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Development of Multi Model Algorithms for Cardiac Arrest Prediction

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Abstract:- Cardiac arrest or myocardial infarctions pose a significant health risk globally, necessitating effective monitoring and early detection strategies. In this study, we propose a framework comprising two complementary methods for enhancing cardiovascular health management: a text-based prediction system and an image-based analysis approach. The text-based prediction system provides individualized risk estimates for cardiovascular events by analyzing user-input health factors using machine learning algorithms. With the use of a well- chosen dataset and thorough preprocessing, our models show strong predictive capabilities for heart disease. Convolutional neural networks (CNNs) are used in tandem with other image-based analytic techniques to identify anomalies and arrhythmias from electrocardiogram (ECG) information. Through data augmentation and rigorous model training, our approach achieves high accuracy in classifying various cardiac rhythms and arrhythmias. The framework presents a promising approaches for advancing cardiovascular health management, leveraging both text and image-based techniques. Through rigorous evaluation, we demonstrate the efficacy and reliability of our proposed methodology in addressing the challenges of heart attack detection and risk assessment.

Keywords: Cardia Arrest, Convolutional Neural Network, Electrocardiogram

1. Introduction

Every year, Cardiovascular diseases (CVDs) account for a significant portion of the global health burden and cause millions of deaths annually. Despite advancements in therapy and medical technology, preventing and early detection of cardiovascular diseases (CVDs) is still essential for reducing mortality and enhancing patient outcomes. The healthcare industry has seen a transformation due to the confluence of deep learning and machine learning techniques, which have provided novel methods for risk assessment and cardiovascular

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health monitoring. This study offers a thorough framework for improving risk assessment and cardiovascular health monitoring using image- and text- based analytic methods. Our method seeks to give early identification of cardiac problems and personalized risk forecasts by utilizing convolutional neural networks (CNNs) and machine learning algorithms. This will allow for earlier intervention and better patient care.

The first component of our framework focuses on text-based prediction, where users input relevant health parameters such as age, gender, medical history, and clinical measures to receive personalized risk predictions for cardiovascular events. Our models show strong performance in properly forecasting the possibility of heart disease by utilizing curated datasets and machine learning methods such as Logistic Regression, Decision Trees, and K nearest neighbor (KNN). This allows for proactive risk assessment and treatment.

In addition to text-based prediction, we introduce an image- based approach for detecting abnormalities and arrhythmias from electrocardiogram (ECG) signals. By training CNN architectures on a dataset of ECG images, our method effectively classifies various cardiac rhythms and arrhythmias with high accuracy. Through rigorous preprocessing, data augmentation, and model evaluation, we showcase the efficacy of our approach in enabling early detection and intervention for cardiac abnormalities.

Furthermore, we present a web application implemented using Django and Flask frameworks, providing users with seamless access to both text-based risk predictions and ECG analysis. Our system integrates user profile management, data visualization, and model inference capabilities, offering a user-friendly interface for cardiovascular health monitoring and risk assessment.

In closing, this framework represents a promising avenue for advancing the management of cardiovascular health. By text and image-based techniques, we offer a comprehensive approach to addressing the challenges associated with detecting heart attacks and assessing risks. Our thorough evaluation underscores the efficacy and reliability of our proposed methodology, paving the way for improved strategies in cardiovascular care.
The proposed work has the following features which will contribute to the betterment of the health of the user: heart health monitoring, cardiac arrest risk detection, ECG analysis, Covid effects on heart health.

2. Related Works and Contribution

The study done by Ji-Han Liu, Hsiao-Ko Chang, Cheng-Tse Wu [1] proposes a system for detecting cardiac arrest (CA) before a cardiopulmonary resuscitation (CPR) event occurs, aiming to assist physicians in early diagnosis and warning, thereby improving medical

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quality. In order to predict CA and CPR episodes, the study uses a dataset of adult patients in an emergency room, performs data preprocessing, and uses a variety of classifiers for model training. According to the findings, the random forest classifier functions best when a CPR event takes place, with LSTM and logistic regression exhibiting encouraging outcomes one to four hours prior to the CPR time. According to the study's findings, their method, like current Early Warning Score (EWS) systems, can identify CA and CPR episodes around three to 3.5 hours in advance. It also successfully resolves dataset imbalance concerns to improve prediction accuracy.

The work by Abhishek Rairikar, Vedant Kulkarni, Vikas Sabale, Harshavardhan Kale, and Anuradha Lamgunde [2] focuses on predicting heart disease using data mining methods. The paper analyses systems that employ different input qualities including gender, blood pressure, and cholesterol to forecast the chance of a patient acquiring heart disease. It then offers a back propagation-based, efficient genetic method for predicting cardiac disease. To improve prediction accuracy in the healthcare industry, the study evaluates healthcare data utilizing K-nearest neighbor (KNN), decision trees, and Naive Bayes classification techniques.

The work done by Ramya G. Franklin and Dr. B. Muthukumar [3] provides a comprehensive review of the various machine learning and data mining techniques used in the early detection and prediction of heart illness. The goal of the project is to evaluate the flaws of prior research, detect and forecast heart disease using a range of approaches, and examine the numerous risk factors related to heart disease research. This approach has the advantage of suggesting the use of Long Short-Term Memory (LSTM) and Convolutional Neural Networks (CNN) for improved cardiac illness detection and prediction, in contrast to other commonly utilized approaches. This approach's disadvantage is that it can restrict the exploration of additional potential tools and limit the research to using only the WEKA and ORANGE tools.

Utsav Chauhan, Vikas Kumar, Vipul Chauhan, Sumit Tiwary, Amit Kumar's [4] research work highlights on the application of machine learning algorithms to predict cardiac arrest emphasizes the need of early diagnosis and the use of artificial intelligence in risk assessment. Numerous techniques are discussed, with the greatest accuracy (~85%) coming from the Artificial Neural Network (ANN), followed by Decision Tree, Support Vector Machine, Random Forest, and Logistic Regression. According to the study, additional datasets are needed in order to increase forecast accuracy. The project aims to improve cardiac arrest prediction using machine learning, potentially leading to significant changes in patient outcomes.

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The study by Hsiao-Ko Chang, Cheng-Tse Wu, Ji-Han Liu, and Jyh-Shing Roger Jang [5] from National Taiwan University intends to develop a Medication for Cardiac Arrest Early Warning System (MCAEWS) that predicts patients' likelihood of their condition getting worse using machine learning algorithms. The study aims to enhance medical quality, reduce false positive rates, boost sensitivity, help doctors detect patients early, and issue timely warnings. The study investigates a number of machine learning models, including the models of logistic regression, Random Forest, Decision Tree, and Extreme Random Tree, using data from the emergency department at National Taiwan University Hospital. Compared to the other models, the Random Forest Algorithm performs substantially better. To improve emergency clinical decision-making and hospital quality management, the study emphasizes the need to improve drug factors in vital signs to improve cardiac arrest prediction accuracy.

The work done by Minsu Chae, Sangwook Han, Hyowook Gil, Namjun Cho and Hwamin Lee [6] focuses on utilizing both shallow and deep learning methods to create a prediction model for in-hospital cardiac arrest. By evaluating the effectiveness of several machine learning models and investigating the possibilities of deep learning techniques, such as Gated Recurrent Unit (GRU) and Long Short-Term Memory (LSTM) models, the authors hope to increase the precision of cardiac arrest prediction in hospital settings. The authors have suggested a model that performs better than the conventional Early Warning Scores (EWS) in an effort to overcome the shortcomings of the current research on cardiac arrest prediction. Additionally, they hope to show how well their model works in a particular hospital context and raise the possibility of developing better prediction models in the future utilizing IoT-based sensors in healthcare facilities.

The research done by Joon-myoung Kwon, Youngnam Lee, MS, YehaLee, SeungwooLee, JinsikPark [7] suggests creating and assessing a deep learning-based early warning system (DEWS) to assess a hospital's risk of cardiac arrest. The purpose of the study was to evaluate the DEWS's performance against that of logistic regression and random forest models, as well as conventional track-and-trigger systems (TTSs) like the Modified Early Warning Score (MEWS) and the Single-Parameter Track-and-Trigger System (SPTTS). One method is DEWS, which automatically extracts characteristics from vital sign data using deep learning algorithms. The models' prediction accuracy was assessed using a variety of performance metrics, such as AUROC, AUPRC, sensitivity, specificity, net reclassification index, positive predictive value, negative predictive value and F-measure.

3. Model Design

The following Hardware and software elements have been used in order to achieve the required results.

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A. Python 3.10

Models for cardiac arrest prediction were created using deep learning and Python. The large libraries and ease of reading of this high-level programming language made it a good choice for deep learning applications. It's simple syntax improves code readability and maintainability, which is critical given the iterative nature of deep learning model construction. Python libraries provide pre-built functions and modules for various machine learning applications, facilitating development, and encouraging experimentation with different deep learning architectures.

Fig1. Python logo

B. Spyder

Using Spyder as the Integrated Development Environment (IDE), the project has been developed in Python. Throughout the project process, Spyder's intuitive interface and features like variable exploration and code introspection facilitated effective development and troubleshooting. This enabled a more focused investigation of different architectures by simplifying the process of iterating and improving the deep learning models.

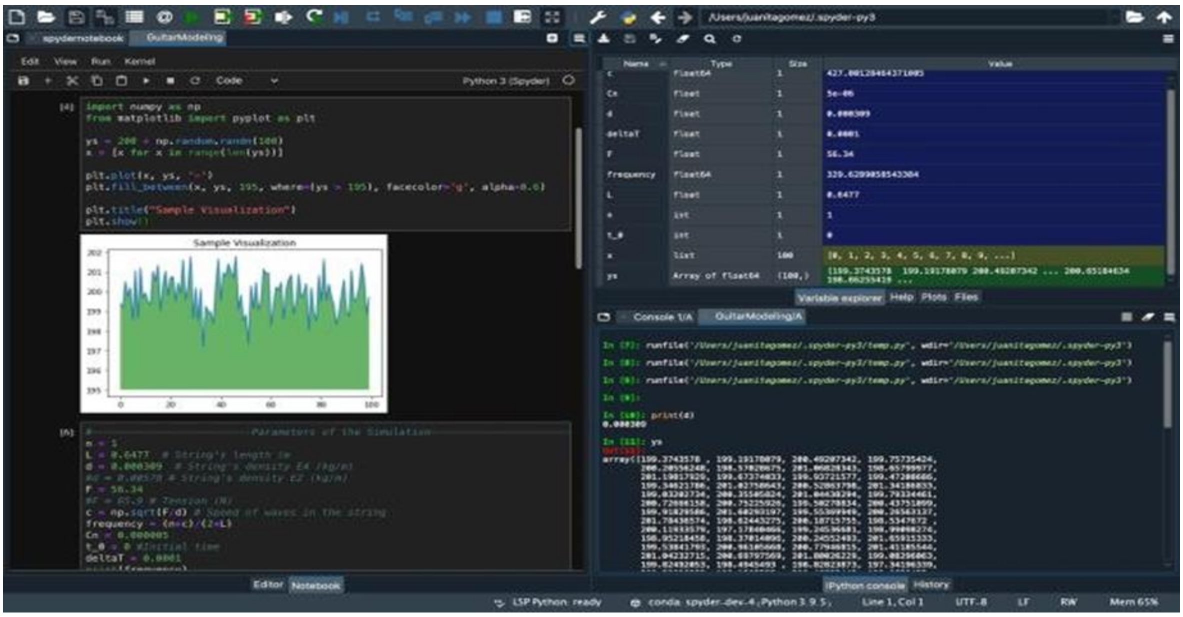

Fig2. SpyderIDE

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C. MS Visual C++Redistributable for Visual studio

The raw medical data utilized for this research likely included medical images (e.g., ECGs) that required preprocessing before being fed into the deep learning models for cardiac arrest prediction. In this case, image processing methods were crucial in getting the picture data ready for effective model training. The image processing libraries utilized in this project were created using Visual Studio 2019. To ensure compatibility and avoid potential dependency issues during deployment, users might need the Microsoft Visual C++ Redistributable for Visual Studio.

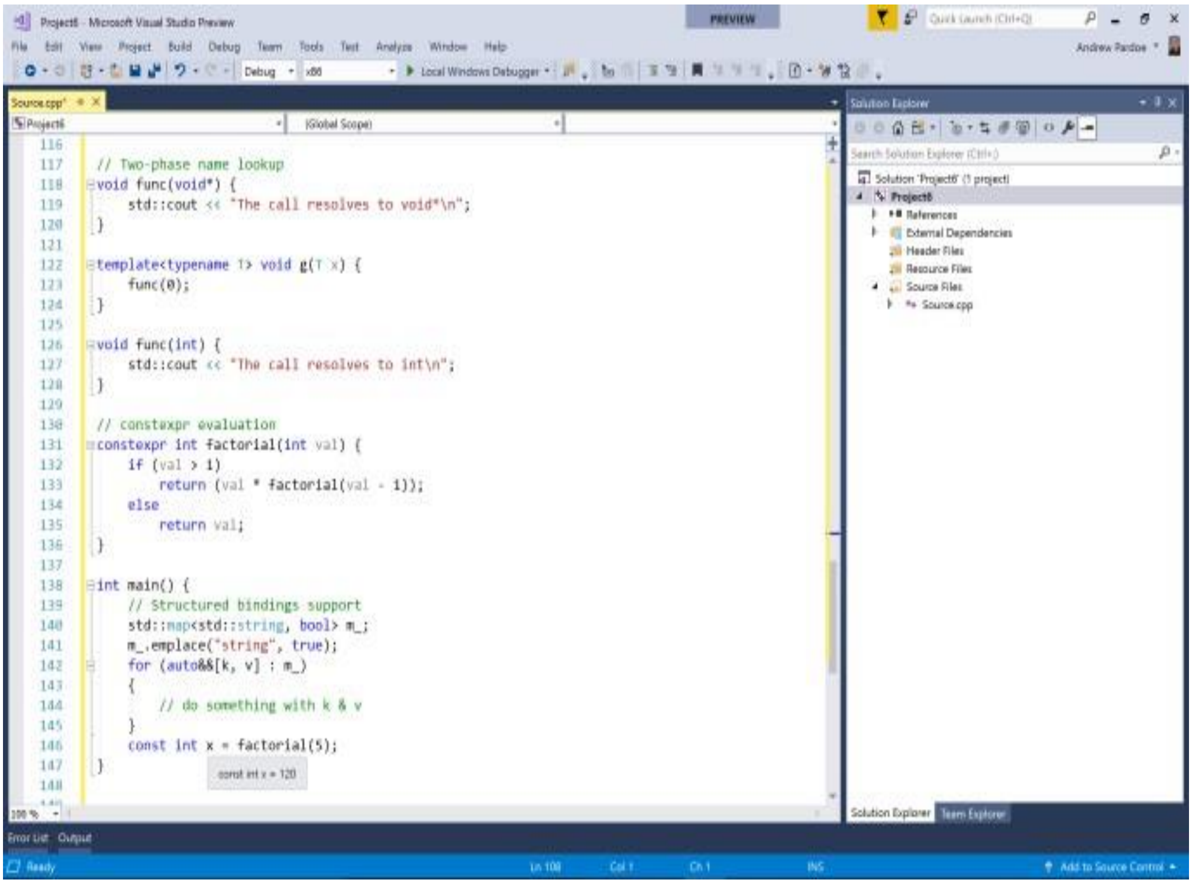

Fig3. Microsoft Visual C++ IDE

D. Django

This project's web application architecture was created with the Django high-level Python web framework. Django provides a stable and effective framework for creating intricate web applications, simplifying the development process, and assuring scalability for future projects User interaction and data management within the application were made secure via Django's integrated user authentication and authorization features.

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E. Flask

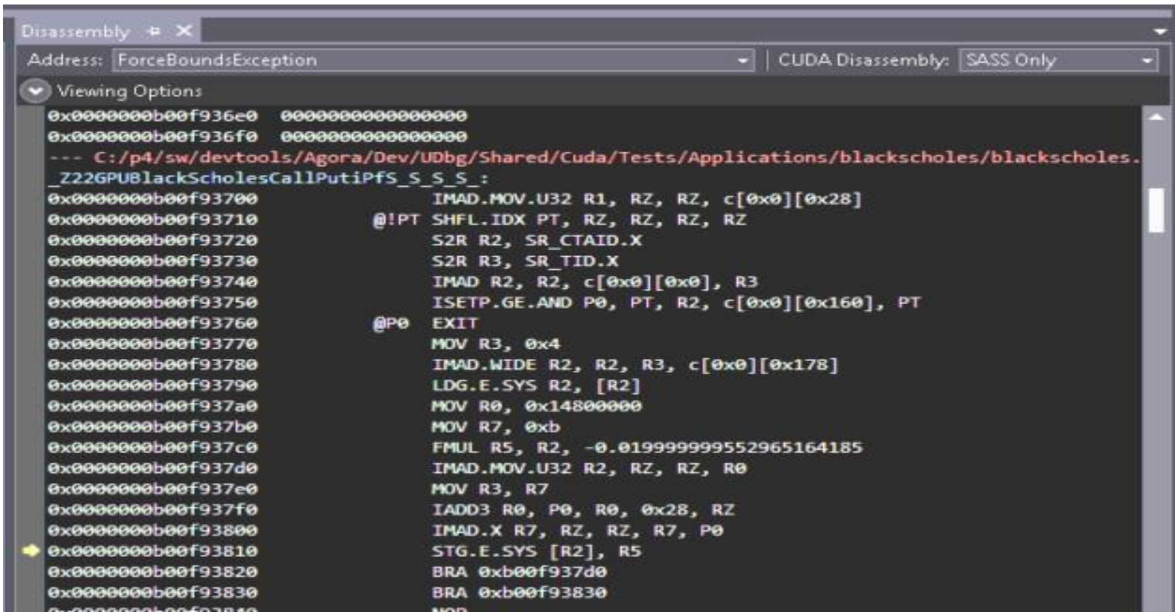
Flask is a lightweight and versatile Python web framework that was used to create the web application architecture for this project. Flask's extensive independent library ecosystem enables developers to incorporate essential features without compromising the simplicity of the core framework. It would have been possible to manage data models and make it easier to develop RESTful APIs for data exchange between the frontend and backend components by employing libraries like Flask-SQL Alchemy or Flask- RESTful.

F. Tensorflow

TensorFlow is an open-source framework that is widely used for large-scale machine learning and numerical computing. It was utilized in the implementation of deep learning models for this purpose. A versatile and potent platform for creating, refining, and implementing deep learning algorithms is provided by TensorFlow. Large datasets frequently used in deep learning projects could be processed more effectively thanks to its high-performance computing capabilities. Furthermore, TensorFlow includes a large number of pre-built functions and modules for various deep learning tasks, including convolutional layers, recurrent layers, and activation functions.

G. CUDA tool kit11.2

Using the CUDA Toolkit 11.2, TensorFlow[4] was configured to take benefit from GPU acceleration. This substantially reduced training times, allowing for a more efficient exploration of various deep learning architectures during the development period.



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H. Scikit-learn

Scikit-learn, a versatile and accessible Python toolkit for machine learning tasks, was employed in the machine learning pipeline for this project. Scikit-learn offer an extensive variety of tools and techniques for data preprocessing, feature engineering, model selection, and evaluation. This allowed for effective assessment of several classic machine learning methodologies as well as deep learning models for cardiac arrest prediction. The functionalities of scikit-learn, in particular, could be used for cleaning data tasks such as dealing with missing values and outliers. Scikit-learn provides techniques for feature scaling, dimensionality reduction, and feature selection in feature engineering, where this might have been very helpful.

4. Results and Discussion

A web application has been designed to cater to the project interface. The project encompasses two interrelated components aimed at enhancing cardiovascular health monitoring and risk assessment. The first component involves a text prediction system where users input relevant health parameters, such as age, gender, and medical history, to receive personalized risk predictions for cardiovascular events. The second component focuses on electro cardiogram (ECG) analysis, leveraging deep learning techniques to detect abnormalities and arrhythmias from ECG signals.

i. Detection from user text input data

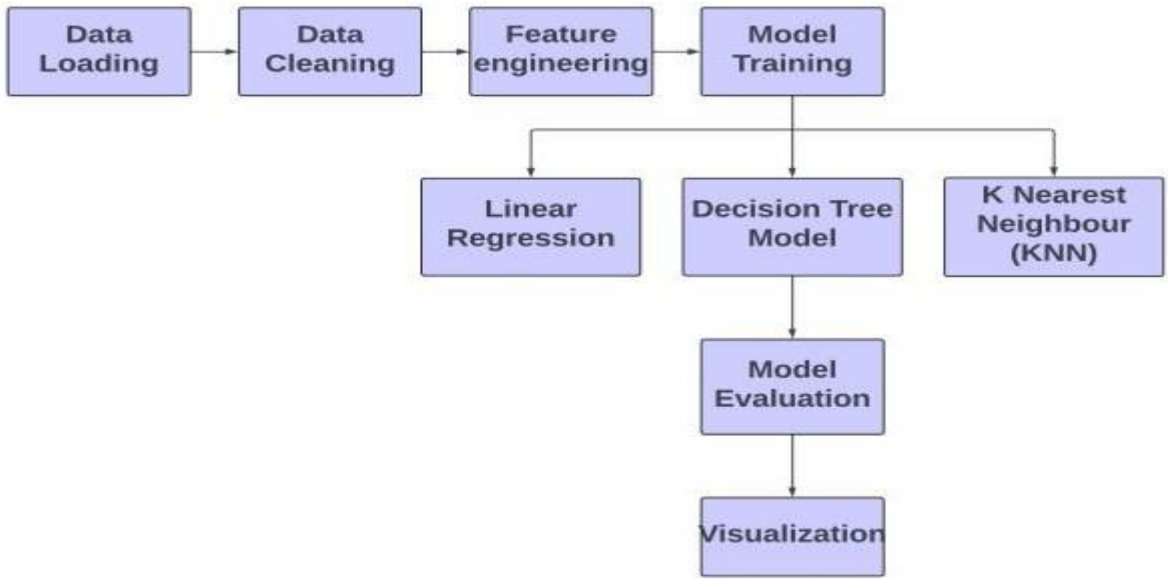

Fig 4.Text data prediction implementation prototype

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We have set up a Django web application for managing the project related tasks, including user profile creation, user authentication, profile management data visualization, and heart disease prediction. All this data is stored in a local data base.

Dataset Description:

The study employed the heart disease dataset, which was sourced through Google forms. It includes 15 characteristics and 304 samples in total, along with clinical measures, medical history, and demographic data. Since this was self-collected data, we have a limited number of samples. The characteristics include blood pressure, age, gender, cholesterol, and other pertinent factors that are known to be associated with heart disease. The dataset underwent preprocessing measures, such as addressing missing values and features calling, prior to model training to guarantee the best possible performance of the machine learning methods.

#	Column	Non-Null Count	Dtype
0	male	4238 non-null	int64
1	age	4238 non-null	int64
2	education	4133 non-null	float64
3	currentSmoker	4238 non-null	int64
4	cigsPerDay	4209 non-null	float64
5	BPMeds	4185 non-null	float64
6	prevalentStroke	4238 non-null	int64
7	prevalentHyp	4238 non-null	int64
8	diabetes	4238 non-null	int64
9	totChol	4188 non-null	float64
10	sysBP	4238 non-null	float64
11	diaBP	4238 non-null	float64
12	BMI	4219 non-null	float64
13	heartRate	4237 non-null	float64
14	glucose	3850 non-null	float64
15	TenYearCHD	4238 non-null	int64

Fig 5. Data set characteristics Machine

Learning Algorithms:

To predict cardiac disease, three machine learning methods were used: K-Nearest Neighbors (KNN), Decision Trees, and Logistic Regression.

Logistic Regression: This linear classification technique uses the input data to estimate the likelihood of a binary outcome, such the presence or absence of heart disease. It uses a logistic function to calculate the likelihood of an occurrence.

Decision Trees: A non-linear classification technique that divides the dataset into

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subgroups according to the most important characteristics by iteratively creating a tree-like structure. It moves from the root node of the tree to a leaf node in order to generate predictions.

K-Nearest Neighbors (KNN): A non-parametric classification technique that uses the nearest neighbor's majority class in the feature space to classify new instances. The number of neighbors taken into consideration depends on the value of k.

Model Training and Evaluation:

Using a stratified technique, the dataset was split into training and testing sets to ensure an equal distribution of classes in both sets. Each machine learning algorithm was evaluated using the testing set after it had been trained on the training set, with accuracy acting as the primary evaluation criterion. Precision, recall, and F1-score were among the performance metrics that were calculated to assess the models' capacity to forecast both positive and negative cases of heart disease. To assess the performance of the models and illustrate the trade- off between true positive rate and false positive rate, confusion matrices and Receiver Operating Characteristic (ROC) curves were employed. The accuracy achieved from logistic regression is 85.25%, using decision tree is 81.97%, and using KNN is 67.21%. Limited number of samples has been a drawback here.

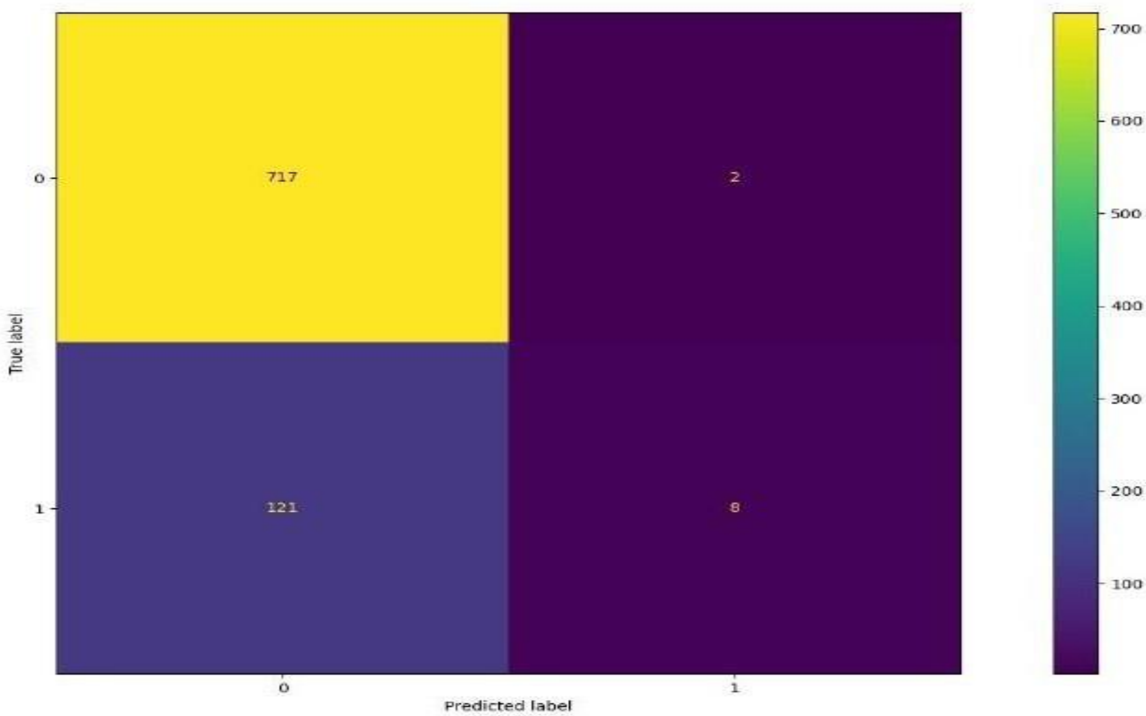

Fig6. Confusion matrix of trained data

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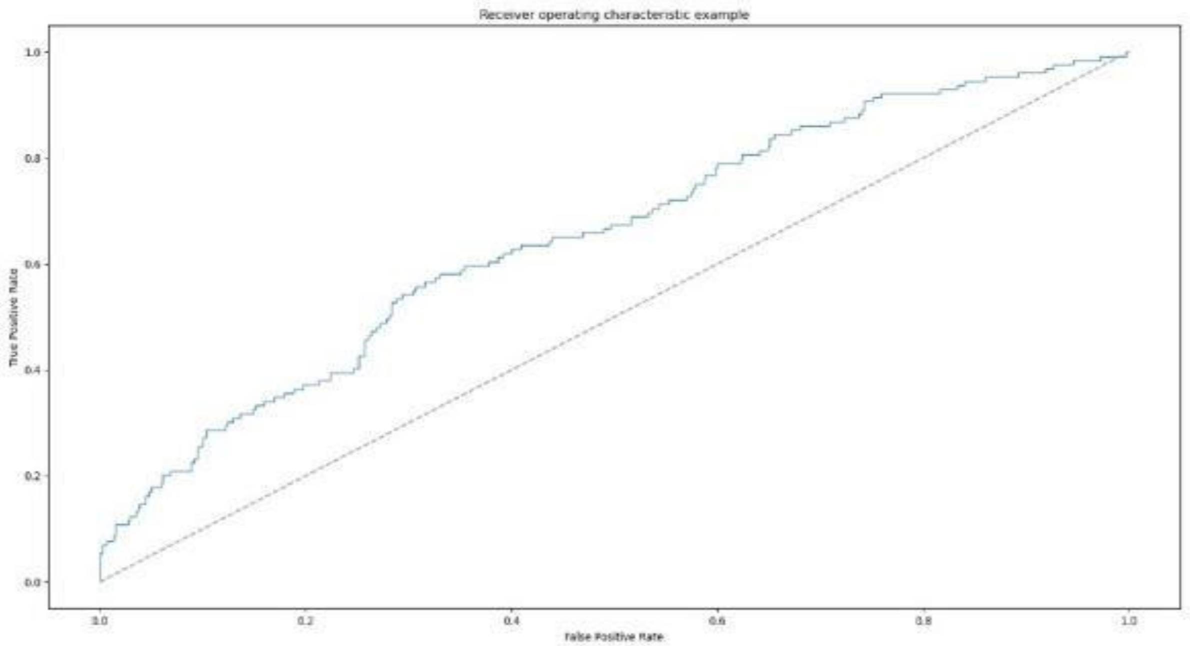
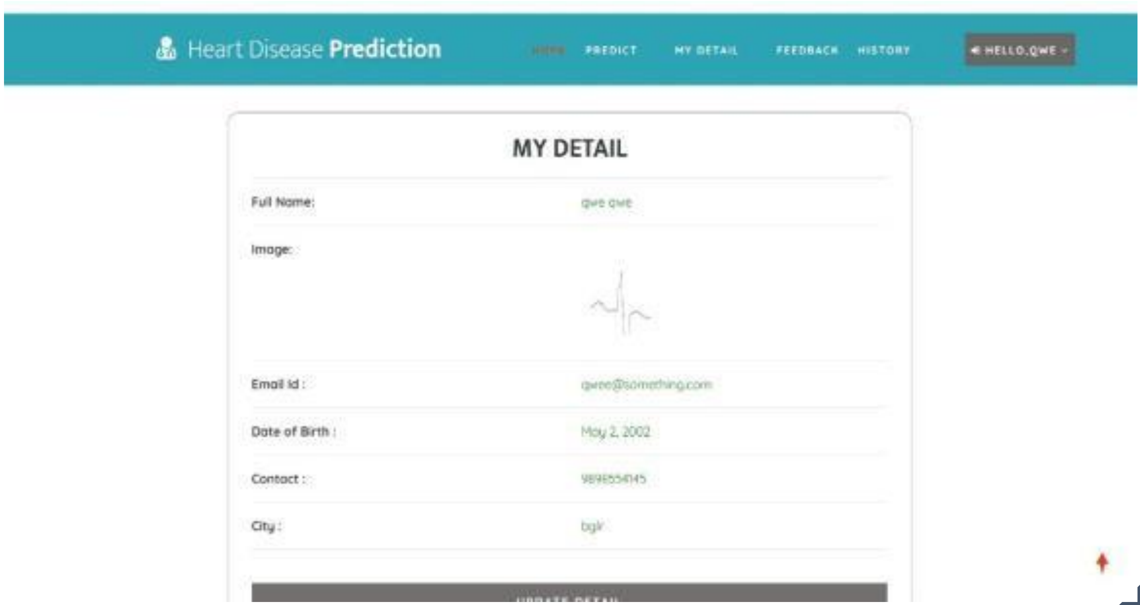


Fig7. ROC curve of the trained model Prediction

The algorithms were utilized to forecast previously unknown data items after training. The trained models' ability to forecast the likelihood of various cardiac ailments was illustrated with an example input data point that represented a person's health factors. Based on the highest likelihood or majority vote among the models, the projected result for the input data point was interpreted and classified into one of the predetermined classifications (heart failure, myocardial infarction, etc.).



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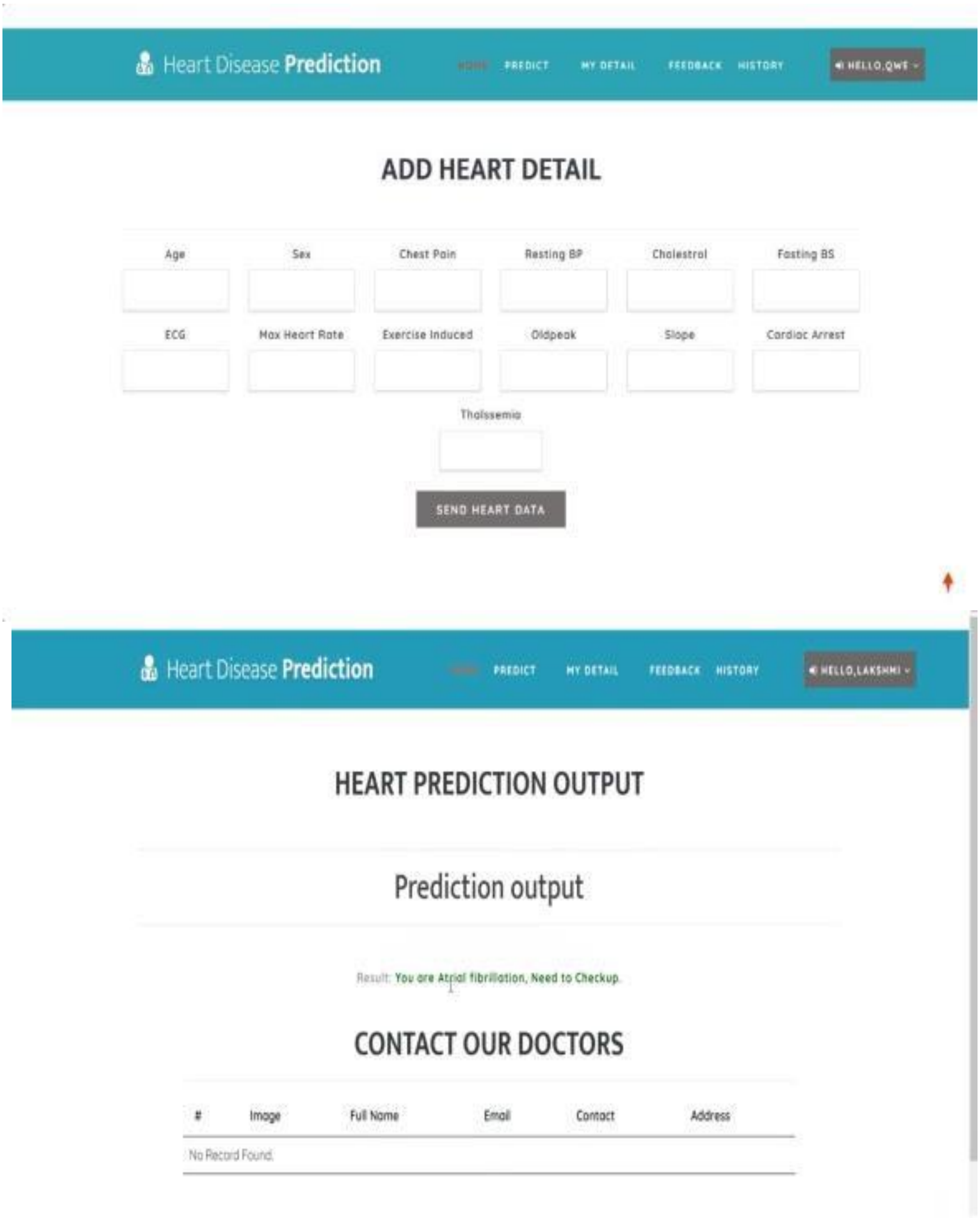

Fig8. Web application for detection through text input

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ii. Detection from Electro cardiogram (ECG) images

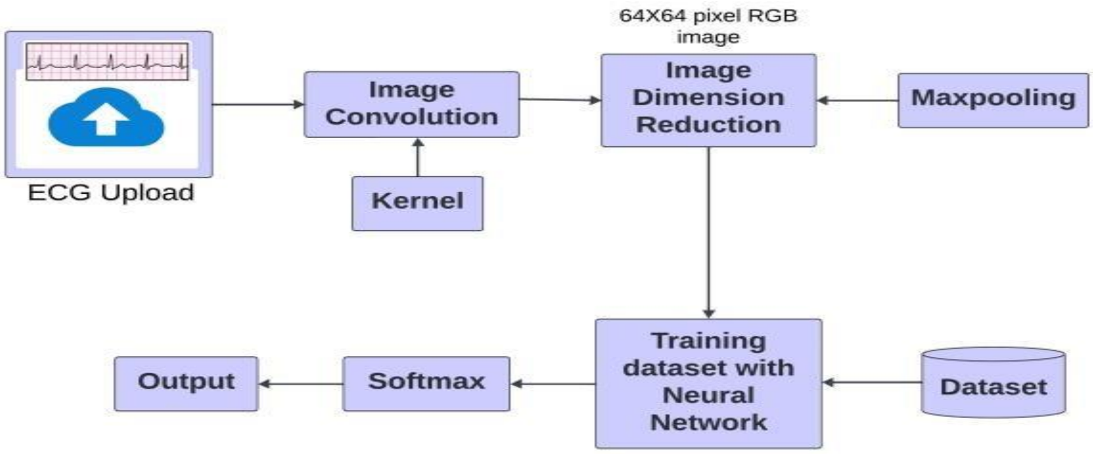

Fig9. ECG image prediction implementation prototype

Data Acquisition and Preprocessing:

We acquired a dataset of electrocardiogram (ECG) images from publicly available repositories, which comprised recordings of both normal cardiac rhythms and different cardiac arrhythmias. Every ECG picture, which captured the heart's electrical activity over a certain amount of time, was displayed as a 64x64 pixel matrix. We preprocessed the dataset to guarantee homogeneity and improve model performance before training the deep learning model. This included classifying the photos according to the respective heart attack kinds, scaling the images to a uniform resolution of 64x64 pixels, and standardizing the pixel intensities. To further enhance the training dataset artificially, we employed data augmentation with the help of the 'Image Data Generator' class from the Keras package. This involved randomly transforming the ECG pictures by zooming, shearing, rescaling, and horizontal flipping to improve the model's capacity to generalize to new data.

Model Training and Evaluation:

Convolutional Neural Network (CNN) architecture for heart attack detection was built using the TensorFlow and Keras deep learning frameworks. Repaired linear unit (ReLU) activation functions were used in the construction of the CNN architecture's two convolutional layers and max- pooling layers in order to extract spatial features from the input ECG pictures. The output layer for multi-class classification, or softmax, was created by feeding the flattened feature maps into fully linked layers. The model's parameters were optimized during training using the Adam optimizer and the categorical cross-entropy loss function. Using the extended training dataset, the model was trained for 10 epochs, with batch sizes of 32 samples each iteration. We evaluated the trained model's performance using standard metrics including accuracy, precision, recall, and F1-score, using both the training and validation datasets. The accuracy of the model is 91%. Furthermore, a qualitative investigation was conducted in

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which the model's predictions were visualized and its ability to differentiate between different types of heart attacks was assessed. This part of the project primarily used the Keras library for building and training the deep learning model and flask for creating the web application and serving the trained model as a web service.

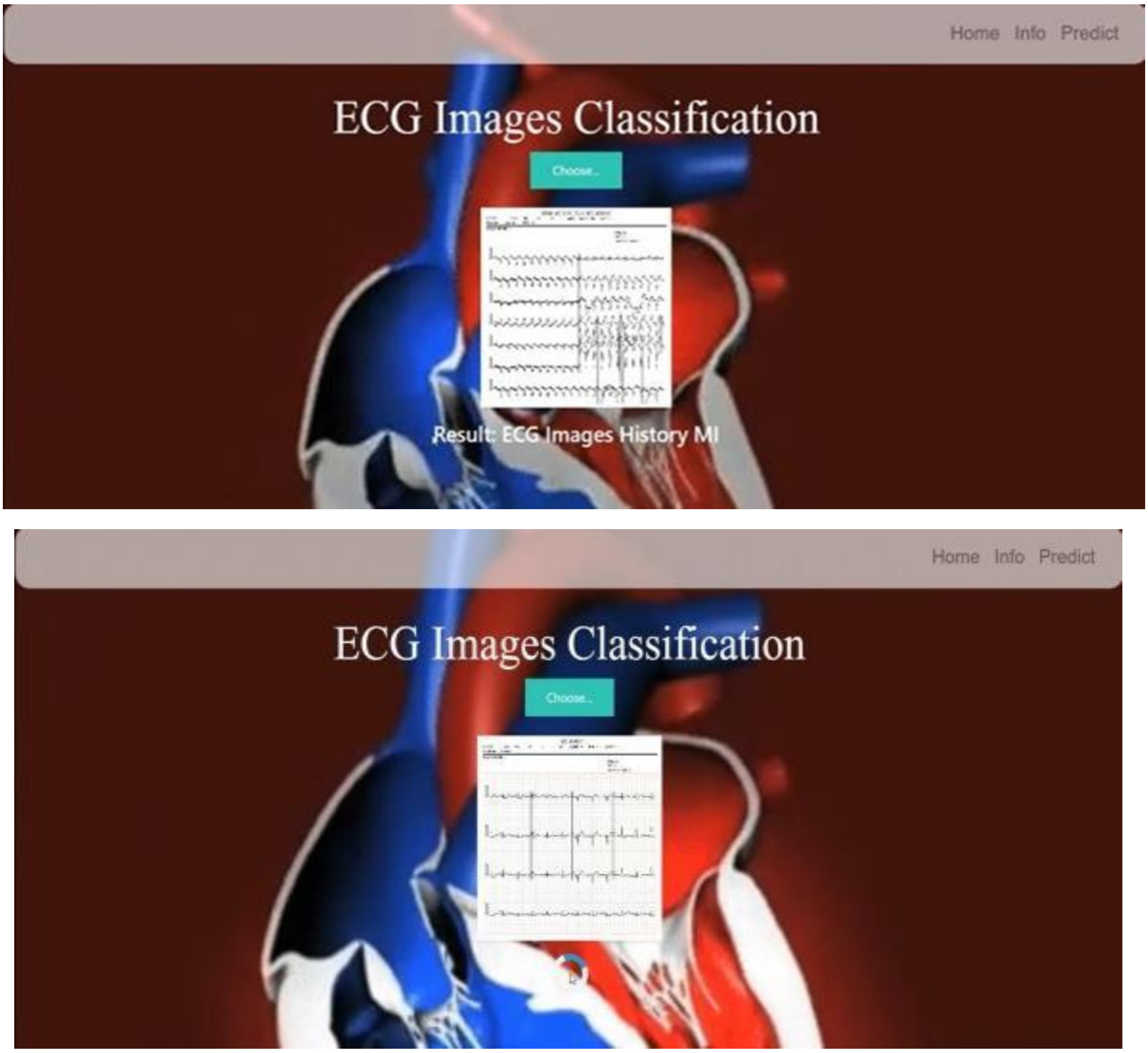

Fig10. Web application for detection through ECG images

5. Conclusion

The integration of machine learning and deep learning techniques into cardiovascular health monitoring and risk assessment represents a significant leap forward in the quest for proactive management of cardiovascular diseases (CVDs). Through our comprehensive frame work, combining text-based prediction systems and image-based analysis techniques, we have developed a robust approach aimed at personalized risk assessment and early

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detection of cardiac abnormalities.

Looking ahead, the future scope for this research holds immense potential for further advancement and impact in the field of cardiovascular health. One avenue for future exploration lies in the continual refinement and expansion of our machine learning algorithms to enhance the accuracy and granularity of risk predictions. Incorporating additional data sources such as genetic information, lifestyle factors, and environmental influences could enable even more personalized risk assessments, empowering individuals to make proactive decisions tailored to their unique health profiles. Furthermore, leveraging emerging technologies such as wearable devices and remote monitoring systems could facilitate real-time data collection, enabling continuous monitoring of cardiovascular health and timely intervention when need. Collaborations with healthcare providers and researchers could also facilitate the integration of our framework into clinical practice, ensuring widespread adoption and maximizing its potential to improve patient outcomes on a global scale. Additionally, ongoing research into novel imaging modalities and biomarkers could further enrich our image-based analysis techniques, enabling more precise detection and characterization of cardiac abnormalities. In sum, the future holds exciting possibilities for the continued evolution and application of our framework, with the potential to revolutionize the prevention, diagnosis, and management of cardiovascular diseases.

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