OPEN ACCESS
Global Journal of Research in Engineering & Computer Sciences
ISSN: 2583-2727 (Online)
Volume 04 | Issue 02 | March-April | 2024
Journal homepage: https://gjrpublication.com/gjrecs/
Review Article

A Comprehensive Review on AI-Enabled Diagnosis for Heart Disease

Nihal Athri S[1], *Jabasingh Daniel[2], Shetty Thrishika Shridhar[3], Mohammed Ziyad K S[4], Prof. Daya Naik[5]

[1,2,3,4,5]Department of AIML Srinivas Institute of Technology Mangaluru, India

DOI: 10.5281/zenodo.10975711 **Submission Date: 20 March 2024 | Published Date: 16 April 2024**

***Corresponding author: Jabasingh Daniel**
Department of AIML Srinivas Institute of Technology Mangaluru, India

Abstract

Heart disease continues to be the world's top cause of death, making effective and precise diagnostic technologies essential for early identification and treatment. This literature review explores the advancements in AI-powered diagnostic systems for heart disease, leveraging machine learning algorithms to enhance early detection and personalized treatment strategies. The study investigates the application of supervised machine learning algorithms, including random forest, gradient boosted trees, artificial neural networks, support vector machine, XG- boost, logistic regression, and ensemble methods, to predict arrhythmias with increased accuracy. Furthermore, the research compares a novel LSTM deep learning approach with traditional machine learning methods, emphasizing the importance of feature selection techniques for improved classification precision. The results demonstrate the potential of these AI-driven methods in transforming cardiac care by providing rapid and reliable diagnostic insights, facilitating prompt intervention and individualized treatment plans. By combining diverse patient data sources and leveraging advanced data analysis techniques, these systems aim to enhance clinical decision-making, improve patientoutcomes, and alleviate the global burden of cardiovascular diseases.

Keywords: Heart Disease, Deep Learning, CNN, Heartbeat,Classification.

I. INTRODUCTION

Two critical aspects in today's healthcare environment the rising incidence of chronic illnesses and the demographic trend toward an older population have brought attention to how important it is to have cutting edge healthcare solutions. Heart disease continues to be a major worldwide health concern, with a substantial impact on rates of morbidity and death across a variety of demographics. The World Health Organization (WHO) estimates that 17.9 million deaths worldwide occur from cardiovascular illnesses each year, or around one-third of all fatalities. For heart disease-related problems to be effectively managed and prevented, early identification and precise diagnosis are essential. However, making a diagnosis of cardiac disorders can be challenging and frequently requires combining a variety of clinical data sets with the knowledgeof medical specialists.

The potential of transforming healthcare through enhancing clinical decision-making processes has been demonstrated by advances in artificial intelligence (AI) and machine learning (ML). AI-powered diagnostic systems have shown great promise in enhancing the precision and efficacy of illness detection across various medical specialties. AI cardiology applications can potentially improve heart disease diagnosis accuracy, allowing for prompt intervention and individualized treatment plans.

An AI-powered diagnostic system is created especially for the early identification and diagnosis of heart disease in response to this urgent demand. Using cutting-edge machine learning algorithms and deep learning techniques, the model analyzes a wide range of patient data. It seeks to give medical practitioners rapid and reliable diagnostic insights by combining many data sources, enabling educated clinical decision- making and enhancing patient outcomes.

This review paper provides a comprehensive analysis of earlier studies and publications in the area of AI-enabled cardiac illness diagnostics in the part that follows. The goal of this part is to present a thorough overview of the current state of research, emphasizing significant developments, approaches, obstacles, and trends in the creation and verification of AI- based diagnostic systems.

II. LITERATURE REVIEW

A. An intelligent learning approach for improving ECG signalclassification and arrhythmia analysis [1]

In" An intelligent learning approach for improving ECG signal classification and arrhythmia analysis" introduces an innovative framework for analyzing Electrocardiogram (ECG) signals, focusing on enhancing signal quality, feature extraction, and arrhythmia classification. The research addresses the critical challenge of accurately predicting cardiac arrhythmias, which can range from benign to life-threatening conditions. Through experiments conducted on ECG records from the MIT-BIH arrhythmia database and the noise stress test database, the proposed model achieved an impressive overall accuracy of 99.7%, sensitivity of 99.7%, and positive predictive value of 100%. The framework consists of three main phases: noise suppression using dedicated filters, feature extraction through a specialized wavelet design, and arrhythmia classification using a hidden Markov model. Additionally, it also discusses the importance of adhering to standards such as the AAMI guidelines in arrhythmia analysis and highlights the limitations of existing methods, such as the inability of Support Vector Machine classifiers to effectively interpret ECG signal feature.

B. The Impact of the MIT-BIH Arrhythmia Database [2]

The Impact of the MIT-BIH Arrhythmia Database" offers overview of the evolution and significance of common databases in the development of arrhythmia detection technology. It discusses the pioneering role of the MIT-BIH Arrhythmia Database and its collaboration with the American Heart Association (AHA) Database in setting new standards for evaluating arrhythmia analyzers. The document highlights the shift in development efforts following the availability of these databases, emphasizing the improved performance and competitiveness among manufacturers due to standardized testing protocols. Furthermore, it delves into the challenges faced by researchers and industry professionals prior to the existence of common databases, underscoring the critical need for well-characterized data for algorithm evaluation. It also touches upon the emergence of additional databases, such as the European ST-T Database, inspired by the successes and limitations of the MIT-BIH and AHA Databases. Overall, the literature survey showcases the transformative impact of shared databases on the advancement of arrhythmia detection technology and the collaborative efforts driving innovation in the field.

C. ECG based machine learning algorithms for heartbeat classification [3]

Machine learning based heartbeat classification" presents a comprehensive literature survey on the use of machine-learning algorithms for ECG signal analysis and heartbeat classification. The authors build upon existing research in the field, incorporating techniques such as the TERMA and FrFT algorithms to enhance the accuracy and efficiency of ECG signal processing. The study references key works in the domain of ECG signal analysis, including research by Dagenais et al. on variations in common diseases among middle- aged adults, Rajni on electrocardiogram signal analysis, and Clifford et al. on advanced methods for ECG data analysis. Additionally, foundational texts like Malmivuo and Plonsey's" Bio electromagnetism" and Moody and Mark's study on the MIT-BIH arrhythmia database are cited to provide a theoretical background for the proposed algorithm. The significance of cross-database processing is acknowledged, as demonstrated, which compares the performance of the algorithm on the INCART and SPH databases for various heart conditions. The incorporation of wavelet transforms and Shannon energy in R peak detection algorithms, as discussed by Thiam Choo and Phukpattaranont, also contributes to the methodology employed in the study.

D. Comparing different supervised machine learning algo-rithms for disease prediction [4]

A thorough review of the literature on the use of supervised machine learning algorithms in illness prediction is given by Uddin et al. (2019). The study assesses how well different algorithms work in forecasting the course of diseases, pointing out the advantages and disadvantages of each strategy. Through a comprehensive analysis of several papers, the authors pin- point commonalities in algorithm selection and performance measures among various disorders. The research also emphasizes the importance of data collection and preprocessing techniques in improving prediction accuracy. Furthermore, the study discusses the ethical considerations and competing interests in disease prediction research. Overall, the valuable insights into the current landscape of supervised machine learning in disease prediction and serves as a useful resource for researchers and practitioners in the field.

E. Supervised Machine Learning Algorithms for ArrhythmiaClassification and Diagnosis [5]

The research addresses the global concern of preventing arrhythmic risks in patients with cardiac ailments by proposing a machine learning-based approach for predicting arrhythmia. The implementation of seven machine learning algorithms aims to improve upon the existing VF15 algorithm and cardiologists in predicting arrhythmia. The models, including random forest, gradient boosted trees, artificial neural networks, support vector machine, XG-boost, logistic regression, and ensemble methods, were evaluated using various metrics such as classification accuracy, precision, recall, F1 score, gain, lift,ROC, and confusion matrix.

The results indicate that the ensemble method outperforms other models with the highest accuracy, gain, F1 score, and ROC, although it has moderately high false negatives. The support vector machine, on the other hand, achieves the highest recall value and minimum false negatives. The best performing model in the study surpasses the accuracy of the existing VF15 technique by more than 20% and the sensitivity of cardiologists by 13%. Arrhythmia, characterized by an irregular heartbeat rhythm, is a leading cause of death globally, with a rising number of patients at risk of sudden cardiac death. Traditional diagnosis methods are flawed, leading to delayed treatment or misdiagnosis. The study's approach of grouping the response variable into two sections simplifies the model, and the use of k-fold cross-validation helps minimize bias and variance in the dataset.

F. Cardiac Arrhythmia Disease Classification Using LSTM Deep Learning Approach [6]

In the area of arrhythmia classification, this provides a thorough summary of the methods and strategies already in use. From basic statistical learning to conventional machine learning and, more recently, deep learning approaches, it charts the development of methodologies. In the past, arrhythmias have been identified and categorized using a variety of supervised learning methods, such as support vector machines, random forests, decision trees, and neural networks. Modern strategies for classifying arrhythmias that are based on traditional machine learning approaches are contrasted with the suggested LSTM deep learning methodology in this study. To improve classification accuracy, this highlights the significanceof feature selection strategies such crucial mutual information based selection.

Additionally, the paper addresses challenges such as class imbalance in high-dimensional datasets, where one class dominates the samples, leading to complexity in classification tasks. Various methods to tackle class imbalance have been explored, including data preprocessing, feature selection, and algorithmic adjustments. The proposed LSTM deep learning approach aims to overcome these challenges and improve the accuracy of arrhythmia classification by leveraging the power of deep learning models and advanced data analysis techniques.

G. Early prediction of heart disease with data analysis using supervised learning with stochastic gradient boosting [7]

As researchers have been seeking for new approaches to enhance efficiency and accuracy, heart disease prediction algorithms have witnessed significant advancements in recent years. According to Jawalkar et al., machine learning techniques specifically, decision tree-based random forest (DTRF) classifiers are becoming increasingly important for improving cardiac illness prediction. Through the effective management of nonlinear data and the successful resolution of missing values, their work highlights the advantages of DTRF classifiers, which contribute to the development of more accurate prediction models. Additionally, stochastic gradient boosting (SGB) loss optimization techniques are included into DTRF classifiers to further enhance prediction skills. According to their research, by lowering overfitting and raising convergencerates, this strategy tackles significant problems with heart disease prediction.

This outcome is consistent with other research emphasizing the crucial part machine learning techniques play in clinical judgment. In order to facilitate the adoption of the required preventative measures and improve patient outcomes, their research highlights the critical need of accurately estimating the risk of heart disease. The research emphasizes the increasing agreement about the effectiveness of machine learning techniques, especially DTRF classifiers enhanced with SGB optimization, in improving the prediction of heart disease. Building on this basis, the suggested technique seeks to improve the precision and efficacy of heart disease predictionmodels even more.

H. Cardiac arrhythmia detection using deep learning approach and time frequency representation of ECG signals [8]

As the primary cause of mortality worldwide, cardiovascular diseases (CVDs) require fast and accurate diagnostic techniques. Traditional methods of identifying cardiovascular diseases (CVDs), particularly when utilizing an electrocardiogram (ECG), usually need a significant amount of manual interpretation, which can be time-consuming and prone to error. To overcome this, researchers are utilizing deep learning techniques, namely convolutional neural networks (CNNs), for automated ECG signal categorization. Previous studies have looked at how well a number of deep learning models, including AlexNet and ResNet-50, can distinguish between irregular rhythms such atrial flutter and congestive heart failure (CHF) and normal sinus rhythm (NSR). These models show potential in achieving high accuracy in classifying ECG data, outperforming both traditional methods and even alternative deep learning architectures like CNN–LSTM hybrids and EfficientNet. However, problems like overfitting and robustness of the model continue, highlighting the need for more research to optimize model performance. The purpose of this study is to evaluate the performance of the AlexNet and ResNet-50 models in categorizing ECG signals to previous approaches in order to boost diagnostic accuracy and efficiency in identifyingCVDs.

I. Analysis and classification of cardiac arrhythmia based on general sparsed neural network of ECG signals [9]

The medical community has shown a great deal of interest in the development of effective methods for the categorization of Electrocardiogram (ECG) signals in recent years. Numerous strategies have been put out to use machine learning and neural network techniques to correctly diagnose cardiac arrhythmias and other heart-related diseases. Prior studies have concentrated on training and testing classification models using various datasets, such as the MIT-BIH arrhythmia dataset. Many methods have been investigated for processing ECG signals, removing noise, extracting features, and recognizing QRS complexes. Additionally, research has looked into the use of neural networks, such as General Sparsed Neural Networks (GSNN), for effective ECG signal classification. These methods are intended to raise the recall, accuracy, and precision of arrhythmia detection systems. Notably, researchers have demonstrated encouraging results in terms of classification accuracy and computing efficiency by evaluating the performance of proposed approaches using metrics like Precision, Recall, and F1 Score.

J. Heart Diseases Prediction using Deep Learning NeuralNetwork Model [10]

In this research, the Talos optimization is used to construct a Deep Learning Neural Network (DNN)-based model for the prediction of heart disease. This model has an activation function, hidden layers, input, and output. Talos optimization might make it possible to utilize the model in conjunction with Keras. The Heart Disease UCI dataset, which has 303 instances and 14 characteristics, was used. Subsequently, the dataset is split into two primary sets: the test data set and the training data set. The training data set comprises the output fields that the model will analyze. Following that, a variety of algorithms, including KNN, SVM, Na¨ıve Bayes, and Random Forest, are used to complete the categorization. When the outcome is compared to other algorithms and optimizations, it predictably shows the best outcomes. Compared to other models, which have an average accuracy of 80% to 85%, Talos generates an accuracy of 90.76%.

K. Detection of Arrhythmia in Real-time using ECG Signal Analysis and Convolutional Neural Networks [11]

With cardiovascular diseases (CVD) ranking as the world's leading cause of death, cardiac arrhythmias represent a serious health danger on a worldwide scale. Because arrhythmias are asymptomatic, prior research has brought attention to the difficulties in promptly detecting and classifying them. Real-time monitoring is limited by the limits of traditional methods of identifying arrhythmias, like cardiac electrocardiograms (ECGs). Advancements in wearable electrocardiogram (ECG) equipment have demonstrated potential to address these constraints by facilitating ongoing monitoring and prompt identification of arrhythmias.

In view of this, the current work suggests a unique method for the real-time identification and categorization of cardiac arrhythmias that combines a wearable ECG monitor with a CNN-based classification model. By offering a logical mix of hardware and software solutions, the study overcomes the shortcomings of earlier research and enables effective and affordable real-time monitoring of arrhythmias. Furthermore, the research utilizes cutting edge classification methods like Borderline-SMOTE to tackle the difficulties presented by unbalanced datasets. The suggested method increases the accessibility and usefulness of arrhythmia monitoring devices for both personal and clinical usage, in addition to improving the accuracy of arrhythmia identification.

L. Automated Arrhythmia Classification on A Combination Network of CNN And LSTM [12]

It presents an automated arrhythmia classification system based on a combination network of Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks. The proposed model utilizes a deep learning approach to classify six types of ECG signals, aiming to pro- vide rapid and accurate identification of abnormal heartbeats. The system incorporates various features such as parameter settings, activation functions, weight initialization algorithms, and the use of dropout and batch normalization layers to enhance model performance. The study compares its results with existing literature, demonstrating improved accuracy, positive predictive value, sensitivity, and specificity. Additionally, the approach addresses limitations related to QRS detection and imbalanced datasets. The findings suggest that the CNN+ LSTM network structure, combined with diverse training data and regularization measures, enhances the model's ability to recognize new data. The study's implications include the potential for efficient and robust automatic computer-aided diagnosis systems, which could contribute to accurate diagnosis and early prevention of arrhythmias, thereby reducing the incidence of heart disease. It presents an automated arrhythmia classification system based on a combination network of Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks. The proposed model utilizes a deep learning approach to classify six types of ECG signals, aiming to provide rapid and accurate identification of abnormal heartbeats. The system incorporates various features such as parameter settings, activation functions, weight initialization algorithms, and the use of dropout and batch normalization layers to enhance model performance. The study compares its results with existing literature, demonstrating improved accuracy, positive predictive value, sensitivity, and specificity. Additionally, the approach addresses limitations related to QRS detection and imbalanced datasets. The findings suggest that the CNN + LSTM network structure, combined with diverse training data and regularization measures, enhances the model's ability to recognize new data. The study's implications include the potential for efficient and robust automatic computer-aided diagnosis systems, which could contribute to accurate diagnosis and early prevention of arrhythmias,thereby reducing the incidence of heart disease.

M. Arrhythmia classification using SVM with selected features[13]

Narendra Kohli and Nishchal K. Verma use a variety of Support Vector Machine (SVM) based techniques to study how arrhythmias are classified in ECG datasets. They mention multiclass SVM classification techniques such Decision Directed Acyclic Graph, Fuzzy Decision Function, One Against One, and One Against All. After comparing various approaches, Kohli and Verma come to the conclusion that the One Against All approach produces the best accuracy rate. The University of California, Irvine (UCI) Cardiac Arrhythmias Database, which includes datasets with 377 cases and 166 characteristics divided into six kinds of arrhythmias, is the platform on which they do their studies. They also use Principal Component Analysis (PCA) to pick features, which improves classification accuracy by removing noisy data and dimensionality.

III. CONCLUSION

As a conclusion, the review of the literature highlights the important progress made in applying machine learning algorithms to the diagnosis and prognosis of cardiac disease. Reducing overfitting, speeding up convergence, and improving the precision of heart disease prognostications have all been achieved with the use of AI-driven techniques. It has showed potential to automate ECG signal categorization and increase diagnostic efficiency with the incorporation of deep learning techniques, especially convolutional neural networks.

Moreover, the combination of decision tree-based random forest classifiers with stochastic gradient boosting optimization has demonstrated success in managing nonlinear data and addressing missing values, leading to more accurate prediction models. These findings highlight the increasing importance of machine learning methods in clinical decision-making and their crucial role in early detection and treatment of cardiovascular diseases.

Continued research and development in this field offer significant potential for further enhancing the precision and efficacy of heart disease prediction models. Ultimately, these advancements can lead to improved patient outcomes and moreeffective healthcare practices.

REFERENCES

1. Sangaiah, A. K., Arumugam, M., & Bian, G. B. (2020). An intelligent learning approach for improving ECG signal classification and arrhythmia analysis. Artificial intelligence in medicine, 103, 101788.
2. Moody, G. B., & Mark, R. G. (2001). The impact of the MIT-BIH arrhythmia database. IEEE engineering in medicine and biology magazine, 20(3), 45-50.
3. Aziz, S., Ahmed, S., & Alouini, M. S. (2021). ECG-based machine-learning algorithms for heartbeat classification. Scientific reports, 11(1), 18738.
4. Uddin, S., Khan, A., Hossain, M. E., & Moni, M. A. (2019). Comparing different supervised machine learning algorithms for disease prediction. BMC medical informatics and decision making, 19(1), 1-16.
5. Shetty, N. (2020, June). Supervised Machine Learning Algorithms for Arrhythmia Classification and Diagnosis. In Proceedings of the 2020 IISE Annual Conference. Edited by L. Cromarty, R. Shirwaiker, P. Wang. New Orleans: IISE.
6. Khan, M. A., & Kim, Y. (2021). Cardiac Arrhythmia Disease Classification Using LSTM Deep Learning Approach. Computers, Materials & Continua, 67(1).
7. Jawalkar, A. P., Swetcha, P., Manasvi, N., Sreekala, P., Aishwarya, S., Kanaka Durga Bhavani, P., & Anjani, P. (2023). Early prediction of heart disease with data analysis using supervised learning with stochastic gradient boosting. Journal of Engineering and Applied Science, 70(1), 122.
8. Daydulo, Y. D., Thamineni, B. L., & Dawud, A. A. (2023). Cardiac arrhythmia detection using deep learning approach and time frequency representation of ECG signals. BMC Medical Informatics and Decision Making, 23(1), 232.
9. Sanamdikar, S. T., Hamde, S. T., & Asutkar, V. G. (2020). Analysis and classification of cardiac arrhythmia based on general sparsed neural network of ECG signals. SN Applied Sciences, 2(7), 1244.
10. Sharma, S., & Parmar, M. (2020). Heart diseases prediction using deep learning neural network model. International Journal of Innovative Technology and Exploring Engineering (IJITEE), 9(3), 2244-2248.
11. Reddy, S., Seshadri, S. B., Bothra, G. S., Suhas, T. G., & Thundiyil, S. C. (2020, September). Detection of arrhythmia in real-time using ECG signal analysis and convolutional neural networks. In 2020 IEEE 21st International Conference on Computational Problems of Electrical Engineering (CPEE) (pp. 1-4). IEEE.
12. Chen, C., Hua, Z., Zhang, R., Liu, G., & Wen, W. (2020). Automated arrhythmia classification based on a combination network of CNN and LSTM. Biomedical Signal Processing and Control, 57, 101819.

13. Kohli, Narendra & Verma, Nishchal. (2012). Arrhythmia classification using SVM with selected features. International Journal of Engineering, Science and Technology. 3. 10.4314/ijest. v3i8.10.

CITATION
Nihal A. S, Jabasingh D, Shetty T. S, Mohammed Ziyad K S, & Daya N. (2024). A Comprehensive Review on AI-Enabled Diagnosis for Heart Disease. In Global Journal of Research in Engineering & Computer Sciences (Vol. 4, Number 2, pp. 110–115). https://doi.org/10.5281/zenodo.10975711