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Optimized Cardiac and Circulatory Disorders Prediction: A High-Accuracy Model Selection Approach that utilizes Machine Learning and Deep Learning.

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Abstract: Cardiac and Circulatory Disorders are among the primary causes of death globally, making early detection crucial for successful treatment and prevention, This research presents an advanced predictive cardiac and circulatory Disorders risk assessment model using machine learning and deep learning techniques. Three different datasets were analyzed, and the most accurate dataset was selected to train the models. Various algorithms, including Decision Tree, XGBoost(Extreme Gradient Boosting), Ada-Boost, Multi-Layer Perceptron (MLP), and Tabnet were implemented and compared. The MLP model attained the highest accuracy of 98% among all evaluated approaches, surpassing traditional machine learning models. The proposed system is designed to support healthcare professionals in identifying at-risk patients early, enabling timely intervention and improved healthcare results.
Keywords: Cardiac and Circulatory Disorders, Machine Learning, Deep Learning, Multi-Layer Perceptron (MLP), Decision Tree, Tabnet, Early Diagnosis.

I. INTRODUCTION

Cardiac and circulatory disorders refer to a diverse group of conditions that affect both the heart and blood vessels, contributing significantly to global mortality. According to recent studies, approximately 17.7 million fatalities occur worldwide each year because of cardiac and circulatory disorders, with 7.4 million deaths linked to heart-related disorders and 6.7 million resulting from strokes [1]. Stress is a major contributing factor to cardiovascular disease, as individuals experience various forms of stress, such as job-related, health-related, and personal stress, which can increase the risk of developing CVD [2]. Medical data is essential for predicting cardiac and circulatory disorders. Various datasets are available for this purpose, and selecting the most suitable dataset is essential for accurate early-stage detection. Early prediction and timely intervention are critical in reducing the fatality rate associated with these diseases. This research aims to develop a robust predictive system to assist experts in recognizing high risk individuals early, enabling timely medical interventions and preventive measures. In this study, three different datasets are analyzed, and the dataset that provides the highest prediction accuracy is selected for cardiovascular disease detection. For each dataset, Different machine learning and deep learning algorithms are utilized to predict cardiac and circulatory disorders at an early stage. The proposed approach utilizes past patient data to train models and identifying the presence or absence of the disease in a patient, leveraging machine and deep learning techniques.

II. RELATED WORK

Murugesan M, et.al,[1] This research explores the application of advanced learning algorithms in health analytics to refine the effectiveness of patient diagnostics. By leveraging data mining methods, an intelligent model can be developed using patient risk factor datasets. The study examines how deep learning and machine learning techniques contribute to diagnosis of heart diseases. In recent years, several data mining classification methods have been utilizes to enhance the accuracy and efficiency of heart disease detection. One such approach is the MLP, a sophisticated categorization algorithm that utilizes artificial neural networks with deep learning capabilities. The suggested approach combines deep learning with data mining methods to deliver accurate and dependable diagnostic results.

Sarita Charkha, et.al,[2] This review paper aims to create a predictive model for assessing the likelihood of cardiovascular disease (CVD) in patients while also increasing awareness about the condition. The model achieves high accuracy through
advanced categorization techniques, using Recurrent Neural Networks (RNN) integrated with Long Short-Term Memory (LSTM) for precise prediction.

Mokammel Hossai Tito, et al,[3] Introduced a method leveraging deep learning techniques for predicting cardiovascular diseases. They utilized algorithms such as Multi-Layer Perceptron (MLP), Radial Basis Function Network (RBFN), and WekaDeeplearning4j. Among these, RBFN demonstrated the highest accuracy, achieving 84.07%. This system aims to facilitate the early diagnosis of heart and blood vessel disease.

Abhishek, et al[4] This research developed a predictive system for CVD risk using machine learning, focusing on benchmark datsets. It explored various imputation methods-such as mean, median, most frequent, and k- nearest neighbours imputation(KNN) – to determine their effectiveness. The study adopted the CatBoost algorithm, achieving a 91% accuracy rate on the Hungarian dataset, contributing to advancements in AI-supported healthcare.

Mohammad Ibrahim, et.al[5] This work combined ML and DL techniques to improve CVD. By leveraging advanced computational models, this research aims to facilitate early diagnosis and proactive healthcare interventions. It tested multiple classifiers—including Decision Tree, Logistic Regression, Support Vector Machines (SVM), and Random Forest—are evaluated alongside DL models such as Long Short-Term Memory (LSTM), Neural Networks, and Convolutional Neural Networks (CNN). Additionally, an ensemble classification model is introduced, combining the strengths of multiple algorithms to improve prediction accuracy. The proposed ensemble model demonstrates promising results, offering a robust and comprehensive approach to heart disease detection.

Dr. M. Kavitha, et.al, [6].

This research introduces an innovative machine learning framework designed to enhance heart disease diagnosis using the Cleveland Heart Disease dataset. The methodology incorporates predictive analytics methods, including regression and classification algorithms, to evaluate cardiovascular health indicators. Three algorithmic models—Random Forest, Decision Tree, and an integrated approach combining these techniques—were developed and tested to optimize diagnostic precision. Experimental results demonstrate that the hybrid model outperforms individual algorithms, achieving superior predictive accuracy in identifying cardiac conditions.

The study highlights the potential of ensemble learning strategies in advancing data-driven healthcare solutions for early disease detection. Experimental results indicate that the hybrid model achieves an accuracy of 88.7% in heart disease prediction, demonstrating its effectiveness. Furthermore, an interactive interface is developed to collect user input parameters and provide real-time heart disease predictions using the proposed hybrid model.

Ann Romalt .A, et.al, [7] This research aims to develop a highly accurate predictive model for CVD by integrating deep learning with ML techniques. Early identification of symptoms through this approach can enable timely medical intervention, ultimately improving patient outcomes.

K.Alamelu, et.al, [8] This study provides an overview of various ML techniques developed for cardiovascular disease prediction, highlighting their significance in enhancing early diagnosis and prevention strategies.

Deep learning (DL) models have become a cornerstone in predicting cardiovascular diseases, with Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) architectures being commonly applied for their ability to analyze sequential or temporal data. However, a key challenge arises from the inherent structure of most cardiovascular datasets, which are typically static, tabular, and lack the sequential format these models are designed to process.

This mismatch often reduces their efficacy. Furthermore, current prediction methods are prone to elevated false positive rates, resulting in unwarranted medical procedures, heightened healthcare costs, and psychological distress for patients. These shortcomings emphasize the necessity to develop more precise and robust prediction frameworks, ensuring safer clinical decision-making and minimizing risks to patient well-being.

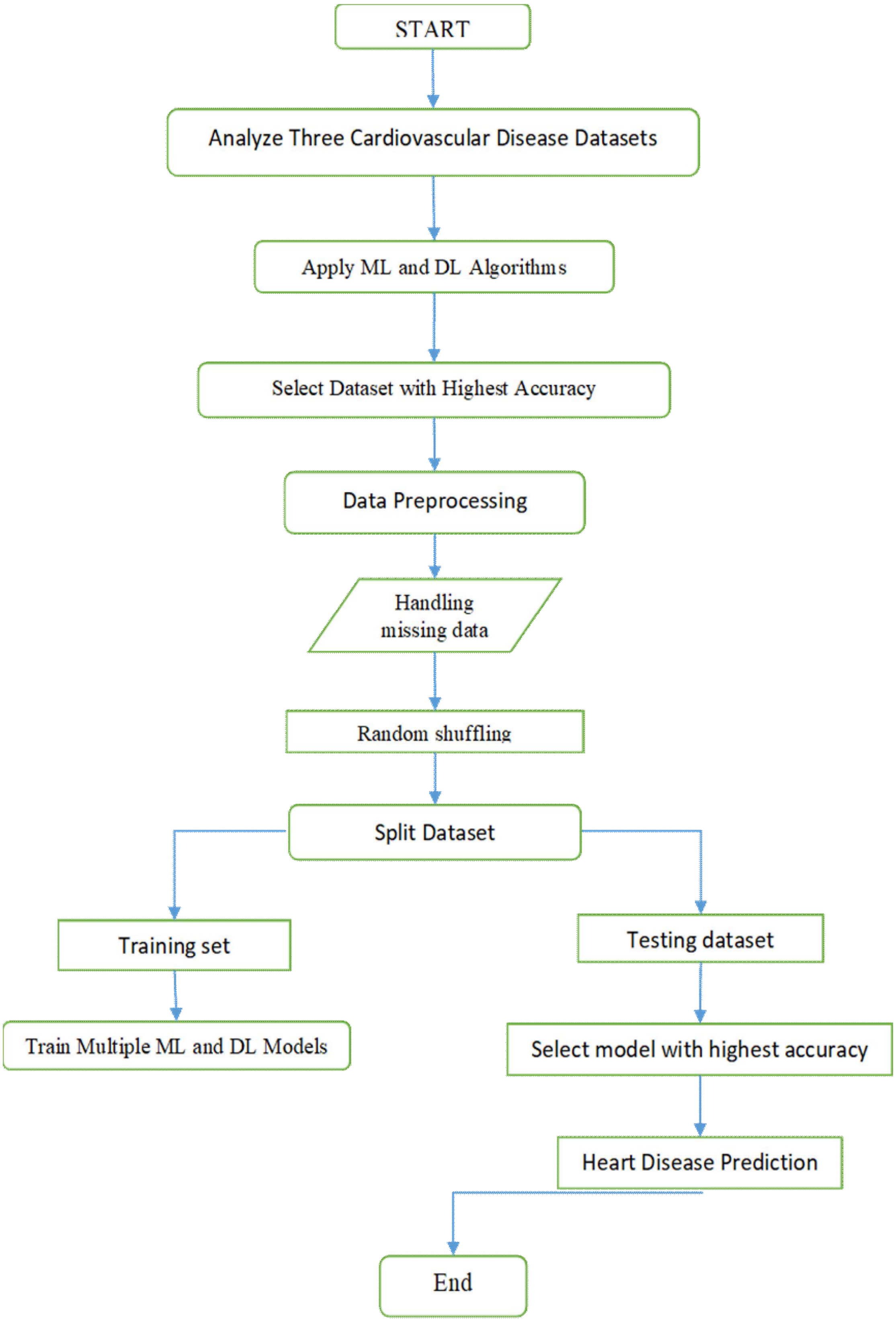

Figure 1: Flowchart of Cardiovascular Disease Prediction System

III. PROPOSED METHODOLOGY

A. Dataset Collection

Three different types of cardiovascular disease datasets are collected, each with different attributes and sizes:

1) Heart Disease Dataset (1,000 samples, 13 features)**:** This dataset includes patient records with clinical attributes such as age, biological sex, chest pain type, resting blood pressure, serum cholesterol levels, fasting blood sugar, resting electrocardiogram (ECG) results, maximum heart rate achieved, exercise-induced angina status, ST depression (oldpeak), slope of peak exercise ST segment, number of major blood vessels, and a target variable indicating heart disease diagnosis [9].
2) Cardiovascular Disease Dataset (10,000 samples, 13 features): Comprising a larger sample size, this dataset tracks variables like age, sex, height, weight, systolic and diastolic blood pressure (ap_hi and ap_lo), cholesterol and glucose levels, smoking habits, alcohol intake, physical activity status (active cardio), and a binary classification for cardiovascular disease presence [10].
3) Heart Disease Dataset (303 samples, 14 features): This smaller dataset expands on similar clinical parameters, including age, sex, chest pain type, resting blood pressure, cholesterol, fasting blood sugar, resting ECG results, maximum heart rate, exercise-induced angina, oldpeak measurement, slope characteristics, major vessel count, thalassemia diagnosis, and a target variable for heart disease detection [11].

B. Dataset Selection

Among the three datasets, only one is selected for cardiovascular disease prediction. Machine learning and deep learning technique were implemented across all three datasets, with the dataset demonstrating the highest predictive performance being selected for subsequent in-depth evaluation.

C. Data Preprocessing

The selected dataset may include missing values, which can result in inconsistencies. To enhance the accuracy of the results, data preprocessing is essential, as it significantly improves the efficiency of the algorithm. This involves handling outliers and transforming variables as needed. To address these challenges effectively, a chart function is utilized.

D. Data Splitting

The dataset was divided into training and testing subsets following standard machine learning practices. The training data was employed to construct predictive algorithms, whereas the testing subset served to validate their effectiveness by benchmarking performance metrics.

E. Model Implementation And Training

Various machine learning techniques such as, Random Forest, Decision Tress, Support Vector Machines, XGBoost, and Naïve Bayes were applied to the training data. Deep learning models, including Multi-Layer Perceptron (MLP) and Tabnet, were also implemented for comparison.

F. Prediction And Model Selection

Among all models tested, the MLP Neural Network achieved the highest accuracy of 98% for cardiovascular disease prediction. Consequently, this model was chosen as the final predictive model.

G. Deployment

A Flask web application was developed for real-time cardiovascular disease prediction based on the MLP model. The application was developed using the render platform, making it accessible for users to predict CVD risk effectively.

IV. EXPERIMENTAL ANALYSIS

This section outlines the experimental evaluation of multiple machine learning and deep learning models across three distinct datasets. The algorithms were assessed using key performance metrics, including accuracy, precision, recall, and F1-score. Among the datasets analyzed, the one producing the highest accuracy was chosen for final deployment. A comparative study of the models revealed that the MLP Neural Network outperformed others, achieving an accuracy of 98%, thereby emphasizing the potential of deep learning frameworks in cardiovascular disease prediction. The outcomes highlight the robustness of these advanced techniques. The classification reports are shown below.

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Data set1 : Cardio vascular Disease(1000,13).

Model	Accuracy(%)	Precision(%)	Recall(%)	F1 Score(%)
Logistic Regression	96	97	95	96
Decision Tree	96	96	98	97
Support Vector Machine (SVM)	95	96	95	96
Random Forest:	94	94	96	96
K-Nearest Neighbors (KNN):	94	91	94	92
Gradient Boosting	97	95	98	96
XGBoost	97	96	95	96
AdaBoost	96	96	95	95
Naive Bayes	97	98	96	97
RBFN	98	96	96	97
MLP Neural Network	99	98	99	98
Deep Learning	96	95	94	96
Tabnet	95	96	93	94

Data set 2 : Cardiovascular Disease(303,14).

Model	Accuracy(%)	Precision(%)	Recall(%)	F1 Score(%)
Logistic Regression	85	87	84	86
Decision Tree	85	93	78	85
Support Vector Machine (SVM)	87	90	84	87
Random Forest:	85	87	84	86
K-Nearest Neighbors (KNN):	90	93	88	90
Gradient Boosting	79	77	79	78
XGBoost	82	86	78	82
AdaBoost	80	86	75	80
Naive Bayes	87	90	84	87
RBFN	87	90	84	87
MLP Neural Network	85	90	81	85
Deep Learning	82	80	85	80
Tabnet	85	87	84	86

Data set 3: Cardiovascular Disease Dataset(303,14).

Model	**Accuracy(%)**	**Precision(%)**	**Recall(%)**	**F1 Score(%)**
Logistic Regression	72	75	67	71
Support Vector Machine (SVM)	74	77	68	72
Random Forest:	71	73	67	70
Gradient Boosting	73	77	66	71
XGBoost	72	74	67	70
AdaBoost	73	77	65	71
RBFN	74	77	68	72
MLP Neural Network	68	69	65	67
Deep Learning	71	68	70	69
Tabnet	74	76	69	73

V. CONCLUSION

The integration of machine learning and deep learning methodologies has significantly transformed the accuracy and efficiency of predictive models in cardiovascular disease (CVD) risk assessment. These advanced computational approaches have pioneered new possibilities in analysing complex medical data, enabling earlier detection and more personalized strategies for managing heart-related conditions. By leveraging patterns within large datasets, these technologies enhance clinical decision-making and contribute to proactive healthcare interventions. enabling early diagnosis and risk assessment with high accuracy. The MLP Neural Network, achieving 98% accuracy, was selected as the optimal model and deployed via a Flask web application on the Render platform**.** Subsequent studies ought to prioritize on enhancing model interpretability, scalability, and real-world applicability to further improve patient outcomes.

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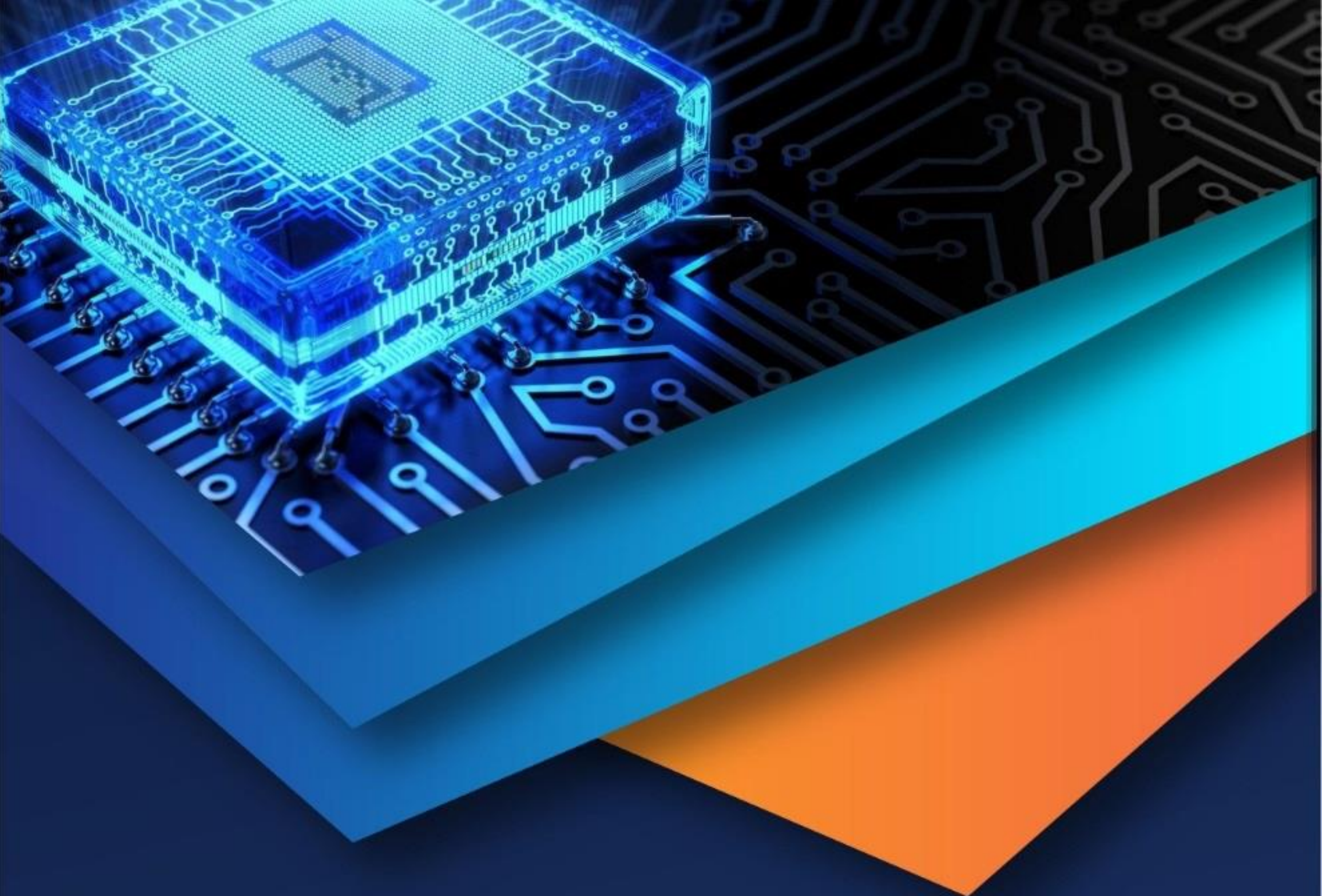

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