

A Fuzzy Approach to T2Dm in Young Adults in India

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ABSTRACT

Designing a Fuzzy Expert System (FES) for the diagnosis of Type 2 Diabetes Mellitus in young adults is the goal of this work. Diabetes is a chronic condition brought on by a lack of either insulin production or action, or both, leading to long-term consequences. Diabetes prevalence has been quickly increasing over the world. Numerous techniques have been developed to detect diabetes at an early stage; however, the majority of these techniques lack interpretability, making it impossible to describe the diagnostic procedure. Although there is currently no cure for diabetes, early diagnosis allows patients to begin treatment sooner and lowers the risk of serious complications.

There are number of techniques used for diagnosis of diabetes, few methodologies or techniques used in Mathematical Science including Neural Network, Naive Bayes, and Support Vector Machine, are used in the previous system to diagnose diabetes. But the current system's performance is ineffective. Existing methodologies do not diagnose diabetes in its early stages. In this essay, we suggest a more effective and efficient method for diagnosing diabetes. Early stage fuzzy inference system diabetes diagnostic determines a person's diabetes status based on the information provided and treatment recommendations for a specific kind of diabetes.

Keywords-- Diagnoses, Classifications, Fuzzy Inference Systems, Recommendations, Type 2 Diabetes Mellitus, Soft Computing, Medicine

Blood glucose levels are excessive in people with diabetes mellitus because the insulin hormone is either not created or is not functioning properly [1]. There are three different types of diabetes mellitus: type I, also known as insulin-dependent diabetes mellitus (IDDM), in which the patient must receive insulin injections; type II, also known as non-insulin-dependent diabetes mellitus (NIDDM), in which the patient does not require insulin injections; and gestational diabetes, in which the condition only affects the pregnant woman during pregnancy [2].

Diabetes can be identified in two ways: by symptoms or through a screening test. The most typical symptoms are frequent urine (polyuria), constant thirst (polydipsia), constant hunger (polyphagia), loss of weight for no apparent reason, blurred eyesight, and slow wound healing [3]. The patient will undergo diagnostic testing if they exhibit these symptoms. When a patient is over 65 years old, has high blood pressure, high blood cholesterol or triglycerides levels, or has had a miscarriage that cannot be explained or given birth to a baby that weighs 4 kg or more, screening tests are performed even if the patient does not exhibit any symptoms. Usually screening test involve blood test, urine test and the latest screening is Glycated Haemoglobin (HbA1c). For gestational diabetes case, oral glucose tolerance test (OGTT) is conducted. Diabetes should be put an extra attention because it can lead to several complications and thus can lead to fatal. Diabetes with long-term complications might affect the kidney, nerve, foot, and eyes. Kidney failure, often known as end-stage illness, is the result of diabetic nephropathy, which slows kidney function (ESRD).

Additional diabetes Neuropathy is a problem where nerves are attacked. Damage to the nerves can make it such that the hands, feet, legs, and arms are paralysed, sometimes even unable to feel pain, and that they become weaker and more susceptible to amputation. However, due to interference with the autonomic nerve system, autonomic neuropathy causes digestive issues, diarrhoea, erectile dysfunction, a quick heartbeat, and low blood pressure.

Retinopathy also one of common diabetes complication and affect small blood vessel in the retina

I. INTRODUCTION

Diabetes is one of the alarming disease in high number of people and a condition for which there are still no solutions. It is a condition where the body's capacity to create or react to the hormone insulin is compromised, leading to improper carbohydrate metabolism and increased blood glucose levels. Diabetes is of two types, diabetes mellitus and diabetes insipidus. In diabetes mellitus, the level of glucose in your blood also called blood sugar is too high and kidneys try to remove extra glucose in urine. In diabetes insipidus, blood glucose levels are normal, but kidneys can't properly concentrate urine. Vasopressin plays a role in diabetes insipidus, a condition when the body is unable to respond because of damage from a virus or injury.

and as a result vision of a patient decline. If action is not taken, it can lead to blindness [4]. Ketoacidosis happens because of ketones excess that build up in blood and can be poison result to diabetic coma or even death. The use of expert systems and artificial intelligence techniques in disease diagnosis has been increasing gradually [5]–[9]. Back propagation neural network algorithms have been used to construct a method for diagnosing diabetes, but the data set contains missing values [10]. The issue was then resolved by adding the missing value back into the data sets and increasing the percentage of correctly classified data [11]. Fuzzy logic theory has advantages over artificial neural networks, however gained many interests in medical field [12]–[16]. Fuzzy logic controller was developed that contain inner and outer by using mamdani type fuzzy logic to observe the blood glucose level [17]. A stochastic model was designed to assess glucose metabolic control and to revise the tearpeutic control for short and long term [18]. Correlation fuzzy logic was proposed to overcome the overlapping problem between each every function when plotting the membership function in fuzzy expert system for diagnosis of diabetes [19]. Other than fuzzy logic theory, genetic algorithm also has gained interests by many researchers for diagnose of diabetes [20]. A Genetic Programming (GP) approach has been proposed in evolution and natural selection in order to construct solution but different in use variable [21]. A hybrid prediction model for diabetes using Support Vector Machine (SVM) with F score feature selection was proposed in order to increase accuracy, sensitivity, specificity of the model performance [22]. A modified Artificial Immune Recognition System² (MAIRS²) was developed by using fuzzy K-nearest neighbors to improve the diagnostic accuracy of diabetes diseases [23], [24]. Apart from that, decision trees and fuzzy expert systems also had been implemented as a decision tool for disease diagnosis systems [25]–[27]. A fuzzy verdict mechanism that is separately imply the possibility of an individual to get diabetes and transfers the possibility into sentence term [28].

More rules could be added to this system, though, to achieve even better results. A fuzzy expert system is being created in this work to estimate a person's % risk of developing diabetes. These rules are gathered and encoded as part of an expert system, which also includes an inference engine for assessing the rule base given a set of inputs. The development of this system involves the following four steps: choosing the fuzzy set, creating the membership function, creating the if-then rules, and defuzzification. Diagnosing diabetes early on is an extremely important endeavour. Fuzzy Inference System is the innovative methodology that has been proposed for greater accuracy and early diagnosis. Fuzzy Inference System not only detects diabetes early but also suggests a course of action.

II. WORKING METHOD

The use of Soft Computing Techniques in Medicine

Hazy reasoning Science, engineering, and medicine have all been transformed by fuzzy thinking. Zadeh [37] was the one who first proposed this idea. Not only did Zadeh discover this idea, but he also quickly created the foundation for modern usage patterns like fuzzy programming, relations of similarity, and decision-making.

For any statement, there are only two possible outcomes according to logic: True or False. When we discuss the characteristic function of the membership of an x element of a set A , we are attempting to define the set theory. The function that produces the values 0 and 1 for each element of universal set X is known as the characteristic function.

How can we respond to the inquiry, "What is FL approach?" FL is more than true-false or 0-1 in Boolean logic; it is a computation-based technique to determining the truth of a situation in the actual world. The first article describing FL's applications in biology led to its application to medical science [38].

Acquiring, evaluating, and using the vast quantity of knowledge required to address challenging clinical problems is a challenge for modern medicine. Working with precise definitions, descriptions, or assertions is rare in the medical field. Rarely are diseases clearly distinguished from one another in medical diagnosis. When multiple diseases manifest in a patient at once, the disease's symptom pattern is destroyed, making a diagnosis and course of treatment more challenging. It is arbitrary to categorise laboratory test findings into normal or abnormal categories in borderline situations. Only verbal descriptions of pain can accurately convey its severity, which is based on the patient's subjective assessment. Precise connections between symptoms and diseases can very seldom be identified while describing the disorders [2]. Numerous words, like "often," "typical," "not required," "40–70%," "nearly always," "rarely," and "almost proving," are ambiguous and frequently used in medical terminology. These days, there are numerous medical applications for fuzzy logic ([1, 4, 7, 23, 26, 32, 33, 36]). Additionally, using an MRI system, it is possible to calculate the volume of brain tissue [8], analyse functional MRI data [22], find breast and lung cancers [12, 30], see human brain nerve fibres [3], represent quantitative estimates of drug use [24], examine diabetic neuropathy [20], find early diabetic retinopathy [40], and more.

Input Data

The information that was chosen as the input for fuzzy logic was gathered through journals, doctor interviews, and also based on the experience of medical professionals. Six output variables and a total of 17 input variables were used in this fuzzy expert system. The age of the patient is given in Table 1. Due to the high

prevalence in India, we only concentrate on the age span of 18 to 80 years.

Table 1:

Input	Range	Fuzzy set
age	18-34	Very young
	33-49	young
	48-59	medium
	58-80	Old

Body mass index (BMI) input is shown in Table 2, and systolic and diastolic blood pressure input is shown in Table 3.

Table 2: INPUT OF BMI

Body Mass Index (kg/m ²)	Indicator
0-18.5	Underweight
18.4-24.9	Normal
25-29.9	Overweight
30-50.0	Obesity

Table 3: INPUT BLOOD PRESSURE SYSTOLIC AND DIASTOLIC

Systolic (mmHg)	Diastolic (mmHg)	Indicator
90-120	60-80	normal
119-139	79-89	Prehypertension
138-159	88-99	Stage I Hypertension
158-200	98-150	Stage II Hypertension

In actuality, fuzzy logic is a precise approach to problem solving. It can manage algebraic data and grammatical or lexical knowledge simultaneously.

A specific method of employing fuzzy logic to calculate from an input to an output is called a fuzzy inference system. The procedure includes if-then rules, fuzzy logic operators, and all types of membership functions.

Blood that contains oxygen and carbon dioxide cannot be distributed or moved when a blockage in the blood wall occurs. As a result, the pressure will rise and new disorders like hypertension will develop. The girth is measured with a measuring tape and the waist circumference is calculated based on the top of the iliac crest. Table 4 displays the waist circumference's input data.

Table 4: INPUT OF WAIST CIRCUMFERENCE (WC)

Men	Women	Indicator
50-94cm	50-80cm	Normal
93-102cm	87-150cm	High
101-150cm	87-150cm	Very high

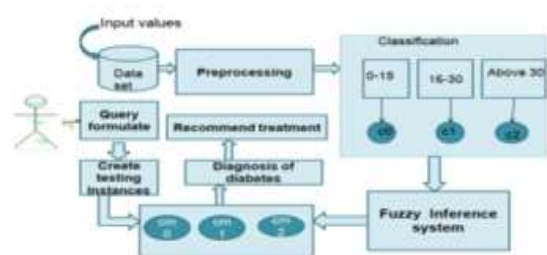
Table 5: INPUT OF WAIST-TO-HIP RATIO (WHR)

Male	Female	Indicator
0.5-0.95	0.5-0.80	Low risk
0.94-1.0	0.79-0.85	Moderate risk
0.99-1.5	0.84-1.5	High risk

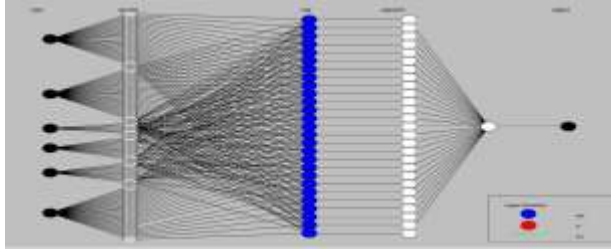
Hip circumference is divided by waist circumference in order to calculate the waist-to-hip ratio. As indicated in Table 5, the hip circumference was measured at the level of the gluteal region's largest diameter.

We will construct more tables on the basis of the input data for additional characteristics like smoking, exercise frequency, alcohol use, and glycated haemoglobin (HbA1c).

III. SYSTEM FOR FUZZY INFERENCE



The fuzzy inference system is known by a variety of names due to its multidisciplinary character, Including fuzzy-rule-based system, fuzzy expert system, fuzzy model, fuzzy associative memory, fuzzy logic controller, and simply fuzzy system.



Adaptive Network Fuzzy Inference System Structure Designed

Mathematical model using set theory [42]

nilam & prof.powar, diagnosis of diabetes using fuzzy inference system 2016.

$P = \{P_i; 0 < I < n\}$ - set of patient records.

Where n = number of patient record.

$\exists P_i | p := \{ \text{age, gender} \}$ - set of attribute value

$Q = \{q_i; 0 < I < n\}$ - set of query attribute value.

n = no. of attribute value.

$\exists q_i | q_i = |P_i|$

Processing set

$P' = \{P'_i; 0 < I < n\}$ - Set of patient record without null values.

Where,

N = no. of patient record

$\exists P'_i | P'_i \{ \{ \text{true, } p'_{ij} \neq Q \}, \{ \text{false otherwise} \} \}$

P'_{ij} = j th value of P_i th record

$C = \{C_i; 0 < I < K\}$ - Set of clusters

Where,

K = no. of clusters

$\exists C_i | C_i \{ \{ \text{true, } P'_i \in C_i \cap \text{flag}(0,15)(16,30)(\text{above } 31) \}, \{ \text{false otherwise} \} \}$

Flag = value of age attribute.

$R = \{r_i; 0 < I < n\}$ - set of rules.

Where,

N = no. of rules generalized

$\exists r_i | r_i \{ \{ \text{true } r_{ij} \subseteq r_{ix} \cap r_{ic} \phi \}, \{ \text{flag otherwise} \} \}$

$M = \{m_i; 0 < I < k\}$ - set of training module.

Output set

$P = \{p_i; 0 < I < q\}$ - set of probabilities.

Where,

$\exists P_i | P_i \{ \{ \text{prob}(Q, m_i), \{ \text{false otherwise} \} \}$

$T = \{t_i; 0 < I < n\}$ - set of treatment

Where

T = no. of treatment

$\exists t_i | t_i \{ \{ \text{true } t_i \cong p'_i \}, \{ \text{false otherwise} \} \}$

Let Y be the system, we can mathematically represent Y using set of theory as

$Y = \{P, Q, P', C, R, M', T\}$

Evolving Clustering Method(ECM)

Step 1:

Create cluster C_0 taking first center

And set value 0 for its cluster

Step 2:

Value of X_j taken and calculating distance between previously created center.

In this step no any existing cluster updated and no new cluster is created. Algorithm goes to next step or it return from step.

Step 3:

Find cluster C_a from all n existing cluster center through calculating value.

Step 4:

Using step 0 new clusters is created and it returns to

Step 1.

Algorithm /Technique of Fuzzy Inference System

To measure the output of this fuzzy system given the inputs, and follow the following six steps:

1. Fuzzy rules are finding.
2. Using the input membership functions inputs are fuzzifying.
3. Using fuzzy rules combine the fuzzified inputs to create rule strength.
4. By combining the rule strength and the output membership function, finding the consequence of the rule.
5. To get an output distribution combining the consequences.
6. Defuzzifying the output distribution.

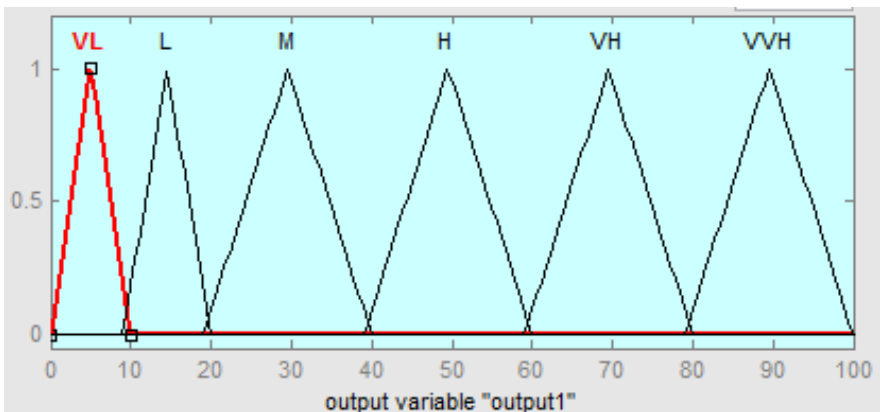
Time complexity of these above algorithms is define follow

$O(n \cdot r \wedge \log V)$

Where, n = no. of input records.

r = no. of rules generated.

V = no. of fuzzifying/defuzzifying variables.



Membership functions of output variables.

Output Prediction in percentage of diabetes.

Recommend treatment and exercise.

IV. CONCLUSION

Early diabetes diagnosis is a difficult assignment in the real world. It is essential for healing. The research demonstrates how to diagnose diabetes using both the fuzzy inference method and ECM classification. Here, a

fuzzy inference system and ECM categorization according to age are employed for data clustering and the early stage diagnosis of diabetes. That suggests a course of treatment for a certain form of diabetes.

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