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Hypertension Diagnosis Using Fuzzy Expert System

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ABSTRACT
Hypertension, also referred to as high blood pressure, is a condition in which the arteries have persistently elevated blood pressure. Blood pressure is the force of blood pushing up against the blood vessel walls. The higher the pressure the harder the heart has to pump. Hypertension can lead to damaged organs, as well as several illnesses, such as kidney failure, heart failure, stroke, or heart attack. High blood pressure during middle age may raise the risk of cognitive decline later in life**.** So for the better diagnosis and treatment of hypertension patients, an intelligent and accurate system is needed. In this study, we design fuzzy expert system to diagnose hypertension for different patients. Fuzzy expert system is based on set of symptoms and rules. The input parameters for this system are age, body mass index, blood pressure, heart rate, diabetes, physical activity, genetics and the output parameter is risk of hypertension. It is expected that this proposed Fuzzy Expert System can provide a faster, cheaper and more accurate result.
Keywords- Diabetes, fuzzy expert system, genetics, hypertension

I. INTRODUCTION

Fuzzy logic is used to model nonlinear systems which are difficult to model mathematically. It is a system of logic and is based on set theory and continuous variables. Conclusions that are based on vague, imprecise, missing input information are simply provided by fuzzy logic (FL). Fuzzy logic uses different words, i.e. fuzzification, defuzzification, membership function, linguistic variables, domain, rules etc. In Boolean algebra or Boolean logic crisp sets are used, which has only two values 0 and 1, but in fuzzy logic, sets have infinite logic values between 0 and 1. In Boolean logic completely inclusive, exclusive membership is used, but in FL completely inclusive, exclusive or between these two memberships is used. Fuzzy logic control systems are used to handle difficult processes on the bases of human knowledge. FLC controller uses linguistic rules that show the strategy of the user.

The basic advantage of this method is that it does not require the model. Knowledge based systems in which fuzzy logic controllers are explained with the help of IF-THEN rules are based on professional's knowledge about system controllers, performance and established. The reason for designing and application of FLCS is to handle the ambiguous, unclear and difficult processes which are not easily handled by old techniques of the control systems. Also the fuzzy expert system is a system in which fuzzy rules are used with MF to find the conclusion or result.

Fuzzy logic has been applied to many areas or fields, for example fuzzy logic has played an important role in the field of medicine [1] [2]. They are used in control, automobiles, household appliances and decision making systems.

Hypertension or high blood pressure, sometimes called arterial hypertension, is a chronic medical condition in which the blood pressure in the arteries is elevated. The normal level for blood pressure is below 120/80, where 120 represent the systolic measurement (peak pressure in the arteries) and 80 represents the diastolic measurement (minimum pressure in the arteries). Blood pressure between 120/80 and 139/89 is called prehypertension (to denote increased risk of hypertension), and a blood pressure of 140/90 or above is considered hypertension.

Hypertension may be classified as essential or secondary. Essential hypertension is the term for high blood pressure with unknown cause. It accounts for about 95% of cases. Secondary hypertension is the term for high blood pressure with a known direct cause, such as kidney disease, tumours, or birth control pills.

In this study, we present a Fuzzy Expert System for the diagnosis hypertension. As laboratory data, blood pressure, Body Mass Index (BMI), age, heart rate, diabetes, genetics and life-style of the patient are used. Using this data and help from an expert doctor,

the fuzzy rules to determine the risk factor of having high blood pressure are developed.

II. METHODOLOGY

1.1 DATA COLLECTION

The process for the clinical diagnosis of hypertension starts when an individual consults a physician (doctor) and presents a set of complaints (symptoms). The physician then requests further information from the patient or from others close to him. Data collected include patient's previous state of health, living condition and other medical conditions [3] [4] [5].

Many patients were selected to get the parameters like age, BMI level, blood pressure, heart rate, diabetes, physical activity, and genetics. In addition to medical tests, questions such as working background, medical history and life style were asked from patients for obtaining an additional knowledge.

First parameter age is divided into three categories: age of 0 to 25 years is considered as young, 20 to 60 as middle age and above 55 as old.

To get the BMI, the scales for weight and height gain is used. Body mass index is defined as the individual's body weight divided by the square of his or her height. BMI is measured in kg/m2. The BMI can be divided to three categories of BMI range. First category range 15 to 25 is having a healthy weight. The second category in range 5 to 15 is an underweight. The third category is ranged 25 to 35 are considered to be overweight.

To measure the blood pressure, Non invasive blood pressures (NIBP) are used to get the reading. The Non-invasive blood pressure measurement uses the oscillometric method to produce numeric values for systolic, diastolic, and mean blood pressure. The normal blood pressure is 120/80mmHg where the 120mmHg is a Systolic (maximum) and 80mmHg is a Diastolic (minimum). When the blood pressure more than 139/89mmHg, the hypertension can occur.
Heart rate is monitored to get heart rate readings. It can also be divided into three categories: low (50-95), normal (85-135), high (130-185).
Diabetes is a disease in which blood glucose, or blood sugar, levels are too high Over time, having too much glucose in blood can cause serious problems. It can damage eyes, kidneys, and nerves. Diabetes can also cause hypertension. To measure diabetes, blood test is performed and readings are taken. Diabetes is divided into three categories: normal, early diabetes, established diabetes. It is measured in mg/dl. Range of Normal diabetes is (70-110), early diabetes is (100-140), established diabetes is(>140).
Physical activity is estimated by asking the questions to patients about their life style. Persons are less active if they work for only 0-2 hours a day, normal active if work for 2-7 hours and very active if they work for more than 7 hours.
Patients are also asked about their parents if they had suffered from hypertension in the past [6] [7] [8].
The output parameter is risk of hypertension. It is divided into low, medium and high categories.

1.2 DESIGN AND DEVELOPMENT OF FES

A fuzzy expert system is a collection of membership functions and rules that are used to reason about data [9] [10] [11] [12] [13]. The part of the rule between the "if" and "then" is the rule's _premise_ or _antecedent. This is a fuzzy logic expression that describes to what degree the rule is applicable. This design has been divided into several steps. Steps are fuzzification, rule evaluation and finally defuzzification. To design the system, the FIS tool in MATLAB R2010a is used.

In this study, the analysis focused on how to design an expert system to diagnosis hypertension is performed by range of age participants. First, the linguistic values and corresponding membership functions have been determined. Samples of values and corresponding membership functions for the input age, BMI, BP, heart rate, diabetes, physical activity, genetics are shown in Fig 1, Fig 2, Fig 3, Fig 4, Fig 4, Fig 5, Fig 6 and Fig 7 respectively. Fig 8 shows the membership function and linguistic variables for the output risk of hypertension (%).

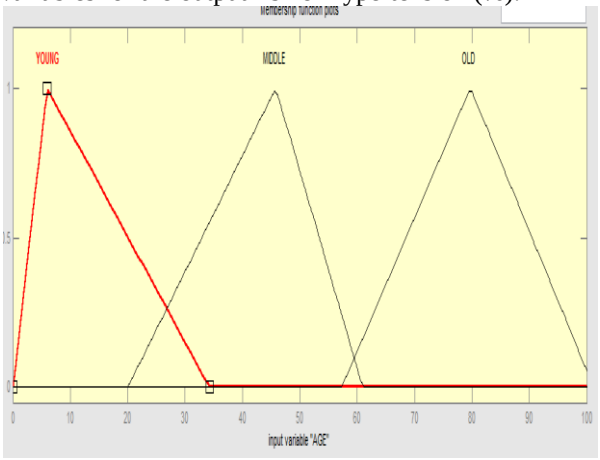

Fig 1: Linguistic variable and membership function of 'Age'

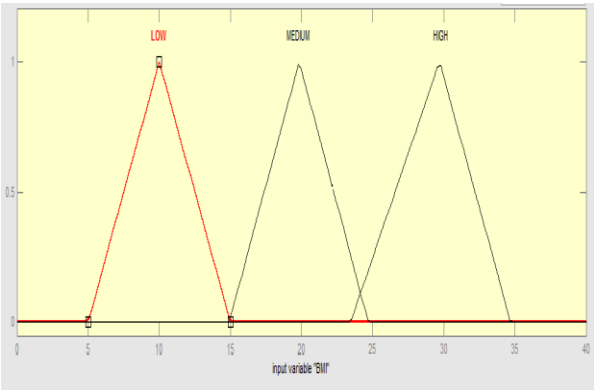

Fig 2: Linguistic variable and membership function of 'BMI'

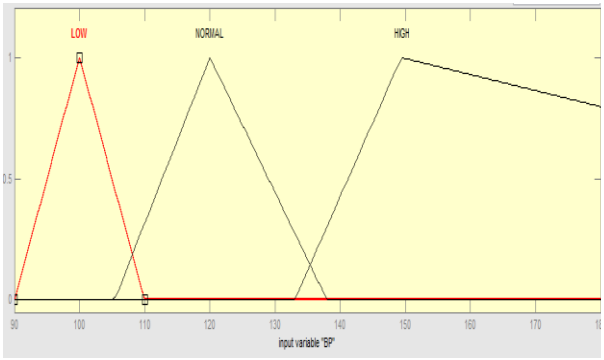

Fig 3: Linguistic variable and membership function of 'BP'

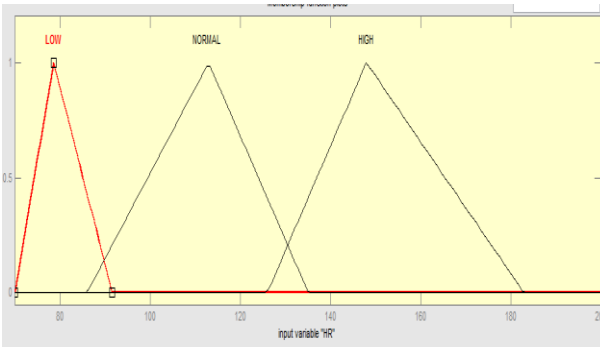

Fig 4: Linguistic variable and membership function of 'HR'

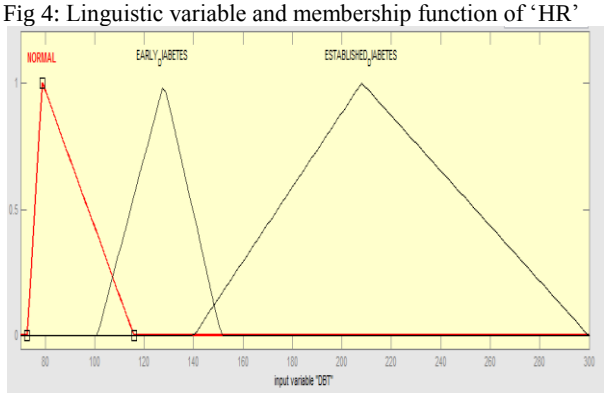

Fig 5: Linguistic variable and membership function of 'DBT'

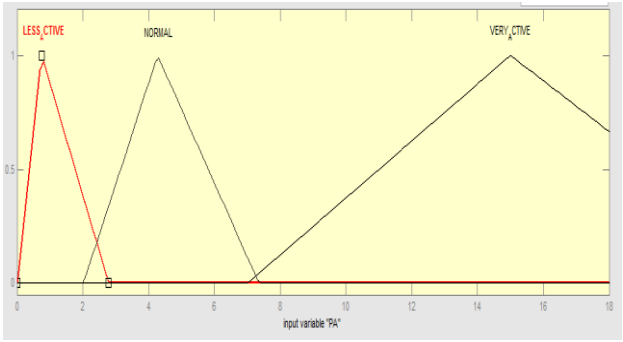

Fig 6: Linguistic variable and membership function of 'PA'

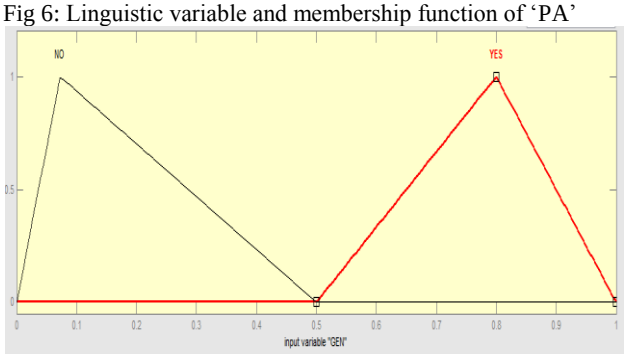

Fig 7: Linguistic variable and membership function of 'GEN'

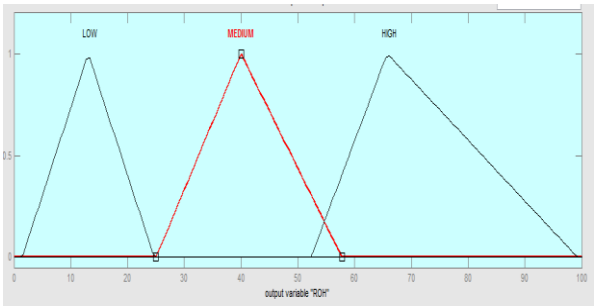

Fig 8: Linguistic variable and membership function of 'ROH'

III. RESULTS AND DISCUSSION

Table 1 shows the data collected from various patients. Fuzzy expert system is used to determine risk of hypertension. This design consists of 7 inputs and 1 output. The inputs consist of age, blood pressure, BMI, heart rate, diabetes, physical activity and genetics while the output is the risk of hypertension (%). The variables are used like low, normal, medium and high for input and low, medium and high for output. The outline of our proposed fuzzy expert system can be shown in Fig. 9 and in this system, Mamdani method is used for fuzzification.

Table 1: Data Collection

Age	BMI Kg/m2	BP mmHg	HR Bmp	DBT mg/dl	PA h/d	GEN
23	20.3	112/68	82	95	12	0.3
24	20.3	120/79	104	95	12	0.3
22	18.6	107/79	90	150	5	0.5
23	25	111/68	67	220	13	0.8
23	25.7	115/76	75	95	3	0.1
26	24.7	123/74	66	106	4	0.3
30	22.1	121/81	81	107	9	0.1
33	23.9	122/73	79	84	14	0.1
30	23.1	126/91	81	95	10	0.2
45	23.7	114/73	70	95	13	0.8

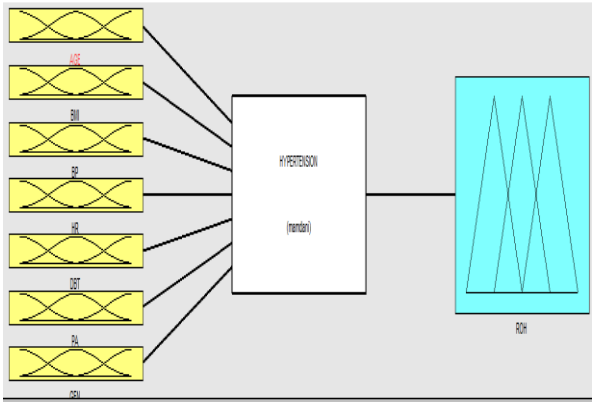

Fig 9: Fuzzy expert system

Rule base is shown in Fig 10. Eleven rules are used in this system and the rules have been developed using *if-then* method. Using these rules, the result risk in term of percentage (%) has been computed. Fig 11 shows the result for the ROH at the age of 50 years old, BMI is 20 kg/m², blood pressure is 135/68 mmHg and heart rate is 135 bpm, diabetes is 185mg/dl, physical activity is 9 hours and geneticly no i.e 0.5 . Hence, the output risk is of hypertension 65.2%. For the surface result, we can see the output for BMI versus Age, PA versus HR in three dimensions as shown in Fig 12 and Fig 13.

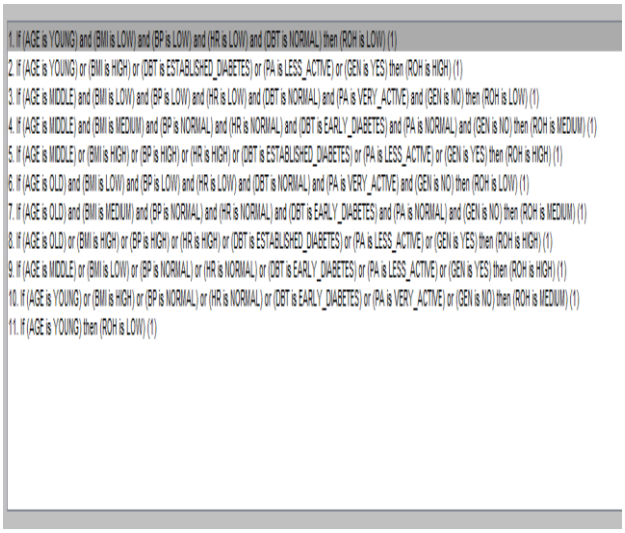

Fig 10: Fuzzy Rules

Fig 11: The result rules of fuzzy expert system

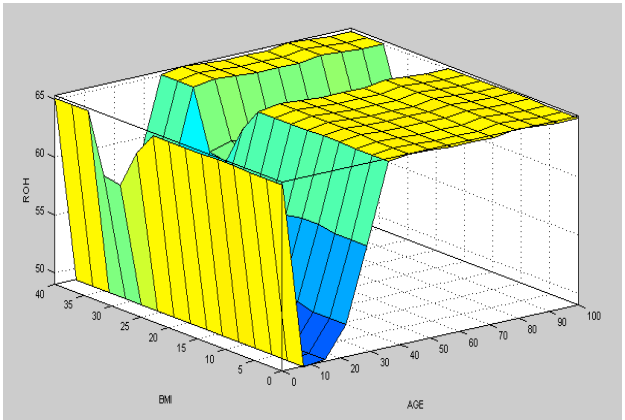

Fig 12: Surface view of fuzzy expert system

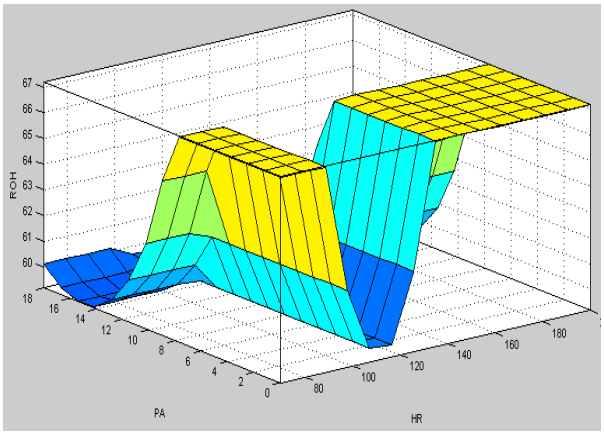

Fig 13: Surface view of fuzzy expert system

The overall result for the risk of hypertension can be shown in Table 2.

Table 2: Hypertension Using Fuzzy Expert System

Age	BMI Kg/ m2	BP mmHg	HR Bmp	DBT mg/ dl	PA h/ d	GEN	ROH (%)
23	20.3	112/68	82	95	12	0.3	55.5
24	20.3	120/79	104	95	12	0.3	58.2
22	18.6	107/79	90	150	5	0.5	50.2
23	25	111/68	67	220	13	0.8	57.4
23	25.7	115/76	75	95	3	0.1	56.2
26	24.7	123/74	66	106	4	0.3	59.7
30	22.1	121/81	81	107	9	0.1	59.6
33	23.9	122/73	79	84	14	0.1	59.6
30	23.1	126/91	81	95	10	0.2	59.8
45	23.7	114/73	70	95	13	0.8	60.1

IV. CONCLUSION

In this paper, a fuzzy expert system is presented for diagnosis of hypertension. Seven input variables age, BMI, heart rate, blood pressure, diabetes, physical activity and genetics are used for the fuzzification method while risk of hypertension (%) is used as output. This is a very efficient, less time consuming and more accurate method to calculate the risk of hypertension.

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