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Arduino-Powered Remote Monitoring System for Real-Time Heart Rate Detection via Bluetooth

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Abstract: With the increasing need for continuous health monitoring, this study presents the development of an Arduino-powered remote monitoring system for real-time heart rate detection via Bluetooth. The system uses an Arduino microcontroller connected to a pulse sensor to measure heart rate, with data wirelessly transmitted via Bluetooth to a remote device, enabling continuous monitoring without direct patient interaction. Initial self-monitoring trials showed consistent heart rate detection within the normal range of 62-70 beats per minute (BPM), suggesting proper functionality for preliminary use. The system also maintained a stable Bluetooth connection with no noticeable data loss. This cost-effective and efficient system is a valuable tool for telemedicine and remote patient care. Future enhancements may include integrating advanced microcontrollers and developing a more sophisticated mobile app with expanded health monitoring features.
Keywords: Real-time heart rate monitoring, Arduino, Bluetooth, Pulse Sensor, Telemedicine

I. INTRODUCTION

Remote health monitoring has become increasingly vital in modern healthcare, particularly for managing patients where immediate medical attention is not feasible [1]. As healthcare systems strive to improve accessibility and efficiency, remote monitoring technologies play a crucial role in enhancing patient care. Monitoring heart rate is essential for detecting and managing conditions such as hypoxemia, a critical issue for patients with chronic respiratory problems or during acute health events [2]. Hypoxemia, characterized by an abnormally low concentration of oxygen in the blood, can lead to severe health complications if not addressed promptly.

Effective management of hypoxemia is crucial, as it can prevent serious health issues and improve patient outcomes. Without proper monitoring tools, patients may experience worsening conditions that could be preventable with timely intervention. Despite advancements in medical technology, there remains a significant need for affordable, portable, and efficient monitoring devices [3]. These devices must provide accurate, real-time diagnostics to facilitate timely medical interventions.

This paper proposes a novel solution using easily accessible hardware components, including an Arduino Uno, a Bluetooth module, and a pulse sensor. By integrating these components with the Terminal application, the system offers real-time data visualization on a smartphone, enhancing accessibility and ease of use. The primary aim of this system is to provide a reliable and cost-effective method for monitoring heart rate, particularly useful for patients in remote locations or those with limited access to healthcare facilities.

By improving accessibility and real-time monitoring capabilities, this solution has the potential to enhance patient care and remote health management significantly.

II. METHODS

A. System Components

The system comprises the following key components:

1) *Arduino Board:* The Arduino UNO serves as the central microcontroller in the system. It receives analog signals from the pulse sensor, which measures heart rate, and converts these signals into a digital format [4]. The Arduino processes and communicates this data to a smartphone via Bluetooth. The board features a user-friendly programming environment, making it easy to write and upload code to handle the data acquisition and processing tasks. With its versatile input/output capabilities and wide range of compatible sensors, the Arduino UNO is an ideal choice for prototyping and implementing this remote heart rate monitoring system.

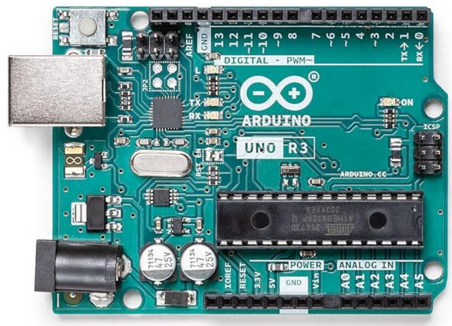

Fig. 1 Arduino Uno

2) *Pulse Sensor:* The pulse sensor is designed to measure heart rate by detecting changes in blood flow. It uses LED light to illuminate the fingertip and a photodetector to measure variations in light absorption caused by the pulsing of blood. As blood volume in the fingertip changes with each heartbeat, the sensor produces an analog signal that corresponds to these variations [5]. This signal is then sent to the Arduino UNO, where it is processed to determine the heart rate. The pulse sensor is compact and easy to use, making it suitable for real-time monitoring applications.

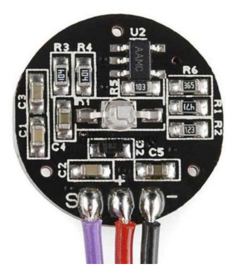

Fig. 2a Front of Pulse sensor

Fig. 2b Back of Pulse sensor

3) *Bluetooth Module (HC-05):* The HC-05 Bluetooth module facilitates wireless communication between the Arduino UNO and a smartphone. It is a versatile and widely-used module for establishing serial communication over Bluetooth [6]. The HC-05 allows the Arduino to transmit heart rate data to a smartphone in real-time, enabling remote monitoring. It supports both master and slave modes, though in this system, it operates in slave mode to receive data from the Arduino. The module is easy to interface with the Arduino and requires minimal configuration, making it ideal for wireless data transfer applications.

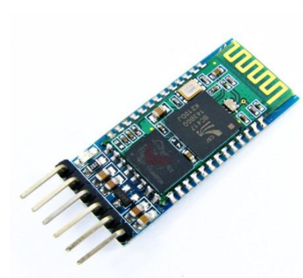

Fig. 3 HC-05 Bluetooth Module

4) Smartphone with Terminal App: The smartphone, using the Terminal application, receives data from the Bluetooth module and displays it digitally. The app connects to the HC-05 Bluetooth module and shows the real-time heart rate data in a straightforward digital format. This allows users to monitor their heart rate directly on their smartphone screen, providing an easy and accessible way to view the data as it is transmitted from the pulse sensor through the Arduino UNO.

B. System Design and Operation

The pulse sensor is attached to the fingertip, where it employs photoplethysmography to detect changes in blood volume. The sensor's LED light illuminates the fingertip, and a photodetector measures the light that passes through, which varies with the flow of blood. This variation in light absorption is converted into an analog signal by the sensor [7].

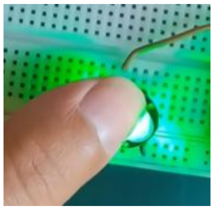

Fig.4a Finger on the pulse sensor

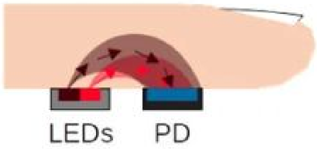

Fig. 4b Working Mechanism of Pulse sensor

This analog signal is then transmitted to the Arduino Uno, which processes it to determine the Beats Per Minute (BPM) using custom algorithms. The Arduino Uno converts the analog signal into a digital format and applies algorithms to calculate the heart rate based on the detected pulse intervals.

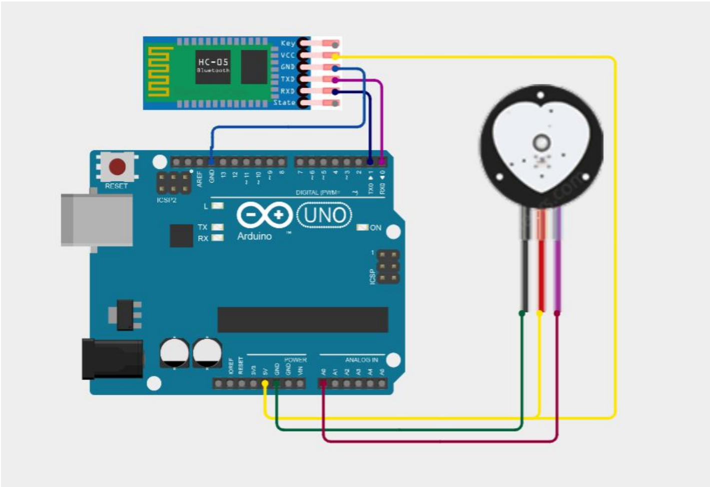

Fig. 5 Circuit Diagram of a system

The processed heart rate data is transmitted wirelessly via Bluetooth to the Terminal application on a smartphone. The Bluetooth module (HC-05) communicates with the smartphone, sending the real-time data. On the smartphone, the Terminal application receives the data and displays it in a user-friendly interface. The app shows the heart rate data in real-time, providing a simple digital readout for the user to monitor.

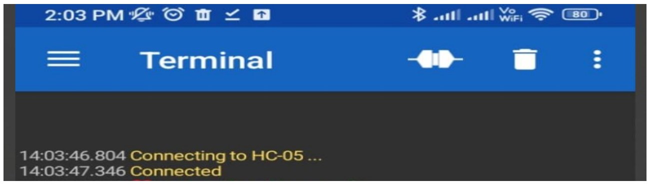

Fig. 6 Connection between Bluetooth module and a smartphone

C. Data Acquisition and Analysis

The data acquisition process involves using a pulse sensor attached to the patient's fingertip. The pulse sensor is connected to an Arduino Uno microcontroller, which is responsible for capturing the sensor's data and calculating the Beats Per Minute (BPM). The Arduino is programmed to continuously monitor the pulse data, which is then transmitted to a connected computer via a USB interface.

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The setup, as shown in Fig. 7 , involves the pulse sensor being connected to a breadboard and interfaced with the Arduino Uno. The Arduino is connected to a laptop running a coding environment, such as the Arduino IDE, where the data is processed and visualized. During the testing phase, an LED on the breadboard remained constantly lit, indicating that the system was powered and active, although it did not blink in sync with the heartbeat as initially expected.

To visualize and record the BPM, the data captured by the Arduino is transmitted to a smartphone via Bluetooth. This setup allows for real-time monitoring and recording of the patient's heart rate. The smartphone application used in this process provides a graphical representation of the BPM, facilitating easy interpretation and monitoring of the patient's cardiovascular health.

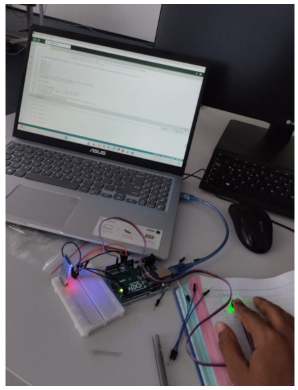

Fig. 7 The connection of the sensor, Arduino, and Bluetooth with the data shown in the monitor.

III. RESULTS

The performance of the system was evaluated based on its ability to measure and transmit heart rate data accurately. The Arduino Uno and pulse sensor system successfully processed and displayed real-time heart rate data via the Terminal app on a smartphone. The data was transmitted smoothly via Bluetooth, and the displayed BPM values were consistent with the expected range for the individual tested.

While formal testing with a diverse sample of individuals was not conducted, the system's performance aligns with the expected results based on the sensor's specifications and previous similar implementations. The consistency of the displayed data, despite the absence of rigorous testing, suggests that the system is capable of providing reliable heart rate measurements under standard conditions.

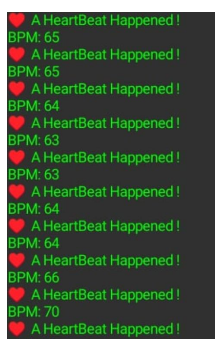

Fig. 8 The real-time data of BPM

IV. DISCUSSION

The proposed system reliably measures and transmits heart rate data, demonstrating strong performance in both accuracy and efficiency. Its design, featuring an Arduino Uno and Bluetooth modules, is both portable and cost-effective, making it well-suited for remote and resource-limited settings.

Bluetooth connectivity enables real-time monitoring, which is crucial for prompt intervention in cases of abnormal heart rates. This feature enhances the system's effectiveness in continuous patient monitoring.

The cost efficiency of the system is a key advantage, especially for low-income regions. By using affordable components, the system remains accessible without compromising its functionality. Additionally, compatibility with the Terminal app provides a straightforward interface for data visualization, facilitating remote monitoring.

V. CONCLUSION

This research introduces a cost-effective, portable system for remote heart rate monitoring. By integrating an Arduino Uno microcontroller, a pulse sensor, and a Bluetooth module with a smartphone application, the system offers a practical solution for remote diagnostics and monitoring. Its accurate measurement of beats per minute (BPM) and user-friendly design make it an effective tool for early detection and management of heart rate abnormalities. This system represents a significant advancement in accessible healthcare technology, especially for remote or resource-limited settings.

VI. FUTURE WORK

Future enhancements to the system will include the integration of advanced microcontrollers such as the ESP32, which incorporates built-in Bluetooth capabilities, eliminating the need for an extra module. Additionally, improvements will focus on the development of a more advanced smartphone application with enhanced data analytics capabilities, including graphical displays, message sending facilities, and alert notifications. Despite current limitations in SpO2 measurement, future work may explore the integration of additional sensors to monitor a broader range of vital signs, further enhancing the system's diagnostic capabilities.

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