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Health Monitoring System for Heart Attack Risk Prediction using IoT and Machine Learning

Chetana Sanjay Chaudhary , Dr.Brijendra Gupta
Student, Associate Professor & HOD IT Dept
Computer Engineering
Siddant College of Engineering,Sudumbre,Maharashtra,412109

Abstract:

The initiative centers on the creation of a health monitoring system utilizing Internet of Things (IoT) technology, designed to forecast the likelihood of a heart attack by assessing critical physiological indicators, including Blood Oxygen Saturation (SpO2), Heart Rate (BPM), and Body Temperature. These metrics are collected through a NodeMCU ESP32 microcontroller, which is equipped with a MAX30102 Pulse Oximeter and Heart Rate Sensor, as well as an MLX90614 Infrared Temperature Sensor. The gathered data is subsequently transmitted to a Firebase Realtime Database for processing, utilizing the Arduino IDE. On the client side, an Android application accesses the data from Firebase and employs a Decision Tree Machine Learning Algorithm to evaluate the heart attack risk. The system classifies the risk into three categories based on the input parameters: No Risk, Medium Risk, or High Risk. The objective of this project is to facilitate real-time monitoring and provide early alerts to individuals at risk of cardiovascular complications, thereby allowing for prompt medical response.

Keywords: Health monitoring system, heart attack prediction, heart rate, blood oxygen saturation, body temperature, firebase real-time database.

INTODUCTION:

The Internet of Things (IoT) encompasses a network of interconnected physical devices that communicate data through sensors, software, and connectivity. In recent years, the healthcare sector has experienced a profound transformation driven by advancements in IoT, cloud computing, artificial intelligence (AI), and machine learning (ML). Numerous experts predict that the growing potential of IoT will enhance healthcare delivery. This technology has the capacity to globally transform healthcare by facilitating cost-effective services, enabling remote health monitoring, promoting wellness management, and supporting virtual rehabilitation. Furthermore, healthcare analytics can yield valuable insights into disease patterns and drug discovery, thereby introducing a new dimension to the field.

The contemporary landscape necessitates more efficient and prompt interventions to address the growing health challenges. Although conventional healthcare systems demonstrate effectiveness, they frequently exhibit sluggishness and rigidity. The COVID-19 pandemic has intensified the demand for remote and precision healthcare, goals that can only be realized through the adoption of emerging technologies. Integrating an IoT-enabled framework within a healthcare ecosystem can enhance the collection and processing of real-time data from sensors, such as body sensors strategically positioned on or within a patient's body, thereby supporting immediate data acquisition.

Heart diseases are one of the leading causes of mortality worldwide. Early detection of heart attack risk factors can greatly enhance the chances of prevention. This project introduces a real-time health monitoring system that leverages IoT devices to track key physiological metrics. The integration of machine learning allows for intelligent prediction and classification of the risk level of a heart attack.

Objective:

1. To design an IoT-based system for measuring SpO2, heart rate, and body temperature using the MAX30102 and MLX90614 sensors.

2. To transmit the real-time data to Firebase Realtime Database via a NodeMCU ESP32 microcontroller.

3. To develop an Android application that fetches the sensor data and applies a machine learning model to predict heart attack risk levels.

4. To categorize the risk levels as No Risk, Medium Risk, or High Risk using a Decision Tree Machine Learning Algorithm.

Methodology:

1. Hardware: NodeMCU ESP32, MAX30102 Pulse Oximeter and Heart Rate Sensor, MLX90614 Infrared Temperature Sensor,12v Dc adaptor,LM2596 DC converter,Zero PCB.

2. Software: Arduino IDE for sensor programming, Firebase Realtime Database for data storage, and Android Studio for mobile application development.

3. Data Flow: Sensor data is sent from the ESP32 to Firebase. The Android app retrieves this data and applies a pre-trained Decision Tree model to classify the risk of a heart attack.

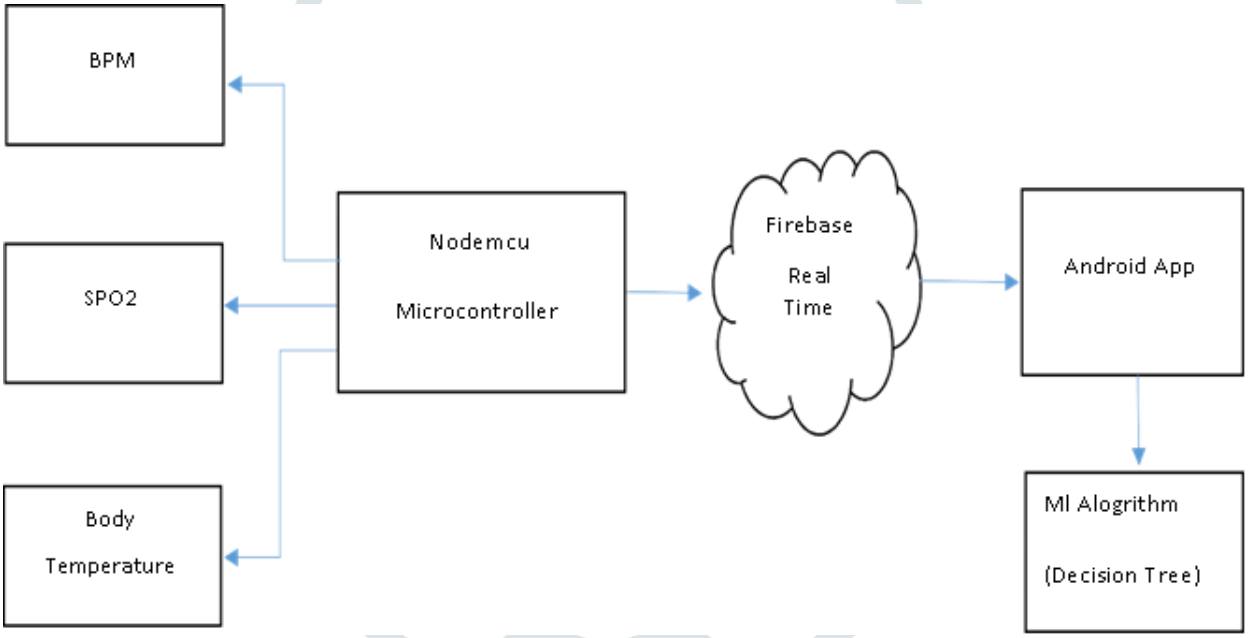

Fig: Block diagram

Literature Survey:
Paper 1: Machine Learning for Healthcare-IoT Security:A Review and Risk Mitigation
Author Name: Mirza Akhi Khatun , Sanober Farheen Memon, Ciarán Eising And Lubna Luxmi Dhirani

Description: The Healthcare Internet-of-Things (H-IoT), often referred to as Digital Healthcare, constitutes a data-centric framework that significantly depends on intelligent sensing devices, such as blood pressure monitors and temperature sensors, to enhance response times, treatment efficacy, and diagnostic accuracy. Nevertheless, as the cyber threat landscape continues to evolve, IoT devices are increasingly susceptible to a wider array of risks, including those linked to generative AI and 5G-IoT technologies. If these vulnerabilities are exploited, they could result in data breaches, unauthorized access, a breakdown in command and control, and potential harm to patients. This paper examines the core principles of healthcare IoT, alongside the privacy and data security challenges posed by machine learning and H-IoT devices. Additionally, it underscores the necessity of monitoring various layers of healthcare IoT, including perception, network, cloud, and application layers. The detection and response to anomalies necessitate the implementation of various cyber-attack protocols and technologies, such as Wi-Fi 6, Narrowband Internet of Things (NB-IoT), Bluetooth, ZigBee, LoRa, and 5G New Radio (5G NR). To safeguard H-IoT devices against escalating cybersecurity threats, a robust authentication framework leveraging machine learning and deep learning methodologies is essential. Consequently, this review paper delves into the security and privacy challenges, as well as risk mitigation strategies, aimed at fostering resilience within the H-IoT ecosystem.

Paper 2: An Efficient IoT-Based Patient Monitoring and Heart Disease Prediction System Using Deep Learning Modified Neural Network
Author Name: Simanta Shekhar Sarmah

Description: The primary contributors to mortality on a global scale are chronic diseases, including diabetes, heart disease, cancer, and chronic respiratory conditions. Diagnosing heart disease can be particularly challenging due to its varied symptoms and characteristics. With the increasing prevalence of smart wearable technology, the potential for implementing an Internet of Things (IoT) solution has expanded significantly. Unfortunately, individuals experiencing sudden heart attacks often face low survival rates. To address this issue, a patient monitoring system designed for heart patients utilizing a Deep Learning Modified Neural Network (DLMNN) based on IoT technology is proposed to enhance heart disease diagnosis and facilitate appropriate treatment. This proposed method is executed in three stages: I) Authentication, II) Encryption, and III) Classification. Initially, the heart patient from a specific hospital is authenticated using a substitution cipher (SC) in conjunction with SHA-512. Following this, the wearable IoT sensor device attached to the patient continuously transmits sensor data to the cloud. This data is encrypted and securely sent to the cloud using the PDH-AES technique. Subsequently, the encrypted data is decrypted, and classification is performed using the DLMNN classifier. The classified results yield two types of data: i) normal and ii) abnormal, indicating the patient's heart condition. If the result is abnormal, an alert message is sent to the physician for patient intervention. The experimental results indicate that the DLMNN for heart disease diagnosis demonstrates significant improvement compared to existing algorithms. Furthermore, the proposed PDH-AES method for secure data transmission achieves a high security level of 95.87% while ensuring minimal time for both encryption and decryption when compared to traditional AES.

Paper 3: Automated Stroke Prediction Using Machine Learning: An Explainable and Exploratory Study With a Web Application for Early Intervention
Author Name: krishna mridha, sandesh ghimire , jungpil shin, anmol aran , md. mezbah uddin , and m. f. mridha

Description: Stroke is a critical medical condition characterized by the interruption of blood flow to the brain, leading to neurological deficits. It poses a significant global risk, with profound health and economic consequences. In response to this challenge, researchers are developing automated algorithms for stroke prediction, which could facilitate early intervention and potentially save lives. As the population ages, the number of individuals at risk for stroke is increasing, underscoring the necessity for accurate and effective prediction systems. In a comparative study involving six established classifiers, the efficacy of the proposed machine learning technique was assessed based on metrics related to generalization capability and prediction accuracy. Additionally, this research examined two types of explainable techniques, specifically SHAP (Shapley Additive Explanations) and LIME (Local Interpretable Model-agnostic Explanations), to provide insights into the decision-making processes of black-box machine learning models. These methods are recognized for their reliability in elucidating model decisions, particularly within the healthcare sector. The results indicated that more complex models surpassed simpler ones, with the leading model achieving nearly 91% accuracy, while the other models ranged from 83% to 91% accuracy. The proposed framework, which incorporates both global and local explainable methodologies, has the potential to standardize complex models and enhance understanding of their decision-making processes, ultimately improving stroke care and treatment.
Diagnostic testing is required to comprehend the underlying anorectal and/or colonic pathophysiology following a failed empiric use of laxatives. The incidence of stroke has been increasing globally, and it is now considered one of the leading causes of death and disability. Early intervention is crucial in preventing long-term disability and mortality associated with stroke. Traditional methods of predicting stroke risk, however, are often timeconsuming and prone to errors.

Paper 4: Prediction of Cardiovascular Disease Using Machine Learning
Author Name: Bhoopendra Singh, Subodhini Gupta

Description: Health plays an essential role in the lives of individuals. Nevertheless, various factors contribute to the deterioration of health, including poor lifestyle choices, occupational stress, mental health challenges, and external influences such as environmental pollution, unsafe working conditions, and inadequate access to healthcare services. As a result, millions globally suffer from chronic conditions, such as cardiovascular diseases (CVD), which impact the heart and blood vessels, leading to severe consequences, including death or disability. Cardiovascular disease (CVD) represents a major risk to human health, adversely affecting the functionality of the heart and blood vessels, which can lead to mortality or physical incapacitation. The early and automated identification of CVD is essential for preserving lives. Despite numerous initiatives aimed at this objective, there is still potential for improving both performance and reliability. This research contributes to this ongoing effort by utilizing two effective machine learning methods, namely multilayer perceptron (MLP) and K-nearest neighbour (K-NN), for the detection of CVD, drawing on publicly accessible data from the University of California Irvine repository. The performance of the models is significantly improved by eliminating outliers and features with missing values. The experimental findings reveal that the MLP model achieves an impressive accuracy of 82.47% and an area-under-the-curve value of 86.41%, surpassing the performance of the K-NN model. Therefore, the MLP model is recommended for automated CVD detection. Additionally, the methodology outlined in this study shows potential for the detection of other diseases, and the efficacy of the proposed model can be further validated using additional standard datasets.

Paper 5: Effective Heart Disease Prediction Using Hybrid Machine Learning Techniques
Author Name: senthilkumar mohan , chandrasegar thirumalai , and gautam srivastava

Description:
Identifying heart disease presents challenges due to a multitude of contributing risk factors, including diabetes, hypertension, elevated cholesterol levels, irregular pulse rates, and various other elements. To assess the severity of heart disease in individuals, a range of techniques from data mining and neural networks has been utilized. The classification of disease severity is achieved through several methodologies, such as the K-Nearest Neighbor Algorithm (KNN), Decision Trees (DT), Genetic Algorithms (GA), and Naive Bayes (NB). Given the intricate nature of heart disease, it is imperative to approach its management with caution, as neglecting this can lead to adverse effects on cardiac health or even premature mortality. Both medical science and data mining perspectives are employed to uncover different types of metabolic syndromes. In this context, data mining, particularly through classification, plays a crucial role in predicting heart disease and conducting thorough data analysis.Cardiovascular disease ranks among the leading causes of death globally. The prediction of such diseases presents a significant challenge within the realm of clinical data analysis. Machine learning (ML) has demonstrated its efficacy in aiding decision-making and forecasting from the vast amounts of data generated by the healthcare sector. Additionally, ML techniques have been increasingly applied in various advancements within the Internet of Things (IoT). While numerous studies provide preliminary insights into the use of ML for heart disease prediction, this paper introduces an innovative approach focused on identifying key features through machine learning methods, thereby enhancing the accuracy of cardiovascular disease predictions. The proposed prediction model incorporates various feature combinations alongside several established classification techniques. Our results indicate a notable improvement in performance, achieving an accuracy rate of 88.7% with the hybrid random forest and linear model (HRFLM) for heart disease prediction.

Expected Outcome: The system will accurately monitor SpO2, BPM, and temperature, and predict heart attack risk in real-time. It aims to provide individuals with early warnings of potential heart-related risks, thereby assisting in timely medical intervention. Conclusion: This project demonstrates a comprehensive approach to remote health monitoring and risk prediction for heart attacks using IoT and machine learning technologies. It can be expanded to monitor additional health parameters and integrated with cloud-based analytics for more sophisticated health insights.

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