

A STUDY ON FUZZY EXPERT SYSTEM FOR DIAGNOSIS OF DIABETES MELLITUS

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ABSTRACT

The Aim of this paper is to design a Fuzzy Expert System (FES) for Diagnosis of Diabetes in Human Beings. Generally Diabetes occurs when your body does not make enough insulin or cannot use insulin, it leads to Type 1, Type 2 Diabetes. Fuzzy Expert System are extensively used in both Applied and Experimental Medicine and are one of the most prevalent subjects of Today's Medical Informatics. All designed Fuzzy Expert System can help in support decision process of physicians. This paper describes Fuzzy inference engine was designed using MATLAB software, based on Mamdani's fuzzy logic method with max-min composition and centroid defuzzification. Diabetes data obtained will be processed using fuzzy logic approach to programming MATLAB and made Graphical User Interface (GUI). Fuzzy Expert System is very useful and helpful for doctors or users to diagnosis the disease of patient in a short time and effectively via the identified symptoms.

Keywords: Expert System, Web based, Fuzzy Logic, MATLAB, Graphical User Interface (GUI).

1. INTRODUCTION

Nowadays the use of computer technology in the field of medicine area diagnosis, becomes highly increased by which patient ready to treatment of illnesses. Despite the fact that these fields, in which the computers are widely used, have very high complexity and uncertainty and that the use of intelligent systems such as Fuzzy Logic, Artificial Neural Network(ANN) and Genetic Algorithm have been developed. This paper aims to model an intelligent system capable of providing low-risk advice to patients in real time and mentioned risk factors as markers/determinants. Motivated by concepts from earlier researches, the proposed frame work draws and translates knowledge from a diverse array of domains, (including artificial intelligence (AI), and medicine) into a fuzzy inference mechanism using MATLAB. The fuzzy logic approach is to be intended to reduce the classification complexities of similar patterns which may exist between individuals requiring different healthcare paths

This research uses primary data of diabetes mellitus which used as instrumentation to obtain data in process of disease diagnosis. Data is presented in the form of tabular models and variables each of the 50 diabetes patients and 50 non diabetes mellitus patients. To analyze data, this research paper uses Fuzzy Inference System (FIS) Mamdani with matlab Toolbox and Graphical User Interface (GUI).

2. DIABETES MELLITUS

Diabetes mellitus is a disease, which characterized by high blood glucose level as a result of either the body not producing enough insulin, or the body cells not properly responding to the insulin that is produced (insulin-resistance). There are many types of diabetes, the most common types are type 1 diabetes and type 2 diabetes (World Health Organization, 2006). Type 1 diabetes results from pancreatic beta-cells failure to produce insulin, Type 2 diabetes results from insulin resistance, a condition in which cells fail to properly use insulin, combined with an absolute or relative insulin deficiency and presently requires that patients inject themselves with insulin.. The expert system presented in this paper is concerned with type 2 diabetes only. Patients with type 2 diabetes mellitus need external insulin, for their survival.

In the year 2000, a study among 191 World Health Organization (WHO) member states confirms that 2.8% people for all age groups had diabetes, and this is expected to be 4.4% by the year 2030. This implies that the total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million in 2030 [3]. In Bangladesh, diabetes is reaching epidemic proportions; in some sectors of our society more than 10% of people have diabetes . Diabetes causes severe life threatening complications, such as hypoglycemic coma, blurred vision, loss of memory, severe impairment of renal function, insulin allergy, acute neuropathy, etc. Diabetes management requires mainly dietary control, physical exercise and then insulin administration. Medical doctors help in effective diagnosis as well as treatment of diabetes mellitus. However, it obviously associates with too costs. Despite remarkable medical advances, patient self-management remains the cornerstone of diabetic treatment.

3. FUZZY EXPERT SYSTEM DESIGNING

3.1 FUZZY SYSTEM

The most important application of fuzzy system (fuzzy logic) is in uncertain issues. When a problem has dynamic behavior, Fuzzy Logic is a suitable tool that deals with this problem(diagnosis). First step of this fuzzy expert system designing to determination of input and output variables. There are 4 input variables and 1 output variable. After that, we must design a membership functions (MF) of all variables. These membership functions determine the membership value of objects to fuzzy sets. At first, we will describe the input variables with its membership functions. In second step, we introduce the output variable with its membership functions and Next rules of system.

Knowledge-based intelligent system has been proven effective in solving many real-world problems requiring expert skills. Hence, to reduce the cost and improve the effectiveness of early detection as well as self-awareness of diabetes mellitus. Knowledge-based system for diagnosis can be used in variety of domains: plant disease diagnosis, credit evaluation and authorization, financial evaluation, identification of software and hardware problems and integrated circuit failures etc.

3.2 Fuzzy Inference System (FIS) With Mamdani

Fuzzy logic is a logic that has a value of vagueness or ambiguity (fuzzyness) between true and false. In the theory of fuzzy logic a value could be true and false simultaneously. But how much truth and falsity of a value depending on the weight of its membership. But how much truth and falsity of a value is depended on the quantity of its membership. People who are not familiar with fuzzy logic would have

thought that fuzzy logic is a very complicated and unpleasant. However, once people know it, he would be very interested and will be newcomers to participate studying fuzzy logic. Mamdani method is explain with Max-Min method. Mamdani method was introduced by Ebrahim Mamdani in 1975.

3.3 Membership Function

Definition

In this paper, two functions (triangular & trapezoidal) were adopted for membership in there fuzzy values as shown in (I) & (II) respectively.

$$\rho(x) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ \frac{x-a}{b-a}, & b \leq x \leq c \\ 0, & c \leq x \end{cases} \dots\dots\dots>(I)$$

$$\rho(x) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ 1, & b \leq x \leq c \\ \frac{d-x}{d-c}, & b \leq x \leq c \\ 0, & d \leq x \end{cases} \dots\dots\dots>(II)$$

3.4 Matlab Toolbox: Fuzzy

In order to use fuzzy logic functions that exist in Matlab, it must be installed on Fuzzy Toolbox first. Fuzzy Logic toolbox (FLT) provides Graphical User Interface facilities (GUI) to simplify the building, editing, and observing fuzzy reasoning system, namely:

Fuzzy Inference System (FIS) Editor to handle the high-level issues for the system—How many input and output variables are used? What are their labels or names? .Aggregation using max min composition and defuzzification using Centroid Method ,Bisector Method ,Som Method,etc are to be choosen.

Membership Function Editor to define the shapes of all the membership functions associated with its input and output variables of the FIS.

Rule Editor to edit the list of rules that defines the behavior of the fuzzy expert system

Rule Viewer to view the fuzzy inference diagram. Rule Viewer is used as a diagnostic the membership function, for example, which rules are to be active or how individual membership function shapes influence the results. Rule Viewer conclude your view to the detailed behavior of a FIS to help diagnose the behavior of specific rules or study the effect of changing input variables.

Surface Viewer to view the exposure of one of the outputs on any one or two of the inputs. It generates and plots an output surface map for the diagnosis. Surface Viewer generates a 3-D surface from the input variables and the output variable of a FIS.

3.5 Data

Sample data that used in this research is primary data from Hospital in Thanjavur. The object of research is data of patients with diabetes mellitus. Taken as many as 100 patients who randomly selected from 50 patients with diabetes and 50 patients without diabetes mellitus. processing Data will be processed using the approach of Fuzzy Inference System (FIS) Mamdani with supported by matlab toolbox.

4. METHODOLOGY

4.1 Fuzzy Inference System (FIS) Editor

A Fuzzy Expert System(FES) is a collection of membership functions and rules that are used to reason about data. Unlike conventional expert systems, which are mainly represented as symbolic reasoning engines, fuzzy expert systems are oriented toward numerical processing. The main part of the rule between "if" and "then" is the rule's as _premise_ or _antecedent_. This FIS has been divided into several steps. First steps are fuzzification, the second step is the rule evaluation, the third step is aggregation rule, and finally defuzzification with Centroid Method. To design the Fuzzy Expert system, the FIS tool in MATLAB is used.

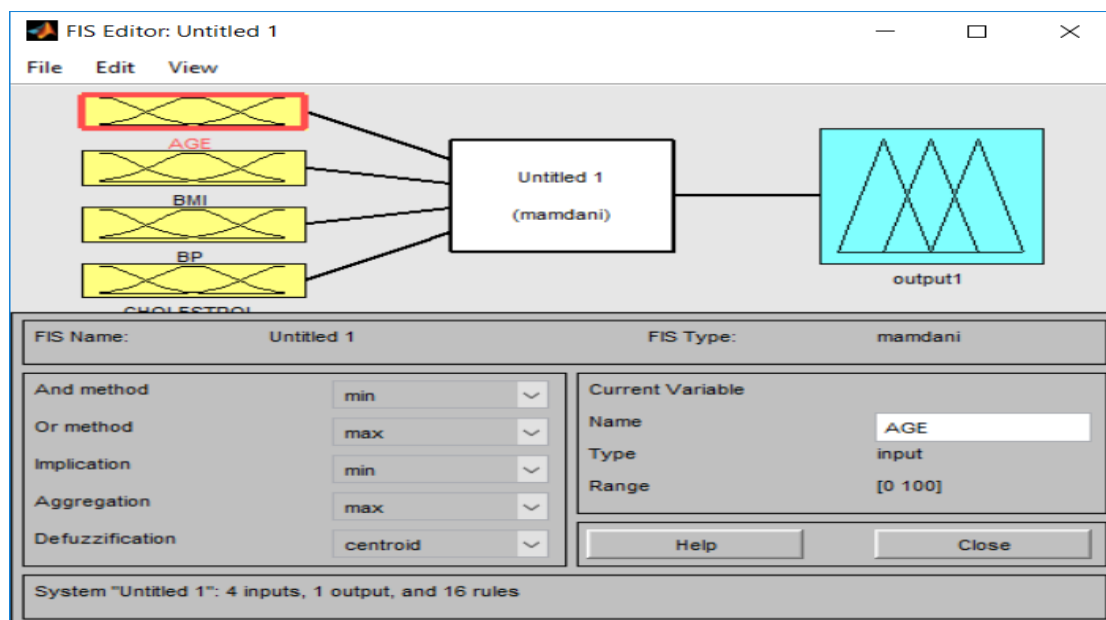


Figure 1: FIS Editor

4.2 Membership Function Editor

In this study, the analysis focused on how to design an expert system to diagnosis, Diabetes performed by range of age participants. The linguistic values and their corresponding membership functions have been determined by the aid of the expert, the statistical analysis of patient data. Examples of values and corresponding membership functions for the input age, BMI, BP and cholesterol are shown in Fig. 2, Fig. 3, Fig. 4 and Fig. 5 respectively. Figure 6 shows the membership function and linguistic variables for the output risk of Diabetes (%)

Input variable

4.2.1 Age : This input field divides to 4 fuzzy sets (Young, Middle, Old, Very old). These fuzzy sets with their ranges will be shown in Table 1 and its membership function editor for Age is in figure 2.

Table 1: Range of values and fuzzy sets of Age

Input	Range of values	Fuzzy sets
Age	< 38	Young
	31 -45	Middle
	41 – 60	Old
	>56	Very Old

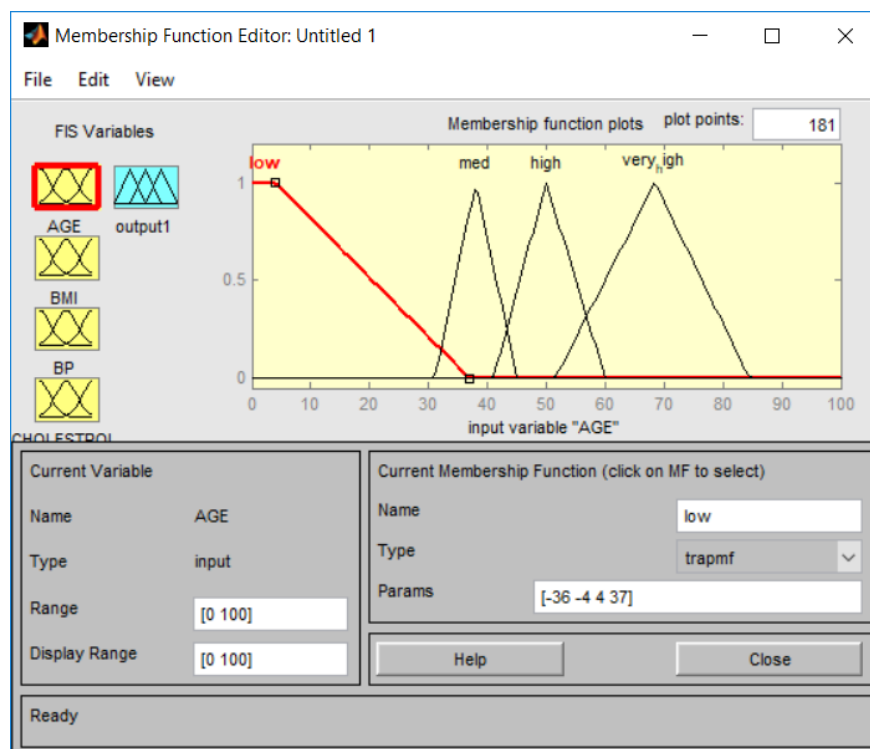


Fig 2: Membership functions of Age

4.2.2 BMI : the scales for weight and height gain is used. Body mass index is to be defined as the individual's body weight divided by the square of his or her height . The formula universally used in medicine create a unit of measure of kg/m^2 . The BMI can be divided in to three categories of BMI range. First category range is of 19 to 25 having a healthy weight. The second category in the range 16 to 18 is an underweight. The third category is ranged from 25 to 30 are considered to be overweight.

Table 2: Range of values and fuzzy sets of Body Mass Index(BMI)

Input	Range of values	Fuzzy sets
Body Index (BMI)	<18.5	Low
	13.5 – 24.9	Medium
	22 – 34.9	High
	>33	Very High

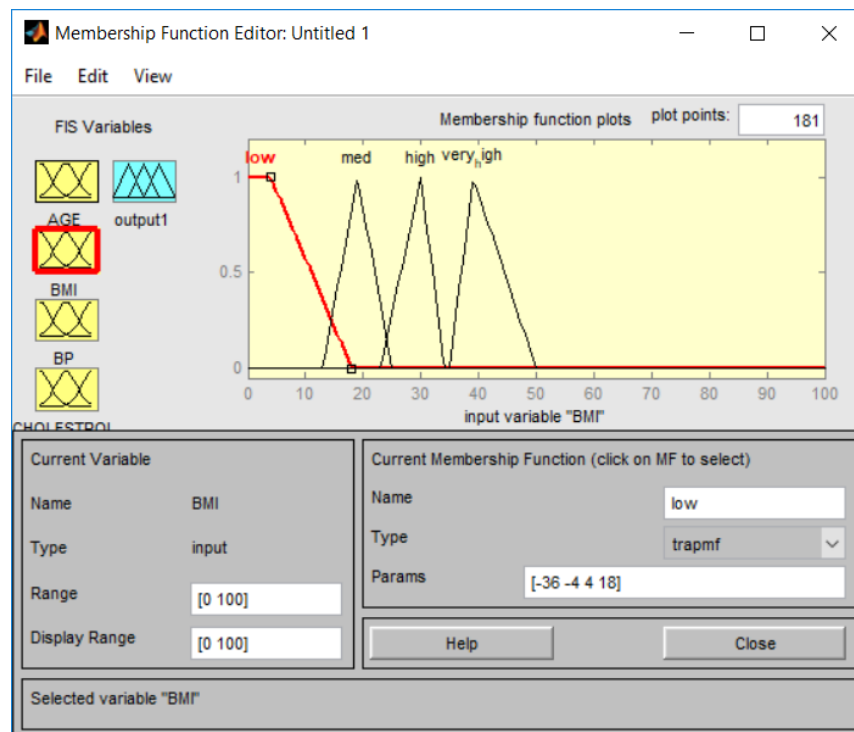


Fig 3: Membership functions of BMI

4.2.3 Blood Pressure: Different values of blood pressure change the result easily. In this field, we use systolic blood pressure. This input variable has been divided in to 3 fuzzy sets. Fuzzy sets are “Low”, “Medium”, “High” “very High”. To measure the Blood Pressure(BP), Non invasive blood pressures (NIBP) are used to get the reading. The normal blood pressure is 120/80mmHg where the 120mmHg is a Systolic (maximum) and 80mmHg is a Diastolic (minimum) [5]. When the blood pressure more than 139/89mmHg, the hypertension occurred.

Table 3: Range of values and fuzzy sets of systolic blood pressure

Input	Range of values	Fuzzy sets
Blood Pressure (BP)	<134	Low
	127 – 153	Medium
	142 – 172	High
	>154	Very High

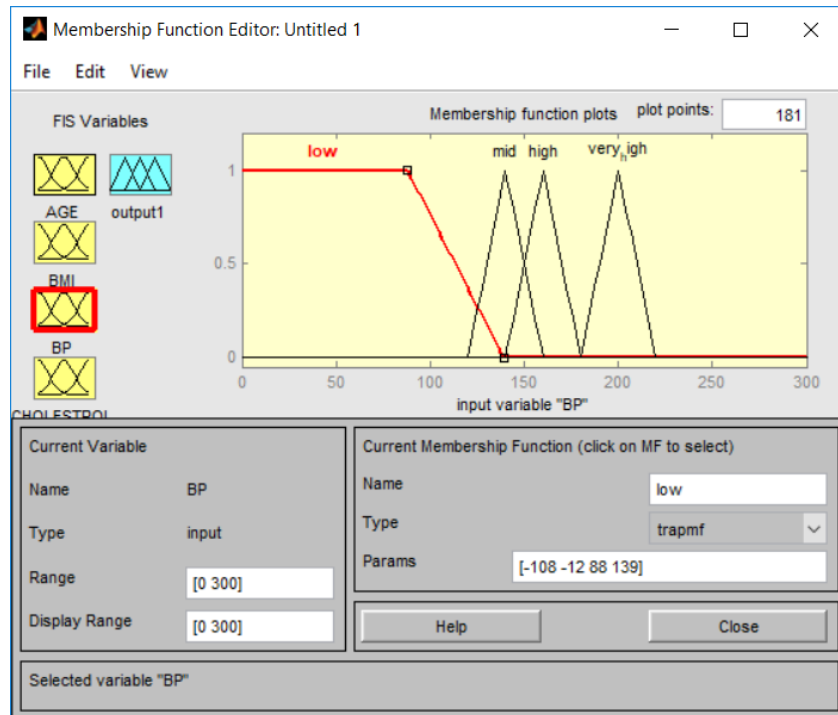


Fig 4: Membership functions of BP

4.2.4 Cholesterol: Cholesterol has salient affect on the result and can change it easily. For this input field, we use the range of low density lipoprotein (LDL) cholesterol. Cholesterol field has 4 fuzzy sets (Low, Medium, High, Very High).

Table 4 Range of values and fuzzy sets of Cholesterol

Input	Range of values	Fuzzy sets
Cholesterol	<197	Low
	188 – 250	Medium
	217 – 307	High
	>281	Very High

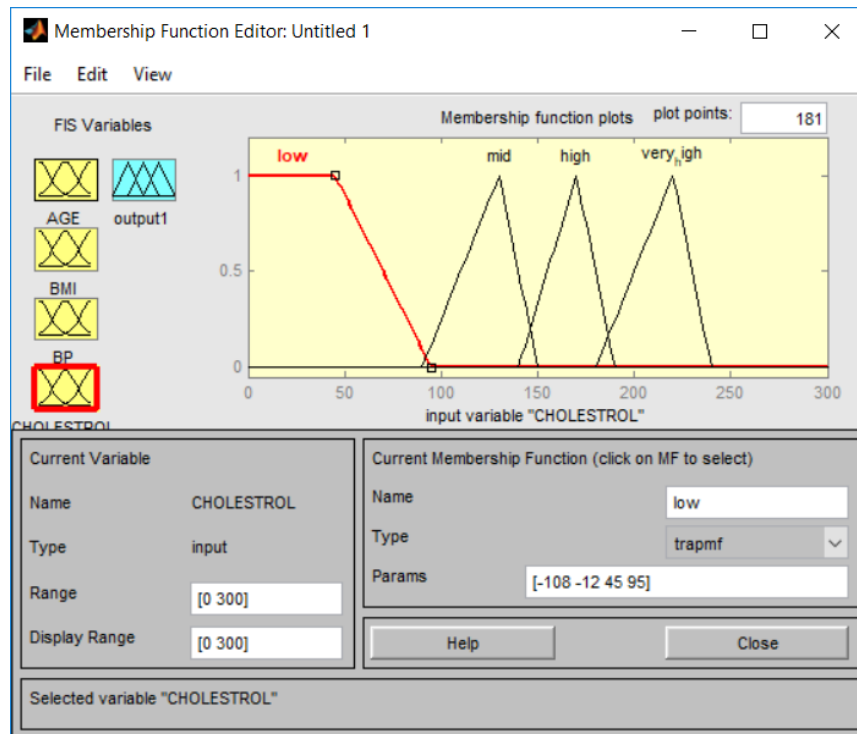


Fig 5: Membership functions of Cholesterol

4.3 FUZZY RULE BASE

Fuzzy Rule base is the main part in fuzzy inference system and quality of results in a fuzzy system depends on the fuzzy rules. This system includes 16 rules. Here, 16 rules are designed using fuzzy rule base as shown in Fig. 6. The rules have been developed using if-then method. For example, if Age is Young and BMI is Low and BP is Low and Cholesterol is low then the output risk is Low. Using these rules, the output result risk in terms of percentage (%) has been computed.

5. RESULT AND DISCUSSION

5.1 FUZZY RULE VIEWER AND SURFACE VIEWER

Figure 6 shows the result for the subject at the age of 50 years old, BMI is 37 kg/m², systolic blood pressure is 200 mmHg and cholesterol is 190 bpm. Hence, the output result obtained for this subject is 77.1%. This means that the subject has 77 % risk to get Diabetes based on the factor of age, BMI, blood pressure and Cholesterol.

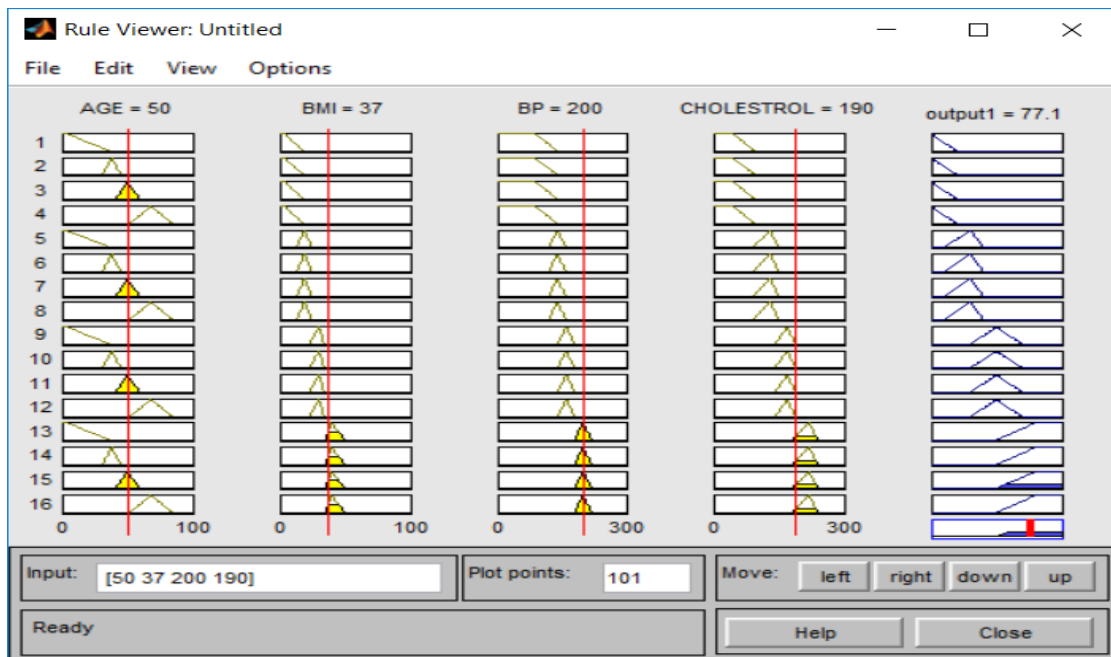


Figure 6: Rule viewer for diabetes

For the surface result, we can see the output for AGE versus BMI in three dimensions as shown in Fig. 7.

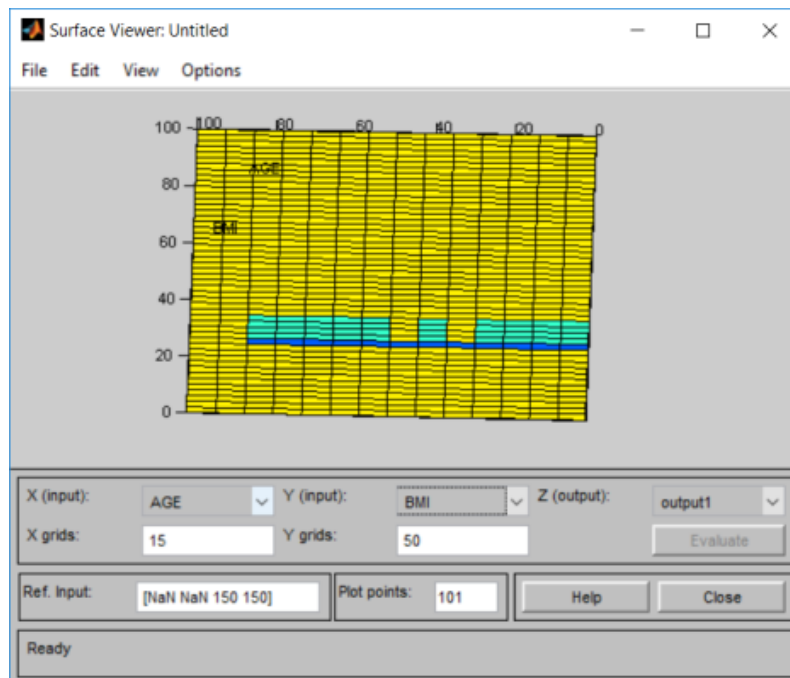


Figure 7: Surface Viewer

5.2 OUTPUT RISK FOR DIABETES

The overall result for the risk of Diabetes can be shown in Table 5. Among 50 patient here, in table 5 we give only 5 patient details. It is consisted of age from 20's to 60's for males and females. For the age 50's the risk to get the Diabetes is about nearly 75%, for the age 40's the risk is about 50% and finally for the age of 40's is 50%. From the result, the old age person have high risk to get the Diabetes. It is may be because of not having a healthy life style such as lack of exercises, depression and stress.

Table 5 for output risk

Patient ID	Age	BMI	BP	Cholesterol	Ouput risk (%)
002	23	16	130	90	9.26
010	28	30	130	120	50
045	60	40	190	200	78.8
031	45	18	80	75	50
026	50	37	200	190	77.1

Here, Table 5 explain the output Risk of Diabetes with Low, Medium and High level in Percentage. (i.e) when a person patient ID 002 be an young in the age of 23 their Cholesterol, BMI and BP level are 90, 16 and 130 then the particular patient met an Diabetes of 9.26 % Risk only. Similarly, When we compare to the nearly same Age group of another person with their Patient ID was 010 with Patient ID 002 BP are same as 130, but there is a drastically increase in the level of BMI and Cholesterol, increase the percentage of Diabetes output Risk from 9 to 50%. Next we notice that the two Patient ID 045 and 026 Age, BMI, BP, Cholesterol level are High the person met an Diabetes Output Risk of High percentage as above 75%. Those person needed an immediate medical advice. About 90% of people with Diabetes have Type 2 Diabetes. That's why it's very important to know the risk factors and find out our Risk percentage, so we can do something about it. The Patient ID 026 Age 50, BMI 37, BP 200 and Cholesterol 190 had an Diabetes output Risk of 77.1% was given in the Figure 6 Rule viewer.

6. CONCLUSION

This study is aimed to design a fuzzy expert system for diagnosis of Diabetes. Fuzzy Expert System for Diabetes Diagnosis designed with the membership functions as input variables, output variables and rule base. Rule that has created an effect on the rule evaluation process that occurs, the more precise rule made the results obtained will be more accurate. For current progress, age, BMI, Cholesterol and blood pressure are used as input for the fuzzification method while risk of Diabetes (%) is used as output. patients can take immediate preventive measures in the prevention or early treatment. The fuzzy expert system can simulate as an expert doctors behavior in order to diagnose diseases. In my Future work, More fuzzy rules will be developed in order to get a better result and determine the risk factor of Diabetes.

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