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Heart Checkmate: An Integrated Platform for Predictive Heart Health Management

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***Abstract*— Heart Checkmate is a web application designed to revolutionize the landscape of cardiovascular health management by providing users with an accessible and proactive approach to heart care. Leveraging machine learning models, the platform predicts the likelihood of heart diseases based on user-provided data. With a prediction accuracy of 83%, HeartCheckmate offers reliable early detection and risk assessment. The platform seamlessly integrates comprehensive medical services, connecting users with heart specialists and facilitating appointment bookings in case of predicted heart conditions. For users without predicted heart diseases, personalized home remedies and exercises are suggested. This paper details the development, features, and technological aspects of HeartCheckmate.**

***Index Terms*— Heart Disease, Cardiovascular Heart Disease, HeartCheckmate, Cardiovascular Health management, Risk assessment, Random Forest Classifier**

I. INTRODUCTION

Cardiovascular diseases are a leading cause of morbidity and mortality worldwide. Timely detection and management are crucial for preventing adverse outcomes. HeartCheckmate addresses this by providing users with a tool for predicting heart diseases and accessing relevant medical services. The primary motivation is to empower individuals to take control of their heart health from the comfort of their homes.

In the past decade and a half, Heart Diseases have persistently ranked as the leading cause of death globally, according to the World Health Organization (WHO -2019) [13].With millions of individuals diagnosed with Heart Diseases annually, it has become the foremost cause of mortality worldwide, claiming the lives of approximately twelve million people, as per WHO analysis. The alarming statistic reveals that someone succumbs to Heart Diseases nearly every 34 seconds (Patel Jaymin et al. [1] (2016)). Despite its prevalence, accurately diagnosing Heart Diseases remains a challenging and intricate task for healthcare professionals in hospitals and clinics. This challenge motivated our team to develop a Web-based Heart Diseases Prediction application utilizing advanced Machine Learning algorithms named 'HeartCheckMate'.

Our proposed system addresses this critical issue by leveraging the power of Machine Learning (ML), an emerging Artificial Intelligence (AI) technology capable of solving complex classification problems with precision. ML algorithms, specifically Logistic Regression, KNN, and Random Forest Classifier, are applied to predict Heart

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Diseases in patients. By employing these algorithms, our system compares their accuracy and training time, providing a comprehensive and efficient solution.
The primary objective of this project is to deliver a user-friendly web-based application named 'HeartCheckMate' that accurately predicts the presence of Heart Diseases in patients. By analyzing individuals' medical history, the system identifies potential Heart Disease cases, allowing for timely and effective medical intervention. With an impressive accuracy rate of 83% achieved through the implementation of the Random Forest algorithm, our project empowers individuals to conveniently assess whether they may have heart disease from the comfort of their homes. If the algorithm detects a potential issue, the platform facilitates a connection with a specialized heart care professional. On the other hand, if no signs of heart disease are identified, the website provides users with tailored exercise routines and home remedies to promote a healthy lifestyle.
This advanced system not only aids doctors and healthcare professionals in making informed decisions but also facilitates timely diagnoses and effective treatments. By reducing the need for extensive medical tests, our application optimizes healthcare resources and provides a valuable tool in the fight against Heart Diseases. The 'HeartCheckMate' software is poised to significantly improve the diagnostic process, potentially saving countless lives and strengthening healthcare decision-making processes in hospitals and clinics worldwide.

II. Problem Statement

Heart Disease encompasses a range of conditions affecting the heart, including Coronary Artery Disease, Congenital Heart Diseases, Mitral Valve Prolapse, Arrhythmia, and more. Among these, Cardiovascular Disease (CVD) stands out as a significant threat, characterized by obstructed blood vessels leading to strokes and heart attacks. According to the World Health Organization (WHO) statistics, CVDs account for a substantial portion of global mortality, responsible for approximately 31% of human deaths in 2016. This alarming figure highlights the urgent need for efficient diagnosis and prevention strategies. Often, the lack of clear diagnostic tools and challenges in implementing doctors' decisions contribute to the high mortality rates associated with Heart Diseases.
In response to the pressing issue of Heart Disease diagnosis, we propose a ground-breaking solution: a web-based Heart Disease Prediction Software named 'HeartCheckMate'. This innovative system aims to revolutionize the diagnostic process by providing accurate and efficient predictions of Heart Disease patients. By eliminating the need for extensive testing, the proposed software streamlines the diagnosis procedure. This approach not only enhances the decision-making process for doctors but also significantly reduces the number of tests patients need to undergo.
The system's user-friendly interface makes it suitable for hospitals and clinics, enabling healthcare professionals to evaluate patients for Heart Diseases with ease and precision. The platform seamlessly integrates comprehensive medical services, connecting users with heart specialists and facilitating appointment bookings in case of predicted heart conditions. For users without predicted heart diseases, personalized home remedies and exercises are suggested.

III. Related Work

S.No.	Paper Title	Description	References
1	Heart Disease prediction using Machine learning and Data Mining Technique.	Decision Tree (DT) gave the accuracy of 56.76%, study underscores the need for sophisticated models to enhance heart disease prediction.	Jaymin Patel et al. (2016) [1]
2	Heart Disease Prediction System Using Machine Learning	Naïve Bayes (NB) are employed, that is achieving an accuracy of 88.163%	Ranjit Shrestha et al. (2019) [2]
3	Heart disease prediction using machine learning algorithms	KNN algorithm achieved highest accuracy at 88.52% among the three algorithms employed, predicting heart diseases more accurately	Harshit Jindal et al. (2021) [3]
4	An artificial intelligence model for heart disease detection using machine learning algorithms.	Random Forest Classifier algorithm is deployed and it is giving the accuracy of 83%.	Chang V et al.(2022) [4]
5	Machine learning-based heart disease diagnosis: A systematic literature review.	ML challenges identified after referring to 451 references in heart disease diagnosis, urging real-time patient data experiments.	Md Manjurul Ahsan et al. (2022) [5]

6	A systematic review on machine learning approaches for cardiovascular disease prediction using medical big data.	The study concludes ML's vital role in early cardiovascular disease detection, guiding future research and healthcare procedures.	Javed Azmi et al. (2022) [6]
7	The Efficacy of Machine-Learning-Supported Smart System for Heart Disease Prediction.	KNN demonstrated superior accuracy (100% on CHSLB and 97.82% on Cleveland datasets) compared to RF, AB, and DT models, while RF, AB, and DT models also exhibited high accuracy on the CHSLB dataset.	Nurul Absaral et al. (2022) [7]
8	Multi-Label Active Learning-Based Machine Learning Model for Heart Disease Prediction	Active learning for better heart disease prediction (57.4% accuracy), suggesting improvements for handling numbers and exploring advanced algorithms.	Ibrahim Hasnony et al.(2022) [8]
9	European Society of Cardiology: Cardiovascular Disease Statistics 2021.	ESC report reveals CVD trends, gender-based life expectancy, and healthcare disparities.	Adam Timmis et al. (2022) [9]
10	A hybrid GA and PSO optimized approach for heart-disease prediction based on random forest.	GAPSO-RF achieves 95.6% accuracy in heart disease prediction, overcoming overfitting with RF; challenges include computation	Mohamed G. El-Shafiey et al. (2022) [10]
11	Automated Echocardiographic Detection of Severe Coronary Artery Disease Using Artificial Intelligence	An automated image processing pipeline extracted geometric and kinematic features from stress echocardiograms, achieving acceptable accuracy for severe coronary artery disease identification with 92.7% specificity and 84.4% sensitivity.	Ross Upton et al. (2022) [11]
12	Risk assessment of coronary heart disease based on cloud-random forest	The paper introduces a C-RF model for CHD risk assessment, achieving an 85% classification accuracy, surpassing CART, SVM, CNN, and RF models by 8%, 9%, 4%, and 3% respectively.	Jing Wang et al. (2023) [12]

IV. METHODOLOGY

HeartCheckmate is built on a robust technological foundation, using Flask as the backend framework. The machine learning model, developed with scikit-learn, predicts heart diseases based on 13 input parameters. HTML, CSS, and JavaScript (jQuery) contribute to the frontend, providing an interactive and user-friendly interface. The platform follows a Model-View-Controller (MVC) architecture for maintainability.
Heart disease prediction model using Python and integrating it into a web application involves several steps:

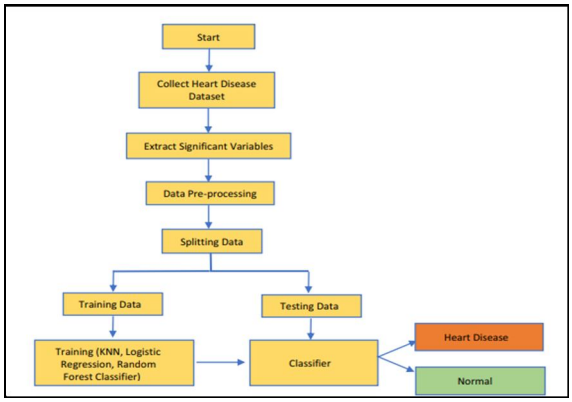

Figure 1. Flowchart depicting the model

A. Data Collection

- Gathered a dataset related to heart disease for purpose of prediction.
- The dataset utilized for this project was sourced from Kaggle [14]
- Ensured the dataset contains relevant features like age, sex, cholesterol levels, blood pressure, etc., along with the target variable indicating the presence or absence of heart disease.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
2	52	1	0	125	212	0	1	168	0	1	2	2	3	0
3	53	1	0	140	203	1	0	155	1	3.1	0	0	3	0
4	70	1	0	145	174	0	1	125	1	2.6	0	0	3	0
5	61	1	0	148	203	0	1	161	0	0	2	1	3	0
6	62	0	0	138	294	1	1	106	0	1.9	1	3	2	0
7	58	0	0	100	248	0	0	122	0	1	1	0	2	1
8	58	1	0	114	318	0	2	140	0	4.4	0	3	1	0
9	55	1	0	160	289	0	0	145	1	0.8	1	1	3	0
10	46	1	0	120	249	0	0	144	0	0.8	2	0	3	0
11	54	1	0	122	286	0	0	116	1	3.2	1	2	2	0
12	71	0	0	112	149	0	1	125	0	1.6	1	0	2	1

Figure 2. Various Attributes used are listed here

B. Data Preprocessing

- Imported necessary libraries: pandas for data manipulation, numpy for numerical operations, matplotlib and seaborn for data visualization.
- Loaded the dataset into a pandas Data Frame.
- Handled the missing data if any by imputing or removing the missing values.
- Splitted the data into features (X) and the target variable (y).

C. Data Exploration and Visualization

- Explored the dataset to gain insights using various statistical and visualization techniques.
- Used histograms, box plots, and correlation matrices to understand feature distributions and relationships.

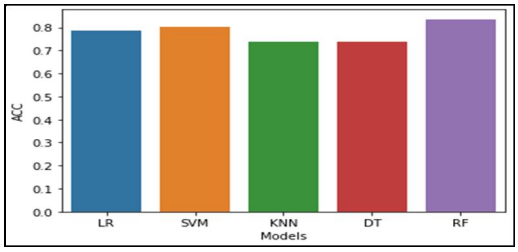

Figure 3. Bar plots showing various Model Training Algorithms

D. Model Selection

- Tested several machine learning algorithms such as KNN (K-Nearest Neighbors Algorithm), Decision Tree(DT), Logistic Regression, Random Forest, Support Vector Machines, etc., for classification problems.
- The Random Forest algorithm was selected due to its superior accuracy, surpassing other machine learning algorithms with a noteworthy rate of 83%.
- Splitted the data into training and testing sets for model evaluation.

	Models	ACC
0	LR	0.786885
1	SVM	0.803279
2	KNN	0.737705
3	DT	0.721311
4	RF	0.836066

Figure 4. Comparison between accuracy of different models

E. Model Training

- Trained the selected machine learning models using the training dataset.
- Tuned hyper parameters using techniques like Grid Search or Random Search for optimal performance.

F. Model Evaluation

- Evaluated the models on the basis of accuracy.
- Selected the model with the best performance based on the evaluation metrics.
- Random Forest Model was selected.

G. Web Development

- Selected a web framework for Python like Flask to build the web application.

- Set up a virtual environment for the project to manage dependencies.
- Created HTML forms to take user inputs for relevant health parameters.
- Used CSS for styling the web interface to make it user-friendly.
- Used JavaScript (jQuery) for dynamic content and client-side validation.

H. Integration of Model with Web App

- Serialized the trained machine learning model using libraries like pickle or other libraries.
- Created a route in the web application to handle form submissions.
- Parsed user inputs from the form and passed them to the loaded model for prediction.
- Displayed the prediction result on a new web page or modal within the web app.

I. Deployment

- Selected a hosting platform for our web application (Netlify).
- Configured the deployment settings and deployed our web application.
- Ensured that the server environment supports the required Python libraries and dependencies.

V. Core Features

- *Predictive Heart Health Analysis*: The platform incorporates advanced machine learning models for analyzing users' heart health based on provided data. This feature enables early detection and risk assessment of potential heart diseases.
- *Medical Services Integration*: In case of a predicted heart condition, HeartCheckmate seamlessly connects users with experienced heart specialists and facilitates hassle-free appointment bookings at reputed hospitals.
- *Personalized Home Remedies*: For users with no predicted heart diseases, the platform offers personalized home remedies and exercises to maintain a healthy heart, promoting proactive heart health management.
- *Communication and Consultation*: Users can engage in communication with healthcare experts through a secure and private system, allowing them to seek advice, clarify doubts, and receive guidance on heart health.
- *Search and Discovery*: HeartCheckmate offers search functionality, enabling users to find specific information, medical services, or resources based on their health concerns or keywords. This feature enhances user navigation and discovery within the platform.
- *Privacy and Security***:** The project prioritizes the privacy and security of user health data. Robust security measures, including data encryption and secure authentication protocols, are implemented to protect sensitive health information.

VI. Results

In the development of HeartCheckmate, the pre-trained Random Forest model is seamlessly integrated into the Flask application using the joblib library. The model, trained to predict the likelihood of heart diseases based on user input, is loaded into the Flask environment. The predict() function within the Flask application handles the prediction process. This function takes user input from the frontend, preprocesses the input data, and leverages the loaded machine learning model to obtain predictions. The input features, such as age, gender, cholesterol levels, and more, are collected from the user through a form on the frontend. Once received, these inputs undergo preprocessing to ensure compatibility with the model's requirements. The preprocessed data is then fed into the Random Forest model to generate predictions. The outcomes, whether indicating the possibility of heart diseases or not, are subsequently communicated back to the frontend for display to the user. This seamless integration of machine learning prediction capabilities within a Flask application empowers HeartCheckmate to offer real-time and accurate insights into users' heart health.

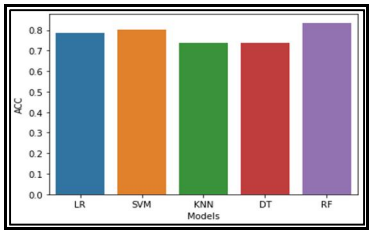

Figure 5. Bar plots showing various Model Training Algorithms

	Models	ACC
0	LR	0.786885
1	SVM	0.803279
2	KNN	0.737705
3	DT	0.721311
4	RF	0.836066

Figure 6. Comparison between accuracy of different models

VII. CONCLUSION

HeartCheckmate emerges as a comprehensive and user-friendly platform for proactive heart health management. By combining predictive analytics, medical services, and a supportive community, the platform aims to transform the way individuals approach cardiovascular health.

HeartCheckmate is a pioneering platform redefining proactive heart health management through predictive analytics and accessible medical services. It connects users with experienced specialists and offers hassle-free appointment bookings for timely healthcare access. Additionally, it provides tailored home remedies and exercises for both predicted and non-predicted heart diseases, fostering inclusivity. The platform's intuitive interface and personalized profiles create a supportive community where users share insights for collective benefit. Overall, HeartCheckmate revolutionizes heart health management in an era where preventive healthcare is paramount.

As technological advancements continue to reshape healthcare landscapes, HeartCheckmate stands as a testament to the potential of integrating machine learning, web development, and community-driven support for proactive health management. With its commitment to user-centric design, data security, and accuracy, HeartCheckmate envisions a future where individuals not only predict and prevent heart diseases but actively engage in a collaborative and supportive ecosystem dedicated to heart wellness.

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