



A REVIEW ON MACHINE LEARNING MODEL FOR AUTOMATIC HEART DISEASE PREDICTION

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Abstract: Heart disease is a leading cause of mortality worldwide, necessitating early detection and prevention strategies. Machine learning (ML) models have emerged as powerful tools for automatic heart disease prediction. This review paper provides an overview of the recent advancements in ML-based approaches for heart disease prediction. We begin by discussing the significance of early detection and the potential of ML in this domain. Next, we conduct a comprehensive literature survey, summarizing the key findings from previous studies. We then present a comparative study of various ML algorithms commonly used for heart disease prediction, highlighting their strengths and limitations. Additionally, we outline the proposed procedure for developing ML models for heart disease prediction and discuss potential future directions. Finally, we conclude by emphasizing the importance of continued research in this area to improve the accuracy and accessibility of automatic heart disease prediction.

Keywords: Classification, Segmentation, Image Processing, Skin Cancer, Machine Learning, Heart Diseases, Feature Extraction.

1. INTRODUCTION

Heart disease is still a significant problem for public health all over the world, and the number of people who are affected by it is growing. Due to the fact that it is one of the leading causes of morbidity and mortality all over the globe [1] it is vital to ensure that early identification and appropriate intervention are carried out in order to effectively manage and avoid adverse outcomes associated with cardiovascular diseases [2]. “Recent developments in the field of healthcare have shown that the use of machine learning methods has the potential to significantly automate the prediction of heart disease risk. In the following study, we will attempt to provide a comprehensive overview of the most recent developments in machine learning models that are used for the autonomous prediction of cardiac disease”[3].

Heart disease encompasses a wide range of disorders that have an effect on the cardiovascular system “including coronary artery disease, heart failure, arrhythmias, valvular heart disease, and congenital heart abnormalities [3]. According to the World Health Organization (WHO) cardiovascular illnesses are responsible for around 17.9 million fatalities annually, which accounts for 31% of all deaths that occur throughout the globe” [4]. In addition, heart disease has a considerable influence on the economy, as it results in direct medical expenditures, lost productivity, and a decrease in quality of life for people who are afflicted by it as well as their families [5].

Diagnostic procedures such as electrocardiograms (ECG), echocardiogram, and cardiac catheterization have been used in the past for the purpose of diagnosing heart disease [6]. Clinical evaluations, medical records, and diagnostic approaches have been utilized in the past. The relevance of these techniques cannot be overstated; nonetheless, they may be lengthy, need a certain level of expertise, and may not always yield the results that are the most accurate. In addition, the increasing complexity and amount of healthcare data need the use of advanced computational methods in order to analyze enormous datasets and derive substantial insights that have the potential to aid in the process of clinical decision-making [7].

Machine learning, which is a branch of artificial intelligence, provides a hopeful method for tackling the difficulties related to predicting cardiac disease [8]. Machine learning models can use computational algorithms and statistical techniques to analyze various data sources, such as electronic health records (EHRs), medical imaging, genetic profiles, and lifestyle factors. This analysis helps identify patterns and trends that indicate underlying cardiovascular risk factors [9]. Moreover, machine learning algorithms have shown the capacity to acquire knowledge from data, adjust to changing healthcare

settings, and provide customized risk evaluations that are specifically matched to the unique profiles of individual patients [10].

This review aims to:

- In this article, you will provide an overview of the machine learning strategies that are used for autonomous heart disease prediction. Learning strategies such as supervised learning, unsupervised learning, and deep learning are included in this category of learning methods.
- The second step is to assess the effectiveness of machine learning models with regard to their predicted accuracy, sensitivity, specificity, and clinical value.
- Bring up the difficulties and restrictions that are involved with the use of machine learning models in clinical practice, including the quality of the data, the interpretability of the results, and the ethical issues that must be taken into account.
- Determine potential future research objectives and possibilities for improving the efficiency and scalability of systems based on machine learning for the prediction of heart disease.

In the following review article, To begin, we will present an introductory review of heart disease as a critical public health concern “as well as the promise of machine learning to revolutionize the prediction of heart disease”. During the second session, we dive into the history and conduct a literature analysis. We investigate the conventional approaches to the prediction of heart disease and synthesise the results from earlier research that included the use of machine learning techniques. As part of the third session, the methodology section provides an overview of the dataset that was used, the preprocessing processes that were implemented, the selection of machine learning models for evaluation, and the metrics that were utilized for performance evaluation. A detailed review of the accomplishments and problems in autonomous heart disease prediction using machine learning is provided in the last section, which is titled "Discussion and Conclusion." This section summarizes the results, evaluates the significance of those discoveries, and suggests future research paths.

2. LITERATURE SURVEY

The literature has given deep learning algorithms for heart disease prediction a lot of attention.

Bakar et al. [1] A thorough evaluation of machine learning methods for the prediction of cardiac disease was carried out, with the purpose of emphasizing the value of early diagnosis and the promise of ML techniques in enhancing diagnostic accuracy. Their research involved an in-depth review of various machine learning methods, “including logistic regression, decision trees, support vector machines, and neural networks, and their applications in predicting heart disease”. The authors emphasized the importance of feature selection, model optimization, and validation procedures for developing reliable prediction models. (Bakar et al., 2019).

Smith and Jones [2], Using a large dataset consisting of patient records, the authors conducted a comparison of the effectiveness of the “logistic regression and random forest models with the purpose of making automated predictions about heart disease. Upon conducting a comparative analysis, they discovered that random forest performed better than logistic regression in terms of the accuracy and robustness of its predictions. In addition to highlighting the significance of ensemble approaches, the study also highlighted the need of doing more research to investigate the potential of sophisticated machine learning algorithms in enhancing the prediction of cardiac disease”. (Smith & Jones, 2020).

Gupta et al. [3] An investigation was conducted into the use of deep learning methods, “more especially convolutional neural networks (CNNs), for the purpose of automatically predicting cardiac illness based on electrocardiogram (ECG) information. A high level of accuracy was achieved by CNNs in identifying aberrant ECG patterns that are linked with cardiac illness, as evidenced by their research, which showed encouraging results. The authors emphasized the potential of deep learning models to improve diagnostic capacities and reduce the number of false-positive results in the prediction of cardiac disease”. (Gupta et al., 2018).

Patel and Kumar [4] did a meta-analysis of machine learning models for the prediction of cardiac disease, which included synthesising the data from many research in order to detect trends and issues in the area. The results of their research showed that there was a large amount of variety in the properties of the datasets, the techniques used to choose features and the “metrics used to evaluate the performance of the models among the various studies”. In order to enable comparisons and enhance the dependability of prediction models, the authors underlined the need of having consistent datasets, methodology that can be reproduced, and rigorous validation approaches.(Patel & Kumar, 2017).

Zhang et al. [5] We have suggested a new method for the prediction of cardiac illness that makes use of a mix of machine learning and feature engineering approaches. To enhance the ability of prediction models to differentiate between different types of medical images, the researchers focused their research on the extraction of important characteristics from

multimodal medical imaging data, such as MRI and CT scans. In addition to demonstrating that their method is successful in properly forecasting the risk of heart disease, the authors emphasized the significance of feature selection and dimensionality reduction in the process of model creation. (Zhang et al., 2021).

Khan et al. [6] Research was conducted to study the impact that genetic markers have in the prediction of heart disease. Additionally, a hybrid machine learning model was suggested that incorporates genetic data with clinical characteristics. In their research, they investigated the applications of genetic algorithms and ensemble learning approaches with the purpose of improving the accuracy of predictions and maximizing the performance of models. When it comes to the prevention and treatment of heart disease, the authors stressed the significance of personalized medicine methods and the incorporation of genetic information into clinical decision-making. (Khan et al., 2019)

Ibrahim et al., [12] “The MMC, Random, Adaptive, Quire, and AUDI algorithms are the five multi-label active learning selection algorithms that have been put into development. The purpose of these algorithms is to decrease labelling costs by continually querying the data that is most relevant to the problem at hand. In addition, a grid search strategy was used in order to increase the accuracy of classification and maximize the F-score for data that was not labelled. All of the many approaches to the classification of heart disease datasets make use of the label ranking classifier, which is an essential component of the classification process to consider. Through the use of sparsely labelled data and the incorporation of user-expert input, active learning (AL) methodologies provide an improvement in classification accuracy. The findings may be extended and applied to new situations using this technique, even if the new examples do not perfectly match the training, test, or validation samples. This is because the approach will enable the results to be generalized. Interoperability is one of the most significant benefits that active learning offers”.

Giuseppe Lippi et al., [13] have brought attention to the “possibility of sickness affecting the cardiovascular system during the COVID-19 pandemic. A number of lockdown procedures have been put into place by the government in response to the state being placed under quarantine in an effort to prevent the spread of COVID-19”. Because of these constraints, inhabitants are required to remain inside their homes, which results in a reduction in the amount of physical activity they engage in. There is a correlation between rigorous confinement and an increased risk of death from cardiovascular disease. This is despite the fact that the World fitness Organization (WHO) has developed standards for maintaining physical fitness via frequent exercise. The quarantine has been shown to have adverse consequences on the health of the individuals. In light of this, the authors suggest that persons continue to participate in physical activity even when they are under quarantine in order to reduce the negative effects that the quarantine has on the cardiovascular system. The design and the primary emphasis of the current research project have been impacted as a result of this advice[27].

Ghulab Nabi et al., [14] Have developed an effective medical diagnosis system for human heart conditions that makes use of machine learning techniques, both with and without the Grid-Search-CV algorithm. In order to determine the ideal collection of features that had a substantial impact on the performance of the classifiers while predicting the target class, four different model selection processes were applied. These procedures included the correlation-based feature subset evaluator and the Gradient Boosting Classifier evaluator. Using Grid Search-CV, the hyperparameters of the Gradient Boosting Classifier (GBC) were fine-tuned. This was accomplished by using the complete attribute set in addition to the best subsets that were determined by attribute evaluators. Out of all the hyperparameters that were evaluated, the Extreme Gradient Boosting Classifier with Grid Search-CV was able to obtain the best degree of precision in terms of accuracy measurement. There is a comparison made between the findings of this study and those of earlier studies into cardiac prediction. In this work, four distinct models and four different algorithms namely “logistic regression, K-Nearest Neighbours, support vector machine, and extreme gradient boosting are adjusted, trained, and evaluated”. This is done with and without the use of hyper parameter tuning methodologies. A comparison is made between their accuracy and the procedures that are already in use. Modifications to the XGB's specs were necessary in order to attain testing accuracy [29].

Xiao-Yan Gao et al., [15] Ensemble learning techniques have been created and are now being applied in order to improve the accuracy of models that are used to forecast heart disease diseases. “Utilizing techniques for feature extraction, such as Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA)” is an essential step in the process of determining which features from the dataset are the most significant characteristics. For the purpose of extracting information that is pertinent from the data, several strategies are used. Specific parameters are analysed in order to make comparisons between various machine learning algorithms and ensemble learning methodologies. “The Data collection, data preprocessing, feature selection, data splitting, model training, and model assessment are the six essential processes that make up the process. There is a possibility that the accuracy of predictions may be increased by combining ensemble methods, such as boosting and bagging, with feature extraction techniques, such as principal component analysis and linear

discriminant analysis”. It is via the application of these feature extraction techniques to the Cleveland heart disease dataset that essential characteristics are successfully identified.

Ibomoiye et al., [16] We have created a deep learning technique with the goal of improving our ability to forecast cardiac disease. A stacked sparse auto encoder network (SSAE) that has been upgraded is developed in order to facilitate efficient feature learning. The network in question is comprised of a soft-max classifier as well as many sparse auto encoders. In addition, the parameters of the algorithm need to be changed appropriately for deep learning models in order to obtain effective performance. The particle swarm optimization (PSO) approach should be used in order to make adjustments to the parameters of the stacked sparse auto encoder. The performance of the SSAE in terms of feature learning and classification was improved as a result of the optimization performed by the PSO. In order to solve this problem, batch normalization was used. This is due to the fact that the internal covariate shift that is brought about by the multilayer design of auto-encoders often hinders the network's ability to generalize. The Soft-max classifier was linked to the hidden layer of the final sparse auto-encoder by the use of this approach, which resulted in the formation of the SSAE network. Notable contributions made by this approach include the use of the PSO for the purpose of optimizing the parameters of the SSAE, which resulted in improved classification performance and further enhancement of feature learning.

Dengqing et al., [17] The embedded feature selection method was used in the development of a prediction algorithm for heart illness, which was accomplished via the development of a deep neural network. The L1 norm was used as a penalty term in this integrated feature selection strategy, which was based on the Linear SVC algorithm. The goal of this technique was to choose a subset of characteristics that are highly related with heart disease. The purpose of which is to construct a deep neural network that is fed with these characteristics. In order to increase prediction performance and avoid gradient vanishing or explosions from occurring inside the system. Testing of this model was performed using a dataset for cardiac disease that was received from Kaggle. As a result of receiving poor scores on each indication, it was discovered that the volume normalization layer was not beneficial for this method. For the purpose of mapping the output to the range [0, 1], “the Binary Cross-Entropy function is used as the loss function, and the Sigmoid function is utilized as the activation function in the second layer of the output. Based on the findings of the experiments, it has been shown that a prediction model for heart disease that is very accurate has been successfully established”.

Table 2.1: Existing Methodology

Sr. No	Paper	Objective	Methodology	Advantages	Disadvantages
1	Ibrahim et al., [12]	Active learning for heart disease classification	Developed five AL selection algorithms (MMC, Random, Adaptive, Quire, AUDI) to reduce labelling cost. Applied grid search for F-score improvement. Used label ranking classifier. Enhanced classification accuracy through AL techniques.	1. Cost-effective labelling 2. Improved F-score using grid search 3. Enhanced accuracy with AL	1. Specific algorithms not detailed 2. Limited explanation of label ranking classifier
2	Giuseppe Lippi et al., [13]	Address cardiovascular risks during COVID-19 quarantine	Highlighted increased cardiovascular risks due to lockdown. Emphasized the importance of maintaining physical activity.	1. Awareness of quarantine's health impacts 2. Emphasis on physical activity	1. Lack of detailed research methods 2. Limited quantifiable data
3	Ghulab Nabi et al., [14]	Efficient medical diagnosis using ML with and without Grid-Search-CV	Utilized four feature selection methods and various classifiers, including logistic regression, K-NN, SVM, and XGB. Tuned models with Grid-Search-CV.	1. Comprehensive model comparison 2. Hyperparameter tuning for improved accuracy	1. Lack of detailed methodology 2. Limited insight into feature selection process

4	Xiao-Yan Gao et al., [15]	Ensemble learning for heart disease prediction	Used PCA and LDA for feature extraction. Employed ensemble techniques (boosting, bagging) with ML algorithms.	1.Feature extraction with PCA, LDA 2.Ensemble learning for accuracy improvement	1.Limited description of ensemble techniques 2.Lack of specific dataset details
5	Ibomoiye et al., [16]	Deep learning strategy for heart disease prediction	Created SSAE network with soft-max classifier using PSO for optimization. Addressed internal covariate shift with batch normalization.	1.Improved feature learning and classification Effective optimization with PSO	1.Incomplete algorithm parameter details 2.Limited discussion on network architecture
6	Dengqing et al., [17]	Deep neural network with embedded feature selection	Used L1 norm for feature selection. Developed deep neural network with specific activation functions and loss function.	1. Effective feature selection 2. High-accuracy prediction model	1. Lack of detailed dataset description 2. Inadequate explanation of network architecture

3. PROPOSED METHODOLOGY

The purpose of the system that has been proposed is to create a reliable machine learning model for the purpose of automatically predicting heart disease. The system will examine medical data such as patient demographics, clinical measures, and past health records in order to properly forecast the possibility of heart disease [12]. This will be accomplished by using sophisticated algorithms and methods in the field of machine learning [24]. The system will make an effort to attain high accuracy and reliability in the prediction of heart disease by using an all-encompassing strategy that will include the procedures of feature selection, model training, and validation [13]. Additionally, the system will be constructed with interpretability in mind, which will provide insights into the elements that influence predictions [25]. This will allow medical practitioners to make choices based on accurate information and to intervene early for preventative treatment [14]. In general, the approach that has been presented has the potential to transform cardiovascular healthcare by making it easier to diagnose heart disease at an early stage and to treat it in a tailored manner. “This would result in better patient outcomes and lower overall healthcare costs [15]”.

Machine learning works on heart disease prediction by analyzing large datasets containing various patient attributes and medical measurements to identify patterns and relationships associated with heart disease risk factors. Here's an overview of how machine learning can be applied in heart disease prediction [16]:

- Data Collection:** The first stage is to gather pertinent data, which includes patient demographics (such as age and gender), lifestyle variables (such as smoking status and physical activity), medical history (such as diabetes and hypertension), and clinical measures (such as blood pressure, cholesterol levels, and EKG readings)
- Data Preprocessing:** Prior to the data being fed into a machine learning model “preprocessing operations are carried out in order to clean the data, deal with missing values”, and normalize or standardize features in order to guarantee consistency and enhance the performance of the model [18].
- Feature Selection:** It is at this stage that the significant traits or variables that are most closely connected with the occurrence of heart disease are identified. Numerous feature selection procedures are used in order to accomplish the goal of picking the subset of characteristics that contribute the most to the accuracy of the model's predictions [19]. “Methods such as correlation analysis, feature significance ranking, and domain expertise are examples of methodologies that fall within this group of methods”.
- Model Selection:** “In order to forecast the occurrence of heart illness, a variety of machine learning methods could be used. Decision trees, logistic regression, neural networks, support vector machines, and random forests are all examples of such methods. Several factors, such as the dataset size, feature complexity, and interpretability criteria, dictate the approach choice” [20].
- Model Training:** On the basis of the pre-processed dataset, the machine learning model that has been selected is trained, “therefore gaining an understanding of the patterns and correlations that exist between the input characteristics and the target variable”. During this phase of training, the model makes adjustments to its parameters in order to reduce the number of mistakes in its predictions and improve its overall performance.

6. **Model Evaluation:** In order to analyze the trained model's performance metrics, either a separate validation dataset or cross-validation methods are used to do the evaluation. "The Accuracy, precision, recall, and F1-score are some of the measures that are included here". It is possible that modifications will be made in order to enhance the performance of the model, which will be evaluated in order to discover whether or not it is capable of properly classifying people as having or not having heart disease.
7. **Prediction and Deployment:** Soon after the model has been trained and verified, it will be possible to use it in clinical practice for the purpose of predicting heart disease. When new patient data is introduced into the model, the model generates an output that indicates the probability or likelihood that the patient has heart disease based on the features of the patient and the medical measurements that are taken [23]

4. CONCLUSION

In conclusion, this review article offers a complete assessment of the present landscape of machine learning models for the autonomous prediction of heart disease. In this part, a succinct overview of the most important results from the literature study is presented, along with a comparative comparison of the major machine learning algorithms. It also provides an overview of the process that is suggested for the development of predictive models. The variability of the datasets, the interpretability of the models, and the clinical application of the findings are some of the problems that still need to be solved, despite the substantial progress that has been achieved in this sector. It is vital to continue research and collaborate between the medical community and the computational community in order to overcome these problems and increase the accuracy and efficacy of automated heart disease prediction.

In order to construct predictive models that are both robust and generalizable, one of the key obstacles is the need for huge datasets that include a wide variety of data. There are worries surrounding data privacy, and there are problems connected with data sharing across various healthcare systems. These considerations further complicate the process of developing and using machine learning models in clinical contexts. In addition, the interpretability of machine learning models presents a barrier. This is because black-box algorithms may lack transparency, which makes it difficult for healthcare personnel to comprehend the rationale that lies behind predictions.

It is recommended that future research directions concentrate on overcoming these obstacles and making progress in the area of automated cardiac disease prediction via the use of machine learning. For this purpose, it is necessary to create novel ways for the selection of features, the interpretability of models, and the exchange of data, all while protecting the privacy and confidentiality of patients. To expedite the progress that is being made in this field and to transform the results of research into practical applications that can be used in the real world, it is vital for researchers, doctors, and other stakeholders in the healthcare industry to work together.

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