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Enhancement in Diagnosis of Coronary Artery Disease using Fuzzy Expert System

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ABSTRACT

Coronary Artery Disease (CAD) is one of the most dangerous diseases on the globe. If it is not treated and detected at an early stage then it may lead to death. According to Global Burden of Disease Report, released on 15 September 2017, CAD is still the leading cause of death in India, killing 1.7 million Indians. The main aim of this paper is to predict Coronary Artery Disease using fuzzy expert system and for database, we have used Cleveland database. The proposed fuzzy expert system consists of three major steps i.e. fuzzification, rule base and defuzzification. Centroid technique is used for defuzzification. This system uses 10 input parameters and 1 output parameter which is either healthy, low risk, high risk or very high risk. An output result depends upon fuzzy rule base, which are combinations of input parameters. MATLAB tool used as a development tool and we have achieved 94.5% accuracy of proposed system.

Keywords: Coronary Artery Disease (CAD); fuzzy expert system; matlab tool; Cleveland database, Centroid Technique

I. INTRODUCTION

As we all know, heart is one of the important organ of our body, our life completely depends on its efficient working. Other important parts of our body like liver, kidney, brain also effects due to improper working of heart. If working of heart is affected due to any disease, whole body gets disturbed. There are various factors, which increases the risk of heart disease. As computer technology grows in every area, medical diagnosis area is not an exception. The diagnostic decision depends upon expertise and use of proper method with powerful logical reasoning ability to work on disease. Fuzzy logic is a powerful reasoning method that can handle uncertainty of data very well. One of the most important causes of death worldwide is heart attack. Therefore, diagnosis of the heart disease is important requirement in daily life but due to lots of uncertainty and risk factor sometimes, heart disease diagnosis is hard for experts. When a heart disease is identified, the speed of detection is highly essential to save the life of heart attack patient and to prevent heart damage. According to the World Health Organization, 12 million deaths occur each year due to heart attack diseases.

This paper organized as follows: Part 2 shows related work concerning heart disease diagnosis; Part 3, proposed algorithm and flowchart are given. In Part 4 reveals method and implementation of designing of fuzzy expert system. In the next part 5, Result analysis is given by the help of confusion matrix and

finally, we have concludes this study and scope for future.

II. Related Work

Baihaqi et al. [1] designed a review paper on fuzzy expert system and data mining technique with algorithm. In this paper, they also gave comparison between two techniques for accuracy. In this paper, they used UCI machine repository dataset for CAD. Agrawal-Chopde [2] presented a survey paper on CAD. In this paper, author mentions the entire possible attribute to determine heart condition with comparison of all the techniques. In this paper, they mentioned that ANFIS is better techniques to predict heart condition. Krishnasree-Rao[3] introduced a Bayesian regularization model, which is one of the statistical models for calculating nonlinear dataset. In this paper, they have implemented this model and achieved 91% accuracy. Muthukaruppan [4] presented a particle swarm optimization (PSO)-based fuzzy expert system for the diagnosis of heart disease. They have used decision tree (DT) for taking proper input attributes because dataset consist of lots of attributes. In this paper, they have given complete attribute information with their ranges and remarks.

Kasbe-Pippal [5] implemented a fuzzy expert system for diagnosis heart disease. In this paper, they have used 13 input attribute and 1 output attribute with UCI machine dataset. They have also compared a previous study with accuracy and in this paper, they achieved 93.33% accuracy. Nagar-Jain [6] presented a survey paper to diagnosis heart disease by expert system. In this paper, author gave all the important information like input variable with their values and how mamdani interface work, and dataset from UCI machine repository. Wagh-Paygude [7] implemented a heart disease diagnosis using Neuro-Fuzzy Expert System (NFES) with 90% accuracy. Author used MATLAB tool for implementation and given a table to compare Neuro fuzzy system with and without genetic algorithm. Rathod-Gawande [8] proposed a fuzzy expert system to diagnosis heart disease of any patient. In this paper, author gave complete details of all 11 attribute with their membership functions and given a rules. They achieved 94% accuracy in this paper. Pathania-Ritika [9] implements a fuzzy controller for diagnosis. They used 6 Input parameter and 1 output attribute for identify risk level and also used UCI machine repository dataset. In this paper, they achieved 92% accuracy.

Kumar-Kaur [10] developed a fuzzy logic system for diagnosis from the database of Parvati Devi hospital, Ranjit Avenue and EMC hospital Amritsar and International Lab. In this paper, they have used 6 Input attribute with 1 output variable and achieved 90% accuracy. Abushariah et al. [11] proposed an adaptative Neuro-Fuzzy Inference System (ANFIS), which is the part of hybrid neuro-fuzzy inference expert systems. In this paper, they have used hybrid learning algorithm with MATLAB software. Venkatalakshmi- Shivsankar [12] designed a Naïve Bayes, Decision tree and Clustering algorithm to diagnosis heart disease diagnosis. They have used UCI machine database and also given performance comparison to above mention algorithm. Senthil Kumar [13] developed an expert system to diagnosis heart disease by using advance fuzzy resolution mechanism. In this paper, they have used MATLAB tool and Cleveland dataset for implementation process with 93.88% accuracy. Eswara Rao- Govinda Rao [14] implemented a fuzzy expert system using mamdani interface and UCI machine repository dataset. Author has used 11 input parameters with their membership functions and rules. Sen et al. [15] presented a paper on data mining techniques using neuro fuzzy expert system to diagnosis heart disease. In this paper, they have used MATLAB tool with 11 input parameter and UCI machine dataset.

Khatibi-Montazerac [16] proposed a hybrid interface engine to find out risk level and achieved 91.58%. Their prediction model was based on Dempster–Shafer theory of evidence and fuzzy sets theory. Chitra- Seenivasagam [17] designed a Supervised

Learning Algorithm is adopted for heart disease prediction. In this paper, they have used 270 patient databases from UCI with confusion matrix. Barman-Choudhury [18] implemented a fuzzy rule base for heart disease diagnosis. In this paper, they have used mamdani interface with UCI machine database. Baihaqi et al. [19] developed used a data mining techniques with 81.82% accuracy. For rule base, they have used C4.5, CART and RIPPER. In this paper, they have also given comparison among all three fuzzy rule based techniques and implemented their system on 411 data sets. Paul et al. [20] implemented genetic algorithm based fuzzy decision support system for the diagnosis of heart disease. In this paper, they have used FDSS based on the preprocessed datasets and the selected effective attributes generated by correlation coefficient by the help of required and WLS method. Sayad-Halkarnikar [21] presented a neural network approach. This paper consists of Multi-Layer Perception Neural Network (MLPNN) and used back-propagation algorithm. For diagnosis of heart disease, significantly 13 attributes are used in proposed system as per the medical literature with 94% accuracy.

III. PROPSED AGORITHIM & FLOWCHART

INPUT

Input the fuzzy set for A1, A2, A3, A4, A5, A6, A7, A8, A9, A10

OUTPUT

Output the fuzzy set for DC

METHOD

Begin

Step1: Input the crisp values for A1, A2, A3, A4, A5, A6 A7, A8, A9, A10

Step 2: Set the triangular membership function for the fuzzy number with equation.

$$\mu_A(x) = \begin{cases} 0, & x \le a \\ \frac{x-a}{m-a}, & a<x\le m \\ \frac{b-x}{b-m}, & m<x<b \\ 0, & x\ge b \end{cases}$$

Step 3: Built the fuzzy numbers for A1, A2, A3, A4, A5, A6 A7, A8, A9, and A10 for input set

Step 3.1: Built the fuzzy number for DM for the output set.

Step 4: Fuzzy inference are executed by Mamdani's method.

Step 4.1: Input the rule as {Rule 1, 2...k}

Step 4.2: Matching degree of rule with OR fuzzy disjunction are calculated for fuzzy input set (A11, A12, A13,A14, A21, A22, A23,A24, A31, A32, A33, A41, A42, A43,A44, A51, A52, A53, A61, A62, A63, A64, DC1, DC2,DC3,DC4 and DC5).

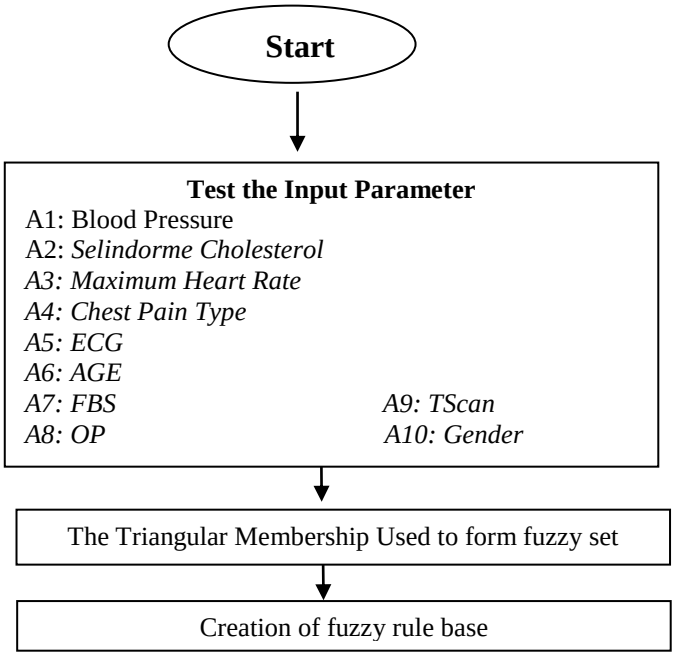
Step5: Defuzzify into the crisp values by **DC=**

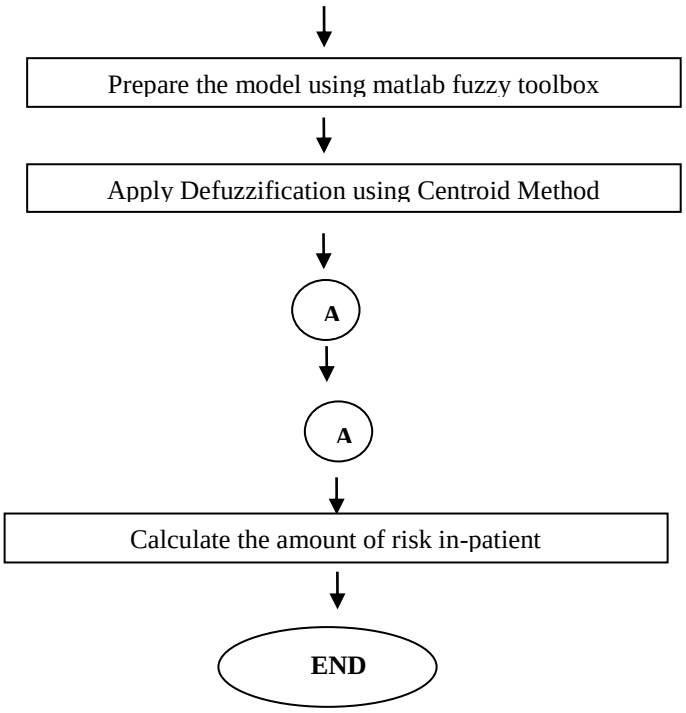
$$DC \leftarrow \frac{\sum_{i=1}^{\cdot\cdot} Z_i \mu(Z_i)}{\sum_{i=1}^{i=n} \mu(Z_i)}$$

Where Zi means the weight for μ(Zi) and μ(Zi) means the number of fuzzy numbers of the output fuzzy variable DC.

Step6: Present the knowledge in the form of human nature language.

End.





IV. PROPOSED METHODS

We have used MATLAB R2008 tool, which is best tool for implementing fuzzy interface system. We have used 10 Input variables & one output variable for identification of disease risk level. Following images are used as a screenshots of MATLAB window while using fuzzy interface system and providing screenshot of input variables, fuzzy rules creation editor and view editor [5] [12].

MATLAB Window

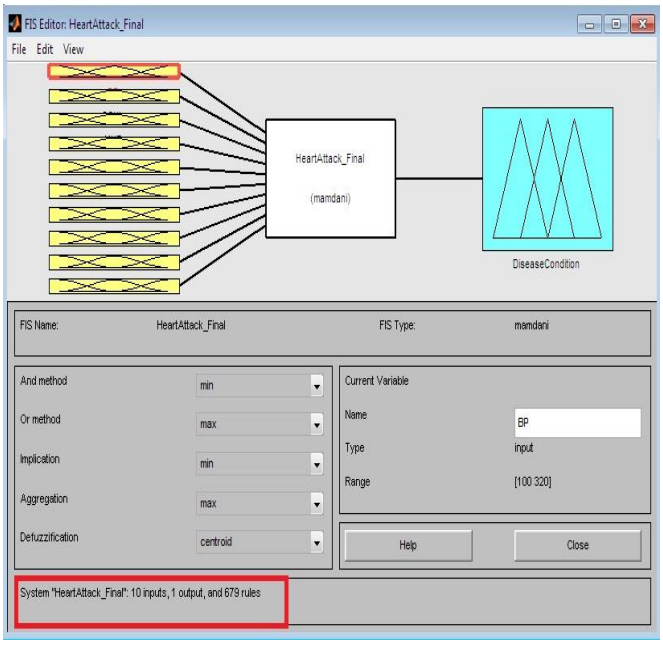


Figure 1. It shows 10 Input variables & 1 Output variable

Step 1:

In this step, we are providing ranges of input variable by using membership functions and providing ranges of output variable. We have used triangular and trapezoidal member functions [5] [8] [10].

Following are the table, in which we have mention all input variable with their range and fuzzy set values:

TABLE I: Input Attribute with their Ranges

Input Filed	Ranges	Fuzzy Set Value
BP	100 - 134	Low
	127 - 153	Medium
	142 - 172	High
	154 - 320	Very High
SCHL	40 - 197	Low
	188 - 250	Medium
	217- 307	High
	281 - 681	Very High
MHR	70 - 141	Low
	111 - 194	Medium
	152 - 400	High
CP	0 - 2	TAngina
	1 - 3	ATAngina
	2 - 4	NonAngina
	3 - 5	Asynpt
FBS	-1 - 1	False
	0 - 2	True
OP	0 - 2	Low
	1.5 - 4.2	Medium

	2.55 - 5	High
ECG	-0.5 - 0.4	Normal
	0.25 - 1.8	ST_T_abnormal
	1.4 - 2.5	Hypertrophy
ThaScan	1 - 5	Normal
	4 - 8	FixedDef
	5.5 - 10	RevDef
Gender	-1 – 1	M
	0 - 2	F
Age	20 - 38	Young
	33 - 45	Medium
	40 - 58	Old
	52 - 100	VeryOld

TABLE III: Output Attribute with their Ranges

Output Filed	Ranges	Fuzzy Set Value
DiseaseCondition	-1 - 1	Healthy
	1 - 2	LowRisk
	2 - 3	Risk
	3 - 4	HighRisk
	4 - 5	VeryHighRisk

Step 2:

After above step, we have created rules for all possible output, which is the most important part and contain any one of the output. Result accuracy is fully depends upon the combinations & strength of rule. If we have created rules with proper combination of input variable then surely we will get a good result. All the rules prepared with the help of AND & OR connection [22]. We have made **679 rules** for diagnosis of heart disease.

Fuzzy Rule Base

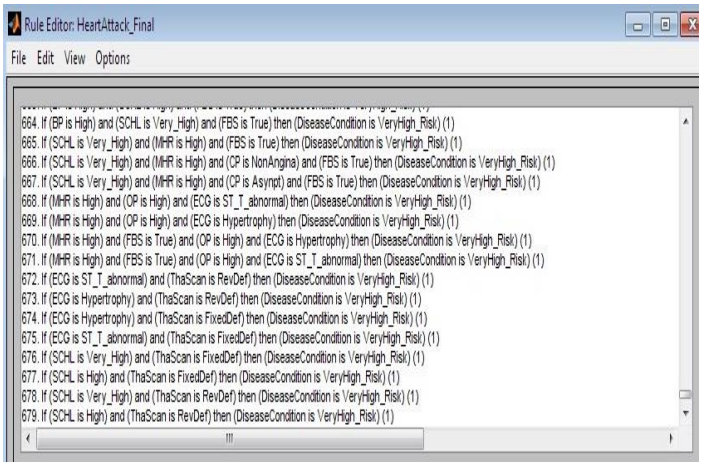


Figure 2. Rule Base Editor

Step: 3: Rule Viewer

By the help of rule viewer, we can check the disease condition (Risk Level) depends upon given input parameter. Rule Viewer is a place, where we will use all the input parameter from the UCI database [23] and result is displayed according to given input parameter. We are providing the screenshot of our implementation.

Rule Viewer

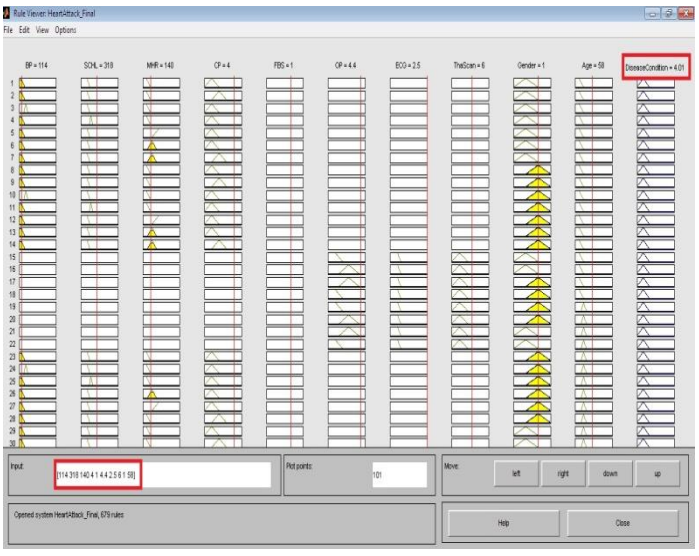


Figure 3. Rule Viewer

With the help of above matlab rule viewer, the result can tested easily. After testing on 200 patient databases (UCI) [25], 94.5% accuracy has been

achieved by the proposed diagnosis system. The experimental results are compared with earlier research in Table III and shows that the proposed system is more efficient and accurate as compare to other existing diagnosis systems.

TABLE IIIII: Comparisons of Previous Research

Diagnosis System	Accuracy
Rathod-Gawande [8], Sayad-Halkarnikar [21]	94%
Senthil Kumar [13]	93.88%
Kasbe-Pippal [5]	93.33%
Muthukaruppan [4]	93.27%
Pathania-Ritika [9] Kumar-Kaur [10]	92%
Khatibi-Montazerac [16]	91.58%
Proposed Method	**94.5%**

V. RESULT ANALYSIS AND DISCUSSION

The most important part of any expert system is input given by the user. In this proposed study, we have used Cleveland database from UCI machine repository [23].We have used 200 patient data, and make fuzzy rule according to the input parameter given in the UCI. We have used all the 10 input variables which exist in UCI dataset [5] [10] [23]. After testing on this implementation system, accuracy & sensitivity of system is 94.5% & 90.1 9%. We have measured the accuracy and sensitivity by the help of confusion matrix. The following table shows the confusion matrix:

TABLE IV. CONFUSION MATRIX

Total = 200	Predicated Value : NO	Predicated Value : YES
Actual Value: NO	TN=143	FP=6
Actual Value: YES	FN=5	TP=46

True Positive (TP) = In this case, we have predicated a heart disease and according to database, actual it is.

True Negative (TN) = In this case, we have predicated a no heart disease and they do not have the disease.

False Negative (FN) = In this case, we have predicated a no heart disease and they have the heart disease.

False Positive (FP) = In this case, we have predicated a heart disease and they do not have the heart disease.

VI. CONCLUSION

In this paper, expert system is designed by the help of fuzzy logic toolbox and used mamdani interface system. We have used 10 input variables, 679 fuzzy rules and dataset from Cleveland database (200 dataset). We have used centroid technique for defuzzification. It is one of the most efficient methods to create an expert system and diagnosis the heart disease. The proposed implementation system has better performance and accuracy compared with the previous research to diagnosis heart disease. We have archived 94.5% accuracy, which is the highest accuracy using fuzzy expert system, so far. From the result accuracy, it can be concluded that the proposed system has highest accuracy but still it will require to get more accuracy.

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