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A Literature Review for Detection and Projection of Cardiovascular Disease Using Machine Learning

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Abstract

The heart is a vital organ that is indispensable in ensuring the general health and welfare of individuals. Cardiovascular diseases (CVD) are the major health concern worldwide and a leading cause of death, leaving behind diabetes and cancer. To deal with the problem, it is essential for early detection and prediction of CVDs, which can significantly reduce morbidity and mortality rates. Computer-aided techniques facilitate physicians in the diagnosis of many heart disorders, such as valve dysfunction, heart failure, etc. Living in an "information age," every day million bytes of data are generated, and we can turn these data into knowledge for clinical investigation using the technique of data mining. Machine learning algorithms have shown promising results in predicting heart disease based on different risk parameter. In this study, for the purpose of predicting CVDs, our aim is to appraise and examine the outputs generated by machine learning algorithms including support vector machines, artificial neural network, logistic regression, random forest and decision trees.This literature survey highlights the correctness of different machine learning algorithms in forecasting heart problem and can be used as a basis for building a Clinical decision-making aid to detect and prevent heart disease at an early stage.

Keywords: Support Vector Machine (SVM), Naïve Bayes, K-Nearest Neighbor, Coronary artery disease, Arterial pressure, Data Mining, Decision tree

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1. Introduction

Stress and trauma are the common experience of modern-day lifestyle. Along with those, other risk factors such as high BP, HC, obesity, smoking habits, type 1 or 2 diabetes, and predecessor history lead to causes cardiovascular problems. Cardiovascular problem, otherwise called as heart disease, is a state that affects the heart as well as blood vessels. Nowadays heart problem is the root source of death. As per the WHO report of 2019, 32% of all global death causes due to CVD. Studies have found that individuals who have contracted COVID-19 are increased likelihood of developing cardiovascular complications, including heart attacks, even if they have no prior history of heart disease. This is thought to be due to the direct effects of the virus on the cardiovascular system and the systemic inflammation that occurs with COVID-19.

Early detection and diagnosis of heart problems are crucial to prevent complications and improve patient outcomes. Machine learning algorithms have shown great potential in accurately predicting heart disease and identifying high-risk patients. The machine learning algorithms that are frequently utilized for heart problem detection and projection are neural networks, SVM, logistic regression, decision trees and random forests. Datasets that are mind-boggling for human beings to understand can easily be explored with machine learning algorithms. These algorithms are applied for analysing and evaluating a large, complex dataset, to identify the desired patterns with absolute accuracy. The assessment of heart disease incidence using diverse machine learning

approaches includes the use of datasets containing information about patient demographics, medical history, and various diagnostic test results. The pre- processed 3 data is provided to the machine learning algorithms as input, which then learn from the data and create a predictive model.

Table-1: Signs and Vulnerability factors of different types of CVD

CVD Types	Characterization	Signs	Vulnerability Factors
I. Heart Stroke	Various forms of Stroke • Transient ischemic attack (TIA) • Ischemic stroke • Hemorrhagic stroke	• Sudden Physical impairment • Brain hemorrhage • Weakness feelings	• High BC • Diabetes, • Old age, Tobacco addi- tive • Unhygienic diet.
II. Coronary Heart Problem	IHD	• Difficulty in breathing • Tightness in the chest • Nausea, Tired	• High cholesterol levels and BP, Diabetes • Old age, Smoking • Inherited, disposition
III. Congenital Heart Problem	• Malfunction of Heart. • Problems in Central Blood Vessels (Birth) • Gestation	• Breathlessness. • Deviation in growth and development	• Maternal infection. (Rubella) • Inadequate maternal nutrition • Close Proximity of blood relationship between parents • Alcoholic additive
IV. Rheumatic Heart and Fever	• Heart Inflammation (heart valves/muscle) • Sore throat or tonsillitis (children)	• Shortness of breath fatigue, • irregular heartbeats, chest pain, Joint swelling • Nausea,Stomach amps,vomiting	• High BC and BP, • Diabetes
V. PE (pulmonary embolism) and DVT (Deep vein thrombosis)	• Tightness in the chest or discomfort • Sudden onset of shortness of breath • Rapid heartbeat or palpitations.	• Joints swelling, • Nausea, • Stomach pain • vomiting	• Obesity, • Cancer (Contraceptive and hormone Therapy
VI. Peripheral vascular disease	Peripheral arterial disease; Two important forms; • Functional PAD • Critical limb ischemia (CLI)	• Nausea • stomach • cramps • vomiting	• Obesity • Family history • High cholesterol • Diabetes ,Smoking • inflammatory ,disorders
VII.Other cardiovascular diseases	• Tumors develops in heart; Brain tumors • Disorders in heart muscle; Heart valve diseases	• Nausea • Stomach • cramps • vomiting	• High BC and BP • Diabetes

BP- Blood Pressure, BC- Blood Cholesterol, IHD-Ischemic Heart disease

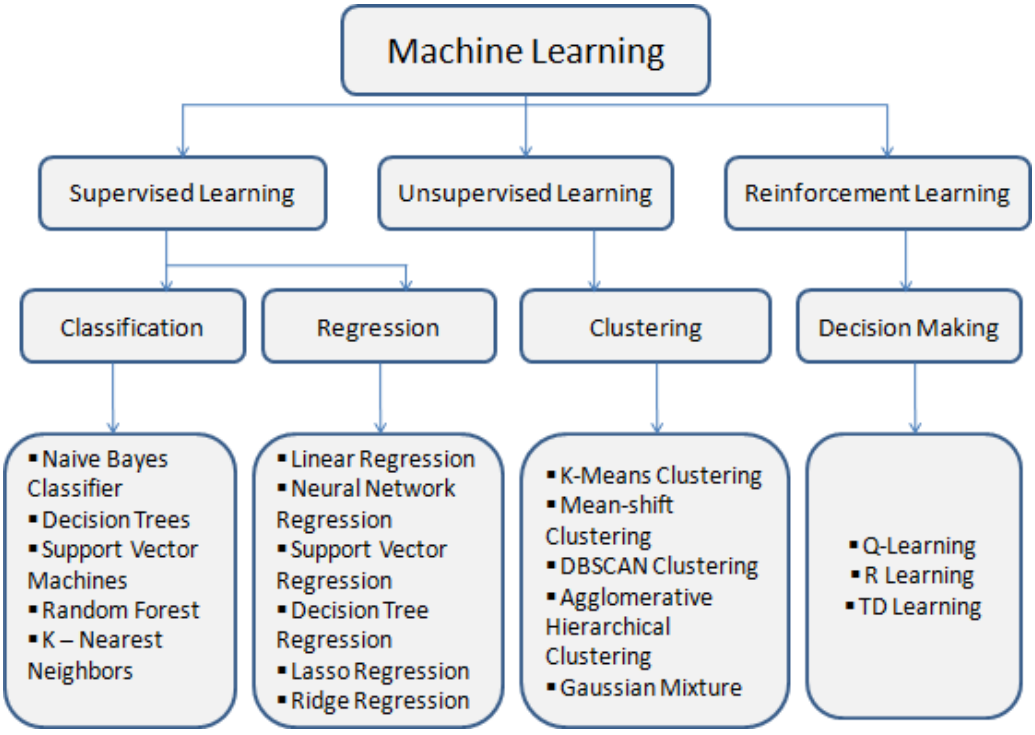

Fig 1: Types and Classification of Machine Learning Algorithm 1.1

K-Nearest Neighbors(KNN)

The K-Nearest Neighbors algorithm (KNN) is a commonly used supervised learning method that is capable of performing classification and regression tasks. Initially, based on similarity indices, the data are classified. The KNN algorithm doesn't require any assumptions regarding basic data. Noise data cannot be efficiently handled by this method.

Support Vector Machine Algorithm

Support Vector Machine is a supervised learning model used for solving classification and regression tasks. The goal of SVM is to identify the hyper-plane that can create the largest margin of separation between data points of different classes. The space or gap between the hyper-plane and the nearest data points in each class maximizes by the hyper-plane (optimal hyper-plane).

Random Forest Algorithm

The technique of Random Forest is a frequently used ensemble method implemented for the purposes of classification and regression, which based on decision trees, where each tree is constructed by choosing a subset of features and a subset of the training data samples.

K-Means Clustering

K-Means clustering is a widely recognized unsupervised machine learning approach, efficiently applied to the grouping of similar data points into clusters based on similarity indices. The most common application of this algorithm in the domain of pattern recognition and data mining and image segmentation.

Decision Tree Algorithm

The utilization of the Decision Tree algorithm in supervised machine learning is widespread for both classification and regression analysis similar to that of Random Forest (RF), which is a non-parametric algorithm that builds a decision pattern which looks like a tree with possible consequences.

Logistic Regression

Logistic regression analysis is a well-known statistical method utilized to determine the association between a binary dependent variable and one or multiple independent variables. This method is common for classification problems where the objective is to predict a binary outcome.

2. Literature Review

Ali et al. [1] evolved a model with two SVM to diagnose heart disease effectively. Elimination of the unnecessary features was done with the first SVM and prediction was done with the help of the second SVM. 3.3% more exactness was accomplished by using hybrid gird search algorithm (HGSA) than the traditional SVM model.

Javeed et al. [2] promoted a prototype for both training and testing data which contains two algorithms i.e Random Search algorithm (RSA) and random forest algorithm (RFA). It was seen that RSA-RF system performance was 3.3% more than a random forest model.

Santhana Krishnan. J[3] used decision trees and Nave Bayes machine learning algorithms, to predict heart attacks. The Decision Tree Model achieved a precision rate of 91% and Nave Bayes' accuracy level was 87%. They presumed that the best algorithm was a decision tree for handling data sets.

Aditi Gavhane et al. [4] worked on machine learning applications by using certain parameters like lifespan, gender, heart rate, etc. to foresee the vulnerability of heart problem. To train and test the dataset, they used neural network supervised algorithms, that is MLP (multilayer perceptron), which gives reliable outcomes from the user's input. Machine learning algorithm using neural network is the most accurate and reliable algorithm.

Devansh Shah et al. [5] developed a system using some supervised classification techniques such as Random Forest, Decision Tree, KNN, and Naïve Bayes. To identify heart problems, the Cleveland database from the UCI repository was employed. Out of 76 attributes, only 14 attributes such as age, pain in the chest, gender, etc. are taken and found a K-nearest neighbor, which gives the most noteworthy precision.

Archana Singh et al. [6] developed a system using LR, SVM, decision tree and KNN machine learning algorithms. For training and testing, UCI repository dataset was used. They found that KNN is more precise and effective in contrast to different algorithms.

Apurb Rajdhan et al. [7] carried out various approaches such as LR, RF, Decision tree and Naive Bayes algorithms to predict heart problems over UCI repository dataset. They found that 90.16% accuracy was achieved by the RF algorithm to forecast heart problem.

Rati Goel [8] worked on SVM, LR, RF, Decision tree, Naive Bayes and KNN algorithms of ML and compare their efficiency based on basic parameters like chest pain (CP), gender, blood pressure (BP), and cholesterol to predict heart disease. He concludes that the SVM has better performance in comparison to other machine learning algorithms.

Ekta Maini et al. [9] used different types of ML algorithms [RF], Logistic Regression, Naıve Bayes, k-Nearest Neighbors and AdaBoost, using Python to do the prediction. Utilizing a sample of 1670 patients from the UCI dataset who presented to a private tertiary care facility in southern India and considered 13 clinical parameters, such as anxiety, ancestry, nicotine consumption, indulging in alcoholic beverages etc. They developed a model using ensemble techniques (RF and AB), which excelled in comparison to LR. RF is the best to do the prediction, accomplishing 3.8% accuracy, 92.8% sensitivity, and 94.6% particularity.

Apurv Garg et al. [10] worked on KNN and Random Forest ML supervised Algorithms to separate CVD patients. from normal persons. They used Kaggle's data set for his experimental analysis using the Python programming language. They concluded that K-Nearest Neighbors (KNN) provides better performance (86.885% accuracy) in comparison to the Random Forest algorithm (81.967% accuracy).

Md. Mahbubur Rahman, et al. [11] used KNN, Ada Boost, LR, XGBoost, SVM, DT, Naive Bayes, and RF various ML algorithms considering the basic parameters like lifespan, gender, angina, arterial pressure, electrocardiogram, etc. to predict heart disease accurately. A dataset of 1026 patients was taken. They have statistical measurement parameters. criteria like sensitivity, exactness, selectivity, F-measure, precision, and classification errors. They determined that the decision tree demonstrated the greatest precision (99%) and responsiveness (98%) in contrast to alternative techniques, with the lowest classifications errors for the identical dataset.

Manjula P et al. [12] used various ML techniques like SVM, Decision Tree, LR, RF, Navie Bayes and KNN in their model with Vulnerability factors like age, gender, arterial pressure, cholesterol levels, and family background of heart problem to train and test their models of machine learning. The random forest algorithm achieved exceptional precision in their model.

Pavan Kumar Tadiparthi et al. [13] reviewed several types of machine learning algorithms for predicting heart issues. They determined that the precision of the machine learning algorithms for disease prediction can be enhanced with proper feature selection and ensemble methods. Python environment was used for experiment. Logistic Regression gives 81.9% accuracy and better performance given by the classification model on the data set, which uses 14 features.

Joloudari et al. [14] used SVM, CHAID and RTs ML algorithm for artery disease identification. 303 patients' information from Z-Alizadeh Sani dataset was used, out of which 216 CAD patients and 88 normal patients. According to the study, random tree model outperforms other classification models with an accuracy rate of 91.47%.

Padmanabhan et al. [15] evaluated AutoML performance. UCI data repository and the CDD (Cardiovascular Disease Dataset) were both used as cardiovascular datasets in the experiments. The experiments yielded a 74% correct prediction rate with 70,000 cardiovascular disease results and an 85% correct prediction rate with the Heart UCI dataset.

Chen et al. [16] stated that the XGBoost algorithm created decision trees in sequential order. Independent variables were given weights, which were employed by the decision tree to generate prediction. If a wrong prediction is made by the tree, then variables are used in the next decision tree as its importance is increased. Each predictor's output is then merged to form a accurate and reliable model. Fayez et al. [29] studied that through a 10-fold cross-validation with 49,000 instances used for training and 21,000 instances used for testing, the XGBoost model attained a precision of 73% on a dataset consisting of 70,000 instances for cardiovascular disease (CVD)

Reldean Williams et al. [17] used a set of eight machine learning methods, including Artificial Neural Networks, RF, LR, SVM , Decision Trees, XG Boost and Naive Bayes for heart problem prediction with elements like Systolic and diastolic pressure, cholesterol level and Chest tightness. UCI data repository is used. They found that out of the machine learning methods utilized, Random Forest demonstrated the highest accuracy for forecasting the incidence of the illness.

Weng et al. [18] employed Four deep learning techniques, namely Neural Networks (NN), Gradient Boosting, RF and LR to forecast the likelihood of heart disease. The CPRD (Clinical Practice Research Datalink) dataset encompasses a comprehensive medical record, comprising information on population, medical history, medication use, health outcomes, and hospital admission particulars. Several vulnerable factors like Nicotine addiction, Arterial pressure, High blood sugar, cholesterol level etc. were taken and found that for the ML model, diabetes was not the top gamble factor. It was found that neural networks were best, with 3.6% more accuracy for predicting heart disease.

Kishore et al. [19] Demonstrated that in comparison to other methods like CNN, NB, and SVM, Recurrent Neural Networks (RNNs) exhibit decent precision. Furthermore, neural networks perform effectively in detecting heart disease.

Avinash Golande [20] used Machine Learning Techniques to predict Heart Attack effectively. Experts used a few data mining policies to predict heart attacks. Naive Bayes, decision trees, k-Nearest Neighbors are prevalent machine learning techniques used for classification tasks. However, the precision of each technique may differ based on specific problem and dataset being analysed. In some cases, decision trees may achieve higher accuracy than other algorithms.

V.V. Ramalingamet et al. [21] applied various computational learning methods to analyse complex datasets. The researchers discovered that combining multiple algorithms, such as with Random Forest and Ensemble models, has successfully addressed the problem of overfitting. Random Forest, in particular, achieves this by utilizing multiple Decision Trees. On the other hand, Naïve Bayes' model was observed to be highly computationally efficient while still achieving good performance. SVM performed very well in maximum cases.

Mohan et al. [22] employed a range of machine learning models, such as RF, LR, SVM, Decision Tree, KNN, J48, Naïve Bayes and Neural Networks, to forecast the occurrence of heart problem. Prediction exactness increases with the use of a larger number of attributes. Their findings indicated that the Naïve Bayes classifier outperformed all other machine learning algorithms.

Himanshu st al. [23] briefly examined a large data set and a small data set of heart diseases prediction. Deep learning showed higher accuracy for medical diagnosis. They shared that small data sets take minimal time for training as well as testing and performed prediction using SVM and KNN algorithms.

S. Bashir et al. [24, 25] Various feature selection techniques, including decision tree (DT), logistic regression (LR), random forest (RF), Naïve Bayes (NB), and Support Vector machine (SVM), have demonstrated comparable efficacy in predicting the occurrence of the disease.

Arsalan Khan et al. [26] studied the results of a predictive ML algorithm for CVD patients. The researchers utilized patient information gathered from two hospitals located in Pakistan, specifically Khyber Teaching Hospital and Lady Reading Hospital. The RF algorithm is the most effective for predicting and classifying CVD.

M. Kavitha et al. [27] employed RF, decision trees, and hybrid algorithms to forecast illness with great precision. The hybrid algorithms exhibited a high degree of accuracy, approximately 88.7%, in disease prediction compared to other models.

Chintan M. Bhatt et al. [28] used different ML models to find their effectiveness. Experiments were conducted on Google COLAB using Python. More than 86.5% accuracy for all ML classifiers was achieved. Through hyperparameter tuning, the accuracy of RF was raised from 86.48% to 86.90%, and XGBoost algorithm accuracy was raised from 86.4% to 87.02%.

Hasan and Bao et al. [30] conducted a study to find out the best feature selection approach, i.e. filter, wrapper, and embedding, for identifying heart disease. Various ML algorithms including RF, SVM, k-Nearest Neighbors, Naive Bayes, and XGBoost, were employed to identify the optimal

predictive model. They noticed that the XGBoost classifier technique gave the most trustworthy forecasts for heart problems. The gradient boosted model produced an accuracy of 73.74%, which was higher than SVC (73.18%) and ANN (73.20%).

3. Discussion & Future Scope

After a through systematic literature review of different techniques of Machine Learning for cardiovascular disease projection and detection, it is realized that all the research studies towards disease detection and prediction follow a traditional silo approach. Most of the machine learning techniques have adopted limited datasets with selected parameters and have not achieved 100% accuracy in predicting the diseases. So as an extension to this literature review new algorithms, feature engineering techniques or data preprocessing methods can be explored to improve the accuracy of ML models. Also, large-scale diverse datasets that contain data from different populations, demographics, and geographical regions are proposed to be used to achieve the above goal. So, future research of the present paper could focus on validating and implementing ML models in real-world clinical settings.

4. Conclusion

The goal of this literature review is to make a precise and efficient machine learning approaches for forecasting heart disease, which can be employed by medical practitioners to detect high-risk patients and establish customized treatment plans. Through enhancing the accuracy of heart problem prognosis, machine learning approaches can aid in decreasing mortality rates and enhancing the general health results for patients.

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