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Machine learning Approach for Detection of Cardiovascular Disease: A Comprehensive Review

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Abstract: One of the major problems facing the globe today is heart sickness, which is also one of the main killers in many countries. Electrocardiogram (ECG) and patient data can be used to detect cardiac illness in early stages, as shown by recent advancements in machine learning (ML) application**.** Machine learning is becoming more precise and accurate in its classification of clinical cardiac disease datasets in recent years. Early heart disease identification is a major issue for healthcare services (HCS). This study offers a quick overview of countless machine learning techniques for detecting heart sickness. This research examines the use of machine learning methods to identify cardiac disease. Five methods were examined to assess how well they could identify cardiac illness, including "SVM (Support Vector Machine), RF (Random Forest), DT (Decision Tree), KNN (K-Nearest Neighbors), and NB (Naïve Bayes). Among all the ML technique, we found out the best with respect to Accuracy is SVM (which gives the highest average accuracy of 96.19%).Additionally, this review paper provides a valuable resource for researchers and field worker, as it eliminates the need to study all 48 papers individually .By reading our paper, they can efficiently grasp the key insight and gain a solid understanding of the examined technique of the without the burden of reviewing each individual study.

Keywords: heart disease; machine learning; support vector machine; random forest; decision tree; K-Nearest Neighbors; Naive Bayes.

1. Introduction

Identifying signs of cardiovascular illness as early as feasible is one of the most difficult challenges for medics. Every year, cardiovascular disease claims many lives throughout the world [1]. Alcoholism, smoking, hypertension, high cholesterol, an unbalanced diet, and a family history all play a role in the development of CVD [2]. "The World Health Organization (WHO)" also reports that above 17.6m people died in 2016, and it is anticipated that this figure would increase to 23.6m by 2030 [3]. Along with CVD, other acute heart disorders include "myocarditis, congenital heart sickness, arrhythmias, cardiomyopathy, congestive heart failure, angina pectoris, and myocardial infarction". The symptoms of each form of heart disease vary. However, identifying these heart disorders that share high-risk, It is extremely challenging to include "blood pressure, diabetes, irregular pulse rate (PR), and many others". "More than 75% of all deaths due to cardiovascular disease (CVD) occur in low- and middle-income nations" [4]. Due to the economic crises and inadequate access to competent and fair health care facilities, proper screening protocols for patients with heart disease symptoms are still disputed in less developed countries like Bangladesh, India, and several African countries. It is getting harder to give people affordable diagnoses as both the population and patients with heart disease are increasing. The current facilities do not allow the common people to afford the chance to benefit from a heart sickness diagnosis.CVD is identified using electrocardiograms

(ECGs). An electrocardiogram (ECG) is a common diagnostic tool in the field of cardiology. It is a non-invasive procedure that archives the electrical action of the heart and captures a visual picture of the heart's electrical rhythm. An ECG can detect a variety of diseases, including arrhythmias, myocardial infarction, and heart block. The normal ECG has 12 leads, which are placed at certain places on the chest, arms, and legs. After detecting the electrical activity of the heart from various angles, the leads create a graph that shows the electrical impulses moving through the heart. The ECG can be used to determine the rhythm, conduction system, and rate of the heart. The "pre cordial leads," or the first six leads (V1toV6), are introduced into the patient's chest. These leads record the electrical activity of the heart at various angles in the horizontal plane. The six remaining leads, known are the "limb leads," are applied to the patient's arms and legs. These leads record the electrical activity of the heart at various angles in the vertical plane. By analyzing the waves and intervals on the ECG graph and determining whether the heart is functioning normally or if there are any abnormalities or irregularities in the heart's electrical activity, doctors and other healthcare professionals are able to diagnose a variety of heart conditions, including arrhythmias, heart attacks, and other cardiac disorders. Research investigations can benefit from ECGs because they provide unbiased, quantitative data [5]. The influence of artificial intelligence and machine knowledge on the medical industry is now well recognized. We can use a variety of machine learning models to detect the condition, classify the data, or predict the results. Building algorithms that can learn from experience is the focus of the artificial intelligence field of machine learning (ML). In order to create models, ML algorithms mine the input dataset for hidden patterns. Then, for new datasets that are completely unknown to the algorithms, they can produce accurate forecasts. As a result, the machine developed intelligence through learning and was able to detect patterns that would have been extremely difficult or impossible for humans to notice on their own. ML algorithms and techniques may leverage large datasets to generate judgments and predictions [6].

2. Research Methodology

A systematic literature review (SLR) is a appraisal where queries are formulated and data collected and analyzed from the research included in the review to find, select and critically analyze appropriate material. Systematic and clear methods are used. The major objective of doing this systematic literature evaluation was to categories the best methods for applying machine learning to diagnose heart disease. This approach was chosen because it offers a precise and reliable way to summarize academic material and is well-liked across many study fields.

2.1 Research Objective

The key objective of this SLR is to use machine education to investigate how heart diseases classified using different machine learning algorithms which have high accuracy over time, from 2017 to 2023.

1. This review article gives a general overview of the machine education classification methods applied to the field of heart sickness diagnosis.
2. In this article we show the comparison between machine learning algorithms on the bases of accuracy.

2.2 Research Questions

The question covered in this review study are listed below.

1. In research paper from 2017-2023 which types of machine learning algorithm are applied for the predication of heart sickness?
2. Which one ML technique is best for detection of heart sickness?

2.3 Search String

("Heart disease" OR "heart disease classification" OR "heart disease prediction" OR "detection" OR "heart disorder" AND ("Machine learning" OR "ml")

("cardiovascular disease" OR "cardiovascular disease classification" OR "cardiac disease predication" OR "detection" OR "cardiac disorder" AND ("Machine learning" OR "ml")

Inclusion and exclusion criteria is provided in Table 1.

Table 1. Inclusion and exclusion criteria of study.

Inclusion criteria	Exclusion criteria

Paper that provide technological procedures for detecting heart disease using machine learning.	Paper that provide technological method for identifying heart sickness using deep learning.
Only journal paper are included.	Conference paper are excluded.
Paper that are written in English language.	Paper that are not written in English language.
Paper that are published after 2017.	Paper that are published before 2017.

We found 100 papers in our search. A total of 70% of our papers are downloaded via Google Scholar, 30% from IEEE Explore. Due to year limit, 15 paper was rejected. Out of 85 papers, 71 papers were included in the English journal and 14 papers were disqualified because they didn't meet the requirements for inclusion. After screening 71 papers, 60 papers were included and 11 papers were excluded because 6 papers were not matching the title criteria and 5 papers were duplicates. Then we screened these papers from which 30 papers were excluded because 15 papers were conference papers and 15 papers were Indian papers and 30 papers are left and from these 30 papers 10 irrelevant papers were excluded. Finally, we still have 20 publications to research and analyses in order to come up with useful conclusions Figure 1.

3. Machine Learning Approaches

Machine learning is a branch of artificial intelligence (AI) and computer science that focuses on using data and procedures to improve the way humans learn while gradually improving its correctness. Five machine learning algorithms support vector machine (SVM), Naive Bayes, decision tree (DT), random forest (RF), and K nearest neighbor (KNN) were examined for our review study. Each of these procedures use an own methodology for knowledge and making predictions. We can use machine learning to acquire insights into our research and increase our understanding by putting these algorithms to usage.

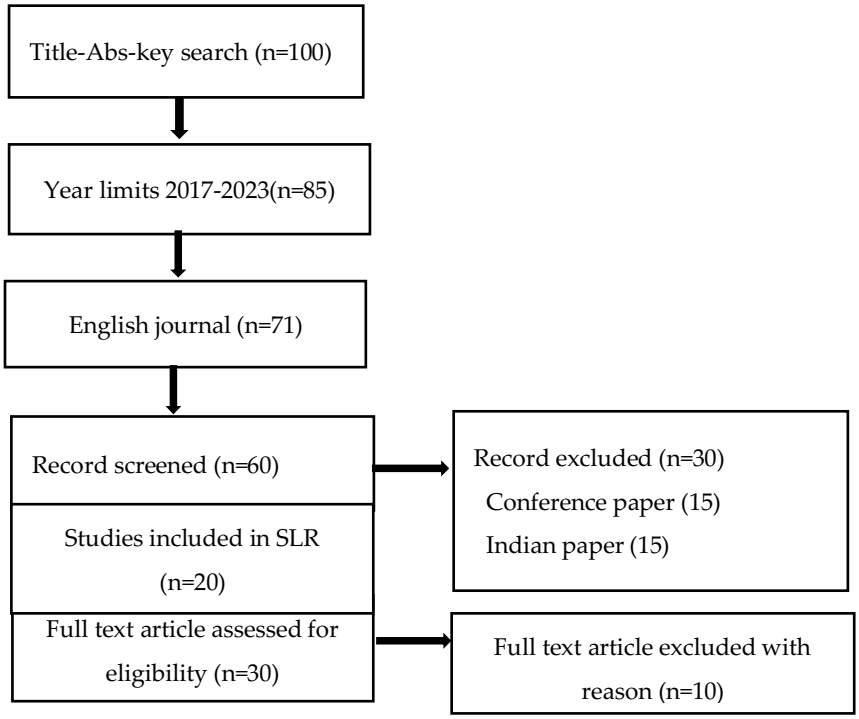

Figure 1. PRISMA method flowchart used in this study

3.1 Support Vector Machine

Support vector machines are a group of supervised learning techniques for classifying data, performing regression analysis, and recognizing outliers Figure 2. A hyperplane is built with samples from one class lying on one side and samples from another class lying on the other in order to do classification. The hyper plane is optimized to ensure the largest separation between the two classes. The data facts from

classes that are closest to the hyperplane are known as support vectors. [7]. There is a regression version as well, however it is mainly employed for classification. SVM is available in both linear and non-linear configurations. SVM uses two kinds of data: the train dataset and the test dataset [8].

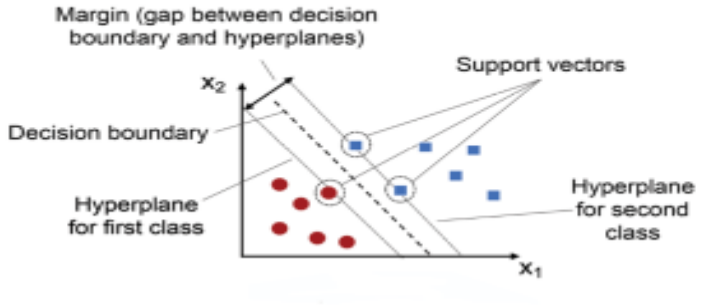

Figure 2. Support vector machine

3.2 Random forest (RF)

The popular machine learning method random forest is a subset of the supervised learning method Figure 3. It can be applied to ML tasks including classification and regression. It is based on the idea of ensemble learning, which is the process of combining different classifiers to solve a complex problem and increase the performance of the model. This bagging technique builds multiple decision trees to classify samples using the best results [9]. An ensemble model or classification using random, forest. Two hyper parameters that are extremely important for arrangement are the quantity of decision trees and the size of the random forest involved in the classification process [10].

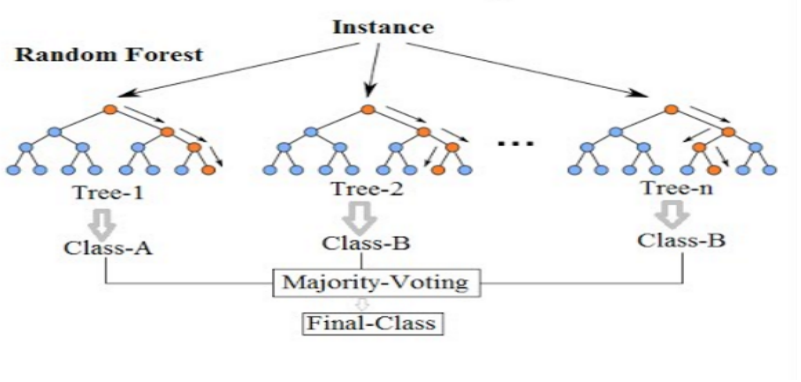

Figure 3. Random forest

3.3 K-Nearest Neighbor (KNN)

The k-nearest neighbor algorithm, often called KNN or k-NN, is a directed learning classifier that uses proximity to classify or make forecasts about groupings of a single data fact Figure 4. It makes a number of assumptions, including that the dataset has useful characteristics, has some noise, and is labelled. It takes a long time to process KNN applications in large datasets [11]. For the training data prediction procedure, the KNN algorithm uses Euclidian distance. The KNN algorithm has the following stages: Calculate the value of k, define class, sort training data, and compute distance using the Euclidian distance [12].

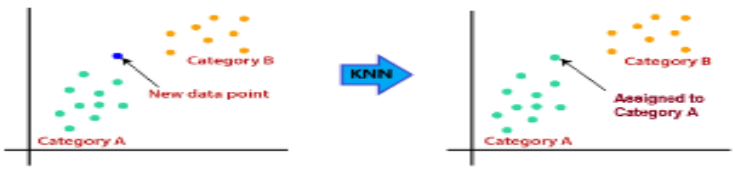

Figure 4. K-Nearest Neighbor

3.4 Decision Tree (DT)

A decision tree is a non-parametric directed learning process used for both sorting and regression submissions Figure 5. It aims to recursively partition, or the process of creating an appropriate "partition"

to build a tree structure that correctly assigns a given label to the input feature vector. Importantly, trees can be combined with other trees to use ensemble learning to produce efficient classifiers such as random forests and spanning trees [13].

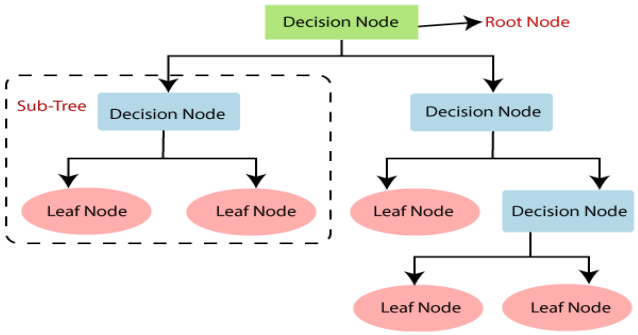

Figure 5. Decision Tree

3.5 Naïve Bayes (NB)

For arrangement tasks like text sorting, the Naive Bayes classifier, a managed machine education method, is used. It moreover falls under the heading of "generative learning algorithms," which means that it makes an effort to mimic how inputs are distributed within a certain class or category. This method is typically applied when the input's dimensionality is high. This classification model is based on a straightforward Bayesian probabilistic model with strong independence assumptions. By taking into account the possibility of an alternative event that has already occurred, it applies the Bayes statement to ascertain the likelihood of an outcome occurring [14]. All types in a Naive Bayes network are provisionally self-governing. As a result, modifications to one feature have no influence on other features [15].

Table 2. Machine learning technique overview table

Algorithm	Paper name	Author	Years	Accuracy	Journal	Data set
SVM	Automatic recognition of arrhythmia based on principal components analysis network and svm[16]	WeiyiYang,Yujuan Si	2018	97.77%	Computers in biology and medicine	MIT-BIH
SVM	Similarity based attribute weighting method via clustering algo in the classification of imbalance medical data set [17].	Kemal polat	2018	97%	Neural computing and application	UCI
SVM	Heart disease predication using machine learning technique [18].	Devansh shah, Samir patel	2020	95%	SN computer science	Cleveland data set

SVM	Empirical analysis of ML algorithm imbalance electrocardiogram based arrhythmia dataset for heart disease detection [19]	Shwetketu, pramod Kumar, Mishra	2021	99%	Arabian journal for science and engineering	MIT-BIH
SVM	An optimized stacked svm based expert system for the effective prediction of heart failure [20]	Liaqat Ali, AwaisNiamat	2019	92.22%	IEEE	Cleveland
DT	Classification techniques for CVD using supervised ML [21]	John minou, John mautas	2020	91%	Medical Archives	4270 patient data
DT	A ml approach for chronic heart failure diagnosis [22]	Dafni K Plati, Arisbechlioulis	2021	91.23%	MDPI diagnostic	487 patient data
DT	Data mining approach using DT algo[23]	Muhammad Tajfard,Ali Reza	2017	94%	Computer method and program in bio medicine	Personal health record
DT	Early predication of heart disease using DT algo [24]	M.safishmaryA.SankariKarthiga	2017	99%	IJARBEST	Personal health record
KNN	Computer aided decision making for heart disease detection using hybrid neural network [25]	Roohallah Alizadehsani ,Ali Asghar Yarifard	2017	93.85%	Computer method and program in bio medicine	Z-Alizada'sAani
KNN	A comprehensive review on heart disease	LamidoYahaya,N David oye	2020	86.6%	American journal of	UCI

	predication data mining and ML technique [26]				Artificial intelligent	
KNN	A case study with cardiovascular disease risk predication [27]	MeghanaPadmanabhan,Pengyuyuan	2019	86%	Journal of clinical medicine	UCI
KNN	Congestive HF Diagnosis Health vs congestive HF [28]	LalHussain ,Imtiaz Ahmad	2020	88%	Hindawi	MITBIH
KNN	Exploring multi technique for coronary heart disease predication [29]	Hishamkhdair	2021	73.2%	IJACSA	South African heart disease data
RF	Ml applied to energy waveform ECG for predication of stage B heart failure in the community [30]	Elizabethl pother, David Ascher	2020	76%	JACC	Cleveland
RF	A statistical analysis based recommender model for heart disease patient [31]	Syed Muhammad Anwar, Muhammad Majid	2017	97.8%	International journal of medical informatics.	POF hospital
RF	Predictive modeling of hospital mortality for patient with heart failure by using an improved Random survival forest [32]	Fenmiao,Yun-peng CAI	2018	82.1%	IEEE	MIMICC
NB	Heart disease predication [33]	Sumit Sharma	2020	85.25%	IJITEE	UCI

NB	Machine learning predictive model for coronary Artery Disease [34]	LJ.Muhammad,Ibrahem Al-Shourbaji	2021	87.50%	SN computer science	General hospital in Kano State – Nigeria
NB	Coupling a fast Fourier transformation with a machine learning ensemble model to support recommendation for heart disease patient [35]	JiJzhang,RLlafta	2017	94.83%	IEEE	Tunstall's
NB	Improvement of heart attack predication by the feature selection methods [36]	Hidayet TAKCI	2018	84.81%	Turkish journal of electric engineering and computer science	Stat log
NB	Identification of significant feature and data mining technique in predicting heart disease [37]	Mohammad shafenoorAmin,Yin Kia Chiam	2019	87.4%	Telematics and informatics	UCI

4. Discussion

When Nasarian used the Coronary Artery Disease (CAD) dataset, which included task area and environmental options as well as various clinical functions, the results showed that the expected quality option technique outperformed SMOTE as well as the XGBoost classifier. Left behind had produced an accuracy of 81.23% [38].

In a comparative analysis of six machine learning models, A. Akella and S. Akella attained precision values above 80%, with the "neural network model" reaching exactness values exceeding 93% [39].

Waqas Nadeem presented a novel architecture for SVM-based heart disease prediction. Compared to other models, the accuracy rate of the proposed model is extremely high at 96.23% [40].

Another work by [41] employed a thorough heart sickness prediction based on an investigation employing approximately of the best well-liked machine knowledge classifiers. The Cleveland (UCI) datasets, which have 303 records, are just 14 characteristics are used for training and testing. A dataset consisting of 296 records was produced after data preparation was done. A greater accuracy of 90.00% was attained by the SVM classifiers' output.

Compared the accuracy of several machine learning procedures at forecasting the likelihood of speedy advancement of coronary atherosclerosis. Nine hundred and eighty three patients' measurable and qualitative computed tomography angiography sign sorts were examined. Atherosclerosis risk score for cardiovascular disease was contrasted with the model's total. Comparative analysis was done on the most

crucial clinical factors. The authors do point out that analyzing ignored biases in the dataset using machine education approaches is static difficult [42].

SVM was applied in paper [43] to predict cardiac disease with respective accuracy rates of 92.37% and 64%.However, KNN proved to be the most accurate, with a range of 85% to 90%. Developed HD recognition methods utilizing an improved SVM-based duality optimization method [44].

Five machine learning methods are employed in this experimental investigation [45] to predict the development of early-stage cardiac disease: Random Forest, Decision Tree, K-Nearest Neighbors, Support Vector Machine, and Naive Bayes. 4241 occurrences total are present in the dataset. The SVM and Nave Bayes both have high accuracy ratings of 84.08% and 83.96%, respectively.

The authors [46] employed k-nearest neighbor (KNN), decision tree (DT), random forests (RF), AdaboostM1 (ABM1), logistic regression (LR), and multilayer perceptron (MLP) algorithms to predict heart illness using a heart sickness dataset they obtained from Kaggle. KNN, RF, and DT classifiers all produced results with 100% accuracy.

The authors of the study conducted research to build new hybrid classifiers based on random forest, Ada boost boosting method, decision tree, k-nearest neighbors, and gradient boosting [47]. They developed a model using machine learning techniques using relief and LASSO feature selection. Random Forest outperforms other algorithms with an accuracy rating of 99.35%.

To assist in identifying heart abnormalities in patients and those exhibiting symptoms, the authors [48] develop a medical application. Their effort is more precise since it uses the random forest method.

5. Conclusion

In conclusion, our review paper aimed to evaluate various machine learning techniques, including Support Vector Machine (SVM), Naive Bayes, Decision Tree (DT), Random Forest (RF), and K Nearest Neighbor (KNN). By thoroughly studying numerous papers and analyzing the performance of these techniques based on their accuracy, we have determined that SVM demonstrates the highest accuracy rate. Our findings reveal that SVM achieves an impressive accuracy percentage of 96.19 %, outperforming the other methods examined in our study.

The results highlight the potential of SVM as an effective machine learning technique for a wide range of applications. Its ability to accurately classify and predict outcomes is particularly noteworthy, making it a valuable tool in various fields such as image recognition, natural language processing, and medical diagnostics. Furthermore, the high accuracy achieved by SVM underscores its reliability and robustness, further solidifying its position as a preferred choice in the machine learning community.

In conclusion, our review study has provided valuable insights into the performance of various machine learning techniques. SVM has emerged as the frontrunner in terms of accuracy, showcasing its effectiveness and potential for numerous applications. Further research and exploration in this field are encouraged to enhance our understanding of machine learning techniques and uncover novel approaches that can further improve accuracy and address the challenges associated with real-world applications.

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