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SERVICES FOR SCIENCE AND EDUCATION

Remote Health Monitoring System for Quarantined/Isolated Cases

Ziyad Aloqalaa
Department of Biomedical Technology, College of Applied Medical Sciences,
King Saud University, Riyadh 11451, Saudi Arabia

ABSTRACT

Global viruses could affect many people's health and quality of life, as seen during the Coronavirus (COVID-19) pandemic. Most people infected with COVID-19 have experienced mild to moderate respiratory illness and recover without special treatment. However, some cases have developed into serious illnesses, especially cases with previous conditions like cardiovascular disease, diabetes, chronic respiratory disease, and cancer. Social distancing, quarantine, and isolation are the most effective ways to prevent viruses such as COVID-19 from spreading. Consequently, this social distancing creates challenges to monitor vital signs of quarantined and isolated cases. Hence, a medical practitioner needs a system that facilitates the monitoring process. This research will develop a remote health monitoring system that helps monitor vital signs of quarantined and isolated cases. This system has many benefits, including minimizing direct contact between healthcare providers and quarantined/isolated cases, predicting the number of cases that might need critical care treatment in the future, and facilitating the development of a national health registry regarding any pandemic. A remote health monitoring system is a sensor-based system to measure body temperature, respiratory rate, oxygen saturation (SpO2), and heart rate. This system will be interactive by incorporating an Internet of Things (IoT) feature that monitors cases in real-time or at specified intervals, then sends the result to healthcare providers.

Keywords: Vital signs, Internet of Things (IoT), Contagious viruses, Quarantined/Isolated Cases.

INTRODUCTION

Since the first official case of a Covid-19 patient in December 2019, our lives have changed significantly in every aspect, politically, economically, socially, and financially. Social distancing, quarantine, and isolation effectively decreased the spreading of this virus [1]. Consequently, many challenges have arisen due to protective measures during the pandemic. These challenges include monitoring vital signs of socially distanced, quarantined, and isolated cases. Knowing the vital signs of a patient (heart rate, respiratory rate, body temperature, and blood pressure) is crucial to classify the seriousness of the patient's situation. Hence, a medical practitioner needs an effective system that facilitates the monitoring process. Healthcare providers risked so much in this pandemic that some do not see their families regularly, so they do not spread the virus if they catch it; most countries have acknowledged and appreciated their efforts. Therefore, these providers need help from technology to decrease the rate of their infections and facilitate their daily working routine for them.

This project aims to develop a remote health monitoring system that helps monitor vital signs of quarantined and isolated cases. This system has many benefits, including minimizing direct contact between healthcare providers and quarantined/isolated cases, predicting the number of cases that might be transferred to critical care treatment in the future, and facilitating the development of a national health registry regarding viruses and pandemics.

MATERAIL AND METHODS

Figure 1 shows the remote health monitoring system. This system includes a microcontroller (Arduino), ECG module plus metal dry reusable electrodes to determine heart rate, temperature sensor, Saturation of Peripheral Oxygen (SpO2) sensor, Carbon Dioxide sensor to calculate respiratory rate, and Bluetooth module.

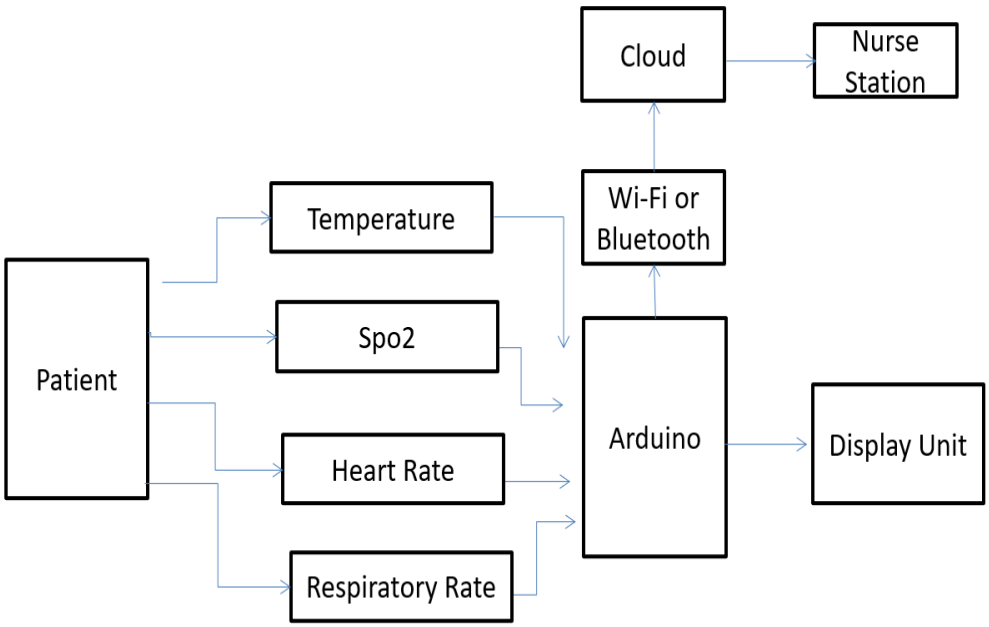


Figure 1: Block diagram of the remote health monitoring system.

ECG Module (AD8232)

AD8232 is an integrated signal measurement module for ECG [2]. AD8232 will read the ECG signal using metal limbs electrodes. The limbs were used to position these electrodes according to Einthoven's triangle, following the instructions in the AD8232 user manual [3]. The acquisition of ECG data was carried out on a subject who was in a relaxed seated position with minimal movement. The ECG data was utilized to determine the heart rate using the Pan-Tompkins algorithm [4].

Temperature Sensor (MLX90614)

It is a sensor called the MLX90614 [5], which measures temperature using infrared technology without requiring direct contact. It contains a thermopile detector sensitive to infrared radiation, an ASIC for signal conditioning, a low noise amplifier, a 17-bit ADC, and a powerful DSP unit. Despite its small size and low cost, this thermometer is highly accurate and has excellent resolution.

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Spo2 Sensor (MAX30102)

The MAX30102 [6] includes a pulse oximetry sensor that integrates two LEDs, a photodetector, optimized optics, and low-noise analog signal processing. This combination leads to the accurate detection of pulse oximetry.

Carbon Dioxide Sensor (CCS811)

CCS811 [7] is a digital gas sensor that detects indoor low levels of equivalent Carbon dioxide (CO2) and operates on low power. Monitoring levels of equivalent CO2 is one way to calculate breath rate.

Bluetooth Module (HC-06)

The HC06 [8] is a Bluetooth module with Bluetooth V2.0+Enhanced Data Rate (EDR), a 2.4GHz radio, and Adaptive Frequency Hopping Feature (AFH).

RESULTS

Heart Rate

Figures 2 shows the results recorded in real time from Arduino after the application of Pan-Tompkins algorithm.

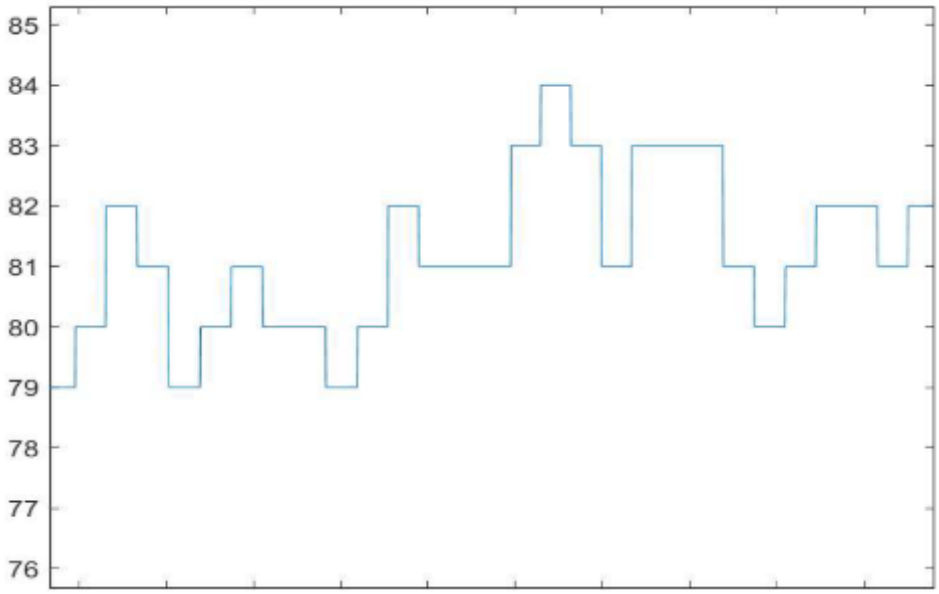


Figure 2: Heart rate.

Temperature

The accuracy of the sensor has been evaluated through two tests (room and skin temperature) as illustrated in Figures 3 and 4.

ROOM TEMPERATURE

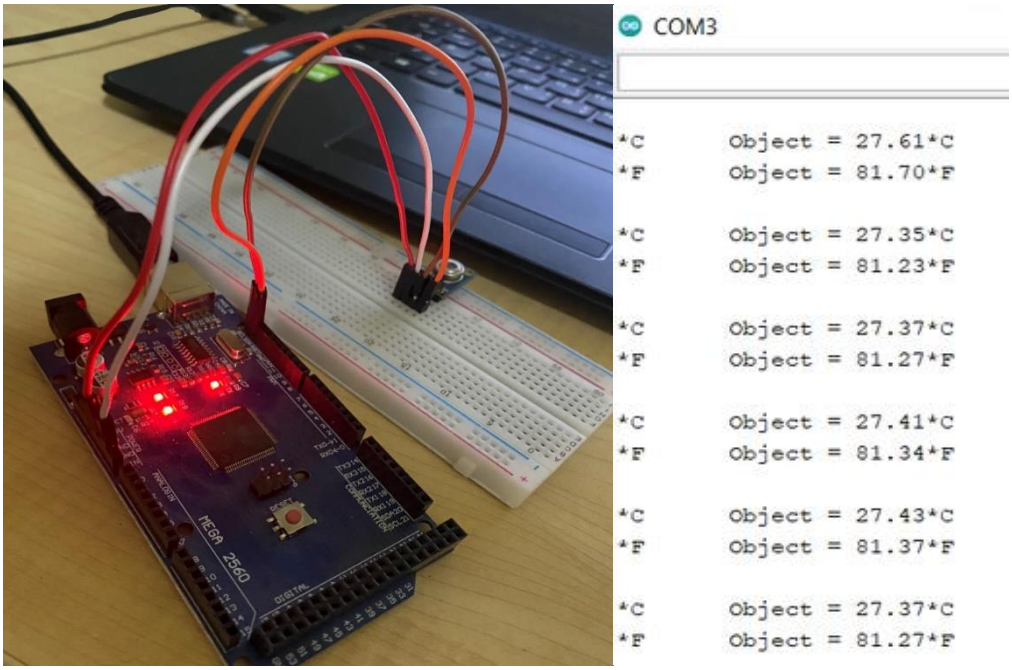


Figure 3: Experiment setup and Arduino with real time results of temperature sensor in room temperature.

SKIN TEMPERATURE

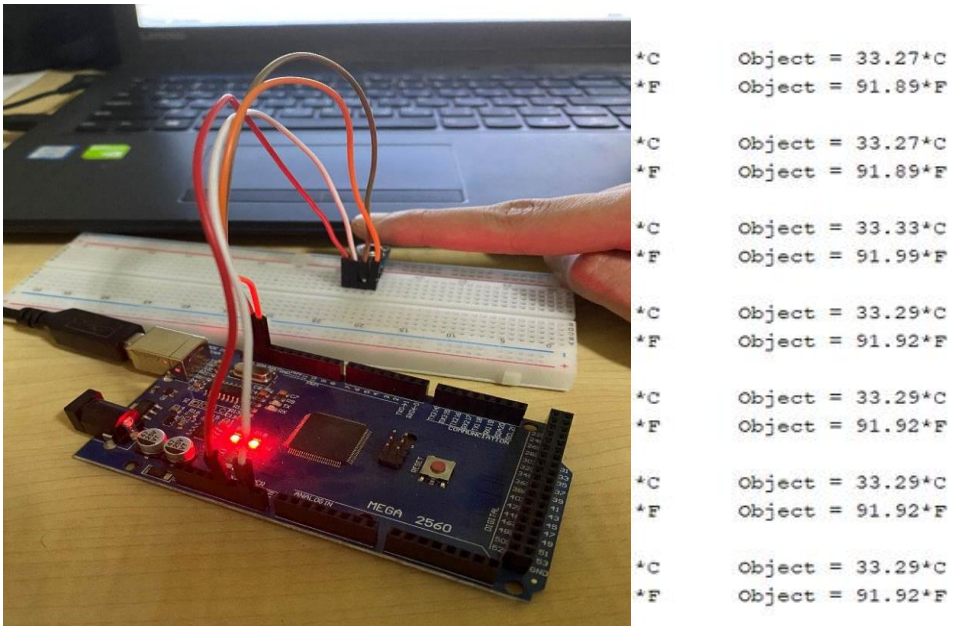


Figure 4: Experiment setup and Arduino with real time results of temperature sensor in skin temperature.

Spo2

Figure 5 illustrates the Spo2 experiment and its results.

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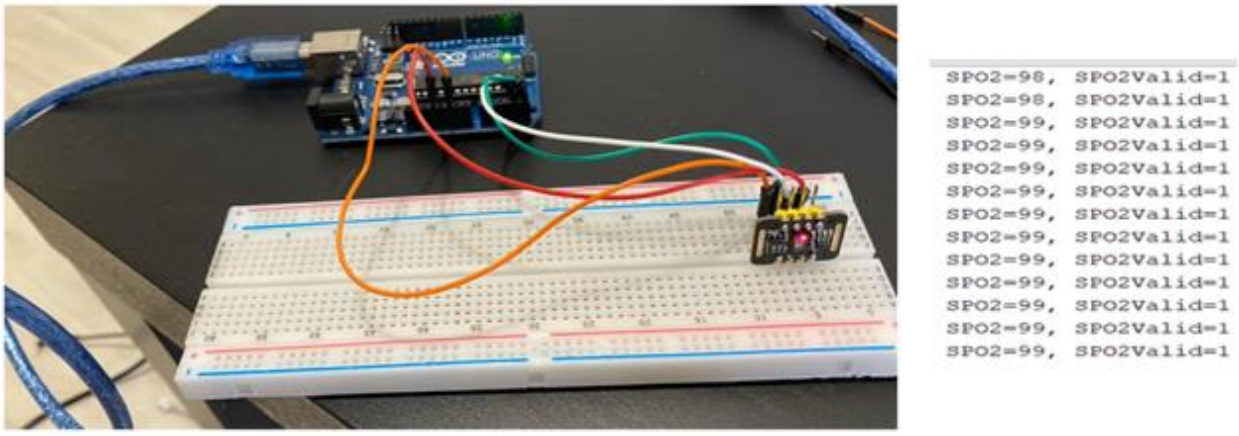


Figure 5: Experiment setup and Arduino with real time results of Spo2 experiment.

Carbon Dioxide Sensor and Breath Rate

Figure 6 demonstrates the breath rate experiment and its results.

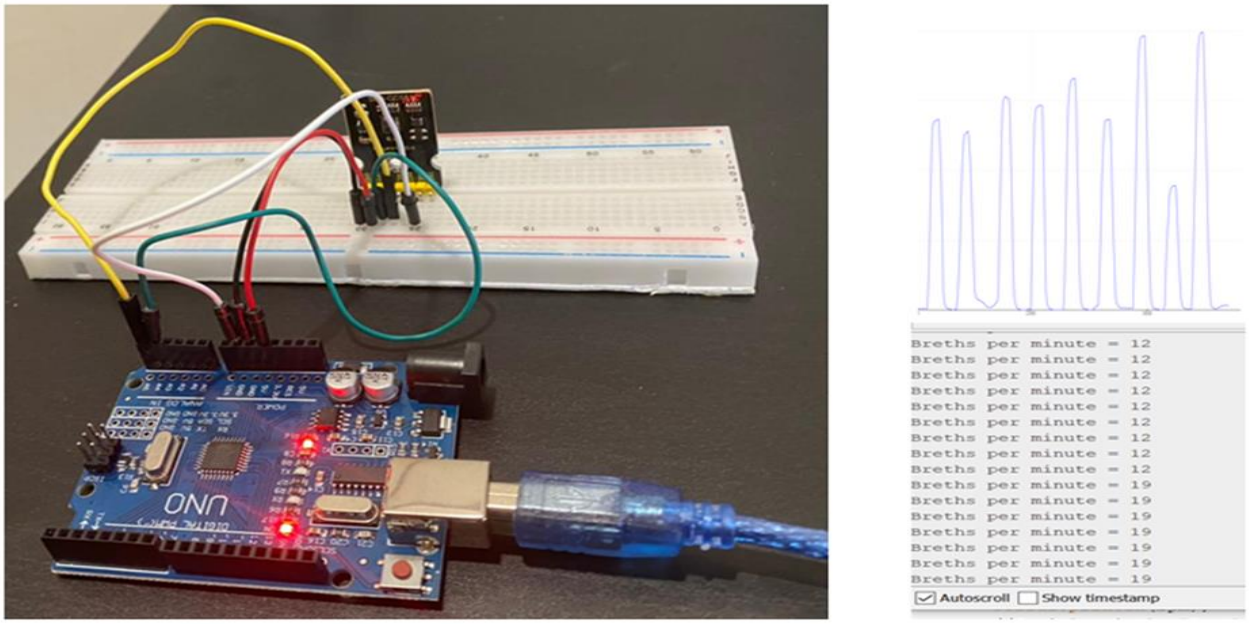


Figure 6: Experiment setup and Arduino with real time results of breath rate experiment.

Bluetooth

The connection between a phone and an Arduino was established via the Bluetooth HC-06 chip using the "Serial Monitor" app downloaded from Google Play. Figures 7 explain this setup using previously discussed temperature sensor experiment.

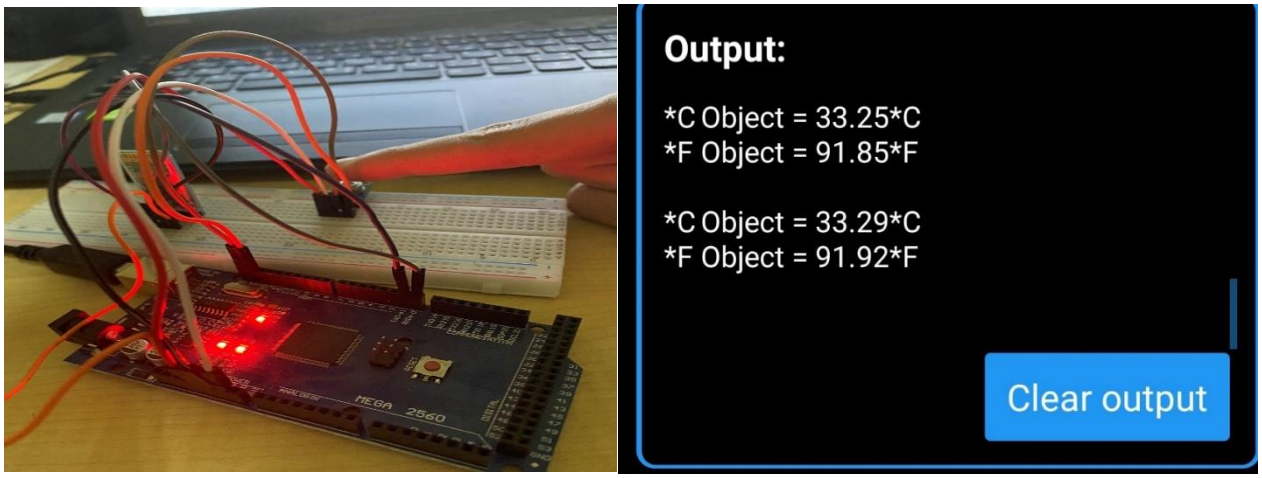


Figure 7: Bluetooth experiment with skin temperature in real time, results were captured from the mobile phone.

DISCUSSION

AD8232 sensor succeeded with the Pan-Tompkins algorithm in calculating heart rate efficiently, as shown in Figure 2. AD8232 is versatile in displaying and analyzing the ECG signals, which is helpful with different patients and different conditions.

MLX90614 sensor is very reliable and convenient for measuring skin temperature, as illustrated in Figures 3 and 4. Non-invasive temperature sensors are not the most accurate (oral, rectal, and axillary sensors are usually more accurate). However, these sensors are more convenient and easier to use. Also, MLX90614 showed good responses, which could be used as an indication of the seriousness of quarantined patients.

MAX30102 demonstrated an excellent ability to monitor Spo2, as illustrated in Figure 5. However, more than five commercially available sensors have been tried, and only one worked correctly.

CCS811 sensor was used to calculate breath rate, as shown in Figure 6. It produced reasonable results and proved the ability to monitor breath rate by detecting equivalent CO2 indoor levels. The output of the Bluetooth Module (HC-06) appears in Figures 7. The output of skin temperature experiment was transferred through HC-06 to a mobile phone.

CONCLUSION

This study conducted multiple experiments to test the feasibility of a remote health system. However, these experiments must be done in the future as a whole system to create one instrument using a single microcontroller, communication device, and display system.

This research plays a vital role in our battle against viruses such as COVID-19. Remote health monitoring system will open the door to many essential benefits, including:

1. Predicting cases that may require critical care in the future and could require transfer to health care facilities. Knowing and predicting critical cases will allow health authorities to plan hospitals' capacities in terms of beds, medical devices, and healthcare staffing.

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2. Decreasing the direct contact between quarantined cases and healthcare providers.
3. Creating a national registry regarding the history of quarantined cases.

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