Cardiac Status Prediction using Machine Learning

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***Abstract*:**

This work focuses on creating an IoT platform using machine learning to predict cardiac status with a Raspberry Pi. The system uses a DS18B20 sensor for temperature measurements and a MAX30100 sensor for monitoring heart rate and oxygen saturation. It incorporates various user-specific health features such as age, gender, smoking status, cigarettes per day, hypertension prevalence, blood pressure medication usage, diabetes status, BMI, heart rate, and temperature to improve prediction accuracy. The data collected is processed on the Raspberry Pi using a pre-trained machine learning model (Logistic Regression) to predict cardiac health status. A Flask-based web application provides an intuitive user interface, allowing users to input their health data and receive cardiac status predictions. This work aims to offer a low-cost, efficient, and user-friendly tool for early detection and monitoring of cardiac health, with potential benefits in preventive healthcare and personalized medicine.

***Keywords*:Machine Learning, Logistic Regression, Cardiac Status Prediction.**

I. Introduction

The World Health Organization (WHO) reports that over 17 million people have died from cardiovascular disease (CVD).Detecting and treating heart conditions early is crucial, and machine learning algorithms offer promise in predicting the likelihood of heart disease based on different risk factors. These algorithms take into account various clinical and lifestyle factors such as age, gender, smoking, blood pressure, diabetes, BMI, body temperature, and heart rate. Before building the models, the data undergo preprocessing and feature selection, with the Logistic Regression model proving the most effective in this dataset. Identifying and preventing heart disease early can significantly reduce mortality rates by identifying individuals at high risk.

Healthcare is undergoing a revolution because of the combination of machine learning (ML) and the Internet of Things (IoT), which is allowing creative solutions for ongoing health monitoring and early illness identification. The goal of this workis to create a Raspberry Pi-based machine learning (ML) platform that can forecast cardiac state. The platform provides insights into an individual's heart health by utilizing lifestyle characteristics and physiological data from sensors such as the MAX30100 and DS18B20. The major goal is to create a prediction system that can evaluate heart health and enable early intervention by using sensor data and demographic and lifestyle information.

The Raspberry Pi functions as the central processing unit, overseeing the gathering of sensor data and facilitating communication with the machine learning model. The DS18B20 serves as a digital temperature sensor to track body temperature, and a combination pulse oximeter and heart rate sensor detects blood oxygen levels and heart rate. Early intervention is made possible by the Machine Learning Model, which analyses the data using a variety of variables to anticipate probable cardiac problems.

II. LITERATURE SURVEY

We have thoroughly examined past and current research on cardiac complications. Cardiovascular diseases and chronic respiratory conditions pose significant public health risks, leading to an estimated 19 million deaths globally each year. Cutting-edge medical advancements that monitor physiological parameters like blood pressure, cholesterol levels, and blood glucose have the potential to reduce this mortality rate. These advancements enable timely interventions by healthcare professionals and empower patients to manage their health with regular updates from healthcare providers. Through the use of machine learning, we propose a method for predicting and classifying future vital sign values associated with cardiovascular and chronic respiratory conditions [1]. By predicting these values, the system can evaluate patient health and alert caregivers and medical professionals of any deterioration. The machine learning algorithm, trained on a real dataset of vital signs, was tested with various regression algorithms to forecast vital sign readings for the next 1-3 minutes. Three machine learning algorithms—SVM, Naive Bayes classifier, and Decision Tree classifier—were utilized to assess patients' well-being based on predicted vital sign values [3]. The results demonstrate that the Decision Tree classifier effectively categorizes patients' health status based on abnormal vital signs and supports appropriate healthcare intervention.
The idea for the work was inspired by the following IEEE publication, as the accompanying TABLE 1 explains.

TABLE 1. IEEE REFERENCES AND CONCEPTS ADOPTED

Sr. No.	REFERENCE NO.	KEY IDEA	REMARKS
1.	[6]	Creating a single IoT platform using sensor modules to take all the current status of the body.	Need to discuss more about practical implementation of methodologies discussed.
2.	[7]	To use ML algorithms and train and model to predict the abnormal behavior of heart.	Data was not shareable and no memory unit is used to store the outputs.
3.	[8]	Use cloud technology to display the sensor outputs on mobile app /display unit.	Not sufficient data is generated to accurately predict any illness.

III. METHODOLOGY

In this section, we present our proposed methodology along with the essential factors crucial for the success of our work. Additionally, we provide an overview of the entire prototype concept and detail our progress to date on the given key parameters, as shown in Fig1.

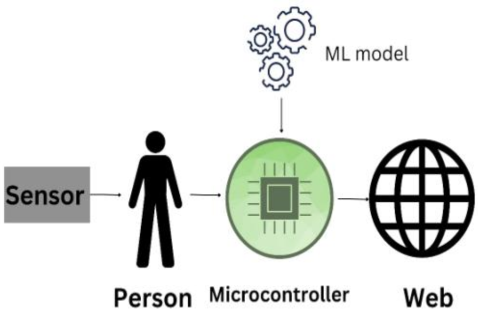

Fig1. Flow diagram

A. Parameter

Since the health of patients' hearts is our main concern, we aim to create a database of individuals diagnosed with heart disease. Prior research in the field of cardiology has identified a total of 75 relevant factors. However, researchers have found that focusing on 11 specific factors provides sufficient accuracy for analysis. Therefore, our research will concentrate exclusively on these 11 factors. Additionally, we have demonstrated that using these parameters yields equivalent results. As a result, we can reliably predict a patient's cardiovascular condition based on these attributes. The sensors currently in use are designed to measure these factors.

Input Parameters

- ***Gender:*** This refers to the classification of individuals as male or female, which can play a role in understanding differences in health outcomes and risk factors between genders.
- ***Age:*** Age is a crucial factor in assessing cardiovascular risk, as the prevalence of heart disease tends to increase with age.
- ***Current Smoker***: This indicates whether the individual is currently a smoker or not, as smoking is a major risk factor for cardiovascular diseases.
- ***Cigarettes per Day:*** This represents the number of cigarettes smoked per day by the individual, providing insight into the extent of smoking habits.
- ***BP Medication:*** BP Medication refers to the usage of medication for controlling blood pressure, which is important as hypertension is a significant risk factor for heart disease.
- ***Stroke***: This variable indicates whether the individual has a history of stroke, which is relevant as strokes can have cardiovascular origins and are associated with increased risk of subsequent cardiovascular events.
- ***Hypertension:*** This denotes whether the individual has hypertension (high blood pressure), which is a major risk factor for heart disease.
- ***Diabetes:*** Diabetes status is important as diabetes significantly increases the risk of developing cardiovascular complications.
- ***BMI:*** Body Mass Index is a measure of body fat based on height and weight, and obesity is associated with an increased risk of heart disease.
- ***Heart Rate:*** This represents the number of heart beats per minute, which can indicate the efficiency of the heart and potential cardiovascular issues.
- ***Temperature of Body***: Body temperature can provide information about the individual's physiological state and potential presence of infection or inflammation, which can impact cardiovascular health.

B. Target

The machine learning model will give output either a '1' or a'0', representing 'yes' or 'no', respectively.

***Heart disease**:* A history of heart disease indicates a previous occurrence of a cardiovascular condition, highlighting significant heart disease in the individual's medical history.
Details about the features and data type are provided in the following TABLE 2.

TABLE 2. DATASET INFORMATION

Sr. No.	**Data**	**Data type**
1.	Gender	Male/Female
2.	Age	Integer
3.	Current Smoker	Yes/No
4.	Cigarettes per Day	Integer
5.	BP Medication	Yes/No
6.	Prevalent Stroke	Yes/No
7.	Prevalent Hypertension	Yes/No
8.	Diabetes	Yes/No
9.	BMI	Float
10.	Heart Rate	Integer
11.	Temperature	Float

C. Design Overview

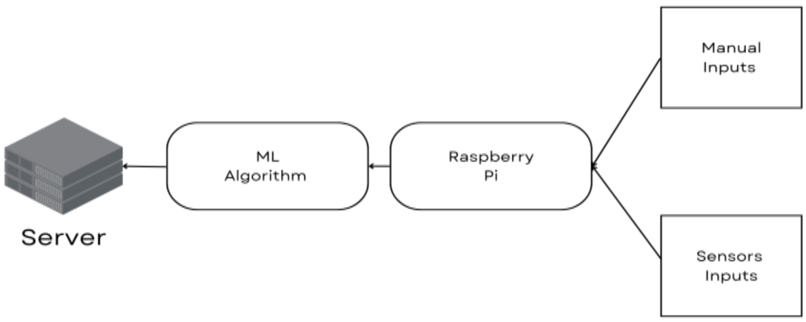

Fig2. Block diagram of Proposed Method

Our proposed prototype, which we want to put into practice, has a basic block diagram provided, as shown in Fig2. We have advised adding a Raspberry Pi to our system. All required modules and sensor devices will be linked to the Raspberry Pi. After consolidating all parameters, they will be delivered to the local host so that the ML algorithm can run. The patient will then receive the results.

D. Prototype

1) MAX30100 Pulse Oximeter Sensor

The pulse sensor was developed to determine the maximum heart rate of a customer. The detailed circuit design provides us with valuable insights into the individual's heart rate, as shown in Fig3.

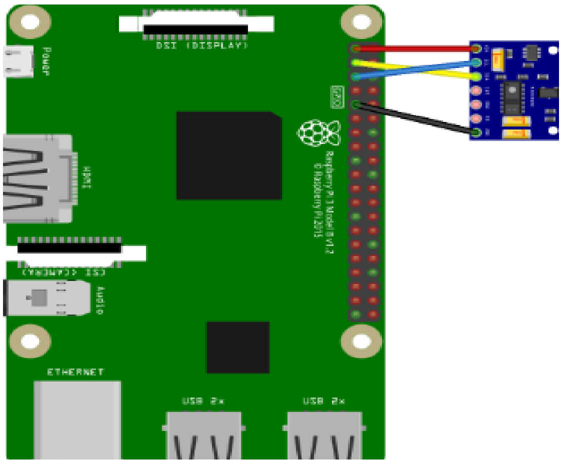

Fig3. Interconnection of MAX30100 with Raspberry Pi

2) DS18B20 Temperature Sensor

The purpose of constructing the temperature sensor is to obtain the body temperature of a customer. The circuit design is thoroughly explained, providing us with comprehensive details regarding the individual's temperature, as shown in Fig4.

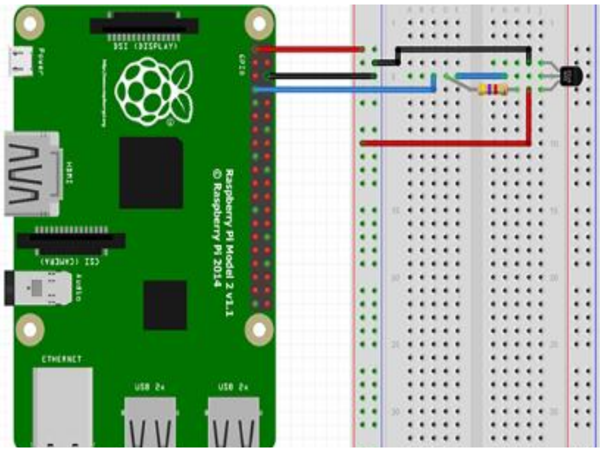

Fig4. Interconnection of DS18B20 with Raspberry Pi

3) Combined Circuit

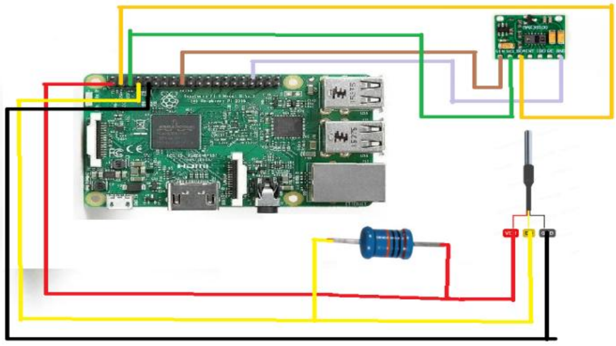

Fig5. Complete interconnection of the circuit

IV. RESULTS AND DISCUSSION

The effective integration of the DS18B20 and MAX30100 sensors is depicted in Fig. In contrast to traditional methods, these sensors enable continuous, non-invasive, and economical health monitoring, rendering the system appropriate for both domestic and clinical settings. By capturing vital physiological data, the collaboration of these sensors with machine learning on a Raspberry Pi improves predictive accuracy and facilitates the prompt identification of potential cardiac concerns. The information gathered from these sensors is recorded manually and later input into a web platform for additional analysis and monitoring. Moreover, the patient participates in a personal consultation to provide insights into other health parameters that cannot be directly measured by the sensors, such as heart rate and body temperature. This methodology ensures a comprehensive evaluation of the patient's health status by merging sensor data with self-reported information, thus allowing for a more accurate and thorough assessment.

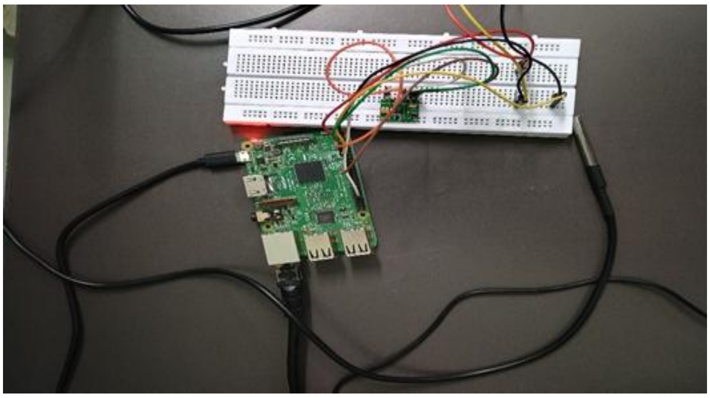

Fig6. Cardiac status prediction model

A) Heart Rate Sensor

The sensor begins taking readings as soon as the Raspberry Pi runs the MAX30100 code, as seen in the Fig7. The user must keep their finger on the LED light without touching the GPIO pins.

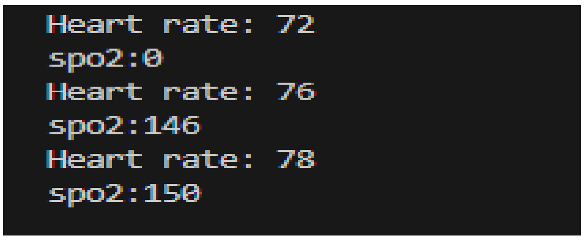

Fig7. Readings of MAX30100

B) Temperature Sensor

The Fig8 illustrates how the temperature sensor begins to take data when the DS18B20 code is launched on the Raspberry Pi. For reliable readings, the person using it has to hold the sensor head for a considerable amount of time.

Fig8. Readings of DS18B20

C) BMI

The user must provide their height and weight when the BMI code runs through the Raspberry Pi terminal; after that, the function returns the user's BMI as seen in the Fig9.

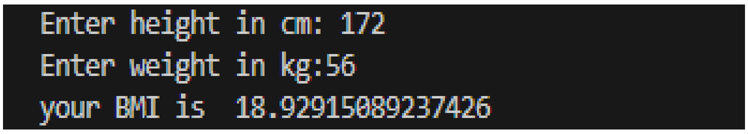

Fig9. BMI Readings

D) Web Page Development

Users may submit their health information and receive real-time heart state forecasts with a Flask-based web application designed to increase accessibility and user engagement. Both desktop and mobile devices may use the UI, which is snappy and easy to use. The program incorporates sensor data from the DS18B20 temperature sensor and MAX30100 pulse oximeter, has a user input form for health metrics, and uses logistic regression to run a machine learning model that predicts heart health state. HTML, CSS, and JavaScript are used to create the front end, while Flask, a Python framework, is used to control processing and allow for real-time communication with the Raspberry Pi.

E) Final Prediction

Simply click the 'Predict' button after completing the remaining parameters. The following Fig10 and Fig11 illustrate how the predictions will be displayed as output and indicate whether the heart is healthy or not.

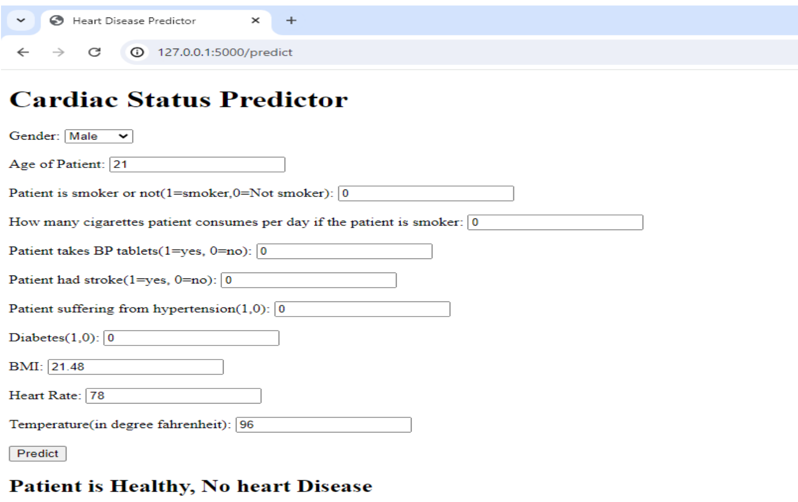

Fig10. Prediction when the patient is healthy

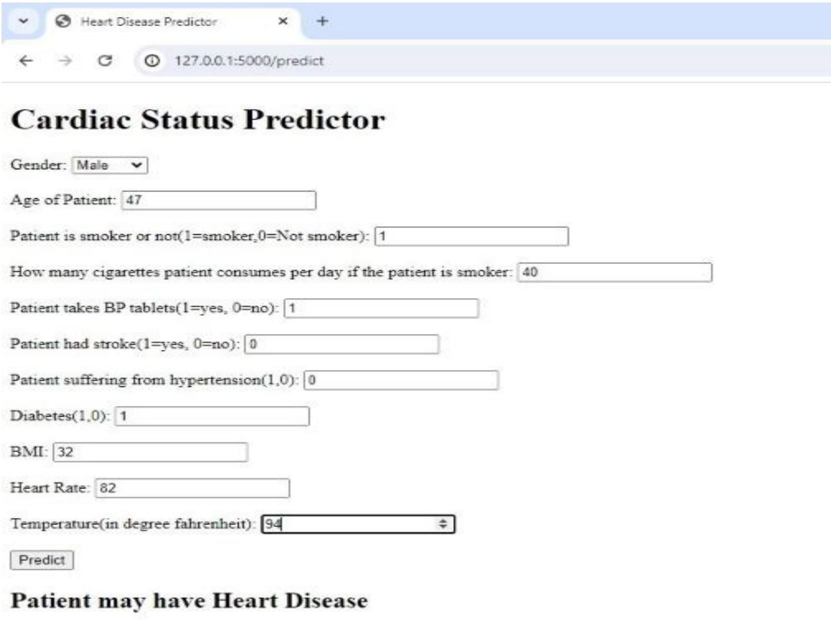

Fig11. Prediction when the patient is unhealthy

V.CONCLUSION

The system for predicting cardiac status using a Raspberry Pi and logistic regression offers a promising method for continuous cardiovascular monitoring. By integrating sensors like the MAX30100 pulse oximeter and DS18B20 temperature sensor, it efficiently gathers physiological data. This data is then processed by the logistic regression model to accurately predict the risk of cardiac events, providing timely insights. Displaying these predictions on a web page ensures accessibility for healthcare professionals and patients. Leveraging the affordability and versatility of the Raspberry Pi, this setup is practical for both clinical and home healthcare environments. Ultimately, it has the potential to improve patient outcomes by enhancing early detection and intervention for cardiovascular diseases, thus decreasing the burden on healthcare systems.

VI. FUTURE SCOPE

Future advancements in predicting cardiac status with sensors like the DS18B20 and MAX30100 may focus on enhancing model accuracy and generalizability. By incorporating larger, diverse datasets representing various demographics and health conditions, predictive accuracy could improve significantly, making the model more resilient and reliable across different populations.

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From the perspective of model development, the investigation of advanced machine learning techniques has the potential to enhance predictive capabilities significantly. The adoption of methodologies such as deep learning architectures, ensemble strategies, or time-series analysis may yield more profound insights into trends associated with cardiac health, thereby augmenting the system's predictive accuracy over time. These approaches are particularly adept at uncovering intricate, nonlinear relationships within the data that conventional models, including logistic regression, might fail to detect. Nevertheless, the application in real-world scenarios encounters obstacles related to data integrity, model generalization, and the scarcity of labeled datasets. Addressing these challenges through strategies such as sensor calibration, noise mitigation, cross-validation, and semi-supervised learning will be essential for the successful implementation of cardiac status prediction systems in practical healthcare environments.

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