CARDIOVASCULAR DISEASE DETECTION USING MACHINE LEARNING TECHNIQUES

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ABSTRACT

Cardiovascular (CVD) conditions are the world's leading cause of death, killing more people annually than any other cause. CVDs in 2008 murdered 17.3 million people world-wide, representing 30% of all deaths. CVDs are expected to kill almost 23.6 million people by 200, particularly by heart disease and stroke. CVDs are the world's leading cause of death and cost an estimated 17.9 million lives each year. Examples of CVDs include heart disease, stroke, cardiovascular disease, rheumatic heart and other cardiovascular disorders. Four out of every 5 CVDs are killed by heart attack and stroke, and about one third are killed before the age of 70. This paper discusses the most popular classification methods for machine learning, including logistic regression, nearest k-neighborhoods, support vector machines, decision-making tree classification, forestry random classifications and XGBoost classification. SVM algorithms provide smart accurate results and good accuracy in comparison with the above algorithms in this study.

Keywords: Decision Tree Classifier, K-Nearest Neighbors, Logistic Regression, Random Forest, Support Vector Machine, XGBooster Classifier.

1. INTRODUCTION

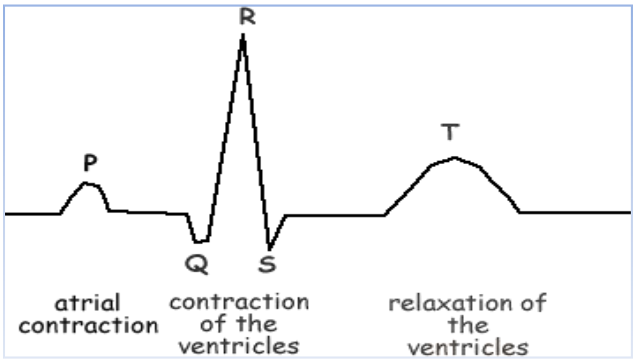
Cardiovascular disease means a group of heart and blood vessel diseases. Coronary artery disease (CAD) is shown by angina and myocardial infarction (commonly known as a heart attack). A group of cardiovascular conditions affecting the blood vessels is called "vascular disease." A variety of factors have been associated with heart disease, including: smoking; poor diet; high blood pressure; high cholesterol; obesity; inactivity; and hypertension.

In cardiovascular research, certain of these variants are used. In some cases, the knowledge of the doctor and the recent test results of the patient are employed for the diagnosis. Heart disease is divided into different types. Coronary heart disease (CHD) is the most common kind of cardiovascular disease in the planet, and is also known as coronary artery disease (CAD). Angina pectoris is the medical term for pain in the chest caused by a decrease in heart circulation. It is a heart disease warning sign. Heart failure occurs when the heart cannot pump the rest of the body with enough blood. It's known as heart failure. Insufficient heart pumping causes cardiomyopathy, a weakening or alteration in the structure of the heart muscle. Cardiomyopathy can be caused by hypertension, alcohol consumption, viral infections, or genetic abnormalities. The development of an irregular heart as a result of a defect in the structure or function of the heart is known as congenital heart disease. It is also a congenital disorder that affects children from the moment they are born. Arrhythmia is a disorder in which the heart does not beat in a regular pattern. Heartbeats can be slow, fast, or irregular. Myocarditis is a condition in which the heart muscle is irritated as a result of heart infection caused by viruses, fungi, or bacteria.

An echocardiogram is a moving image of a beating heart produced by sound waves in real time (ultrasound). Echocardiograms are noninvasive tests used to evaluate the foetus during pregnancy. It could show how well the heart chambers and valves work before and after treatment, as well as other factors. An electrocardiogram shows the electrical activity of the human heart (ECG). There are five waves in the ECG: P, Q, R, S, and T. In a typical engagement, this signal may be calculated using electrodes from the human body. Amplifiers and analogue-to-digital converters route signals from these electrodes to simple electrical circuits. The three electrical entities that repeat themselves in a standard ECG trace are:

- P wave (atrial depolarization)
- QRS complex (ventricular depolarization)
- T wave (ventricular depolarization) (ventricular repolarization).

Figure I: Normal ECG Signal



- The rate and rhythm of your heart.
- Any damage to the heart's muscle cells or other abnormalities in the method of conduction.
- Adverse effects of heart medications.
- The reason for pacemakers being implanted.

2. RELATED WORKS

The author of this work [1] offers an integrated decision-making method for predicting cardiac disease. The purpose of this proposed model is to use classifiers to improve the performance and accuracy of heart disease predictions by eliminating meaningless and inappropriate characteristics from the dataset and selecting only those that are most useful for the classification task. The suggested integrated decision-making system will assist doctors in professionally predicting and diagnosing heart patients, as well as be useful for future exploration in predictions using various datasets and the ensuing relevant knowledge on Heart Disease.

In the suggested study [2], the author presents DMHZ, a computationally intelligent framework for heart disease diagnostics. The goal of DMHZ is to extract features from the Z-Alizadeh Sani CAD dataset using categorical and numeric features individually, utilizing MCA and PCA, respectively. For classification of normal participants and heart patients, the machine prediction models RF, LR, and SVM are trained and verified. With an accuracy of 94.74 percent employing RF, the framework DMHZ beats state-of-the-art approaches proposed for the Z-Alizadeh Sani dataset.

The system will handle large-scale data processing for heart disease detection and monitoring, the corresponding paper [3] says. The system can classify ECG data using the Decision Tree and the Random Forest. The Decision Tree has a 97.14% precision rate and the Random Forest 98.92% exactness rate.

The author of this study [4] proposed an effective feature extraction strategy. The created approach is based on a wavelet transform that has been improved. The programme can readily find the R peaks locations using the appropriate wavelet coefficients. The MIT-BIH Arrhythmia database was used to test this strategy. The method provides promising results with the least amount of computing, as evidenced by the sensitivity and positive predictivity scores.

The author of this work [5] presents encouraging results that point to the possible application of a machine learning-based heart disease prediction system as a screening tool for diagnosing heart disorders in India's primary healthcare centres. ML was successful in predicting the risk of heart disease. The best (RF) prediction method accurately identified 470 of 501 medical data, resulting in a diagnosis accuracy of 93.8 percent.

The authors describe in their research paper an automated method for detecting early New York Heart Association class changes in patients with heart failure using classified techniques [6]. The approach is divided into three main phases: a) data processing, b) selection of functions, and c) classification. The best results are achieved when used in conjunction with filter based selection technique for the rotational forest classification. The highest accuracy in detection on both, three and four classification issues is 97%, 87% and 67%.

The purpose of this work [7] paper is to underline the importance of TDA in the medical profession. Using two UCI heart illness datasets, the mapper method was utilized to predict heart disease (Cleveland and Statlog). Overall, the author claims that TDA mapper is a powerful tool, reaching an accuracy rate of 99.32 percent with the Cleveland dataset and 99.62 percent with the Statlog dataset.

The authors of a relevant paper [8] evaluated the algorithm performance; on the MIT-BIH Arrhythmia database statistical metrics like sensitivity and positive preview are examined and promising results are achieved through the use of the Wavelet Transform algorithm, which is 98.22% accurate.

The author of this study paper [9] described how to compare tools in big data analytics using machine learning algorithms, as well as the data set that was utilized to see if cardiovascular death rates are higher than other diseases like diabetes prevalence.

The author demonstrated whether a memory-capable LSTM network can be utilized to handle the characteristics of time series high correlation problems and optimize the amount of LSTM network hidden layer nodes in forecasting heart disease in this work paper [10]. LSTM is shown to be the most effective technique for solving the aforementioned problems because it has better characteristics than the MLP technique. When compared to the multi-layer perceptron model, the suggested model performs exceptionally well in the prediction of heart disease. The results revealed that the LSTM significantly improved the predictive system's efficiency.

The author of the related research [11] advocated using a statistical indicator called the dissimilarity factor (D) to classify normal and inferior myocardial infarction (IMI) data without the requirement for any direct clinical feature extraction. To create multivariate time series data, time aligned ECG beats were obtained by filtering and wavelet decomposition methods, followed by PCA-based beat augmentation. The promise of descriptive statistical methods as an alternative to medical signal analysis is demonstrated in this research. Combining the proposed approach with the usual feature-based strategy can increase the classifier's performance.

In a related article [12], the author developed a framework based on two distinct classifications: Decision Tree and Naive Bayes. In these two classifications, the Decision Tree gave more reliable results than Naive Bayes. The Decision Tree is 98.27 percent precise, while Naive Bayes is 89.90 percent precise.

One corresponding paper [13] found that Navie Bayes produced the best results before selecting attributes, but that SVM was the best rating, with a precision of 87.8%, after a controlled and careful selection of the features.

The risk prediction procedure is discussed in paper [14] and applied in the data mining section using a set of six data mining classificatory, which is significantly higher than the C4.5, Nave Bayes and SVM. It has a total precision of 79.3 percent. This is considerably greater. The test results show a bright future in the system and diagnosis of the hospital doctors for the proposed method.

The classification rates of the estimated MLP-based ANN model with an error back propagation algorithm are evaluated in the related paper [15], while the comparative analysis of results showed an excellent rating accuracy of 86.67 percent and a sensitivity of 93.75 percent of the estimated MLP-based ANN model with an error back spreading algorithm. The MLP neural network model produced highly accurate results for the classification of cardiac arithmetic.

An accompanying paper [16] examined the various risk models used in cardiovascular risk calculations. In this study, the researchers used Indian-specific risk profiles to stratify the subjects. Similar approaches to improving health quality could be adopted by other developing countries.

The authors of the study [17] identified risk variables for early readmission following esophagectomy and used machine learning-based algorithms to predict early readmission in two scenarios: clinical decision making and quality review. To give targeted support and standardize quality metrics, machine learning techniques can be used. Two machine learning models were developed to predict early readmission: one with 71.7 percent sensitivity for clinical decision making and the other with 84.8 percent accuracy and 98.7% specificity for quality review.

In order that patients obtain their ECG signal and detect instantly the probability of cardiovascular disease in their research work approaches [18], the Author develops a low-cost ECG signal generator. The research suggests a low-cost ECG system and an algorithm for the extraction and detection of cardiovascular disease. This study is both cost-effective and healthy.

The author has merged these characteristics in the suggested work [19] to build a mobile-based ios application that allows users to enter information and view system predictions, resulting in a fast and accurate interface for consumers who value speed and accuracy. The study emphasizes the importance of making the IOS system more efficient in terms of time. The XGboost machine learning algorithm yielded an efficiency of up to 72.70 percent. Logistic regression had 72.39 percent efficiency, decision trees had 62.87 percent efficiency, and random forest had 69.18 percent efficiency.

3. DATASET DESCRIPTION

In the heart disease database, there are a total of 303 records from UCI Repository. The total records are divided into two datasets, one for training and the other for testing. The training dataset contains 70% (212) records and the testing dataset contains 30% (91). Although there are 76 attributes in this database, all published experiments only use 14 of them. The presence of heart disease in the patient is indicated by the "goal" field. It has a value of 0 (no presence) to 4 (there is no presence). The patients' names and social security numbers were recently removed from the database, and dummy values were added in their place.

4. CLASSIFICATION METHODS

4.1 Logistic Regression

One of the most common machine learning algorithms is logistic regression. The goal of logistic regression is to estimate event probabilities, which includes establishing a link between features and the likelihood of specific outcomes. It's one of the most widely used machine learning algorithms, and it can be applied to a variety of classification problems such as spam detection, diabetes prediction, cancer detection, and so on.

Pseudocode for Logistic Regression:

- Set the following as the first step:

The cost function's acceptable

threshold is Ɛ

Maximum Number of EpochsN_{max}

N. Number of Epochs

Create an Augmented Weight Matrix

with a value of 1 as the starting Point.

Set J(θ) to 0 to start the Cost Function.

- For input features, choose a mapping function.
- Utilize the Augmented Weight Matrix to update the weight matrix.

$$\theta_{1(n)=}\theta_{1(n-1)\}+}\alpha.u_j$$

- Using the formula)) + (1-)))), find the Cost Function or Average Cost J( )

$$J(\theta) = J(\theta) + \left(-\frac{1}{m}\right)(\sum_{i=1}^{m} y^{(i)} \log(h_{\theta(} x^{(i)})) + (1\text{-}y^{(i)}) \log(1h_{\theta(} x^{(i)})))$$

- If $N=N_{max}$, go to Step 3 to update the Augmented weight Matrixθ.
- Obtain optimal weights forθ.

4.2 K-Nearest Neighbour

Levy The K-Nearest Neighbour algorithm, which is based on the Supervised Learning technique, is Machine learning one of the most basic algorithms. It takes the new case-data and the current case into consideration and assigns the new case to the most similar category to the existing category. All available data are saved by the K-NN algorithm and categorized as new data points based upon similarities. This means that the K-NN algorithm can classify it quickly when new data are generated. The KNN can be used for regression or classification and the classification is the most common application. It's an algorithm that is not parametrical, meaning no data assumptions can be made. It is also called a lazy learner algorithm since it doesn't immediately begin to learn from the training set; instead it stores and uses the dataset to classify.

- Make a copy of the ECG data and store it on your computer.
- Train a k-nearest neighbour classifier on EEG data, where k denotes the number of predictors that have the same number of nearest neighbours.
- Ensure the consistency of non-categorical predictor data.
- Find the k most closely related training set instances using a distance metric.
- Among the k closest instances, the Resulting Class is the most common class label.

During the training phase, the KNN algorithm simply saves the dataset and then classifies new data into a category that is very similar to the old data.

4.3 Decision Tree

Decision trees are, by their simplicity and practicality, one of the most widely used data classification techniques. Decision trees is a division and conquer classifier built recursive partition top-down. The classification tree for the study was created by CART. CART is a common tree structure statistical procedure which can produce classification or regression trees depending on whether the categorical or numerical variable is dependent on the tree structures. For each internal node, it builds binary trees with two outgoing edges. This is done using the binary recursive partitioning process, an iterative process in which data is split into partitions and split on each branch further.

- Create a classification tree using the ECG data set
- Default values tend to grow deep trees in large sample sizes in training.
- For training of a classification tree use the default tree depth control settings.
- Set the variables of the predictor to a common set of values.
- Total tree splits established
- Because of the value of the minimum size, division may stop prior to the maximum number of divisions;

Since a decision tree is a test hierarchy, it usually involves passing the example through all branches of the node where the unknown feature value is identifying, each branch producing a class distribution. Since a decision tree is an unknown function value. The result is a total of the different classes.

4.4 Support Vector Machine

Support Vector Machines work by putting a "boundary" on either side of a hyperplane, dividing five different classes of data. It has been shown that the expected generalization error is reduced by increasing the scope and thus creating the greatest distance possible between the hyper separator and the instances on both sides. Despite the possibility of the SVM selecting from a variety of candidate hyper planes with a maximum margin, misclassified instances can prevent SVM from finding a different hyper plane for several datasets.

- Open your computer with the ECG data set. Use the class label as a forecast.
- Use the SVM Classifier Predictor Data.
- Remove the classifier to one of the cells in the cell array.
- To transfer data to an educated SVM model, the SVM Model is used.
- Use range to generate a random number of seed before classifier training.
- Retrain the classificatory for the SVM but with various arguments.
- Choose the model with the least classification error level.

The number of characteristics in training data therefore does not affect an SVM's model complexity (the number of support vectors selected by the SVM learning algorithm is usually small).

4.5 Random Forest

Random Forest is a supervised classification and regression learning technique. The bagging technique is used in the random forest to produce random sample characteristics is only difference is that the process of locating the root knot and the splitting of the node in a random forest is done randomly. Please see the procedures below.

- Load the data, which contains a number of functions representing the behaviour of the dataset.
- This model trains a new sample from the bag sample to create samples (1/3rd of the data), used to determine the unbiased OOB error, and called the bootstrap algorithm or bagging techniques, in order to generate random samples. .
- Determine the node d by using the best split. Distribute the node to smaller nodes.
- Upon finding n trees, repeat steps.

Total votes for the predicting target for each tree. The final prediction of the random forest is the most popular class.

4.6 XGBoost Classifier

The machine learning algorithm XGBoost has recently dominated Kaggle competitions for structured or tabular results. XGBoost, a high-speed and high-performance implementation, is used to create gradient boosted decision trees. Ensemble learners are commonly used in two different ways: tagging and boosting. Though these two methods can be used with a variety of statistical models, decision trees have become the most popular.

Pseudocode of XGBoost:

*Input***:** D: Micro-blog dataset

N: The number of trees in XGBOOST

*Output***:** Discrete data

for i=0; i<D; i++ do

preprocessing the data

text participle

end for

While LDA does not converge *do*

extraction text subject individuality

end while

extracting user uniqueness U, Constructing union feature C

for i=0; i<D; i++ do

using XGBOOST to discretize the feature

end for

5. PERFORMANCE ANALYSIS AND EVALUATION

5.1 Performance Analysis

A number of performance metrics are used to validate the segmentation. To assess performance, the segmentation results of an image are compared to the image's ground truth. The proposed works' performance evaluations are simulated in MATLAB in a Windows environment. This framework is tested using a heart disease dataset from the UCI machine learning repository. The algorithm is fed a heart disease dataset, which is divided into training and test data. The neural network's training set accounts for 70% of the total dataset, while the testing set accounts for 30%.

5.2 Performance Evaluation

This is a method that is used to quantify results.

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN}$$

$$\text{Recall} = \frac{TP}{TP+FN}$$

$$\text{Precision} = \frac{TN}{TN+FP}$$

$$F_1 = 2 * \frac{precision * recall}{Precision + recall}$$

- The recall rate, also known as the true positive rate (TP), is the percentage of correctly detected positive cases.
- The false-positive rate (FP) is the proportion of cases reported as positive when they were actually negative.
- The proportion of correctly classified negative cases is known as the true negative rate (TN).
- The false-negative rate (FN) refers to the number of positive cases that were reported as negative when they were not.
- The percentage of correct predictions out of a total number of correct predictions is called accuracy (AC).
- The percentage of true positive cases that are correctly reported is referred to as sensitivity or recall.
- Accuracy refers to how many true negative cases are reported correctly.
- The F1 Score, also referred to as the F Score or the F Measure, is equal to 2* ((precision*recall) / (precision + recall))

6. RESULTS AND DISCUSSION

Figure II: Cholesterol Wise Heart Disease Risk

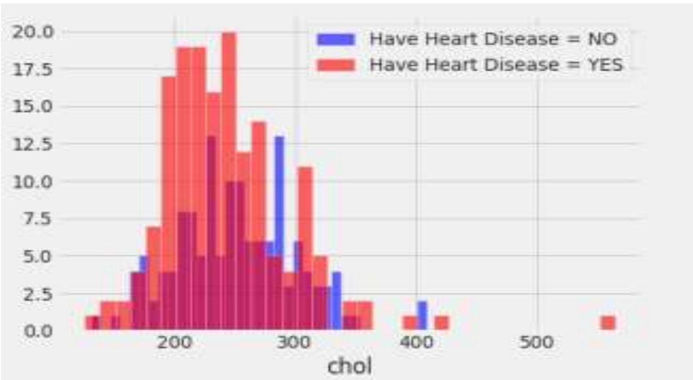


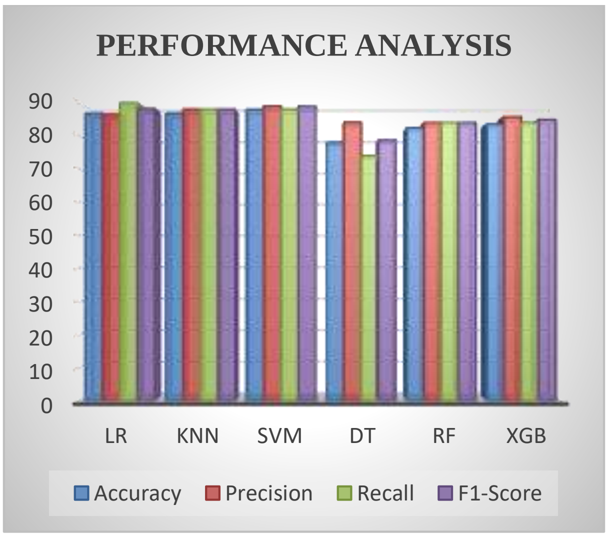
Table I: Performance Metrics Report of Classifiers

Classifiers	Accuracy	Precision	Recall	F1-Score
LR	86.81	86.54	90	88.24
KNN	86.81	88	88	88
SVM	**87.91**	**89**	**88**	**88.89**
DT	78.02	84.09	74	78.72
RF	82.42	84	84	84
XGB	83.52	85.71	84	84.85

The above Table I depicts **Support Vector Machine** obtain higher accuracy compare with other algorithms like Logistic Regression, K-Nearest Neighbour, Decision Tree, Random Forest Classifier, XG Boost Classifier.

Figure III: Training and Testing Level Accuracy of Classifiers

Figure IV: Overall Report of Accuracy Wise Classifiers



The above chart Figure IV shows the overall performance of the all algorithms. We conclude that **Support Vector Machine** got best performance compare with other algorithms.

7. CONCLUSION

The overall goal of our research is to compare the results to heart disease detection in order to better predict the presence of heart disease. Heart disease datasets from the UCI repository are used in this implementation work to get more accurate results. Machine learning classification techniques algorithms were compared based on the work that was reviewed, including Logistic Regression with a classification accuracy of Training is 86.79 percent and Testing is 86.81 percent, K-Nearest Neighbor with a classification accuracy of Training is 86.79 percent and Testing is 86.81 percent, and Support Vector Machine with a classification accuracy of Training is 93.4 percent and Testing is 93.4 percent. Training has a classification accuracy of 100 percent, while Testing has a classification accuracy of 78.02 percent. Random Forest Classifier Model has a classification accuracy of 100% for Training and 82.42 percent for Testing, while XGBoost Classifier Model has a classification accuracy of 98.58 percent for Training and 83.52 percent for Testing. Support Vector Machine classification provides training and testing level accuracy, resulting in more accurate results. Based on the results of this paper's implementation, it was discovered that Support Vector Machine classification provides smart accurate results with good accuracy. As a result, an implementation of the support vector machine classification algorithm will be helpful in continuing the research effectively.

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