Smart Life Monitor: A Low-Cost Health Monitoring System Using Ultrasonic and PIR Sensors

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Abstract

This study presents a low-cost, real-time health monitoring system utilizing an ultrasonic sensor, a PIR motion sensor, and a Bluetooth module interfaced with an Arduino Nano. The system is designed to detect a person's breathing rate, movement, and potential distress conditions. The ultrasonic sensor measures chest movement to calculate breath rate, while the PIR sensor detects motion to confirm if the person is alive. The HC-05 Bluetooth module transmits the collected data to a mobile device for remote monitoring. This project aims to provide an accessible and efficient solution for health monitoring in resource-constrained environments, offering potential applications in elderly care, patient monitoring, emergency response scenarios, and accident detection. Additionally, the system can be employed in road accident scenarios to determine whether an injured individual is alive and, if so, transmit their breathing rate to medical personnel for immediate action.

Keywords

Health monitoring, Arduino Nano, Ultrasonic sensor, PIR sensor, Bluetooth, SDG 3.

I. Introduction

Health monitoring systems are essential for early disease detection and patient care [1], [2]. Traditional monitoring solutions are often expensive and inaccessible in low-resource settings. To address this challenge, we propose a cost-effective health monitoring system that tracks vital signs using simple sensors [3]. The system utilizes an ultrasonic sensor to measure breath rate and a PIR sensor to detect body movement. If an abnormal condition is detected, an alert is sent via Bluetooth to a caregiver’s device [4]. IoT-based health monitoring has been widely explored in research [6], [7], and our study contributes by integrating low-cost sensors into a practical solution. Additionally, this system can be used in road accidents to determine whether an injured person is still alive. If the person is alive, their breathing rate is transmitted to a doctor for further action.

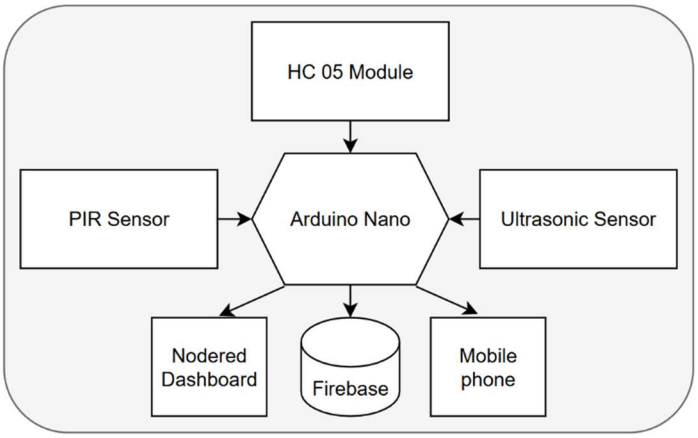
II. Methodology

A. System Architecture

The proposed system architecture is presented in fig.1, that consists of three key components:

- **Ultrasonic Sensor (HC-SR04)**: Measures chest movement to calculate breath rate [8].
- **PIR Motion Sensor**: Detects motion to confirm if the person is alive [9].

- **HC-05 Bluetooth Module**: Transmits data to a mobile device [10].
- **Arduino Nano**: Serves as the processing unit to collect and analyze data [6].
- **Firebase Integration**: Stores collected health data for remote access.

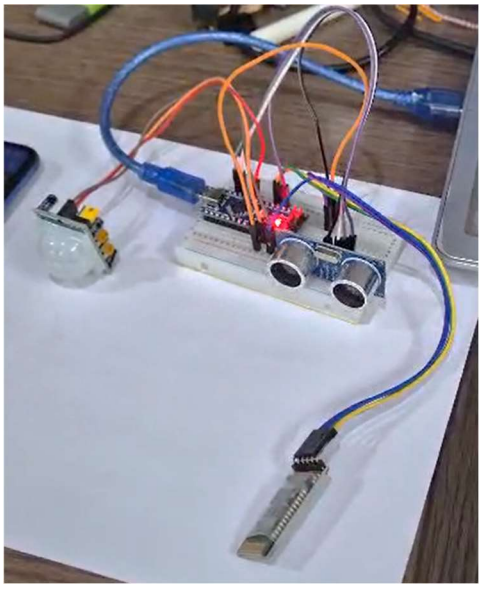


[Fig. 1- System Architecture]

B. Working Principle

The ultrasonic sensor calculates the distance of a moving object (chest/abdomen), determining the breathing rate based on periodic expansion and contraction. The PIR sensor detects body motion, indicating whether the person is alive [5]. If motion stops for an extended period and no breath is detected, an alert is sent via Bluetooth [4].

This system can also be used in road accidents to check if a person is alive. If the PIR sensor detects motion and the ultrasonic sensor measures breathing, the system transmits the breathing rate to emergency medical personnel through a Bluetooth-connected mobile device. The recorded data is also sent to Firebase, allowing doctors to access real-time updates on the patient's condition.



[Fig. 2- Working Principle]

III. Implementation

A. Hardware Setup

The components are connected to an Arduino Nano as follows:

- **HC-SR04 (Ultrasonic Sensor)**: Trig pin to D9, Echo pin to D10.
- **PIR Sensor**: Signal pin to D7.
- **HC-05 Bluetooth Module**: TX to D2, RX to D3 (via voltage divider).

B. Software Development

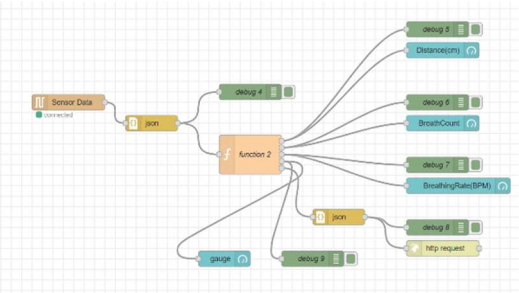
The Arduino program continuously reads data from the ultrasonic and PIR sensors. If the detected breathing rate is irregular or motion ceases, an emergency signal is transmitted through Bluetooth [1], [7]. The system outputs a JSON-formatted data stream for further processing.

The system also integrates Firebase to store and manage collected health data remotely. The breathing rate and motion status are uploaded to Firebase in real time, allowing caregivers or medical professionals to access the information via a mobile app or web interface. This enables continuous monitoring and timely intervention in critical situations.

C. Node-RED Flow

Node-RED is used to process and visualize the health data. The data flow consists of the following steps:

1. Bluetooth data from the HC-05 module is received on the mobile phone.
2. The mobile app sends the data to Firebase.
3. Node-RED extracts the data from Firebase and displays it on a live dashboard.
4. Alerts are generated based on predefined thresholds, notifying caregivers of critical conditions.



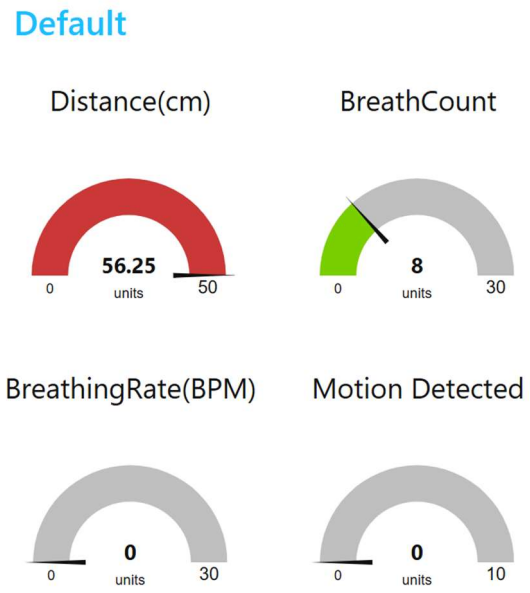
[Fig. 3 - Node-RED Flow]

IV. Results and Discussion

The prototype was tested in different scenarios to evaluate its accuracy in measuring breath rate and motion detection [2]. The system successfully detected breathing patterns with an accuracy of ±2 BPM and reliably identified motion presence [8]. When tested on a static

person, the PIR sensor correctly identified a lack of movement, triggering an emergency alert via Bluetooth [9]. The low power consumption and affordability make this system suitable for deployment in homes and healthcare facilities [5].

In road accident scenarios, the system was able to identify whether a person was still breathing and transmit the data to a mobile phone, which could then be sent to emergency responders. This functionality could be crucial in improving emergency response times and saving lives. The collected data was also successfully stored in Firebase and visualized using Node-RED, allowing for real-time monitoring and remote access by medical professionals.



[Fig. 4 - Testing and Results]

V. Conclusion and Future Work

This paper presents a cost-effective, real-time health monitoring system using an ultrasonic sensor, a PIR motion sensor, and a Bluetooth module. The system successfully detects breathing patterns and motion to determine a person's health status [10]. Additionally, this system has applications in road accident scenarios, where it can determine whether an injured individual is still alive and transmit their breathing rate to medical personnel. The integration of Firebase allows remote storage and access to health data, enhancing real-time monitoring capabilities. Future work will focus on integrating machine learning algorithms to enhance anomaly detection and incorporating additional biometric sensors for a comprehensive health analysis.

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