Wearable Device for Detection of COVID-19 and Tracking Symptoms

Team 17

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Abstract—**The purpose of this project is to create a wearable device that provides the user with valuable health diagnostic information related to common COVID-19 symptoms. COVID-19 is a respiratory disease that is fast spreading and difficult to identify. The common symptoms currently include fever, dry cough, shortness of breath, low blood oxygen levels, and respiratory failure. In order to identify and monitor for these symptoms, the following project consists of an SPO2 sensor, temperature sensor, accelerometer, and a control unit. The data acquired from the device is sent to a mobile app which is able to indicate temperature, heart rate, SPO2 levels, and heart vibrations. This device provides a unique solution to allow for remote COVID-19 patient monitoring through the array of sensors included in the design.**

Keywords-COVID-19, Wearable Device, Health Diagnositic Informaiton

I. Introduction

According to the CDC, there are over 30 million COVID-19 cases reported in the U.S., causing the world to be placed under a global pandemic. COVID-19 is a disease caused by a virus known as severe acute respiratory syndrome or SARS-CoV-2. The structure of these viruses has an organized “crown” like shape consisting of spike proteins. Spike proteins mediate coronavirus entry into host cells through a large ectodomain, a single-pass transmembrane anchor, and a short intercellular tail. Together these elements conduct receptor binding and membrane fusion, creating a never-ending vicious cycle. Stopping this cycle is very difficult due to the virus’s ability to adapt to new environments through mutation and recombination mechanisms. The human body serves as the primary means for indicating COVID-19 infection. The transmission of this virus is primarily through respiratory droplets that are released into the air. This project aims to provide indication of a potential COVID-19 infection by monitoring temperature, SPO2 levels, and respiratory data. The data collected through this device can assist with detecting the virus of asymptomatic individuals.

II. Device design

The wearable COVID-19 device design features an accelerometer, temperature sensor, SPO2 sensor, MCU, and a lithium-ion battery. Each component was selected based on size, accuracy, and low-cost. The accelerometer included in the design offers a low power solution with a 2V to 3.6V supply voltage. Its compact size (3mm x 5mm x 1mm) and user-defined bandwidth allowed for the most ideal sensor. A high accuracy (±0.1°C from -20°C to 50°C) temperature sensor was choosen for the design. The SPO2 sensor for the design features both a heart rate and pulse oximetry capabilities. A development board was selected in order to allow proper integration of all previously listed sensors. Lastly, an interchangeable rechargeable lithium-ion battery charger was implemented into the design to allow users to continusly wear the device. The block diagram of the device is indicated below:

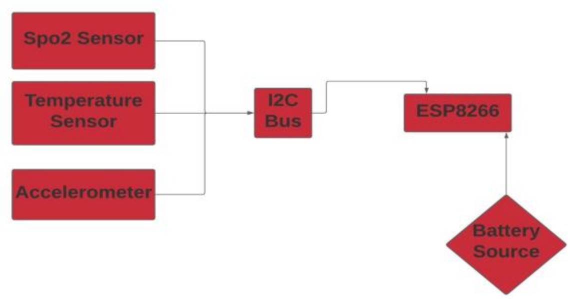

Figure 1. Block Diagram of System

III. Testing & Data acquistion

Each of the sensors included in the wearable design were individually tested using a data acquisition device followed by Arduino IDE software. In order to ensure that each sensor was working properly, a LabJack was used to generate data. Ultimately, a few sensors that were purchased were deemed unfit for the application and new sensors were purchased. An analog temperature sensor (LMT70) was generating inaccurate data and was eliminated from the project design. In addition, an analog accelerometer (ADXL335) was also removed from the final design based on the inaccurate data acquisition measurements. Both a new temperature (TMP117) and accelerometer (ADXL345) sensor were then tested for accuracy using Arduino IDE. The new temperature sensor demonstrated accurate readings when compared with a digital thermometer. The ADXL345 accelerometer was tested by solely examining the Z-axis. Compared to the X and Y axes, the Z-axis picks up a heart signal significantly better since it is out of plane. The Z-axis is also able to indicate chest wall vibrations which includes cough vibrations. The ADXL345 was placed on the chest wall by medical tape in order to avoid unwanted body motion. Heart sounds and forced cough measurements were taken. To test the SPO2 sensor, the blood oxygen content along with heart rate generated from the sensor was compared with the data acquired from a phone app.

IV. Results

The following graph in figure 2 represents the Z-axis of the ADXL345 accelerometer. This measurement was collected by placing the sensor on the chest wall and inducing a forced cough. The more drastic shaped peaks represent the forced cough action done by the user. The x-axis of the graph represents time in seconds and the y-axis is given in m/s^2.

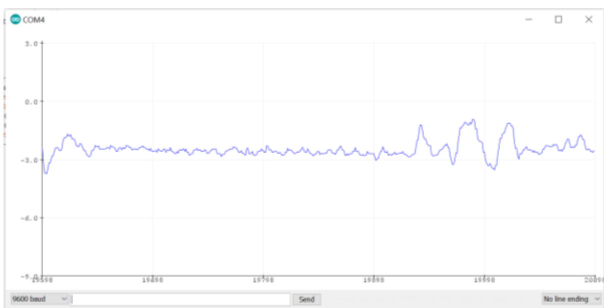

Figure 2. Accelerometer Data

To test the temperature sensor, Arduino IDE was utilized. The sensor was placed on the chest of the user as the data was being collected from the sensor. As shown in figure 3, the TMP117 exhibited accurate body temperature measurements. The measurements were then compared to those given by a digital thermometer which gave a reading of 97.2 degrees Fahrenheit.

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COM4

Temperature in Fahrenheit: 97.19

Temperature in Celsius: 36.22
Temperature in Fahrenheit: 97.19

Temperature in Celsius: 36.23
Temperature in Fahrenheit: 97.21

Temperature in Celsius: 36.23
Temperature in Fahrenheit: 97.21
```

Figure 3. Temperature Data

A MAX30102 SPO2 sensor was tested for accuracy by comparing the data generated with a phone app. Figure 4 illustrates the data from the sensor which was outputting an oxygen saturation of 99%. This data was then compared to that of the phone app (figure 5) which gave a 98% oxygen saturation indicating accurate readings from the SPO2 sensor.

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COM8

IR=179853, BPM=58.08, Avg BPM=55 Oxygen=99% Temp(F)=93.43° IR=179853
IR=178425, BPM=58.08, Avg BPM=55 Oxygen=99% Temp(F)=93.31° IR=178425
IR=178974, BPM=58.08, Avg BPM=55 Oxygen=99% Temp(F)=93.43° IR=178974
IR=179076, BPM=58.08, Avg BPM=55 Oxygen=99% Temp(F)=93.31° IR=179076
IR=179738, BPM=58.08, Avg BPM=55 Oxygen=99% Temp(F)=93.54° IR=179738
IR=180067, BPM=58.08, Avg BPM=55 Oxygen=100% Temp(F)=93.31° IR=180067
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Figure 4. SPO2 Sensor Data

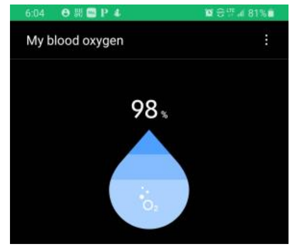

Figure 5. SPO2 Phone Data

After all three sensors were successfully tested for accuracy, the sensors were integrated into wearable encasements. The SPO2 sensor was placed into an ear mold and the accelerometer and temperature sensor were placed into a TPU chest encasement.

Figure 6. Chest Encasement

V. Conclusion

The wearable device for detecting and tracking COVID-19 related symptoms seeks to relieve the dependance on the healthcare system for monitoring patient health. By providing temperature, SPO2 measurements, and heart sound data to the user via a mobile app, this device has the capability of reducing the spread of COVID-19.

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References

[1] Fang L, “Structure, Function, and Evolution of Coronavirus Spike Proteins.” *Annual review of virology*, vol3(1): 237-261, Aug 2016, (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5457962/)