

# 1 A Fuzzy Rule based Approach to Predict Risk Level of Heart 2 Disease

3 Kantesh Kumar Oad<sup>1</sup> and Xu DeZhi<sup>2</sup>

4 <sup>1</sup> Central South University

5 *Received: 6 December 2013 Accepted: 5 January 2014 Published: 15 January 2014*

6

---

## 7 **Abstract**

8 Health care domain systems globally face lots of difficulties because of the high amount of risk  
9 factors of heart diseases in peoples (WHO, 2013). To reduce risk, improved knowledge based  
10 expert systems played an important role and has a contribution towards the development of  
11 the healthcare system for cardiovascular disease. To make use of benefits of knowledge based  
12 system, it is necessary for health organizations and users; must need to know the fuzzy rule  
13 based expert system's integrity, efficiency, and deployments, which are the open challenges of  
14 current fuzzy logic based medical systems. In our proposed system, we have designed a fuzzy  
15 rule based expert system and also by using data mining technique we have reduced the total  
16 number of attributes. Our system mainly focuses on cardiovascular disease diagnosis, and the  
17 dataset taken from UCI (Machine Learning Repository). We explored in the existing work.  
18 The majority of the researcher's experimentation was made on 14 attributes out of 76. While,  
19 in our system we took advantage of 6 attributes for system design. In the preliminary stage  
20 UCI, data participated in suggested system that will get outcomes. The performance of the  
21 system matched with Neural Network and J48 Decision Tree Algorithm.

22

---

23 *Index terms*— fuzzy reasoning, heart disease and diagnose, data mining

## 24 **1 Introduction**

25 Just recently peoples are pressured over their health and wellness troubles, in the majority of the countries  
26 proportion of cardiovascular disease enhancing really quick and it has actually become the leading cause / death  
27 worldwide [1] [2], and it is came to be taken into consideration a "second epidemic," changing transmittable  
28 conditions as the leading cause of death [3] [4]. Health domain application is one of one of the most active  
29 study area nowadays. Ideal example of health domain application is the detection system for cardiovascular  
30 disease based on computer system assisted diagnosis strategies, where the information acquired from numerous  
31 other sources and is evaluated based on computer-based application. Before it was very time consuming job to  
32 get knowledge from physician and include this knowledge to computer system program by hand into data base  
33 medical decision support system and this was totally depending upon clinical experts' concepts which may be  
34 subjective.

35 This trouble has really been resolved using expert systems; get physician, group, knowledge and certain human  
36 client details, intelligently. In boosting outcomes at a couple of healthcare companies and strategy internet sites,  
37 expert system has actually operated by making needed clinical knowledge quickly readily available to know-how  
38 users [5] Taking care of clinical needs, such as making certain specific medical diagnoses, evaluating in a quick  
39 manner for avoidable health problem, or avoiding undesirable drug occasions, are the most standard exploitation  
40 of Expert System [6]. Expert System could also be possibly lessened costs, progression performance, and reduce  
41 client stress. These systems are classified into 2 groups namely (1) Knowledge based and (2) non-knowledge based  
42 [7]. The knowledge based system consists of rules (if-then statements). Expert system that is implemented with

## 7 C) ATTRIBUTES SELECTION

---

43 the assistance of artificial intelligence has the ability to support in a new setting and to learn for instance [8] [9].  
44 Given that the concept of computer-based Clinical Decision Support System aroused at first, significant research  
45 has actually been made in both academic and practical areas. Many obstacles are longer to impede the effective  
46 application of expert systems in scientific environments, among which portrayal and reasoning concerning clinical  
47 understanding predominantly under anxiety is the locations that require improved methodologies and strategies  
48 [10] [11].

49 In our proposed system, mainly focus on cardiovascular disease diagnosis. We have taken dataset taken from  
50 UCI (Machine Learning Repository). UCI database consists of 76 attributes; we investigated in the existing  
51 work. Most of the experiments were made by using a subset of 14 from UCI. While, in our system we reduced  
52 the number of input attributes that will reduce the number of diagnostic results and we used seven attributes  
53 to experiment. From seven attributes, we used six attributes as input, and one attribute for output. Numerical  
54 data will enter in into suggested system, and in the last; system will get prediction results. The primary objective  
55 of our research is to make and carry out fuzzy rule based system for heart disease people.

## 56 2 Kantesh Kumar Oad ?

57 Xu DeZhi ? & II.

## 58 3 Related Work

59 Mehdi.N. Mehdi. Y. (2009) [12] designed a Fuzzy Expert System of diagnosing the hepatitis B intensity rate and  
60 making comparisons with Adaptive Neural. M. Neshat, M. Yaghobi, M.B. Naghibi, A. Esmaelzadeh (2008) [13]  
61 designed a fuzzy expert system for Diagnosis of liver disorders. P.K. Anooj (2012) [14] developed Clinical decision  
62 support system: Risk level prediction of heart disease using weighted fuzzy rules. Persi Pamela I, Gayathri. P,  
63 N. Jaisankar (2013) [15] uses a Fuzzy Optimization Technique for the Prediction of Coronary Heart Disease  
64 Using Decision Tree. Nidhi Bhatla, Kiran Jyoti (2012) [16] used Novel Approach for Heart Disease Diagnosis  
65 using Data Mining and Fuzzy Logic. Vijay Kumar Magoa, Nitin Bhatia, Ajay Bhatia, Anjali Mago (2013) [17]  
66 designed clinical decision support system for dental treatment. Syed Umar Amin, Kavita Agarwal, Dr. Rizwan  
67 Beg (2013) [18] used Data Mining in Clinical Decision Support Systems for Diagnosis, Prediction and Treatment  
68 of Heart Disease. Asha Rajkumar, Mrs. G. Sophia Reena (2010) [19] used diagnosis of Heart Disease according  
69 to the data mining Algorithm "GJCST Classification J.3. M. Anabarsi. Anupriya \\*, N. CH. Iyengar (2010) [20]  
70 enhanced prediction of Heart Disease with Feature Subset Selection using Genetic Algorithm. K. Rajeswari. V.  
71 Vaithianathan (2011) [21] designed Heart disease diagnosis: an efficient decision support system based on fuzzy  
72 logic and genetic algorithm.

## 73 4 III.

## 74 5 A Fuzzy Rule based Approach to Predict Risk Level of Heart 75 Disease

76 As you can see in figure (1) the process begins with data processing (see section 3.1). In a second step, we reduced  
77 the number of attributes and then this processed data (symptoms) inserted into fuzzy system using MATLAB  
78 programming. After the fuzzy model is successfully developed, the prediction of the symptoms will start and  
79 lastly performance based on the result will be analyzed at the end of the development phase.

## 80 6 a) Data Processing

81 The function of data processing is to draw out the significant information from the raw data collection useful  
82 for heart disease prediction, and these data sets should be transformed into the needed style for the level of  
83 risk prediction. Due to large amount of data there are chances of errors on it so before processing heart disease  
84 datasets, the original raw datasets must be processed; as a result in data processing phase, we cleaned, transformed  
85 and analyzed it into the row column format after taking out the unnecessary ones. For recap or view purpose we  
86 should make data in a format so it can be easily reviewed. We have converted data to a .csv (Comma Separated  
87 Values) documents format also called comma delimited file. .csv file is a particularly configured text file; which  
88 establishes spreadsheet or standard database-style information in a quite easy style, with one record for each  
89 line, and each field within that document separated by a comma.

## 90 7 c) Attributes Selection

91 To minimize disease data sets (feature selection), we have used data reduction technique. Attribute selection  
92 lessens the data set size by getting rid of redundant or unnecessary and extracting with a minimized set of  
93 characteristics has an extra benefit [22]. Primarily we have actually made use of the data mining tool to get  
94 decreased collection of datasets. An attributes selection method contains four steps, named (1) subset generation;  
95 (2) subset evolution, (3) stop criterion (4) outcome validation [23] subset generation is a searching technique and  
96 we have made use of Best First Search Method using DM tool. Each new subset evaluated and matched with  
97 earlier best one according to a certain evolution criterion. It changes the previous finest subset if the new subset

98 turns out to be much better. The process of subset generation and evolution is duplicated till a given quitting  
99 criterion is pleased.

100 By using selected method, we have obtained 6 attributes from a total of 14 attributes. Fuzzy system used in  
101 circumstances where we have a trouble of uncertainty. When the trouble has a dynamic behavior; Fuzzy Rule  
102 Base is an appropriate system for handling this issue. In the primary step of fuzzy expert system design; figure out  
103 the input and result variables. As it is described in section (4.3) we selected six inputs and one output variable.  
104 Then, we have actually made the membership functions for all variables used in the system. Membership function  
105 is primarily a visual portrayal of a fuzzy set; and determines the membership degree of objects to fuzzy sets.  
106 Rule evolution and defuzzification process described in the next sections. Fuzzification is a process of fuzzifying  
107 all inputs and output. Determine the degree to which these inputs and outputs belong to each of the suitable  
108 fuzzy sets. Age:

109 We have actually separated age into 3 fuzzy sets (Young. Middle and Old) and ranges of these fuzzy sets are  
110 determined in Table ??1 Blood Pressure:

111 We have actually separated this input fuzzy set into 4 levels called (Low, Medium, High and Very high).  
112 Trapezoidal MFs are used for (Low and Very high) and MFs of (medium and high) sets are triangular. Heart  
113 Rate:

114 Heart Rate split into 3 fuzzy sets named (Low, Medium and High). Ranges for these fuzzy sets are identified  
115 in table (1). MFs of (Low and High) sets are trapezoidal and MF of (Medium) is triangular. Old Peak:

116 Old Peak divided into 3 fuzzy sets (Low, Risk and Terrible). These fuzzy sets have actually been shown in  
117 Table (1) with their ranges. This input field includes 3 fuzzy sets: (Normal, Fix Defect and Reverse Defect).  
118 For each and every fuzzy fuzzy set we have defined a value that we use them for system testing. These fuzzy  
119 sets with their values are shown in Table (1).?low(x) = 1 when x ? [0, 1] ?low(x) = (2-x)/(2-1) when x ? [1, 2]  
120 ?low(x) = 0 otherwise. ?risk(x) = (x-1.5)/(2.?normal(x) = (x-1)/(2-1) when x ? [1, 2] ?normal(x) = (3-x)/(3-2)  
121 when x ? [2, 3] ?normal(x) = 0 otherwise.

122 ?Fix Defect(x) = (x-3)/(4.5-3) when x ? [3, 4.5] ?Fix Defect(x) = (6-x)/(6-4.5) when x ? [4. 5, 6] ?Fix Defect(x)  
123 = 0 otherwise.

124 ?Rev Defect (x) = (x-6)/(6.5-6) when x ? [6, 6.5] ?Rev Defect(x) = (7-x)/(7-6.5) when x ? [6.5, 7] ?Rev  
125 Defect(x) = 0 otherwise. Over we have actually selected chosen features, now we have split all inputs into fuzzy  
126 sets; we have actually utilized trapezoidal and triangular membership functions in system.

## 127 8 Table 1 : Risk factors and Ranges

128 ii. Rules Evolution In Fuzzy Rule Base System, rules play an important role in the prediction. The rules  
129 deliver/provide a sense to linguistic variables and MF (membership function). So we have occupied these fuzzyfied  
130 inputs in antecedent part of the rules. In this research, we have actually utilized 19 rules to predict heart disease  
131 in the patient.

132 In our system antecedent part of the rule consist of only single part that will opinion result of antecedent  
133 development. Fuzzy logic will govern risk level and this prediction indeed relies on rules that we have made.  
134 The made rules we have applied in using Mat Lab R2012a in the rule editor. After then fuzzification, crisp will  
135 certainly examine by passing in rule instance. CoA is the center of area/gravity; x is the linguistic variable and  
136 x (min) and x (max) signifies the arrays of variables.

## 137 9 IV.

## 138 10 System Testing

139 To compare the performance of our system with Neural Network and J48 Decision Tree, we have divided Cleveland  
140 Heart Disease datasets into 2 parts e.g. training data 60% and testing data 40%. And this efficiency/performance  
141 is usually matched in term of sensitivity, specificity and accuracy. These terms normally took advantage of  
142 diagnostic approaches to enhance analysis results. iii. Output (Defuzzification)

143 In this system, we have one output variable, which divided to 2 fuzzy sets (healthy and sick). For defuzzification  
144 procedure, designed system makes use of the Centroid method, determines the area of membership functions  
145 within the range of (output) variable.

146 We use specificity to analyse and assess the amount of true positives predicted accurately. Specificity analyses  
147 and measure the amount of true negative predicted accurately. Accuracy can be obtained by sum of True Positive  
148 and True Negative divided with the total number of instances.

149 Example: No of healthy (True Positive) and sick (True Negative) peoples predicted correctly. V.

## 150 11 Conclusion

151 This proposed system "Fuzzy Rule Based Support System" modelled to predict heart disease intelligently and  
152 efficiently, and to replace manual efforts. Experts system can be more proficient and fast so it can be more  
153 accurate then manual work. Our system modelled to diagnosis and detecting cardiovascular diseases, the system  
154 involves two major phases, one that performs classification and diagnosis, the other one that detects the rate of  
155 risks of the respiratory diseases. For this system we have used mamdani inference system. In final this system

## 11 CONCLUSION

---

tested and compared with Neural Network and J48 Decision Tree model to check performance of the system.



Figure 1: Figure 1 :

156 1  
157

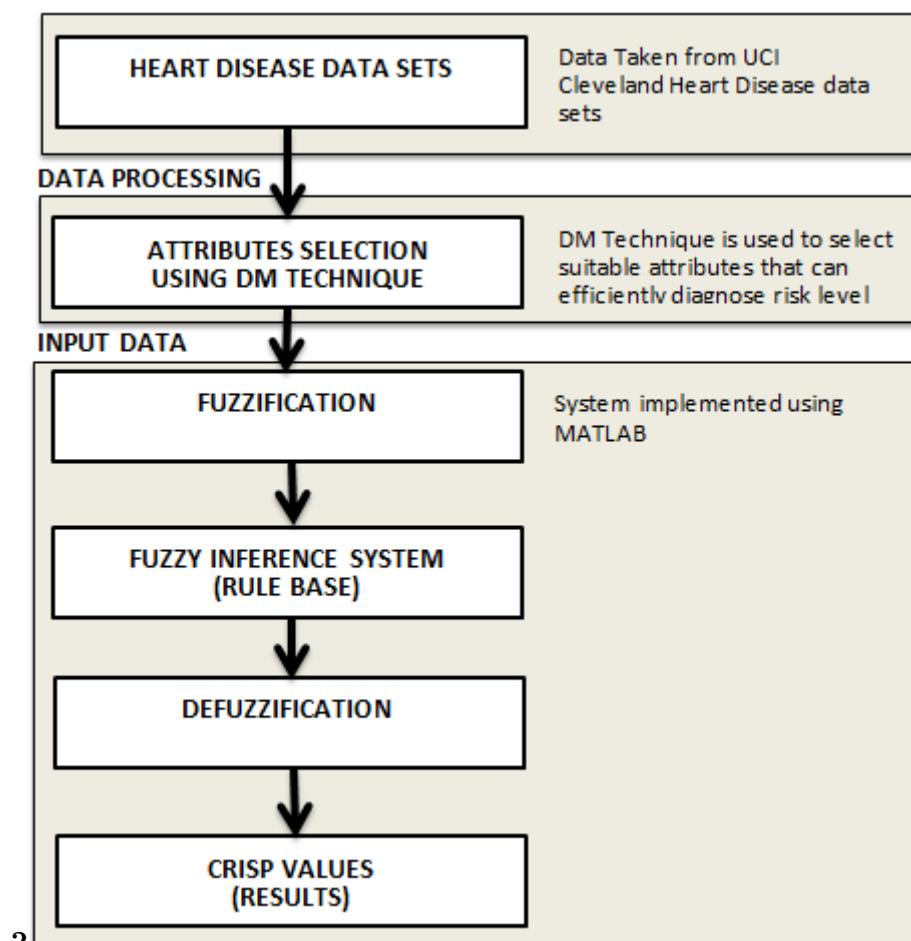


Figure 2: Figure 2 :

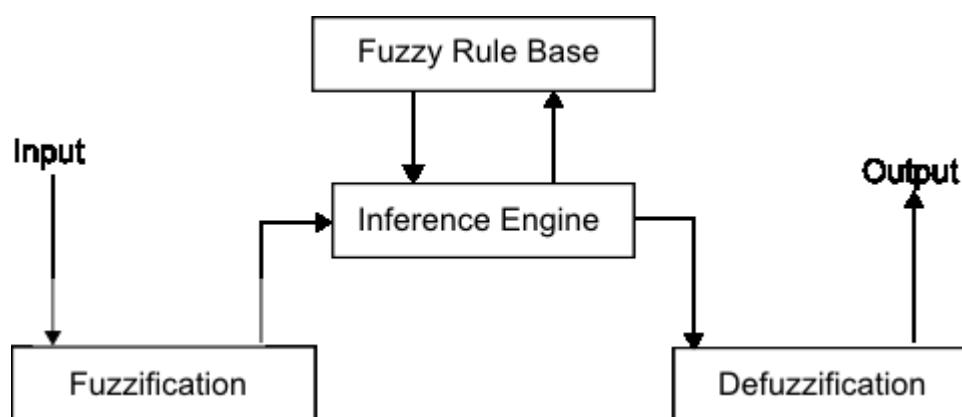


Figure 3:

## 11 CONCLUSION

---

		Condition		+Prediction value $= TP / (TP + FP)$
		Condition Positive	Condition Negative	
Test	Test Positive	TP	FP	-Prediction value $= TN / (FN + TN)$
	Test Negative	FN	TN	
		Sensitivity $= TP / (TP + FN)$	Specificity $= TN / (FP + TN)$	

Figure 4:

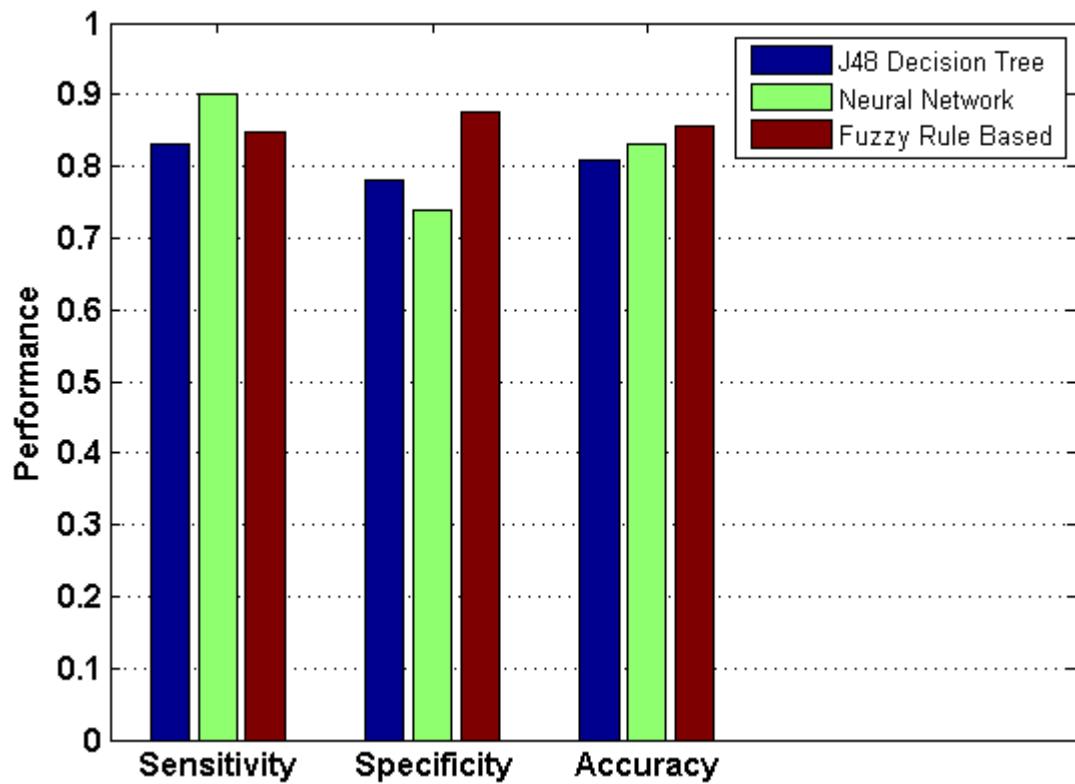


Figure 5:

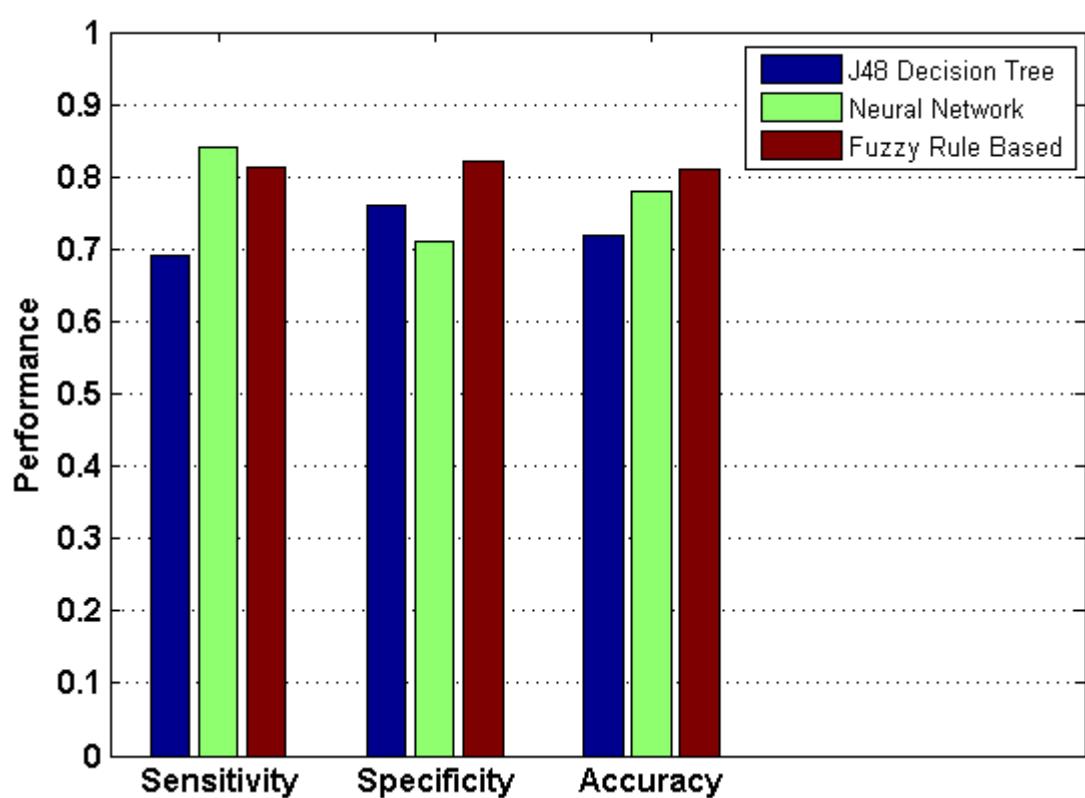


Figure 6:

## 11 CONCLUSION

---

### 158 .1 Acknowledgement

159 [Pamela et al. ()] 'A Fuzzy Optimization Technique for the Prediction of Coronary Heart Disease Using Decision  
160 Tree'. Persi Pamela , I P Gayathri , Jaisankarn . *International Journal of Engineering and Technology (IJET)*  
161 2013. 5 (3) .

162 [Bhatla and Jyoti ()] 'A Novel Approach for Heart Disease Diagnosis using Data Mining and Fuzzy Logic'. Nidhi  
163 Bhatla , Kiran Jyoti . *International Journal of Computer Applications* 2012. 54 (17) p. .

164 [Andersonj ()] *Clearing the way for physicians use of clinical information systems* *Communication of the*,  
165 Andersonj . 1997. ACM. p. .

166 [Merijohn et al. ()] 'Clinical decision support chair side tools for evidence-based dental practice'. G K Merijohn  
167 , J D Bader , J Frantsve-Hawley . *The Journal of Evidence-Based Dental Practice* 2008. 2008. 8 (3) p. .

168 [Kumar Magoa et al. ()] 'Clinical decision support system for dental treatment'. Vijay Kumar Magoa , Nitin  
169 Bhatia , Ajay Bhatia . *Journal of Computational Science* 2012. 2012. (3) p. .

170 [ AnoojpK ()] 'Clinical decision support system: Risk level prediction of heart disease using weighted fuzzy rules'.  
171 AnoojpK . *International Journal of Research and Reviews in Computer Science (IJRRCS)* 2012. 3 (3) p. .

172 [Musenm et al. ()] *Clinical decision support systems*, Musenm , Shahary , H Shortliffe . 2001.

173 [Kashiyarndis ()] *Clinical decision support systems: a discussion on different methodologies used in health care*,  
174 Abbasim M Kashiyarndis . 2006.

175 [Syed Umar Amin et al. ()] 'Data Mining in Clinical Decision Support Systems for Diagnosis, Prediction and  
176 Treatment of Heart Disease'. Kavita Syed Umar Amin , Dr Rizwan Agarwal , Beg . *International Journal of*  
177 *Advanced Research in Computer Engineering & Technology. (IJARCET)* 2013. 2. (Issue 1)

178 [Linl et al. ()] *Decision Support Systems*, Linl , J H Hup , O R L Sheng . 2006. 42.

179 [Neshat and Yaghobi ()] 'Designing a Fuzzy Expert System of Diagnosing the Hepatitis B intensity Rate and  
180 comparing it with Adaptive Neural Network Fuzzy System'. M Neshat , M Yaghobi . *International Conference*  
181 *in Modelling Health Advances pp*, 2009. p..

182 [Rajkumar et al. ()] 'Diagnosis of Heart Disease Using Data mining Algorithm'. Asha Rajkumar , . G Mrs ,  
183 Sophia Reena . *GJCST Classification J.3. Global Journal of Computer Science and Technology* 2010. 10.  
184 (Issue 10 Ver. 1.0)

185 [Garg and Adhikari ()] 'Effects of computerized clinical decision support systems on practitioner performance  
186 and patient outcomes'. N K Garg , Mcdonaldh Adhikari . *Journal of the American Medical Association.*  
187 *PubMed* 2005. (10) p. .

188 [Anupriya et al. ()] 'Enhanced Prediction of Heart Disease with Feature Subset Selection using Genetic Algo-  
189 rithm'. Anbarasim Anupriya , \* E Iyengarn , Ch . *International Journal of Engineering Science and Technology*  
190 2010. 2 (10) p. .

191 [Liuh ()] 'Feature selection for classification. Intelligent Data Analysis'. Dashm Liuh . *An International Journal*  
192 1997. 1 (3) p. .

193 [Neshat et al. ()] *Fuzzy Expert System Design for Diagnosis of liver disorders*, M Neshat , M Yaghobi , B  
194 Naghibim . 2008. IEEE Computer Society. p. .

195 [Warren et al. (2000)] 'Fuzzy logic in clinical practice decision support system'. J Warren , G Beliakov , B Zwaag  
196 . *Proceedings of the 33rd Hawaii International Conference on System Sciences*, (the 33rd Hawaii International  
197 Conference on System SciencesMaui, Hawaii) 2000. January 2000. p. .

198 [Mendis et al. ()] *Global Atlas on cardiovascular disease prevention and control*, S Mendis , P Puska , B Norrvig  
199 . 2011.

200 [Han and Kamber ()] J Han , M Kamber . *Data Mining: Concepts and Techniques. Second Edition*, (San  
201 Francisco) 2006. Morgan Kaufmann Publishers.

202 [Rajeswari and Vaithianathan ()] 'Heart disease diagnosis: an efficient decision support system based on fuzzy  
203 logic and genetic algorithm'. \* K Rajeswari , Vaithianathan . *International Journal of Decision Sciences*  
204 2011. 3 (2) . (Risk and Management)

205 [Kelly ()] 'Promoting cardiovascular health in the developing world: a critical challenge to achieve global health'.  
206 *Countries, Committee on Preventing the Global Epidemic of Cardiovascular Disease: Meeting the Challenges*  
207 *in Developing; Fuster, Board on Global Health; Valentin; Academies, Bridget B Kelly (ed.)* (Washington, D.  
208 C.) 2010. National Academies Press. (Institute of Medicine of the National)