Fuzzy-based Decision for Coronary Heart Disease Diagnosis: Systematic Literature Review

Afrina Safira Dianirani1*, Zefanya Debby Claudia2
1,2 Computer Science Department, School of Computer Science, Bina Nusantara University, Jakarta, Indonesia 11480 afrina.dianirani@binus.ac.id; zefanya.claudia@binus.ac.id
*Correspondence: afrina.dianirani@binus.ac.id

Abstract – A build-up of fatty substance and plaque within the coronary arteries typically causes coronary heart disease. Around the world, the mortality rate caused by coronary heart disease is threatening. The majority of people from developed countries have suffered from heart disease over the last two decades. At early stages, the diagnosis of these illnesses helps patients decrease the risk of mortality and therefore minimize the cost of care. Health diagnostic decisions are often focused on the experiences of specialists. In certain cases, not all the insights of the expert lead to the accurate diagnosis of a disease. For medical diagnosis in the area of healthcare, several experimental approaches have been proposed. However, it remains difficult to determine the functionality of testing devices for coronary heart disorders. The purpose of this paper is to undertake a literature review on fuzzy-based decision-making for the diagnosis of coronary heart disease. The study then gathered results pertaining to fuzzy-based decision-making for the diagnosis of coronary heart disease from 2016-2021.

Keywords: Coronary Heart Disease; Fuzzy-based System; Medical Diagnosis.

I. INTRODUCTION

Competent heart function greatly affects our life, because the heart is an important part of our body. If the heart function does not work properly, it will affect other parts of the human body such as the brain, kidneys etc [18]. Some heart diseases are caused by bad habits that humans do such as watching TV for too long, letting stress, ignoring snoring, drinking alcohol, eating too much, smoking and living with smokers, not consuming fiber, especially fruits and vegetables and so on. Because there are many and less clear risk factors for heart disease, ordinary people will find it difficult to know this disease. The most common death is due to the condition that affects the heart is Cardiovascular disease (CVD). The foremost reason of illness and death that causes by narrowing the blood vessels those supplying oxygen and blood to the heart[15], leads to the symptoms like fatigue and chest pain (angina) [2]. The Heart disease is one of risky disease and need to diagnosis in early time to surmount it’s risk[1]. Basically, most heart failure occurs due to coronary problems, high blood pressure, and diabetes which can damage the heart. In 2015, the World Health Organization (WHO) estimated that one-third of all causes of global death were cardiovascular disease and estimated that approximately 17.7 million people lost their lives due to cardiovascular disease. This population represented 31% of all deaths [4]. Based on WHO estimates in 2030, nearly 23.6 million people suffer from heart disease. So, to minimize this it is necessary to analyze coronary disease. Coronary disease examination is usually in terms of signs, manifestations and physical examination of the patient [17]. For many people the first sign of heart dysfunction is a heart attack that occurs when the blood clot in the coronary arteries blocks the flow of blood into a part of the heart muscle [14].

Diagnosis of heart disease is important, but due to the many uncertainties and risk factors it is sometimes difficult for experts to diagnose heart disease. When a heart attack is identified, the speed of detection is critical to save the lives of those with heart attack and prevent heart damage. Medical diagnosis requires accurate and efficient surgery. To increase the accuracy of diagnosis and reduce the mortality rate of cardiovascular disease, it is necessary to carry out a correct diagnosis at an early stage. There are many factors to analyze heart disease, because it is a difficult job to diagnose a patient. Thus, an accurate and fast tool is
II. METHODS

This paper is based on a systematic literature review. A systematic literature review identifies, selects, and objectively evaluates studies in order to address a clearly stated question. For a systematic assessment, a well-defined protocol or technique should be used, with the conditions explicitly stated before the analysis begins. It's a simple, systematic search that can be continued and replicated by other researchers through a variety of databases and grey literature. It reviews what has been done in the context of a subject. The author uses 20 publications in this paper to diagnose coronary heart disease using a knowledge-based search mechanism related to fuzzy decision-making. Coronary Heart Disease, Fuzzy-based System, and Medical Diagnosis are some of the keywords that were used. The paper used was found on Google Scholar, and it was published between 2016 and 2021.

III. RESULTS AND DISCUSSION

RQ1: What are data needed for a fuzzy-based decision for coronary heart disease diagnosis?

From twenty studies, there are fifteen data needed for a fuzzy-based decision for coronary heart disease.

Table 1: Data needed for a fuzzy-based decision for coronary heart disease

| No | Data Needed | Literature Citations | Number |
|----|-------------|----------------------|--------|
| 1  | Age         | [1][2][3][4][5][6]  | 16     |
|    |             | [7][9][11][12][13]  |        |
|    |             | [14][15][16][17]    |        |
|    |             | [20]                 |        |
| 2  | Sex         | [1][2][3][4][7][12] | 10     |
|    |             | [13][15][16][17]    |        |
Table 2: Steps to use for a fuzzy-based decision for coronary heart disease diagnosis

| Author | Year   | Steps                                                                 | Number of Steps |
|--------|--------|----------------------------------------------------------------------|-----------------|
| Hussin Attya & Wed Kadhim Oleiwi | 2017 | Fuzzification, Defuzzification, Fuzzy Petri Net                        | 3               |
| P. Umasankar & V. Thiagarasu    | 2018 | Pre-Processing Step Interval Vague Set, Fuzzy Association Rule Mining, Fuzzy Correlation Rule Mining | 4               |
| Tanmay Kasbe & Ravi Singh Pippal | 2017 | Fuzzy Membership Function, Fuzzy Expert System Design, Fuzzy Data Rule Base | 3               |
| Kaan Uyara & Ahmet Ilhan         | 2017 | GA based trained RFNN Evaluation criteria                              | 2               |
| Ali Mohammad Alqudah             | 2017 | System algorithm Membership function, inputs, and output               | 2               |
| Hasan Kahtan, Kamal Z. Zamli, Wan Nor Ashikin Wan Ahmad Fathi, Azma Abdullah, Mansoor Abdulleeteef, & Noor Shahiayuniezam Kamarulzaman | 2018 | Fuzzification, Fuzzy Rule Base, Fuzzy Inference Engine, Defuzzification Application using Java | 5               |
| G. Thippa Reddy, M. Praveen Kumar Reddy, Kuruva Lakshman, Dharmendra Singh Rajput, Rajesh Kaluri, & Gautam Srivastava | 2019 | Normalization, Attribute Reduction using Rough Sets Solution, Representation, Fitness Function, Termination Criteria, Prediction Based on Fuzzy Logic System | 6               |
| Peyman Rezaei Hachesu, Mahsa Dehghani Soufi, Ruhollah Khara, Nazila Moftian, & Taha Samad Soltan | 2019 | Fuzzification, Knowledge base, Decision logic, Defuzzification | 4               |
| Iftikhar Naseer, Bilal Shoib Khan, Shazia Saqib, Syed Nadeem Tahir, Sheraz Tariq, & Muhammad Saleem Akhter | 2019 | Proposed DHD-MFI Expert System, Input Fuzzy Sets, Output Fuzzy Sets, Membership Functions, Graphical Representation of Membership Function, Fuzzy Proposition Rule Base, Fuzzy Inference Engine, Product Inference Engine, De-fuzzifier | 10              |

RQ2: What steps to use for a fuzzy-based decision for coronary heart disease diagnosis?

From twenty studies, there are many steps for a fuzzy-based decision for coronary heart disease diagnosis.
| Authors | Year | Contributions |
|---------|------|---------------|
| G. Thippa Reddy & Neelu Khare | 2017 | Discretization Solution encoding Oppostional solution generation Fitness evaluation Novel hybrid OFBAT algorithm Fuzzy system Design of fuzzy system Rule-based fuzzy score computation |
| Nasruddin Hassan, Osama Rashed Sayed, Ahmed Mostafa Khalil, & Mohamed Abdel Ghany | 2016 | Input and output variables Fuzzy membership functions for each variable Fuzzy rules. |
| Ion Iancu | 2017 | Input and output variables Fuzzy rule base Fuzzification and firing level Inferred conclusion Defuzzification and output result |
| S. Moameria & N. Samadinai | 2018 | UCI Heart Data Set Preprocessing Decision Tree The Fuzzy Inference System Cuckoo Search Optimization of Fuzzy Membership Values |
| Farnaz Sabahi | 2018 | Structuring decision hierarchy Combining soft data and statistical data Computing fuzzy validity Developing pairwise matrices with inclusion of validity Deriving Priorities Aggregation of Priorities Ranking |
| Animesh Kumar Paul, Pintu Chandra Shill, Md. Rafiquil Islam Rabin, & Kazuyuki Murase | 2017 | Encoding the fuzzy rules Objective function Weighting the generated fuzzy rules Fuzzy DSS effectiveness |
| Purushottam Sharma & Kanak Saxena | 2017 | Instigation of a decision tree from the data Generation of a set of rules from the decision tree, using disjunctive ordinary structure and detailing of a crisp model Fuzzy model generation using ruleset Enhancing the fuzzy model parameter: the framework was consequently produced from an introductory explained set of data |
| V. Krishnaiah, G. Narsimha, PhD, & N. Subhash Chandra, PhD | 2016 | Classification Clustering Association Prediction |
| Mehrbakhsh Nilashi, Hossein Ahmadi, Azizah Abdul Manaf, Tarik A. Rashid, Sarminah Samad, Leila Shalhoradi, Nahla Alijo, & Elnaz Akbari | 2020 | Data pre-processing Clustering Dimensionality Reduction Classification |
| Animesh Kumar Paul, Pintu Chandra Shill, Md. Rafiquil Islam Rabin, & M. A. H. Akhand | 2016 | Encoding the Fuzzy Rules Objective function Weighting the generated Fuzzy Rules Fuzzy System Effectiveness |

### IV. CONCLUSION

In this study, a fuzzy rule-based system can be used for the diagnosis of coronary heart disease considering its accuracy and transparency. The resulting fuzzy rules can be easily understood by doctors because they use natural linguistic terms that describe the relationship between the factors and the results of the diagnosis. This study proposes a heart disease diagnosis system that uses fuzzy logic in order to assist patients in taking preventive measures.

In addition, the use of fuzzy logic can provide a competent means of assisting inexperienced physicians in diagnosing heart disease quickly and adeptly, with that if there is the possibility of complications can be diagnosed properly. This system will be able to diagnose coronary artery heart disease by including various risk factors such as hypertension, age, gender, smoking, family history and so on.
Several analyzes show that different technologies are used, and the number of samples used in each study is different, so that when you want to know to achieve accuracy results will also be different, it depends on the tools used for implementation.

The fuzzy logic method is considered to be able to develop a heart disease diagnosis system because the fuzzy logic method has the ability to operate in approximate reasoning and find accurate solutions. Fuzzy expert systems integrate fuzzy logic elements, which are a logically consistent way of reasoning that can address the uncertainty, ambiguity and imprecision inherent in medical diagnosis.

REFERENCES

[1] Laftah, Hussin Attya; Oleiwi, Wed Kadhim. (2017). A Fuzzy Petri Nets System for Heart Disease Diagnosis. Journal of Babylon University, Pure and Applied Sciences, 25.

[2] Kasbe, T; Pippal, R. S. (2017). Design of Heart Disease Diagnosis System using Fuzzy Logic. International Conference on Energy, Communication, Data Analytics and Soft Computing (ICE-CDS-2017), 3183–3187.

[3] Kahtan, H; Zamli, K. Z; Fatthi, W. N; Abdullah, A; Abdelleteef, Mr; Kamarulzaman, N. S. (2018). Heart Disease Diagnosis System Using Fuzzy Logic. ICSCA 2018: Proceedings of the 2018 7th International Conference on Software and Computer Applications,

[4] Umasankar, P; Thiagarasu, V. (2018). Decision Support System for Heart Disease Diagnosis Using Interval Vague Set and Fuzzy Association Rule Mining. Fourth International Conference on Devices, Circuits and Systems (ICDCS’18), 223-227.

[5] Uyar, Kaan; Ilhan, Ahmet. (2017). Diagnosis of heart disease using genetic algorithm based trained recurrent fuzzy neural networks. Procedia Computer Science, 120, 588–593.

[6] Reddy, G. T; Reddy, M. P. K; Lakshmannan, K; Rajput, D. S; Kaluri, R; Srivastava, G. (2019). Hybrid genetic algorithm and a fuzzy logic classifier for heart disease diagnosis. Evolutionary Intelligence.

[7] Alqudah, Ali Mohammad (2017). Fuzzy expert system for coronary heart disease diagnosis in Jordan. Health and Technology, 7(2-3), 215–222.

[8] Hachesu, P. R; Soufi, M. D; Khara, R; Moftian, N; Soltani, S. T. (2019). A fuzzy mobile decision support system for diagnosing of the angiographic status of heart disease. Engineering and Applied Science Research.

[9] Naseer, Ifikhar; Khan, Bilal Shoib; Saqib, Shazia; Tahir, Syed Nadeem; Tariq, Sheraz; Akhter, Muhammad Saleem. (2020). Diagnosis Heart Disease Using Mamdani Fuzzy Inference Expert System.

[10] Reddy, G. T; Khare, N. (2017). An Efficient System for Heart Disease Prediction Using Hybrid OFBAT with Rule-Based Fuzzy Logic Model. Journal of Circuits, Systems and Computers, 26(04), 1750061.

[11] Hassan, Nasrudden; Sayed, Osama Rashed; Khalil, Ahmed Mostafa; Ghany, Mohamed Abdel. (2016). Fuzzy Soft Expert System in Prediction of Coronary Artery Disease. International Journal of Fuzzy Systems, 19(5), 1546–1559.

[12] Jain, Prema; Kaur, Amandeep. (2019). A Fuzzy Expert System for Coronary Artery Disease Diagnosis. ICAICR ’19: Proceedings of the Third International Conference on Advanced Informatics for Computing Research, 47, 1-6.

[13] Iancu, I. (2018). Heart disease diagnosis based on meditative fuzzy logic. Artificial Intelligence in Medicine, 89, 51–60.

[14] Maomeri, S; Samadinai, N. (2018). Diagnosis of Coronary Artery Disease via a Novel Fuzzy Expert System Optimized by Cuckoo Search. IJE TRANSACTIONS, Vol. 31, No. 12, 2028-2036.

[15] Sabahi, F. (2018). Bimodal fuzzy analytic hierarchy process (BFAHP) for coronary heart disease risk assessment. Journal of Biomedical Informatics, 83, 204–216.

[16] Paul, A. K; Shill, P. C; Rabin, M. R. I; Murase, K. (2017). Adaptive weighted fuzzy rule-based system for heart disease diagnosis. Applied Intelligence, 48(7), 1739–1756.

[17] Sharma, P, & Saxena, K. (2017). Application of fuzzy logic and genetic algorithm in heart disease risk level prediction. International Journal of System Assurance Engineering and Management, 8(S2), 1109–1125.

[18] Krishnaiah, V; Narasimha, G; Chandra, N. S. (2016). Heart Disease Prediction System using Data Mining Techniques and Intelligent Fuzzy Approach: A Review. International Journal of Computer Applications (0975 – 8887) Volume 136 – No. 2.

[19] Nilashi, M; Ahmadi, H; Manaf, A. A; Rashid, T A; Samad, S; Shahmoradi, L; Aljojo, N; Akbari, E. (2020). Coronary Heart Disease Diagnosis Through Self-Organizing Map and Fuzzy Support Vector Machine with Incremental Updates. International Journal of Fuzzy Systems.

[20] Paul, A. K; Shill, P. C; Rabin, M. R. I; Akhand, M. A. H. (2016). Genetic algorithm based fuzzy decision support system for the diagnosis of heart disease. 2016 5th International Conference on Informatics, Electronics and Vision (ICIEV).

Fuzzy-based Decision for Coronary Heart...... (Afrina Safira Dianirani & Zefanya Debby Claudia) 77