International Journal of Aquatic Science
ISSN: 2008-8019
Vol 14, Issue 01, 2023

Efficient Approach for Detecting Cardiovascular Disease Using Machine Learning

Dikshant Pardeshi[1], Prince Rawat[2], Akshaan Raj[3], Prasanna Gadbail[4], Ram Kumar Solanki[5], Dr. Pawan R. Bhaladhare[6]

[1,2,3,4]B.Tech (Scholar), School of Computer Science & Engineering , Sandip University , Nashik , India
[5]Assistant Professor , School of Computer Science & Engineering , Sandip University , Nashik , India
[6]Professor, School of Computer Science & Engineering, Sandip University , Nashik , India

Email: *[1]dikshantpardeshi.dp.99@gmail.com, [2]dikshantpardeshi.dp.99@gmail.com, [3]Princer2607@gmail.com,[4]prasannagadbail@icloud.com, [5]akshaanjraj@gmail.com, [6]ramkumar.solanki@sandipuniversity*.edu.in

Abstract: Machine learning involves artificial intelligence, and it is used in solving many problems in data science. One common application of machine learning is the prediction of an outcome based on existing data. The machine learns patterns from the existing dataset and then applies them to an unknown dataset in order to predict the outcome. Classification is a powerful machine-learning technique that is commonly used for prediction. Some classification algorithms predict with satisfactory accuracy, whereas others exhibit limited accuracy. This project investigates a method termed ensemble classification, which is used for improving the accuracy of weak algorithms by combining multiple classifiers. Experiments with this tool were performed using a heart disease dataset. A comparative analytical approach was done to determine how the ensemble technique can be applied for improving prediction accuracy in heart disease. The focus of this project is not only on increasing the accuracy of weak classification algorithms but also on the implementation of the algorithm with a medical dataset, to show its utility to predict disease at an early stage. The results of the project indicate that with ensemble techniques such as stacking and by using feature selection we can improve the prediction accuracy of weak classifiers and exhibit satisfactory performance in identifying risk of heart disease.

1. INTRODUCTION

Cardiovascular Diseases (CVDs) are the number 1 cause of death globally: more people die annually from CVDs than from any other cause. An estimated 17.9 million people died from CVDs in 2016, representing 31% of all global deaths. Of these deaths, 85% are due to heart attack and stroke. Over three-quarters of CVD deaths take place in low- and middle-income countries. Out of the 17 million premature deaths (under the age of 70) due to noncommunicable diseases in 2015, 82% are in low- and middle-income countries, and 37% are caused by CVDs. Most cardiovascular diseases can be prevented by addressing behavioral risk factors such as tobacco use, unhealthy diet and obesity, physical inactivity, and harmful use of alcohol using population-wide strategies. People with cardiovascular disease or who are at high cardiovascular risk (due to the presence of one or more risk factors such as hypertension, diabetes, hyperlipidaemia, or already established disease) need early detection and management using counselling and medicines, as appropriate. It is difficult to manually determine the odds of getting heart disease based on risk factors. However, machine learning techniques are useful to predict the output from existing data. Hence, this paper applies one such machine learning technique called classification for predicting heart disease risk from the risk factors. It also tries to improve the accuracy of predicting heart disease risk using a strategy termed ensemble. However, using data mining techniques can reduce the number of tests that are required. In order to reduce heart disease there has to be a quick and efficient detection technique. Decision Tree is one of the effective data mining methods used. This research compares different Decision Tree classification algorithms seeking better performance in heart disease diagnosis. The algorithms which are tested are the SVM algorithm, K Nearest Neighbour algorithm, and Random Forest algorithm.

Background: Cardiovascular disease (CVDs) is the leading cause of death worldwide which counts for about 31% of all global deaths. The heart is a muscular organ cone-shaped that contracts at regular intervals to supply the blood to the different organs of the body [1], [7], [8], [9]. The heart attack occurs due to the blockage in a coronary artery that supplies the blood and oxygen to the heart itself as shown in Fig. 1. Unhealthy diet, hypertension, smoking, and other lifestyle changes are the main cause of CVDs.
The motivation for creating a heart disease prediction website can stem from several factors, including the desire to address a significant health concern, provide valuable information and resources to the public, and potentially save lives. Here are some key motivations behind the development of such a website: Machine learning techniques have been around us and have been compared and used for analysis for many kinds of data science applications. The major motivation behind this research-based project was to explore the feature selection methods, data preparation, and processing behind the training models in machine learning. With first-hand models and libraries, the challenge we face today is data where besides their abundance, and our cooked models, the accuracy we see during training, testing, and actual validation has a higher variance. Hence this project is carried out with the motivation to explore the models. Furthermore, as the whole machine learning is motivated to develop an appropriate computer-based system and decision support that can aid in the early detection of heart disease, in this project we have developed a model which classifies if the patient will have heart disease or not based on various features (i.e. potential risk factors that can cause heart disease). Hence, the early prognosis of cardiovascular diseases can aid in making decisions on lifestyle changes in high-risk patients and reduce complications, which can be a great milestone in medicine.
Early detection of cardiovascular disease can be the difference between life and death. By being cognizant of the early signs of CVD, you'll have a better chance of catching threats early on. When a person has risk factors, their doctor can refer them to a cardiologist for further testing. Some metrics like Blood Pressure, glucose level, age, BMI value, physical exercise, smoking, and alcohol history can be used to predict the risk of heart disease for an individual. Cardiovascular diseases (CVD) are among the most common serious illnesses affecting human health. CVDs may be prevented or mitigated by early diagnosis, and this may reduce mortality rates. Identifying risk factors using machine learning models is a promising approach.

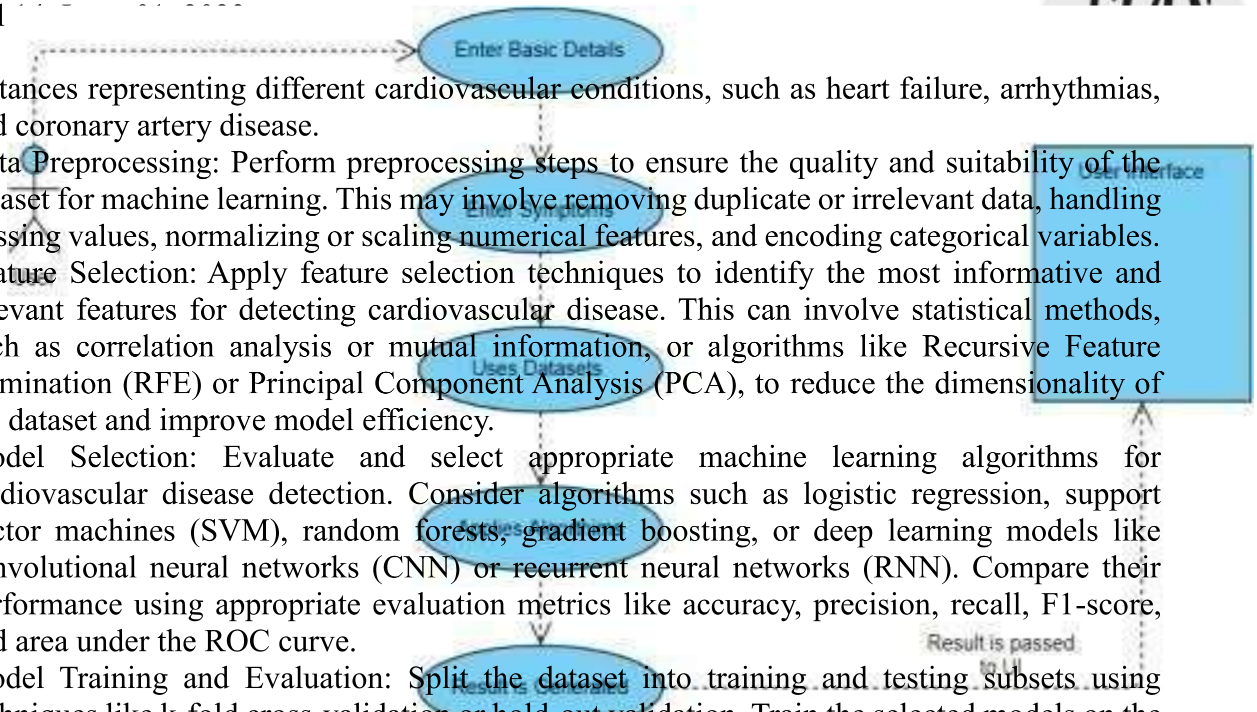
Literature Review: In paper [1], An Enhanced Random Forests Approach to Predict Heart Failure From Small Imbalanced Gene Expression Dat we applied a Random Forests classifier enhanced with features elimination to microarray gene expression of 111 patients diagnosed with STEMI and measured the employed to predict heart failure achieved MCC = +0.87 and

ROC AUC = 0.918, and our analysis identified KLHL22, WDR11, OR4Q3, GPATCH3, and FAH as top five protein-coding genes related to heart failure.
This paper [2], Classification and Detection of Heart Rhythm Irregularities using Machine Learning This paper explores the use of deep neural networks for the task of classifying ECG recordings using recurrent and residual architectures. The proposed method was tested on an ECG dataset of 162 patients' readings that consist of three classes including normal sinus rhythm, cardiac arrhythmia, and congestive heart failure. Results show that the proposed LSTM method has 4 hidden layers and an optimization function as Adam gives maximum accuracy of 99.12% in comparison to other methods.
In this paper [3], Comparative Study of Optimum Medical Diagnosis of Human Heart Disease Using ML Technique With and Without Sequential Feature Selection To predict cardiac disease, researchers employed a variety of algorithms including LDA, RF, GBC, DT, SVM, and KNN, as well as the feature selection algorithm sequential feature selection support vector classifier sfs and Linear Discriminant Analysis have declining accuracy of 100% 98.70%, 97.73%, 94.81%, 90.58%, and 84.09%respectively.
In this paper [4], Early Detection of Late-Onset Sepsis in Premature Infants Using Visibility Graph Analysis of Heart Rate Variability This study was designed to test the diagnostic value of visibility graph features derived from the heart rate time series to predict late-onset sepsis (LOS) in preterm infants using machine learning. Methods: The heart rate variability (HRV) data was acquired from 49 premature new-borns hospitalized in neonatal intensive care units (NICU). The best performance for detecting LOS was obtained with logistic regression, using the feature set including visibility graph features, with AUROC of 87.7% during the six hours preceding the start of antibiotics, and with predictive potential (AUROC above 70%)as early as 42 h before the start of antibiotics.
In this paper [5] Efficient Medical Diagnosis of Human Heart Diseases Using Machine Learning Techniques With and Without GridSearchCV In this paper, various Machine Learning algorithms such as LR, KNN, SVM, and GBC, together with the GridSearchCV, predict cardiac disease. The system uses a 5-fold cross-validation technique for verification. A comparative study is given for these four methodologies. the analysis that the Extreme Gradient Boosting Classifier with GridSearchCV gives the highest and nearly comparable testing and training accuracies of 100% and 99.03% for both the datasets

To summarise the findings of these papers: These studies examine how machine learning methods can be used to identify and forecast heart-related problems. In a study [1], a Random Forests classifier was improved using gene expression data from ST-elevation myocardial infarction (STEMI) patients, resulting in a strong predictive performance for heart failure. Deep neural networks were employed in Paper [2] to identify ECG recordings, and the LSTM approach that was suggested had a high accuracy of 99.12%. LDA performed the best when a comparison of different machine learning algorithms for the identification of heart diseases was made in Paper [3]. Last but not least, research [4] used logistic regression to predict late-onset sepsis in preterm newborns using visibility graph analysis of heart rate variability data.

2. METHODOLOGY AND IMPLEMENTATION

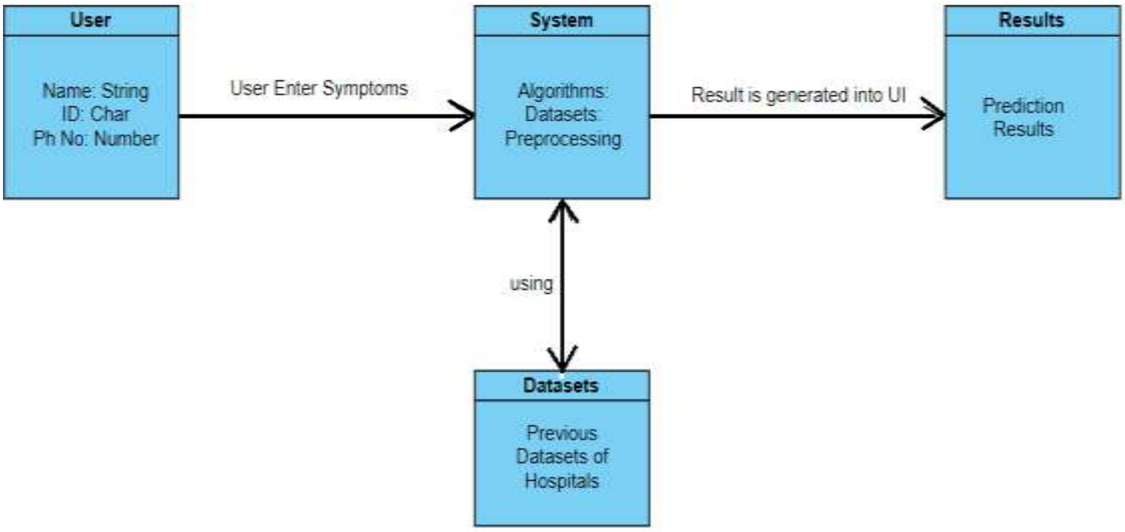
Methodology for an Effective Machine Learning Approach to Cardiovascular Disease Detection:
Data Collection: Obtain a comprehensive and diverse dataset containing relevant features and labels related to cardiovascular disease. This dataset should include a sufficient number of

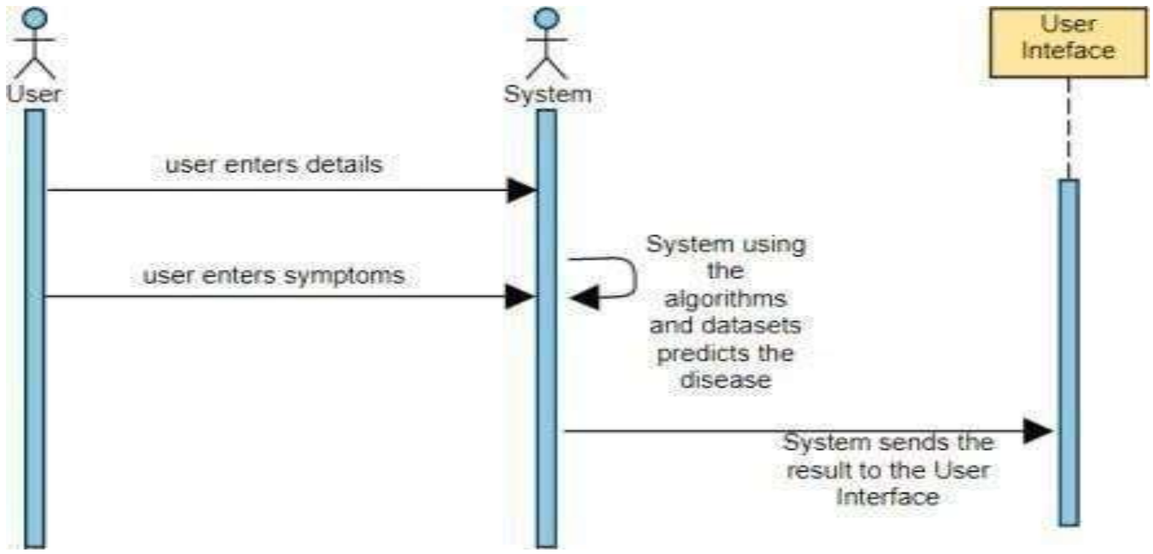


instances representing different cardiovascular conditions, such as heart failure, arrhythmias, and coronary artery disease.
Data Preprocessing: Perform preprocessing steps to ensure the quality and suitability of the dataset for machine learning. This may involve removing duplicate or irrelevant data, handling missing values, normalizing or scaling numerical features, and encoding categorical variables.
Feature Selection: Apply feature selection techniques to identify the most informative and relevant features for detecting cardiovascular disease. This can involve statistical methods, such as correlation analysis or mutual information, or algorithms like Recursive Feature Elimination (RFE) or Principal Component Analysis (PCA), to reduce the dimensionality of the dataset and improve model efficiency.
Model Selection: Evaluate and select appropriate machine learning algorithms for cardiovascular disease detection. Consider algorithms such as logistic regression, support vector machines (SVM), random forests, gradient boosting, or deep learning models like convolutional neural networks (CNN) or recurrent neural networks (RNN). Compare their performance using appropriate evaluation metrics like accuracy, precision, recall, F1-score, and area under the ROC curve.
Model Training and Evaluation: Split the dataset into training and testing subsets using techniques like k-fold cross-validation or hold-out validation. Train the selected models on the training data and fine-tune their hyperparameters using techniques like grid search or random search. Evaluate the models on the testing data to assess their performance and select the model with the highest accuracy or the most suitable trade-off between different metrics.

Model Optimization: Further optimize the selected model by fine-tuning its parameters, exploring ensemble methods, or applying advanced techniques like regularization, dropout, or data augmentation to enhance generalization and prevent overfitting. Continuously monitor and fine-tune the model's performance based on evaluation results.
Deployment and Validation: Deploy the trained model into a real-world cardiovascular disease detection system, considering factors such as computational efficiency, scalability, and interpretability. Validate the model's performance on new, unseen data to ensure its reliability and effectiveness in practical applications.
Continual Improvement: Regularly update and retrain the model using new data to adapt to emerging patterns and improve its accuracy and robustness over time. Stay updated with the latest research and advancements in machine learning techniques for cardiovascular disease detection to incorporate any relevant improvements into the system.

International Journal of Aquatic Science
ISSN: 2008-8019
Vol 14, Issue 01, 2023





Dataset: Instances/Examples: Each instance or example in the dataset represents a specific data point or observation. For example, in a heart disease prediction dataset, each instance may represent a patient and their associated features such as age, gender, cholesterol level, etc.

Features/Attributes: Features or attributes are the individual properties or characteristics of each instance. They provide the information that the machine learning model will use to make predictions. In the heart disease prediction dataset, features could include age, gender, blood pressure, cholesterol level, etc.

Labels/Targets: In supervised learning, datasets often include labels or targets that represent the desired output or prediction for each instance. For heart disease prediction, the label could indicate the presence or absence of heart disease. These labels are used during the training phase to guide the learning process and evaluate the model's performance.

Training, Validation, and Test Sets: Datasets are typically divided into subsets for different purposes. The training set is used to train the machine learning model, the validation set is used to fine-tune hyperparameters and assess performance during model development, and the test set is used to evaluate the final model's performance on unseen data.

Data Preprocessing: Datasets may require preprocessing steps to handle missing values, normalize or scale features, encode categorical variables, or remove outliers. Preprocessing ensures that the data is in a suitable format for training and testing the machine learning model.

Building Model

Applying Algorithms and models:

Decision tree Decision tree is a tree-like structure that classifies instances by sorting them based on the values of the variables. Each node in a decision tree represents a variable, and each branch represents a value that the node can assume. Instances are classified starting at the root node and sorted based on the values of the variables. The variable that best divides the dataset would be the root node of the tree. Internal nodes (or split nodes) are the decision-making part that make a decision, based on multiple algorithms and to visit subsequent nodes. The split process is terminated when a userdefined criteria is reached at the leaf (for the present modeling, we left it to be the default value, which is 20). The paths from root nodes to the leaf nodes represent classification rules.

Random forest Random forest is an ensemble model consisting of multiple regression trees like in a forest. Random forest combines several classification trees, trains each one on a slightly different set of the dataset instances, splitting nodes in each tree considering a limited number of the variables. The final predictions of the random forest are made by averaging the predictions of each individual tree, which enhances the prediction accuracy for unseen data. The number of regression trees chosen for present modeling is (ntree) 500.

Support vector machine In support-vector machine, each data point is plotted in an n-dimensional space with the value of each variable being the value of particular coordinates and classification is performed based on the hyperplane that differentiates the two data classes. Following this, characteristics of new instances can be used to predictthe class to which a new instance should belong.

k-Nearest neighbor k-Nearest neighbor (kNN) is one of the most basic and nonparametric algorithms, it does not make any assumptions about the distribution of the underlying data. The algorithm is based on the principle of Euclidean distance that is the instances within a dataset generally exist in close proximity to other instances that have similar properties. If the instances are tagged with a classification label, then the value of the label of an unclassified instance can be determined by observing the class of its nearest neighbors. For the present modeling, the whole process is repeated three times (repeats = 3) each with a k value of 10 (number = 10) and taking the average of the three iterations.

Logistic Regression Logistic regression is a widely used algorithm for binary classification tasks. It models the relationship between input variables and the probability of a specific outcome (e.g., presence or absence of heart disease) using a logistic function. Logistic regression provides interpretable coefficients and can handle both categorical and continuous features.

XGBoost (Extreme Gradient Boosting) XGBoost is a popular machine learning algorithm that belongs to the family of gradient boosting methods. It is known for its efficiency, scalability, and high predictive performance. XGBoost has been successfully applied to various domains, including heart disease prediction.

Heart Disease Dataset

The "Heart Disease Dataset" is a commonly used dataset for heart disease prediction. Here is an overview of the dataset:

DatasetName:Heart Disease Dataset (UCI Machine Learning Repository)Description:

The Heart Disease Dataset contains 14 attributes that can be used to predict the presence or absence of heart disease. It was compiled by combining data from four different institutions and includes a total of 303 samples. Each sample represents a patient and is associated with several features, including demographic information, medical history, and diagnostic test results.

Features:

Age: Age of the patient (numeric)

Sex: Gender of the patient (1 = male, 0 = female)

Chest Pain Type: Type of chest pain experienced by the patient(0 to 3) **Resting Blood Pressure:** Resting blood pressure in mm Hg (numeric) **Cholesterol:** Serum cholesterol level in mg/dl (numeric)

Fasting Blood Sugar: Fasting blood sugar > 120 mg/dl (1 = true, 0 = false)

Resting Electrocardiographic Results: Results of resting electrocardiogram (ECG) (0 to 2)

Maximum Heart Rate Achieved: Maximum heart rate achieved during exercise (numeric)

Exercise-Induced Angina: Exercise-induced angina (1 = yes, 0 = no)

ST Depression Induced by Exercise Relative to Rest: ST depression induced by exercise relative to rest (numeric)

Slope of the Peak Exercise ST Segment: Slope of the peak exercise ST segment (0 to 2)

Number of Major Vessels Colored by Fluoroscopy: Number of major vessels colored by fluoroscopy (0 to 3)

Thalassemia: Type of thalassemia (0 to 3)

Target: Presence of heart disease (0 = no heart disease, 1 to 4 = different levels of heart disease severity)

The dataset has been preprocessed, and some of the values have been converted into categorical representations. The target variable indicates the presence of heart disease, with values ranging from 0 to 4 to represent different levels of disease severity.

Module Design

Model design refers to the process of designing a mathematical representation of a system or process that can be used to make predictions or decisions. A model is a set of rules or algorithms that can be trained on a dataset to learn patterns and relationships in the data, and then used to make predictions or decisions on new, unseen data.

Module 1

Module name :- Dataset Training

Functionality :- A training dataset is a dataset of examples used during the learning process and is used to fit the parameters. Data Collection is a process of gathering and measuring information on targeted variables in a systematic way. Formal data collection process is required as it ensures the data is defined and accurate so that the decisions based on the data are valid. The data required for the heart disease is the clinical data which vary from each individual.

Input :- Datasets containing activity data , and other health data Output :- Train the Machine

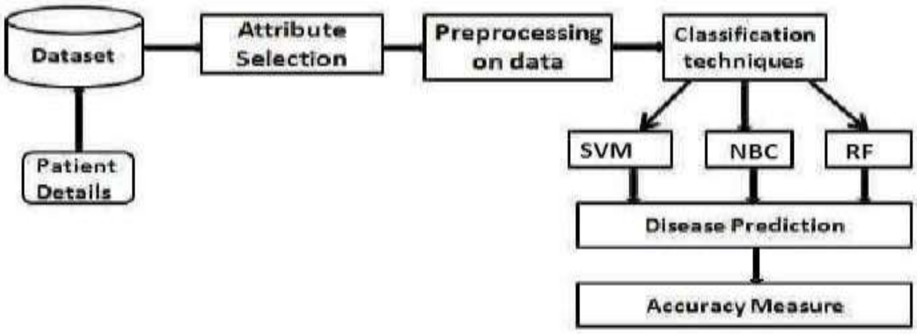
Module 2
Module name :- Data Pre processing Module
Functionality:- The Preprocessing of genetic data includes the following: Data Transformation Normalization: scaling the values to a specific range.• Aggregation: assigning probabilistic valuesto the genes.• Construction: replacing or adding new genes inferred by the existing genes•
Input:- Datasets
Output:- Searching for a lower dimensional space that can best represent the data. Removing the irrelevant data from the genome dataset. Sampling can be used to simplify the process of classification using small dataset.

Module 3
Module name :- Data Synthesization
Functionality:- The collected data were synthesized to remove irrelevant features. For example, the ID column was irreverent to develop a prediction model, thus it was removed. To handle null values, list wise deletion technique was applied where a particular observation was deleted if ithad one or more missing values. Then to extract unnecessary features from the dataset, decision tree algorithm was used. Input:- Pre processed Data
Output:- Labelled Data

Module 4
Module name :- prediction models
Functionality:- With the classified dataset (training dataset) the test data can be predicted for heart disease. And the corresponding positive and negative predictions with their probabilities areobtained. To generate prediction of heart disease, naïve bayes , PCA algorithms had been developed and their accuracy was tested. After attaining results from various types of supervised learning like Linear Input:- Data Input to Algorithms
Output:- Prediction

Module 5
Module name :- Ensemble Model
Functionality:- Ensemble learning is a general meta approach to machine learning that seeks betterpredictive performance by combining the predictions from multiple models.Although there are a seemingly unlimited number of ensembles that you can develop for your predictive modeling problem, there are three methods that dominate the field of ensemble learning. So much so, that rather than algorithms per se, each is a field of study that has spawned many more specialized methods.
The three main classes of ensemble learning methods are bagging, stacking, and boosting, and it isimportant to both have a detailed understanding of each method and to consider them on your predictive modeling project.

Input:- Fitting the model
Output:- Prediction and Classification with knn



3. RESULT , DISCUSSION & FUTURE SCOPE

A web application is developed as the front end to display the results of whether the selected signal is of a patient having arrhythmia or not. The web application is integrated with the machine learning python code using the flask module provided by keras and corresponding trained model is extracted from the code using job lib module as a pickle file. The following snapshots show the web application designed using HTML and CSS and JavaScript.

Fig 1 Home Page

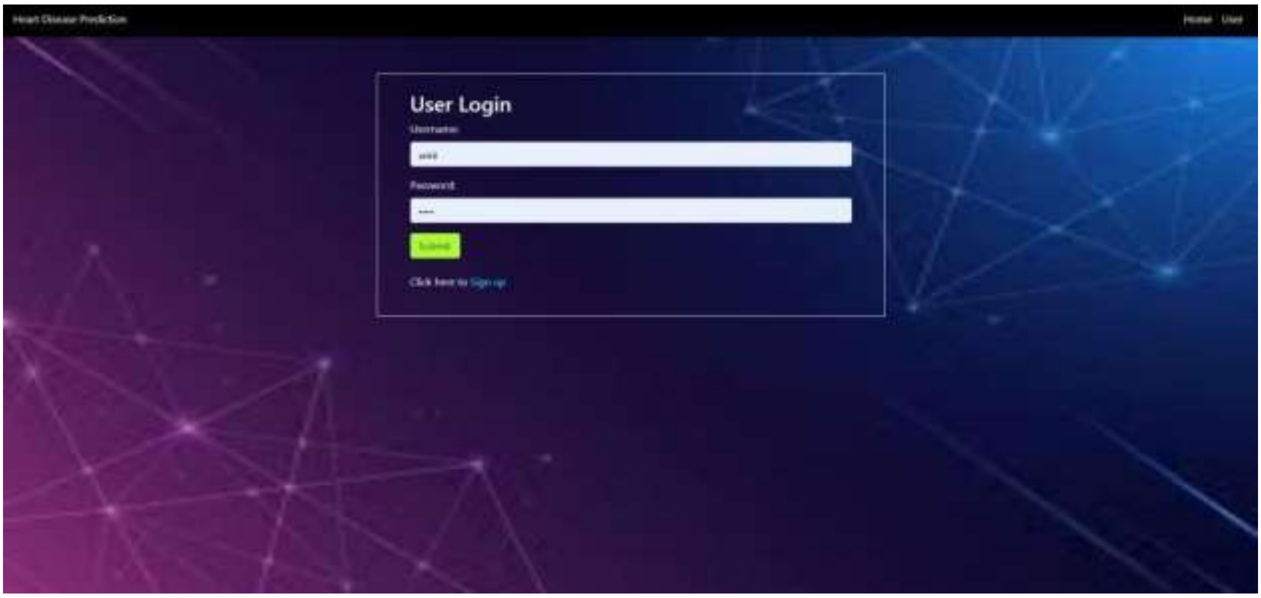
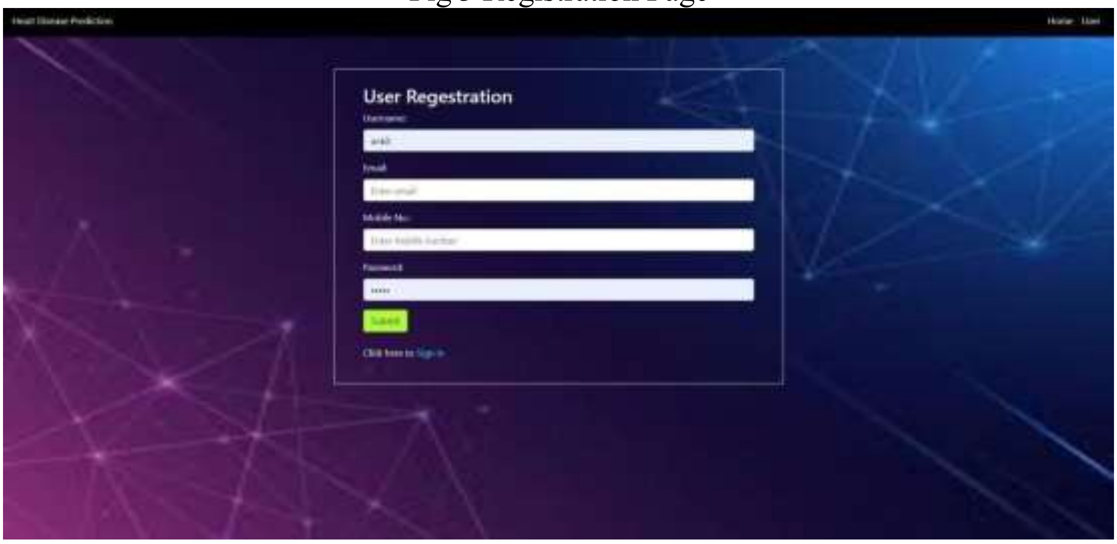


Fig 2 Login Page

Fig 3 Registration Page



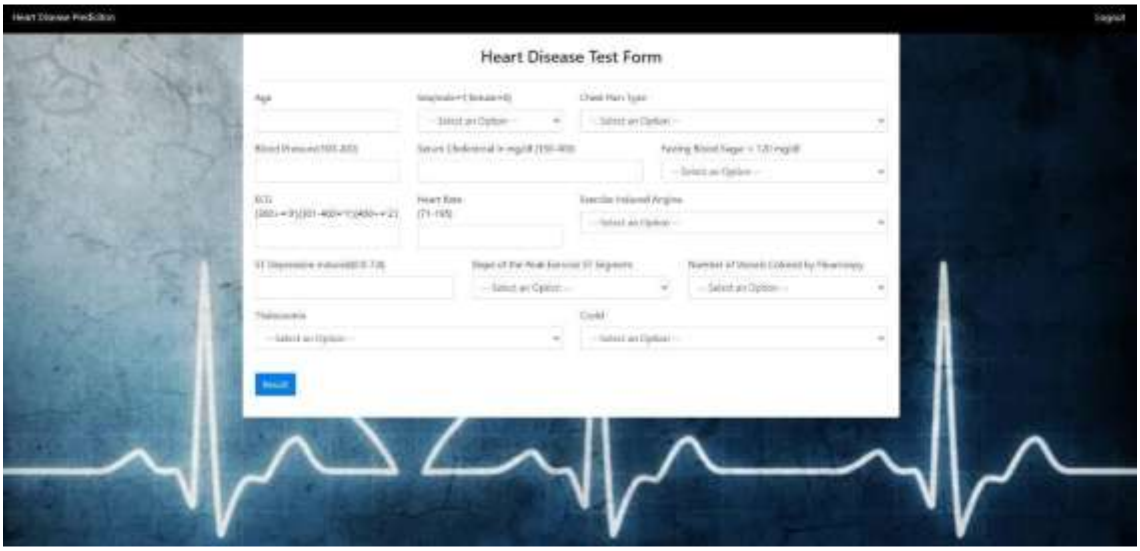


Fig 4 Attributes Page

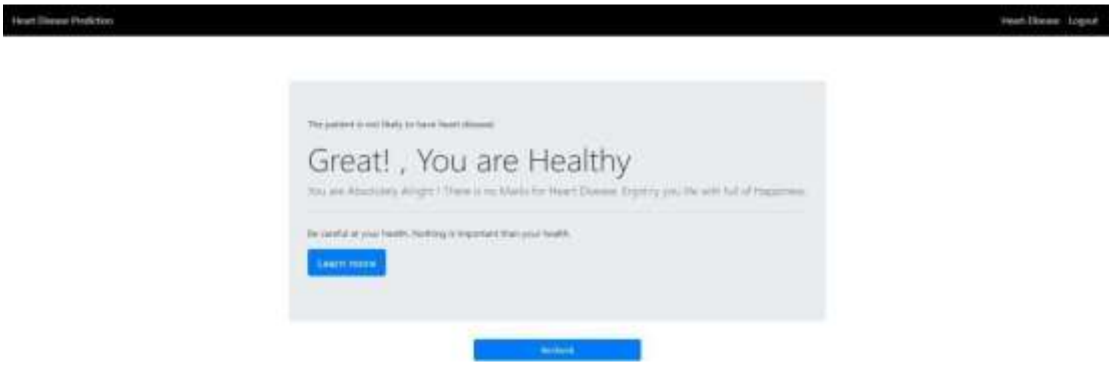


Fig 5 Output Page

4. CONCLUSION

Cardiovascular diseases in the medical field, machine learning algorithms and techniques can be used to predict various heart diseases. The main goal of this model is to provide a tool for doctors to detect heart disease at an early stage. Here, This model will help to prevent and detect the patients earlier from the cardio disease. This component will help in predicting the severity of the heart stroke/cardiovascular disease. After the successful model user will input data, the weights will be cross checked with the given inputs. The prediction of this heart disease system will consist of 13 attribute values that will be input to the system. By format considering all the risk factors whether they lie in the criteria as per the model is trained. Future work in heart disease prediction using machine learning can focus on several areas to improve accuracy, interpretability, and clinical applicability. Here are some potential avenues for future research and development:

Incorporating Advanced Feature Selection Techniques: Explore advanced feature selection methods to identify the most relevant features for heart disease prediction. Techniques like genetic algorithms, recursive feature elimination, or feature importance ranking can help prioritize informative features and reduce dimensionality.

Handling Imbalanced Data: Develop techniques to address class imbalance issues in heart disease datasets, where the number of samples in different classes may be disproportionate.

Techniques like oversampling, undersampling, or hybrid approaches can be explored to handle imbalanced data and improve the model's ability to predict both positive and negative cases accurately.

5. REFERENCES

[1] ABDALLAH ABDELLATIF 1, (Member, IEEE), HAMDAN ABDELLATEF An Effective Heart Disease Detection and SeverityLevel Classification Model Using Machine Learning and Hyperparameter Optimization Methods Received March 27, 2022, accepted April 15, 2022, date of publication April 21, 2022, date of current version April 28, 2022.

[2] Tan, J.; Goyal, S.B.; Singh Rajawat, A.; Jan, T.; Azizi, N.; Prasad, M. Anti-Counterfeiting and Traceability Consensus Algorithm Based on Weightage to Contributors in a Food Supply Chain of Industry 4.0. Sustainability 2023, 15, 7855. https://doi.org/10.3390/su15107855

[3] Rajawat, A.S. et al. (2023). Real-Time Driver Sleepiness Detection and Classification Using Fusion Deep Learning Algorithm. In: Singh, Y., Singh, P.K., Kolekar, M.H., Kar, A.K., Gonçalves, P.J.S. (eds) Proceedings of International Conference on Recent Innovations in Computing. Lecture Notes in Electrical Engineering, vol 1001. Springer, Singapore. https://doi.org/10.1007/978-981-19-9876-8_34.

[4] Rajawat, A.S.; Goyal, S.B.; Bedi, P.; Verma, C.; Ionete, E.I.; Raboaca, M.S. 5G-Enabled Cyber-Physical Systems for Smart Transportation Using Blockchain Technology. Mathematics 2023, 11, 679. https://doi.org/10.3390/math11030679

[5] Rajawat, A.S.; Goyal, S.B.; Chauhan, C.; Bedi, P.; Prasad, M.; Jan, T. Cognitive Adaptive Systems for Industrial Internet of Things Using Reinforcement Algorithm. Electronics 2023, 12, 217. https://doi.org/10.3390/electronics12010217.

[6] Nagaraj, S.; Kathole, A.B.; Arya, L.; Tyagi, N.; Goyal, S.B.; Rajawat, A.S.; Raboaca, M.S.; Mihaltan, T.C.; Verma, C.; Suciu, G. Improved Secure Encryption with Energy Optimization Using Random Permutation Pseudo Algorithm Based on Internet of Thing in Wireless Sensor Networks. Energies 2023, 16, 8. https://doi.org/10.3390/en16010008.

[7] R. S. Chouhan et al., "Experimental Analysis for Position Estimation using Trilateration and RSSI in Industry 4.0," 2022 11th International Conference on System Modeling & Advancement in Research Trends (SMART), Moradabad, India, 2022, pp. 904-908, doi: 10.1109/SMART55829.2022.10047276.

[8] Rajawat, A.S. et al. (2023). Real-Time Driver Sleepiness Detection and Classification Using Fusion Deep Learning Algorithm. In: Singh, Y., Singh, P.K., Kolekar, M.H., Kar, A.K., Gonçalves, P.J.S. (eds) Proceedings of International Conference on Recent Innovations in Computing. Lecture Notes in Electrical Engineering, vol 1001. Springer, Singapore. https://doi.org/10.1007/978-981-19-9876-8_34

[9] A. S. Rajawat, S. B. Goyal, P. Bedi, N. B. Constantin, M. S. Raboaca and C. Verma, "Cyber-Physical System for Industrial Automation Using Quantum Deep Learning," 2022 11th International Conference on System Modeling & Advancement in Research Trends (SMART), Moradabad, India, 2022, pp. 897-903, doi: 10.1109/SMART55829.2022.10047730.

[10] A. S. Rajawat et al., "Security Analysis for Threats to Patient Data in the Medical Internet of Things," 2022 11th International Conference on System Modeling & Advancement in Research Trends (SMART), Moradabad, India, 2022, pp. 248-253, doi: 10.1109/SMART55829.2022.10047322.

[11] P. Pant et al., "Using Machine Learning for Industry 5.0 Efficiency Prediction Based on Security and Proposing Models to Enhance Efficiency," 2022 11th International Conference on System Modeling & Advancement in Research Trends (SMART), Moradabad, India, 2022, pp. 909-914, doi: 10.1109/SMART55829.2022.10047387.

[12] P. Pant et al., "AI based Technologies for International Space Station and Space Data," 2022 11th International Conference on System Modeling & Advancement in Research Trends (SMART), Moradabad, India, 2022, pp. 19-25, doi: 10.1109/SMART55829.2022.10046956

[13] Rajawat, A.S.; Goyal, S.B.; Bedi, P.; Simoff, S.; Jan, T.; Prasad, M. Smart Scalable ML-Blockchain Framework for Large-Scale Clinical Information Sharing. Appl. Sci. 2022, 12, 10795. https://doi.org/10.3390/app122110795.

[14] A. S. Rajawat et al., "Visual Cryptography and Blockchain for Protecting Against Phishing Attacks on Electronic Voting Systems," 2022 International Conference and Exposition on Electrical And Power Engineering (EPE), Iasi, Romania, 2022, pp. 663-666, doi: 10.1109/EPE56121.2022.9959765.

[15] A. S. Rajawat et al., "Electrical Fault Detection for Industry 4.0 using Fusion deep Learning Algorithm," 2022 International Conference and Exposition on Electrical And Power Engineering (EPE), Iasi, Romania, 2022, pp. 658-662, doi: 10.1109/EPE56121.2022.9959762.

[16] Rajawat, Anand Singh and Chauhan, Chetan and Goyal, S B and Bhaladhare, Pawan R and Rout, Dillip and Gaidhani, Abhay R, Utilization Of Renewable Energy For Industrial Applications Using Quantum Computing (August 11, 2022). Available at SSRN: https://ssrn.com/abstract=4187814 or http://dx.doi.org/10.2139/ssrn.4187814

[17] Anand Singh Rajawat, Pradeep Bedi, S. B. Goyal, Sandeep Kautish, Zhang Xihua, Hanan Aljuaid, Ali Wagdy Mohamed, "Dark Web Data Classification Using Neural Network", Computational Intelligence and Neuroscience, vol. 2022, Article ID 8393318, 11 pages, 2022. https://doi.org/10.1155/2022/8393318.

[18] Piyush Pant, Anand Singh Rajawat, S.B. Goyal, Pradeep Bedi, Chaman Verma, Maria Simona Raboaca, Florentina Magda Enescu, Authentication and Authorization in Modern Web Apps for Data Security Using Nodejs and Role of Dark Web, Procedia Computer Science, Volume 215, 2022, Pages 781-790, ISSN 1877-0509, https://doi.org/10.1016/j.procs.2022.12.080.

[19] Robin Singh Chouhan, Anand Singh Rajawat, SB Goyal, Pradeep Bedi , AI-Enabled Augmented Reality-Based Shared Collaborative Experience, Book AI-Enabled Multiple-Criteria Decision-Making Approaches for Healthcare Management Pages 85-96 Publisher IGI Global.

[20] Anand Singh Rajawat, Pradeep Bedi, S. B. Goyal, Piyush Kumar Shukla, Atef Zaguia, Aakriti Jain, Mohammad Monirujjaman Khan, "Reformist Framework for Improving Human Security for Mobile Robots in Industry 4.0", Mobile Information Systems, vol. 2021, Article ID 4744220, 10 pages, 2021. https://doi.org/10.1155/2021/4744220

[21] S. Srivastava and R. Kumar, "Indirect method to measure software quality using CK-OO suite," 2013 International Conference on Intelligent Systems and Signal Processing (ISSP), 2013, pp. 47-51, doi: 10.1109/ISSP.2013.6526872.

[22] Ram Kumar, Gunja Varshney , Tourism Crisis Evaluation Using Fuzzy Artificial Neural network, International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-1, Issue-NCAI2011, June 2011

[23] Ram Kumar, Jasvinder Pal Singh, Gaurav Srivastava, "A Survey Paper on Altered Fingerprint Identification & Classification" International Journal of Electronics

Communication and Computer Engineering Volume 3, Issue 5, ISSN (Online): 2249–071X, ISSN (Print): 2278– 4209

[24] Kumar, R., Singh, J.P., Srivastava, G. (2014). Altered Fingerprint Identification and Classification Using SP Detection and Fuzzy Classification. In: , et al. Proceedings of the Second International Conference on Soft Computing for Problem Solving (SocProS 2012), December 28-30, 2012. Advances in Intelligent Systems and Computing, vol 236. Springer, New Delhi. https://doi.org/10.1007/978-81-322-1602-5_139

[25] Gite S.N, Dharmadhikari D.D, Ram Kumar,” Educational Decision Making Based On GIS” International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-1, Issue-1, April 2012.

[26] Ram Kumar, Sarvesh Kumar, Kolte V. S.,” A Model for Intrusion Detection Based on Undefined Distance”, International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-1 Issue-5, November 2011

[27] Vibhor Mahajan, Ashutosh Dwivedi, Sairaj Kulkarni,Md Abdullah Ali, Ram Kumar Solanki,” Face Mask Detection Using Machine Learning”, International Research Journal of Modernization in Engineering Technology and Science, Volume:04/Issue:05/May-2022