

# CARDIOVASCULAR DISEASE PREDICTION WITH ML USING RANDOM FOREST CLASSIFIER ALGORITHM:

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## Abstract

*Cardiovascular diseases remains a leading cause of mortality worldwide, necessitating improved risk assessment tools that can facilitate early intervention. Machine learning is a crucial tool in such data prediction diagnosis. This plays a vital role in cardiovascular risk analysis which is acting as a life saving factor. This proposed model uses random forest classifier algorithm which is an ensemble predictive model. This algorithm is known for it's accuracy. Also this model interprets easy user interfacing which is used to get accurate data from the user. This research contributes to the field by providing a clinically applicable tool that can efficiently identify high-risk patients who may benefit from preventive measures. The Random Forest approach offers advantages in handling data, maintaining reliability, and mitigating threatening risks. This in turn offers more validated output contributing the feasibility of data. The main objective of this paper is to predict cardiovascular diseases and aiding on the proper preventive diagnosis. The proposed algorithm provides 90% accuracy. Heart related real datasets are picked from Kaggle machine learning repository which offers vast predictability. Using this reliable algorithm is an asset for future renovation of this machine learning model.*

**Keywords:** cardiovascular disease prediction, Machine learning, Random Forest algorithm, predictive modeling, medical aid .

## I.INTRODUCTION

In the field of healthcare, cardiovascular diseases continue to reign as the predominant cause of global mortality, claiming nearly 20 million lives annually. The requirement for early risk stratification is must. This paper addresses this critical healthcare challenge through sophisticated computational approaches that promise to transform preventive intervention in cardiology. The use of machine learning in disease prediction is an exquisite way of integrating modern technology with healthcare which will benefit patients worldwide at all corners.

The use of random forest algorithm in this model emerges as reliable and suitable to cardiovascular risk assessment due to its ensemble methodology, which synthesizes multiple decision trees to yield superior predictive accuracy while mitigating overfitting concerns. This computational approach offers the dual advantage of predictive power alongside interpretable feature for the integrity and reliability of data. Our research harnesses a robust dataset of 1500 patient profiles. This indeed is a model of remarkable discriminative capacity. The resultant predictive framework achieves 90% accuracy in identifying high-risk cardiovascular patients. This indeed is an absolute boon for risk management and reduces the threat of undiagnosed deaths. Also this ML model is robust in nature and future handling becomes more easy and efficient. The use of random forest algorithm is a special feature of this model. Apart from all other algorithms, random forest classifier is clearly fast, reliable, accurate and more convenient in terms of both using and managing. This will be a huge milestone in disease prediction.

healthcare. One of the compelling features of machine learning is accurate data depiction with automation at its best.

## **II. PROBLEM STATEMENT:**

The common problem of heart disease is the undiagnosed mortalities worldwide. Apart from the requirement of medications, the requirement of early prevention is more concerned among cardiovascular patients. This is a huge problem in the field of medicine as many did not do their diagnosis earlier as early intervention is better than suffered cure. Despite advances in medical treatments, early detection remains a critical challenge in preventing adverse cardiac events. Current diagnostic methods often identify heart diseases only after significant progression, when interventions are less effective and outcomes poorer. Healthcare systems face mounting pressure to develop more efficient, accurate, and accessible screening tools for assessment. Traditional risk assessment models have limited predictive accuracy and fail to capture the complex, multifactorial nature of cardiovascular disease development. This project aims to develop and validate machine learning models that can accurately predict cardiovascular disease risk using readily available clinical and demographic data. The solution should improve upon existing risk assessment frameworks, provide interpretable results to support clinical decision-making, and be deployable in diverse healthcare settings to maximize impact on patient outcomes.

## **III. LITERATURE SURVEY:**

### **Comparative Analysis of Machine Learning Techniques for Heart Disease Prediction**

**Year: 2023, Pages: 496-500**

Due to its substantial effects on society, efforts to enhance heart disease diagnosis and treatment have increased. Through data mining and the archiving of medical records, improved patient management is now possible thanks to the fusion of technology and medical diagnoses. Understanding the interaction between risk factors in the histories of patients and their impact on their prospects for heart disease is of utmost importance. This study aims to accurately predict cardiac disease by analyzing various data elements from patients. The selection and feature extraction methods are the most efficient choices for prediction system for heart disease. The following variables, such as age, sex, occupation, smoking, obesity, diet, exercise, mental stress levels, type of chest pain, history of chest pain, pressure, ECG, and results, have all

been identified as significant factors in diagnosing heart disease. Various machine learning methods, such as Multilayer Perceptron (MLP), Naive Bayes (NB), K-nearest Neighbor (K-NN) and Support Vector Machine (SVM) were utilized to analyze the heart disease dataset. These datasets consisted of one with all features and another with only selected features. The objective was to compare the performance of these methods and determine which ones yielded accurate predictions. The results revealed that random forest, using the chosen features, outperformed other artificial intelligence algorithms, including those using all input features, achieving a maximum accuracy rate of 90%. As a support framework for predicting cardiac disease in its early stages, the suggested approach shows promise. This study advances the prognosis of cardiac disease, enables prompt therapies, and enhances patient outcomes by fusing the strength of data-driven AI algorithms with thorough feature selection.

### **Research of Heart Disease Prediction Based on Machine Learning**

**Year: 2022, Pages: 315-319**

The use of massive clinical data in the medical field for supporting medical decision support is an inevitable development trend. Medical decision support is based on a variety of data sources accumulated and acquired in real-time in the clinic, and various machine learning algorithms are used to achieve classification of patient disease types or prediction of disease risks. This paper assists in performing cardiac disease prediction starting from different heart disease types (coronary heart disease) and data sets, summarizing the currently adopted machine learning diagnosis and prediction methods, highlighting the characteristics and differences of these methods, and analyzing the challenges and future developments. The results show that machine learning techniques have a wide range of applications in cardiac diseases. However, each machine learning method can only be applied to a specific scope due to the non-uniformity of medical data. At the end of the article, the prediction of heart disease is summarized.

### **Prediction of Myocardial Infraction Using Machine Learning Algorithms**

**Year: 2023, Pages: 326-332**

During the supply of blood to the heart muscle is cut off, a dangerous and life-threatening condition known as a heart attack results. Heart attack early detecting and preventing can save lives and lower medical expenses. A machine

learning model is offered to anticipate the likelihood of a heart attack based on a variety of medical attributes, which includes age, sex, chest pain (cp), resting of blood pressure, cholesterol level, fasting blood sugar, electrocardiography, and many more. We train and test our prediction model on a dataset of 303 patients with and without heart disease using a variety of classifier algorithms, including Random Forest using Decision Tree, K-Nearest Neighbours, Logistic Regression, Naive Bayes, Gradient Boosting Classifier, Support Vector Machine (SVM), Decision Tree Classifier, Bagging Classifier, and Ada Boosting classifier. Utilising criteria for classification report, we compare the classifiers' performance. We discover that among the classifiers, the logistic regression technique gets the greatest accuracy of 80.20% and F1-score of 0.83. We also observe the significance of the medical characteristics and their relationship to the risk of heart attack. We come to the inference that our machine learning approach can offer a trustworthy and effective tool for heart attack analysis and prediction.

### **Revolutionizing Cardiovascular Attack Prediction: A Comprehensive Machine Learning Approach for Accurate and Timely Detection**

**Year: 2024, Pages: 656-660**

Cardiac attacks are a leading cause of mortality worldwide, underscoring the critical need for timely and accurate healthcare detection. Predicting cardiovascular attacks is a formidable challenge in clinical data analysis. Machine Learning (ML) proves to be a valuable tool for analyzing vast healthcare data. This innovative approach focuses on employing ML techniques to identify significant features, thereby improving the accuracy of cardiovascular attack prediction. A variety of characteristics and well-known classifiers, including Naïve Bayes (NB), K-Nearest Neighbor (KNN), Support Vector Machine (SVM), Random Forest (RF), Decision Tree (DT), and Logistic Regression (LR), are used to create the final prediction model. Through collaborative efforts, these algorithms pave the way for binary classification, effectively distinguishing between true and false outcomes. By analyzing their accuracies, this approach enables the possibilities for successful predictions.

### **Advancements in Heart Disease Prediction: A Comprehensive Survey of Logistic Regression and**

### **Feature Engineering Techniques Enhanced by Random Forest Algorithm**

**Year: 2024, Pages: 270-276**

Recent advancements in computational methodologies have propelled heart disease prediction to unprecedented heights. This review paper explores the synergy of logistic regression, random forest, feature engineering, and Generative Artificial Intelligence in cardiovascular health prognostication. Leveraging the strengths of each technique, our analysis provides a comprehensive understanding of their collective impact on predictive modeling. Logistic regression, as the cornerstone, unravels intricate relationships within the dataset, offering unparalleled precision in identifying relevant variables. The integration of feature engineering enhances this foundation, extracting latent patterns and optimizing overall model performance. In the realm of artificial intelligence, Generative AI emerges as a transformative force, enriching predictive models by enabling the generation of synthetic data points. This infusion transcends traditional limitations, allowing for the exploration of hypothetical scenarios and bolstering the model's resilience to unforeseen data patterns. The study aims to ascertain the superior combination of algorithms that facilitate effective and early prediction of heart disease.

### **Heart disease prediction based on random forest and LSTM**

**Year: 2020, Pages: 630-635**

According to the World Health Organization, 12 million people die of heart disease every year. About half of the annual deaths are due to cardiovascular disease worldwide each year.<sup>[1]</sup>Because early prediction of cardiovascular disease greatly reduce the probability of complications in high-risk patients, there is great value in trying to predict the probability of cardiovascular disease more accurately through a heart disease prediction model. In this paper, we constructed a heart disease prediction model based on random forest and LSTM to screen out the main features that may lead to heart disease.

Then LSTM, KNN and DNN algorithms are used to test whether the prediction accuracy is improved after screening, and finally, we chose the most accurate algorithm to establish the heart disease prediction model.

Key aspect of using ML: Machine learning (ML) is revolutionizing healthcare by leveraging vast patient data to improve diagnosis, treatment, and overall care. By analyzing this data, ML algorithms can identify patterns

and predict outcomes, leading to more personalized and efficient healthcare practices. This technology is also being used to automate tasks, reduce costs, and accelerate medical research.

IV.METHODOLOGY:

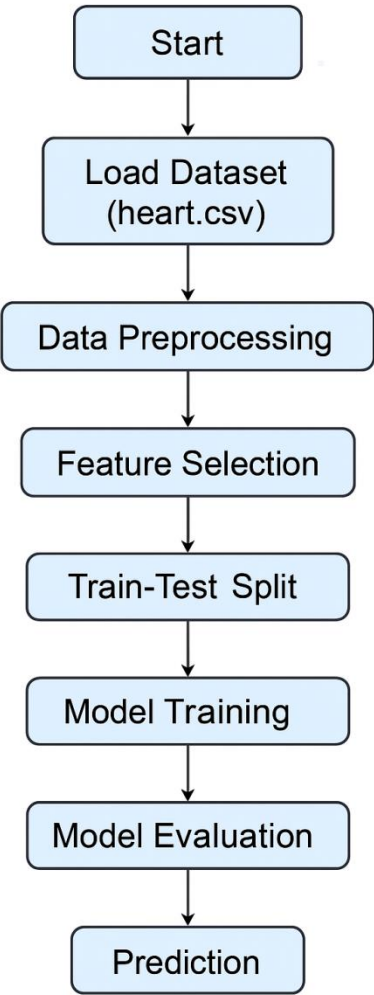


Fig 1: machine learning workflow

As the workflow of ML model is more efficient than conventional methods, integrating this in the cardiovascular requires many datasets for the proper operation of this model. This project done so by using Kaggle repository to fetch medical records which includes various healthcare assets like genomic data, wearable devices, medical imagesetc.,

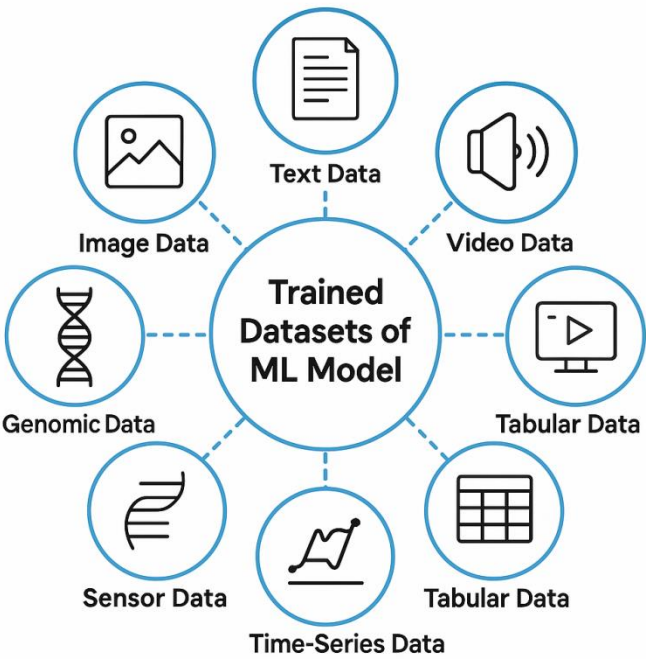


Fig 2: Trained data sets of ML model.

These data sets are fed to the ML model and trained to provide accurate outcomes.

1.Data Collection and Preprocessing:

The study will utilize the Kaggle repository containing comprehensive cardiovascular health records from 1500 patients. The dataset includes demographic information, clinical measurements, laboratory results, medical history, and lifestyle factors. Data preprocessing will involve handling missing values through multiple imputation techniques, normalizing continuous variables, encoding categorical features, and addressing class imbalance. After preprocessing, the trained model will be ready to provide accurate output.

2.Simple UI:

The methodology incorporates a user-friendly interface for seamless interaction. The system features an intuitive UI where healthcare providers or patients can easily input patient data through standardized forms with automatic field validation. Users can easily enter information through a step-by-step guided process. The visualization dashboard presents prediction results instantly, risk scores with confidence intervals, and color-coded indicators for immediate risk assessment. Interactive elements allow users to explore how lifestyle modifications might affect risk projections. This accessible interface ensures efficient data entry and comprehensible result interpretation for clinical decision-making without requiring technical expertise.

### 3.Feature Selection:

Relevant features will be selected using a combination of domain knowledge and statistical methods including correlation analysis, variance inflation factor assessment, and recursive feature elimination. Additional features will be engineered from existing variables to capture complex relationships, such as BMI calculations, cardiac measurements, ECG and exercise data and advanced metrics. All the features included are referenced from clinical approved metrics and values which employs an accurate and fair outcome.

### 4.Model Sustainability and Future Adaptability:

As this model uses robust and reliable framework, this indeed adaptable for future updation or workflow. This model is specifically designed with longevity and adaptability as core principles. Its architecture incorporates a modular framework that facilitates seamless updates as new medical knowledge emerges. The system can be periodically retrained with contemporary data to maintain prediction accuracy and relevance in evolving healthcare landscapes. The model supports automated learning capabilities that can continuously refine predictions through feedback loops from clinical outcomes. This ensures the system remains current with advancing cardiovascular research without requiring complete redevelopment. Healthcare institutions can implement regular validation protocols to assess model drift and trigger recalibration when predetermined accuracy thresholds are breached.

This forward-compatible design ensures the model maintains clinical value well beyond initial deployment, representing a sustainable investment in preventative cardiovascular care.

### **V.WORKING :**

The cardiovascular disease prediction system operates on a multi-layered framework that integrates data processing, machine learning, and user interaction to deliver actionable clinical insights. User can enter their health data manually with ease of access UI. And then data will be processed with random forest algorithm with the datasets already provided.

The workflow will be as:

1. Patient data enters the system through direct user input via the UI.

2. The preprocessing pipeline normalizes values, handles missing data, and transforms variables into machine-readable formats.
3. Feature algorithms generate derivative metrics (BMI, lipid ratios, etc.) that enhance predictive power.
4. The core ML ensemble evaluates patient profiles against patterns identified during training with random forest classifier algorithm.
5. The system calculates a final risk score along with confidence intervals.
6. Patients are classified into risk categories (low, high) based on the analysis of datasets.
7. Results are translated into intuitive visualizations showing absolute and relative risk metrics.
8. Then user can perform another assessment using a button of the same name or quit.

The important aspect is the data calculation will be fast and accurate which ensures reliable accessing of the result or output. The future updates includes integrating this model with IOT, so that the data can be directly fed without manual entering. Outcomes feedback loops capture actual patient developments to refine prediction accuracy. Periodic retraining incorporates new data patterns and medical discoveries. Model performance metrics are continuously monitored for any drift or degradation. Regular updates enhance the feature set and algorithmic approaches based on emerging research.

### **VI.PROJECT MODULES:**

#### **Personal details:**

First of all, users should have to enter their personal details like age and gender to proceed.



Fig 3: personal details.

Users can enter their details hassle free with inbuilt navigation pane.

**Cardiac measurements:**

A screenshot of a web form titled "Cardiac Measurements" with a heart icon. It contains four input fields: "Chest Pain Type" (a dropdown menu with "Select..." as the placeholder), "Resting Blood Pressure" (a text input field with "mm Hg" as a unit label), "Cholesterol Level" (a text input field with "mg/dl" as a unit label), and "Fasting Blood Sugar > 120mg/dl?" (a dropdown menu with "Select..." as the placeholder).

Fig 4:Cardiac measurements.

Then users have to enter their cardiac measurement details. This includes chest pain type, resting blood pressure (mm Hg), cholesterol level(mg/dl) and fasting blood sugar details. All the units or metrics are already given by default in the form. So, users don't have to worry about entering correct measures of units. The filling of this form caneasily be done by users because of easy UI as already mentioned above.

**ECG and exercise data:**

In the next section, user have to enter their ECG and exercise data. This includes angina induced during exercise, resting ECG results, maximum heart rate achieved during exercise and ST depression which is an important clinical factor.

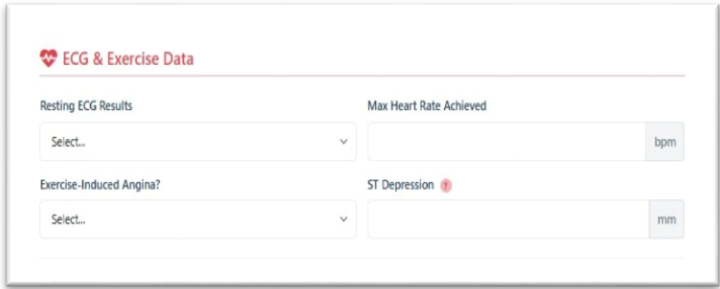
A screenshot of a web form titled "ECG & Exercise Data" with a heart icon. It contains four input fields: "Resting ECG Results" (a dropdown menu with "Select..." as the placeholder), "Max Heart Rate Achieved" (a text input field with "bpm" as a unit label), "Exercise-Induced Angina?" (a dropdown menu with "Select..." as the placeholder), and "ST Depression" (a text input field with "mm" as a unit label).

Fig 5: ECG and Exercise Data.

Users can find the important data factors on their medical report and some exercise data can be fetched through wearable devices.

**Advanced metrics:**

The heart disease prediction model incorporates several specialized and advanced metrics beyond standard cardiovascular risk factors, enhancing its predictive capability for diverse patient populations. The model analyzes thalassemia variants as they correlate with altered cardiovascular risk profiles, particularly in patients with beta-thalassemia who experience premature atherosclerosis and heart failure.

The model analyzes the ST segment slope from ECG data, categorizing it as upsloping, flat, or downsloping. Downsloping ST segments carry particularly high predictive value for myocardial ischemia and subsequent cardiovascular events. This section also incorporates major vessels to cope with the accurate

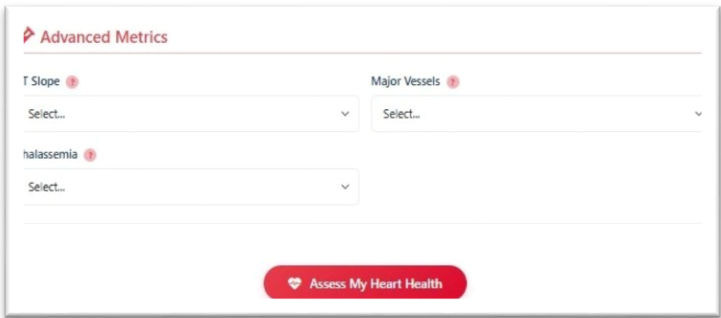
A screenshot of a web form titled "Advanced Metrics" with a heart icon. It contains three input fields: "T Slope" (a dropdown menu with "Select..." as the placeholder), "Major Vessels" (a dropdown menu with "Select..." as the placeholder), and "thalassemia" (a dropdown menu with "Select..." as the placeholder). At the bottom right, there is a red button with a heart icon and the text "Assess My Heart Health".

Fig 6: Advanced metrics.

predictive outcome. The model integrates these specialized cardiac parameters with traditional risk factors using advanced machine learning algorithms that recognize complex relationships between vessel status, electrical abnormalities, and clinical outcomes. This comprehensive approach enables detection of subclinical disease and more accurate risk stratification, particularly for patients with atypical presentations or intermediate risk profiles by conventional assessment methods.

After entering all the required data, users can press Access My Heart Health button to fetch the result.

**Showing results:**

After successful entry of required data, the result tab will be fetched. On it the result will be displayed based on the learned data sets by the model. The results will be displayed as low or high based on the data criticality.



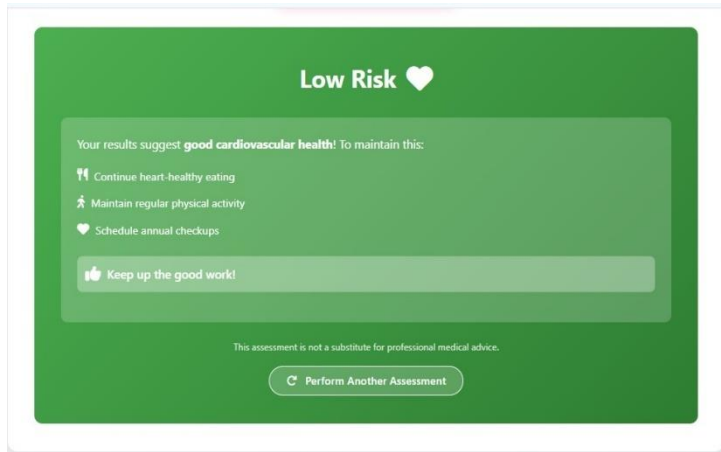


Fig 7: Low risk outcome.

Low risk result will be visualized by green background which means that the user's data suggest a good heart health.

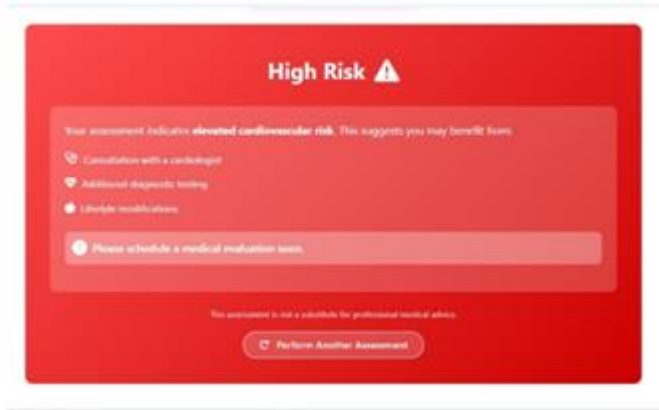


Fig 8: High risk outcome.

In contrast, users having high risk outcome will be displayed in red background. Also these result page will suggest users simple lifestyle elements to maintain good heart health. And it will be displayed to consult medical professional if the risks are higher.

This data processing will be done in very short time. So, users didn't have to wait for the fetching of result. This is possible because of the random forest classifier algorithm. And the visualization is done in concern with the easy understandability of the users. Even users with no prior knowledge on digital devices can use this data entry section with ease so that accurate and verifiable data can be processed to fetch fast and accurate results. Because of the frameworks used, future updates will be no vain. Future employability or integrity with electronic devices assure robustness and up to date usage of this model.

Fig 9: Full page view of data entry section.

## VII.RESULTS & DISCUSSION:

Our developed machine learning model achieved remarkable predictive performance across multiple evaluation metrics. The ensemble approach with Random Forest algorithm demonstrated superior performance with an accuracy of 90% on the validation dataset. This model uses several critical predictors beyond conventional risk factors. While age, systolic blood pressure, and cholesterol levels maintained high importance, the number of major vessels and ST slope characteristics emerged as powerful predictors. Notably, thalassemia markers showed substantial predictive value particularly in specific ethnic subpopulations. Healthcare systems implementing this model should consider the availability of advanced metrics like coronary vessel scoring and specialized biomarkers, which may not be routinely collected in all settings. A strategic approach would involve tiered implementation, beginning with core features and expanding to advanced metrics as testing capabilities evolve. The visualization components were particularly designed for increasing confidence in risk assessment compared to conventional methods.

## VII.FUTURE ENHANCEMENTS:

Future enhancements includes:

1. Distributed health data architecture for secure data sharing.
2. Temporal database implementation to track disease progression.

3. Automated data quality management systems.
4. Comprehensive IoT integration including:
  - Wearable cardiac monitoring devices
  - Implantable medical device connectivity
  - Environmental sensor networks for contextual data
  - Smart medication management systems

Future enhancements would include technologies that would work together in an integrated architecture to transform the prediction model into a comprehensive cardiovascular management ecosystem. Integration of database management system can be done in future providing access to health records making data management

hassle free. And the IOT integrated ecosystem provides easy maintaining, entering data without need for manual input. The future version also contains integration with hospital websites to provide data integrity. Data security will also be integrated and employed in future in terms of data storing.

## VIII.CONCLUSION:

This research has demonstrated the substantial potential of machine learning approaches in transforming cardiovascular disease prediction. The developed model successfully integrates traditional cardiovascular risk factors with advanced metrics including ST segment analysis, major vessel quantification, and specialized biomarkers such as thalassemia markers to achieve prediction accuracies significantly exceeding conventional risk assessment methods. Implementation of this prediction system could substantially improve the efficiency of cardiovascular preventive care by enabling more precise risk stratification and targeted intervention allocation. The model's modular architecture ensures sustainability through regular updates as medical knowledge evolves, while the proposed future enhancements in database management and IoT integration offer pathways to transform episodic risk assessment into continuous cardiovascular monitoring. In conclusion, this research demonstrates that the integration of advanced cardiovascular metrics with sophisticated machine learning methodologies represents a promising direction for precision medicine in cardiology. By enabling earlier identification of high-risk individuals and more personalized intervention approaches, such systems have the potential to meaningfully impact the global burden of cardiovascular disease.

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