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IOT-ENABLED SYSTEM FOR DETECTING ABNORMAL HEART RATE USING MACHINE LEARNING

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ABSTRACT:

Continuous heart-rate monitoring is essential for early detection of cardiovascular abnormalities. Heart-rate ranges vary with age, physiological conditions, and lifestyle factors, requiring adaptable monitoring systems. This work presents an Internet of Things (IoT) based heart-rate detection framework integrating a NodeMCU microcontroller, pulse sensor, ECG module, and cloud connectivity through ThingSpeak.

The system transmits real-time physiological data to remote healthcare personnel, enabling continuous patient supervision. Machine-learning algorithms further analyze the recorded parameters to classify abnormal heart conditions. Using this prototype, clinicians can access patient vitals from any location, while stored cloud data supports future diagnostic assessment. The integration of MQTT provides secure and efficient data communication. Experimental evaluation shows that the K-Nearest Neighbors (KNN) classifier achieved the highest performance with an accuracy of 87% in predicting heart disease.

Keywords: IoT, NodeMCU, Heart-rate monitoring, Machine learning, ECG, MQTT, ThingSpeak.

INTRODUCTION:

The Internet of Things (IoT) has emerged as a transformative technology for healthcare monitoring, allowing real-time acquisition and transmission of vital physiological data.

Conventional heart-rate monitoring systems generally require manual measurement or direct supervision, limiting continuous observation. As most cardiac disorders benefit from early detection and constant tracking, a smart remote-monitoring system becomes crucial.

In this context, the proposed IoT-based framework offers a reliable and user-friendly solution for monitoring heart-rate variations and detecting anomalies. Using IoT connectivity, patient heartbeat information is transmitted through the cloud to physicians, who can remotely track vital trends.

The system also triggers alerts if the heart rate crosses predefined thresholds, ensuring timely medical response. Additionally, collected data is stored securely for future analysis using machine-learning techniques. This enhances diagnostic accuracy and supports long-term cardiac assessment.

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LITERATURE REVIEW

Several researchers have developed heart-rate monitoring solutions using optical, ECG-based, and wireless technologies:

- Tjiharjadi et al. designed a heartbeat-detection application for real-time physiological analysis.
- Pawar developed an IR-based heart-rate monitoring system using Arduino for basic pulse-count measurement.
- Priya et al. explored wireless transmission of vital signs for continuous patient monitoring.
- Saquib et al. evaluated heart-rate measurement using photoplethysmography (PPG) signals for improved signal accuracy.
- Recent studies also integrate IoT, cloud platforms, and machine-learning algorithms to enhance biomedical data analysis and abnormality detection.

The limitations of traditional systems highlight the need for an advanced, integrated, and intelligent monitoring architecture such as the one proposed in this paper.

AIM AND OBJECTIVES

Aim

To develop and implement an IoT-based real-time heart-rate monitoring system enhanced with machine-learning algorithms for accurate detection of abnormal cardiac conditions.

Objectives

To design a hardware prototype using NodeMCU, pulse sensor, ECG module, and additional biomedical sensors.

To transmit real-time physiological data to the cloud using ThingSpeak and MQTT protocol.

To implement a machine-learning–based model for classifying normal and abnormal heart-rate patterns.

To provide remote accessibility of patient vitals for doctors and healthcare staff.

To enable automated alert generation when the heart rate exceeds safe limits.

To store historical heart-rate data for future diagnostic evaluation and research

MATERIALS AND METHODS

System Components

Pulse Sensor

Measures heart-rate signals optically by detecting blood flow variations. The sensor includes noise-filtering and signal-amplification circuitry.

ECG Module

Captures the electrical activity of the heart to detect irregularities. The standard ECG setup utilizes multiple electrodes to measure cardiac potentials.

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DHT11 Sensor

Records ambient temperature and humidity, offering supplementary physiological context.

MEMS Sensor

A micro-electromechanical (MEMS) module enhances motion-based sensing, useful for correlating physical activity with heart-rate variations.

LCD Display

Displays real-time sensor outputs including heart rate, humidity, temperature, and ECG values.

NodeMCU (ESP8266/ESP32)

Acts as the central IoT controller, integrating sensors and enabling Wi-Fi-based data transmission to cloud platforms.

ThingSpeak Cloud

A cloud-analytics platform used to store, visualize, and process the data through MATLAB-based tools.

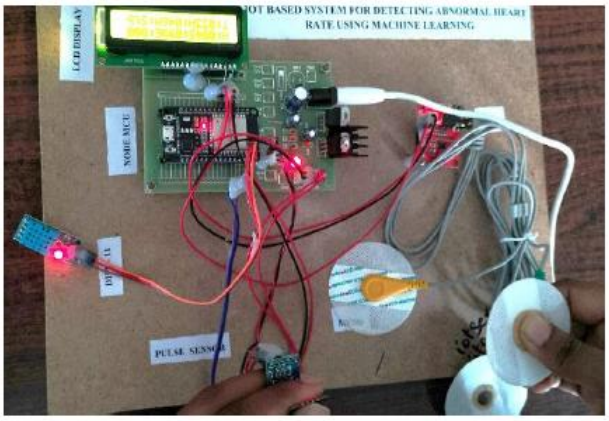
MQTT Protocol

A lightweight publish–subscribe communication protocol that ensures efficient IoT data transfer.

System Architecture

All sensors interface with the NodeMCU microcontroller, which processes the signals and uploads the readings to ThingSpeak in real time. The machine-learning module analyzes historical datasets to detect abnormal patterns. The doctor can access the updated data dashboards remotely. An alert is generated if heart-rate values exceed thresholds.

Fig 1: Output of hardware



RESULTS:

The hardware prototype successfully recorded and transmitted heart-rate values, ECG signals, and environmental data to the cloud. The ThingSpeak interface enabled clear visualization of sensor trends, supporting continuous remote monitoring.

Four machine-learning algorithms were evaluated:

- K-Nearest Neighbors (KNN)
- Support Vector Classifier (SVC)
- Decision Tree Classifier
- Random Forest Classifier

After feature scaling and parameter optimization, the KNN classifier achieved the highest accuracy of 87% using eight nearest neighbors. This demonstrates the potential of machine learning to identify cardiac abnormalities effectively

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DISCUSSION

The proposed IoT-based heart-rate monitoring system demonstrates significant advantages over traditional clinical monitoring methods. The ability to collect and transmit real-time physiological data reduces the need for continuous bedside observation. The integration of machine-learning models enhances diagnostic capabilities by offering predictive analytics based on past data patterns.

The system enables early detection of cardiac irregularities, improving patient safety. Additionally, cloud storage ensures long-term record maintenance, supporting trend analysis and improving clinical decision-making. However, uninterrupted network connectivity is essential to ensure timely alert reception

CONCLUSION

This study successfully developed an IoT-enabled heart-rate monitoring platform integrated with machine-learning algorithms to detect abnormal cardiac conditions. The system supports real-time monitoring, remote accessibility, secure cloud storage, and predictive analytics. With an 87% classification accuracy using KNN, the machine-learning module demonstrates strong potential for clinical decision support. The prototype can be further expanded with advanced biosensors and enhanced predictive models to support large-scale telehealth applications.

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