FUZZY LOGIC APPROACH
FOR DIAGNOSIS OF DIABETES

A PROJECT REPORT

Submitted by

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Introduction:

Diabetes mellitus (DM) is a chronic disease in which the required amount of insulin is not produced by the body or insulin is not properly used by the body, resulting in excessively high blood sugar (glucose) levels. If diabetes is detected in its initial phase, then the disease can be controlled. On the other hand, if diabetes is left undetected or untreated, it can cause serious harm to the body and make it difficult to treat.

Diabetes is currently an incurable disease, and its treatment efficiency is primarily dependent on accurate diagnosis and timely treatment. Therefore, we need a method to control and provide early diagnostic information about DM. In order to detect diabetes, a wide variety of technologies and algorithms have been employed like machine learning (ML), artificial intelligence (AI), data mining, neural networks (NN), etc. But it is crucial to employ technologies that are interpretable and understandable to humans. Fuzzy logic was developed to address these issues. It can be used to deal with uncertainty of medical reasoning.

Working Principle:

Process of fuzzy inference mechanism:
Initialization → Fuzzification → Inference → Defuzzification → Evaluation

The inputs that were considered to build a fuzzy system for diagnosing diabetes mellitus are: *glucose concentration*, *serum insulin*, *body mass index*, *diabetes pedigree function* and *age*. The output in this system is divided into 3 fuzzy sets, namely low, medium and high. During the fuzzification stage, we make the fuzzy sets of each input and output using triangular curves. Then, fuzzy IF-THEN rules are created by experts to map each input to the output. The results of each rule is combined. During the defuzzification stage, the fuzzy output data is converted to a crisp value that can be fed into a controller.

Hence, the diagnosis algorithm can be listed as follows:

Step 1: Input the crisp values for glucose, insulin, BMI, pedigree and age.

Step 2: Set the triangular membership function for each input division and each output division.

Step 3: Build the fuzzy membership functions for the input set. Build the fuzzy membership function for the output (DM).

Step 4: Define the fuzzy if-then rules for expert diagnosis of DM.

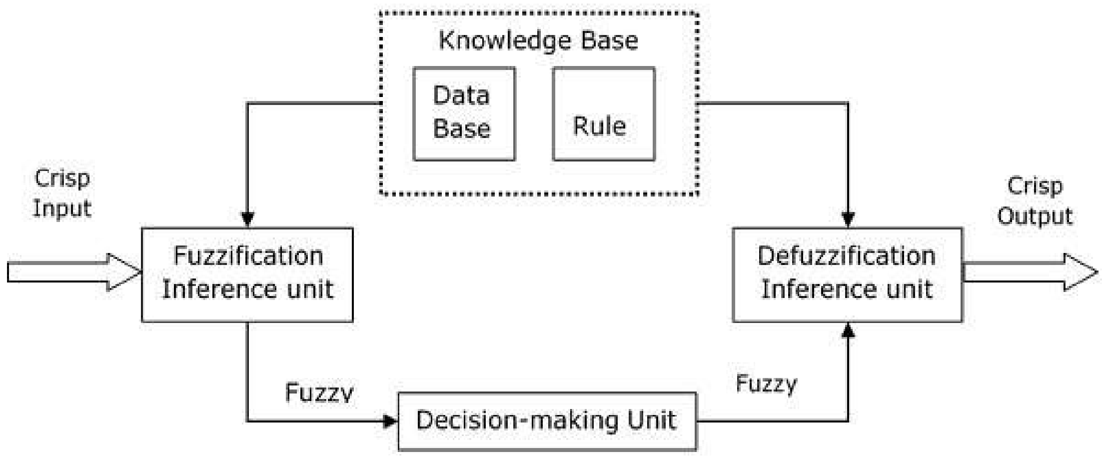
Step 5: Execute fuzzy inference by Mamdani Max-Product method.

Step 6: Combine the result of rules using AND conjunction to get the fuzzy output.

Step 7: Defuzzify into the crisp values using the centroid method.

Step 8: Present the knowledge in the form of natural human language.

Block Diagram:



Design:

The fuzzy membership functions for the input and output variables are defined as follows:

Fuzzy variables	Fuzzy Numbers	Fuzzy Triangular numbers
Plas (X_2)	Low	[0, 88.335, 121.408]
	Medium	[88.335, 121.408, 166.335]
	High	[121.408, 166.335 ,199]
Ins (X_5)	Low	[0 ,17.276, 173.175]
	Medium	[17.276, 173.175, 497]
	High	[173.175,497, 846]

Mass (X_6)	Low	[0, 0, 27.792]
	Medium	[0, 27.792, 38.864]
	High	[27.792, 38.864, 67.1]
Pedi (X_7)	Low	[0.078, 0.272, 0.682]
	Medium	[0.272, 0.682, 1.386]
	High	[0.62, 1.386, 2.42]
Age (X_8)	Young	[21, 25.475, 40.537]
	Medium	[25.475, 40.537, 57.798]
	Old	[40.537, 57.798, 81]
DM (Y)	Very low	[0, 0, 0.25]
	Low	[0, 0.25, 0.5]
	Medium	[0.25, 0.5, 0.75]
	High	[0.5, 0.75, 1]
	Very high	[0.75, 1, 1]

A list of nine fuzzy IF-THEN rules have been defined for Diabetes classification:

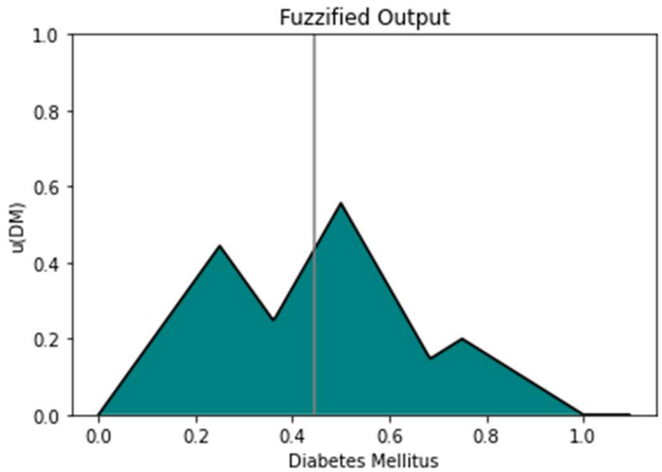
Glucose	***Insulin***	***BMI***	***Pedigree***	***Age***	***DM***
High	High	High	High	High	High
High	Medium	Medium	Medium	Medium	High
Medium	High	High	Medium	Medium	High
Medium	Medium	Medium	Medium	Medium	Medium
Medium	Medium	High	Medium	High	Medium
Medium	High	Medium	High	Medium	Medium
Low	Low	Low	Low	Low	Low
Medium	High	Low	Low	Medium	Low
Medium	Medium	Medium	Low	Low	Low

Results:

Sample data of patient:

Glucose: 110 mg/dL
Insulin: 300 muU/mL
BMI: 30 kg/m^2
Age: 40 years
Pedigree: 0.5

Each rule is evaluated using Mamdani max-product inference. The resultant output is as follows:



Here, the centroid x* = 0.444, hence, the patient has a 44.4% likelihood of having Diabetes Mellitus.

Conclusions:

Fuzzy logic provides many applications of decision support in the medical field. These applications are intended to support healthcare personnel in their decision-making. A doctor bases most of his diagnoses on his experience and perception as an expert on the subject, not carrying out complicated accounts according to input data with high precision. Hence fuzzy logic is suitable for developing knowledge-based systems for interpretation of medical findings, syndrome differentiation, diagnosis of diseases, optimal selection of medical treatments, and for real-time monitoring of patient data. For example, a fuzzy expert system that determines the risk of cancer will facilitate the doctor's decision for if there is a need for biopsy. In diabetes diagnoses, fuzzy approaches are used to analyse diabetic neuropathy and to detect early diabetic retinopathy. The MDLAP Artificial Pancreas system utilizes a fuzzy controller to maintain the normal glycaemic level for type 1 diabetic patients.

References:

1. Benamina, Mohammed & Atmani, Baghdad & Benbelkacem, Sofia. (2018). Diabetes Diagnosis by Case-Based Reasoning and Fuzzy Logic. International Journal of Interactive Multimedia and Artificial Intelligence. inPress. 1. 10.9781/ijimai.2018.02.001.
2. Wardana, Humaidillah & Ummah, Imamatul & Fitriyah, Lina. (2020). Mamdani Fuzzy Inference System (FIS) for Early Diagnosis of Diabetes Mellitus (DM) and Calorie Needs. 10.2991/aer.k.201124.070.
3. https://medium.datadriveninvestor.com/fuzzy-expert-system-for-the-diagnosis-of-diabetes-mellitus-f1eeede27b0b