A systematic review of Machine learning techniques for Heart disease prediction

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One of the most common disease today is Heart Disease,and early diagnosis of such disease is very challenging. Machine learning includes artificial intelligence, which is implemented to solve a number of data science problems. The prediction of outcomes based on existing data is a common machine learning application.Different data mining strategies for the prediction of heart disease have been proposed with varying degrees of effectiveness and accuracy. In this paper, author provide an in-depth literature survey on systems for predicting risk of heart disease.

Keywords: Decision Trees, Heart disease, Machine learning,Naive Bayes Classifiers, Support Vector Machines.

1. INTRODUCTION

Cardiac disease is difficult to classify due to many contributing risk factors such as diabetes, high blood pressure, high cholesterol, irregular pulse rate, and several other factors. According to WHO reports, 24% of deaths from non-communicable conditions in India have been estimated to be caused by heart disease [26,9]. One third of world deaths are caused by cardiovascular disease[20]. Half of deaths are due to heart disease[35] in the United States and other developing countries. Every year, nearly 17 million people worldwide are dying from Cardiovascular Disease (Cardiovascular Disease, CVD).[15,26,42]

Several approaches were used to detect the severity of heart disease in humans for data mining and neural networks. Different approaches such as K-Nearest Neighbor Algorithm (KNN) and Decision Trees (DT), Genetic Algorithm (GA), Genetic Algorithm (NB)[30][16] are used to characterise the disease's severity. The nature of cardiac disease is complex and hence the disease must be carefully controlled. Failure to do so can affect the heart or cause premature death. The medical research and data mining perspective is used to discover different forms of metabolic syndromes. The author has also seen the use of decision trees to predict the accuracy of cardiac disease events[1]. Various abstraction methods have been used using known data mining methods for heart disease prediction. In this article the author studies the proposed systems for predicting heart disease.

The rest of the paper is organized as, in section II dimensionality reduction methods are explained in detail section III gives a brief idea of existing work done by different researchers whereas comparative analysis of prediction algorithms is included in section IV. Last section that is V concludes the summary of the paper.

2. DIMENSIONALITY REDUCTION

Dimensionality Reduction requires the selection of a mathematical representation in such a way that the majority, though not all of the variance within the given data can be calculated, including only the most significant detail. There may be several attributes or dimensions in the data considered for a task or problem but not all of those attributes can have an equal performance

effect. Many attributes or characteristics can affect computing. Complexity and even over-suitability can result in poor outcomes. Dimensional reductions are therefore a very necessary step in the creation of any model. Dimensionality Reduction is generally achieved using two methods-Feature Extraction and Feature Selection.

a) **Feature Extraction:** This removes a new selection of features from the original set. Extraction of features includes the function transformation. This adjustment is not reversible, nor is there any great deal of useful information lost during it[12]and[38]Principal Component Analysis (PCA) is used to extract features. The key component analysis is a frequently used linear algorithm of transformation. In the function space he looks for directions that optimise variance and seeks mutually orthogonal directions. It is a global algorithm that offers the best possible recovery.

b) **Feature Selection:** In terms of hardware configurations, operating systems and versions, OS patch levels, product version and patch levels, diversity in system and product run-time environments, customer use-cases and processes. This manifests in diverse performance profiles of the same code-base at different customer installations.

3. LITERATURE SURVEY

A number of studies on the cardiovascular prediction system were carried out over the years by different authors using several data mining algorithms. They have tried to achieve successful methods and accuracy in detecting cardiac diseases through their work, including datasets and different algorithms and experimental results and future work to achieve more effective results on the system.

In [28] only six medical features are added to predict cardiac disease and obtain more accurate and reliable outcomes. In this paper three classifiers are used to diagnose heart patients as Naive Bayes, cluster classification and decision tree and achieve precision is 96.5%, 88.3% and 99.2%. The 3.6.0 Weka method is used to simulate the work.In [5] the developers of data mining and fluid logic carried out a new approach to the diagnosis of heart disease. The number of characteristics of cardiac disease in this research work is reduced to 4 to decrease the number of patient clinical exams. The method proposed for the prediction of coronary heart disease is also developed. Decision accuracy between 100% and 100%, each using 4 attributes is achieved by decision Tree and Naive. This work shows that Decision Tree and Naive Bayes outperformed other methods of data mining with futile reasoning.

Comparison of various data mining techniques is made using 13 attributes for the prediction of heart disease[32]. The models have been developed and validated using five algorithms, including C5.0, Neural Network, Vector Support Machine (SVM). The accuracy of the models that are built by the C5.0 Decision Tree (KNN) is 93.02% by the 80.23%, 86.05% by the Support Vector Machine (SVC) and 88.37% by the Nearest Neighborhood (KNN). The findings of Decision Tree are easy to understand and use by medical professionals to predict heart disease.In[29] a model has been developed for the prediction of cardiac diseases through classification technologies to respond to complex queries. This work uses 11 simulated attributes of the WEKA instrument. In the development of cardiac model diagnostic data mining algorithms, 99,0741 per cent of 97,222 per cent, 99,0741 of 99,0741 per cent and 98,148 of 97% respectively, are J48, Naïve Bayes, REPTREE, CART, and Bayes net, respectively.

A search algorithm[8] is used to reduce the amount of laws, search for association rules and finally validates them on a stand-alone test collection. The medical value of the regulations is evaluated with motivation, faith and elevation. In order to provide a more accurate statistical approach to predict cardiovascular diseases, researchers apply association rules for an individual data set containing medical records of patients with heart disease. The association rules apply in four different arteries to cardiac perfusion checks and to disease-grade risk factors. Validation quest constraints and set tests greatly reduced the number of association laws and provided a set

of regulations with high heart disease predictive accuracy.

A approach is implemented in [11] that uses SAS- based programme 9.1.3 and 13 attributes to detect heart failure. SAS Base Program is an Intelligent Integrated Framework that helps users to estimate their device output from a range of points of view. The neural network ensemble model is developed by integrating three different neural network models. The number of neural networks in the ensemble model has also been raised, but no change in efficiency has been made. The experimental findings reached 89.01 per cent accuracy, 80.95 per cent sensitivity and 95.91 per cent precision for the detection of heart disease.In [6] four data mining methods, i.e. J48 decision tree, Naive Bayes, KNN and SMO, are analysed and compared using a weka simulated method for cardiac disease dataset. Following a comparison of the decision tree, Naive Bayes, KNN and SMO attained precision of 83.73 percent, 81.81 percent, 82.775 percent and 82.775 percent respectively.A prototype of a model for the prediction of heart disease was developed by data mining[1] such as the Neural Network, K-Means Clustering and Standard Item Set Generation. In presenting this model with medical characteristics, a person knows whether there is a possibility that heart failure will occur. The researcher used 14 medical features, such as age, sex, blood pressure and blood sugar.

Healthcare is a data mining applications area because it has big resources which are hard to handle by hand. Heart disease, also in developed countries, has been identified as one of the leading causes for mortality[24]. One of the causes of heart disease mortality is that risk is either uncertain or later detected. In order to solve this problem and forecast the risks early, however, machine learn strategies can be helpus. The Support Vector Machines (SVM), Neural Networks, Decision Treaties, Regression and Naive Bayes classifications are some of the methods used to solve this type of prediction problems. SVM is the best forecaster with 92.1 percent precision, led by 91 percent accuracy neural networks, and decision-making bodies have recorded 89.6 percent less accuracy[43].The risk factors for heart disease were sex, age, smoking, hypertension and diabetes[24]. Analytical studies in data mining techniques for heart disease prediction show that the prediction of heart disorders is effective across neural networks, decision- making trees, naive bays and related labelling. Even if unstructured data is treated, associated classification offers high precision and flexibility with respect to standard classifiers[3,23].

A Cardiac Disease Prediction and Diagnostic algorithm for healthcare using machine learning methods was proposed by Authors[31] et.al. The UCI repository data set and healthcare sensors are used to test populations with heart disease in this study to establish an effective framework for cardiac disease. In addition, patient data for diagnosis of cardiac disease are organised by recognition algorithms. The classifier is trained with the benchmark data set during the testing phase. The diagnostic procedure is used to classify the onset of the disease by authentic medical records for classification of the disorder. To test the benchmark data sets, J48, Logistic Regression (LR), Multi- layer Perception (MLP) and Vector Machinery Support are used for a series of classifiers (SVM).The re-enactment results ensured that the J48 classifiers demonstrated superior success in terms of various metrics, such as accuracy, precision, recall, F-score and kappa rating.

In [46] et.alproposed Automatic Prediction of Heart Attack Patients using Sparse Discrimination Analysis. In this article the author proposes a novel SDA-Sparse Discriminant Method of Cardiac Disease Identification Classifier. The time complexity of this algorithm will be minimised by the ideal LDA score investigation and will be comprehensive in order to perform a sparse separation by blending Gaussians if the boundaries between classes are non-linear or if subgroups are possible within each class. Overall, relative to prior approaches, our proposed approach is more suitable for diagnosing patients with greater specificity of heart failure.

Heart disease—The Synus Arrhythmia Prediction Method is proposed in the neural network[21] using an ECG analysis. The data processed includes attributes or physiological factors in the data collection for the exploration of the predictability or possible status values of the alternate attributes. This is theDescription wouldemphasise the exploration of typical familiar patterns that represent details that can be interpreted by humans. The author of the project found that

our project could contribute to the discovery of a condition called sinus arrhythmia that is more common these days. With the aid of our professional neural network, authors can predict sinus arrhythmia and its actions in a human more easily and efficiently.

The Machine Learning Algorithm Clinical Support Method to Predict Heart Diseases has been examined[18]. The world's leading cause of death is heart disease. However, doctors cannot predict heart failure because it is a difficult and expensive operation. Thus the researchers have suggested to enable symptomatic physicians to make smarter choices a therapeutic support mechanism for cardiac attack forecasting. In this study, machine-learning algorithms such as Naïve Bayes, K-Nearest Neighbor, Support Vector Machine, Random Forest, and Decision Tree are used to predict cardiovascular diseases using medical knowledge on risk factors. A number of experiments were carried out to estimate HD with a UCI data collection and the result shows that Bayes Naïve performs a precision of 82.17% and 84.28%, respectively, overall cross-validation and train-assay break strategies.The second end is that the performance of both algorithms reduces after the cross- validation technique has been implemented. Finally, a suggestion was made for multi-validation approaches of prospectively gathered evidence to reinforce the suggested method.

The proposed cardiac disease prediction system[41] has been modelled as a Multilayer Perceptron Neural Network. Cleveland dataset was used for the framework. The system's neural network used 13 clinical data collected from Cleveland Dataset as information. Backpropagation Algorithm has been learned to predict whether or not heart disease is present in the patient. This paper suggests a cardiac disease prediction method that uses an artificial neural network backpropagation algorithm. 13 clinical characteristics were used as a contribution to the neural network and the neural network was subsequently trained using a backpropagation algorithm to predict the absence or involvement of cardiac disease with 95 per cent accuracy.

Fast rule — Associative classification mining is proposed in [22] for the prediction of heart conditions. [22]. This thesis presented our knowledge of rules on mining streams from medical data to prediction of diseases. A modern hierarchical tree has been used by writers to handle streaming data. As the world's cardiac disease mortality rate is rising, the developers have developed the SACHDP policy framework to better identify the risk score of cardiac disease prediction. We presented an important method for the prediction of heart disease in this paper. This study uses a classification of associations which produces a classificator with high predictive values. Experimental studies show that this research helps doctors to make treatment decisions.

The segmentation of the coronary artery and the possibility of disease warning is investigated in a deep research algorithm[7]. The experiment showed that the extension of simple data may be detrimental to the test data. The training curve is believed to increase the efficiency of coronary artery segmentation further by improving the nature of the training outcomes, and it is important that physicians and patients have accurate and reliable findings and input in clinical practise to improve the nature of diagnosis and treatment. The aim was reached of assisting experts in real-time diagnosis and analysis.

The Successful Method of Neuro Evolution in Diagnosing Heart Disease[19] is proposed. In this article the authors use these techniques to detect CAD early by using them in a well-known CAD dataset called Z-Alizadeh Sani. As such, the effective Multilayer Perceptron (MLP) based optimising (MVO) algorithm is used, just as nine states of handicraft-supervised learning techniques are used for the prediction of CAD. Since this dataset contains 54 functions, the author uses an approach to pick the best features before implementing supervised learning algorithms. The experimental results show at the end of the day that the MLP model that MVO is trained among the 9 other supervised models for classifying patients with CAD.

Increasing decision tree algorithms show early detection of clinical parameters in heart disease in the [27] segment. The author proposes in this paper a new method of cutting, a combination of pre-tail and post-tamping, with both the accuracy of the classification and the size of the tree. The author induces a decision tree based on this method. The experimental results are measured with 18 UCI Machine Learning Repository benchmark data sets.This test demonstrates that the

heart defect type is the main predictor of the existence of heart disease.

Authors[17] plans to develop an ML model for cardiac disease detection. KNN stands out in this case as the best algorithm compared with other algorithms, including Random Forest, Decision Tree, Support Vector Machine etc. A prototype has also been developed to validate the performance. A series of sensors are created to monitor a person's health, causing heart disease. Finally, it is estimated whether a person would have a previously trained model for heart disease or not. Thus, our response offers vital human benefits and makes constructive health inspection data with an accuracy prediction of 88.52%.

This research[44] introduces techniques for pre- processing and assignment of the medical sensor data model. The author attempts to address the problem of creating an incomplete and messy data system for the diagnosis of cardiac disorders, which is central to medical data. Due to its scale, imbalance and many incomplete, fake and wrong details, the health data collection is often insufficient and confusing. In this analysis, the author uses an over-sampling technique of a synthetic minority with Tomek links to increase the data size and eliminate the imbalance. The author has conducted several experiments and measurements with Cleveland data sets and has performed a study of different prediction models with recent literature algorithms.The author applies semi-monitored pseudo-labeling to the management of additional data from Budapest, Zurich and Basel. This means that the model was trained on unmarked data and coupled with labelled data by unmarked values predicting and pseudo-labeling them. The last exactness of this study technique is 93.4% and 96.92% and 89.99% respectively are higher than previous models employed in the literature. Their precision is 93.99%.

The purpose of the system[36] is to recognise and take all possible precautions in order to prevent various diseases from occurring at an affordable rate at an early stage. The author uses the method 'data mining' in which attributes for the prediction of cardiac disease are fed to SVM, Random Forest, KNN, and ANN classification algorithms. Preliminary readings and studies collected from this test are used to determine the risk of heart disease early detection.

4. COMPARATIVE STUDY

The result of the predictive technique using the same or different dataset shows that Decision Tree[28][32][5] outperforms other techniques and some time Neural Networks[10][11] has the same accuracy as the decision tree. The second conclusion is that hybridization of techniques also offers promising precision for the prediction of heart disease as in [45]. Various types of data mining techniques are used by various researchers to carry out the practical work that has arisen in recent years to diagnose heart disease efficiently and effectively. The study shows that classification approaches are best used to diagnose heart disease correctly and efficiently. The ranking is based on machine learning. The main aim is to group each object into one of the predetermined classes or categories in a collection of data. The methodology is based on statistical approaches including decision-making tree, linear programming, neural network and statistics. The techniques of machine learning, pattern recognition and artificial intelligence are widely used. KNN, Decision Tree, Vector Machine Help, Neural Network and Bayesian Method are various types of classification techniques.Some kinds of classification techniques mostly used to diagnose heart diseases are defined below;

4.1 Decision Tree:

For a decision tree classifier, a tree-like graph is used. The node is called the root node at the highest location in tree- like graphs. Decision Tree, in particular for forecasting heart disease, is also used by health researchers. Decision tree allows decision-makers to choose the best choice and a differentiation of groups based on maximum knowledge gain[4] is suggested by the root-to-leaf cross-section.

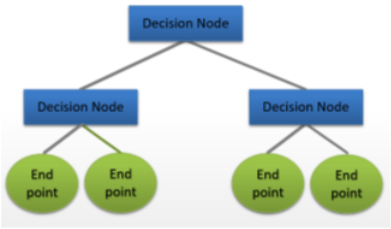

Figure 1. Decision Tree

4.2 Neural Network:

The neurotic network is based on a biology nervous system which works together to solve a particular problem with many interrelated neuron processing elements. Regulations derived from the trained neural network (NN) aims to further improve the network's interoperability[33].

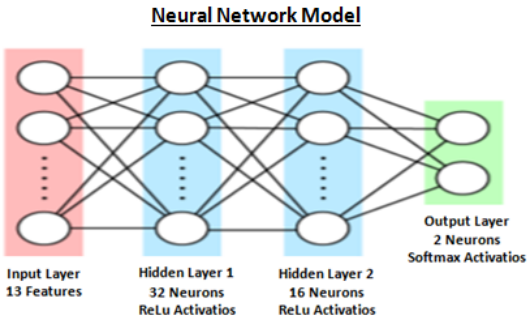

Figure 2.Neural Network [47]

4.3 Support Vector:

Machine A support vector classifier in high dimensional space which serves for classification, regression, and other well- organized tasks is created with hyperplane or multiple levels.. E.Avci has proposed a method for assessing cardiovascular disease that uses an SVM genetic classification. This technique extracts and classifies the signal produced from ultrasound the cardiac valve[14].

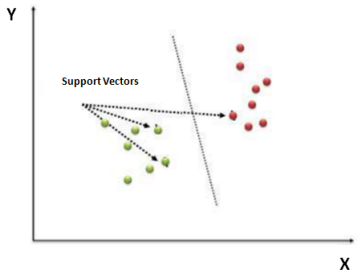

Figure 3. Support Vector Machine [14]

Proposed Methods	Merits	Demerits
IoT based heart disease prediction and diagnosis model for healthcare using machine learning models [31]	It has been shown that J48 is the right algorithm for the IoT health prediction model of cardiomyopathy compared with MLP, SVM and LR classifications.	At the same time, the performance of SVM and LR classifiers is nearly similar to the 84.10 and the 83.70. Finally, the poorer classification performance is recorded.
Automated Prediction of Heart Disease Patients using Sparse Discriminant Analysis [46]	1. Our proposed method improved the prediction accuracy of 96%. 2. The accuracy, time complexity and memory efficiency of this SDA- based machine study model are successively improved and can be fully implemented in an actual cloud-based system which is useful for physicians in the accurate detection of heart disease.	An earlier step, while their predictive accuracy level is less than 90%
Heart disease-Sinus arrhythmia prediction system by neural network using ECG analysis. [21]	The algorithm and technique authors are incorporating into project can be used in order to plan for various forms of cardiovascular disorders, which are more socially damaging and harmful, with other different physiological sets.	The entire system should not be implemented in a single programme such that an average citizen can't work easily and financially
A Clinical support system for Prediction of Heart Disease using Machine Learning Techniques [18]	The best technology in our model because the data set used is not broad and the process did not take a long time to overcome the overlay issue.	It can enhance the awareness on cardiac disease risk prediction by enhancing the diagnosis and understanding.
Heart Disease Using Neural Network [41]	The proposed method gives an accuracy rate of 95%, which is very decent in terms of the corresponding studies.	It cannot be updated to provide more detailed diagnosis for heart disease as an intermediate model using other classification algorithms.
Fast Rule-Based Heart Disease Prediction using Associative Classification Mining [22]	Experimental findings indicate SACHDP's better output compared with other associative grading methods.	However by reducing the number of rules produced, the output of SACHDP is not supported.
Heart coronary artery segmentation and disease risk warning based on a deep learning algorithm. [7]	1. The results demonstrate that the model training effect of the preprocessor line is superior to the initial data. 2. The results of the experiments show that 0.8291 has the best effect.	FCN also has limitations, which means that the achieved results are still relatively fluffy and smooth and not sensitive to picture data. It is also not sufficient for medical photos that are more elaborate.
An efficient Neuroevolution Approach for Heart Disease Detection using CAD [19]	For medical, power systems, businesses, the environment and mechanical applications, the proposed approach and even its multi-class classification version of that methodology are investigated.	Comparison with other existing mixture evolutionary neural network approaches for examining CAD detention effectiveness is not worthwhile. The approach proposed in this paper is not worthwhile.
Early Detection Of Clinical Parameters In Heart Disease By Improved Decision Tree Algorithm [27]	The proposed solution decreases the size of the tree considerably while preserving or increasing the precision of the classification.	A broad cancer database cannot be analysed
HeartCare: IoT based heart disease prediction system using KNN [17]	It giving an efficient and real-time heart disease prediction system for proactive health observing, which can work on live data feed from the sensors.	1. Many of the sensors which were unavailable currently, to get more efficient results. 2. This project can't be extended for the observing and prediction of other diseases like diabetes.
Effective diagnosis of heart disease imposed by incomplete data based on fuzzy random forest [44]	1. The accuracy of each calculation was significantly improved by this approach compared to the previous published findings. 2. The model's accuracy is 93.45 percent with 96.92 and 89.99 percent respectively, precision and sensitivity. 3. It is gradually being adapted to house-friendly technologies or used as an urgency call to healthcare bases.	The primary problem is 3 completely missing columns in the piece of the dataset.
Prediction and Diagnosis of Heart Disease Patients using Data Mining Techniques (KNN, SVM and ANN). [36]	The SVM, random forest, KNN, and ANN algorithms in which the ANN has achieved the best results with the utmost precision are supplied with these attributes.	The nearby data structure is sensitive.

Table I: COMPARATIVE ANALYSIS

5. CONCLUSION

Our work aims to examine different methods of machine learning that may be used in prediction systems of automated heart disease. This paper discuss previous systems, which has emerged in the last few years for a precise and effective diagnosis of cardiac diseases, discusses numerous methods in particular. The study shows that different technology is used in all papers with various attributes and simulated tools. Thus the various technologies used showed each other's different accuracy. Researchers around the world are obviously effective in identifying cardiac disorders, but it is suggested that the number of criteria used for diagnosing cardiovascular disease in patients could decrease.

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