1201N

Smart Systems & Computational Intelligence

Prof. Mohamed Abdel Rahman

Semester Project

"Human Body Analysis Using Fuzzy Logic"

Read carefully the attached paper: ***"Human Blood Pressure and Body Temp Analysis Using Fuzzy Logic Control System"*** and understand the proposed fuzzy system presented.

You will work in **group of 4 – 6 students** to cover the following tasks:-

I. **Analyze carefully the original paper**

Inputs and outputs / Type of MFs for each variable / Rules

II. **Implement the original paper system using python & show results**

III. **Group Contributions**

- ✓ Add / replace input variables
- ✓ Adjust the fuzzy rules (cancel rules / modify rules / new rules)
- ✓ Re-implement the new system using your python fuzzy package
- ✓ Compare results of both systems

IV. **Presentation**

- 10 to 15 minutes / group for presentation and discussion
- All team members should present
- Presentation comprises **five main sections**:
  - ✓ Analysis of the original paper
  - ✓ Original paper code implementation
  - ✓ Modifications & contributions
  - ✓ Proposed code
  - ✓ Results' comparison

Due Date: Week 13

Grading: 10 Marks

Human Blood Pressure and Body Temp Analysis Using Fuzzy Logic Control System

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Abstract:
Usually "hypertension" is referred to as High_Blood_Pressure. Systolic_Blood_pressure and Diastolic_Blood_Pressure are used as measured parameter for BP. In this paper, proposed system based on FL is designed in order to facilitate peoples by generating accurate information related to health condition. In general blood pressure is classified into three categories: Low, Normal and High. Fuzzy logic is based on "Logic" which is based on many-values or credibility of logic; it deals with inference. This inference has approximate values rather than exact, accurate or settled values. In this paper, Blood Pressure and human Body Temperature values are set as input and applied using fuzzy logic algorithm. Finally we are analyzing the output values. The Proposed model for the analysis of Blood Pressure and Temperature gives more Pragmatic results than any linear model.
Keywords:
Fuzzy Logic (FL), Fuzzy Logic Control System (FLCS), Blood Pressure (BP), Systolic_Blood_Pressure (SBP), Diastolic_Blood_pressure (DBP), Temperature (TEMP), Membership Function (MF), Center of Average (CoA)

1. Introduction

Nowadays, majority of peoples are suffering from a diseases like TEMP and BP known as hypertension, are rapidly increase. BP measurement is an exceedingly delicate task because even breathing cans principle variation as_high_as 10mmHg in reading of BP [1]. One prediction by physicians that 1/3 of the world's population will be misfortune from high_BP by 2025 [2]. FLCS are capable of generating accurate result from approximate, insufficient or vague information. FL has been extended to handle the concept of partial truth, where the truth value may rage between completely true or completely false. FL is a system which has variables with the truth value. The range of that truth table is in degree between "0" and "1". It is a scheme which is depends on logic and theory of set and variable continuity. Its implementation can be done by "Hardware" or "Software" or by combining both. The fuzzy rules are applied and simulation for the system can be formulated using MATLAB.

2. Heart_Rate and Blood_Pressure:

Biologically, Heart_Rate is the number of heart beats/minute. The cardiac output is the volume of blood / minute pumps by heart into the aorta artery [3]. Beside, BP is the force strives by the blood against the walls of arteries. Traditionally, BP is recorded as ratio of two numbers, SBP and DBP.

3. Fuzzy Logic:

FL popularized by Dr. Lotif A. Zadeh in 1962 [1]. Fuzzy logic is designed for offering partial set memberships and to overcome the deficiencies of bivalent logic. Fuzzy sets are commonly characterized in terms of their Membership_Function. The MF of a crisp set receives on only two values '0' or '1'; While the membership function of a fuzzy set can range between '0' and '1'.

4. Design Algorithm:

The algorithm devised for this system is subsisting of two fuzzy input variables. The five fuzzy membership functions for BP input are termed as: normal 80-120, pre hypertension 90-140, high_BP_stage_1 100-160, and high_BP_stage_2 110-170, and emergency 130-180.

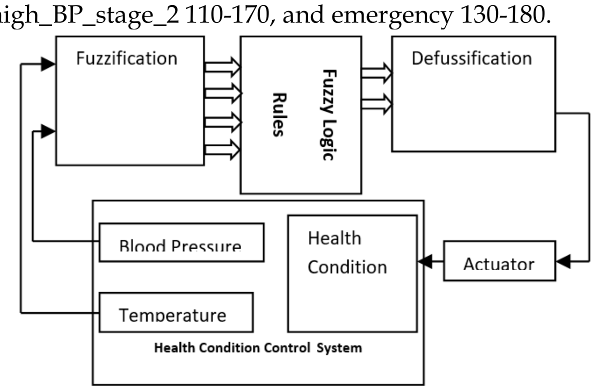

Fig. 1: Block diagram of Health Condition using fuzzy logic system

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The five fuzzy membership functions for TEMP I
The five fuzzy membership functions for TEMP input are: low <100, temp 98-100, temp high_1 101-102, temp high_2 103-104, and emergency 105-106. The control valves for health condition output variable subsists of three MF: Good, Normal and worst.

4.1 Fuzzifier:

The process of illustrate crisp values in linguistic terms is called "Fuzzification". In this method the input crisp values are correlated by the Fuzzifier with certain levels and by the process of Fuzzifier they can generate linguistic values of each input variable for inference engine [4]. The fuzzifier's set point uses the data which contain two input variables, "BP" and "TEMP". Their engaged region depiction, MF and range are given in Table 1 and Table 2.

Table 1: MF and matter of input variable BP

Membership function	Ranges (mmHg)	Region Occupied
Normal	80-120	1
Pre Hypertension	90-140	1-2
High BP Stage 1	100-160	2-3
High BP Stage 2	110-170	3-4
Emergency	130-180	4

Table 2: MF and matters of input variable TEMP

Membership function	Ranges	Region Occupied
Low	<100	1
Temp	100-101	1-2
Temp High 1	101-102	2-3
Temp High 2	102-104	3-4
Emergency	104-106	4

For each input variable, five membership functions are used as shown in fig. 2 and fig. 3.

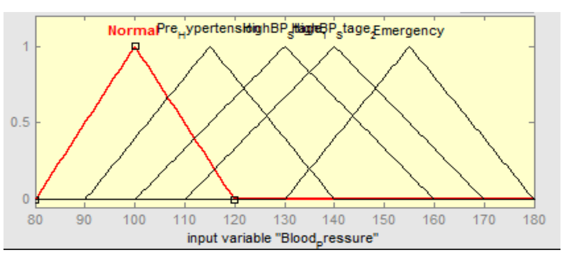

Fig. 2: plot of MF for input variables, "BP"

The five MF, "Normal", "Pre Hypertension", "High BP Stage 1", "High BP Stage 2", and "Emergency" are used to show the various ranges of input fuzzy variables "BP" in a plot consisting of four regions as shown in fig.2.

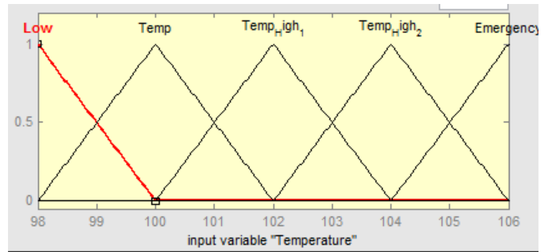

Fig. 3: Plot of membership functions for input variables, "Temperature"

The five MF, "Low", "Temp", "Temp High 1", "Temp High 2", and "Emergency" are used to show the various matters of input fuzzy variables "TEMP" in a plot consisting of four regions as shown in fig.3.
The linguistic values are used to map the values of the fuzzy input variables with the MF occupied in the regions. As we are using two variables, therefore four linguistic values are demonstrated in fig.3. The mapping of input fuzzy variables with the functions of four regions is listed in Table 3.

Table 3: Linguistic values of fuzzifiers outputs in all regions

Input variables	**Linguistic Fuzzifiers Outputs**	**Region 1**	**Region 2**	**Region 3**	**Region 4**
BP	a1	a1[1]	a1[2]	a1[3]	a1[4]
	a2	a1[2]	a1[3]	a1[4]	a1[5]
TEMP	a3	a2[1]	a2[2]	a2[3]	a2[4]
	a4	a2[2]	a2[3]	a2[4]	a2[5]

Table 4: Rule mapping for regions occupied

Case no.	Region occupied		Rules Rules fn[m]= Membership value, where n=No. of input variable, m=No. of membership function MF occupied
	BP Input Variable 1	TEMP Input Variable 2	
1.	1	1	M1 = a1 ^ a3 =a1[1] ^ a2[1] M2 = a1 ^ a4 =a1[1] ^ a2[2] M3 = a2 ^ a3 =a1[2] ^ a2[1] M4 = a2 ^ a4 = a1[2] ^ a2[2]
2.	1	2	M1 = a1 ^ a3 = a1[1] ^ a2[2] M2 = a1 ^ a4 = a1[1] ^ a2[3] M3 = a2 ^ a3 = a1[2] ^ a2[2] M4 = a2 ^ a4 = a1[2] ^ a2[3]
3.	1	3	M1 = a1 ^ a3 = a1[1] ^ a2[3] M2 = a1 ^ a4 = a1[1] ^ a2[4] M3 = a2 ^ a3 = a1[2] ^ a2[3] M4 = a2 ^ a4 = a1[2] ^ a2[4]
4.	1	4	M1 = a1 ^ a3 = a1[1] ^ a2[4] M2 = a1 ^ a4 = a1[1] ^ a2[5] M3 = a2 ^ a3 = a1[2] ^ a2[4] M4 = a2 ^ a4 = a1[2] ^ a2[5]
5.	2	1	M1 = a1 ^ a3 = a1[2] ^ a2[1] M2 = a1 ^ a4 = a1[2] ^ a2[2] M3 = a2 ^ a3 = a1[3] ^ a2[1] M4 = a2 ^ a4 = a1[3] ^ a2[2]
6.	2	2	M1 = a1 ^ a3 = a1[2] ^ a2[2] M2 = a1 ^ a4 = a1[2] ^ a2[3] M3 = a2 ^ a3 = a1[3] ^ a2[2] M4 = a2 ^ a4 = a1[3] ^ a2[3]

7.	2	3	M1 = a1 ^ a3 = a1[2] ^ a2[3] M2 = a1 ^ a4 = a1[2] ^ a2[4] M3 = a2 ^ a3 = a1[3] ^ a2[3] M4 = a2 ^ a4 = a1[3] ^ a2[4]
8.	2	4	M1 = a1 ^ a3 = a1[2] ^ a2[4] M2 = a1 ^ a4 = a1[2] ^ a2[5] M3 = a2 ^ a3 = a1[3] ^ a2[4] M4 = a2 ^ a4 =a1[3] ^ a2[5]
9.	3	1	M1 = a1 ^ a3 = a1[3] ^ a2[1] M2 = a1 ^ a4 = a1[3] ^ a2[2] M3 = a2 ^ a3 = a1[4] ^ a2[1] M4 = a2 ^ a4 =a1[4] ^ a2[2]
10.	3	2	M1 = a1 ^ a3 = a1[3] ^ a2[2] M2 = a1 ^ a4 = a1[3] ^ a2[3] M3 = a2 ^ a3 = a1[4] ^ a2[2] M4 = a2 ^ a4 = a1[4] ^ a2[3]
11.	3	3	M1 = a1 ^ a3 = a1[3] ^ a2[3] M2 = a1 ^ a4 = a1[3] ^ a2[4] M3 = a2 ^ a3 = a1[4] ^ a2[3] M4 = a2 ^ a4 = a1[4] ^ a2[4]
12.	3	4	M1 = a1 ^ a3 = a1[3] ^ a2[4] M2 = a1 ^ a4 = a1[3] ^ a2[5] M3 = a2 ^ a3 = a1[4] ^ a2[4] M4 = a2 ^ a4 = a1[4] ^ a2[5]
13.	4	1	M1 = a1 ^ a3 = a1[4] ^ a2[1] M2 = a1 ^ a4 = a1[4] ^ a2[2] M3 = a2 ^ a3 = a1[5] ^ a2[1] M4 = a2 ^ a4 = a1[5] ^ a2[2]
14.	4	2	M1 = a1 ^ a3 = a1[4] ^ a2[2] M2 = a1 ^ a4 = a1[4] ^ a2[3] M3 = a2 ^ a3 = a1[5] ^ a2[2] M4 = a2 ^ a4 =a1[5] ^ a2[3]
15.	4	3	M1 = a1 ^ a3 = a1[4] ^ a2[3] M2 = a1 ^ a4 = a1[4] ^ a2[4] M3 = a2 ^ a3 = a1[5] ^ a2[3] M4 = a2 ^ a4 = a1[5] ^ a2[4]
16.	4	4	M1 = a1 ^ a3 = a1[4] ^ a2[4] M2 = a1 ^ a4 = a1[4] ^ a2[5] M3 = a2 ^ a3 = a1[5] ^ a2[4] M4 = a2 ^ a4 = a1[5] ^ a2[5]

Fuzzification process for two variables need two separate fuzzifiers. Each fuzzifier consists of: input BP value to crisp value, operation region of a crisp value detector, fuzzy set membership function value and selection arrangement [5]. The design of fuzzifier is shown in fig. 4.

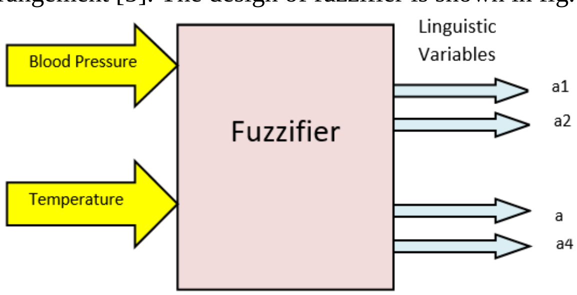

Fig. 4: Fuzzifier Block

4.2 inference engine

The inference engine is a system which consists of four "AND" operators. These AND operators select minimum value input for generate the corresponding output. Our purposed system's inference engine accepts four inputs from Fuzzifier and applies the min-max composition to attain the output R values. The min-max inference method uses min-AND operation among the four inputs. Fig.5 shows this type of inference process.

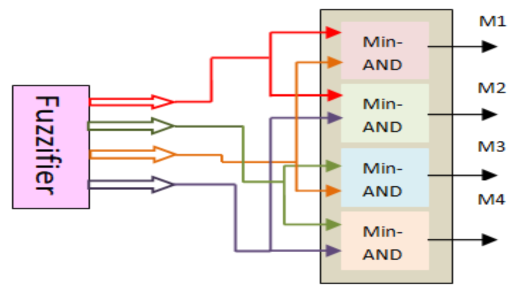

Fig. 5: Block diagram of inference engine

Number of active rules = a^b**,** where a = maximum number of overlapped fuzzy sets and b= number of inputs. For this design, a = 5 and b = 2, so the total number of active rules are 25.The total number of rules is equal to the product of number of functions accompanied by the input variables in their working range [6]. The two input variables described here consisted of five membership functions. Thus, 5 x 5 = 25 rules were required which are shown in Table 5.

Table 5: Total numbers of rules

Input		**Output**
BP	**TEMP**	**Health Condition**
Normal	Low	Good
Normal	Temp	Normal
Normal	Temp High 1	Normal
Normal	Temp High 2	Worst
Normal	Emergency	Worst
Pre Hypertension	Low	Good
Pre Hypertension	Temp	Normal
Pre Hypertension	Temp High 1	Worst
Pre Hypertension	Temp High 2	Worst
Pre Hypertension	Emergency	Worst
High_BP_Stage 1	Low	Normal
High_BP_Stage 1	Temp	Worst
High_BP_Stage 1	Temp High 1	Worst
High_BP_Stage 1	Temp High 2	Worst
High_BP_Stage 1	Emergency	Worst
High_BP_Stage 2	Low	Worst
High_BP_Stage 2	Temp	Worst
High_BP_Stage 2	Temp High 1	Worst
High_BP_Stage 2	Temp High 2	Worst
High_BP_Stage 2	Emergency	Worst
Emergency	Low	Worst
Emergency	Temp	Worst
Emergency	Temp High 1	Worst
Emergency	Temp High 2	Worst
Emergency	Emergency	Worst

4.3 Rule Selector

The rule selector obtain two crisp values of BP and TEMP. It gives singleton values of output functions under algorithm rules applied on design model. For two variables, four rules are needed to find the corresponding singleton values N_1, N_2, N_3 and N_4 for each variable according to these rules are listed in Table 6.

Table 6: Manifest of rules applied model

Rule No	Inputs BP	TEMP	Output Health Condition	Singleton Value
1	110	101	0.822	N_1
2	130	102	0.822	N_2
3	140	104	0.822	N_3
4	155	105	0.822	N_4

The rule base gets two crisp input values. It distributes these values into regions with each region containing two fuzzy variables, fires the rules. And then these rules gives the output singleton values corresponding to each output variable. Fig. 8 shows the main block diagram of the Rule Base.

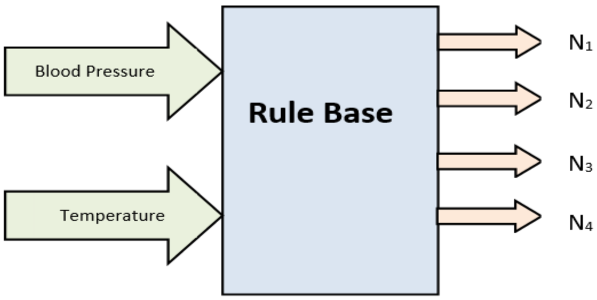

Fig. 6: Rule Base

4.4 Deffuzifier:

The defuzzification process generates the Crisp_Value_Outputs after estimating its inputs [7]. In our purposed system 8 inputs are given to each of the two defuzzifiers. Four values of M1, M2, M3, M4 from the outputs of inference engine and four values N_1, N_2, N_3, and N4 from the rule selector are shown in Fig. 7 (output MF). Each defuzzifier estimates the crisp value output according to the CoA method using the mathematical expression, $\Sigma N_i * \mathbf{M_i} / \Sigma M_i$, where i = 1 to 4. Each output variable membership function plot consists of five functions with the same range values for simplification.

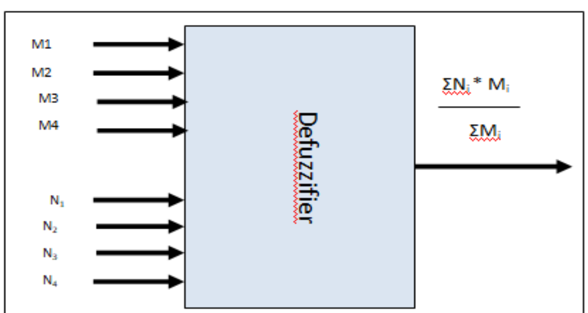

Fig. 7: Defuzzifier Block

Fig. 7 shows the design arrangement of a defuzzifier. One defuzzifier consists of: one adder for ΣM_i, four multipliers for the product of N_i*$\mathbf{M_i}$, one adder for $\Sigma N_i * \mathbf{M_i}$, and one divider for $\Sigma N_i * \mathbf{M_i} / \Sigma M_i$. Finally a defuzzifier gives the estimated crisp value output. Fig. 8 and 9 shows the MATLAB simulation result of proposed system.

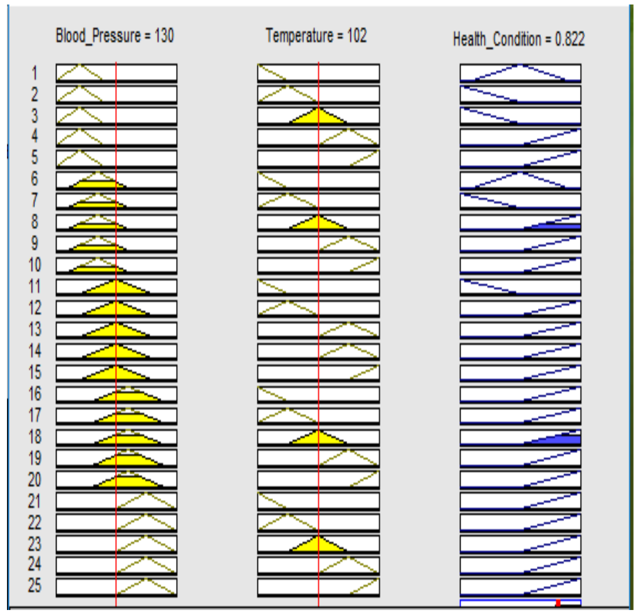

Fig. 8: MATLAB rule viewer and simulation results for health control Fuzzy logic system at Input (BP= 130, Temp = 102)

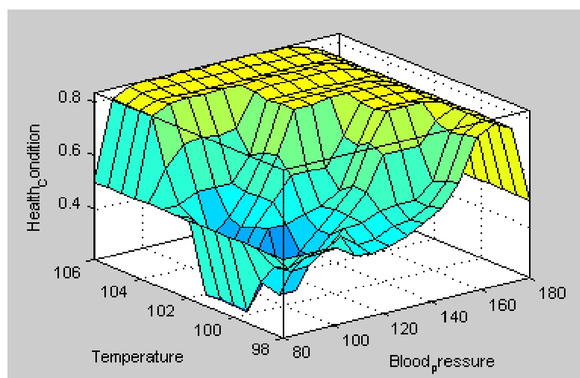

Fig. 9: Plot between Blood Pressure and Temperature at Input (BP= 130, Temp = 102)

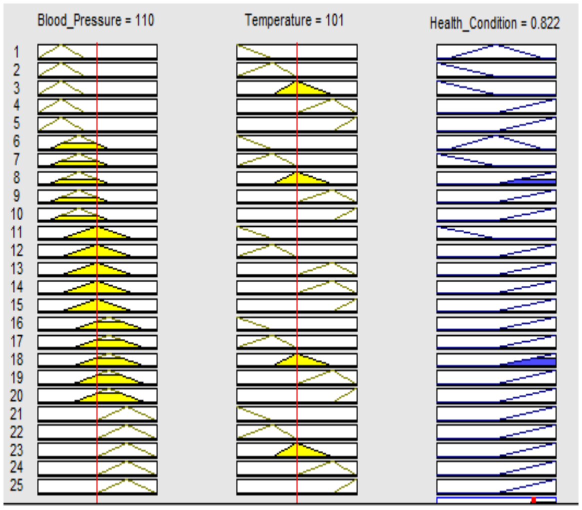

Fig. 10: MATLAB rule viewer and simulation results for health control Fuzzy logic system at Input (BP= 110, Temp = 101)

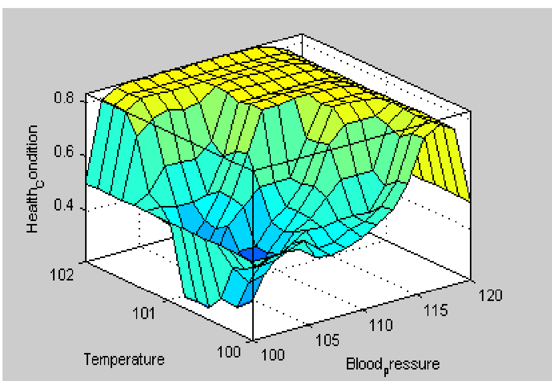

Fig 11: Plot between Blood Pressure and Temperature at Input (BP= 110, Temp = 101)

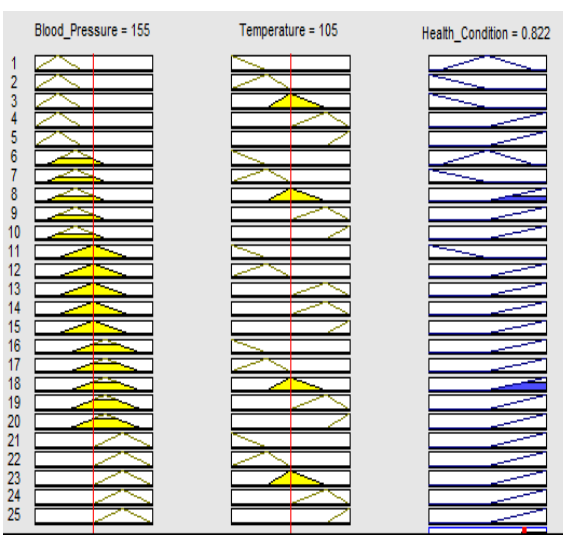

Fig 12: MATLAB rule viewer and simulation results for health control Fuzzy logic system at Input (BP= 155, Temp = 105)

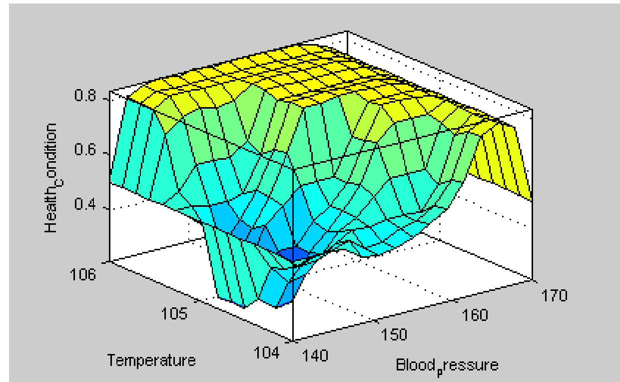

Fig 13: Plot between Blood Pressure and Temperature at Input (BP= 155, Temp = 105)

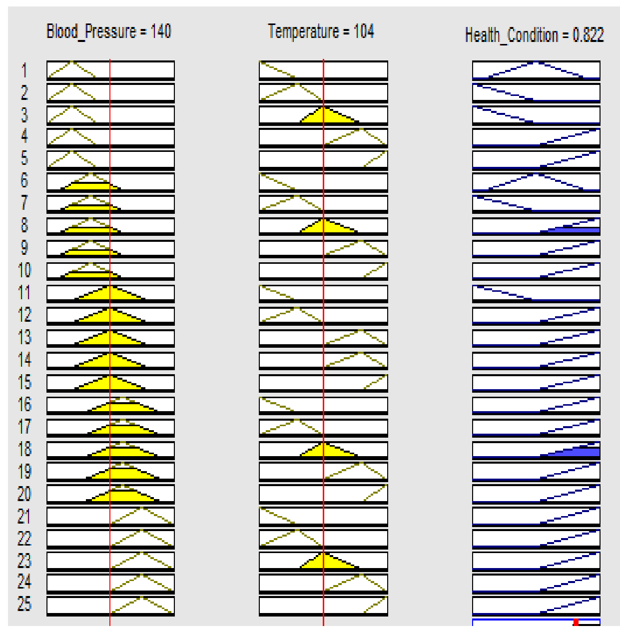

Fig 14: MATLAB rule viewer and simulation results for health control Fuzzy logic system at Input (BP= 140, Temp = 104)

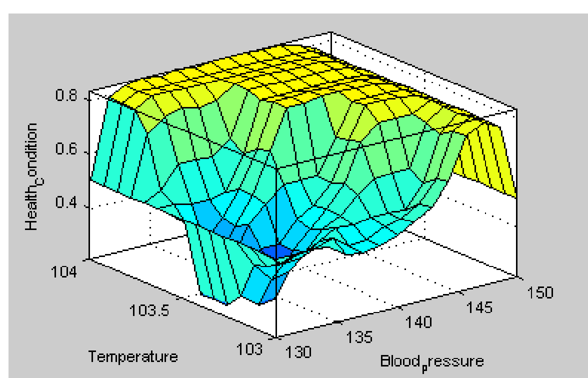

Fig 15: Plot between Blood Pressure and Temperature at Input (BP= 140, Temp = 104)

5. Conclusion:

The BP and TEMP values are taken as an input using fuzzy logic. The output values are produced by fuzzy logic techniques. There are many papers published related to the diagnosis of various diseases. But no one discuss the problem of BP with body TEMP. Here BP level with TEMP is discussed. In future work sugar level and risks factors discussed.

References

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