Prototype 3 - Deliverable H

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Table of Contents

Introduction

Unexpectedly we were impacted by recent events that caused great difficulty to finish this project. We had to respect social distancing, and the CEED facilities were shut down after completing our second prototype so it was hard to make progress under these circumstances. But, we still managed to get a start on our third prototype plan with the time we had before the facilities were closed.

This report is broken down into three parts. The first part will discuss our third prototype test plan and the progress we made since our second prototype. The second part will discuss the final status of our prototype, and the third part will discuss detailed steps to how we would have completed our prototype.

Prototype Test Plan

Since our second prototype was done to analyze the critical functionality of our device, we need to focus this prototype on the app software and necessary battery to power our device. Our plan is to build the app and perform a system integration test to see if everything is functioning properly together.

To build the app we will use MIT app inventor. Our goal is to have the app receiving constant, updated measurements from the sensor via BlueTooth and send out an alert if the oxygen saturation drops to dangerous levels. To complete this we need to build a function in an Arduino script that takes the measurements from the sensor and sends them to the BlueTooth. Once this is done then we just need to focus on the function of our app. We will build the app by implementing logical decisions based on the values being received from the BlueTooth. If the oxygen saturation levels are below 90% the app will send out an alert. The second part of our prototype is the necessary battery to power our device. We have calculations that provide us with the total power consumption of our device, now we need to select a battery that goes well with our design. We are looking for a battery that is discrete and can power our device for around 8 hours. We will test out different types of batteries and find one that has these qualities.

The casing is the final component of our design to be tested. It is a critical component as it is the main interface with the user and is the housing unit for the other components. The next prototype will examine the overall functionality of the device to ensure that when all components are combined the sensor is able to transmit a signal to the user. A key consideration for functionality includes evaluating how well the device can adapt and maintain function in different environmental conditions when exposed to realistic situations such as movement and sweat. The overall appearance and comfort of the device will also be evaluated as part of this next round of prototype testing as it will be important to collect feedback from the user on the range

of parameters (size, weight, shape) for which the user finds this device to be sufficiently discrete (non-bulky) and light. Results will consider whether or not further improvements are needed

What is going on and how is it being done?

The design of this prototype was severely impacted by the events of Covid-19, despite this we were able to still make a significant amount of progress on the overall functionality of the device. We originally planned on using the CEED facilities in order to laser cut and 3D print the appropriate elements of our device, however, with these facilities being shut down we were not able to do this and our device was left in a very rough state looks-wise. We were planning on doing this on March 17th but were unable to. Another element of the device that was unable to be completed was the soldering of the device onto a soldering board, we were unable to complete this for the same reasons that we were unable to create the casing for the device, this was slated to be completed on 19th of March, as we wanted to make sure that all the components of the device would fit into the casing before we soldered them onto the soldering board.

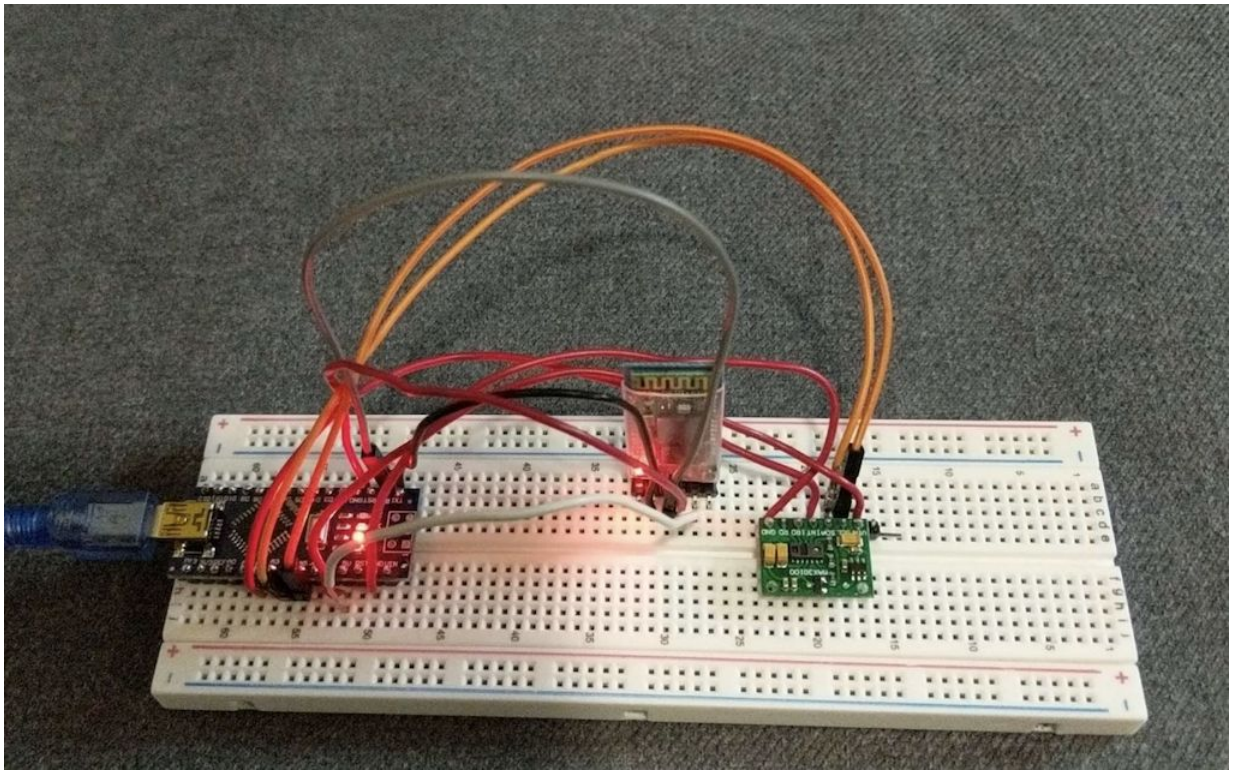
The elements of the design that we were able to complete despite the CEED facilities were the app design and adding a battery onto the device so that it could run without the use of a computer, this was completed on the 14th of March. Originally we wanted to include just one AA battery in order to reduce the size of the device, however, one AA battery did not have enough voltage to power the device. As a result of voltage restrictions, our group had to settle on using four AA batteries and adjusted the device design to make it more compatible for this size. The final aspect of this device that we had to complete in prototype 3 was the app to display the results of the sensor, we were also able to complete this, although this presented its own issue as the person who owned the android phone got separated from the person with the device, this part of the device was completed on the 29th of March.

Status of the final prototype

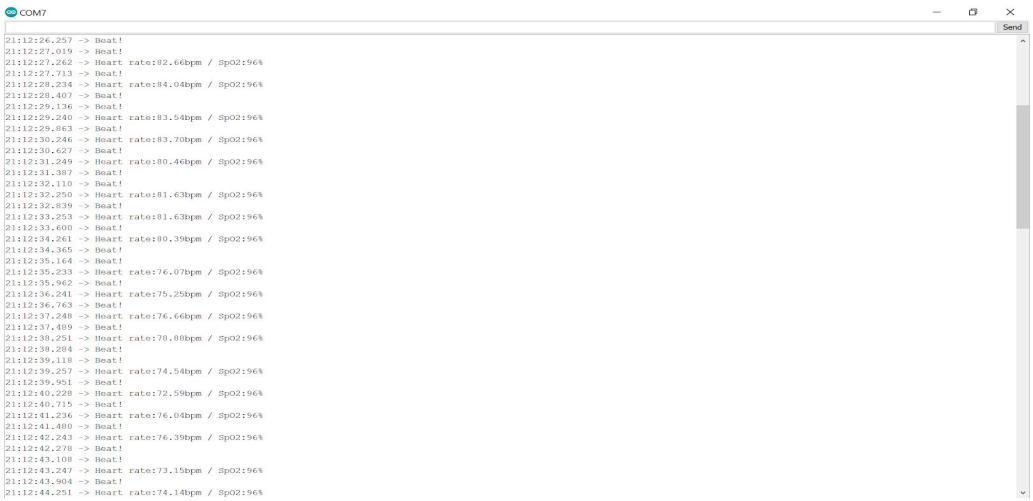
https://youtu.be/PQh93GcJ_-U

In this video, we show how the sensor is working and how it will display the readings. The sensor will read zero for both the heart rate and oxygen level when there is no skin contact with it. When contact is made such as a finger on the sensor, it will start displaying readings of the user's heart rate as well the oxygen levels as a percentage. This percentage should be in the 90's range, as for heartbeat it can vary depending on the person if they are active. However, the average rate would be in the range of 60 to 100 resting.

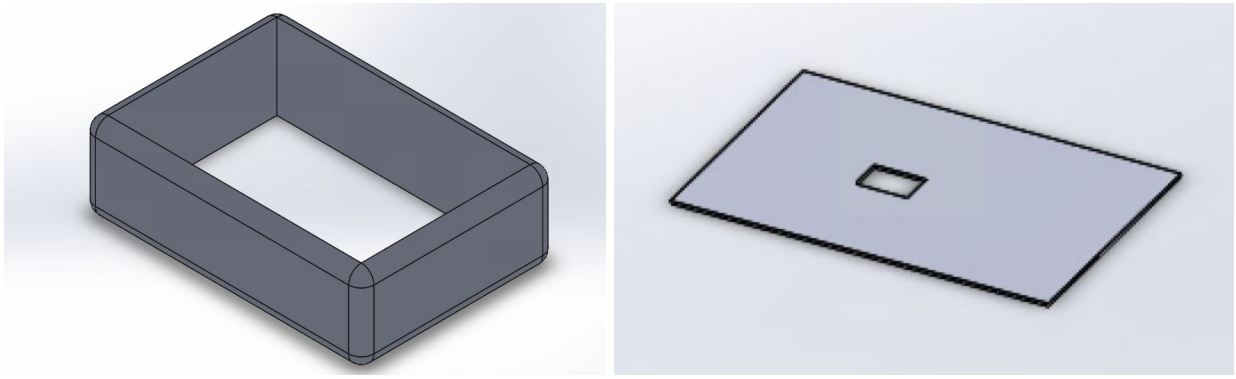
Over the course of the semester, we made good progress on building our device. The final status of our prototype is as follows. We have all of the components connected properly on a breadboard and reading the correct sensor values. Below is a picture of the circuit we built for the proper function of this device.



We connected this circuit to our computers so we can see the values being read by the sensor. When each of us touched the sensor it measured a blood oxygen saturation level between 95-100%, we know this is an appropriate range of values. Below is a picture of the sensor values being displayed on the Arduino serial monitor window.

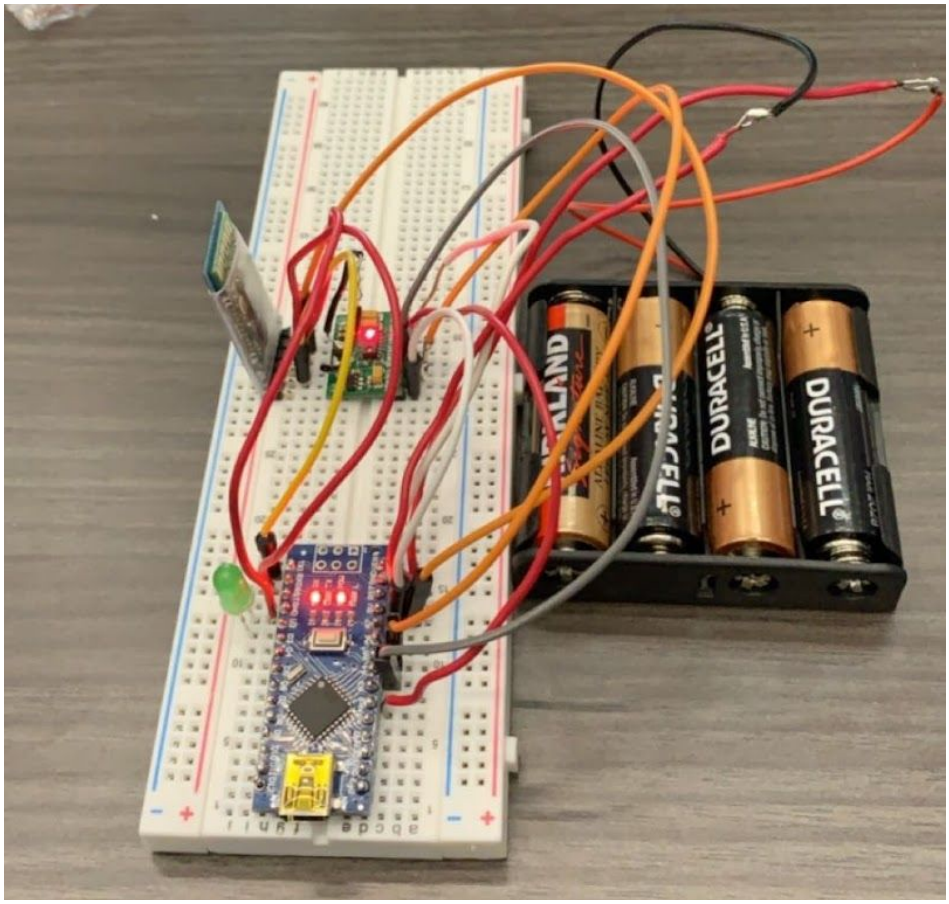


As you can see the SpO2 levels are between 95-100%, so we have our sensor functioning properly. As for the case that was supposed to hold all of the components on the breadboard, we made multiple designs on SolidWorks and picked the one we thought best suited our purpose for the device. Below is an image of our case design.

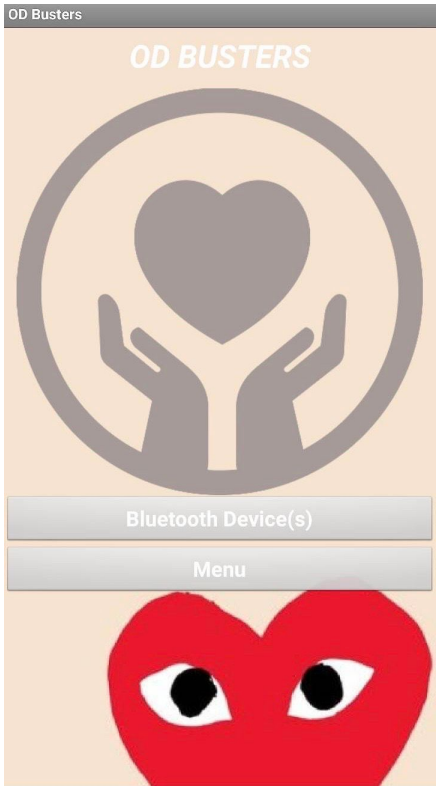


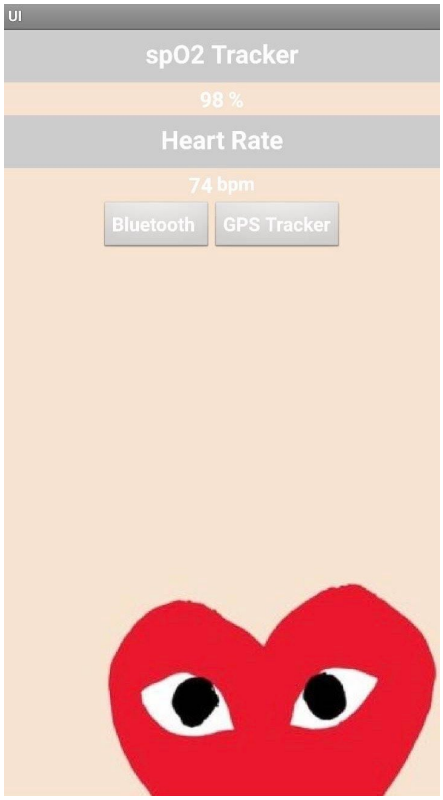
We planned to use this one because we analyzed it to be the most compact in size based on the other designs. We were planning to laser cut or 3D print this case last week, but unfortunately, the CEED facilities were closed so we didn't have the resources necessary to do this.

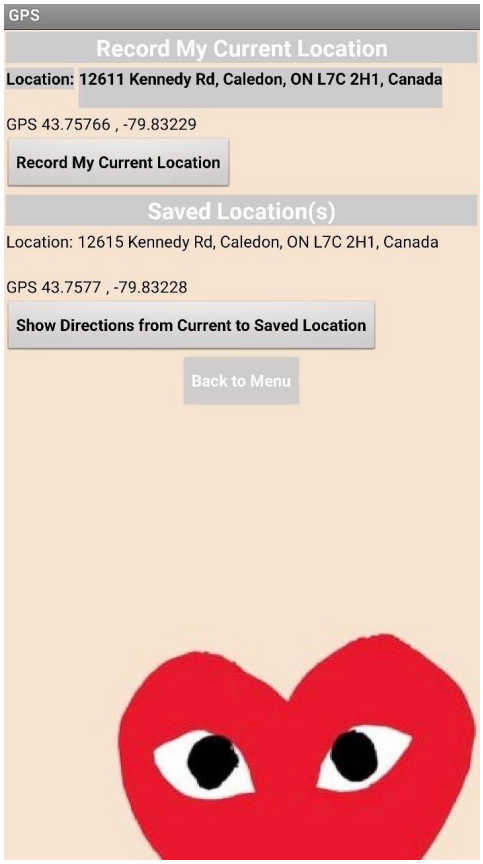
As time was running out and we had no luck on finding a battery that we believed to be suitable for our device, we ended up settling on four AA batteries for power. This was not ideal as it could end up being expensive to replace the batteries all of the time. We did have some ideas in mind to improve our power system which you will see in the Plan to Complete Prototype section. With our battery calculations the four AA batteries would be able to power the device for around 116 hours before dying. Although this is a decent amount of time, having the device run constantly is not ideal.



We were able to complete the user interface for the application we were planning on making. We were unable to actually connect our device to the application and do some testing. The user interface was designed to be simple and appealing to the user. The screen is not crowded and therefore there will be no confusion when using the app.


OD Busters
OD BUSTERS
Bluetooth Device(s)
Menu


UI
spO2 Tracker
98 %
Heart Rate
74 bpm
Bluetooth
GPS Tracker



As you can see we developed the interface so it is very user friendly. The user has the option to select the bluetooth device they need to connect to. Then the data from the arduino will be delivered to the phone and displayed on the app. The oxygen saturation levels and heart rate will be constantly updated for as long as the phone is connected to the bluetooth. If the oxygen saturation levels drop to dangerous levels the app will send out an emergency alert including the users current location.

Plan to complete prototype

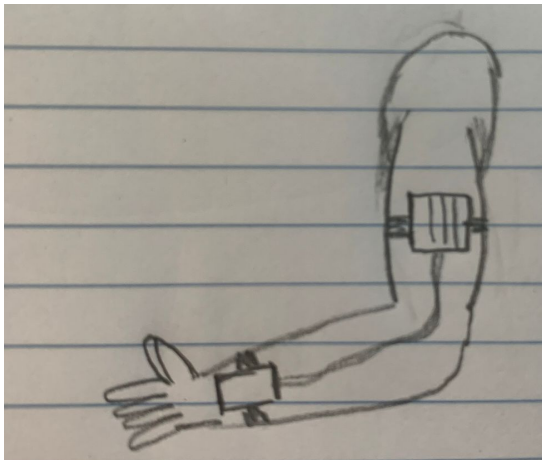
Battery

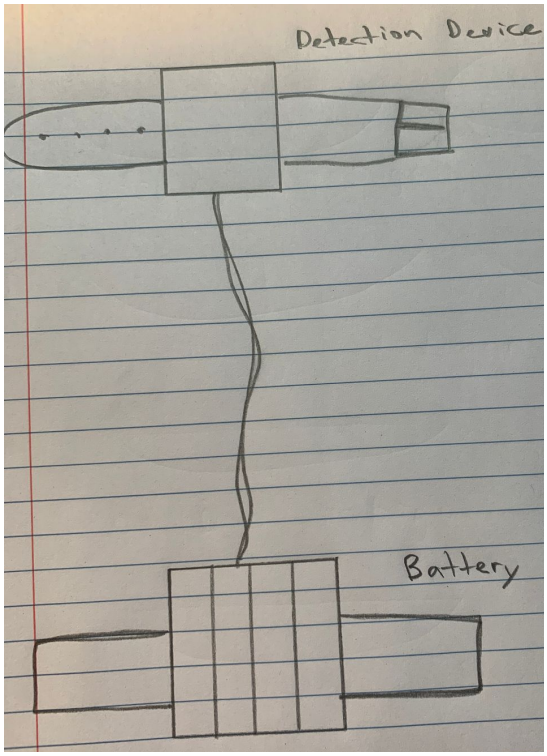
Our current battery setup is capable of powering our device for 116 hours. With this current setup the device would have power for nearly 5 days non-stop. Our plan was to implement an on/off switch on our device so that the device would only run when the user needed. This would greatly improve the battery life of the device. With the average person having a 16 hour day, the device would be off for 8 hours at night. With a battery life of 116 hours and an on/off switch, the

user would be able to power the device for just over 7 days before having to replace the batteries.

Design

Near the end of our prototyping process we made a design change. Our original plan was to encase everything on the wrist of the user. We had measured all parts of the device and decided that it was still small enough to wear on the wrist. However, we had not yet found a suitable battery for our device. We had found a few battery options that we later discovered would not work with our device. Although we expected the battery to increase the size of our device we did not expect it to be such a drastic difference. When we finally settled on AA batteries we decided the parts of the device and the battery could not be encased together. 4 AA batteries would make the device way too bulky. We altered our design so that the battery was encased separately. We decided the battery should go up near the bicep in order to completely hide it. The battery would then be connected to the rest of the parts on the wrist using 2 wires(these wires would be contained together). This design change would make the product more discreet and appealing to the user.





Application

Due to unforeseen circumstances we were unable to complete our app. Unfortunately the app building and bluetooth process only works with android devices. Only one of our team members was in possession of an android device and after the outbreak he no longer had access to our parts. If this had not happened we would have gotten together to connect the bluetooth device and application. However, we were still able to make the user interface that our application would’ve had. The app includes a button to select a specific bluetooth device, a screen that displays the blood oxygen levels and heart rate, and a GPS system that records the user's current location. With more time we would have been able to connect our device to the app and do some testing.

Casing and Final Testing

Customer feedback indicated that a sleek, slender device, that doesn’t protrude or catch, is desirable. In response, the prototype to build and test the casing would laser cut the components of our design using laserable plastic obtained from MakerSpace on Campus. One potential type of laserable plastic that can be used is polycarbonate. This plastic has the advantage of being lightweight, a good insulator (with minimum conductivity) and has high

impact resistance. It is also used in many electrical and telecommunication applications. Once the laser has cut out the shape of the casing it will be screwed together. Attention will be given to the position of the sensor to ensure that it touches the skin.

Overall Approach to Third Prototype

The main purpose of this third prototype is to test system integration, while maintaining the functionality of the device.

Two main areas will be evaluated during this testing: how well the components can be integrated into a device that is comfortable and how well the device functions in a range of environments, with an emphasis on wet conditions.

To test the overall comfort and operation of the device, one member of the group will wear it for three days. The data from the app will determine how well the sensor is transmitting blood oxygen levels of the user during everyday use. Feedback from the group member will be used to evaluate how comfortable the device is while worn. The group member will be asked to rate the extent to which the device catches on clothing, feels heavy or bangs into things.

Separate tests will be conducted to determine the functionality of the device in wet environments. One member of the group will test the performance of the device in the rain during 15 minutes of exposure during a downpour. In the event that there is no rain in the forecast, the device will be worn in the shower for a period of 15 minutes. Another group member will wear the device while running on a treadmill for 30 minutes. During these tests, the

Conclusion

In conclusion, under the circumstances we believe the final prototype of our device was very good. We have the sensor working properly, the user interface, and a good plan to complete the device. We learned a lot in this project throughout the semester so overall it was a good experience.