Survey On Advanced Healthcare System using Hybrid Machine Learning Algorithms

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Abstract- This survey paper explores the potential of hybrid machine learning algorithms to transform healthcare delivery. By integrating machine learning with existing healthcare systems, the goal is to improve patient care, enhance efficiency, and achieve better health outcomes. This paper examines how these systems can be used for improved health data management, personalized treatment plans, and potentially reduced healthcare costs. Additionally, the paper discusses the potential for fostering a more collaborative healthcare environment by empowering patients with access to their health information and providing real-time data to healthcare professionals for informed decision-making. The focus is on the broader impact of hybrid machine learning in healthcare, without revealing specifics of any single project..

Keywords—.Advanced Healthcare system, Hybrid Machine Learning Algorithms, Patient care, Health data management, Heart disease prediction, Appointment booking

I. INTRODUCTION

The Advanced Healthcare System utilizing Hybrid Machine Learning Algorithms aims to transform healthcare by ensuring equitable access to high-quality, cost-effective, and readily available medical services. Its core objectives include expanding healthcare access for all individuals, regardless of geographical location, income level, or insurance status, achieved through efficient illness detection based on symptoms and timely recommendations of nearby and suitable physicians for prompt treatment. The system is also designed to enhance care quality by implementing evidence-based practices, prioritizing patient-centered care, reducing medical errors, and providing healthcare professionals with access to cutting-edge technology.

Moreover, the system emphasizes cost reduction through strategies such as promoting preventive care, minimizing unnecessary diagnostic tests, and utilizing technology for streamlined healthcare delivery. Additionally, the project aims to foster innovation and advancement in medicine by investing in research and development, fostering collaboration between academia and healthcare practitioners, and supporting entrepreneurial endeavors within the healthcare industry. In summary, this Advanced Healthcare System not only seeks to improve healthcare accessibility and quality but also aims to drive innovation and research to enhance overall public health and well-being

II. LITERATURE SURVEY

Santosh Kumar Bharti [1] ,explains that throughout the past few decades, heart disease, also known as cardiovascular disease, has been the main cause of mortality globally. It encompasses a variety of illnesses that have an influence on the heart. Data mining is a popular method for analyzing vast amounts of data in the healthcare industry. To foresee heart illness, researchers examine massive volumes of complex medical data using a range of data mining and ML techniques. This paper presents several heart disease-related features, as well as a model created utilizing supervised learning techniques such as DTs, RF, NB and the K-nearest Neighbor method .It operates on one of the most up-to-date dataset from the database named- “UCI heart disease patient repository's Cleveland”. The dataset Consists 303 instances and categorized by 76 features. Only 14 of these 76 attributes are tested, despite their significance in illustrating the performance of various algorithms. The goal of this study is to forecast the chance that patients would develop heart disease. The statistics indicate that K-nearest Neighbor has the highest accuracy score of 82%.

D. K. Lobiyal [2]. The authors of this paper propose a novel approach for feature selection and machine learning-based heart disease prediction. The study employed data from the UCI ML Repository, which comprises a number of clinical factors such as electrocardiogram (ECG) measures, blood pressure, age, sex and the cholesterol levels. The scientists predicted the risk of heart disease using a number of machine learning techniques, including DTs, RFs, and k-nearest neighbors (k-NN).They used feature selection to identify the most important attributes for prediction.The purpose of developing a classifier system based on ML algorithms is to greatly aid in the resolution of health-

related problems by assisting clinicians in predicting and identifying diseases at an early stage. This research project demonstrates an illness prediction system developed using ML techniques such as the RF classifier, DT classifier, and NB classifier.

A.singh and R. Kumar [3] This article calculates the accuracy of ML approaches used to forecast cardiac disease. The techniques employed include DTs, k-nearest neighbor, SVMs (SVMs) and linear regression. In order to make sure that our models properly generalize to new, unknown cases in addition to learning from the data, the procedure include both training and testing the algorithms.In order to make sure that our models proper generalize to new, unknown cases in addition to learning from the data, the procedure include both training and testing the algorithms.To evaluate the prediction strength of any algorithm, we use strict assessment parameters including accuracy. Our goal is to determine which model is the most successful in predicting cardiac disease, perhaps providing insightful information for clinical decision-making. Our study also examines each algorithm's possible advantages and disadvantages with regard to the prognosis of heart disease.
Future advances in diagnostic tools will be made possible by this thorough investigation, which will deepen our understanding of the potential and constraints of ML techniques in healthcare applications. It had an accuracy of 76.05%.

R. Dinesh [4] The dataset named-"Cleveland heart disease " was mainly used in the proposed study and data mining methodologies such as classification and regression were carried out.ML techniques include DT and RF. The ML model's new technique is developed. The implementation uses three ML algorithms: RF, DT, and Hybrid Model. According to the experimental results, the hybrid model predicts heart disease with an accuracy rate of 88.7%. We used a hybrid model of DT and RF in the interface to collect user input parameters and forecast cardiac disease.

Prathmesh S. Asole [5] The supervised ML algorithms used in this paper to predict heart disease include Gradient Boosting Classifiers (GB), SVMs (SVMs), RFs (RF), DTs (DT), Logistic Regressions (LR), and the algorithm with more preciseness for predicting Heart Disease on a web application. The article recommends using the best accurate algorithm for forecasting heart disease on a web application. SVM was chosen above Gradient Boosting, RF, DT Classifier and Logistic Regression due to its accurate behavior(82.35%).

Md. Rahat Hossain [6] This study evaluated seven computational intelligence approaches, including DT, Logistic Regression, Deep Neural Network, SVM, NB, RF, and K-Nearest Neighbor, for their capacity to predict coronary artery heart disease. The results revealed that a combined approach incorporating all of these algorithms generated remarkable projected accuracy when applied to the Statlog dataset, with an astonishing 98.15% accuracy rate. With potential applications in clinical settings and healthcare decision support systems, this powerful combination of computational techniques has tremendous promise for Enhancing the precision and dependability of predicting coronary artery disease. The generalizability and usefulness of this technique may be established with more study and validation on other datasets.

Parth Patel [7] This study proposes a k-modes clustering approach with Huang initialization to enhance cardiovascular disease classification accuracy using ML. Models such as multilayer perceptrons, XGBoost, DTs and RFs were trained and Evaluated using an authentic dataset comprising 70,000 cases sourced from Kaggle. Results determined the multilayer perceptron model along with cross-validation had achieved the highest accuracy (87.28%), outperforming other algorithms. The use of GridSearchCV for hyperparameter tuning optimized model performance, demonstrating the potential of ML in improving cardiovascular disease diagnosis.

Shanu Khare [8] Information investigation is basic within the restorative segment for legitimate ailment determination. To do this, various inquire about approaches must be chosen and legitimate hardware utilized,Based on the earnestness of the pathology.Artificial Intelligence(AI) is an extraordinary sort of suite that can effectively assess and represent facts in order to form the finest predictions.The framework utilizes a crucial show able of executing diverse information preparing calculations to assess diverse cardiac conditions. The show is created and arranged to function with a certain sort of information. To form a forecast, we begin with preparing the framework with existing information and after that test it with new information. We utilize a few upgrade procedures to classify existing information and increment figure accuracy.Our major objective is to create a system for estimating different cardiac clutters utilizing strategies like KNN, RFs, calculated relapse, and DTs. To do this, we perform an investigation on the heart illness dataset given by the UCI Machine Store. In expansion, our framework has an effortlessly worked interface for comfort of utilization.

Kassim Tawiah [9] Cardiovascular disease (CVD) is a major worldwide health hazard that requires precise prediction and early discovery for successful response.The research was conducted at Khyber Teaching Hospital and Lady Reading Hospital in Pakistan. It utilized machine learning algorithms, including DT, RF, logistic regression, NB, and SVM, to classify and predict CVD patients. Among these methods, RF demonstrated the highest accuracy (85.01%), sensitivity (92.11%), and recursive operative characteristic curve (87.73%), rendering it the most compatible algorithm for cardiovascular disease (CVD) classification and prediction. These findings underscore the potential of ML in enhancing disease diagnosis and treatment globally.

K. Arumugam [10] Data mining in healthcare, stemming from database statistics, aids in assessing medical therapy effectiveness, particularly in diabetes-related heart disease, a condition affecting diabetics. Despite numerous classification methods for predicting cardiac disease, there is insufficient evidence to anticipate diabetes patients. As a result, the DT model, which outperformed the NB and SVM models, was fine-tuned for best performance in forecasting heart disease risk among diabetics.

Mr. NADIKATLA CHANDRASEKHAR [11] In the medical field, early detection of cardiovascular problems is difficult. This work uses ML approaches to increase heart disease prediction accuracy, including six algorithms and datasets from Cleveland and IEEE Dataport. Logistic regression obtained 90.16% accuracy in the Cleveland dataset, but AdaBoost outperformed on the IEEE Dataport dataset, scoring 90% accuracy. A soft voting

ensemble classifier that amalgamated all techniques elevated accuracy to 93.44% and 95% for the Cleveland and IEEE Dataport datasets, respectively, outperforming individual classifiers. The work is innovative in that it uses GridSearchCV with five-fold cross-validation for hyperparameter optimization and evaluates performance through accuracy and negative log loss metrics as well as analyzing accuracy loss for each fold. This technique significantly outperformed previous heart disease prediction trials.

Sudarshan Nandy [12] .Accurately predicting cardiovascular disease is crucial yet challenging. Existing methods often fall short due to insufficient data techniques and prediction methodologies. In response, this research provides an intelligent healthcare system that employs the Swarm-Artificial Neural Network (Swarm-ANN) method. The method achieves 95.78% accuracy on a benchmark dataset by randomly generating and training Neural Networks (NNs) and changing their weights using a heuristic formulation. Sharing global best weights among neurons further enhances prediction accuracy, surpassing traditional learning techniques in performance metrics.

Şevket Ay [13]This work uses ML and meta-heuristic feature selection methods (whale optimization, Harris hawks optimization, cuckoo search and flower pollination) to predict heart disease and estimating survival in patients with heart failure. Experiments using datasets from the Cleveland and Faisalabad Institutes of Cardiology reveal considerable performance gains.K-nearest neighbor gets a maximum F-score of 99.72% for heart disease prediction, but only 97.45% for heart failure. The study underlines the relevance of choosing important criteria to improve classification accuracy.

Mohammad Abood Kadhim* [14] This paper proposes a model for early detection of heart disease, crucial for reducing high death rates associated with heart attacks globally.It consists of three stages: patient data collection and preprocessing, training and testing using various ML algorithms (SVMs, RF, DT, and K-Nearest Neighbor), with RF achieving the highest accuracy of 94.958 percent, and optimization through hyperparameter tuning, with RF achieving the best accuracy of 95.4%. This model aims to enhance decision-making in cardiology and improve early detection of heart disease, potentially saving lives and mitigating healthcare costs.

Mert Ozcan [15] This study utilizes the CART algorithm to predict heart disease and extract decision rules, as a result we achieve an 87% accuracy rate. The identified features influencing heart disease provide valuable insights for clinical applications, potentially simplifying diagnostic processes for healthcare professionals and patients alike.

P .Dileep[16] This research compares deep learning algorithms to standard methods for predicting heart illness, utilizing the UCI heart disease dataset and live, real-time data. The study uses the cluster-based bi-directional long term and short term memory (C-BiLSTM) model to improve the accuracy of older approaches, and it preprocesses both datasets using the K-Means clustering algorithm to reduce duplicates. C-BiLSTM's performance is compared to those of standard classifiers such as Regression Tree, SVM, Logistic Regression, KNN, Gated Recurrent Unit, and Ensemble, using accuracy, sensitivity, and F1 scores. The results show that C-BiLSTM outperforms the six standard approaches in predicting cardiac illness, with an accuracy of 94.78% for the UCI dataset and 92.84% for the real-time dataset.

Niloy Biswas[17] The aim of this project is to develop a ML model for predicting early-stage cardiac disease using a variety of feature selection strategies. Three methods - mutual information, ANOVA, and chi-square - were used to choose significant features, labeled as SF1, SF2, and SF3. Six ML models - SVM (C2), NB (C5), RF (C4), K-Nearest Neighbor (C3), DT (C6), and Logistic Regression (C1). - were then used to find the best model with the optimal feature subset. RF emerged as the most promising model, achieving 94.51% accuracy, 94.87% sensitivity, 94.23% specificity, 94.95 AURC, and 0.31 log loss on the SF3 feature subset. These findings show that the suggested model has the capability to be clinically useful for predicting preliminary-stage cardiac disease while being cost-effective and efficient.

Khader Basha Sk [18] In the evolving landscape of healthcare, there's a notable shift towards digitalization, with a focus on leveraging technological advancements to improve clinical outcomes. Traditional ways to anticipate and diagnose chronic illnesses are giving way to strategies that use predictive modeling and ML to extract insights from medical data. Heart disease remains a significant global concern, necessitating enhanced efforts

TABLE I: Summary Table

Author year [citations]	Techniques	Results	Research Gaps
Santosh Kumar Bharti 2021 [1]	NB, DTs, K-nearest Neighbor, and the RF algorithm	K-nearest Neighbor had the greatest accuracy score of 82% in predicting patients' chance of developing heart disease.	Potential areas for further investigation may include exploring additional ML algorithms, refining feature selection processes, and evaluating model performance on diverse datasets to enhance predictive accuracy and generalizability.
D. K. Lobiyal 2022 [2]	k-nearest neighbors (k-NN). RFs, and DTs.	The developed illness prediction system, utilizing RF, DT, and NB classifiers., achieves an 88% accuracy in forecasting heart disease risk.	It lacks explicit identification of research gaps for further exploration.

A.singh and R. Kumar [3]	The study employs ML algorithms including k-nearest neighbor, DTs, linear regression, and SVMs (SVM) for heart disease prediction.	The study achieves an accuracy of 76.05% in predicting heart disease using the evaluated ML algorithms.	.Future investigations could prioritize exploring model interpretability and addressing potential limitations, thereby improving the practical application of ML in healthcare settings.
R. Dinesh [4]	DT and RF, and a hybrid model of these algorithm	Experimental findings reveal the hybrid model achieves an 88.7% accuracy rate in predicting heart disease, surpassing individual algorithms' performance.	The study overlooks explicit identification of research gaps. Future research could focus on enhancing interpretability and evaluating the hybrid model's performance across diverse datasets for broader applicability in healthcare.
Prathmesh S. Asole (2022) [5].	Logistic Regression ,SVMs, DT, RF, and Gradient Boosting Classifier.	The most accurate algorithm to predict heart disease is SVM (SVM) in a web application, with an accuracy of 82.35%.	The paper does not explicitly address identified research gaps. Future research could focus on exploring interpretability and improving the generalizability of the selected algorithm across diverse populations.
Md. Rahat Hossain [6]	SVM, NB, RF, K-Nearest Neighbor Logistic Regression, Deep Neural Network and DT	A combined strategy employing all algorithms achieves exceptional predicted accuracy of 98.15% on the Statlog dataset, showcasing potential for clinical applications and healthcare decision support systems.	The paper does not explicitly address identified research gaps. Future studies could focus on validating the technique on diverse datasets to assess its generalizability and applicability in clinical settings.
Parth Patel [7]	k-modes clustering approach with Huang initialization	Among several models trained and tested on a real-world dataset of 70,000 occurrences, The multilayer perceptron, when combined with cross-validation, exhibited the highest accuracy of 87.28%, outperforming other approaches.	Future investigations could focus on exploring the interpretability of the model's outcomes and assessing its performance on diverse datasets to enhance its practical application in cardiovascular disease diagnosis.
Shanu Khare [8]	DTs, RFs, logistic regression, and KNN	The primary objective is to construct a prediction framework for various cardiac disorders utilizing these algorithms, leveraging the UCI Machine Repository dataset and providing a user-friendly interface.-	Explicit identification of research gaps is necessary to enhance the framework's effectiveness and its applicability in clinical settings, ensuring it addresses the specific needs and challenges of disease diagnosis accurately.
Kassim Tawiah [9]	RF, SVM, NB, DT, and Logistic Regression.	Among the algorithms tested, RF achieved the highest accuracy (85.01%), sensitivity (92.11%), and recursive operative characteristic curve (87.73%) for CVD classification and prediction. It also demonstrates the lowest specificity (43.48%) and misclassification errors (8.70%).	The potential areas for future research could include exploring the limitations of the chosen algorithms, investigating additional ML techniques, and assessing the generalization of the proposed model across different healthcare settings and populations.
K. Arumugam [10]	The study uses data mining techniques, namely the DT model, to forecast the probability of heart disease in diabetics.	When estimating the likelihood of heart disease in diabetics, the DT model consistently outperforms the NB and SVM models. It is fine-tuned for optimal performance in this context.	The paragraph highlights the gap in available data for predicting heart disease specifically in diabetic individuals. Further research could focus on gathering more comprehensive data for better prediction accuracy in this population subset. Additionally, exploring other ML algorithms and techniques could contribute to improving predictive capabilities in diabetic heart disease prediction.
Mr..NADIKATLA CHANDRASEKHAR [11]	The study employs six ML algorithms (NB, K-nearest neighbor, logistic regression,RF, AdaBoost classifier, and gradient boosting) to enhance heart disease prediction accuracy.	Logistic regression got the maximum accuracy of 90.16% on the Cleveland dataset, while AdaBoost outperformed with 90% accuracy on the IEEE Dataport dataset. A soft voting ensemble classifier that amalgamated all techniques increased accuracy to	The paper emphasizes the originality of utilizing GridSearchCV with five-fold cross-validation for hyperparameter tuning, as well as evaluating performance using accuracy and negative log loss measures.

		93.44% and 95% for the Cleveland and IEEE Dataport datasets, respectively, outperforming individual classifiers.	
Sudarshan Nandy [12]	The proposed approach utilizes Swarm-Artificial Neural Network (Swarm-ANN) strategy for predicting cardiovascular disease.	The Swarm-ANN strategy achieves a high accuracy of 95.78% on a benchmark dataset, outperforming standard learning techniques in various performance metrics.	The paragraph identifies a gap in existing methods related to the lack of data-recognized techniques and proper prediction methodology for cardiovascular disease prediction
Şevket Ay [13]	The study utilizes ML combined with meta-heuristic feature selection algorithms, including cuckoo search, flower pollination, whale optimization, and Harris hawks optimization, to predict heart disease and survival in heart failure.	Experimental findings demonstrate significant performance improvements compared to original datasets. For heart disease prediction, a maximum F-score of 99.72% is achieved using K-nearest neighbor, while for heart failure prediction, an F-score of 97.45% is obtained with the same algorithm.	The potential research gaps may include further exploration into the generalizability and robustness of the proposed approach across diverse datasets and clinical settings. Additionally, the scalability and computational efficiency of the combined ML-metaheuristic framework could be areas for future investigation.
Mohammad Abood Kadhim [14]	RF, SVMs, K-Nearest Neighbor, and DT	RF algorithm achieved the highest classification accuracy of 94.958%, while further optimization using random search hyperparameter optimization technique enhanced accuracy to 95.4%.	further exploration into the robustness of the model across diverse patient populations and clinical settings
Mert Ozcan [15]	The study employs the Classification and Regression Tree (CART) algorithm, a supervised ML method, to predict heart disease and extract decision rules.	The model achieves an 87% accuracy rate in predicting heart disease, demonstrating its reliability in clinical applications	Additional study might investigate the integration of additional ML approaches to improve prediction accuracy and broaden the breadth of therapeutic applications.
P. Dileep [16]	The study employs cluster-based bi-directional long-short term memory (C-BiLSTM) as a deep learning technique to predict heart disease, comparing it with traditional methods such as Logistic Regression, KNN, SVM, Gated Recurrent Unit, Regression Tree, and Ensemble.	Outperforming traditional approaches, C-BiLSTM attains an accuracy of 94.78% on the UCI dataset and 92.84% on the real-time dataset.	While the study showcases the effectiveness of C-BiLSTM in improving prediction accuracy, further research could explore the interpretability and generalizability of the model across diverse patient populations and healthcare settings
Niloy Biswas t [17]	The study uses feature selection approaches such as chi-square, ANOVA, and mutual information to uncover important traits for predicting heart disease. Six ML models -SVM, NB, RF, DT, K-Nearest Neighbor, and LR - are then used to determine the most optimum model and the best-fitting feature subset.	When employing the SF3 feature subset, RF outperformed other methods with 94.51% accuracy, 94.87% sensitivity, 94.23% specificity, 94.95 area under the ROC curve (AURC), and 0.31 log loss. These findings suggest that the proposed model has practical applications in predicting early-stage cardiac disease.	While the study demonstrates promising results, further research could explore the robustness of the model across diverse patient populations and validate its effectiveness in real-world clinical settings. Additionally, investigating the interpretability of the selected features and the model's generalizability could enhance its utility for widespread adoption in healthcare practice.
Khader Basha Sk[18]	The study utilizes a Hybrid ML approach, combining DT (DT) and Ada Boosting algorithms, to predict coronary heart disease (CHD). This hybrid ML algorithm is employed for CHD prediction and classification.	Performance indicators such as accuracy, True Positive Rate (TPR), and Specificity are used to assess the method's effectiveness. The study assesses the effectiveness of the Hybrid ML model in accurately predicting CHD.	While the study shows the promise of Hybrid ML approaches in CHD prediction, further research might look at the model's scalability and generalizability across diverse patient demographics and healthcare settings. Additionally, investigating the interpretability of the model's outcomes and its impact on clinical decision-making could enhance its practical applicability in healthcare practice.

III. CONCLUSION

"Survey on Advanced Healthcare System using Hybrid Machine Learning Algorithms" project represents a significant step towards revolutionizing healthcare through the integration of technology and machine learning. It aims to enhance patient care, reduce costs, and mitigate medical errors, all while prioritizing individualized treatment approaches. Through the prediction of heart disease and offering features such as appointment booking and FAQs, the system empowers both patients and healthcare professionals. By fostering a more connected healthcare environment, it aligns with the increasing demand for high-quality medical care. These advancements hold promise for the future of healthcare delivery, offering potential solutions to complex challenges while respecting patient privacy and confidentiality.

REFERENCES

[1] Shah, D., Patel, S. & Bharti, S.K , "Heart Disease Prediction using Machine Learning Techniques". SN COMPUT. SCI. 1, 345. https://doi.org/10.1007/s42979-020-00365-y , (2020)

[2] Rani, S., Bhandari, A., & Lobiyal, D. K . "A novel approach for heart disease prediction using machine learning techniques with feature selection" , Journal of Ambient Intelligence and Humanized Computing, 13(1), 719-728 , (2022).

[3] A. Singh and R. Kumar, "Heart Disease Prediction Using Machine Learning Algorithms," 2020 International Conference on Electrical and Electronics Engineering (ICE3), Gorakhpur, India, pp.

[4] M. Kavitha, G. Gnaneswar, R. Dinesh, Y. R. Sai and R. S. Suraj, "Heart Disease Prediction using Hybrid machine Learning Model," 2021 6th International Conference on Inventive Computation Technologies (ICICT), Coimbatore, India, pp. 1329-1333, doi: 10.1109/ICICT50816.2021.9358597. 2021

[5] Mihir J. Gaikwad, Prathmesh S. Asole, Prof. Leela S. Bitla , "Effective Study of Machine Learning Algorithms for Heart Disease Prediction", 2nd International Conference on Power Electronics & IoT Applications in Renewable Energy and Its Control (PARC) GLA University, Mathura, India. Jan 21-22, 2022.DOI: 10.1109/PARC52418.2022.9726613

[6] Safial Islam Ayon, Md. Milon Islam & Md. Rahat Hossain (2020): "Coronary Artery Heart Disease Prediction: A Comparative Study of Computational Intelligence Techniques", IETE Journal of Research, DOI: 10.1080/03772063.2020.1713916 (2020)

[7] Bhatt, C.M.; Patel, P.; Ghetia, T.; Mazzeo, P.L. Effective Heart Disease Prediction Using Machine Learning Techniques. Algorithms 2023

[8] Anup Lal Yadav; Kamal Soni; Shanu Khare, Heart Diseases Prediction using Machine Learning. Delhi India. July 08 2023 DOI: 10.1109/ICCCNT56998.2023.10306469

[9] Arsalan Khan, Moiz Qureshi, Muhammad Daniyal,and Kassim Tawi, A Novel Study on Machine Learning Algorithm-Based Cardiovascular Disease Prediction. Kwame Nkrumah University of Science and Technology, Kumasi, Ghan. February 20, 2023.

[10] K. Arumugam. "Multiple disease prediction using Machine learning algorithms". April 27 2023

[11] Mr. NADIKATLA CHANDRASEKHAR " Enhancing Heart Disease Prediction Accuracy through Machine Learning Techniques and Optimization" April 14 2023.

[12] Sudarshan Nandy An intelligent heart disease prediction system based on swarm-artificial neural network May 2021

[13] Şevket Ay "A comparative analysis of meta-heuristic optimization algorithms for feature selection on ML-based classification of heart-related diseases" March 03 2023

[14] Mohammad Abood Kadhim, Abdulkareem Merhej Radhi " Heart Disease classification using optimized machine learning algorithm" February 2023 DOI: https://doi.org/10.52866/ijcsm.2023.02.02.004

[15] Mert Ozcan, Serhat Peker "A classification and regression tree algorithm for heart disease modeling and prediction" DOI: https://doi.org/10.1016/j.health.2022.100130

[16] Dileep, P., Rao, K.N., Bodapati, P. et al. An automatic heart disease prediction using cluster-based bi-directional LSTM (C-BiLSTM) algorithm. Neural Comput & Applic 35, 7253–7266(2023).https://doi.org/10.1007/s00521-022-07064-0

[17] Niloy Biswas,"Precision Medicine and Big Data Research Progress in Inflammatory Diseases" May 02 2023. DOI: https://doi.org/10.1155/2023/6864343

[18] K. B. Sk, R. D, S. S. Priya, L. Dalavi, S. S. Vellela and V. R. B, "Coronary Heart Disease Prediction and Classification using Hybrid Machine Learning Algorithms," 2023 International Conference on Innovative Data Communication Technologies and Application (ICIDCA), Uttarakhand, India, 2023, pp. 1-7, doi: 10.1109/ICIDCA56705.2023.10099579.