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Analysis of Patient Health Using Arduino and Monitoring System

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The proposed project is a health monitoring system using Arduino that measures key health parameters such as heart rate, blood oxygen level, and body temperature. The system consists of sensors such as DHT11 for temperature, MAX30100 for heart rate and blood oxygen level, and an Arduino Nano for processing the data. The measured results are displayed on an LCD screen and a buzzer sounds when the results are ready. The system has been designed with simplicity and ease-of-use in mind, making it accessible for personal use. While the system has limitations such as sensor accuracy and lack of IoT functionality, it still has potential for improving individual health monitoring and wellness. In the future, potential areas for development include the inclusion of more sensors, IoT functionality, and machine learning algorithms for personalized insights and recommendations. Overall, the proposed health monitoring system is a promising step towards empowering individuals to take a more active role in monitoring their health and wellness.

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1. INTRODUCTION

Health monitoring is an essential aspect of maintaining good health and wellness, and advancements in technology are making it easier than ever to do so at home. This project aims to develop a more accessible and user-friendly alternative to existing health monitoring solutions, specifically wearable devices. While wearable devices offer continuous monitoring, they often come with steep price tags, and their constant physical contact can lead to sweating, skin irritation and discomfort, especially for children and users who require long-term monitoring. In contrast, our proposed health monitoring system using Arduino utilizes a simple fingertip press to deliver accurate results instantly. This eliminates the need for continuous wear, addressing the comfort concerns associated with wearables. Additionally, by leveraging the affordability and open-source nature of Arduino, this project offers a significantly more cost-effective solution, empowering individuals to take charge of their health without financial constraints [1,2].

This distinction positions our project as a valuable option for individuals seeking a convenient, affordable, and comfortable way to monitor their health parameters. It caters to those who are cost-conscious or sensitive to wearables, and its simplicity promotes regular self-monitoring, potentially leading to improved health outcomes, reduced healthcare costs, and overall well-being [3].

1.1 Objectives of the Project

The primary objective of this project is to design and develop a health monitoring system using Arduino that can measure key health parameters such as heart rate, blood oxygen level, and body temperature. The system should be affordable, accessible, and easy-to-use for personal health monitoring. Additionally, the system should be able to display real-time health data on an LCD screen and sound a buzzer when the results are ready. The system should also have the capability to be powered by a simple bus bar to reduce the complexity of the system. The secondary objectives of this project are to test and validate the system's accuracy by comparing the results with standard medical devices, simulate and analyze the system's performance under different conditions, and identify potential areas for future development, such as the inclusion of more sensors or IoT functionality. Overall, the project objectives aim to develop a reliable and user-friendly health monitoring system that can improve individual health outcomes and promote overall wellness [4].

1.2 Organization of the Report

The report begins with an introduction that provides an overview of the project background, objectives, and scope. The literature review section presents the existing literature related to health monitoring systems and their components. The methodology and modeling section describe the components used in the project, their working principle, and the process of work. The results and discussion section present the measured response and experimental results and compares the numerical and experimental results. The limitations and future work section discuss the limitations of the project and potential areas for future development. Finally, the conclusion and future endeavors section provide a summary of the project and suggest possible avenues for future work.

2. LITERATURE REVIEW

There are several research papers on “Patient Health Monitoring using ESP8266 & Arduino”. Prof. P.H. Kadam, Yogesh R. Tetwar, Shubham R. Langade, Gayatri N. Nalge, Ketaki N. Shete, Mohanish C. Jadhao, Lavkush M. Sable, Chandrakant B. Borkar published “A Review Paper on Monitoring System using Arduino” in 2023 where they proposed a temperature sensor which is a Celsius temperature heat exchanger that can effortlessly take Celsius measurements without the need for transmitting large, continuous power interruptions [5].

In 2023, “Design and Implementation of Health Care Monitoring System using Cloud and Mobile Applications” was published by P. Suryanarayana, R. Kalyankumar, S. Bhaskarakrishna, R. Chinnu, where they proposed a model that will display body temperature, heartrate, glucose level, blood pressure, room temperature, oxygen saturation as well as track the patient’s location using Arduino Uno and several sensors [4]. In the paper of Sowjanya Masna, Ashwini Gadusu named “ICU Patient Health Monitoring System over IoT using Arduino”, a health monitoring system concept is suggested, which utilizes temperature, heartbeat, and humidity sensors to track human body health parameters. The data is then displayed on an LCD screen and transmitted to an IoT server [6]. For ensuring the health and safety issues of the ICU patients Shirisha et al published “Arduino Based ICU Patient Health Monitoring System over IOT” [7]. The proposal involves a health monitoring system incorporating temperature sensors, heartbeat sensors, and humidity sensors to track human body health parameters. The data is displayed on an LCD and sent to an IoT server. If there are fluctuations in the heart rate, indicating low or high blood pressure, the system triggers a buzzer alert, and the corresponding information is also updated on the server. To reduce the hassles of going outside for health checkup during pandemic in 2021, Mohammad Monirujjaman Khan et al published “IoT-Based Smart Health Monitoring System for COVID-19 Patients” and submitted a proposal to keep a track of the patient by using mobile application and Arduino Uno where there will be doctor’s interface and patients’ interface and if something goes wrong with the patient, the doctor will be notified through a sensor. In addition, the doctor can see the patients’ health report and condition [8].

3. METHODOLOGY

The Arduino-based health monitoring system is a nonreal-time monitoring system that can measure and record vital health parameters like blood oxygen levels, body temperature, and heart rate. It uses an Arduino microcontroller, along with sensors like the pulse oximeter, temperature sensor, and heart rate sensor, to measure these parameters. The system then displays this data on an LCD screen for the user to view. This health monitoring system can be used in hospitals, clinics, and even at home to monitor the health of patients [9].

3.1 Block Diagram

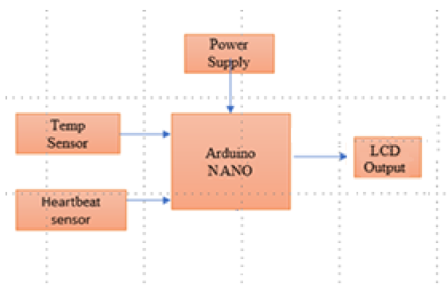

Fig. 1. Block diagram of an Arduino based health monitoring system.

3.2 Working Principle

Temperatur Measurement: The DHT11 temperature sensor measures the ambient temperature of the surroundings and sends analog signals to the Arduino Nano microcontroller. Heart Rate and Blood Oxygen Measurement: The MAX30100 sensor measures the heart rate and blood oxygen levels by shining a light through the skin and measuring the reflected light. The sensor sends analog signals to the Arduino Nano microcontroller. The Arduino Nano microcontroller converts the analog signals received from the temperature sensor and the MAX30100 sensor into digital signals for further processing. The processed data is then displayed on the LCD screen, which shows the measured temperature, heart rate, and blood oxygen levels in real-time. The buzzer is used as an alert system that notifies the user when the results are ready. For example, when the measured data is displayed on the LCD screen, the buzzer will sound like it is alerting the user that the results are ready [10].

Power Supply: The bus bar is used to provide power to each of the components in the system, ensuring that they function correctly.

Overall, the system works by measuring the ambient temperature, heart rate, and blood oxygen levels using the DHT11 and MAX30100 sensors, processing the data using the Arduino Nano microcontroller, and displaying the results on the LCD screen. The buzzer is used to notify the user when the results are ready, and the busbar provides power to the components [11].

3.3 Components

The components used in the system are widely available, easy, and cheap to implement.

3.3.1 Arduino NANO

The Arduino Nano is a compact and versatile microcontroller board built around the ATmega328 (for the Arduino Nano 3.x version) or ATmega4806 (for the Arduino Nano Every version). With its small size and compatibility with breadboards, it offers similar capabilities to the Arduino Uno but in a different form factor. Notably, it doesn't include a DC power jack and utilizes a Mini-B USB cable for connectivity [12].

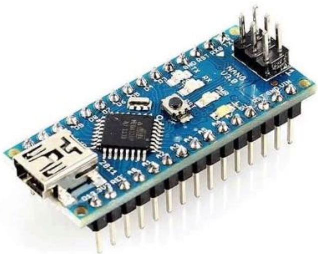

Fig . 2. Arduino NANO [12]

3.3.2 DHT11 temperature sensor

The DHT11 is a digital sensor designed to gauge the temperature and humidity of the environment it is placed in. It has a measuring range of 0-50 °C and an accuracy of ±2 °C. The sensor uses a single-wire communication interface and provides a digital output signal that can be read by the Arduino Nano microcontroller [13].

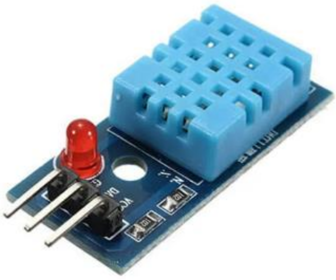

Fig. 3. DHT11 temperature sensor [13]

3.3.3 Max30100 pulse oximeter and heart-rate sensor

The MAX30100 sensor functions as a pulse oximeter and heart-rate sensor. It measures the oxygen saturation in the blood and the heart rate by shining a light through the skin and measuring the reflected light. The sensor has an integrated LED and photo detector and provides analog output signals that can be read by the Arduino Nano microcontroller [14].

Fig. 4. Max30100 pulse oximeter and heart-rate sensor [14]

3.3.4 Power Supply

The power supply consists of an LM7805 5V voltage regulator and a 9V battery. Additionally, the Arduino can be powered using a 9V supply or from a connected computer through USB [15].

Fig. 5. Battery [15]

3.3.5 LCD Display

The LCD display is a 16x2 character display that is used to display the measured temperature, heart rate, and blood oxygen levels in real-time. It communicates with the Arduino Nano microcontroller using the I2C protocol, which requires only two wires for data transmission [16].

Fig. 6. LCD display [17]

3.3.6 Buzzer

The buzzer is a small electronic component that produces sound when an electric current is passed through it. It is used to provide an audible alert when the measured data is ready to be displayed on the LCD display. The buzzer is connected to one of the digital pins of the Arduino Nano microcontroller [18].

Fig. 7. Buzzer [19]

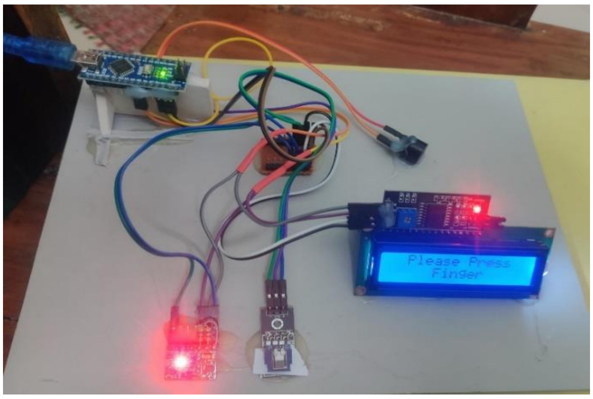

Fig. 8. Experimental setup when the system turned on

4. TEST/EXPERIMENTAL SETUP

The experimental setup for the proposed Arduino based health monitoring system involved connecting various components through a busbar to the Arduino Nano. We used the DHT11 temperature sensor to measure the ambient temperature, and the MAX30100 sensor to measure heart rate and blood oxygen levels. We also used an LCD display with I2C interface to show the real-time results, and a buzzer to provide an audible alert when the measurements were complete. All of the sensors and displays were properly connected and wired to the busbar and Arduino Nano, with the system being powered by an external power supply. We tested the system by placing a fingertip on the MAX30100 sensor and measuring the body temperature, heart rate and blood oxygen levels. Fig. 8 shows the experimental setup of our health monitoring system when it was initially turned on. The LCD screen displays a message prompting the user to press his/her fingertip on the MAX30100 sensor [20].

5. RESULTS AND DISCUSSION

5.1 Simulation Analysis

Fig. 9 shows the simulation design and connection of all the components to the Arduino. An Arduino UNO board was used while simulating in the Proteus software. The temperature sensor output as well as the heart beat sensor output will be in analog form which needs to be converted into digital output. There are 6 analog to digital conversion pins present on the Arduino board (A0 – A5) which takes in analog signals as input and converts it into digital output. Hence, the heart beat sensor is connected to pin A0 while the temperature sensor is connected to the A1 pin of the Arduino board [21].

The result of this simulation is shown in Fig 10. The obtained results are:

Heartbeat: 90 BPM & Temperature: 32^{o}C

5.2 Measured Response/Experimental Results

Three health parameters of three different individuals were measured using our health monitoring system. The health parameters were: Body Temperature (F), Heart Beats Per Minute (BPM) & Oxygen Saturation Percentage/SpO$_2$ Level (%).

Fig. 11 shows the measured response after user 1 pressed on the MAX30100 *sensor.* The LCD screen displayed the readings as follows:

T: 98.13 F, BPM: 93.21, O2: 94

Fig. 12 shows the measured response after user 2 pressed on the MAX30100 *sensor.* The LCD screen displayed the readings as follows:

T: 98.34 F, BPM: 109.46, O2: 95

Fig. 13 shows the measured response after user 3 pressed on the MAX30100 *sensor.* The LCD screen displayed the readings as follows:

T: 97.67 F, BPM: 70.26, O2: 95

Table 1 shows a summary of the results obtained after measuring the temperature and BPM of 3 different users.

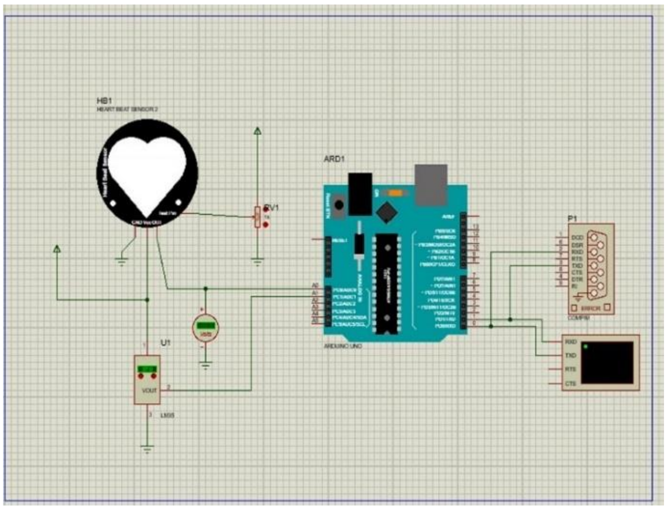

Fig. 9. Proteus simulation of the health monitoring system

Fig.10. Simulation result obtained in Proteus

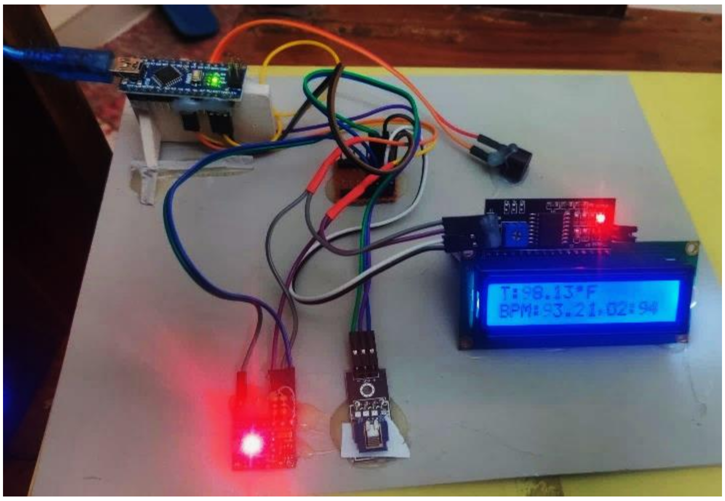

Fig. 11. Experimental result when user 1 pressed on the MAX30100 sensor

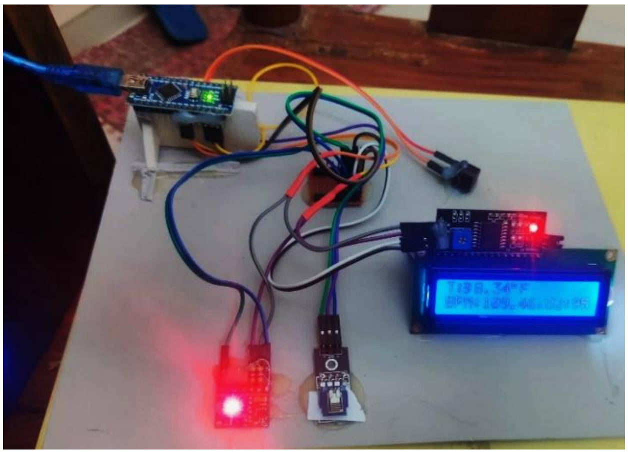

Fig. 12. Experimental result when user 2 pressed on the MAX30100 sensor

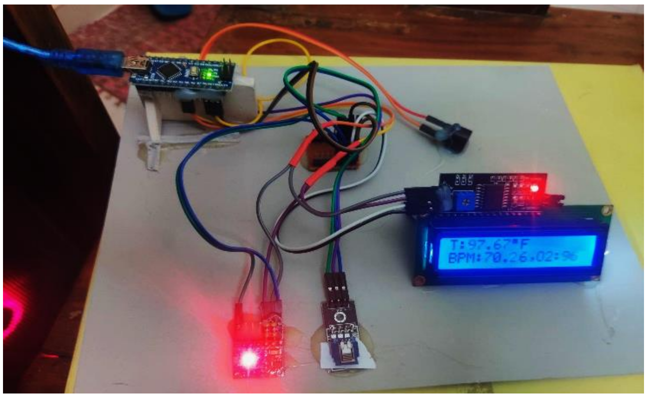

Fig. 13. Experimental result when user 3 pressed on the MAX30100 sensor

Table 1. Summary of the results obtained

User	Temperature (F)	BPM	O2 (%)
1	98.13	93.21	94
2	98.34	109.46	95
3	97.67	70.26	96

During real-world testing of a health monitoring system, it's important to account for individual variability to ensure that the system is accurately measuring and monitoring an individual's health. Differences in age, physiology, health status, and other factors can affect the measured response for different people and thus we can see the variation in the results obtained from 3 different users. Additionally, it's important to establish baseline values for normal ranges for each measurement to properly interpret the results. The normal range of measurements can vary depending on factors such as age, gender, and health status. Consulting with a healthcare professional can help to establish these normal ranges and interpret the results of the health monitoring system. By accounting for individual variability and establishing baseline values, a health monitoring system can provide accurate and useful information to individuals and healthcare professionals alike [22].

6. FUTURE POTENTIAL

In the future, there will be several areas of development for the health monitoring system. One potential area for improvement is the inclusion of more sensors to monitor additional health parameters such as blood pressure or respiratory rate. Additionally, incorporating IoT functionality could allow for real time data transmission to healthcare professionals or caregivers, enabling remote monitoring and support [23].

Another potential area for development is the integration of machine learning algorithms to analyze the collected data and provide personalized insights and recommendations for individuals. Overall, the proposed health monitoring system is a promising step towards empowering individuals to take a more active role in monitoring their health and wellness [24].

7. CONCLUSION

In conclusion, critical health metrics like body temperature, heart rate and blood oxygen level have been measured and monitored using the suggested health monitoring system using Arduino, with encouraging results. The system is usable for personal use because it has been created with simplicity and usability in mind. Although the system has some drawbacks, such as sensor inaccuracy and a lack of IoT functionality, it nevertheless has the potential to enhance personal health monitoring and wellness [25].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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