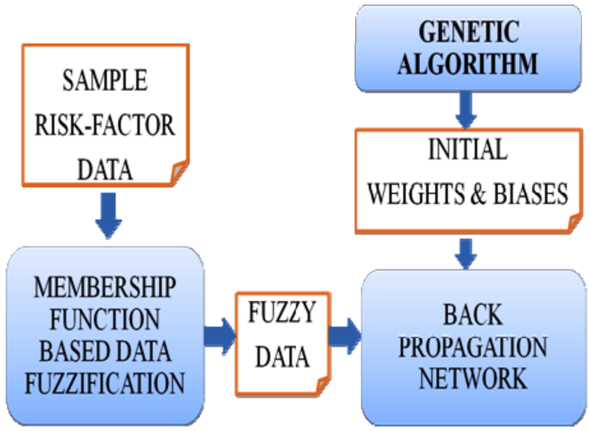

Fig. 2 Genetic Neuro Fuzzy System

This paper has been arranged as follows: Section II presents a brief literature review in the use of AI techniques for hypertension diagnosis. Section III presents the details of the sample data used for training and testing of the system. Section IV gives the methodology of the system forming different subsections which is followed by conclusion and references.

II. LITERATURE REVIEW

Researchers have been using Artificial Intelligence techniques to diagnose risk of Hypertension. One of the oldest works is by Riccardo, et al. (1991) [11] presenting a Neural Network based tool named Hypernet for hypertension diagnosis using Artificial Neural Networks. B. Sumathi, et.al. (2011) [9] and Rahul Samant, et.al. (2013) [3],[4] have used Feed Forward Back Propagation Network with varying input factors for diagnosing hypertension risk. Mevult Ture, et.al. (2005) [10] and N. Shehu, et.al. (2013) [5] have proved artificial neural network approach better as compared to other classification methods for the diagnosis of hypertension. Azian . X.Y. Djam, et.al. (2011) [8] , Azamimi Abdullah, et.al. (2011) [7] and Pankaj Shrivastava, et.al. (2013) [6] have presented Fuzzy expert systems with different input variables. Sujit Das, et.al. (2013) [1] has made a comparison between Fuzzy and Neuro-Fuzzy System for the purpose of Hypertension Diagnosis proving Neuro Fuzzy system more reliable as compared to Fuzzy system.

III. MEDICAL DATA

The sample data used for training and testing of the system has been collected under the supervision of experienced physicians in different medical clinics at Hoshiarpur from January to February, 2014. The data contained 516 samples out of which 366 samples were used for system training while 150 samples were kept for system testing. Each record consisted of patient's health parameters as well as the physician's diagnosis of hypertension risk. Table 1 gives a range of normal and high values of the health parameters used as system inputs.

TABLE I
HYPERTENSION DIAGNOSIS PARAMETERS

S.No.	Parameter	Normal Values
1	Systolic Blood Pressure (SBP)	120 mmHg
2	Diastolic Blood Pressure (DBP)	80 mmHg
3	Body Mass Index (BMI)	19-25
4	Heart Rate (HR)	60-80/minute
5	Cholesterol (Ch)	150-200 mg/dL
6	Glucose (Gl)	70-140 mg/dL
7	Blood Urea (BU)	15-50 mg/dL
8	Creatinine (Cr)	0.6-1.5 mg/dL
9	Uric Acid (UA)	2.5-7.0 mg/dL
10	Hypertension Risk (0 to 100%) Diagnosed by Physician	

IV. METHODOLOGY

The coding of the system has been performed using three different toolboxes form the Matlab tool:

Fuzzy Toolbox: For data fuzzification

Optimization Toolbox: For Genetic Algorithm

Neural Network Toolbox: For Back Propagation Network

The establishment of the proposed system consists of three steps viz. data fuzzification, genetic algorithm and back propagation network. This section presents a detailed methodology of the Genetic-Neuro-Fuzzy System.

A. Data Fuzzification

First step in the Genetic Neuro Fuzzy System is data fuzzification. Fuzzy Variables can represent the knowledge of the Subject Matter Experts more properly as compared to actual values. Each input variable has been represented as fuzzy variables using triangular fuzzy membership functions (trimf) named 'Normal' and 'High'. The range of values for each of the membership variables has been taken as suggested by the medical experts. The Hypertension Risk parameter has been represented as 'Low', 'Moderate' and 'Severe' risk. Fuzzy Membership functions for each of the parameters have been given below:

Systolic Blood Pressure

SBP_{Normal}=trimf(SBP,[110 120 129])

SBP_{High}=trimf(SBP,[126 219 220])

Diastolic Blood Pressure

DBP_{Normal}=trimf(DBP,[60 88 89])

DBP_{High}=trimf(DBP,[87 139 140])

Body Mass Index

BMI_{Normal}=trimf(BMI,[19 20 27])

BMI_{High}=trimf(BMI,[25 79 80])

Heart Rate

HR_{Normal}=trimf(HR,[60 72 81])

HR_{High}=trimf(HR,[80 119 120])

Cholesterol

Ch_{Normal}=trimf(Ch,[150 170 200])

Ch_{High}=trimf(Ch,[195 399 400])

Glucose

Gl_{Normal}=trimf(Gl,[70 110 145])

Gl_{High}=trimf(Gl,[140 349 400])

Blood Urea

BU_{Normal}=trimf(BU,[15 30 46])

BU_{High}=trimf(BU,[45 79 200])

Creatinine

Cr_{Normal}=trimf(Cr,[0.6 0.9 1.6])

Cr_{High}=trimf(Cr,[1.5 9.0 10.0])

Uric Acid

UA_{Normal}=trimf(UA,[2.5 4 6.5])

UA_{High}=trimf(UA,[6.0 14.0 15.0])

Risk

$Risk_{Low}$=trimf(RiskPercent,[-1 20 41])

$Risk_{Medium}$=trimf(RiskPercent,[40 60 81])

$Risk_{Severe}$=trimf(RiskPercent,[80 99 100])

B. Genetic Algorithm

A Neuro Fuzzy System can be obtained by feeding the fuzzified data into the Back Propagation Network. To get more reliability with larger number of input parameters, the back propagation network has been initialized with optimized weights and biases. Thus a Genetic Neuro Fuzzy System has been developed in which the Genetic Algorithm has been used for optimizing the initial weights and biases of Neuro Fuzzy System.

Table 2 gives the detailed configuration of genetic algorithm used in this work.

TABLE III
GENETIC ALGORITHM CONFIGURATION

Parameter	Value
Fitness Function	Mean Square Error = $\frac{\sum \text{(Outputs- Targets)2}}{\text{Number of Samples}}$
Population	Weights and Biases of Back Propagation Network
Population Size	20 Individuals
Initial Population	Weights = Zeros Biases = Ones
Maximum Generations	100

C. Training Back Propagation Network

Final Step in the System is training and testing of the Genetically Optimized Back Propagation Network with Fuzzy data. The GO-BPN has been trained with LM Back Propagation Network. The results of the developed system have been compared with the Neuro Fuzzy System in terms of Accuracy, MSE and Regression. The results of the Genetic Neuro Fuzzy System have been found more reliable as compared to the Neuro Fuzzy System. Figures 3 to 5 present the results of both the systems from the Matlab tool.

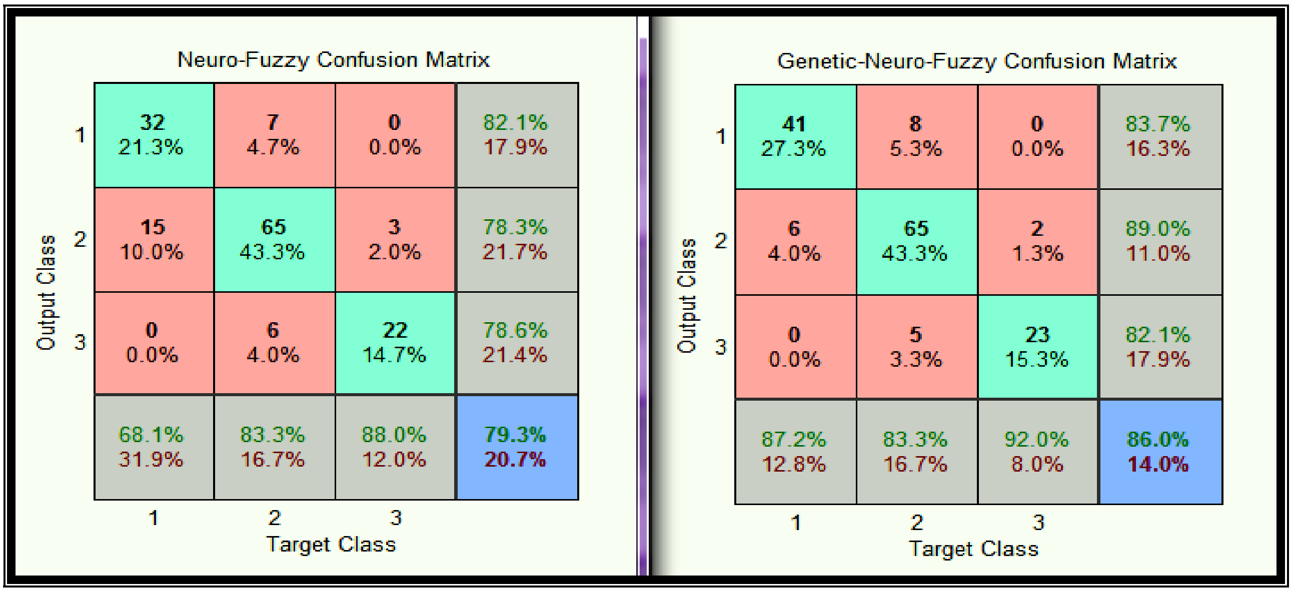

Fig 3. Confusion Matrix

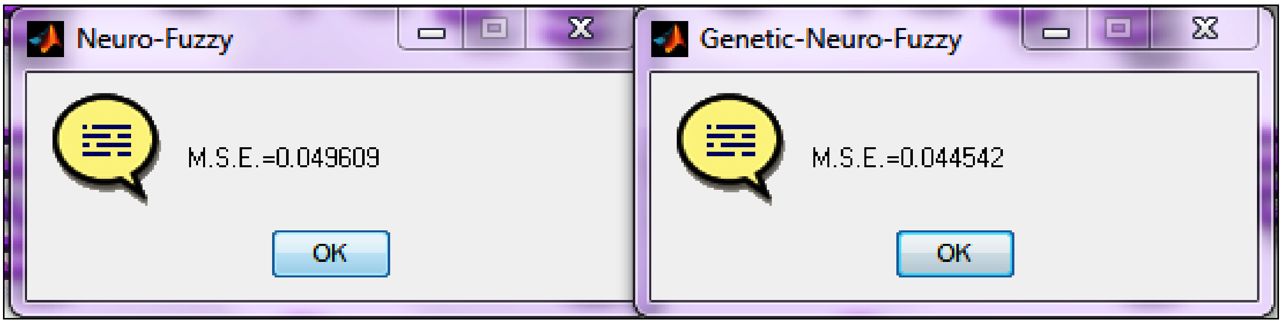

Fig 4. Mean Square Error

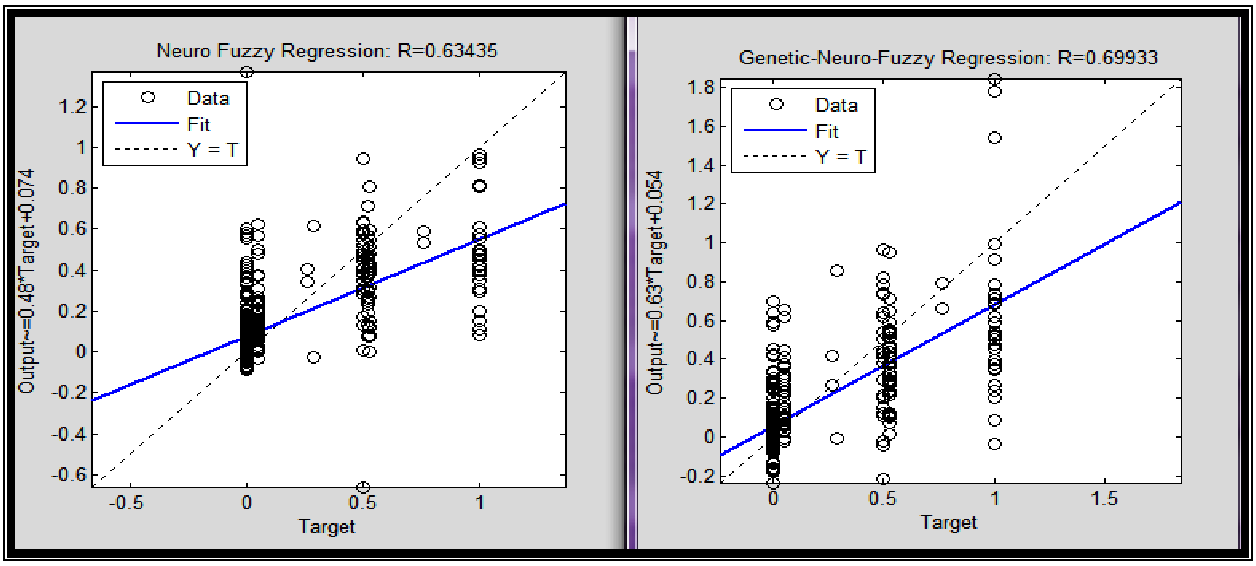

Fig 5. Regression

V. Conclusions

The Genetic Neuro Fuzzy System classifies the input samples into 'Low', 'Medium' and 'High' risk samples by taking Obesity, Diabetes, Cholesterol, Renal factors etc. as the input parameters. The proposed system achieved a classification accuracy of 86% as compared to 79.3% by the Neuro Fuzzy System. The developed system is also better than Neuro Fuzzy System in terms of Mean Square Error and Regression. Thus it may be concluded that the results of the system are reliable for the system to be used as an aid or substitute to the medical experts.

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