Detection of Heart Diseases using Fuzzy Logic

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***Abstract*— Nowadays the use of computer technology in the fields of medicine area diagnosis, treatment of illnesses and patient pursuit has highly increased The objective of this paper is to detect the heart diseases in the person by using Fuzzy Expert System. The designed system based on the Parvati Devi hospital, Ranjit Avenue and EMC hospital Amritsar and International Lab data base. The system consists of 6 input fields and two output field. Input fields are chest pain type, cholesterol, maximum heart rate, blood pressure, blood sugar, old peak. The output field detects the presence of heart disease in the patient and precautions accordingly. It is integer valued from 0 (no presence) to 1 (distinguish presence (values 0.1 to 1.0). We can use the Mamdani inference method. The results obtained from designed system are compared with the data in upon database and observed results of designed system are correct in 92%.**

***Keywords*— FIS, Membership function, Rule base and Surface viewer.**

I. INTRODUCTION

Using a Database is a well known method for storing information. In regular database systems, sometimes because of existence of huge data it is not possible to fulfil the user's criteria and to provide them with the exact the information that they need to make a decision. Nowadays the use of computer technology in the fields of medicine area diagnosis, treatment of illnesses and patient pursuit has highly increased. Despite the fact that these fields, in which the computers are used, have very high complexity and uncertainty and the use of intelligent systems such as fuzzy logic, artificial neural network and genetic algorithm have been developed.

There are huge data management tools available within health care systems, but analysis tools are not sufficient to discover hidden relationships amongst the data. Most of the medical information is vague, imprecise and uncertain. Medical diagnosis is a complicated task that requires operating accurately and efficiently. According to the World Health Organization, 12 million deaths occur each year due to heart diseases. It is the primary reason behind deaths in adults. In the United States, 50% of deaths occur due to cardio vascular disease. In fact, one person dies every 34 seconds due to cardiovascular diseases in the United States. Similarly, in other developed countries heart disease is one of the main reasons behind adult death. In order to decrease the mortality rate of cardiovascular disease, it is necessary for the disease to be diagnosed at an early stage. So having so many factors to analyse to diagnose the heart disease of a patient makes the physician's job difficult. So, experts require an accurate tool that considering these risk factors and show certain result in uncertain term. Motivated by the need of such an important tool, in this study, we designed an expert system to diagnose the heart disease. The designed expert system based on Fuzzy Logic.

This fuzzy expert system that deals with diagnosis has been implemented and experimental results showed that this system did quite better than non-expert urologist and about 94 % as a well as the expert did. The designed system aims to achieve the following:

- Detection of heart diseases and risks using fuzzy logic
- The system also defines the precautions according to the risk of the patient.
- System have 6 inputs and 2 outputs
- Each input and output have fuzzy variables
- Each fuzzy Variable is associated with membership function
- The rules strength is calculated based on the membership function of the fuzzy variable.

II. DATASET

Designed system based on the CMC Hospital Amritsar and Civil hospital Amritsar. The purpose of this dataset is to diagnose the presence or absence of heart disease given the results of various medical tests carried out on a patient. This system uses 6 attributes for input and 2 attribute for result. Input fields (attributes) are chest pain type, blood pressure, cholesterol, resting blood sugar, resting maximum heart rate, old peak (ST depression induced by exercise relative to rest), . The output field refers to the presence of heart disease in the patient and the Precautions according to the risk. It is integer value from 0 (no presence) to 1 ; increasing value shows increasing heart disease risk. In this study, we use low density lipoprotein (LDL) cholesterol. About the blood, we use systolic blood pressure. In this dataset, fields divide to some sections and each section has a value. For instance, in this dataset, chest pain has 4 section (very low, low, normal , high and very high), resting blood sugar has 2 section (very low , low , normal, high and very high).

1. Chestpain: In Chest pain there are five different membership functions. The five different types are very low, low, moderate, high and very high. The range of chest pain is 0-1.

2. Blood Pressure: In Blood Pressure there are five different membership functions. The five different types are very low, low, medium, high and very high. The range of Blood Pressure id given by 60-200.

3. Cholesterol: Cholesterol has salient affect on the result and can change it easily. For this input field, we use the value of low density lipoprotein (LDL) cholesterol. In cholesterol there are five different membership functions. The five different types are very low, low, medium, high and very high. The range of cholesterol is 100-400.

4. Blood Sugar: Blood sugar field is one of the most important factors in this system that changes the result. In Blood Sugar there are five different membership functions. The five different types are very low, low, medium, high and very high.Thus the range of Blood Sugar is 50-250.

5. Maximum Heart Rate: In Maximum Heart Rate there are five different membership functions. The five different types are very low, low, medium, high and very high. The range of Maximum Heart is 70-150.

6. Old Peak: This input field means ST depression induced by exercise relative to rest. Old peak field has 5 fuzzy sets (Very Low, Low, Medium ,Terrible and risk). These fuzzy sets have been shown in Table 5 with their ranges In Old Peak there are five different membership functions. The five different types are very low, low, medium, high and very high . The range for old peak is given by 0-1.

III. OUTPUT VARIABLES

1. Result: The "goal" field refers to the presence of heart disease in the patient. It is integer value from 0 (no presence) to 1. By increasing of this value, heart disease risk increases in patient. In this system, we have considered a different output variable, which divides to 5 fuzzy sets Healthy, Low Risk, Moderate Risk, Risk, and High Risk. Table shows these fuzzy sets with their ranges. Membership functions of “Healthy” & “High Risk” fuzzy sets are trapezoidal and membership functions of “Low”, “Moderate risk” and “Risk” are triangular. The range is from 0-1.These membership functions will be shown in Fig.

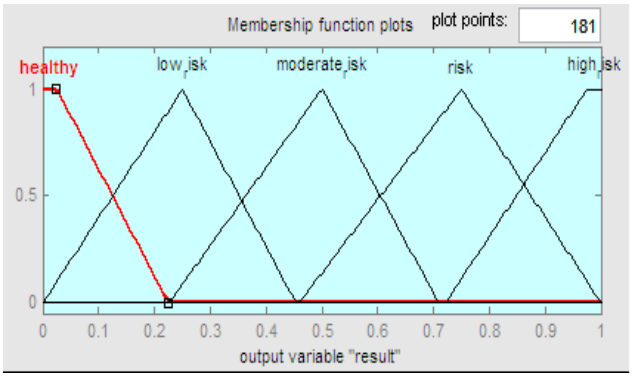


Fig: Membership Function of result

2. Precautions: The output variable is precautions; this system gives the precautions according to the risk and result of the patient. The range of precaution is set from 0-1.

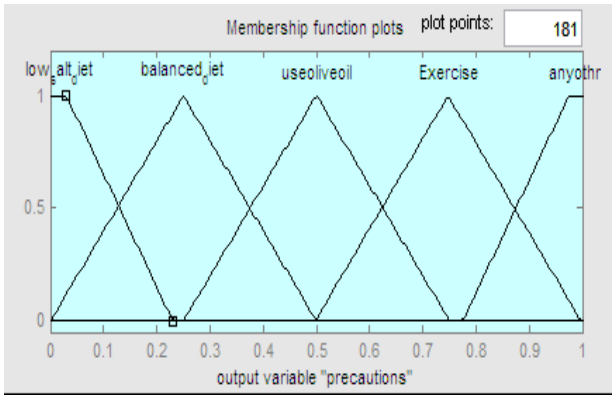


Fig. Membership functions of precautions

IV. Rule Base:

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 22 rules. Antecedent part of all rules has one section. This system designed with another rule bases (64 rules, 15 rules, 10 rules and 5 rules) and results showed in 44 rules system are best in comparison with results of the other rule bases. In the other hand, results with 22 rules tend to the expert's idea and laboratory results. The rules are shown below:

1. If (Chestpain is veryLow) and (cholestrol is very_low) and (max.heartrate is very_low) and (blood_pressure is very_low) and (bloodsugar is low) and (oldpeak is very_low) then (result is healthy)(precautions is Exercise)
2. If (Chestpain is veryLow) and (cholestrol is very_low) and (max.heartrate is very_low) and (blood_pressure is very_low) and (bloodsugar is low) and (oldpeak is low) then (result is healthy)(precautions is Exercise)
3. If (Chestpain is veryLow) and (cholestrol is very_low) and (max.heartrate is very_low) and (blood_pressure is very_low) and (bloodsugar is medium) and (oldpeak is medium) then (result is low_risk)(precautions is Exercise)
4. If (Chestpain is veryLow) and (cholestrol is very_low) and (max.heartrate is very_low) and (blood_pressure is high) and (bloodsugar is medium) and (oldpeak is medium) then (result is low_risk)(precautions is low_salt_diet)
5. If (Chestpain is veryLow) and (cholestrol is very_low) and (max.heartrate is high) and (blood_pressure is high) and (bloodsugar is high) and (oldpeak is terrible) then (result is moderate_risk)(precautions is low_salt_diet)
6. If (Chestpain is veryLow) and (cholestrol is high) and (max.heartrate is high) and (blood_pressure is high) and (bloodsugar is high) and (oldpeak is terrible) then (result is risk)(precautions is low_salt_diet)
7. If (Chestpain is high) and (cholestrol is high) and (max.heartrate is high) and (blood_pressure is high) and (bloodsugar is high) and (oldpeak is terrible) then (result is risk)(precautions is low_salt_diet)
8. If (Chestpain is moderate) and (cholestrol is medium) and (max.heartrate is medium) and (blood_pressure is medium) and (bloodsugar is medium) and (oldpeak is medium) then (result is moderate_risk)(precautions is useoliveoil)
9. If (Chestpain is veryHigh) and (cholestrol is veryhigh) and (max.heartrate is veryhigh) and (blood_pressure is veryhigh) and (bloodsugar is veryhigh) and (oldpeak is risk) then (result is high_risk)(precautions is anyothr)
10. If (Chestpain is veryHigh) and (cholestrol is veryhigh) and (max.heartrate is veryhigh) and (blood_pressure is veryhigh) and (bloodsugar is veryhigh) and (oldpeak is terrible) then (result is risk)(precautions is anyothr)
11. If (Chestpain is veryHigh) and (cholestrol is veryhigh) and (max.heartrate is veryhigh) and (blood_pressure is veryhigh) and (bloodsugar is veryhigh) and (oldpeak is terrible) then (result is high_risk)(precautions is anyothr)
12. If (Chestpain is veryHigh) and (cholestrol is veryhigh) and (max.heartrate is veryhigh) and (blood_pressure is veryhigh) and (bloodsugar is medium) and (oldpeak is

terrible) then (result is risk)(precautions is anyothr)

13. If (Chestpain is veryHigh) and (cholestrol is veryhigh) and (max.heartrate is veryhigh) and (blood_pressure is medium) and (bloodsugar is medium) and (oldpeak is medium) then (result is risk)(precautions is anyothr)
14. If (Chestpain is veryHigh) and (cholestrol is veryhigh) and (max.heartrate is medium) and (blood_pressure is medium) and (bloodsugar is normal) and (oldpeak is medium) then (result is moderate_risk)(precautions is anyothr)
15. If (Chestpain is veryHigh) and (cholestrol is medium) and (max.heartrate is medium) and (blood_pressure is medium) and (bloodsugar is normal) and (oldpeak is medium) then (result is low_risk)(precautions is anyothr)
16. If (Chestpain is high) and (cholestrol is medium) and (max.heartrate is medium) and (blood_pressure is medium) and (bloodsugar is normal) and (oldpeak is medium) then (result is low_risk)(precautions is balanced_diet)
17. If (Chestpain is low) and (cholestrol is veryhigh) and (max.heartrate is veryhigh) and (blood_pressure is medium) and (bloodsugar is normal) and (oldpeak is medium) then (result is low_risk)(precautions is balanced_diet)
18. If (Chestpain is moderate) and (cholestrol is high) and (max.heartrate is high) and (blood_pressure is veryhigh) and (bloodsugar is veryhigh) and (oldpeak is risk) then (result is high_risk)(precautions is balanced_diet)
19. If (Chestpain is moderate) and (cholestrol is high) and (max.heartrate is high) and (blood_pressure is veryhigh) and (bloodsugar is veryhigh) and (oldpeak is risk) then (result is risk)(precautions is useoliveoil)
20. If (Chestpain is low) and (cholestrol is medium) and (max.heartrate is medium) and (blood_pressure is medium) and (bloodsugar is medium) and (oldpeak is medium) then (result is moderate_risk)(precautions is useoliveoil)
21. If (Chestpain is low) and (cholestrol is very_low) and (max.heartrate is very_low) and (blood_pressure is medium) and (bloodsugar is medium) and (oldpeak is medium) then (result is low_risk)(precautions is useoliveoil)
22. If (Chestpain is very Low) and (cholestrol is very_low) and (max.heartrate is high and (blood pressure is high) and (blood sugar is high) and (old peak is terrible) then (result is risk)(precautions is useoliveoil)

V. .DEFUZZIFICATION

Membership functions are used to retranslate the fuzzy output into a crisp value. This method is known as Defuzzification. The fuzzy inference evaluates the control rules stored in the fuzzy rule base. Defuzzification is a process to convert the fuzzy output values of a fuzzy inference to real crisp values. Fist a typical value is computed for each term in the linguistic variable and finally a best compromise is determined by balancing out the results using different methods like center of sum, center of area, center of area mean of maximum etc. But for this application we use centroid method to process defuzzification of the output variable extension time. This method is mostly used because thismethod has better performance in terms of continuity, computer complexity and counting.The surface of bloodsugar and chestpain is shown in fig.

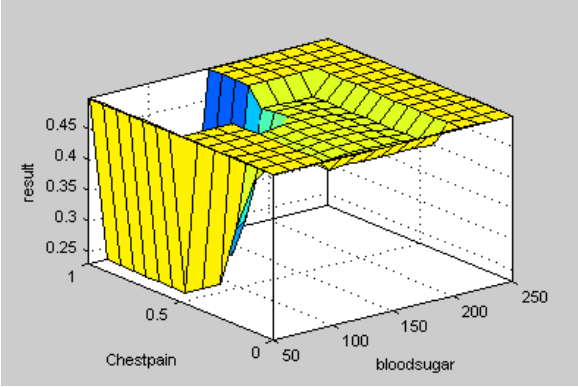
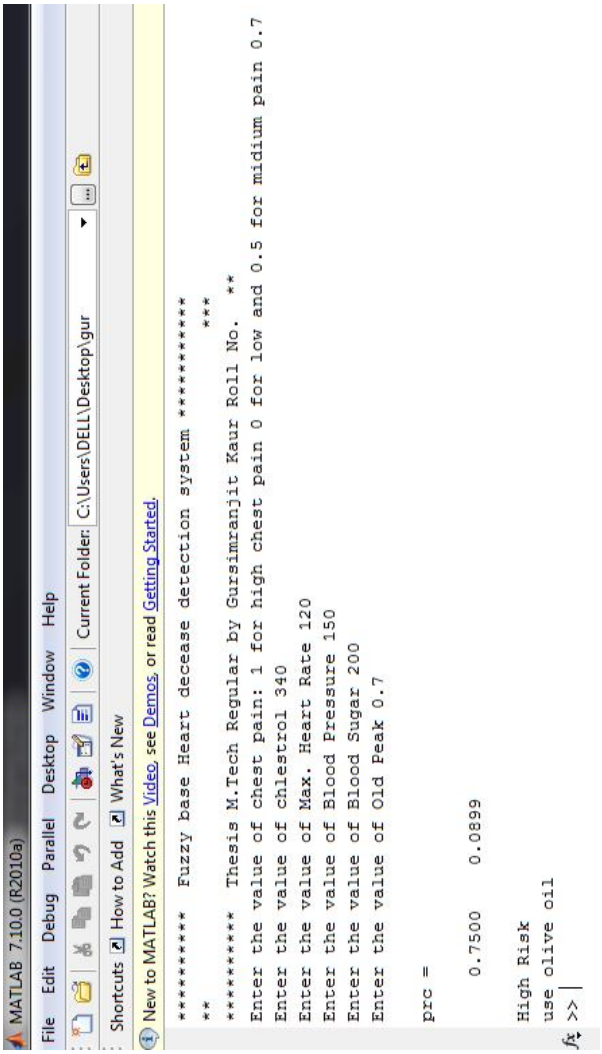


Figure: Surface Viewer of Chestpain and Blood Sugar

VI. .REAL TIME EVALUATION

We can also check the results by Real Time Evaluation. In this first coding is done in the MATLAB then after debugging the program we can check the output. Thus we can check the diseases and risks in the patient according to the values of the attributes. If the values of the attributes or inputs are high then the patient has high risk and if the values or inputs are low than the patient has low heart risk. And similarly if the values are normal then the patient and results shows that the patient is normal. Here we are showing the some examples that show the high risk, low risk etc in the person.



We have tested the designed system with following values for each field and graphical result. In the following table we can see the different the different values of different input variables and their results accordingly. If the values of the inputs lies in their low ranges then the risk is also low that is the result is of minimum value. Similarly, for the high values of the input.

Table 6.1 : System Testing

Chest pain	Cholestrol	Maximum heart rate	Blood Pressure	Blood Sugar	Old Peak	Result
0	100	70	60	50	0	0.07
0.1	155	78	74	83	0.1	0.1
0.16	158.5	83.2	78.9	123	0.2	0.25
0.5	250	110	130	150	0.5	0.5
0.1	281	121	150	161	0.7	0.62
0.89	353.5	136.8	190.9	231	0.866	0.77
1	400	150	185.3	235	0.92	0.80

VII. CONCLUSIONS

Fuzzy Expert System for Heart Disease Diagnosis designed with follow membership functions, input variables, output variables and rule base.In this thesis there are 6 inputs or input variables and two outputs or output variables. Designed system has been tested with expert-doctor. As in this we can check whether a person have any heart disease risk or not. This is one of the simple and more efficient method for the diagnosis of heart diseases analysis. Designing of this system with fuzzy base in comparison with classic designed improves results.. 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% as a well as the expert did.

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