Patient Health Care Analysis based on ANFIS Sugeno Model

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***Abstract*— The main research formulation of the problem deals with how blood pressure affects the different parts of the human body with the use of the proposed fuzzy logic controller. The proposed work focus about Adaptive Neuro Fuzzy Interface System (ANFIS) depends on fuzzy logic controller to diagnose the various level of health risk factor value which is aggregated with Blood Pressure, Pulse Rate and Kidney function based on various Input Parameters. In this paper, Fuzzy Logic circuit was developed with 2's Complement in full adder using the input such as Blood Pressure value taken from Systolic and Diastolic value, Pulse Rate and GFR value. Due to increase in blood pressure measurement values, such as systolic and diastolic values how the kidney and other parts of our body function values are heavily affected are also discussed in this paper. The proposed ANFIS system is validated with blood pressure data set values using Mat Lab Fuzzy Tool Box, and simulated output analyse the risk factor value of a human being.**

Keywords— Pulse rate; Glomerular Filtration Rate; Adaptive Neuro Fuzzy Interface System; Systolic; Diastolic; membership function.

I. INTRODUCTION

Blood carries oxygen and food to all the body cells. Blood flow in a human body will be regular if there is no disturbance by the risk factors. The risk factors become a great risk, due to inexactness of blood pressure and cholesterol. Hence, to capture and overcome the unexpected, unknown and uncertain level of risk factors and kidney functions are identified using the blood pressure levels. Using the powerful mathematical logic called fuzzy logic is applied to mitigate the rate of mortality by kidney failure, in developing countries like India. Blood pressure is one of the most pre-dominant diseases in the modern world and focuses not only a medical but a social problem. Fuzzy approaches can play an important role in data mining [1]-[3]. Blood pressure is summarized by two measurements, systolic and diastolic, which depend on whether the heart muscle is contracting (systole) or relaxed between beats (diastole). Hence, in this paper, it is planned to implement an ANFIS system to overcome the uncertainties of different types of Blood pressure ranges. This proposed work helps to estimate the pulse rate and risk factors value and Kidney function value of a human being.

II. LITERATURE REVIEW- FUZZY LOGIC HEALTH CARE SYSTEM

The existing work published upon Fuzzy Expert System in medical cases encountered a broad spectrum including feedbacks, applications, innovations, conceptual studies and development of medical tools[8]-[9]. In the early time reported studies, the need, specialization, potential, requirements of fuzzification and strategies for implementing medical domain expert systems is discussed. The expert system layers are displayed for automatic creation of fuzzy expert systems with applicable to certain diseases and decision support systems.

The domain that are developed for implementing a fuzzy expert systems with reference to specific diseases, common usage medical diagnostic systems as well as for consulting of personal health[5][10]. The existing methodology are proposed for the implementation and improving performance of a rule based diagnostic decision support systems related to medical diagnosis.

III. PROPOSED METHODOLOGY

Problem Statement: Using the ANFIS fuzzy logic, A controller can be designed and experimented with a set of available knowledge to estimate the risk factor value of a human being with the use of sample data case related to various range of blood pressure flow with systolic and diastolic values and kidney function GFR values are represented. Therefore, in this research work, it is planned to propose a design methodology using ANFIS

controller to control the life risk factor values and analyse the different organs that are affected due to blood pressure, which in turn reduces the rate of mortality.ANFIS represent Sugeno Tsukamoto fuzzy models.

Mathematical Model for ANFIS - Layer 1 : Collect the Current status of the patient regarding blood pressure by set of facts and represented using domain knowledge. Blood pressure are taken as a parameter range is divided into four fuzzy sets, namely, 'low', 'medium', 'high' and 'very high'.

The output of each node for systolic and diastolic Blood pressure range value is represented by:

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

$$O_{1,i} = \mu_{B_{i-2}}(y) \qquad for\ i = 3,4$$

Where $O_{1,i}(x)$ is essentially the membership grade for x and y. μA_i represents the any membership grade functions. For a zero-order Sugeno model, the output level z is a constant (a=b=0).The output level z_i of each rule is weighted by the firing strength w_i of the rule. Typical membership function is followed by the formula,

$$\mu_A(x) = \frac{1}{1+\left|\frac{x-c_i}{a_i}\right|^{2b_i}} \qquad (1)$$

where a_i, b_i, c_i are parameters to be learnt. These are the premise parameters.

Layer 2 : The pulse rate was analyzed by given Systolic and Diastolic values. Every node in this layer is fixed. This is where the t-norm is used to sum 'OR' the membership grades is represented by

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

Layer 3 : It contains fixed nodes which calculate the ratio of the firing strengths of the rules:

When the IF (condition) part of the rule matches a fact, the rule is fired and its THEN (action) part is executed. The condition is check blood pressure is mf1, pulse value represents mf2, and kidney function is representing as mf3.

$$If\ x\ is\ A_1\ and\ y\ is\ B_1 \quad THEN\ f_1 = p_1x + q_1y + r_1$$

$$, O_{3,i} = \overline{w_i} = \frac{w_i}{w_1 + w_2}$$

Layer 4 : The nodes in this layer are adaptive and perform the consequent of the rules: Using AND , OR operator to input the value mf value to the rule, the rule was analyse in to the engine and single truth value to be determine for the patient risk stage.

$$O_{4,i} = \overline{w_i} f_i = \overline{w_i}(p_i x + q_i y + r_i)$$

The parameters in this layer (p_i, q_i, r_i) are to be determined and are referred to as the consequent parameters.

Layer 5 : There is a single node here that computes the overall output: Defuzzification is the process of converting the final output of a fuzzy system to a crisp value. The health risk are determines the level of severity of depression risk given the input variables.

$$O_{5,i} = \sum_i \overline{w_i} f_i = \frac{\sum_i w_i f_i}{\sum_i w_i}$$

Pseudo code for ANFIS

Step 1 : start the process

Step 2: State the variables Blood pressure, kidney function GFR and pulse values.

Step 3: Calculate the pulse rate and each w_i is scaled into in the normalization layer.

Step 4 : Each $\overline{w_i}$ weighs the result of its linear regression f_i in the function layer, generating the rule output.

Rule 1 : IF X is low AND Y is low AND Z is low AND W is very high then P is Low

Rule 2 : IF X is low AND Y is normal AND Z is low AND W is very high then P is very Low

Rule 3 : IF X is low AND Y is low AND Z is low AND W is very high then P is medium

Rule 4 : IF X is low AND Y is very high AND Z is low AND W is high then P is short

Step 5: Estimate the ANFIS membership functions for different set of blood pressure ranges.

μagg(p) = max{min(2/5, μL(p)), min(1/2, μVL(p)), min(2/5, μM(p)), min(1/2, μS(p))}

Membership function for calculating blood pressure range is estimated as

Membership function for calculating blood pressure range is estimated as

$$\mu BP(x) \begin{cases} \mu L(x) = 120\text{-}x/60 \quad for 60 <= x <= 120 \\ 80\text{-}x/40 \quad for\ 40 <= x <= 80 \\ \mu N(x) = x\text{-}60/60 \quad for\ 60 <= x <= 120 \\ 140\text{-}x/20 \quad for\ 140 <= x <= 60 \\ x\text{-}80/5 \quad for\ 80 <= x <= 85 \\ 95\text{-}x/10 \quad for\ 85 <= x <= 95 \end{cases}$$

Step 6: Each rule output is added in the output layer by range value of $\sum_i \overline{w_i f_i} = \frac{\sum_i w_i f_i}{\sum_i w_i}$

Step 7 : Compute the patient risk stage using AND , OR operator and Fuzzy Inference System(FIS) defuzzification which r(t) = d(t)+s(t)
Step 8: stop the process

IV. PROPOSED ANFIS ARCHITECTURE

The proposed adaptive neuro fuzzy system generally comprises the following steps:

(i)Selection of different blood pressure range from database as input

(ii)implementing the appropriate fuzzy membership functions and operators

(iii) identify the accurate fuzzy inference system

(iv)Formulation of knowledge Blood pressure rule base

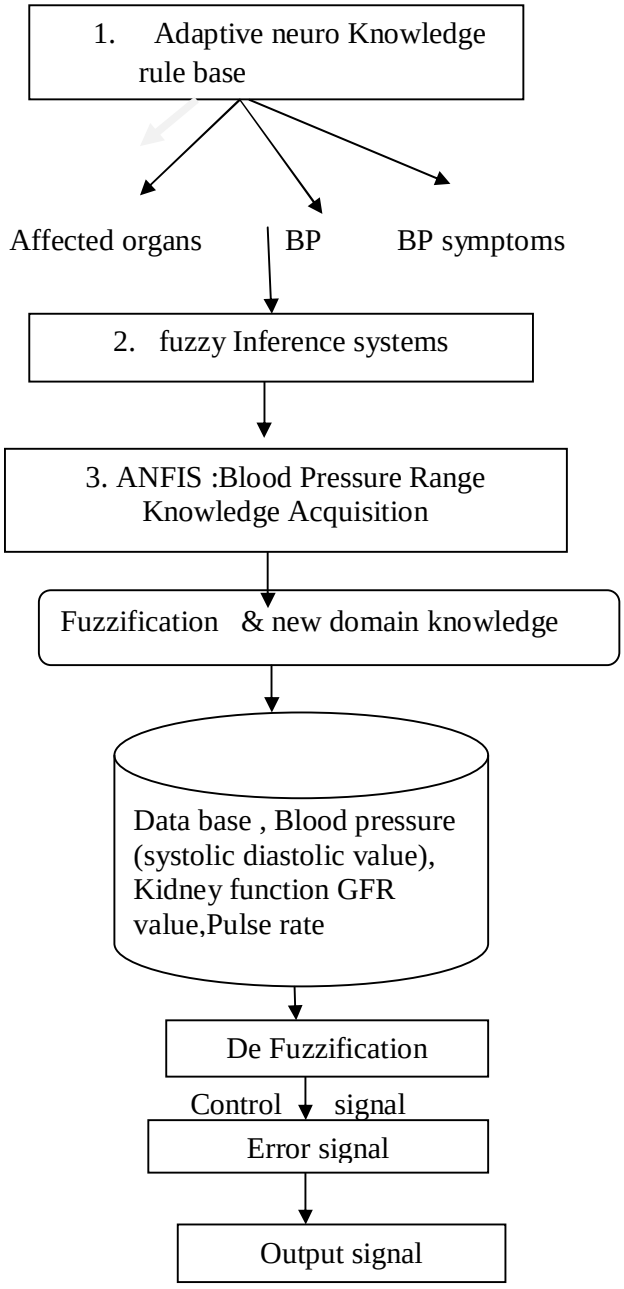

Fig 1. ANFIS Architecture

Figure 1 represents the architecture of a proposed system showing the data flow through the neuro fuzzy interface system. It consists of mainly knowledge rule base, knowledge acquisition , blood pressure range, kidney function and pulse rate knowledge base and inference engine modules. In the adaptive neuro fuzzy system, the user can get

the details such as blood pressure range, affected organs and symptoms from the knowledge base to inference. The knowledge acquisition module allows user to seek the inputs as well as to build the new domain knowledge. The input variables are fuzzified whereby the membership functions defined on the input variables are applied to their actual values, to determine the degree of truth for each rule antecedent. The fuzzy rule base is characterized in the form of *if-then* rules in which the antecedents and consequents involve linguistic variables.. The following figure represents the architecture of the proposed adaptive neuro fuzzy interface system.

V. EXPERIMENTAL RESULTS AND DISCUSSIONS

Under the process fuzzification was handle for first step a proper choice of process state variables and control variables is essential to characterization of the operation of a fuzzy logic control system. In decision making logic, If..Then rule base follow for measuring the membership values obtained. Finally the defuzzification is processed for combining the fuzzy outputs of all the rules to give one crisp value

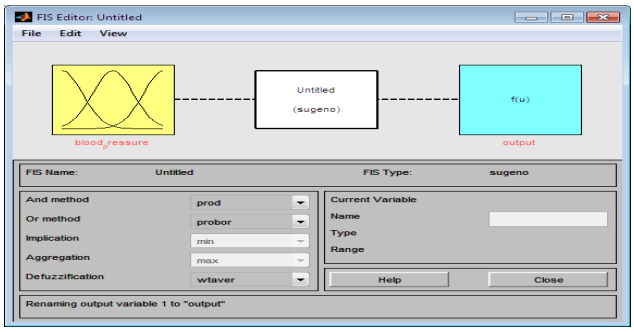

Fig.2. Member function of Blood Pressure

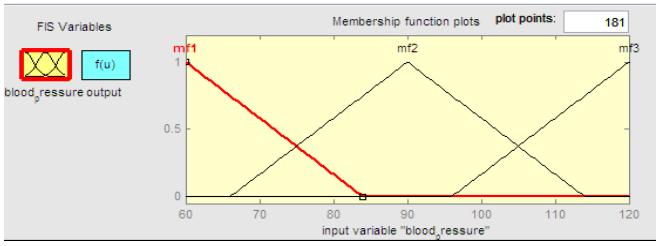

Fig.3. Final plot of Member function - Blood Pressure

From fig.2 and fig.3 represents the member function of blood pressure are constructed for finding the risk factor. The inference engine compares each rule stored in the knowledge base with facts contained in the database. When the IF (condition) part of the rule matches a fact, the rule is fired and its THEN (action) part is executed. The condition is check blood pressure is mf1, pulse value represent mf2, kidney function is represent as mf3. The inference engine uses a system of rules to make decisions through the fuzzy logical operator and generates a single truth value that determines the outcome of the rules. This way, they emulate human cognitive process and decision making ability and finally they represent knowledge in a structured homogenous and modular way.

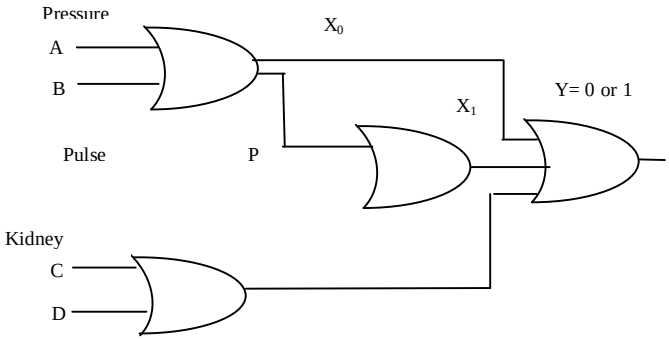

Fig.4. Logic gate for finding the risk rate

From the figure 4 and 5 describe, A and B are pressure value which represent as X0, pulse values are derived from given pressure value which represent X1, C and D are Kidney function value which represent X2. The pulse rate was analyzed by given Systolic and Diastolic values. Finally risk factor was analyzed by pulse rate and analysis by GFR rate of kidney functions.

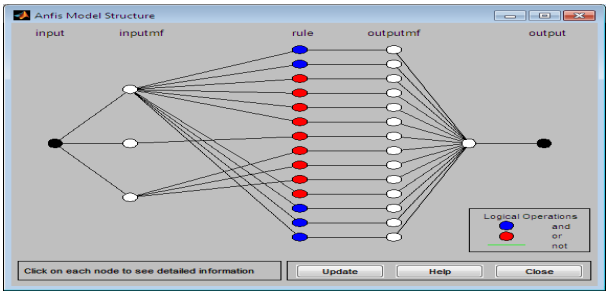

Fig.5 analyse the rule using logical operator

VI. Result and Discussion

Using Sugeno FIS method the patient health risk was found from the given input of linguistic variable of Blood pressure, Pulse rate and kidney functions. Using If ... Then rule and inference strategies are chosen for processing the rule base to determine the risk factor among the blood pressure, kidney function and pulse rate by logical decision making analysis. Through the defuzzification, fuzzy system provides an objective process of risk factor, also to view the surface view of the risk determination using simulation.

Conclusion

The main focus of this research work is the design of a fuzzy controller to analyse the risk factors value of the human being. The novel idea has been implemented and tested using Mat Lab successfully. The use of this approach is contributed to medical decision-making and the development of computer-assisted diagnosis in medical domain and identifies the major risk of the patient in earlier. The validation of the fuzzy logic controller is tested with blood pressure data and it is used to determine the risk factor value of an human being which is affected by blood pressure. The most innovative feature is the simulated of the rule viewer which shows the fuzzification and defuzzification using AND, OR gate. Rule base is also an predominant for our system to add or delete the rules. In future, this system is extended to analyse the risk factor values of different organs affected by blood pressure.

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