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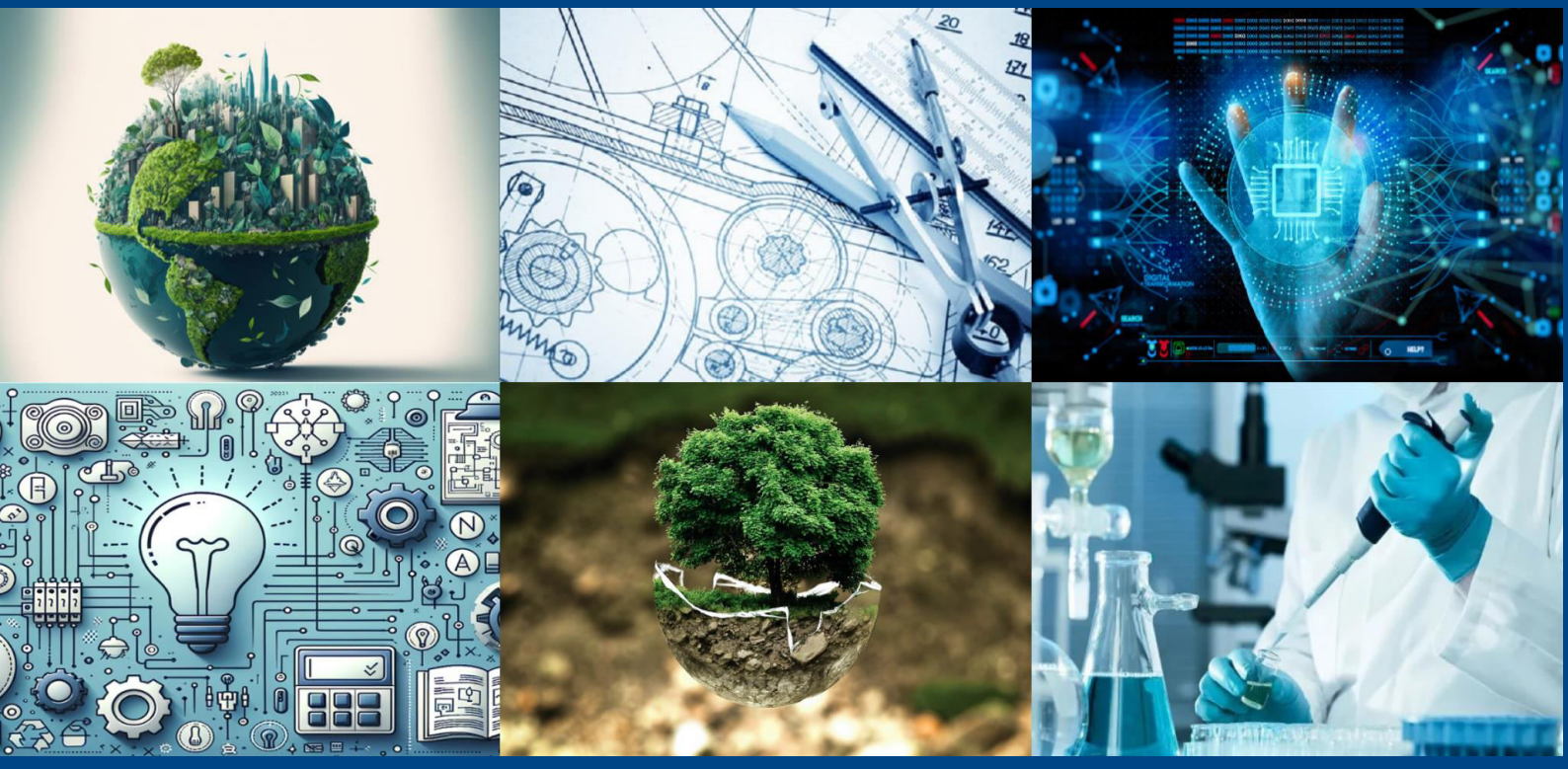

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Heart Failure Prediction Using KNN

Rakshana V, D Pavithra

Student, Sri Krishna College of Arts and Science, Coimbatore, Tamil Nadu, India

Assistant Professor, Sri Krishna College of Arts and Science, Coimbatore, Tamil Nadu, India

ABSTRACT: Heart disease is one of the leading causes of mortality worldwide, making early diagnosis and timely treatment essential for improving patient outcomes. Traditional diagnostic methods often require extensive clinical examinations, laboratory tests, and expert medical evaluation, which can be time-consuming and expensive. To address these challenges, this paper presents a Heart Failure Prediction System based on Machine Learning techniques for predicting the likelihood of heart disease using patient health data.

The proposed system utilizes the K-Nearest Neighbors (KNN) algorithm to classify patients as either having heart disease or not based on various medical attributes, including age, sex, chest pain type, resting blood pressure, cholesterol level, fasting blood sugar, resting electrocardiogram (ECG), maximum heart rate, exercise-induced angina, oldpeak, and ST slope. The model is trained using the heart.csv dataset after performing data preprocessing, feature encoding, and feature scaling to improve prediction performance. The trained model is deployed as a user-friendly web application using the Flask framework, enabling users to enter patient details and receive instant prediction results through a simple interface.

The proposed system provides a fast, efficient, and reliable method for preliminary heart disease prediction. It can assist healthcare professionals in clinical decision-making by offering quick risk assessments and promoting early diagnosis. Although the application is not intended to replace professional medical evaluation, it serves as an intelligent decision-support tool that can improve healthcare efficiency and patient awareness. Future enhancements may include the use of larger datasets, advanced machine learning algorithms, cloud-based deployment, and integration with hospital information systems to further improve prediction accuracy and practical applicability.

I. INTRODUCTION

Machine Learning is a branch of Artificial Intelligence that enables computer systems to learn from data and make predictions or decisions without being explicitly programmed for every task. It has transformed numerous sectors, including healthcare, finance, education, and manufacturing, by providing intelligent solutions based on data analysis. In the healthcare sector, machine learning techniques are increasingly being used to predict diseases, assist in diagnosis, and improve patient outcomes through data-driven decision-making.

The project “Heart Failure Prediction Using Machine Learning” is designed to predict the presence or absence of heart disease using patient medical information. The system utilizes a dataset named “heart.csv,” which contains various attributes associated with cardiovascular health. The dataset is processed and analyzed using Python.

Programming in the Jupyter Notebook environment. Appropriate preprocessing Techniques are applied to prepare the data for model training. The machine learning model learns patterns from historical patient records and can generate predictions for new patient data.

After successful model development, the prediction system is deployed using Visual Studio Code to create an interactive interface. Users can enter medical parameters including age, sex, chest pain type, resting blood pressure, cholesterol level, fasting blood sugar, resting ECG results, maximum heart rate achieved, exercise-induced angina, oldpeak value, and ST slope. The trained model processes the entered values and displays a prediction indicating whether the person has heart disease or not. Although the system cannot replace professional medical diagnosis, it can function as an effective decision-support tool that promotes early detection and timely healthcare interventions.

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II. BACKGROUND

Heart disease is one of the leading causes of death worldwide and has become a major public health concern. Early detection and timely diagnosis play an important role in reducing the risk of severe complications and improving patient survival rates. Traditionally, heart disease is diagnosed through clinical examinations, laboratory tests, electrocardiograms (ECG), echocardiography, and the expertise of healthcare professionals. Although these methods are reliable, they are often time-consuming and expensive, and they require specialized medical equipment. Patients may also need to undergo multiple diagnostic procedures before receiving a final diagnosis.

With the rapid advancement of Artificial Intelligence (AI) and Machine Learning (ML), intelligent healthcare systems have become increasingly popular. Machine learning algorithms can analyze large volumes of patient data, identify hidden patterns, and generate accurate predictions within a short period. This project, Heart Failure Prediction System, uses the heart.csv dataset and the K-Nearest Neighbors (KNN) algorithm to predict whether a patient has heart disease based on medical parameters such as age, sex, chest pain type, blood pressure, cholesterol level, fasting blood sugar, resting ECG, maximum heart rate, exercise-induced angina, oldpeak, and ST slope. The application is developed using Python and deployed with the Flask framework to provide a simple web-based interface for users.

III. PROBLEM DEFINITION

Heart disease is a life-threatening medical condition that requires early diagnosis and treatment. Traditional diagnostic methods often involve multiple clinical tests, laboratory investigations, and expert analysis, making the diagnosis process time-consuming and costly. In many cases, patients living in rural or remote areas have limited access to specialized healthcare facilities, resulting in delayed diagnosis and treatment. Manual analysis of patient data may also increase the workload of healthcare professionals and lead to inconsistencies in diagnosis.

Therefore, there is a need for an intelligent prediction system that can analyze patient medical information quickly and accurately. The proposed system aims to support healthcare professionals by providing preliminary heart disease predictions using machine learning techniques. This helps reduce diagnosis time, improves decision-making, and promotes early detection of heart disease.

IV. PROPOSED SOLUTION

The proposed solution is to develop a Heart Failure Prediction System using Machine Learning. The system utilizes the K-Nearest Neighbors (KNN) algorithm to analyze a patient's medical data and predict whether a person has heart disease or not. The application is trained using the heart.csv dataset, which contains various health-related attributes required for prediction.

The system is developed using Python, while Flask is used for deployment as a web application. Users can enter patient details through a simple web interface, including age, gender, chest pain type, resting blood pressure, cholesterol level, fasting blood sugar, resting ECG, maximum heart rate, exercise-induced angina, oldpeak, and ST slope. After preprocessing and feature scaling, the trained machine learning model analyzes the data and instantly displays either "Heart Disease Detected" or "No Heart Disease." This provides users with a fast, reliable, and user-friendly prediction system.

V. OBJECTIVES AND SCOPE

Objectives

- To develop a machine learning-based Heart Failure Prediction System.
- To predict the presence or absence of heart disease using patient medical data.
- To improve the speed and accuracy of preliminary heart disease prediction.
- To develop a user-friendly web application using the Flask framework.
- To assist healthcare professionals by providing quick prediction results.
- To reduce the time required for preliminary diagnosis and improve healthcare decision-making.

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Scope

The scope of this project is to develop a web-based application that predicts heart disease using machine learning techniques. The system analyzes patient medical parameters and generates prediction results based on the trained KNN model. It can be used as a decision-support tool for preliminary health assessment and educational purposes. Although the system provides accurate predictions based on the available dataset, it is not intended to replace professional medical diagnosis. Future enhancements may include larger datasets, advanced machine learning algorithms, integration with hospital management systems, mobile application support, cloud deployment, and personalized health recommendations to improve the effectiveness of the system.

VI. SYSTEM STUDY

EXISTING SYSTEM

The traditional diagnosis of heart disease primarily depends on clinical examinations, laboratory investigations, electrocardiograms (ECG), echocardiography, blood tests, and the expertise of healthcare professionals. Physicians carefully analyze various medical parameters such as blood pressure, cholesterol level, heart rate, and patient medical history before diagnosing heart disease. In many cases, additional diagnostic procedures are required to confirm the disease accurately.

Although these conventional methods are reliable and widely accepted, they are often time-consuming, expensive, and require specialized medical equipment. Patients may need to undergo multiple tests and repeated hospital visits before receiving a final diagnosis. This process can delay treatment, especially in emergency situations. In addition, healthcare facilities in rural and remote areas may not always have access to advanced diagnostic equipment or experienced cardiologists, making early detection more difficult.

The increasing number of cardiovascular patients also places a heavy workload on healthcare professionals. Traditional diagnostic methods generally do not utilize machine learning techniques to analyze historical patient data and identify hidden patterns. As a result, there is a growing need for intelligent systems that can assist doctors by providing fast and accurate preliminary predictions of heart disease.

PROPOSED SYSTEM

The proposed system is a Heart Failure Prediction System developed using Machine Learning techniques. The application uses the K-Nearest Neighbors (KNN) algorithm to analyze patient medical information and predict whether a person has heart disease or not. The system is trained using the heart.csv dataset, which contains various medical attributes required for prediction.

The application is developed using Python and deployed as a web application using the Flask framework. Users enter patient details such as age, gender, chest pain type, resting blood pressure, cholesterol level, fasting blood sugar, resting ECG, maximum heart rate, exercise-induced angina, oldpeak, and ST slope through a simple web interface. The system preprocesses the input data, performs feature scaling, and sends it to the trained KNN model. Based on the analysis, the application displays either "Heart Disease Detected" or "No Heart Disease."

The proposed system provides quick, reliable, and user-friendly predictions, reducing diagnosis time and supporting healthcare professionals in making better clinical decisions. It serves as an intelligent decision-support system for the early detection of heart disease.

The Heart Failure Prediction System can be developed and executed on a standard personal computer without requiring high-end hardware. The system requires sufficient processing power and memory to perform machine learning operations efficiently.

VII. MODULES AND DESCRIPTION

The Heart Failure Prediction System is divided into several modules, each responsible for performing a specific task. These modules work together to ensure accurate prediction of heart disease based on patient medical information.

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USER INTERFACE MODULE

The User Interface Module provides a simple and interactive platform through which users can enter patient medical details. This module is developed using HTML and consists of input fields for age, gender, chest pain type, resting blood pressure, cholesterol level, fasting blood sugar, resting ECG, maximum heart rate, exercise-induced angina, oldpeak value, and ST slope. The user enters the required information and submits the form for prediction. The interface is designed to be user-friendly and easy to operate, allowing users to obtain prediction results efficiently.

DATACOLLECTIONMODULE

The Data Collection Module is responsible for obtaining and loading the heart disease dataset named "heart.csv." The dataset contains various medical attributes that are used to train the machine learning model. The collected data serves as the foundation for model development and prediction. This module ensures that the required patient information is available for analysis and model training.

DATA PREPROCESSING MODULE

The Data Preprocessing Module prepares the collected data for machine learning operations. In this module, categorical attributes such as gender and exercise-induced angina are converted into numerical values through encoding techniques. One-hot encoding is applied to categorical variables such as chest pain type, resting ECG, and ST slope. The preprocessing stage also ensures that the input data structure matches the format used during model training. This module plays a vital role in improving the performance and reliability of the prediction model.

FEATURE SCALING MODULE

The Feature Scaling Module standardizes the input values using a previously trained scaler model. Since the dataset contains attributes with different numerical ranges, scaling is necessary to ensure that all features contribute equally during prediction. The saved scaler file is loaded and applied to the user input data before it is sent to the machine learning model. This process improves the accuracy and efficiency of the K-Nearest Neighbors algorithm.

PREDICTION MODULE

The Prediction Module is the core component of the system. This module loads the trained K-Nearest Neighbors (KNN) machine learning model and uses it to analyze the processed patient data. The model compares the entered values with patterns learned from historical patient records and predicts whether the patient is likely to have heart disease. The prediction process is completed within a few seconds, providing quick and reliable results.

RESULT DISPLAY MODULE

The Result Display Module presents the prediction outcome to the user. Based on the prediction generated by the machine learning model, the system displays either "Heart Disease Detected" or "No Heart Disease." This module ensures that the prediction result is displayed clearly and understandably. It acts as the final stage of the application and provides users with immediate feedback regarding the entered medical information.

DEPLOYMENT MODULE

The Deployment Module is responsible for integrating the machine learning model with the Flask web framework and making the application accessible through a web browser. The application is developed using Python and deployed using Visual Studio Code. Flask manages user requests, processes the input data, communicates with the prediction model, and returns the prediction result to the user interface. This module ensures the smooth operation of the complete system in a real-time environment.

TESTING

Testing is an essential phase in the development of the Heart Failure Prediction System. The primary objective of testing is to verify that the application functions correctly, accepts user inputs without errors, processes the data accurately, and generates reliable prediction results. The system was tested after successful model training and deployment using Flask. Different combinations of patient health parameters were provided as input to evaluate the performance of the machine learning model and ensure the correctness of the prediction process.

The testing process involved validating each module of the application, including user input handling, data preprocessing, feature scaling, model prediction, and result display. The application successfully accepted medical details such as age,

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sex, chest pain type, resting blood pressure, cholesterol level, fasting blood sugar, resting ECG results, maximum heart rate achieved, exercise-induced angina, oldpeak value, and ST slope. These values were processed and analyzed by the trained K-Nearest Neighbors (KNN) model to predict whether the patient had heart disease or not.

The prediction results generated by the system were compared with expected outcomes to ensure accuracy and reliability. Multiple test cases were executed using different patient records representing low-risk, moderate-risk, and high-risk conditions. The system produced the expected outputs in all cases and demonstrated stable performance throughout the testing phase.

UNIT TESTING

Unit testing was performed to verify the functionality of individual components of the system. Each module was tested separately to ensure proper operation. The user input module was tested for accepting valid data, the preprocessing module was tested for correct data conversion and encoding, and the prediction module was tested for generating appropriate outputs. The results confirmed that all individual modules worked as expected.

INTEGRATION TESTING

Integration testing was carried out to ensure that all modules functioned correctly when combined. The flow of data from the user interface to the prediction module and finally to the result display module was verified. The successful communication between Flask, the machine learning model, and the web interface confirmed that the system operated smoothly without any integration issues.

SYSTEM TESTING

System testing was conducted on the complete application to verify overall performance. The deployed application was tested through a web browser by entering different patient details. The system successfully processed all inputs and displayed the correct prediction results. This testing confirmed that the application met all specified functional requirements.

VIII. TEST CASES

Test Case 1: Prediction for a Healthy Person

Description:

This test case was performed to verify whether the system correctly identifies a patient with normal health parameters as not having heart disease. The entered values represented a healthy individual with normal blood pressure, cholesterol level, and heart rate.

Expected Output:

No Heart Disease

Actual Output:

No Heart Disease

Status:

Pass

Test Case 2: Prediction for a High-Risk Patient

Description:

This test case was conducted to verify the system's ability to detect heart disease in a patient with high-risk medical conditions. The entered values indicated elevated blood pressure, high cholesterol levels, abnormal ECG results, and exercise-induced angina.

Expected Output:

Heart Disease Detected

Actual Output:

Heart Disease Detected

Status:

Pass

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Test Case 3: Prediction for a Moderate-Risk Patient

Description:

This test case was performed to ensure that the application correctly processes patient information with moderate risk factors and generates an appropriate prediction based on the trained machine learning model.

Expected Output:

No Heart Disease

Actual Output:

No Heart Disease

Status:

Pass

TEST RESULT ANALYSIS

The testing results demonstrate that the Heart Failure Prediction System performs accurately and efficiently under different conditions. The application successfully accepts user inputs, preprocesses the data, applies feature scaling, and predicts the outcome using the K-Nearest Neighbors machine learning algorithm. All test cases produced the expected outputs, indicating that the system is reliable and capable of assisting users in obtaining preliminary heart disease predictions. The successful completion of testing validates the effectiveness of the proposed system and confirms that it meets the objectives of the project.

IX. CONCLUSION AND FUTURE SCOPE

CONCLUSION

The Heart Failure Prediction System developed during the internship training successfully demonstrates the application of Machine Learning in the healthcare domain. The main objective of the project was to predict whether a person has heart disease or not based on various medical parameters such as age, sex, chest pain type, resting blood pressure, cholesterol level, fasting blood sugar, resting ECG results, maximum heart rate achieved, exercise-induced angina, oldpeak value, and ST slope.

The project utilized a dataset named “heart.csv” for training the machine learning model. Various stages such as data collection, preprocessing, feature scaling, model training, testing, and deployment were successfully completed. The K-Nearest Neighbors (KNN) algorithm was used to build the prediction model, and the application was deployed using the Flask framework. A user-friendly web interface was developed using HTML, allowing users to enter medical information and obtain prediction results instantly.

The system successfully predicts whether a person is likely to have heart disease and displays the result as either “Heart Disease Detected” or “No Heart Disease.” The testing phase confirmed that the application performs accurately and reliably under different input conditions. This project demonstrates how machine learning techniques can assist in the early detection of heart disease and support healthcare decision-making. Although the system is not intended to replace professional medical diagnosis, it serves as an effective tool for preliminary health assessment and awareness.

FUTURE SCOPE

The Heart Failure Prediction System can be enhanced further by incorporating advanced machine learning and artificial intelligence techniques to improve prediction accuracy and overall system performance. Future versions of the project can utilize larger and more diverse healthcare datasets, allowing the model to learn from a wider range of patient records and provide more accurate predictions.

The system can also be integrated with hospital management systems and electronic health record databases to enable real-time patient analysis. A mobile application can be developed to improve accessibility and allow users to perform heart disease prediction directly from smartphones and tablets. Additional medical parameters such as body mass index (BMI), smoking habits, family medical history, diabetes status, and lifestyle factors can be included to provide a more comprehensive prediction model.

Future enhancements may also include graphical reports, health recommendations, risk score analysis, and appointment scheduling features that can assist both patients and healthcare professionals. Integration with cloud computing

technologies can improve scalability and allow the application to serve a larger number of users efficiently. These improvements will make the system more intelligent, user-friendly, and beneficial in supporting preventive healthcare and early disease detection.

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6. The above references played a significant role in understanding machine learning concepts, developing the prediction model, implementing the Flask web application, and successfully completing the Heart Failure Prediction System.

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