International Journal of Advanced Trends in Engineering and Management

(ISSN 2583-7052)

pp. 235-239, April

Heart Disease Prediction and AI Powered Recommendation System

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ABSTRACT: This paper presents a human-centered intelligent heart disease prediction and AI-powered recommendation system designed for early risk detection and preventive healthcare. The proposed system continuously monitors key physiological parameters including Blood Oxygen Saturation (SpO_2), Heart Rate (BPM), and Body Temperature using IoT sensors integrated with a Node MCU ESP32 microcontroller. Data collected from MAX30102 and MLX90614 sensors is transmitted to a Firebase Realtime Database through the Arduino environment. An Android application applies a Decision Tree machine learning algorithm to classify heart attack risk into No Risk, Medium Risk, and High Risk categories. Upon detecting abnormal conditions, personalized health recommendations and medical alerts are generated to support timely intervention. The system ensures real-time monitoring, privacy-aware analysis, and remote health tracking, promoting proactive cardiovascular care and reducing healthcare burden through continuous intelligent monitoring.

Keywords*:* Real-time Captioning, Heart disease prediction, IoT based healthcare, AI powered recommendation system, Preventive Healthcare, Risk categories.

1. Introduction

Heart Disease has emerged as one of the most persistent and life -threatening health challenges across the world, affecting individuals irrespective of Age, gender or Socioeconomic background .An Intelligent IoT- based heart disease prediction and AI – powered recommendation system for early risk detection and preventive healthcare. The system monitors physiological parameters such as blood Oxygen saturation (SPo2), Heart Rate (BPM), and Body Temperature using sensors integrated with a Node MCU ESP32 microcontroller. Collected data is transmitted to a real time Database and analyses through Android application using Tiny ML model to classify heart attack risk levels. Based on detected abnormalities, personalized health recommendations and medical alerts are provided. The proposed system enables real – time monitoring, remote health tracking and proactive cardiovascular care for improved early preventive.

2. Objectives

The main objectives of the proposed system are:

To design and develop an IoT- based health monitoring system for continuous measurement of vital physiological parameters such as heart rate, SpO2 and body temperature.

To implement a real – time data acquisition and transmission system using Node MCU ESP32 and firebase cloud storage an develop an Android application for visualization and monitoring of health data.

To apply a Machine Learning Decision Tree algorithm to classify heart attack risk into No Risk, Medium Risk and High Risk categories and provide AI- based recommendations and alerts for preventive healthcare.

3. Literature Review

Several researches have proposed heart disease prediction system using machine learning and IoT technologies to improve early diagnosis. V. Selvi et al. (2024) proposed "An Enhanced Probabilistic Elastic Net Regression Model (EPERM) for Heart Disease Prediction", improving prediction accuracy through effective feature selection and regularization.

N. Sabri et al. (2023) introduced "Heart Inspect: Heart Disease Prediction Using Naïve Bayes Algorithm", which classifies patients based on clinical and lifestyle factors for early risk detection.

V. Malik et al. (2023) developed "Coronary Heart Disease Prediction Using GKFCM with RNN", combining fuzzy clustering and deep learning to enhance prediction performance.

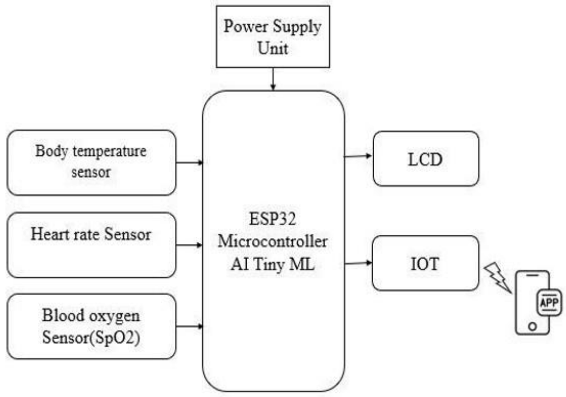
J. Zhang (2024) presented "Heart Disease Prediction Based on Logistic Regression and CART Classification", improving interpretability and decision-making accuracy.

Lakshmi and R. Devi (2023) proposed "Heart Disease Prediction Using Enhanced Whale Optimization Algorithm Based Feature Selection", achieving better classification accuracy using optimized features.

S. Mall et al. (2024) introduced "Prediction of Heart Disease Using Machine Learning Technique", utilizing classical ML algorithms for early cardiovascular risk prediction.

4. Proposed Methodology

The proposed heart disease prediction and AI powered recommendation system is designed as an integrated health monitoring framework that supports continuous observation, intelligent analysis, and proactive decision making. The architecture follows a structured flow where physiological data is collected, processed, interpreted, and communicated in a seamless manner. Each functional block in the system contributes to transforming raw health indicators into meaningful insights that assist users in understanding their cardiac condition and taking timely preventive actions.



A Tiny ML model is deployed directly on the ESP32 device to perform local data processing and heart attack risk prediction, enabling low latency, reduced power consumption and privacy – preserving analysis without continuous cloud dependency. The processed data is transmitted to a Firebase real time data base for remote monitoring through an Android application. Based on the prediction result, it is support preventive healthcare management.

1. Algorithm Used

In your Tiny ML model, we used a small fully-connected neural network (also

called a multilayer perceptron, MLP) with:

Input layer: 3 features → HR, SpO_2, Temperature

Hidden layers: 2 layers of 12 neurons each with ReLU activation

Output layer: 3 neurons with Softmax activation (predicts Normal / At Risk / Critical)

So the algorithm is:

MLP Neural Network (Supervised Classification)

2 .How it Works

Input normalization:

Your raw HR, SpO_2, Temp are scaled to [0,1]:

HR / 180.0, SpO2 / 100.0, Temp / 45.0 Tiny ML models work better on normalized inputs.

Selection of Node MCU ESP32 as the main microcontroller. Integration of MAX30102 sensor for heart rate and Integration of MLX90614 infrared sensor for body temperature measurement. Development of sensor interfacing and data acquisition circuits

2. Data Collection and Transmission

• Continuous collection of physiological parameters from sensors. SpO_2 measurement.

Forward pass through network:

Each neuron calculates a weighted sum + bias and applies activation function: Output = ReLU(W * input + b

Output layer:

Final layer uses Softmax, converting raw values into probabilities for each class: p(Normal), p(At Risk), p(Critical) Prediction:

Pick the class with highest probability:

risk = argmax([p Normal, p At Risk, p Critical])

Why MLP is Use

Small, fast, and lightweight → perfect for ESP32 memory constraints.

Works well for tabular health data (HR, SpO_2, Temp).

Easy to train in Python and deploy as .tflite → then convert to C array for Edge AI.

Summary

Your Tiny ML uses a Fully Connected Neural Network (MLP) with ReLU

Activations in hidden layers and Softmax output, doing multiclass classification for heart risk prediction.

The methodology of the project involves the following stages:

1. System Design and Hardware Integration

• Transmission of sensor data to Firebase Realtime Database using Wi-Fi communication and Arduino IDE programming.

3. Mobile Application Development

Development of an Android application to retrieve data from Firebase.

Real-time display of vital parameters and historical trends for users.

4. Machine Learning Risk Classification

Implementation of a Decision Tree Machine Learning algorithm.

Training and testing the model using physiological parameter datasets.

Classification of heart attack risk into three levels: No Risk, Medium Risk, and High Risk.

5. AI-Based Recommendation System

• Generation of personalized recommendations such as lifestyle changes,

Stress management tips, and medical consultation alerts based on risk levels.

5. Results and Discussion

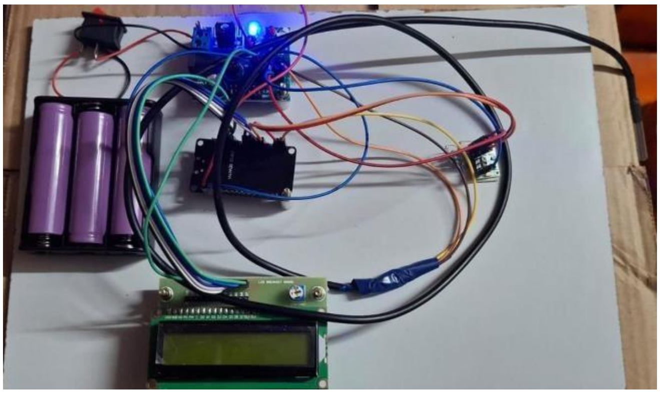


Figure 1: *Hardware Setup*

5.1 Remote Monitoring and Alert System

Secure access for caregivers and doctors to review health trends.

Alert generation when abnormal conditions or high-risk levels are detected.

The proposed IoT-based intelligent heart disease prediction and recommendation system was successfully designed and implemented. The system continuously monitored physiological parameters such as heart rate, blood oxygen saturation (SpO_2), and body temperature using the MAX30102 and MLX90614 sensors interfaced with the Node MCU ESP32 microcontroller. The collected data were transmitted in real time to the Firebase Realtime Database and accessed through an Android application for visualization and analysis.

The Decision Tree machine learning algorithm was implemented to classify cardiovascular risk into three categories: No Risk, Medium Risk, and High Risk. Experimental testing demonstrated that the system could accurately detect abnormal variations in vital parameters and provide timely alerts and recommendations. The Android application displayed real-time values, historical trends, and risk classification results in a user-friendly manner, enabling users to understand their health status easily.

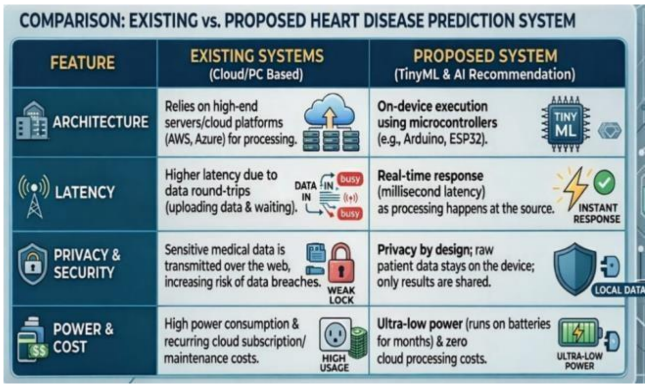
The system also generated AI-based personalized recommendations such as lifestyle guidance, stress management suggestions, and alerts for medical consultation when high-risk conditions were detected. Remote monitoring functionality enabled caregivers and healthcare professionals to review patient data and intervene when necessary. Overall, the prototype demonstrated reliable performance, low latency in data transmission, and efficient risk classification.

6. Conclusion

This project successfully developed an intelligent IoT-based heart disease prediction and AI-powered recommendation system for continuous cardiovascular health monitoring. By integrating wearable sensors, embedded systems, cloud storage, mobile application development, and machine learning techniques, the system provides a proactive approach to heart health management.

The proposed solution shifts healthcare from reactive treatment to preventive care by enabling early detection of abnormal physiological patterns and timely medical intervention. The system is affordable, portable, and easy to use, making it suitable for home-based monitoring and community healthcare deployment. It empowers individuals to actively monitor their heart health and reduces the burden on healthcare facilities by minimizing emergency cases through early warnings.

Future enhancements may include integration of additional physiological parameters such as blood pressure and ECG signals, implementation of advanced machine learning models for improved accuracy, and deployment of secure data encryption techniques to enhance privacy. The system has strong potential for real-world healthcare applications and can contribute significantly to reducing cardiovascular disease-related complications and mortality.


COMPARISON: EXISTING vs. PROPOSED HEART DISEASE PREDICTION SYSTEM

FEATURE	EXISTING SYSTEMS (Cloud/PC Based)	PROPOSED SYSTEM (TinyML & AI Recommendation)
ARCHITECTURE	Relies on high-end servers/cloud platforms (AWS, Azure) for processing.	On-device execution using microcontrollers (e.g., Arduino, ESP32). TINY ML
LATENCY	Higher latency due to data round-trips (uploading data & waiting). DATA IN busy busy	Real-time response (millisecond latency) as processing happens at the source. INSTANT RESPONSE
PRIVACY & SECURITY	Sensitive medical data is transmitted over the web, increasing risk of data breaches. WEAK LOCK	Privacy by design; raw patient data stays on the device; only results are shared. LOCAL DATA
POWER & COST	High power consumption & recurring cloud subscription/ maintenance costs. HIGH USAGE	Ultra-low power (runs on batteries for months) & zero cloud processing costs. ULTRA-LOW POWER

Novelty of Proposed Work

The proposed system introduces a Tiny ML-based heart disease prediction and AI-powered recommendation framework designed for resource-constrained healthcare devices. Unlike existing cloud-dependent models, the proposed approach performs on-device intelligence enabling real-time prediction with low latency and minimal power consumption. The integration of lightweight machine learning with automated health recommendations enhances early diagnosis and preventive healthcare support, making the system suitable for smart wearable and IoT-based medical applications.

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