International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 04 | Apr 2021 www.irjet.net p-ISSN: 2395-0072

Survey on predicting Heart Disease using Machine learning algorithms

F. Allwin Edilbert , Iwin Thanakumar Joseph

Department of Computer Science and Engineering, Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu, India.

Abstract: Heart disease is a fatal illness with the largest population in the world. The invention of a cardiac disease prediction machine-based diagnostic system provides a more accurate diagnosis than normal. The effects of this system give a percentage risk for heart disease. The used data sets are categorised according to medical parameters. The datasets are analysed by pythons programming with machine learning algorithms namely Logistic Regression, Naive Bayes, Support Vector Machine, K-Nearest Neighbours, Decision Tree, Random Forest, XGBoost Artificial Neural Network with 1 Hidden layer. which shows the best degree of accuracy of heart disease among these algorithms.

Keywords Machine Learning, Data Mining, Prediction, Logistic Regression, Naive Bayes, Support Vector Machine, K-Nearest Neighbours, Decision Tree, Random Forest, XGBoost Artificial Neural Network with 1 Hidden layer.

1. Introduction:

Heart disease has created a lot of serious concerned among researches; one of the major challenges in heart disease is correct detection and finding presence of it inside a human. Early techniques have not been so much efficient in finding it even medical professor are not so much efficient enough in predicating the heart disease [3].

There are various medical instruments available in the market for predicting heart disease there are two major problems in them, the first one is that they are very much expensive and second one is that they are not efficiently able to calculate the chance of heart disease in human. According to latest survey conducted by WHO, the medical professional able to correctly predicted only 67% of heart disease [2] so there is a vast scope of research in area of predicating heart disease in human. With advancement in computer science has brought vast opportunities in different areas, medical science is one of the fields where the instrument of computer science can be used. In application areas of computer science varies from metrology to ocean engineering. Medical science also used some of the major available tools in computer science; in last decade artificial intelligence has gained its moment because of advancement in computation power. Machine Learning is one such tool which is widely utilized in different domains because it doesn't require different algorithm for different dataset. Reprogrammable capacities of machine learning bring a lot of strength and opens new doors of opportunities for area like medical science. In medical science heart disease is one of the major challenges; because a lot of parameters and technicality is involved for accurately predicating this disease.

Machine learning could be a better choice for achieving high accuracy for predicating not only heart disease but also another diseases because this vary tool utilizes feature vector and its various data types under various condition for predicating the heart disease, algorithms such as Naive Bayes, Decision Tree, KNN, Neural Network, are used to predicate risk of heart diseases each algorithm has its speciality such as Naive Bayes used probability for predicating heart disease, whereas decision tree is used to provide classified report for the heart disease, whereas the Neural Network provides opportunities to minimise the error in predication of heart disease. All these techniques are using old patient record for getting predication about new patient. This predication system for heart disease helps doctors to predict heart disease in the early stage of disease resulting in saving millions of lives.

2. Related Works

In [1] they proposed prediction of Heart Disease Using Machine Learning. Here model is predictive and the accuracy is effective they used multilayer perceptron for their prediction process and MLP gives a reliable output based on the input provided by the user.

In [2] they proposed A Hybrid Intelligent System Framework of for the prediction of Heart Disease Using Machine Learning Algorithms. And the model accuracy percentage was 100 percent using ANN (MLP) with 16 hidden layer apart from that their feature selection is excellent.

In [3] they proposed Prediction of Heart Disease using Machine Learning Algorithms and their model Decision Tree outperform the other classifier Naïve Bayes. The improvement in accuracy arises from increased attributes.

In [4] they proposed prediction of Heart disease using Neural Network. And Neural network was trained with back propagation algorithm with accuracy of 95 percentage. And more accurate for heart disease.

In [5] they proposed Prediction of heart Disease Using Machine Learning Algorithms. They used Decision Tree model and acquired accuracy level is 91 percentage and Naive Bayes classifier accuracy is p87 percentage. Decision Tree algorithm is best for handling medical dataset.

In [6] they proposed Heart Disease Prediction System Using Data Mining Techniques. They used Data mining, Decision Tree, Neural Network and Naive Bayes. In this study, the aim was to design a predictive model for heart disease detection using data mining techniques from Transthoracic Echocardiography Report dataset that is capable of enhancing the reliability of heart disease diagnosis using echocardiography. The models were built on the pre-processed Transthoracic Echocardiography dataset with three different supervised machine learning algorithms i.e. J48 Classifier, Naïve Bayes and Multilayer Perception using Weka 3.6.4 machine learning software.

In [7] they proposed Decision Support in Heart Disease Prediction System using Naive Bayes. They used data mining, decision support, heart disease, Naïve Bayes. This model could answer complex queries, each with its own strength with respect to ease of model interpretation, access to detailed information and accuracy.

In [8] they proposed Prediction of Heart Disease using Classification Algorithms. Data mining algorithms such as J48, Naïve Bayes, REPTREE, CART, and Bayes Net are applied in this research for predicting heart attacks. The research result shows prediction accuracy of 99%. Data mining enable the health sector to predict patterns in the dataset.

In [9] they proposed Efficient Heart Disease Prediction System. . The main contribution of this study is to help a non-specialized doctors to make correct decision about the heart disease risk level. The rules generated by the proposed system are prioritized as Original Rules, Pruned Rules, and Rules without duplicates, Classified Rules, Sorted Rules and Polish. The execution of the framework is assessed as far as arrangement precision and the outcomes demonstrates that the framework has extraordinary potential in anticipating the coronary illness risk level all the more precisely.

In [10] they proposed Human Heart Disease Prediction System using Data Mining Techniques. The main motivation of this paper is to provide an insight about detecting heart disease risk rate using data mining techniques. Different technologies give different precision depending on a number of attributes considered. Using KNN and ID3 algorithm the risk rate of heart disease was detected and accuracy level also provided for different number of attributes.

In [11] they proposed Analysis of Data Mining Techniques for Heart Disease Prediction. ich demands expertise and higher knowledge for prediction. This paper addresses the issue of prediction of heart disease according to input attributes on the basis of data mining techniques. We have investigated the heart disease prediction using KStar, J48, SMO, Bayes Net and Multilayer Perceptron through Weka software.

In [12] they proposed Intelligent Heart Disease Prediction System Using Data Mining Techniques. A prototype heart disease prediction system is developed using three data mining classification modelling techniques. The system extracts hidden knowledge from a historical heart disease database. DMX query language and functions are used to build and access the models. Five mining goals are defined based on business intelligence and data exploration. The goals are evaluated against the trained models. All three models could answer complex queries, each with its own strength with respect to ease of model interpretation, access to detailed information and accuracy.

In [13] they proposed Heart Disease Prediction System using Naive Bayes. This paper presents a classifier approach for detection of heart disease and shows how Naive Bayes can be used for classification purpose. This system classifies the given data into different categories and also predicts the risk of the heart disease if unknown sample is given as an input. As we have developed generalised system, in future we can use this system for analysis of different datasets by only changing the name of dataset file which is given for training module.

In [14] they proposed a coronary heart disease prediction model: the Korean Heart Study. The present study provides the first evidence that the Framingham risk function overestimates the risk of CHD in the Korean population where CHD incidence is low. The Korean CHD risk model is well-calculated alternations which can be used to predict an individual's risk of CHD and provides a useful guide to identify the groups at high risk for CHD among Koreans.

In [15] they proposed Effective heart disease prediction system using data mining techniques. In this study, an EHDPS has been presented using data mining techniques. From ANN, an MLPNN together with BP algorithm is used to develop the system. The MLPNN model proves the better results and assists the domain experts and even the person related to the medical field to plan for a better and early diagnosis for the patient. This system performs realistically well even without retraining. Furthermore, the experimental results show that the system predicts heart disease with ~100% accuracy by using neural networks.

In [16] they proposed Intelligent and Effective Heart Disease Prediction System using Weighted Associative Classifiers In this paper, we have presented an intelligent and effective heart attack prediction system using Weighted Associative Classifier. Firstly, we have evaluated the performance of WAC in terms of accuracy using benchmark (UCI machine learning repository). Different weights have been assigned to the attributes after consulting with expert doctor. The maximum accuracy (81.51%) have been achieved using support value 25% and confidence to be 80%. A GUI has been designed to enter the patient's records and the presence of Heart disease for the patient is predicted using the rules stored in the rule base.

In [17] they proposed Prediction of Coronary Heart Disease Using Risk Factor Categories. Recommended guidelines of blood pressure, total cholesterol, and LDL cholesterol effectively predict CHD risk in a middle-aged white population sample. A simple coronary disease prediction algorithm was developed using categorical variables, which allows physicians to predict multivariate CHD risk in patients without overt CHD.

In [18] they proposed Coronary Heart Disease Prediction from Lipoprotein Cholesterol Levels, Triglycerides, Lipoprotein (a), Apo lipoproteins A-I and B, and HDL Density Sub fractions The Atherosclerosis Risk in Communities (ARIC) Study. Optimal LDL-C values are, 100 mg/dL in both women and men. LDL-C, HDL-C, TG, and Lp (a), without additional Apo lipoproteins or lipid sub fractions, provide substantial CHD prediction, with much higher RR in women than men.

In [19] they proposed Review on Heart Disease Prediction System using Data Mining Techniques. The objective of our work is to provide a study of different data mining techniques that can be employed in automated heart disease prediction systems. Various techniques and data mining classifiers are defined in this work which has emerged in recent years for efficient and effective heart disease diagnosis. The analysis shows that different technologies are used in all the papers with taking different number of attributes.

In [20] this research paper we presented a lazy data mining approach for heart disease classification. We applied information centric arrtibute measure PCA to generate class association rules. This class association rules will be used to predict the occurrence of heart disease. The system is designed for Andhra Pradesh population. Andhra Pradesh is in risk of more death due to heart disease. Heart disease can be handled successfully if more research is encouraged to develop prediction system in this area.

In [21] they proposed there is a huge scope for machine learning algorithms in predicting cardiovascular diseases or heart related diseases. Each of the above-mentioned algorithms have performed extremely well in some cases but poorly in some other cases. . Models based on Naïve Bayes classifier were computationally very fast and have also performed well. SVM performed extremely well for most of the cases. Systems based on machine learning algorithms and techniques have been very accurate in predicting the heart related diseases.

In [22] an IoT Framework for Heart Disease Prediction Based on MDCNN Classifier. The results demonstrate that the proposed methodology provides a higher level of accuracy than the other approaches. In the future, we will perform more experiments to increase the performance of these predictive classifiers for heart disease diagnosis by using others feature selection algorithms and optimization techniques. Also, the proposed work will be trained and tested with fully wearable devices which will be available in the market.

In [23] this paper proposes a combination of rough sets based attri859 Bute reduction with interval type-2 fuzzy logic system for heart 860 disease diagnosis. The rough sets based attribute reduction using chaos firefly algorithm is proposed.

It can efficiently find mini- 861 mal attribute reduction from high-dimensional dataset that 862 enhances the performance of the classification system.

In [24] The research focuses on establishing SHDP (Smart Heart Disease Prediction that takes into consideration the approach of NB (Naive Bayesian) classification and AES (Advanced Encryption Standard) algorithm for resolving the issue of heart disease prediction. its revealed that in regard to accuracy, the prevailing technique surpasses the Naive Bayes by yielding an accuracy of 89.77%in spite of reducing the attributes. AES yields in high security performance evaluation in comparison to PHEA (Parallel Hemimorphic Encryption Algorithm).

In [25] the main ambition of this paper is to improve accuracy in prediction of heart disease by using feature selection techniques. Different data mining techniques i.e. Decision Tree, Logistic regression, Logistic regression SVM, Naïve Bayes and Random forest are applied individually in Rapid miner on a UCI heart disease date set and compared results with the past researches. The accuracy of Decision Tree is 82.22%, Logistic Regression 82.56%, Random Forest 84.17%, and Naïve Bayes 84.24% and Logistic Regression SVM is 84.85.

In [26] Heart disease is one of the leading causes of death worldwide and the early prediction of heart disease is important. From the analysis it is concluded that, data mining plays a major role in heart disease classification. Neural Network with offline training is a good for disease prediction in early stage and the good performance of the system can be obtained by pre-processed and normalized dataset. The classification accuracy can be improved by reduction in features.

In [27] they proposed we propose efficient genetic algorithm with the back propagation technique approach for heart disease prediction. This paper has analysed prediction systems for Heart disease using more number of input attributes. The System uses medical terms such as Gender, blood pressure, cholesterol like13 attributes to predict the likelihood of patient getting a Heart disease.

In [28] they proposed by analysing the experimental results, it is concluded thatJ48 tree technique turned out to be best classifier for heart disease prediction because it contains more accuracy and least total time to build. We can clearly see that highest accuracy belongs to J48 algorithm with reduced error pruning followed by LMT and Random Forest algorithm respectively. The best algorithm J48 based on UCI data has the highest accuracy i.e. 56.76% and the total time to build model is 0.04 seconds while LMT algorithm has the lowest accuracy i.e. 55.77% and the total time to build model is 0.39seconds.

In [29] the objective of our work is to predict more accurately the presence of heart disease with reduced number of attributes. Originally, thirteen attributes were involved in predicting the heart disease. In our work, Genetic algorithm is used to determine the attributes which contribute more towards the diagnosis of heart ailments which indirectly reduces the number of tests which are needed to be taken by a patient.

In [30] this research work, various data mining classification algorithms have been implemented on Cleveland dataset for heart disease. First, the results have proved the minimum execution and maximum accuracy of the proposed model. The proposed model would be expected to reduce the number of deaths from heart disease. With data constantly increasing due to information explosion, in near future health care dataset will be much larger than current dataset. In such a scenario, cloud will give much better accuracy and minimum execution time as compared to standalone machine model.

REF NO	METHODOLOGY	PERFORMANCE METRICS	MERITS
1	Prediction of Heart Disease Using Machine Learning.	This model predictive accuracy IS effective.	MLP gives reliable output based on the input provided by the user.
2	A Hybrid Intelligent System Framework for the Prediction of Heart Disease Using Machine Learning Algorithms.	The best sensitivity was 100 percentage of classifier ANN (MLP) with 16 hidden layers.	Feature selection is excellent.
3	Prediction of Heart Disease Using Machine Learning Algorithms.	Decision tree outperforms.	The improvement in accuracy arises from increased attributes.
4	Prediction of heart Disease	NN was trained with back	More accurate diagnosis for

	Using Neural Network.	propagation algorithm accuracy of 95 percentage.	heart disease.
5	Prediction of heart Disease Using Machine Learning Algorithms.	Decision tree model Accuracy level is 91 percentage. Naïve Bayes classifier accuracy is 87 percentage.	Decision tree algorithm is best for handling medical dataset.
6	Heart Disease Prediction System Using Data Mining Techniques.	J48 classifier implemented on selected attributes with a classification accuracy of 95.56 percentage.	The selected model built with J48 Decision Tree Algorithm successfully met all three data mining goals.
7	Decision Support in Heart Disease Prediction System Using Naïve Bayes.	Decision Tree is the most effective model to predict patients with heart disease.	Decision tree outperforms.
8	Prediction of Heart Disease using Classification Algorithms.	Data mining algorithm such as J48, Naïve Bayes, REPTEE, CART and Bayes.	This serves important tool for physicians to predict risky cases in the practise and advice accordingly.
9	Efficiency Heart Disease Prediction System.	Trained and Test the system using 10 fold method and find the accuracy of 86.3 and 87.3 respectively.	It gives the early determination and give the patient to have result as it performs sensibly well even without retraining.
10	Human Heart Disease Prediction System using Data Mining Techniques.	Naïve Bayes. KNN. Decision Tree. NN.	Using ID3 and KNN algorithm risk of heart disease was detected and accuracy level was also promising.
11	Analysis of Data Mining Techniques For Heart Disease Prediction.	Bayes Net. SMO, KStar, MLP and J48.	Bayes net and SMO classifier are the optimum mong the investigated five classifiers.
12	Intelligent Heart Disease Prediction System Using Data Mining Techniques.	Data Mining, Decision Tree. Neural Network, Navies.	Detailed information and accuracy.
13	Heart Disease Prediction System using Naïve Bayes.	Naïve Bayes.	They served can be served as training tool for medical students.
14	A coronary heart disease prediction model: the Korean heart study.	CHD model is well – calculated alternatives. And used to predict individual risk of CHD.	Provides a useful guide to identify the groups at high risk for CHD among Koreans.
15	Effective heart disease prediction system using data mining techniques.	Neural Network. Multiplayer perceptron neural network, backprogration.	Shows that the system predicts heart disease with – 100 percentage by using neural networks.
16	Intelligent and Effective Heart Disease Prediction System using Weighted Associate Classifier.	Weighted Associative Classifier Prediction. UCI machine learning repository accuracy. The accuracy is 81.51 percentage.	The performance and accuracy is optimistic.
17	Prediction of coronary Heart Disease Using Risk Factor categories.	Used non categorical prediction function.	Predict CHD effectively.
18	Coronary Heart Disease Prediction From Lipoprotein Cholesterol	Optimal LDL-C values are <100mg/dl in both men and women. Without additional	Detailed information and accuracy.

	Levels, Triglycerides, Lipoprotein(a), Apolipoproteins A-I and B, and HDL Density Sub fractions The Atherosclerosis Risk in Communities (ARIC) Study	apolipoproteins or lipid sub fractions, provide substantial CHD prediction, with much higher RR in women than men.	
19	Review on Heart Disease prediction System Using Data mining Techniques.	Neural Network Decision Tree	Neural Network works best according to heart prediction is concerned.
20	Heart Disease Prediction using Lazy Associative Classification	Associative Classification. Heart Disease Principle component analysis.	It has handled successfully with more research in it.
21	Heart Disease prediction using machine learning techniques.	Naïve Bayes KNN Support Vector Machine Decision Tree	Each and every algorithm has performed very well.
22	An IoT Framework for Heart Disease Prediction Based on MDCNN Classifier	AEHO, cuttlefish algorithm, MDCNN, Iot	MDCNN classifier also offers a higher level of accuracy than the existing approaches.
23	Expert Systems with Applications	Rough sets 17 Attribute reduction 18 Feature selection 19 Chaos firefly algorithm 20 Type-2 fuzzy logic system	The proposed model is thus useful as a decision support system for 32 heart disease diagnosis.
24	Design And Implementing Heart Disease Prediction Using Naives Bayesian.	Data Mining; Smart Heart Disease Prediction (SHDP); Navies Bayesian; Advanced Encryption Standard (AES); Classification;	The prevailing technique surpasses the Naive Bayes by yielding an accuracy of 89.77%in spite of reducing the attributes. AES yields in high security performance evaluation in comparison to PHEA (Parallel Homomorphic Encryption Algorithm).
25	Improving Heart Disease Prediction Using Feature Selection Approaches	The accuracy of Decision Tree is 82.22%, Logistic Regression 82.56%, Random Forest 84.17%, and Naïve Bayes 84.24% and Logistic Regression SVM is 84.85.	As Logistic regression is with higher accuracy
26	Review of heart disease prediction system using data mining and hybrid intelligent techniques	Neural Network, Hybrid Intelligent Algorithm, Computer Aided Decision Support System.	The computer aided heart disease prediction system helps the physician as a tool for heart disease diagnosis.
27	Heart disease prediction using data mining techniques	KNN, Data Mining, Genetic Algorithm, Heart Disease Prediction.	That KNN is best among all the classification techniques after we name prediction or classification of a nonlinear knowledge. KNN uses nearest neighbour to find the optimal solution.
28	Heart Disease Prediction Using Machine learning and Data Mining Technique	Data Mining; Decision Support System Classification.	The best algorithm J48 based on UCI data has the highest accuracy i.e. 56.76% and the total time to build model is 0.04 seconds while LMT algorithm has the lowest

			accuracy i.e. 55.77% and the total time to build model is 0.39seconds
29	Enhanced Prediction of Heart Disease with Feature Subset Selection using Genetic Algorithm	Data Mining; Genetic Algorithm; Naive Bayes; Decision tree; Classification by clustering; Feature Subset Selection.	Decision Tree data mining technique outperforms other two data mining techniques after incorporating feature subset selection with relatively high model construction time
30	Intelligent heart disease prediction in cloud environment through ensembling	big data, cloud computing, ensembling, Hadoop, heart disease, machine learning	The results have proved the minimum execution and maximum accuracy of the proposed model.

3. Conclusion

Heart attack is crucial health problem in human society. This paper has summarised state of art techniques and available methods for predication of this disease. Deep learning an emerging area of artificial intelligence showed some promising result in other field of medical diagnose with high accuracy. It is still an open domain waiting to get implemented in heart disease predication. Some methods of deep learning has been discussed which can be implemented for heart disease predication, along with pioneer machine learning algorithms. An analytical comparison has been done for finding out best available algorithm for medical dataset. In future our aim is to carry forward the work of temporal medical dataset, where dataset varies with time and retraining of dataset is required.

4. References

[1.] Gavhane, A., Kokkula, G., Pandya, I. and Devadkar, K., 2018, March. Prediction of heart disease using machine learning. In *2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA)* (pp. 1275-1278). IEEE.

[2.] Haq, A.U., Li, J.P., Memon, M.H., Nazir, S. and Sun, R., 2018. A hybrid intelligent system framework for the prediction of heart disease using machine learning algorithms. *Mobile Information Systems*, *2018*.

[3.] Nikhar, Sonam, and A. M. Karandikar. "Prediction of heart disease using machine learning algorithms." *International Journal of Advanced Engineering, Management and Science* 2.6 (2016): 239484.

[4.] Karayılan, Tülay, and Özkan Kılıç. "Prediction of heart disease using neural network." *2017 International Conference on Computer Science and Engineering (UBMK)*. IEEE, 2017.

[5.] Krishnan, Santhana, and S. Geetha. "Prediction of Heart Disease Using Machine Learning Algorithms." *2019 1st international conference on innovations in information and communication technology (ICIICT)*. IEEE, 2019.

[6.] Taneja, Abhishek. "Heart disease prediction system using data mining techniques." *Oriental Journal of Computer science and technology* 6.4 (2013): 457-466.

[7.] Subbalakshmi, G., K. Ramesh, and M. Chinna Rao. "Decision support in heart disease prediction system using naive bayes." *Indian Journal of Computer Science and Engineering (IJCSE)* 2.2 (2011): 170-176.

[8.] Masethe, Hlaudi Daniel, and Mosima Anna Masethe. "Prediction of heart disease using classification algorithms." *Proceedings of the world Congress on Engineering and computer Science*. Vol. 2. 2014.

[9.] Saxena, Kanak, and Richa Sharma. "Efficient heart disease prediction system." *Procedia Computer Science* 85 (2016): 962-969.

[10.] Thomas, J., and R. Theresa Princy. "Human heart disease prediction system using data mining techniques." *2016 international conference on circuit, power and computing technologies (ICCPCT)*. IEEE, 2016.

[11.] Sultana, Marjia, Afrin Haider, and Mohammad Shorif Uddin. "Analysis of data mining techniques for heart disease prediction." *2016 3rd international conference on electrical engineering and information communication technology (ICEEICT)*. IEEE, 2016.

[12.] Sa, S. "Intelligent heart disease prediction system using data mining techniques." *International Journal of healthcare & biomedical Research* 1 (2013): 94-101.

[13.] Medhekar, Dhanashree S., Mayur P. Bote, and Shruti D. Deshmukh. "Heart disease prediction system using naive Bayes." *Int J Enhanced Res Sci Technol Eng* 2.3 (2013).

[14.] Jee, Sun Ha, et al. "A coronary heart disease prediction model: the Korean Heart Study." *BMJ open* 4.5 (2014).

[15.] Singh, Poornima, Sanjay Singh, and Gayatri S. Pandi-Jain. "Effective heart disease prediction system using data mining techniques." *International journal of nanomedicine* 13.T-NANO 2014 Abstracts (2018): 121.

[16.] Soni, Jyoti, et al. "Intelligent and effective heart disease prediction system using weighted associative classifiers." *International Journal on Computer Science and Engineering* 3.6 (2011): 2385-2392.

[17.] Wilson, Peter WF, et al. "Prediction of coronary heart disease using risk factor categories." *Circulation* 97.18 (1998): 1837-1847.

[18.] Sharrett, A. Richcv, et al. "Coronary heart disease prediction from lipoprotein cholesterol levels, triglycerides, lipoprotein (a), apolipoproteins AI and B, and HDL density subfractions: The Atherosclerosis Risk in Communities (ARIC) Study." *Circulation* 104.10 (2001): 1108-1113.

[19.] Kaur, Beant, and Williamjeet Singh. "Review on heart disease prediction system using data mining techniques." *International journal on recent and innovation trends in computing and communication* 2.10 (2014): 3003-3008.

[20.] Jabbar, M. Akhil, Bulusu Lakshmana Deekshatulu, and Priti Chandra. "Heart disease prediction using lazy associative classification." *2013 International Mutli-Conference on Automation, Computing, Communication, Control and Compressed Sensing (iMac4s)*. IEEE, 2013.

[21.] Ramalingam, V. V., Ayantan Dandapath, and M. Karthik Raja. "Heart disease prediction using machine learning techniques: a survey." *International Journal of Engineering & Technology* 7.2.8 (2018): 684-687.

[22.] Khan, Mohammad Ayoub. "An IoT framework for heart disease prediction based on MDCNN classifier." *IEEE Access* 8 (2020): 34717-34727.

[23.] Long, Nguyen Cong, Phayung Meesad, and Herwig Unger. "A highly accurate firefly based algorithm for heart disease prediction." *Expert Systems with Applications* 42.21 (2015): 8221-8231.

[24.] Repaka, Anjan Nikhil, Sai Deepak Ravikanti, and Ramya G. Franklin. "Design and implementing heart disease prediction using naives Bayesian." *2019 3rd International Conference on Trends in Electronics and Informatics (ICOEI)*. IEEE, 2019.

[25.] Bashir, Saba, et al. "Improving heart disease prediction using feature selection approaches." *2019 16th international bhurban conference on applied sciences and technology (IBCAST)*. IEEE, 2019.

[26.] Chitra, R., and V. Seenivasagam. "Review of heart disease prediction system using data mining and hybrid intelligent techniques." *ICTACT journal on soft computing* 3.04 (2013): 605-09.

[27.] Rairikar, Abhishek, et al. "Heart disease prediction using data mining techniques." *2017 International Conference on Intelligent Computing and Control (I2C2)*. IEEE, 2017.

[28.] Patel, Jaymin, Dr TejalUpadhyay, and Samir Patel. "Heart disease prediction using machine learning and data mining technique." *Heart Disease* 7.1 (2015): 129-137.

[29.] Anbarasi, M., E. Anupriya, and N. C. S. N. Iyengar. "Enhanced prediction of heart disease with feature subset selection using genetic algorithm." *International Journal of Engineering Science and Technology* 2.10 (2010): 5370-5376.

[30.] Gupta, Nishant, et al. "Intelligent heart disease prediction in cloud environment through ensembling." *Expert Systems* 34.3 (2017): e12207.