International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-12 Issue-11, October 2023

A Review, Synthesizing Frameworks, and Future Research Agenda: Use of AI & ML Models in Cardiovascular Diseases Diagnosis

Dhavalkumar Upendrabhai Patel, Suchita Patel

Abstract: ***Cardiovascular diseases (CVDs) continue to be a leading cause of morbidity and mortality worldwide. Early detection and accurate diagnosis of the initial phases of CVDs are crucial for effective intervention and improved patient outcomes. In recent years, advances in intelligent automation and machine learning (ML) techniques have shown promise in enhancing the accuracy and efficiency of CVD detection. This systematic review aims to comprehensively analyze and synthesize the existing literature on the application of intelligent automation and ML adaptive classifier models in the detection of the initial phase of cardiovascular disease within the realm of medical science. The review follows a rigorous systematic methodology, including a comprehensive literature search, study selection, data extraction, and quality assessment. A wide range of scholarly articles from the reputed journal were searched to identify relevant studies published over a specified period. The selected studies were critically evaluated for methodological robustness and relevance to the research objective. The synthesis of findings reveals a diverse landscape of research endeavours focused on employing intelligent automation and ML adaptive classifier models for CVD detection. The review highlights the various types of ML algorithms utilized, such as neural networks, decision trees, and support vector machines, and their potential to enhance the accuracy of diagnosis by analyzing complex and heterogeneous data sources, clinical records, and omics data. Furthermore, the review discusses the challenges and limitations encountered in implementing these models, including issues related to data quality, interpretability, and ethical considerations. It also underscores the importance of interdisciplinary collaboration between medical practitioners, data scientists, and domain experts to ensure the seamless integration of these innovative technologies into clinical practice. In conclusion, this systematic review highlights the significant advancements made in the field of intelligent automation and ML adaptive classifier models in detecting the initial phase of cardiovascular disease. While acknowledging the potential of these approaches, it also emphasises the need for further research, standardisation, and validation to harness their full capabilities and contribute to more accurate, timely, and personalised cardiovascular disease diagnosis and management.***

Keywords: - Cardiovascular Diseases (CVDs), Heart Disease Prediction, Heart Disease, Machine Learning, Optimization, Initial Phases of Cvds, Machine Learning (Ml) Techniques, Ml (Machine Learning) Adaptive Classifier Models

Manuscript received on 16 September 2023 | Revised Manuscript received on 27 September 2023 | Manuscript Accepted on 15 October 2023 | Manuscript published on 30 October 2023.

*Correspondence Author(s)

Mr. Dhavalkumar Upendrabhai Patel*, Assistant Professor, Indukaka Ipcowala College of Pharmacy, The CVM University, V.V.Nagar- Anand, India. E-mail: dhavalkumar.patel@cvmu.edu.in, dhavalpatel@iicp-cvm.edu.in, ORCID ID: 0000-0003-2069-3900

Dr. Suchita Patel, Assistant Professor, Department of Computer Science, ISTAR College, The CVM University, V.V.Nagar- Anand, India. E-mail: suchita.patel@cvmu.edu.in, suchitapatelit@istar.edu.in, ORCID ID: 0000-0002-8034-5839

I. INTRODUCTION

Data mining, a process that involves extracting valuable insights from datasets and transforming them into usable formats, holds great potential for addressing contemporary challenges in medical science. One such challenge is the early detection of cardiovascular diseases (CVDs), which continue to pose a substantial global health burden. Timely identification of the initial phases of CVDs is essential for effective intervention and improved patient outcomes. With the advent of intelligent automation and machine learning (ML) techniques, there is a growing opportunity to enhance the accuracy and efficiency of CVD detection. This systematic review delves into the application of intelligent automation and ML adaptive classifier models within the context of medical science, particularly in the realm of detecting the initial phase of cardiovascular disease. By synthesizing and analyzing existing literature, this review aims to provide a comprehensive overview of the current landscape, methodologies, challenges, and potential future directions in the integration of advanced technologies for improving cardiovascular disease diagnosis and management.

II. LITERATURE SURVEY ENHANCING EARLY DETECTION OF CARDIOVASCULAR DISEASE: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING MODELS IN CARDIOVASCULAR DIAGNOSIS

In this paper, we refer to various algorithms, methods, approaches, paradigms, and techniques for intelligent automation and machine learning (ML) to enhance the accuracy and efficiency of CVD detection.

1. **Viren Viraj Shankar, Varun Kumar, Umesh Devagade, Vinay Karanth & K. Rohitaksha Heart Disease Prediction Using CNN Algorithm SN Computer Science volume 1, Article number: 170 (2020) proposed [1]**

They proposed that the Convolutional Neural Network algorithm is a means for determining early heart disease risk using structured data. The accuracy obtained using their model [10] goes up to 85%. The CNN algorithm can also be used with unstructured data and images.

2. **Fatma Zahra Abdeldjouad, and Nada Matta Menaouer Brahami, A Hybrid Approach for Heart Disease Diagnosis and Prediction Using Machine Learning Techniques, The Impact of Digital Technologies on Public Health in Developed and Developing Countries,18th International Conference, ICOST 2020, Hammamet, Tunisia, June 24–26,2020, https://doi.org/10.1007/978-3-030-51517-1, Page-299 [2]**

This paper analyses several classification algorithms, including Logistic Regression (LR), Adaptive Boosting (AdaBoostM1), and Multi-Objective Evolutionary Fuzzy Classifier (MOEFC). The highest accuracy of 80.20 is achieved by majority voting, while LR yields the lowest accuracy, and AdaBoostM1 achieves the highest accuracy when applied individually.

3. **Sarthak Vinayaka and P. K. Gupta, Heart Disease Prediction System Using Classification Algorithms, Advances in Computing and Data Sciences 4th International Conference, ICACDS 2020, Valletta, Malta, April 24–25, 2020. , https://doi.org/10.1007/978-981-15-6634-9,Page-395[3]**

They have applied various machine learning algorithms to the dataset and measured the accuracy of their predictions for heart disease. They have achieved the highest accuracy of 86.84% with the proposed modified random forest algorithm. The proposed algorithm performs equally well in real-time, and its accuracy can be further enhanced by collecting more data and implementing other deep learning-based techniques, such as convolutional neural networks.

4. **Muhammad Affan Alim, Shamsheela Habib, Yumna Farooq, Abdul Rafay., Robust Heart Disease Prediction: A Novel Approach based on Significant Feature and Ensemble learning Model, 2020 3rd International Conference on Computing, Mathematics and Engineering Technologies (iCoMET), DOI: 10.1109/iCoMET48670.2020[4]**

In this paper, we propose a novel method that utilises machine learning algorithms for the early prediction of heart disease. Essentially, the paper aims to identify features through correlation that can contribute to robust prediction results. For this purpose, the UCI vascular heart disease dataset is used, and our results are compared with those of a recently published article. Our proposed model achieved an accuracy of 85.43%

5. **Mamatha Alex P and Shaicy P Shaji, Prediction and Diagnosis of Heart Disease Patients using Data Mining Technique, International Conference on Communication and Signal Processing, April 4-6, 2019, India, DOI:10.1109/ICCSP.2019.8697977[5]**

This project aims to diagnose various heart diseases and take all possible precautions to prevent them at an early stage, at an affordable rate. They follow the 'data mining' technique, in which attributes are fed into SVM, Random Forest, and KNN classification Algorithms for the prediction of heart diseases. The accuracy obtained using SVM is 85%, Random Forest is 85% and KNN is 83%.

Table 1: Summary of UCI Dataset Attributes, Detailed Information

Num.	Code	Feature	Type	Description
1	Age	Age	Continuous	Age in years
2	Sex	Sex	Discrete	sex (1 = male; 0 = female)
3	cp	Chest pain type	Discrete	1 = typical angina; 2 = atypical angina; 3 = non-angina pain; 4 = asymptomatic
4	Trestbps	Resting blood pressure (mmHg)	Continuous	At the time of admission to the hospital [94, 200]
5	Choi	Serum cholesterol (mg/dl)	Continuous	Multiple values between [Minimum Chol: 126, Maximum Chol: 564]
6	Fbs	Fasting blood sugar > 120 mg/dl	Discrete	1 = yes; 0 = no
7	Restecg	Resting electrocardiographic results	Discrete	0 = normal; 1 = ST-T wave abnormal; 2 = left ventricular hypertrophy
8	Thalach	Maximum heart rate achieved	Continuous	Maximum heart rate achieved [71, 202]
9	Exang	Exercise-induced angina	Discrete	1 = yes; 0 = no
10	Oldpeak	ST depression induced by exercise relative to rest	Continuous	Multiple absolute number values between 0 and 6.2.
11	Slope	The slope of the peak exercise ST segment	Discrete	1 = upsloping; 2 = flat; 3 = downsloping
12		Number of major vessels (0— 3) colored by fluoroscopy	Discrete	Number of major vessels coloured by fluoroscopy (values 0—3)
13	Thal	Exercise thallium scintigraphy	Discrete	3 = normal; 6 = fixed defect; 7 = reversible defect
14	Class (Target)	The predicted attribute	Discrete	0 = no presence; 1 = presence

[2] Description of the Dataset and Attributes: The data used in this study originates from the UCI Repository of Machine Learning Databases, specifically the Heart Disease Dataset. The author opted to employ the Cleveland (Cleveland Clinic Foundation) database for this investigation due to its widespread use among machine learning researchers and its comprehensive and complete medical records. This dataset comprises a total of 303 records, each encompassing 14 distinct medical features. Table 1 provides an overview of these various features, along with their descriptions. Additionally, within this dataset, there is a categorical feature labelled "Class" that indicates whether a patient has heart disease or not. To simplify this categorical attribute, we transformed its original values (1, 2, 3, and 4) into a binary format, where 1 signifies the presence of heart disease.

6. **Xin Qian, Yu Li, Xianghui Zhang, Heng Guo, Jia He, Xinping Wang, Yizhong Yan, Jiaolong Ma, Rulin Ma, Shuxia Guo, A Cardiovascular Disease Prediction Model Based on outine Physical Examination Indicators Using Machine Learning Methods: A Cohort Study, Frontiers in Cardiovascular Medicine, June 2022 | Volume 9 | Article 854287[6]**

In this study, the performance of the CVD prediction model based on the L1-LR algorithm was higher than that of other ML algorithms. [9]In addition to the traditional single risk factors for cardiovascular disease, complex lipid metabolism indicators, such as LpH and TyG, and obesity indicators, such as BMI and BAI, were found to be important factors for predicting the incidence of CVD in this population.

7. **Pardeep Kumar, Ankit Kumar, Heart Disease Classification and Recommendation by Optimized Features and Adaptive Boost Learning, (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 14, No. 3, 2023, DOI: 10.14569/issn.2156-5570, Page-909[7]**

The study focused on developing an efficient Machine Learning technique for the accurate identification of cardiac diseases across five classes: one normal category and four disease categories. The researchers designed a method that optimised feature weighting and selection, followed by adaptive boosting using tree and K-nearest neighbour (KNN) bases. Compared to previous methods, this approach resulted in an improvement of 3-4% in sensitivity (detection of actual positive cases), 4-5% in specificity (detection of actual negative cases), and 3-4% in overall accuracy.

The study explored various adaptive boosting approaches, including basic adaptive boosting, hybridisation with trees, and hybridisation with KNN. These approaches were compared using multi-objective genetic optimization to assign appropriate weights to features. This optimization ensured that features did not overlap, thereby enhancing performance. The incorporation of tree-based methods was particularly effective in improving performance due to the mapping of entropy and information gain.

The proposed [8], model's focus on maximizing sensitivity led to improved recall values. The ultimate goal of this research is to enable long-term preservation of individuals' health by processing primary health records through machine learning techniques. Detecting irregularities in heart health at an early stage is emphasized, as it significantly reduces fatality rates. The proposed five-class classification system enhances the diagnosis of specific heart diseases and provides recommendations for further action. Notably, the sensitivity of the classification was significantly increased, outperforming traditional methods like SVM and KNN.

In future work, the researchers plan to enhance their approach by utilising deep learning techniques for non-linear mapping and optimising the latent space to reduce overlap between different disease classes. This holistic approach aims to revolutionize the prediction and management of heart diseases, ultimately improving healthcare outcomes.

III. STUDY OF AN ARCHITECTURE AND METHODOLOGY

1. **Viren Viraj Shankar, Varun Kumar, Umesh Devagade, Vinay Karanth & K. Rohitaksha Heart Disease Prediction Using CNN Algorithm, SN Computer Science volume 1, Article number: 170 (2020) proposed [1]**

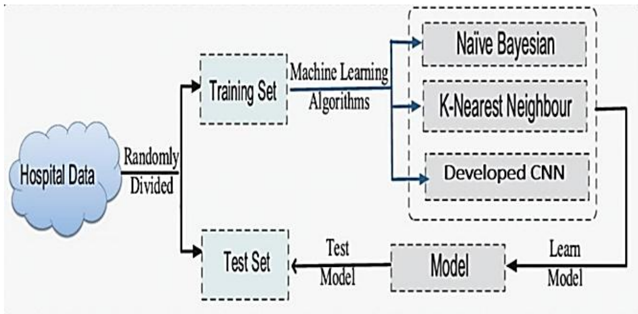

Fig.1. Proposed heart disease prediction model

Description (Fig. 1): - 1. It begins with data collection, where different types of data, primarily structured, semi-structured, or unstructured, can be gathered from various sources, such as hospitals.
2. Once the data are collected, the obtained data are first cleaned to remove missing values, and then, the cleaned data are classified into training data and test dataset.
3. After the data segregation, the data are fed into various machine learning algorithms, such as Naive Bayes, KNN, or CNN. This step is primarily performed using training data to teach the machine, thereby increasing its predictive accuracy.
4. Once the data has learnt enough, our learned model will be ready for testing.
5. The learned model is tested using test data to check its predictive accuracy.

2. **Fatma Zahra Abdeldjouad, and Nada Matta Menaouer Brahami, A Hybrid Approach for Heart Disease Diagnosis and Prediction Using Machine Learning Techniques, The Impact of Digital Technologies on Public Health in Developed and Developing Countries,18th International Conference, ICOST 2020, Hammamet, Tunisia, June 24–26,2020,[2]**

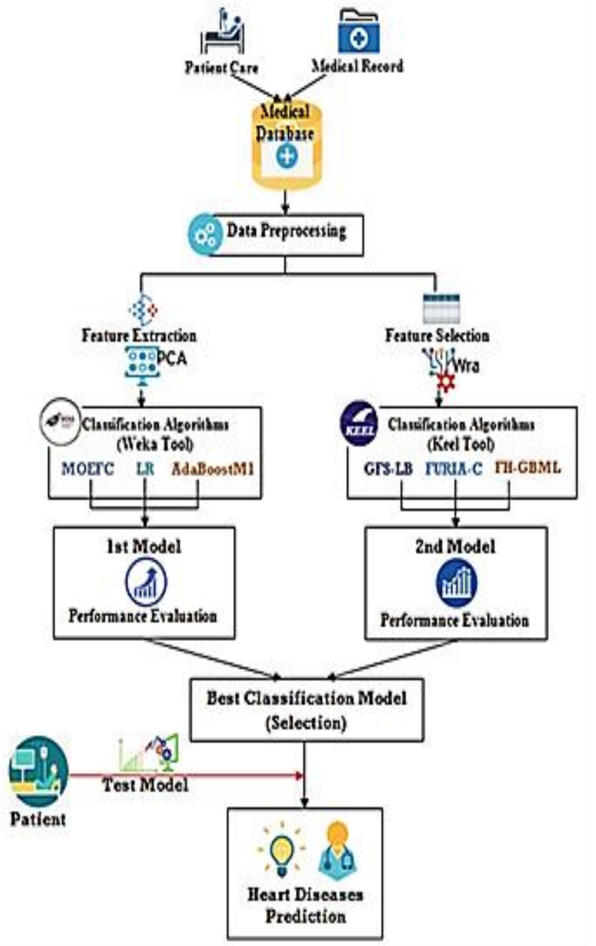

Fig. 2. Illustration of the Innovative Hybrid Approach and Its General Architecture

Description (Fig. 2): - [2] **Data preprocessing** involved removing seven records with missing values from a dataset of 303 patient records, resulting in 296 records for analysis. **Feature selection** was conducted using a wrapper method, with two attributes (age and sex) used for patient identification, while the remaining 12 attributes, containing critical clinical data, were retained. **Feature extraction** employed PCA to reduce attribute dimensions to 6 for enhanced cardiovascular disease diagnosis. **Classification algorithms,** including MOEFC, LR, and AdaBoostM1 in Weka, and GFS-LB, FURIA, and FH-GBML in Keel, were applied to build models. **The best-performing model** was chosen for accurate medical data classification. **Model testing** assessed performance on unseen patient data, providing insights into its **predictive** capability in real-world scenarios.

3. **Sarthak Vinayaka and P. K. Gupta, Heart Disease Prediction System Using Classification Algorithms, Advances in Computing and Data Sciences 4th International Conference, ICACDS 2020, Valletta, April 24–25, 2020. [3]**

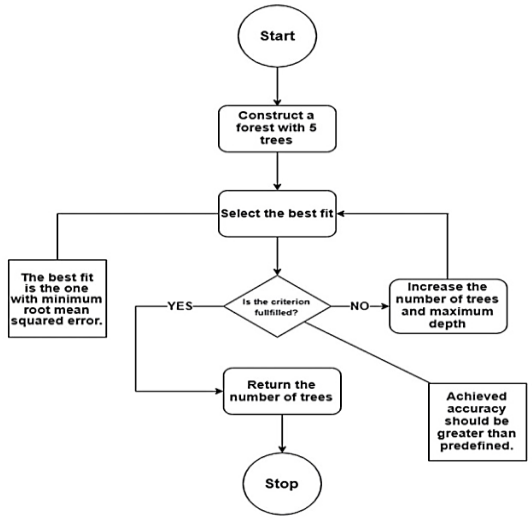

Fig. 3. Innovative Architecture: Heart Disease Prediction System Using Classification Algorithms.

Description (Fig. 3): -[3]Random Forest is an alternative machine learning algorithm that effectively addresses the nonlinearity present in datasets, often yielding superior results when compared to decision trees. This ensemble method consists of numerous trees, each with intentionally randomised input values. Achieving optimal performance with Random Forest requires careful tuning of its parameters. Adjustments such as controlling randomness, varying the number of trees, and limiting the maximum depth of these trees can significantly enhance accuracy.

4. **Muhammad Affan Alim, Shamsheela Habib, Yumna Farooq, Abdul Rafay., Robust Heart Disease Prediction: A Novel Approach based on Significant Feature and Ensemble learning Model, 2020 3rd International Conference on Computing, Mathematics and Engineering Technologies (iCoMET), DOI: 10.1109/iCoMET48670.2020[4]**

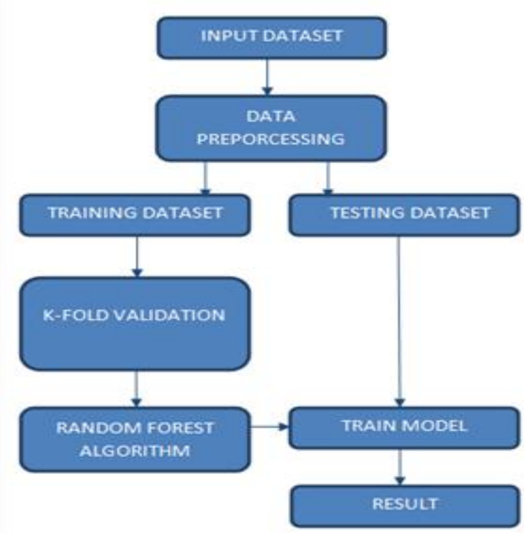

Fig. 4. Unlocking Insights: Flowchart of the Novel Heart Disease Prediction Ensemble learning model.

Description (Fig. 4): - The dataset, obtained from the UCI machine learning website, comprises over 300 tuples with 14 attributes, including age, gender, chest pain, blood pressure, and cholesterol. Data preprocessing is crucial for unbiased results. Python, Spyder (with Anaconda), and libraries such as NumPy, Pandas, scikit-learn, and Matplotlib were used for modelling. Random Forest, pioneered by Leo Breiman, is an ensemble technique that builds multiple trees from the dataset and combines their outputs. It's used for classification and regression, is resistant to overfitting, and can handle missing values. Stratified KFold cross-validation ensures model accuracy and uniform data splitting, making it robust and effective, mainly when used with Random Forest.

5. **Mamatha Alex P and Shaicy P Shaji, Prediction and Diagnosis of Heart Disease Patients using Data Mining Technique, International Conference on Communication and Signal Processing, April 4-6, 2019, India, DOI:10.1109/ICCSP.2019.8697977[5]**

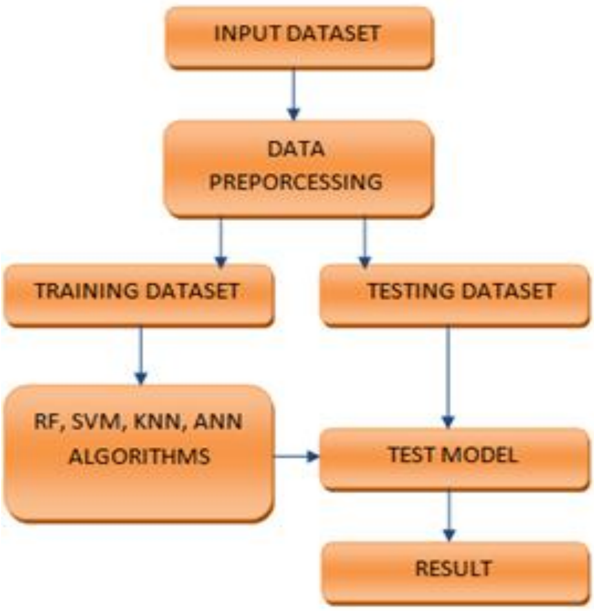

Fig. 5. Charting the Course: Architecture of Data Mining Approach

Description (Fig.5): -
[5] **Input Dataset**: Gather a comprehensive dataset containing patient information, including age, gender, blood pressure, cholesterol levels, ECG readings, and other relevant medical attributes.
Data Processing: Preprocess the dataset by handling missing values, normalizing or scaling features, and encoding categorical variables to prepare it for analysis.
Training and Testing Data Split: Divide the preprocessed data into a training dataset (used to train the models) and a testing dataset (used to evaluate model performance).
Training Models: Apply various data mining algorithms, such as Random Forest (RF), Support Vector Machine (SVM), and Artificial Neural Network (ANN), to the training dataset to build predictive models for heart disease diagnosis.
Testing Model: Use the testing dataset to assess the accuracy and performance of the trained models in predicting heart disease in new, unseen data.
Results: Analyze the results, including model accuracy, precision, recall, and F1-score, to determine which data mining technique provides the most accurate and reliable predictions for diagnosing heart disease patients.

6. **Xin Qian, Yu Li, Xianghui Zhang, Heng Guo, Jia He, Xinping Wang, Yizhong Yan, Jiaolong Ma, Rulin Ma, Shuxia Guo, A Cardiovascular Disease Prediction Model Based on outine Physical Examination Indicators Using Machine Learning Methods: A Cohort Study, Frontiers in Cardiovascular Medicine, June 2022 | Volume 9 | Article 854287[6]**
    1. Data Collection: This stage involves collecting data from the research cohort participants.
    2. Baseline Survey (2010 - 2012): The first stage of data collection, where baseline information is gathered from participants.
    3. Follow-up (Ending Dec 2017): This involves tracking the participants' progress and collecting follow-up data until December 2017.
    4. Baseline Survey (Sep-Dec 2016): The second-phase baseline survey was conducted for a subset of participants.
    5. Follow-up (Ending Aug 2021): Follow-up data collection for the second-phase baseline survey participants, ending in August 2021.
    6. Data Analysis & Model Building: In this stage, the collected data is analyzed, and a predictive model for cardiovascular disease (CVD) is built. Various feature selection methods, including Lasso regression, logistic regression forward partial likelihood estimation (FLR), random forest (RF) feature importance, and RF variable importance, are applied here.
    7. CVD Prediction Model: The selected subset of variables is used to create a CVD prediction model utilising techniques such as L1-regularised logistic regression (L1-LR), random forest (RF), support vector machine (SVM), and AdaBoost algorithms.
    8. Incidence Analysis of CVD: The incidence of cardiovascular disease (CVD) within the studied population is analysed using a well-established prediction model.
7. **Heart Disease Classification and Recommendation by Optimized Features and Adaptive Boost Learning Pardeep Kumar, Ankit Kumar Computer Science and Applications, Baba Mastnath University, Asthal Bohar, Rohtak, India [7]**

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

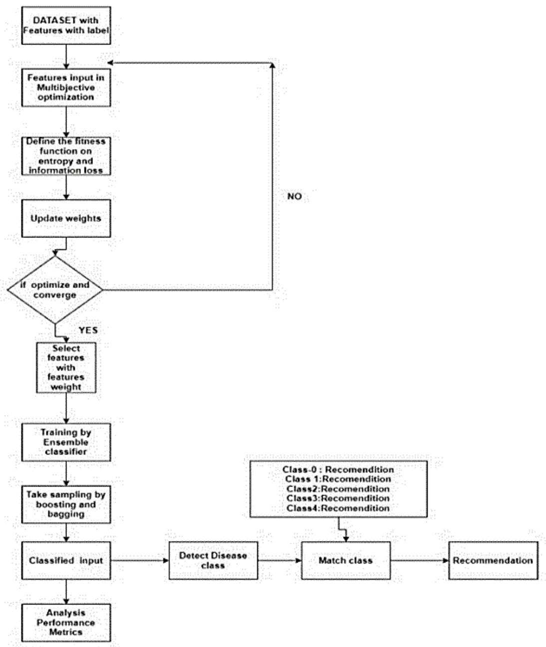

Fig. 6. Proposed Classification and Recommendation Approach.

IV. STUDY OF AN ARCHITECTURE AND METHODOLOGY

Description (Fig. 6): - [7] **Data Input**: Start by loading the heart disease dataset containing both features and labels for each patient.

Feature Optimisation: Utilise multi-objective optimisation, considering both entropy and information gain, to assign efficient weights to features, thereby optimising their relevance.

Pareto Space Selection: After crossover, identify the efficient Pareto space using an activation or fitness function, highlighting promising feature combinations.

Weight Optimization: Fine-tune feature weights within the Pareto space to maximize their impact on predictive accuracy.

Weighted Feature Learning: Utilise optimised feature weights to train a classifier, thereby enhancing its performance and predictive power.

Classifier Training: Train the classifier using the weighted features, enabling it to learn and make predictions based on the optimised information.

Recommendation: For a given instance, predict the class using the trained classifier and provide relevant suggestions or recommendations based on the expected outcome.

V. COMPARISON OF THE METHODS OR ALGORITHMS USED IN THE PAPERS YOU'VE PROVIDED FOR HEART DISEASE PREDICTION:

CNN Algorithm for Heart Disease Prediction [1]:

- Algorithm: Convolutional Neural Network (CNN)
- Accuracy: Up to 85%
- Notable Points: Used CNN for structured data and achieved good accuracy. Mentioned applicability to unstructured data and images.

2. Hybrid Approach for Heart Disease Diagnosis and Prediction [2]:

- Algorithms: Logistic Regression (LR), AdaBoostM1, Multi-Objective Evolutionary Fuzzy Classifier (MOEFC), Ensemble (majority voting)
- Accuracy: Up to 80.20% (with majority voting)
- Notable Points: Explored various classification algorithms and ensembles. AdaBoostM1 performed well without an ensemble.

3. Heart Disease Prediction Using Classification Algorithms [3]:

- Algorithms: Various machine learning algorithms, Proposed Modified Random Forest
- Accuracy: 86.84% (with modified random forest)
- Notable Points: Achieved high accuracy with a proposed modified random forest and suggested potential for improvement with more data and deep learning techniques.

4. Robust Heart Disease Prediction [4]:

- Algorithms: Machine learning algorithms, not specified
- Accuracy: 85.43%
- Notable Points: Focused on finding features for robust prediction using correlation. Compared with a published article, it achieved good accuracy.

5. Heart Disease Prediction using Data Mining Technique [5]:

- Algorithms: SVM, Random Forest, KNN
- Accuracy: SVM (85%), Random Forest (85%), KNN (83%)
- Notable Points: Applied data mining techniques using different classification algorithms for prediction.

6. Cardiovascular Disease Prediction Model Based on Physical Examination Indicators[6]:

- Algorithm: L1-LR (Logistic Regression)
- Notable Points: L1-LR algorithm performed best compared to other ML algorithms. Identified additional indicators for predicting cardiovascular disease.

7. Heart Disease Classification and Recommendation by Optimized Features and Adaptive Boost Learning[7]:

- Algorithms: Adaptive Boosting (with tree and KNN bases)
- Notable Points: Focused on efficient ML techniques for cardiac disease identification. Used feature weighting and selection, adaptive boosting, and achieved improved sensitivity, specificity, and overall accuracy. Each paper utilizes a different set of algorithms and techniques to predict heart disease. The accuracy achieved varies across the papers, and different papers highlight different aspects of heart disease prediction, including the use of structured data, ensembles, feature selection, and optimisation. The choice of algorithms and approaches often depends on the characteristics of the dataset, the specific research goals, and the desired level of accuracy and interpretability.

VI. CONCLUSION

In the realm of heart disease prediction, a diverse array of methodologies and algorithms has been explored, each with its unique strengths and findings. Convolutional Neural Network (CNN) algorithms have shown promise by capitalising on structured data to achieve commendable accuracy levels of up to 85%, suggesting potential applications to unstructured data and images.

Retrieval Number: 100.1/ijitee.K973310121123
DOI: 10.35940/ijitee.K9733.10121123
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Meanwhile, a hybrid approach combining Logistic Regression (LR), AdaBoostM1, and Multi-Objective Evolutionary Fuzzy Classifier (MOEFC), supplemented by ensemble techniques such as majority voting, highlighted the significance of algorithm diversity in achieving accuracy levels of up to 80.20%. Another perspective emerged with the utilization of various machine learning algorithms, with a proposed modified random forest algorithm standing out with an impressive accuracy of 86.84%. In the pursuit of robust prediction, an emphasis on correlation-based feature identification has led to notable outcomes, as evidenced by an accuracy of 85.43% compared to previous work.

Adopting a data mining approach, the SVM, Random Forest, and K-Nearest Neighbours (KNN) algorithms demonstrated their predictive capabilities, with SVM and Random Forest achieving accuracies of 85% and KNN reaching 83%. Exploring traditional examination indicators in cardiovascular disease prediction, the L1-LR algorithm emerged as a frontrunner, outperforming other machine learning algorithms and shedding light on the significance of previously undervalued indicators. In tandem with these endeavours, a concentrated effort was directed toward optimising feature selection and implementing adaptive boosting, resulting in significant improvements in sensitivity, specificity, and overall accuracy, particularly in comparison to established techniques such as SVM and KNN.

Overall, these studies underline the multifaceted nature of heart disease prediction, each paper contributing a distinct facet of insight into the complex interplay between algorithms, dataset attributes, and prediction accuracy. The variability in achieved accuracies and the specific strategies employed underscore the importance of tailored approaches, aligning with the unique requirements of the dataset and the intended application. As the field advances, the integration of cutting-edge techniques, deeper explorations of correlations, and optimisation processes holds the potential to revolutionise cardiac disease prediction further, ultimately enhancing healthcare outcomes and early intervention strategies.

DECLARATION STATEMENT

Funding/ Grants/ Financial Support	No, I did not receive.
Conflicts of Interest/ Competing Interests	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval or consent to participate, as it presents evidence that is already publicly available.
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	All authors have equal contributions to this article.

REFERENCES

1. Viren Viraj Shankar, Varun Kumar, Umesh Devagade, Vinay Karanth & K. Rohitaksha Heart Disease Prediction Using CNN Algorithm, SN Computer Science volume 1, Article number: 170 (2020) proposed https://doi.org/10.1007/s42979-020-0097-6
2. Fatma Zahra Abdeldjouad, and Nada Matta Menaouer Brahami, A Hybrid Approach for Heart Disease Diagnosis and Prediction Using Machine Learning Techniques, The Impact of Digital Technologies on Public Health in Developed and Developing Countries,18th International Conference, ICOST 2020, Hammamet, Tunisia, June 24–26,2020, https://doi.org/10.1007/978-3-030-51517-1,Page-299 https://doi.org/10.1007/978-3-030-51517-1
3. Sarthak Vinayaka and P. K. Gupta, Heart Disease Prediction System Using Classification Algorithms, Advances in Computing and Data Sciences 4th International Conference, ICACDS 2020, Valletta, Malta, April 24–25, 2020. , https://doi.org/10.1007/978-981-15-6634-9,Page-395
4. Muhammad Affan Alim, Shamsheela Habib, Yumna Farooq, Abdul Rafay., Robust Heart Disease Prediction: A Novel Approach based on Significant Feature and Ensemble learning Model, 2020 3rd International Conference on Computing, Mathematics and Engineering Technologies (iCoMET), DOI: 10.1109/iCoMET48670.2020 https://doi.org/10.1109/iCoMET48670.2020
5. Mamatha Alex P and Shaicy P Shaji, Prediction and Diagnosis of Heart Disease Patients using Data Mining Technique, International Conference on Communication and Signal Processing, April 4-6, 2019, India, DOI:10.1109/ICCSP.2019.8697977 https://doi.org/10.1109/ICCSP.2019.8697977
6. Xin Qian, Yu Li, Xianghui Zhang, Heng Guo, Jia He, Xinping Wang, Yizhong Yan, Jiaolong Ma, Rulin Ma, Shuxia Guo, A Cardiovascular Disease Prediction Model Based on outine Physical Examination Indicators Using Machine Learning Methods: A Cohort Study, Frontiers in Cardiovascular Medicine, June 2022 | Volume 9 | Article 854287 https://doi.org/10.3389/fcvm.2022.854287
7. Pardeep Kumar, Ankit Kumar, Heart Disease Classification and Recommendation by Optimized Features and Adaptive Boost Learning, (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 14, No. 3, 2023, DOI: 10.14569/issn 2156-5570, Page-909 https://doi.org/10.14569/IJACSA.2023.01403103
8. Ghosh P, Azam S, Jonkman M, Karim A, Shamrat FJM, Ignatious E, et al. Efficient prediction of cardiovascular disease using machine learning algorithms with relief and LASSO feature selection techniques. IEEE Access. (2021) 9:19304–26. doi: 10.1109/ ACCESS.2021.3053759 https://doi.org/10.1109/ACCESS.2021.3053759
9. Maiga J., Hungilo G. G. (2019). “Comparison of machine learning models in prediction of cardiovascular disease using health record data.” in 2019 International Conference on Informatics, Multimedia, Cyber and Information System (ICIMCIS) IEEE, 45–48 https://doi.org/10.1109/ICIMCIS48181.2019.8985205
10. Suchita B. Patel, Dr. Samratvivekanand O Khanna, “2-Tier Trust Based Model For Intrusion Detection System in Mobile Adhoc Network” International Journal of Research and Innovation in Applied Science (IJRIAS) |Volume I, Issue IV, July 2016|ISSN 2454-6194

AUTHORS PROFILE

Dhaval Patel, an Assistant Professor at Indukaka Ipcowala College of Pharmacy (IICP), CVM University, V.V. Nagar, Anand, Gujarat, has been in this position since 2007. His area of interest is in Artificial Intelligence and Machine Learning. His commitment to fostering knowledge is underscored by his receipt of government grants to conduct impactful workshops and seminars. His long-standing tenure at CVM University (IICP) demonstrates his unwavering commitment to academic excellence, making significant contributions to the institution's reputation and the advancement of students in the field of computer science. Additionally, he has conducted diverse research projects during his academic journey, further enriching his contributions to the field of AI and machine learning.

Dr. Suchita Patel has been working as an Assistant Professor in the Computer Science department of the Institute of Science & Technology for Advanced Studies & Research (ISTAR) College, CVM University, V.V. Nagar, Anand, Gujarat, since 2012. She received her MCA degree from Virani Science College, Saurashtra University, Rajkot, Gujarat. She obtained her Ph.D. in Computer Science (CS) from Sardar Patel University, Anand, Gujarat. Her areas of interest include Network Security, MANET Security, Cloud Computing, Internet of Things, Mobile Application Development, Machine Learning, and Artificial Intelligence. She has published more than 17 research papers in various national and international journals and conferences. Her.