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Expert System for Heart Problems

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Abstract-Paper respected to written about Fuzzy Expert System for heart problems. The system has 11 input fields and one output field. This is rule based and having required data with respect to kind of chest problem, blood pressure, cholesterol, resting blood sugar, maximum heart rate, resting electrocardiography, exercise, previous peak, thallium scan, sex and age. The result will show the status (is there) of heart problem of the man. It has the index of values by starting from 0 to 4 (1, 2, 3, and 4). Outputted data (results) compared with the data which was loaded system and that ensured reliability is between in 90-93%.

Key words:Fuzzy Expert System, Rule based, blood sugar

INTRODUCTION

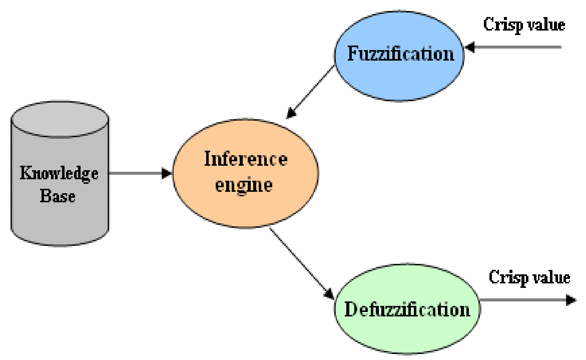
About Fuzzy Expert System:

Fuzzy Inference System: A Fuzzy Inference System (FIS) is a way of mapping an input space to an output space using fuzzy logic. A FIS tries to formalize the reasoning process of human language by means of fuzzy logic (that is, by building fuzzy IF-THEN rules). For instance:

"If the service is good, even if the food is not excellent, the tip will be generous"

FIS are used to solve decision problems, i.e. to make a decision and act accordingly.

Structure of a fuzzy inference system: In general, a fuzzy inference system consists of four modules:



Fuzzification module: transforms the system inputs, which are cri sp numbers, into Fuzzy sets. This is done by applying a fuzzification function.

Knowledge base: stores IF-THEN rules provided by experts.

Inference engine: simulates the human reasoning process by making fuzzy inference on the inputs and IF-THEN rules.

Defuzzification module: transforms the fuzzy set obtained by the inference engine into a crisp value.

Why should we use Fuzzy Inference Systems?

Fuzzy logic does not solve new problems. It uses new methods to solve everyday problems. Mathematical concepts within fuzzy reasoning are very simple. Fuzzy logic is flexible: it is easy to modify a FIS just by adding or deleting rules. There is no need to create a new FIS from scratch. Fuzzy logic allows imprecise data. It handles Elements in a fuzzy set, i.e. membership values. For instance, fuzzy logic works with 'He is tall to the degree 0.8' instead of 'He is 180cm tall'. Fuzzy logic is built on top of the knowledge of experts: it relies on the know-how of the ones who understand the system. Fuzzy logic can be blended with other classic control techniques.

Fuzzy IF-THEN rules:

In its simplest form, a fuzzy "if-then" rule follows the pattern:

"If x is A then y is B"

A and B are linguistic values defined by fuzzy sets in the universes of discourse X and Y.

x is the input variable and *y* is the output variable.

The meaning of *is* different in the antecedent and in the consequent of the rule. This is because the antecedent I s an interpretation that returns a value between 0 and 1,and the consequent assigns a fuzzy set B to the variable y

The input to the rule is a crisp value given to the input variable *x* of the antecedent (this value belongs to the universe of discourse of A).

The output to the rule is a fuzzy set assigned to the output variable *y* of the consequent.

The rule is executed applying a fuzzy implication operator, whose arguments are the

Antecedent's value and the consequent's fuzzy set values. The implication results in a

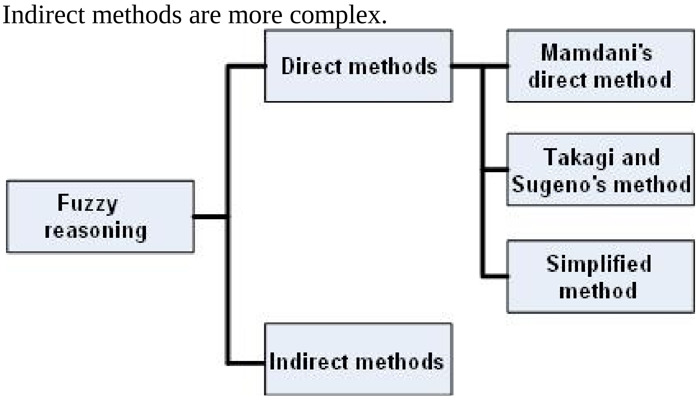
Fuzzy set that will be the output of the rule.

Classification of fuzzy inference methods

Fuzzy inference methods are classified indirect methods and indirect methods. Direct

Methods, such as Mamdani's and Surgeon's, are the most commonly used (these two

Methods only differ in how they obtain the outputs). Indirect methods are more complex.



About Mamdani Inference Fuzzy Expert System:
Mamdani's method is the most commonly used in applications, due to its simple structure of 'min-max' operations. We will go through each one of the steps of the method with the help of the example shown in the **Motivation** section.
Step 1: Evaluate the antecedent for each rule.
Step 2: Obtain each rule's conclusion.
Step 3: Aggregate conclusions.
Step 4: Defuzzification.

Current System:
There are so many algorithms based heart disease diagnosis expert systems and classification systems have been used for heart disease diagnosis problem too. But by above methods we obtain just 50-77 % classification accuracy. Having so many factors to analyze to diagnose the heart disease of a patient makes the physician's job difficult.
Proposed system:
Experts need an accurate tool that considering these risk factors and show certain result in uncertain term. For this designed an expert system based on Fuzzy logic. This fuzzy expert system that deals with diagnosis has been implemented and experimented results showed that this system did quite better than non-expert urologist and about 90-93% as well as the expert did. Dataset regarding to this expert system for diagnose the presence or absence of heart problems given the results of various medical tests carried out on a patient, is taken from the databases at the University of California. This database contains 76 attributes and 303 examples of patient, but we've just used 12 attributes in this system, 11 attributes for input & 1 attribute for result. Just used 44 rules in knowledge base. Steps included are:

- Give the Test results and other details (input 11 fields).
- Calculate the individual severities on various test results.
- Diagnose the Severity of the Heart Disease (Final output).

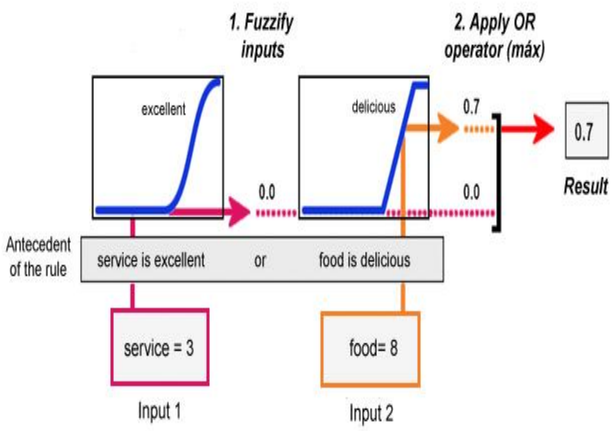
Paper Scope:
The scope of the system is to input 11 test-results as input to provide severity of the heart disease as a final result.

Paper Objective:
The objectives of the system are as follows.
- Initial classification of the 11 parameters inputted by user.
- Fuzzification will be done using associated membership functions, and perform aggregation if needed.
- Match the classified inputted parameter with rules and identify the maximum degree of occurrence of result, membership functions and aggregation will be done for the final result if needed and then defuzzify the result.
- Provide the severity of the heart disease to the user on the basis of the result.

Paper Overview:
The overview of the system is as follows.
- System takes 11 parameters as input.
- Initial individual classification on inputted test results.(Fuzzification)
- Match with rules in rule base and aggregate output.
- Defuzzify the aggregate output.

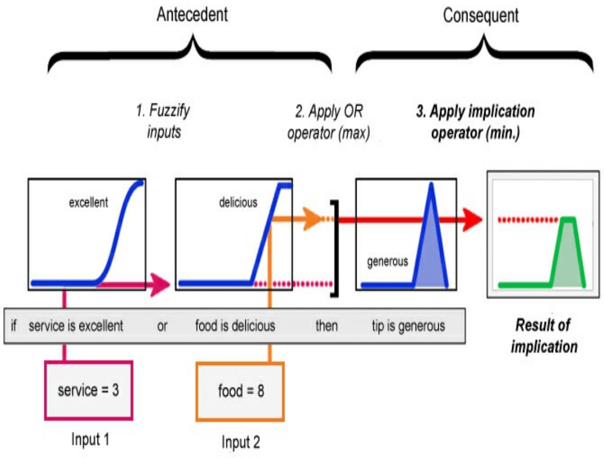
Functional Requirements:
<u>Inputs:</u>
1. Input 11 test results by user.
- **<u>Outputs:</u>**
1. Severity of the heart disease.
- **<u>Computations:</u>**
1. Initial classification of severity on the test results entered.
2. Match with rules and aggregate the result.
3. Defuzzify the aggregate output.
4. Display the severity of the heart disease on the basis of the defuzzified value.

Algorithms
About Mamdani Inference Fuzzy Expert System:
Mamdani's method is the most commonly used in applications, due to its simple structure of 'min-max' operations. The steps of the method includes
Step 1: Evaluate the antecedent for each rule.
Step 2: Obtain each rule's conclusion.
Step 3: Aggregate conclusions.
Step 4: Defuzzification.
Step 1. Evaluate the antecedent for each rule:
Given the inputs (cri sp values) we obtain their membership values. This process is called 'input fuzzification'. If the antecedent of the rule has more than one part, a fuzzy operator (t-norm or t-conform) is applied to obtain a single membership value. Let's take a look at the **Example:**



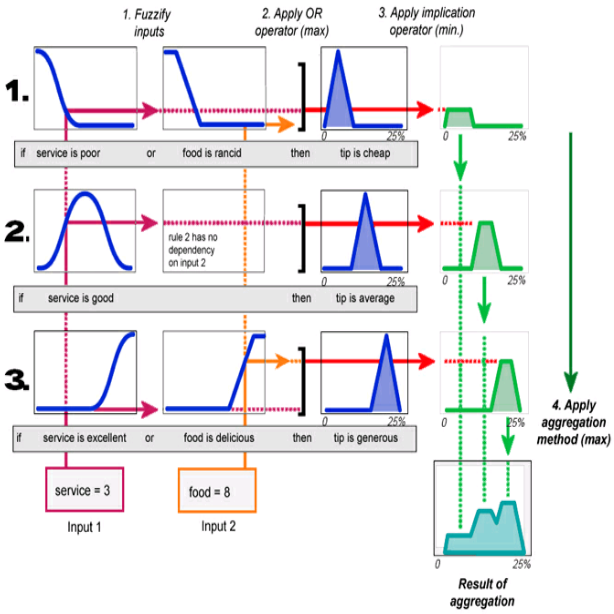
Step 2. Obtain each rule's conclusion:
Given the consequent of each rule (a fuzzy set) and the antecedent value obtained in step 1, we apply a fuzzy implication operator to obtain a new fuzzy set. Two of the most commonly used implication methods are the minimum, which truncates the consequent's membership

function, and the product, which scales it. In the example below, the minimum operator is used:



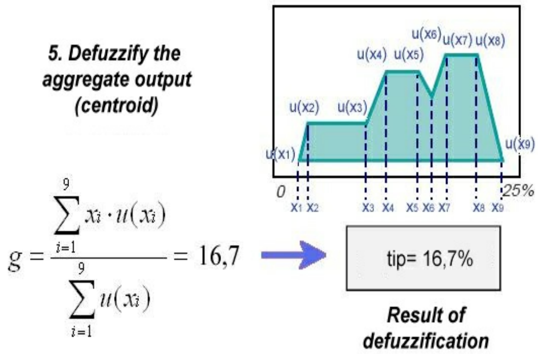
Step 3. Aggregate conclusions:

In this step we combine the outputs obtained for each rule i n step 2 (obtain conclusion) into a single fuzzy set, using a fuzzy aggregation operator. Some of the most commonly used aggregation operators are the maxi mum, the sum and the probabilistic sum.



Step 4. Defuzzification:

When we try to solve a decision problem, we want the output to be a number (cri sp value) and not a fuzzy set. For the tipping problem for instance, we do not want the system to tell us to give a generous tip. What we want to know i show much tip we should give. So, we need to transform the fuzzy set we obtained in step 3 into a single numerical value. One of the most popular de fuzzification methods is the centroid, which returns the center of the area under the fuzzy set obtained in step 3. The calculations are shown below:



Classification and Membership functions associated to each test results:

1). Chest pain:

1=typical angina

2=atypical angina

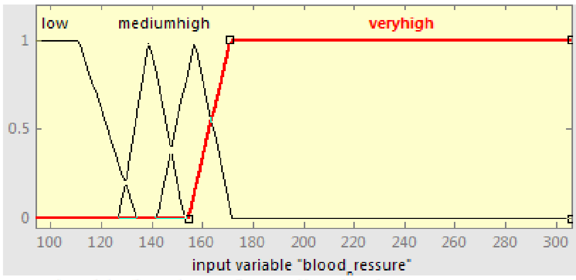
3=non-angina pain

4=asymptomatic

2). Blood Pressure:

Classification of the systolic blood pressure

INPUT FIELD	RANGE	FUZZY SETS
Systolic Blood Pressure	<134	Low
	127-153	Medium
	142-172	High
	154>	Very high



Membership functions of Systolic Blood Pressure

$$\mu_{low}(x) = \begin{cases} 1 & x < 111 \\ \frac{134 - x}{23} & 111 \le x < 134 \end{cases}$$

$$\mu_{medium}(x) = \begin{cases} \frac{x - 127}{12} & 127 \le x < 139 \\ 1 & x = 139 \\ \frac{153 - x}{14} & 139 \le x < 153 \end{cases}$$

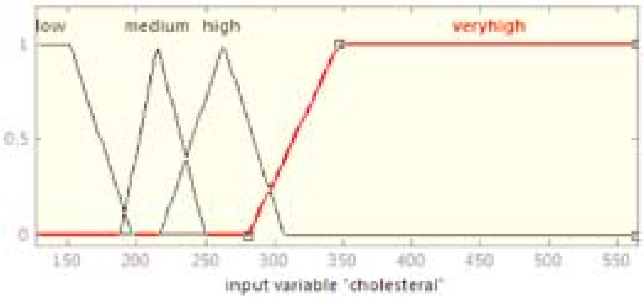
$$\mu_{high}(x) = \begin{cases} \frac{x - 142}{15} & 142 \le x < 157 \\ 1 & x = 157 \\ \frac{172 - x}{15} & 157 \le x < 172 \end{cases}$$

$$\mu_{veryhigh}(x) = \begin{cases} \frac{x - 154}{17} & 154 \le x < 171 \\ 1 & x \ge 171 \end{cases}$$

3. Cholesterol:

Classification of the Cholesterol

INPUT FIELD	RANGE	FUZZY SETS
Cholesterol	<197 188-250 217-307 281>	Low Medium High Very high



!. Membership functions of Cholesterol

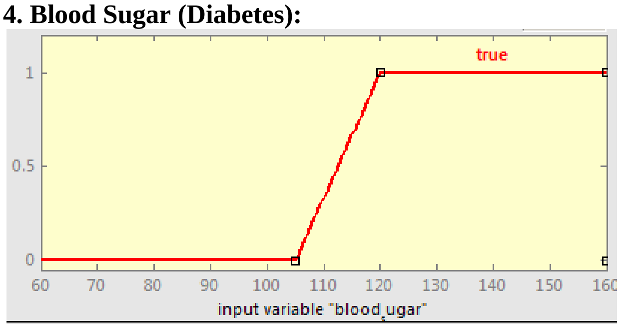
$$\mu_{low}(x) = \begin{cases} 1 & x < 151 \\ (197 - x)/46 & 151 \le x < 197 \end{cases}$$

$$\mu_{medium}(x) = \begin{cases} (x - 188)/62 & 188 \le x < 215 \\ 1 & x = 215 \\ (250 - x)/35 & 215 \le x < 250 \end{cases}$$

$$\mu_{high}(x) = \begin{cases} (x - 142)/15 & 217 \le x < 263 \\ 1 & x = 263 \\ (172 - x)/15 & 263 \le x < 307 \end{cases}$$

$$\mu_{veryhigh}(x) = \begin{cases} (x - 281)/66 & 281 \le x < 347 \\ 1 & x \ge 347 \end{cases}$$

4. Blood Sugar (Diabetes):



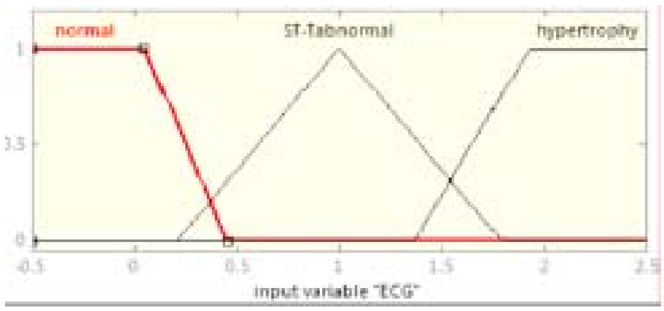
Fuzzy membership expressions for blood sugar field

$$\mu_{veryhigh}(x) = \begin{cases} (x - 105)/66 & 105 \le x < 120 \\ 1 & x \ge 120 \end{cases}$$

5. Resting Electrocardiography (ECG):

Classification of ECG.

INPUT FIELD	RANGE	FUZZY SETS
Resting Electrocardiography (ECG)	(0) [-0.5, 0.4] (1) [2.45, 1.8] (2) [1.4, 2.5]	Normal ST-T abnormal Hypertrophy



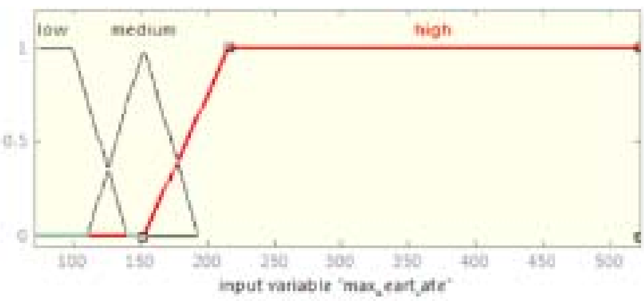
ST_T wave abnormality = T wave inversions and/or ST

Evasion or depression of > 0.05 mV.
Hypertrophy = showing probable or definite left Ventricular hypertrophy by Estes' criteria.

6. Maximum Heart Rate:

TABLE 4 .CLASSIFICATION OF MAXIMUM HEART RATE

INPUT FIELD	RANGE	FUZZY SETS
Maximum Heart Rate	<141 111-194 152>	Low Medium High



Membership functions of the max_heart_rate:

$$\mu_{low}(x) = \begin{cases} 1 & x < 100 \\ (141 - x)/41 & 100 \le x < 141 \end{cases}$$

$$\mu_{medium}(x) = \begin{cases} (x - 111)/41 & 111 \le x < 152 \\ 1 & x = 152 \\ (194 - x)/42 & 152 \le x < 194 \end{cases}$$

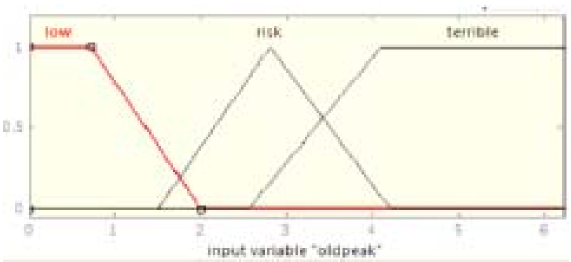
$$\mu_{high}(x) = \begin{cases} (x - 152)/64 & 152 \le x < 216 \\ 1 & x \ge 216 \end{cases}$$

7. Exercise: This input field has just 2 values (0, 1) and one fuzzy set (true). If doctor determines exercise test for patient, value 1 will enter in system, otherwise, value 0 will enter in
It.

8. Old Peak:

TABLE 5. CLASSIFICATION OF OLD PEAK

INPUT FIELD	RANGE	FUZZY SETS
Old Peak	<2	Low
	1.5-4.2	Risk
	2.55>	Terrible



Membership functions of Old Peak

$$\mu_{low}(x) = \begin{cases} 1 & x < 1 \\ (2 - x)/1 & 1 \le x < 2 \end{cases}$$

$$\mu_{risk}(x) = \begin{cases} (x - 1.5)/1.3 & 1.5 \le x < 2.8 \\ 1 & x = 2.8 \\ (4.2 - x)/1.4 & 2.8 \le x < 4.2 \end{cases}$$

$$\mu_{terrible}(x) = \begin{cases} (x - 2.55)/15 & 2.55 \le x < 4 \\ 1 & x \ge 4 \end{cases}$$

9. Thallium Scan:

TABLE 6. CLASSIFICATION OF THALLIUM SCAN

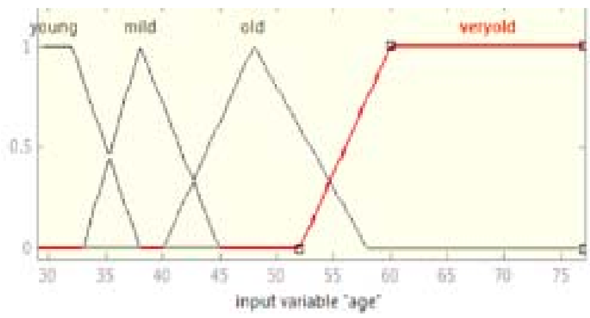
INPUT FIELD	RANGE	FUZZY SETS
Thallium scan	3	Normal
	6	Fixed Defect
	7	Reversible Defect

10. Sex: This input field has just 2 values (0, 1) and sets (Female, Male). Value 0 means that patient is male and value 1 means that patient is female.

11. Age: This input field divides to 4 fuzzy sets (Young, Mild, Old, Very old). These fuzzy sets with their ranges will be shown in Table 7. Membership functions of "Young" & "Very old" are trapezoidal and membership functions of "Mild" & "Old" are triangular. The membership function expressions have been shown below

TABLE 7. CLASSIFICATION OF AGE

INPUT FIELD	RANGE	FUZZY SETS
Age	<38	Young
	33-45	Mild
	40-58	Old
	52>	Very old



Membership functions of Age

$$\mu_{young}(x) = \begin{cases} 1 & x < 29 \\ (38 - x)/46 & 29 \le x < 38 \end{cases}$$

$$\mu_{mild}(x) = \begin{cases} (x - 33)/62 & 33 \le x < 38 \\ 1 & x = 38 \\ (250 - x)/35 & 38 \le x < 45 \end{cases}$$

$$\mu_{old}(x) = \begin{cases} (x - 40)/8 & 40 \le x < 48 \\ 1 & x = 48 \\ (58 - x)/10 & 48 \le x < 58 \end{cases}$$

$$\mu_{veryold}(x) = \begin{cases} (x - 52)/8 & 52 \le x < 60 \\ 1 & x \ge 60 \end{cases}$$

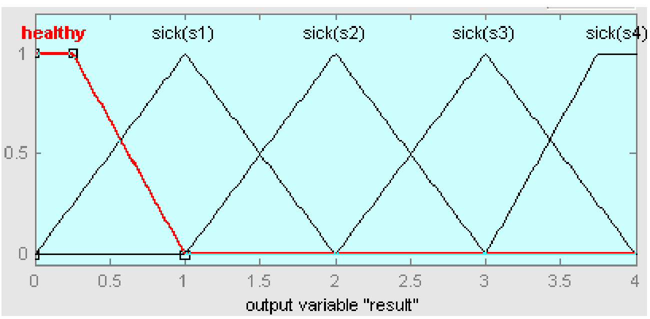
Dataset (Rule base) to this expert system:

1. If (chest_pain is angina) then (result is healthy) (1)
2. If (chest_pain is atangina) then (result is sick(s1)) (1)
3. If (chest_pain is nonangina) then (result is sick(s2)) (1)
4. If (chest_pain is asymptomatic) then (result is sick(s3)) (1)
5. If (chest_pain is asymptomatic) then (result is sick(s4)) (1)
6. If (sex is female) then (result is sick(s1)) (1)
7. If (sex is male) then (result is sick(s2)) (1)
8. If (blood_pressure is low) then (result is healthy) (1)
9. If (blood_pressure is medium) then (result is sick(s1)) (1)
10. If (blood_pressure is high) then (result is sick(s2)) (1)
11. If (blood_pressure is high) then (result is sick(s3)) (1)
12. If (blood_pressure is veryhigh) then (result is sick(s4)) (1)
13. If (cholesteral is low) then (result is healthy) (1)
14. If (cholesteral is medium) then (result is sick(s1)) (1)
15. If (cholesteral is high) then (result is sick(s2)) (1)
16. If (cholesteral is high) then (result is sick(s3)) (1)
17. If (cholesteral is veryhigh) then (result is sick(s4)) (1)
18. If (blood_sugar is true) then (result is sick(s2)) (1)
19. If (ECG is normal) then (result is healthy) (1)
20. If (ECG is normal) then (result is sick(s1)) (1)
21. If (ECG is ST-Tabnormal) then (result is sick(s2)) (1)
22. If (ECG is hypertrophy) then (result is sick(s3)) (1)
23. If (ECG is hypertrophy) then (result is sick(s4)) (1)
24. If (max_heart_rate is low) then (result is healthy) (1)
25. If (max_heart_rate is medium) then (result is sick(s1)) (1)
26. If (max_heart_rate is medium) then (result is sick(s2)) (1)
27. If (max_heart_rate is high) then (result is sick(s3)) (1)
28. If (max_heart_rate is high) then (result is sick(s4)) (1)
29. If (exercise is true) then (result is sick(s2)) (1)
30. If (oldpeak is low) then (result is healthy) (1)
31. If (oldpeak is low) then (result is sick(s1)) (1)
32. If (oldpeak is terrible) then (result is sick(s2)) (1)
33. If (oldpeak is terrible) then (result is sick(s3)) (1)
34. If (oldpeak is risk) then (result is sick(s4)) (1)
35. If (thal is normal) then (result is healthy) (1)
36. If (thal is normal) then (result is sick(s1)) (1)
37. If (thal is fixdef) then (result is sick(s2)) (1)
38. If (thal is rev.def) then (result is sick(s3)) (1)
39. If (thal is rev.def) then (result is sick(s4)) (1)
40. If (age is young) then (result is healthy) (1)
41. If (age is mild) then (result is sick(s1)) (1)
42. If (age is old) then (result is sick(s2)) (1)
43. If (age is old) then (result is sick(s3)) (1)
44. If (age is veryold) then (result is sick(s4)) (1)

Final Result:

Classification of the output (final result)

OUTPUT FIELD	RANGE	FUZZY SETS
Result	<1.78	Healthy
	1-2.51	Sick (s1)
	1.78-3.25	Sick (s2)
	1.5-4.5	Sick (s3)
	3.25>	Sick (s4)



Membership functions Result are as the above figure.

CONCLUSIONS

Fuzzy Expert System for Heart Disease Diagnosis designed with follow membership function, input variables, output variables and rule base. Designed system has been tested with expert-doctor. Designing of this system with fuzzy base in comparison with classic designed improves results. Results have been shown from this system in compression with past time system are logical and more efficient. This system simulates the manner of expert-doctor. This system is designed in way that patient can use it himself. This fuzzy expert system that deals with diagnosis has been implemented. Experimental results showed that this system did quite better than non-expert urologist and about 90-93% as well as the expert did.

REFERENCES

[1] Novruz ALLAHVERDI & Serhat TORUN & Ismail SARITAS, DESIGN OF A FUZZY EXPERT SYSTEM FOR DETERMINATION OF CORONARY HEART DISEASE RISK,International Conference on Computer Systems and Technologies - CompSysTech'07

[2] M.Nikravesh & Janusz & Lotfi A.Zadeh, Forcing New Frontier: Fuzzy Pioneer I, Springer 2007

[3] Robert Detrano & M.D & PhD, V.A. Medical Center, Long Beach and Cleveland Clinic Foundation. Available: www.archive.ics.uci.edu/ml/datasets/Heart+Disease