GNG1103

Design Project User Manual

Submitted by:

[OD Busters Group 11]

[Brandon Joseph Broderick 300128727]

[Michel Pellerin, 300131059]

[Cian Brushett, 3001289045]

[Matthew Yakubu, 300123797]

[Nathan Gaudaur, 300138966]

[Andrew Bui, 300116223]

Date: April 21, 2020

University of Ottawa

Abstract

The purpose of this report is to allow someone to recreate the design for our opioid overdose detection device that we have come up with this semester. This was done by providing a short summary of all of the most important things that were done this semester. This document will also provide a list of all materials used, and how much money we spent in total when designing this product.

The first section in this manual documents how to make the prototype. This was done by using a breadboard and an arduino uno, a blood oxygen sensor, and a bluetooth module, and wiring them all together after uploading a set of code to the arduino.

The second section of this manual outlines how to use the prototype. In order to use the prototype you must have a smart phone with the app that we designed on it. Then you must pair the app to the bluetooth module on the device. Then all you have to do is place your finger on the sensor and look at the values displayed on your phone.

The last section of this manual describes how to maintain the device. The device is rather easy to maintain, as the only maintenance that you should have to perform would be switching the batteries in the device every 115 hours. As long as noting breaks on the device this should be the only necessary maintenance.

Table of Contents

1 Introduction

Our group was tasked with the problem of building a device that can detect when someone is having an overdose on opiods. This report will outline the fundamental steps taken to build our overdose detecting device. It will start by explaining the process we used to build our prototypes. Then we will discuss the necessary components to build our prototype, they will be grouped together in the bill of materials (BOM). The BOM will provide a list of components and the price we paid for each one. After this explanation we will describe the specific steps we used to put our components together. Next, we will explain how the prototype should be used to its full potential. Lastly, we will explain how the prototype needs to be maintained to get maximum usage out of it.

1.1 Importance of Issue

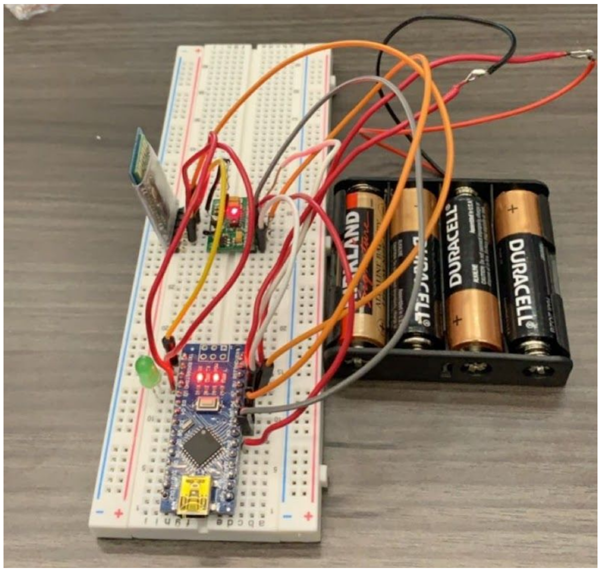
This is an important problem to solve because it has caused many deaths over the past decade. The main problem is people who use opioids often are by themselves. Once someone starts to overdose they are unable to control their body. Once the overdose stage begins there are precious minutes after that they need medical attention to stay alive. If the user can receive medical attention within this period of time there is a great chance the medical staff will be able to provide the right care to save their life.

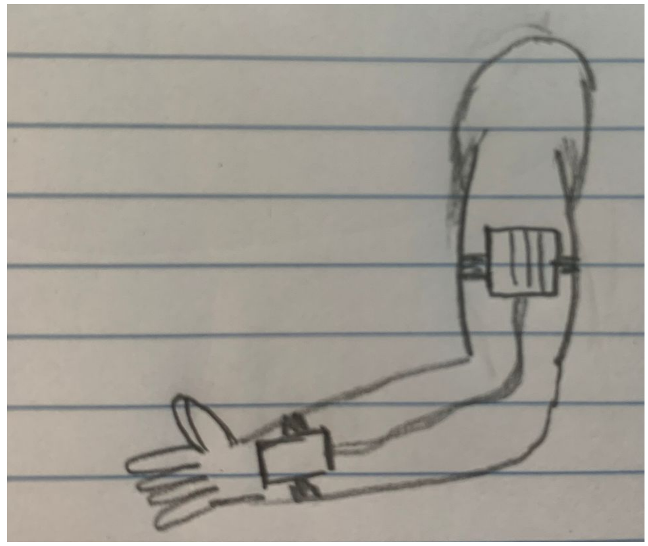
1.1.1 User Needs

This device has very specific and important aspects it must be able to do so it can be used effectively. There are 4 major things the device must do. One, provide accurate measurements of the blood oxygen saturation level of the user. Two, send out a notification to medical staff within the critical period .Three, the device needs to be portable so the battery life of this device must last for more than 8 hours. Four, the device needs to be discrete so users/customers will actually purchase and use this device.

1.1.1.1 What Separates Our Device From The Rest

What makes our project stand out from the other groups is the fact our device effectively meets the user needs. Our device is reliable, and discrete which is very important. We also have our device priced at a reasonable amount so people are more likely to try it out. Below are images of our final prototype and the design of how the casing of the device is going to look on the users arm.





This first image shows the final functioning circuit of our device, and the second image shows our discrete design. It is worth noting that this device was effectively measuring blood oxygen saturation levels, so this circuit design is proven to work.

1.2 Mechanical

1.2.1 BOM (Bill of Materials)

1. Arduino Nano (17.65 for 3)
2. Arduino board (Matt has it) ($10.98 for 3)
3. Velcro(8.99)/buckle (9.99 for 4) /cloth ($3 for 6x12in this is the cheapest fabric)
4. Wires from Maker store $1.00/10 wires
5. Blood oxygen sensor (MH-ET Live MAX30102 Heart Rate Sensor Module Puls Detection Blood Oxygen Concentration Test for Arduino Ultra-Low Power) (3.85+2.00 shipping)
6. Bluetooth module (J-DEAL® HC-05 Wireless Bluetooth Host Serial Transceiver Module Slave and Master RS232 For Arduino) ($10.99)
7. AA Battery case ($9.98)
8. AA Batteries around $15 but we have some
9. Coin battery adapter($14.99)
10. Coin Battery $1.25 for 3
11. Solder wire ($9.99)

1.2.2 Equipment list

Soldering iron

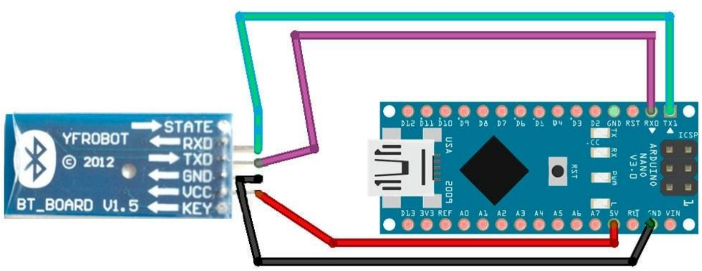
3-D printer

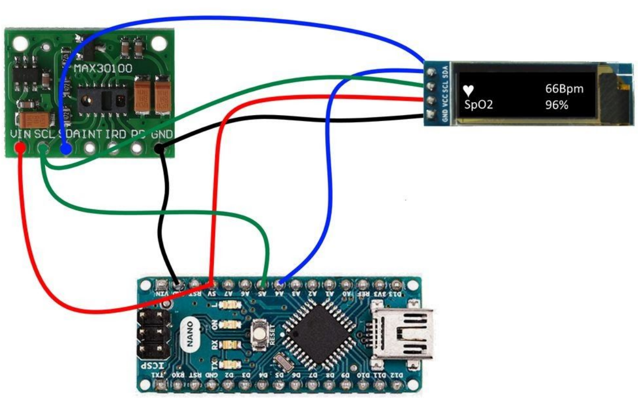
Breadboard

1.2.3 Instructions

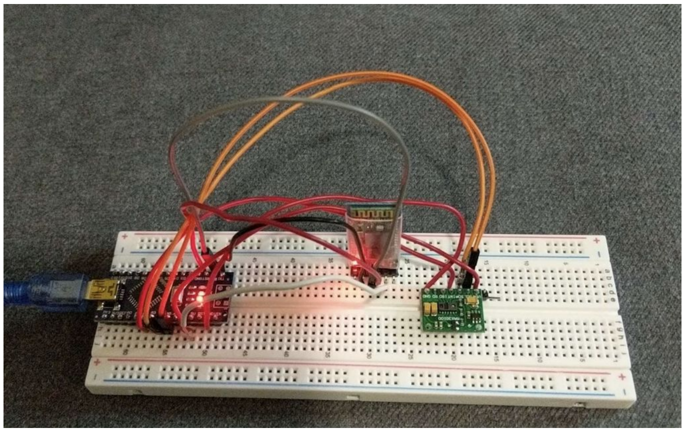
Explain step by step instructions on how to build this specific part. Include as many pictures and diagrams for clear understanding of the process. Make sure to attach all files you are referencing.

The first step to building the part is obviously to get all of the materials required. Once we have all the materials we start by building our circuit. The following 2 images show how to connect both the bluetooth module and the MAX30100 sensor to the arduino nano.





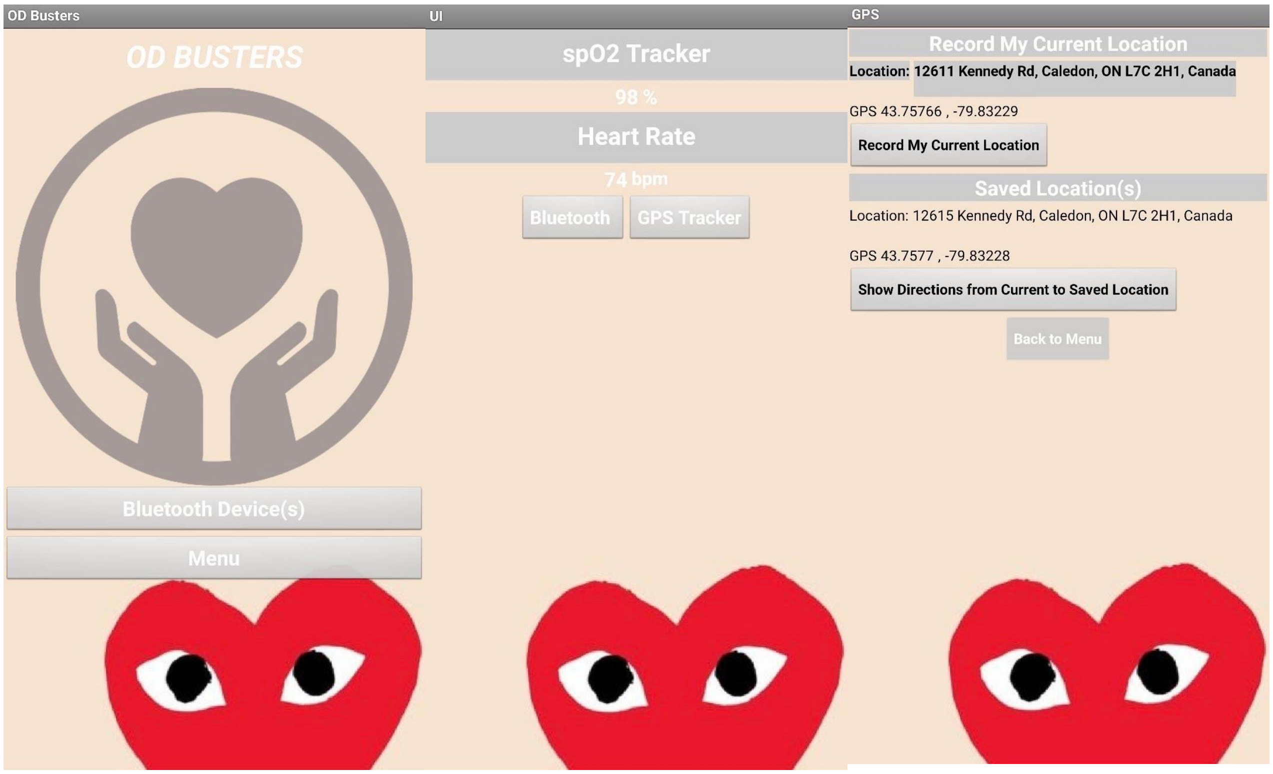
After following these instructions your circuit should look something like this:



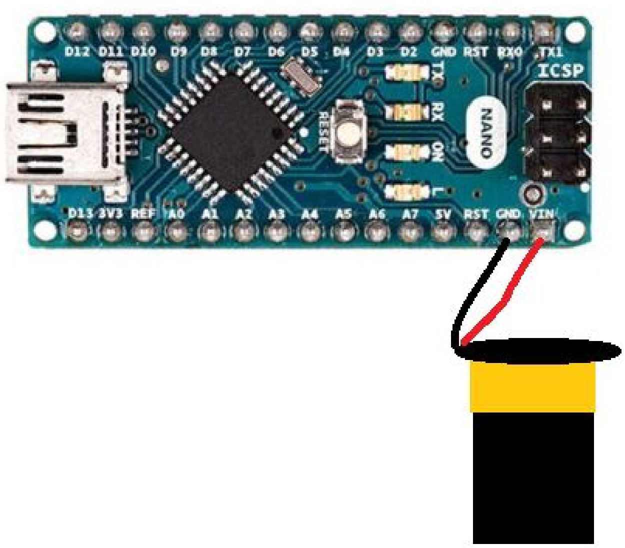
Once you have your circuit constructed it is time to develop or download the code required to receive blood oxygen saturation from the sensor. The code found in appendix II of the report will work for this purpose.

Once you have your code you must upload the code to the arduino nano. This should be fairly simple and will not take much time. Once you have your code uploaded to your arduino and you run a test to see if your circuit is working you will either get spO2 readings from the sensor or you will not. In the case that you are not getting readings from the sensor, this means that you have a faulty sensor. To fix this problem you will need to solder a wire from one part of the sensor to another as shown in the following image.

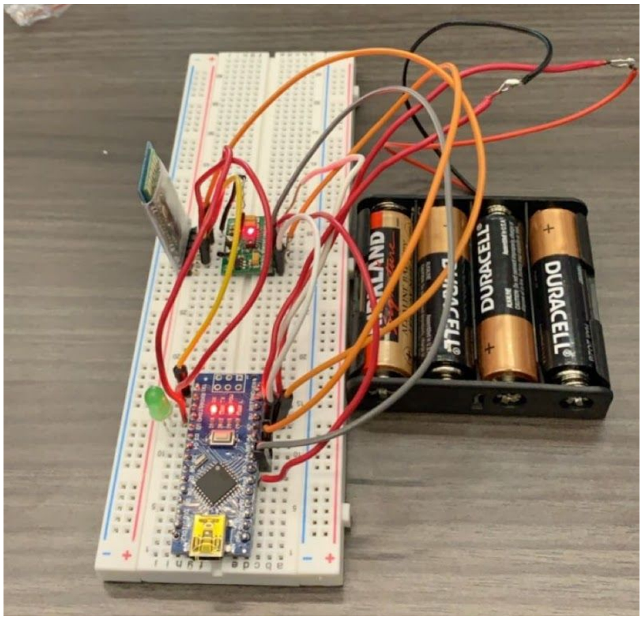
Now that you have your sensor reading values it is time to move onto the next step. You will start to develop your application. Unfortunately this will only work if you have an android device. You will need to make a user interface of your liking. Here is an example:



Once you have your application designed the way you like it is now time to connect your application to your device and test it out. After you complete your tests and you have your device connected to your app you will want to add the battery. Adding the battery is quite simple as it is only 2 wires that need to be added to your circuit. Follow the diagram below.

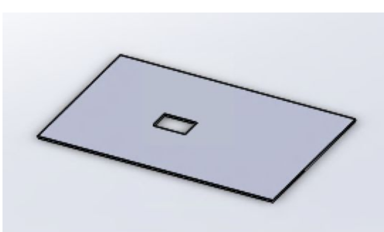
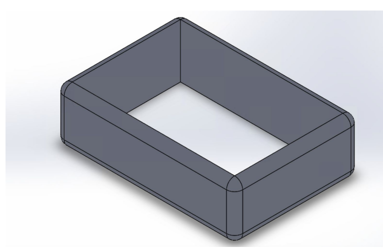
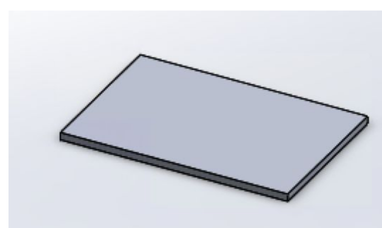


After adding the battery your circuit should look something like this:

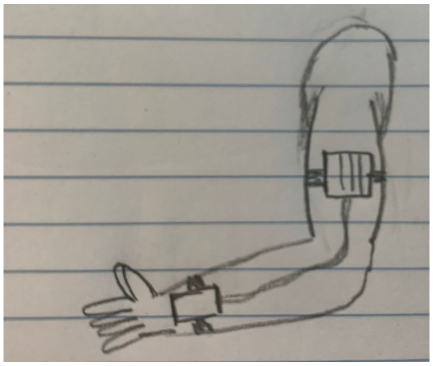


Your device is now fully functional and it is time to move it from the breadboard to a soldering board. The soldering board should be connected in the same way as the breadboard. The soldering board should be made as small as possible in order to minimize the casing size.

Once you have your soldering board set up it is time for the final step, the casing. The casing is to be 3-D printed using an acrylic material so that it is durable and somewhat waterproof. The following designs are the ones we used for our device. The bottom must be quite thin with a cut-out so that the sensor makes contact with the skin. The sides are made thicker in order to have rounded edges that make the device more aesthetically pleasing. The top was made slightly thicker than the bottom to ensure that the device is durable.

You must also include a hole in the side of the casing to allow a wire to run from the main device to the battery as shown in the image below.



Now that the casing is complete all there is left to do is attach a strap to both the main device and the battery compartment. You have now completed the device and are ready to use it.

2 How to Use the Prototype

There are three main components to our prototype. The Arduino Nano, Bluetooth module and the blood oxygen sensor. Each one has their own functions and need each other to work as one device. The nano holds all the necessary code for the functionalities of the others. For example the code for the bluetooth module allows for connection to the mobile device and displays to the screen. As for the sensor, the separate code allows the sensor to read oxygen levels and the user's heart rate. After reading the values, it sends the information to the nano which transfers over so that the user may see the readings on their phone screen.

To operate the device, there are two casing sections which are placed in different places. One of which is used for the hardware and the other is for the power source. Surcerly strap the power source to the upper arm using the adjustable straps. Similarly, adjust the second strap of the smaller casings with the hardware to the wrist. This way it becomes more comfortable and discrete. Make sure that the bottom of the smaller case is in contact with the skin. This makes it possible for the sensor to give proper readings and minimize risks to your health.

Simple to operate while using four AA batteries. Located in the larger casing of the two, open up the compartment that is connected with latches and replace the batteries when needed. Strap on the two casins as instructed tightly enough that the device won't move around but loose enough that blood circulation is not cut off.

3 How to Maintain the Prototype

There are three components that need to be validated for the final design.These include validation of the casing, the code and the electronics. All suggested testing are testing undertaken from prototypes 2 and 3 however we were able to undertake a final test and obtain results that can be presented in this manual.

Validation of the casing should focus on 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 emphasis on wet conditions. To test the overall comfort and operation of the device it should be worn for a period of three days. During this period attention should be give to the extent to which the device catches on clothing, feels heavy on the wrist and bangs into things. If any of these conditions are noticed more than three times a day than the device device does not meet the comfort and operational criteria.

The casing should also be tested to ensure that it is waterproof. To perform this test, the user must wear the casing in the shower with the water on for a period of 15 minutes. Another test will have the user run on a treadmill for 30 minutes. For both tests there should be no water entering the device.

Testing of the electronics comprises testing of the sensor, bluetooth and battery. To test the sensor, the device, when turned on, should be reading values. There should be no output when the device is turned off or not touching the skin. To test the bluetooth it is important to ensure that the device can connect to the app on a portable phone. This can be done by linking the device to the bluetooth signal. The device should last for 116 hours, or over seven days, with 4 AA batteries. To test for this, leave the device running and periodically check on to make sure that it is not overheating or short circuiting from the voltage.

Regular maintenance includes changing the AA batteries every 115 hours given there is a maximum battery life of 116 hours. No maintenance is required on the casing because it should be solid and waterproof. Under extreme circumstances from user negligence, the battery match may break and need to be replaced. This is a part that the user cannot fix and the device would need to be serviced. Maintenance is not expected for the code and electronics because they are secured inside the casing and should not be subject to wear.

The app can be updated if issues are found in the coding or if upgrades are developed. This can be done external to the device.

4 Conclusions et Recommendations for Future Work

Unfortunately, we were unable to finish designing the final product but we believe that the lessons we learned throughout our journey compensated for it. As a group, we learned that coming together early and getting organized was a key factor in improving the overall quality of our working conditions and our product. This included the assigning of roles to each group member as well as tasks based on their specific role so that every week, we completed objectives that would benefit the creation of our device. By doing so we realized that by implementing our prototypes early we were able to discover flaws earlier and reduce the risk of any particular attributes of our device. When we were testing prototype 1, we discovered that the code we uploaded into the Arduino Nano was not reading the users BPM or O2 levels, but another value entirely. Because we had noticed early on, we decided to look further into our prototype for any other possible errors and discovered that our sensor was not working either. To make sure our sensor was functioning was vital for our device and figuring out that it wasn’t working closer to design day would have posed a problem.

For future work on this project, we suggest for any future work that a team may decide to do is that if they were to still create more prototypes, to make them comprehensive including a tangible approximation of how the device would be worn on various users. Doing so would allow for the device to be further refined and the feedback received will most likely aid in doing so as well. Furthermore, we recommend that the application after it is successfully displaying heart rate readings from the device should be designed to be aesthetically pleasing to make it more appealing to the users because a customer's satisfaction is our satisfaction.

APPENDICES

APPENDIX I: Design Files

Deliverable B: This was when we got the raw customer statements and used this to find user needs for our device. The file is below.

The Sandy Hill Community Health Center has assigned us the task of designing a product that will be able to detect when a drug user is having an opioid overdose.

Needs:

- Must detect an opioid overdose
- Must be able to notify someone that the person is having an overdose
- Should be discreet so that users will wear it
- Should allow them to wear it for long periods of time
- Should be durable
- Must be able to detect within 3 minutes
- Price range between 100-200
- Should work hands-free
- The device should not interfere with the hands of the user
- Measure the respiratory rate
- Measure blood oxygen level
- Can't respond when people are not overdosing
- Resistant to water
- Affordable for a middle-class person

Problem Statement:
We need to design a discreet and cost-efficient product for people who consume opioids. This device will be able to detect an overdose and alert someone so healthcare professionals can be notified.

- Additional Problems (?)
    - Increase in harm reduction efforts (take-home naloxone and overdose prevention sites/supervised consumption sites) responsible for a decrease of opioid deaths (NOT overdoses) in BC
    - Opioid-related fatalities are now over-represented in small/rural communities, with the greatest number of people dying at home

- Stigma/discrimination – barriers to accessing existing services
- Harm reduction resources not distributed equally across Canada
- **How do we reduce overdose death for people who use alone?**

Prioritized List of Needs

Ranked on a scale from 1 to 5. **5** being **most** important, and **1** being the **least** important.

Need: Should be discreet so that users will wear it
Justification: This device should be indistinct, since the target customer is an everyday working man who does not want to be noticed wearing this device. The stigma around this device would be high so to get customers this need should be met.
Rank: 4
Need: Should work hands-free
Justification: This device needs to work hands-free, the user will not use it otherwise. This is because most people who use are alone and often need both hands at the time. If the person is alone and starts to overdose it will be too late for them to reach over and put on the device.
Rank: 5

Need: Price range between 100-200
Justification: The device should be in the price range of 100-200$. Our target customer is the middle-class tradesmen, so anything more would be too expensive.
Rank: 3

Need: Measure blood oxygen level
Justification: The optimal way of detecting an opioid overdose is by measuring the blood oxygen level. The device should be able to detect when someone's blood oxygen level is less than 90%.
Rank: 5

Number (not rank)	Need	Design Criteria
1	The monitor needs to be discrete (aesthetics)	
2	Cost: $100-	
3		
4		
5		

6		
7		

Ideas: chip implant

Deliverable C: This was the report where we gathered the prioritized list of user needs and did benchmarking. The file is below.

We have created this document to outline the criteria for this project. The document will discuss each need and then turn it into a direct criterion. Next, we ranked the specifications of the project on a functional, non-functional and constraint basis. Finally, we compared our design to other products on the market.

Number (not rank)	Need	Design Criteria
1	The monitor needs to be non-invasive (aesthetics)	discrete
2	Cost efficient	Below $100
3	Measure blood oxygen level	Detect if blood oxygen level is less than 90%
4	Measure the respiratory rate	Detect if person is taking less than 10 breaths per minute
5	Responds when people are overdosing	The device is accurate
6	Should not affect their day to day life	Work hands-free

Activity 4 – Benchmarking

	Design Specifications		
	Functional Requirements		
1	Measures blood oxygen level		
2	Measures breaths per minute		
3	Sends an alert		
4	Hands free		
5			
6			
	Constraints		
7	Size		
8	Cost		
9			
10			
11			
12			
	Non-Functional Requirements		
13	Aesthetics		
14	Comfort		
15			
16			

17			
18			

Benchmarking

Monitoring Device/Specifications	Hope Band	Pulse Oximeter	Shoulder Detector	Glucometer
Company	N/A	ToronTek	N/A	DexCom
Cost	N/A	$80-90	N/A	$100
Material	Rubber	Plastic	plastic	Plastic
Shape/concept	wristband	Fingertip device	Shoulder clamp	Oval
Size	small	small	small	1 inch
Method of detection	Blood oxygen and breaths (wrist mounted pulse oximeter)	Blood oxygen level and breaths per minute	Respiration rate (breaths per minute)	Sensor
Method of alerting someone	Connected to app	None	None	N/A
Non-invasive	Yes	Yes	No	Yes

In conclusion, these are the key aspects for the design of this product and the information provided in this document has given us a deeper understanding of the design requirements for this project.

Deliverable D: This was where we used the prioritized design criteria and started to produce possible designs of how the final product would look. The file is below.

Conceptual Design - Deliverable D

Nathan Gaudaur (300138966), Brandon Joseph Broderick (0300128727), Michel Pellerin (0300131059), Andrew Bui (300116223), Matthew Yakubu (300123797)

February 8, 2020

Table of Contents

Prioritized Design Criteria

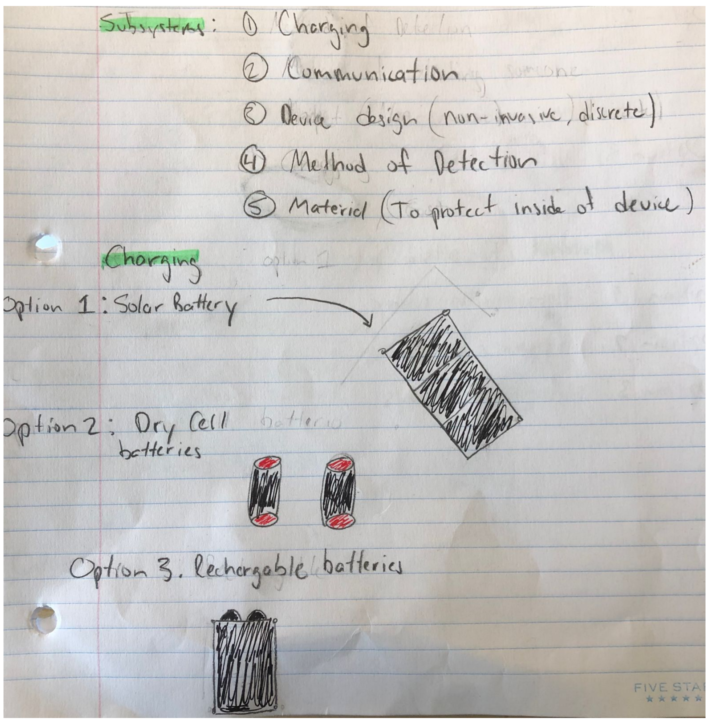
- The device is discrete
- The device is cost-efficient (below $100)
- The device is able to detect if a person's blood oxygen level is below 90%
- The device is able to detect if a person is taking less than 10 breaths per minute
- The device is accurate
- The device can be operated hands-free

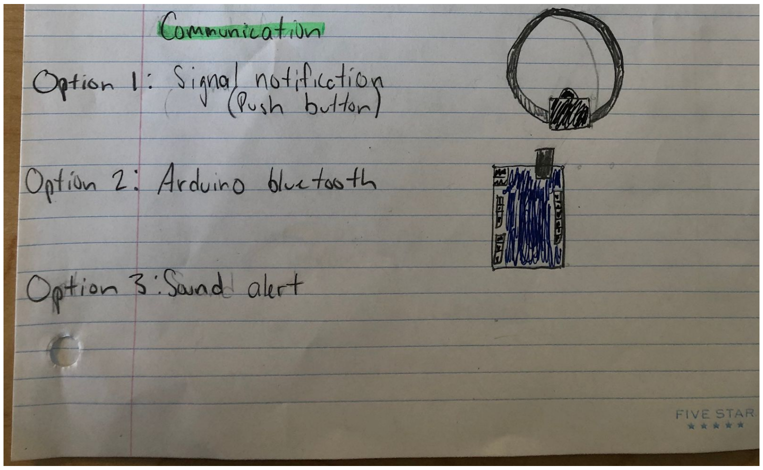
Concepts

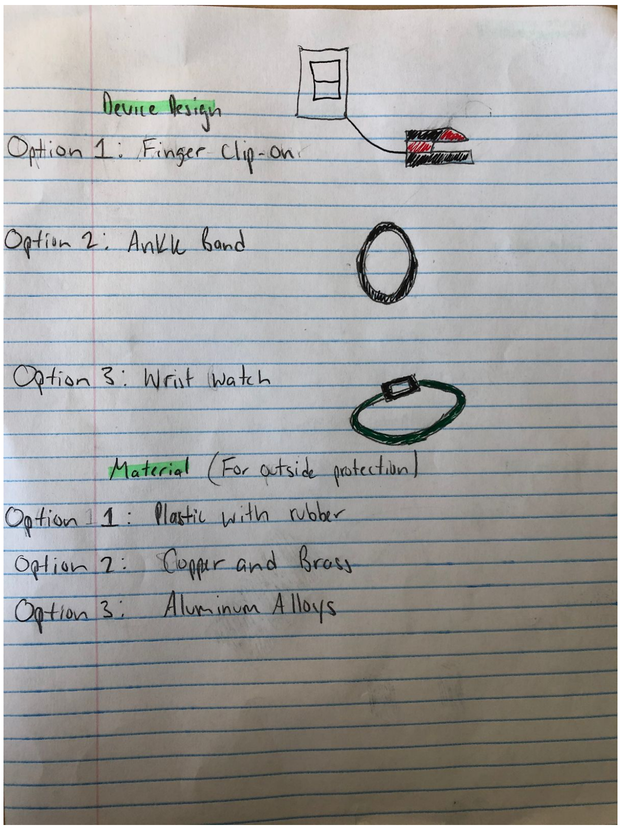
Concept #1 (Brandon Joseph Broderick)

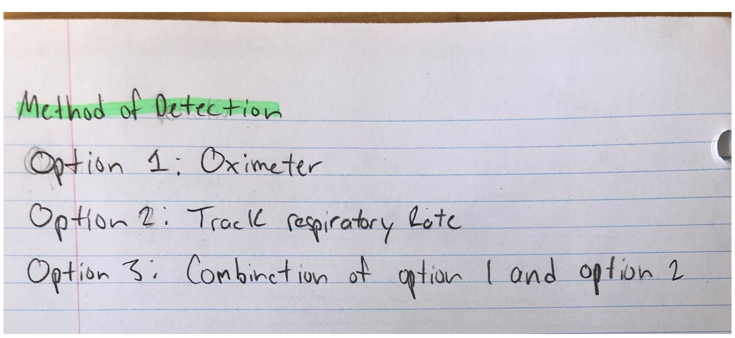
1. Charging
    a. Solar battery
    b. Dry cell batteries
    c. Rechargeable batteries
2. Communication
    a. Signal Notification
    b. Arduino Bluetooth
    c. Sound alert
3. Device design

a. Finger clip-on
    b. Watch
    c. Ankle band
4. Method of Detection
    a. Pulse oximetry
    b. Breaths per minute
    c. Pulse oximetry and breaths per minute
5. Material used
    a. Plastic and Rubber
    b. Aluminum Alloys
    c. Copper and Brass




Communication
Option 1: Signal notification (Push button)
Option 2: Arduino bluetooth
Option 3: Sound alert
FIVE STAR


Device Design
Option 1: Finger Clip-on
Option 2: Ankle band
Option 3: Wrist watch
Material (For outside protection)
Option 1: Plastic with rubber
Option 2: Copper and Brass
Option 3: Aluminum Alloys


Method of Detection
Option 1: Oximeter
Option 2: Track respiratory rate
Option 3: Combination of option 1 and option 2

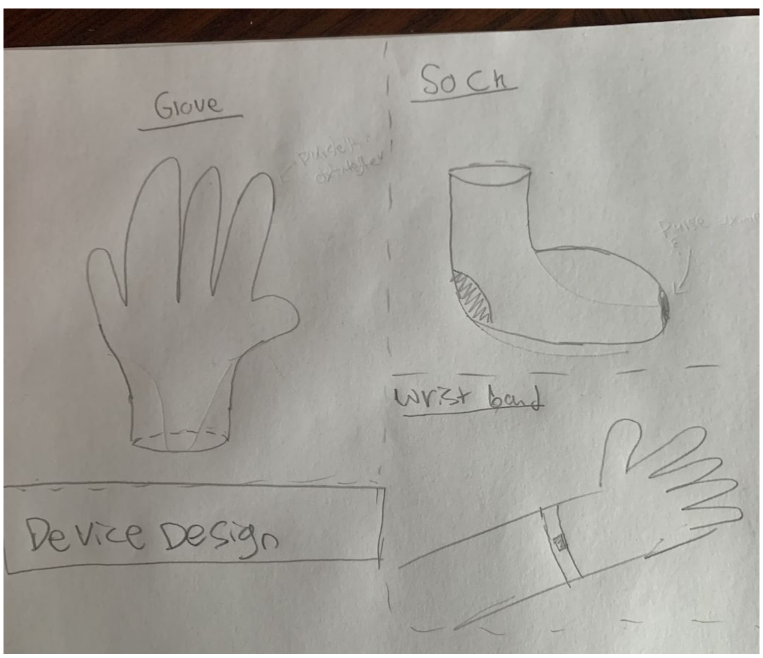
Concept #2 (Michel Pellerin)

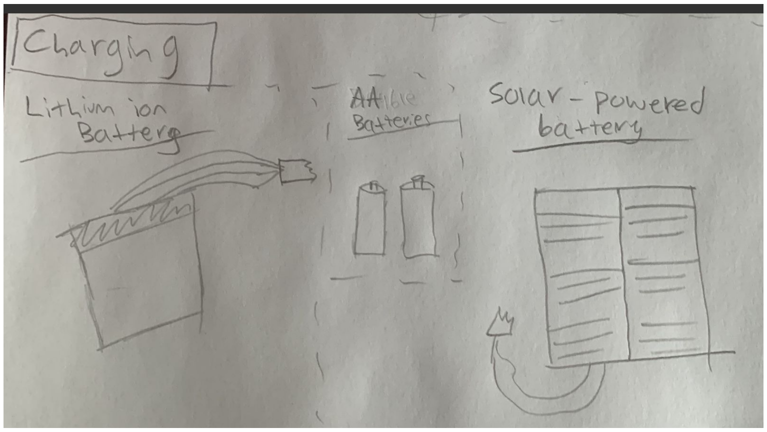
1. Charging
    a. Rechargeable battery (plugs into the wall)
    b. Wireless charging
    c. Lithium coin batteries (replace when dead)
2. Communication
    a. App
    b. Text message
    c. Separate device (comes with a device that receives alerts)
3. Device design
    a. Wristband
    b. Ring
    c. Armband (around bicep)
4. Method of Detection
    a. Pulse oximeter
    b. Breaths per minute
    c. Pulse oximetry and breaths per minute
5. Material used
    a. Rubber
    b. Metal
    c. Plastic

Concept #3 (Nathan Gaudaur)

1. Charging
    a. Rechargeable lithium-ion battery
    b. AA batteries
    c. Solar-powered battery
2. Communication
    a. Sends a text message to all emergency contacts on the user's phone
    b. Sends a signal to emergency services with the user's location

    c. Loud noise plays when the device detects an overdose to alert nearby people
3. Device design
    a. Glove
    b. Sock
    c. Wristband
4. Method of Detection
    a. Skin colour (turns blue when an overdose is taking place)
    b. Oximetry
    c. Breathing rate
5. Material used
    a. Stainless steel
    b. Cloth
    c. Plastic





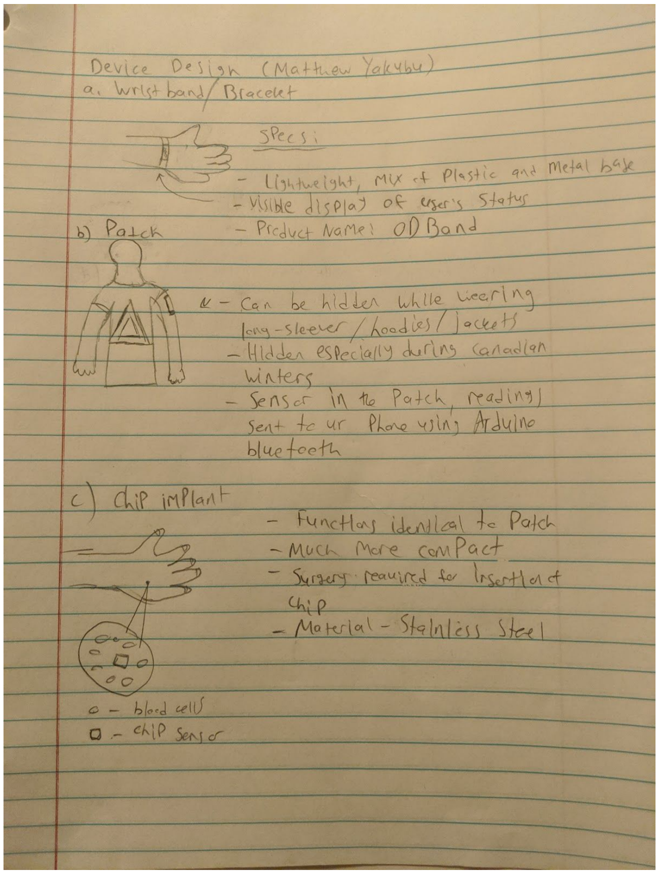
Concept #4 (Andrew Bui)

1. Charging
    a. Rechargeable Battery (Plug-in)
    b. Charges through movement (like in auto watches, power is stored in a spring and will last 38 hours when fully charged)
    c. Solar-powered (Should be able to last long after charging)
2. Communication
    a. Bluetooth (Like in lab) will send feedback to an app and will send a notice when there is an abnormality
    b. Device will keep constant measure while in contact, makes a loud enough noise to be noticeable
    c. Same as the last but vibration instead for people doing drugs at loud environments (parties) or are hard of hearing
3. Device design
    a. Watch
    b. Finger band
    c. Pad (cheap and disposable)
4. Method of Detection(Multiple should be used in combination)
    a. Breathing Rate
    b. Oxygen Level
    c. Temperature Spikes (?)
5. Material used
    a. Stainless steel

b. Aluminum (for cost)
c. Silver (good conductor for the temperature idea)
d. Copper (same as silver just cheaper)

Concept #5 (Matthew Yakubu)

1. Charging
    a. Solar Power (not as efficient, less costly,
    b. Plug-in (all-day battery to accommodate for wired charging)
    c. Wireless (Place on a port and immediately start charging, costly)
2. Communication
    a. Arduino Bluetooth (cheap and works, easy to make and maintainable)
    b. Wireless alert - function similar to that of an Amber alert (Bluetooth/airdrop), those in the area with Bluetooth on will receive a notification about overdose
    c. Phone option, **1 contact** - Call function can only call emergency services within the region of the product
3. Device Design
    a. Wristband/Bracelet
    b. Discrete patch
    c. Chip implant (most discrete, most likely around the hand/wrist area)
4. Method of Detection
    a. Oxygen sensors
    b. Oxygen blood sugar rate
    c. BrPM (Breaths per minute)
5. Material Used (Could be a combination of materials listed below)
    a. Plastic (cheap, not well-suited for cold weather)
    b. Aluminum
    c. Gold (just silver coated with gold, appeal to middle-class users)



Abstract

In this report our group has come up with plenty of different ways to approach the problem at hand, that being creating a cheap and discreet wearable device that detects when a user is having an opioid overdose after we had come up with these different concepts we all got together and talked about which concepts we thought were the best overall.

After speaking with each other for a while we decided that the best option for the charging of the device would be to use a lithium-ion battery that you could use a power cable to charge up. We decided that the best way for the device to signal someone when a user is having an overdose would be to use Bluetooth to pair the device to your phone and then send an alert using your phone. For the design of the device. Our group believed that out of all the options we had come up with that a wristband was the best choice based on our design criteria. For the method of detection, the group decided

using pulse oximetry was the best option as it is one of the only known ways to detect blood-oxygen levels, which is one of the main symptoms of having an opioid overdose, and finally, the materials that our group thought best suited a wristband design was plastic and rubber as they are discrete, inexpensive and stylish materials.

Introduction

This document will analyze multiple design ideas that we have devewoped. We will compare them to the design criteria that we have made. Throughout the document, we will state the advantages and disadvantages of our different ideas. We will decide on the best and most practical idea to continue developing throughout our project.

Description of 3 solutions

We will now begin to analyze and describe our 3 best functional solutions for each subsystem and conclude the one we will continue to use for the semester.

Charging: Rechargeable lithium-ion battery

- We were concerned about the use of solar batteries since in Canada the winters can be long and people are not exposed to much sun.
- The AA batteries were also a close choice for us but we decided it may become too expensive and inconvenient to buy batteries every time the device dies.
- We decided to use the rechargeable battery since it will be the most reliable. Compared to our design criteria we said the device should hold a full day worth of charge. So at the end of each day the user can go home and charge the device every night, without needing to go out and buy new batteries.

Communication: Arduino Bluetooth

- We had some concerns with using a loud noise from the device as the source of communication. If the user was in a very isolated location, which most people using tend to be in, the communication device would fail to notify anyone.
- We decided the Arduino uno Bluetooth device would be the optimal choice for our design. This is because if we design some circuitry connected to the board this will allow us to send messages directly to phones. Based on the design criteria this is the optimal choice for communication.

Method of Detection: Pulse oximeter

- The breaths per minute was an option for the device, but it may be complicated to implement into our design. So, for now, we will consider this a secondary option and if later on, we find a way to include this may consider it.
- A respiratory rate detector was considered but concerns arose when we realized this is not the most accurate way of detecting an overdose.
- We decided the pulse oximeter was the optimal choice for our design. Based on the design criteria this was ranked the most important as it is the most reliable way to detect a user overdosing.

Material used: Mix of plastic and rubber

- The group did not want to use metals as they are heavier. We wanted to make sure that the device would be light and comfortable for the user.
- The group also thought that using metal would be more expensive. We want to make sure that we don't go over our budget for the project.
- The group did not use cloth as we decided not to go through with the device that this material associated with.

- We thought that plastic and rubber would be the best because it is light, cheap and easy to form. These materials best matched our design criteria

Device Design: Wristband

- The group felt as though a ring was not the optimal design for the device, as we felt as though it would be difficult to fit all the appropriate features to detect an overdose within it.
- The group did not want to use an armband as the design for the device as we thought that they are less comfortable than a wristband, which did not fit our design criteria as well, so as a result we decided not to go for this design
- Our group thought that a wristband would be the best as it is quite discrete and stylish while still being relatively inexpensive to create.

Conclusions and Recommendations

In conclusion, we decided that the wristband would be the best design to continue developing. The wristband was the idea that best matched the design criteria that we developed.

References

Hope Band Article
Wearable Overdose Detector

Deliverable E: This was where we made our overall project plan and estimated the cost of our components. **The file is below**.

Project Plan and Cost Estimate - Deliverable E

Nathan Gaudaur (300138966), Brandon Joseph Broderick (0300128727), Michel Pellerin (0300131059), Andrew Bui (300116223), Matthew Yakubu (300123797)

February 23, 2020

Table of Contents

Introduction

This document will outline our project plan and give an estimation of the cost and components that we will use to build our device. The project plan will include our tasks and the duration for each task that we have established to ensure we have all 3 of our prototypes done by their deadlines. The estimation of the costs section will include all of the components we plan to use, and how much each will cost. Our goal is to have the final price of the device to be under 100$.

First Prototype

For the first prototype, our plan is to build the device with cheap and easily accessible materials so we can have a visual representation of what we are thinking. This will allow us to see if we are forgetting anything important. We will also include the analysis of critical components to make sure these components will perform as expected in our device. These are the tasks and timelines required to complete the first prototype. The first task is the overall design of the device (aesthetics), and block diagram to show the inputs and outputs of how the device will perform. This will be done by Joseph, the task will be completed by February 20th. The next task is the material list and BOM (bill of materials). This will be done by Andrew, and the task will be completed by February 24th. The next task is a program algorithm for how the Arduino will be connected to the sensors. This task will be done by Matthew and will be completed by February 27th. The last task is building the actual prototype and ensuring it will function as expected. This will be done by Nathan and Michel Pellerin, the task will be completed by February 29th.

Second Prototype

For the second prototype, we plan on refining our design from the first prototype and making it look and feel slightly more polished. In order to do this, we will use feedback from our customer as well as fixing anything that we noticed wasn't working as we intended. One major goal for this prototype would be to eliminate the need for a breadboard, as they are dissalowed on design day.

Third Prototype

The final prototype will be our device that is 90% complete. By this time we will be aware of all the components that will successfully work with our design. We will use our data recorded from the second prototype to see what worked and what needs to be changed. Based on this data we will be able to build a very good prototype that will most likely be our final product.

Potential Risks

When designing a device that is used for medical purposes such as the one that we are, there are many potential risks that are present. Our project group has taken on the task to design a device that can detect opioid overdoses and notify emergency services when one is detected. The risks that are present with this project would be the device not detecting the overdose or the device not sending out a signal.

It is almost impossible to completely remove risks such as these, however, we can take precautions to avoid them by building targeted prototypes to try and make sure that these systems work as best as possible.

In order to prevent our device from not sending a signal when an overdose is detected we have decided to create a prototype of the BlueTooth device we plan to use in the wristband.

We have decided to use the same method to make sure that our device can detect an overdose. This device will be harder to test the functionality of because we cannot test it on someone who is actually experiencing an overdose. To overcome this obstacle we figured that the best approach would be to test the device on people who have normal blood oxygen levels and see if the readings are accurate. We believe by testing these components of the devices with prototypes we can reduce the chance of them failing when the final product is built.

These two risks only deal with the medical aspect of the product, however, there are actually several other components that we would need to test in order to ensure that the product functions and looks the way we intended. These will also be tested using appropriate prototypes.

Bill of Materials

First Prototype

- Arduino Nano (17.65 for 3)
- Arduino board (Matt has it) ($10.98 for 3)
- Velcro(8.99)/buckle (9.99 for 4) /cloth ($3 for 6x12in this is the cheapest fabric)
- Wires from Maker store $1.00/10 wires
- Blood oxygen sensor (MH-ET Live MAX30102 Heart Rate Sensor Module Puls Detection Blood Oxygen Concentration Test for Arduino Ultra-Low Power) (3.85+2.00 shipping)
- Bluetooth module (J-DEAL® HC-05 Wireless Bluetooth Host Serial Transceiver Module Slave and Master RS232 For Arduino) ($10.99)
- AA Battery case ($9.98)
- AA Batteries around $15 but we have some
- Coin battery adapter($14.99)
- Coin Battery $1.25 for 3
- Solder wire ($9.99)

BOM (most likely for the final list of material):

$71.95

- This is cutting the AA batteries and case

$59.30 (final product)

- If materials are bought in singles instead of bulk and cutting AA batteries and case and the Arduino testing board

Maybe 3D print case to protect internal wiring etc

Second Prototype

(Cut some unneeded material)

Due Dates

- Prototype I - March 1, 2020
- Prototype II - March 8, 2020
- Prototype III - March 22, 2020
- Design day - March 26, 2020
- Final project presentation, March 20-27, 2020

Project Schedule

- Task - Completion date; Duration; Person responsible
- Benchmarking existing products -
- Overall design - February 16, 2020; 3 days; Joey Broderick
- Bill of materials - February 16, 2020; 1 day; Andrew Bui
- Order materials - February 17, 2020; 1 day; Andrew Bui
- Develop code - February 23, 2020; 3 days; Matthew Yakabu
- Test materials(sensors and arduino) and code - February 26, 2020; 3 days; Matthew Yakabu
- Build prototype I - February 28, 2020; 2 days; Nathan Gaudaur
- Prototype I presentation and feedback - March 1, 2020; 1 day; Group
- Discuss feedback - March 2, 2020; 1 day; Group
- Adjust design accordingly - March 2, 2020; 1 day; Joey Broderick
- Order materials for prototype II if needed - March 2, 2020: 1 day; Andrew Bui
- Test materials and code - March 6, 2020; 3 days; Matthew Yakabu
- Build prototype II - March 7, 2020; 3 days; Nathan Gaudaur
- Prototype II presentation and feedback - March 8, 2020; 1 day; Group
- Discuss feedback - March 9, 2020; 1 day; Group
- Adjust design accordingly - March 9, 2020; 1 day; Joey Broderick
- Order materials for prototype III if needed - March 9, 2020; 1 day; Andrew Bui
- Test materials and code - March 14, 2020; 3 days; Matthew Yakabu
- Build prototype III(final product) - March 20, 2020; 5 days; Nathan Gaudaur
- Prototype III presentation - March 22, 2020; 1 day; Group

Conclusion

In conclusion, this report discussed the main tasks that need to be completed in order to have our prototypes done by their deadlines. The report also provided a list of items and the estimated cost for each one. Based on the information provided our group is confident we will meet the deadlines for the 3 prototypes if all of the tasks get completed on time.

Deliverable F: This was where we built and tested our first prototype. You will find all of our results and lessons learned. **The file is below**.

Prototype 1 - Deliverable F

Nathan Gaudaur (300138966), Brandon Joseph Broderick (0300128727), Michel Pellerin (0300131059), Andrew Bui (300116223), Matthew Yakubu (300123797), Cian Brushett

March 2nd, 2020

Abstract

In this report, our group needed to investigate the riskiest assumptions that would be needed to be made in order to build our prototypes. After this, we had to come up with different prototypes that we thought would be necessary to build in order to test all the components of the device that we weren't sure about. Using these different prototypes

will also help us give a better presentation to our client when we have to do that because we will have a much better idea about what works well and what doesn't with our design.

Our group got into a group to decide what the necessary assumptions and prototypes were for our design. When we met up, we decided that the necessary assumptions were that all the necessary components for the device could be held within a wrist-band, another assumption that we had to make was that we would not have any losses in power from our theoretical to experimental results, and lastly that we could program an app with all the components outlined by our third prototype.

Using these three assumptions we came up with three prototypes to make us feel more confident that the assumptions will not hurt the overall quality of the device, these prototypes were casing/formatting, where we came up with the dimensions of all the components for the device and saw that we could fit them within a wrist-band, the second prototype we designed was the calculations for the battery life of the device, and the third prototype was the interface and functionality designs for the app that we will be using to send notifications to the user of our apps emergency contacts. We also developed some code prototype that will send a notification to a user's emergency contact.

Introduction

This document will analyze and develop multiple assumptions and prototype designs. In order to come up with the necessary assumptions, we talked with each other and used the slides from lecture 11, we then used these assumptions and brainstormed to come up with a list of things that we were concerned about with the project, which we then turned into our prototypes.

Prototype Test plan

This report was created for the purpose of defining our prototype test plan and for documenting the results. Our group decided to make discrete prototypes with the goal of testing a specific and important part of the overall design. We have a total of 3 prototypes, as well as power calculations based on the requirements of each component.

The first prototype we designed was for the dimensions of the device. We analyzed each component that contributed a significant amount to the overall size of the device. We added all the components together and made a prototype that is roughly the same size as our final product. The purpose of this prototype is mainly for customer feedback, the customer can now communicate accurately with us regarding the size of the device.

Our second prototype is the app required to receive data from the Arduino via Bluetooth and send out a notification message based on the oxygen saturation level. This prototype was designed to analyze the app so we can ensure it will function properly. The app is a major part of the final product since it collects the data and decides when to send a help message, we must have this functioning properly.

Our second prototype is the Arduino sketch required to measure the pulse oximeter and send a notification to the app we create. The purpose of creating this was for reducing the risk for later prototypes. The Arduino sketches can be complex, so we designed a prototype specifically to ensure the code is correct so our next prototype will be more accurate when we aggregate our prototypes.

The final aspect we decided to examine this device is the total power consumption. This was done so we can reduce the risk when building our second prototype. We need to ensure the battery we choose is capable of powering all of the components in our device for a significant amount of time, at least 7 hours.

1st prototype - Plan-casing/formating

Why are we doing this test?

The general objective of this test is for learning and understanding of the physical design for the casing that will house the electronic components of the device. The intent is to move from an analytically designed prototype towards a physical one. This prototype will need to incorporate the results from other design prototypes on battery size, coding and the app needed for the program interface.

Although this prototype testing is focused on the casing, it will take a comprehensive look at this aspect of our design. This comprehensive test is however at the pre-alpha stage. The main parameters that will be considered include size and functionality.

Test Objectives Description

The test objectives are to validate initial design concepts for the casing that will provide the external structure for our device.

A key objective is to evaluate the appeal of a housing design that provides the needed structure to ensure that the device runs effectively. This testing will identify what aspects of the design work well and which aspects do not. This information will allow for improvements in the next iteration of the design. The next round of testing can then be more focused.

*What **exactly** is being learned or communicated with the prototype?*

The prototype testing will help us learn which measurements for the casing are feasible. In particular, the size (length, width and weight) as well as the form of the casing for the device. If will also provide information on whether or not people will wear the device, how comfortable it will be and the likelihood that there will be uptake by the users (i.e. functionality).

What are the possible types of results?

Possible results include confirmation that the design concept works. There may also be partial results that indicate which components of the design are acceptable and which are not. For example, the design may confirm that the weight is acceptable however the device is too bulky. Worst case, none of the design concepts are feasible and the result is that we have to look at alternative options for our product (ie pocket device vs something worn on the wrist).

Feedback will provide improvement ideas that can be used for adjustments that will be included in the next prototype.

How will these results be used to make decisions or select concepts?

The results from the prototype testing will identify aspects of the design that work (are favourable) and other aspects that are not functional. The aspects that work will be retained. Aspects of the design that do not are the aspects of the casing that will need to be modified.

The main attributes to me tested are weight, size (length, width and amount of space the casing occupies), bulkiness (i.e. protrude from the wrist when worn) and comfort. We may possibly look at the heat generated.

The prototype testing will also consider the location of the device and whether or not it catches on clothing or hits against things when worn.

What are the criteria for test success or failure?

This is a pre-alpha testing that is intended to evaluate the casing parameters when housing the various components of the device (i.e. battery, program app and code).

Criteria for success is that the casing for the device is within a 30% margin for existing specifications for wrist-worn devices (i.e. apple watches, fitness and GPs watches). (These specs to be determined from market research of existing products). In particular, success will be determined as to whether or not the weight, length and width fall within this 30% margin. A qualitative evaluation will be given to the contour and bulkiness and how similar the shape is to existing wrist-worn devices.

The next round of testing will be with a sample of the targeted audience (blue-collar workers). Overall success would then be having results that indicate that 70% of users would wear the device and find it useful.

What is going on and **how** is it being done?

*Describe the prototype **type** (e.g. focused or comprehensive) and the reason for the selection of this type of prototype.*

Comprehensive testing is being undertaken of the casing design. This is because we are in the early stages of the design and this is the first jump from an analytical model to a more physical one. It is also the first time that the other components of the design (batteries, code, program app) are being integrated.

A comprehensive approach was chosen because it allows us to take an overview of all the different components and make adjustments as needed before becoming too detailed in specific areas of the design process. Ideally, this should allow us to identify critical flaws (i.e. whether or not a wrist-worn device feasible given the components needed to operate the device) and correct early in the design process.

Describe the testing process in enough detail to allow someone else to build and test the prototype instead of you.

Concept drawing with dimensions can be programmed into a 3D printer. This will provide information on the height, width and overall bulkiness of the design. The weight can be scaled based on the internal components needed for the other design areas (i.e. batteries). The 3D printed model can then have weights added to it.

This weighted model can then be strapped to the wrist of the design team to determine the functionality of the design parameters described above. Measurements can be taken and compared to similar types of devices. In addition, measurements can be taken as to how far the device protrudes outside of the wrist of the user.

Once the parameters of the initial design have been taken, the casing will need to be optimized. For example, a critical component is whether or not the device can be designed with a lighter weight.

*What information is being **measured**?*

The protocol testing will measure the physical design characteristics of the device. In particular the weight, length, height and depth, shape (i.e. contour on the wrist) and bulkiness.

*What is being observed and how is it being **recorded**?*

In addition to the measured parameters, information on the shape and bulkiness are also being recorded. This information will provide information on the position of the device on the user's wrist and look at whether or not it protrudes and if it catches on things like clothing. This information is important for assessing the overall fit of the device.

What materials are required and what is the approximate estimated cost?

A $100 budget has been provided for all four testing protocols. The casing is made of plastic that must be durable to house the following components:

- Arduino Nano
- 1 double AA battery case that holds 4 batteries
- 1 AA battery case that holds 2 batteries
- Arduino Bluetooth module (J-DEAL® HC-05 Wireless Bluetooth Host Serial Transceiver Module Slave and Master RS232 For Arduino)
- Pulse oximeter sensor (Lysignal MAX30100 Pulse Oximeter Heart Rate Sensor Module for Arduino for Wearable Health Fitness Assistant Devices Medical Monitoring Devices)
- Copper wire

This casing will be the cheapest of the 4 testing protocols. Most of the expenses will be for the plastic resin used in the 3D printer.

What work (e.g. test software or construction or modelling work or research) needs to be done?

Research needs to be done on the following areas:

- Fabrication process and how this can be done while ensuring materials remain lightweight.
- Average design specifications for other wrist devices to determine the weight and size ranges for the variety of products already on the market.
- Plastic materials that can be used to house the device with consideration to weight
- Use of a 3D printer for modelling

When is it happening?

*How long will the test take and what are the **dependencies** (i.e. what needs to happen before the testing can occur)?*

The casing design is dependent on the fabrication of the internal components (i.e. battery, coding, program app). The first prototype will need to be sufficient to house these other design parameters.

Once the initial design has been determined the next step is to optimize to minimize weight, size and bulkiness, while still ensuring maximum functionality. The ability to optimize also needs to be compared to the specifications of existing devices to determine if the results are within a 30% range of what has been deemed acceptable for existing devices

2nd prototype - Battery life

These are the 3 main aspects of our device that will draw from the battery. We must find a battery that is both suitable to power our device and also to fit inside of our device without having a big effect on the device's size.

We have two options when it comes to choosing a battery to power the module:
- A rechargeable battery with a good and efficient charging method.
- A disposable battery that is cheap and easy to change. This battery would preferably last a decently long time.

Power Consumption of the Main Devices:

- Arduino Nano:
  - Power consumption 19 mA
- Bluetooth Module:
  - Power consumption 30 mA

- Blood Oxygen Sensor:
    - Power consumption 20 mA

All together these 3 parts of our device have a power consumption of roughly 69 mA. Our goal is for our device to run for at least 16 hours before needing to be recharged. This allows the user to power the device for a full day without needing to recharge the device. With a draw of roughly 69 mA, the battery used in the device should have a battery capacity of at least 1100 mAh.

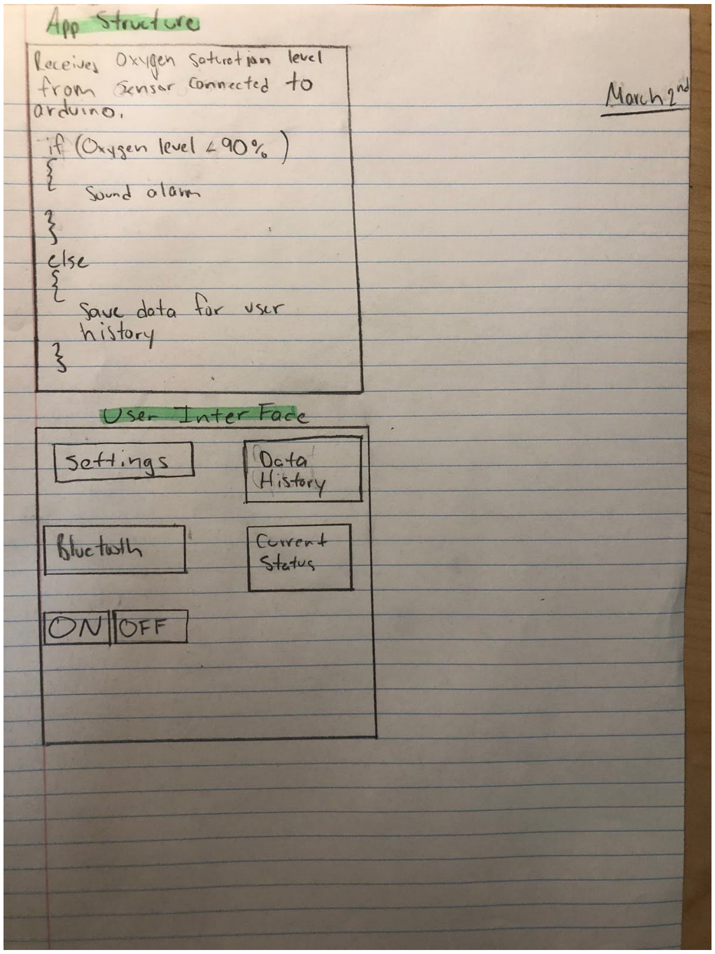
We need to find a battery that fits our device best. We need to find a balance between all the aspects of the battery.

- Size
- Cost
- Battery capacity
- Rechargeable or non-rechargeable
- Charging method or replacement method

3rd prototype - App Structure

The purpose of building this prototype for the app is to ensure we have all the necessary components to have it functioning properly once it is built. This prototype will be a focused prototype that will target the app structure and user interface design.

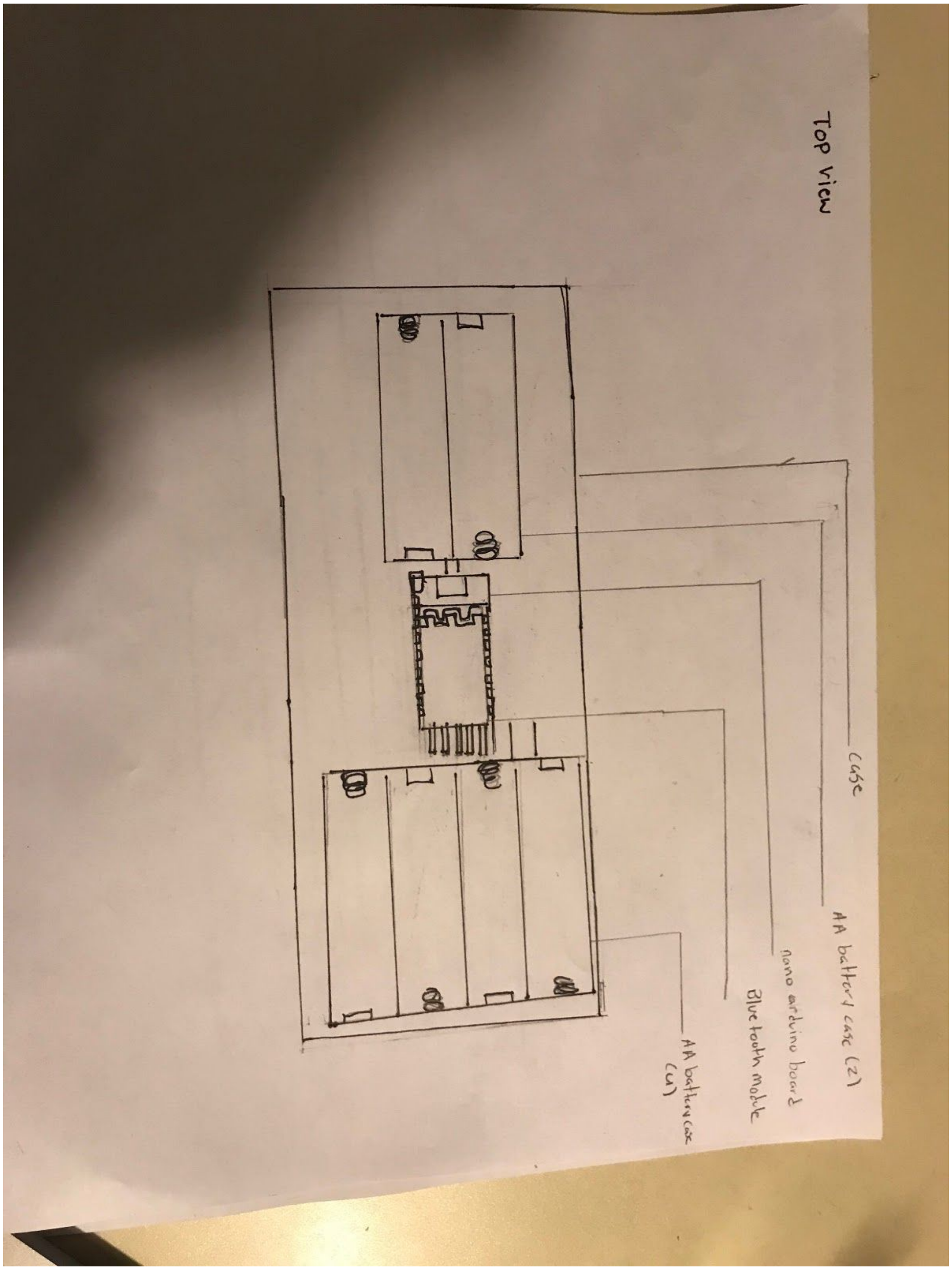
As the image illustrates below, the app will receive data from the Arduino and determine when to sound an alarm or send a notification for help. Based on research the oxygen saturation level should never be below 90%, so this will determine when someone is having an overdose. The Arduino will be programmed to send new data readings from the sensor every 30 seconds, all the sensor readings that are greater than 90% will be saved. The data will be saved so users will be able to look back throughout the course of a day and see if there are any suspicious signs of anything.

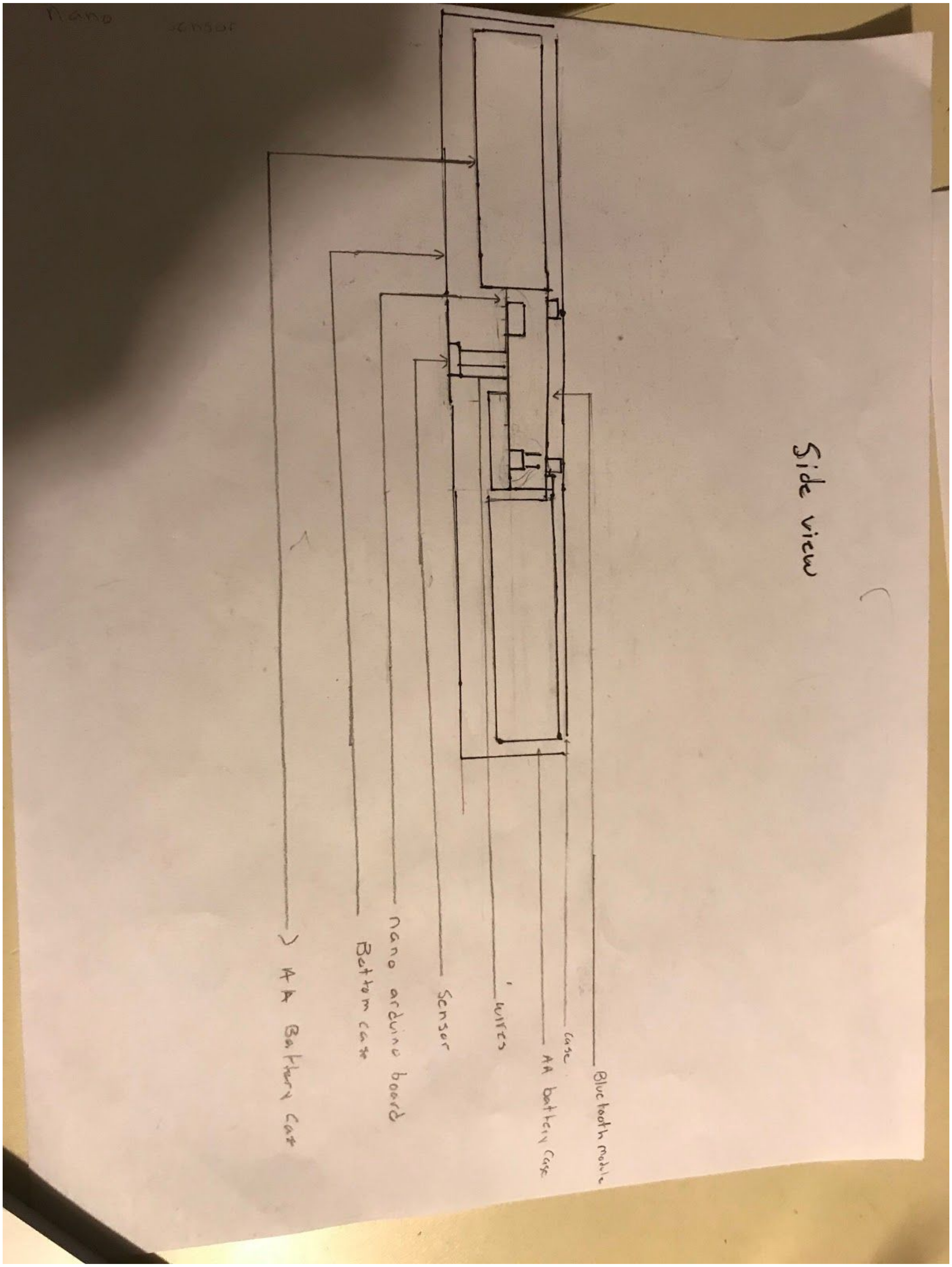


The user interface is the component of this app that the user will interact with. There will be a settings component for the user to change their preferences. There will be a button that the user presses to see the sensor readings history throughout the day. There will be a current status component that the user presses to see up to date readings. Then there will be a BlueTooth component so the user can see when a device is connected or not.

This prototype displays all of the components believed to be necessary for the app to function properly. The results show that if we can successfully build this app then the communication for help will work as we plan it to.

Design prototype1 :

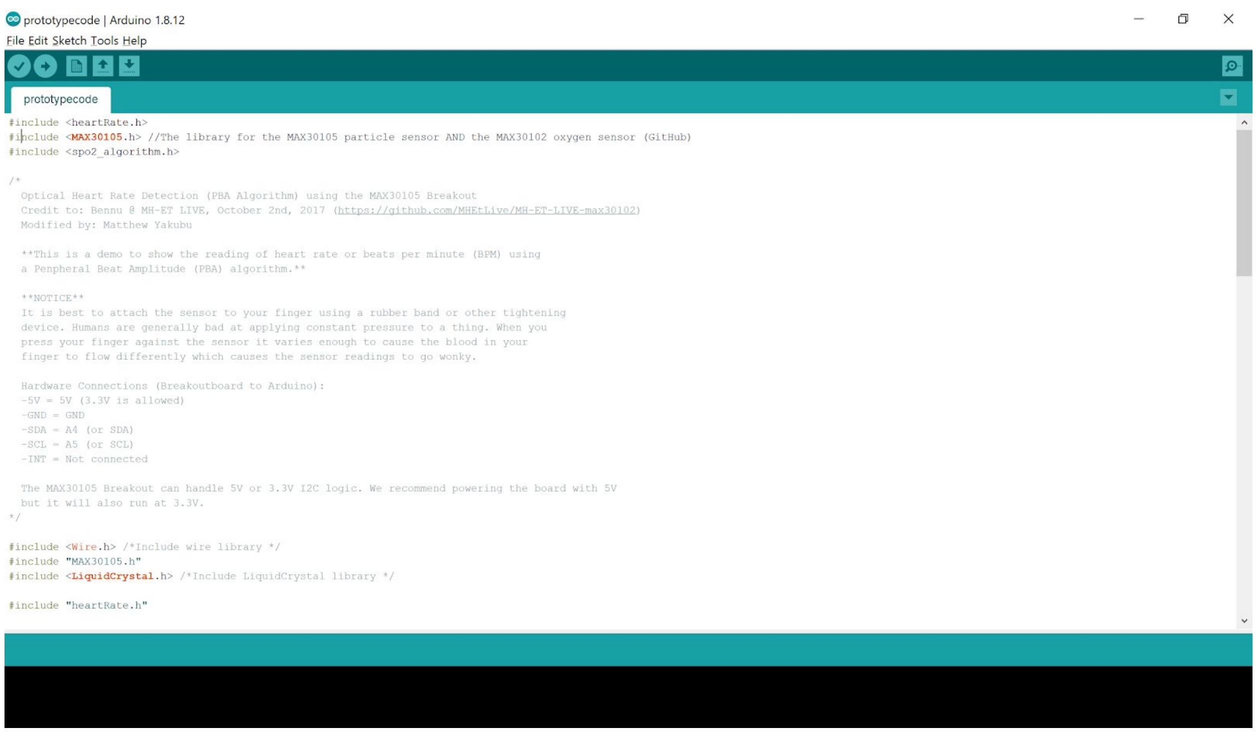

Top View
case
AA battery case (2)
nano arduino board
Bluetooth module
AA battery case (4)


Side view
Bluetooth module
case
AA battery case
wires
Sensor
nano arduino board
Bottom case
AA Battery case

Arduino Sensor Code Prototype

The purpose of this code is to show the reading of heart rate or beats per minute using a Penpheral Beat Amplitude (PBA) algorithm. This will allow us to see if there are any
This will be tested by running the compiled code on any computer device that can run Arduino confidently,

Here is the following code:




```
#include <heartRate.h>
#include <MAX30105.h> //The library for the MAX30105 particle sensor AND the MAX30102 oxygen sensor (GitHub)
#include <spo2_algorithm.h>

/*
  Optical Heart Rate Detection (PBA Algorithm) using the MAX30105 Breakout
  Credit to: Bennu @ MH-ET LIVE, October 2nd, 2017 (https://github.com/MHEtLive/MH-ET-LIVE-max30102)
  Modified by: Matthew Yakubu

  **This is a demo to show the reading of heart rate or beats per minute (BPM) using
  a Penpheral Beat Amplitude (PBA) algorithm.**

  **NOTICE**
  It is best to attach the sensor to your finger using a rubber band or other tightening
  device. Humans are generally bad at applying constant pressure to a thing. When you
  press your finger against the sensor it varies enough to cause the blood in your
  finger to flow differently which causes the sensor readings to go wonky.

  Hardware Connections (Breakoutboard to Arduino):
  -5V = 5V (3.3V is allowed)
  -GND = GND
  -SDA = A4 (or SDA)
  -SCL = A5 (or SCL)
  -INT = Not connected

  The MAX30105 Breakout can handle 5V or 3.3V I2C logic. We recommend powering the board with 5V
  but it will also run at 3.3V.
*/

#include <Wire.h> /*Include wire library */
#include "MAX30105.h"
#include <LiquidCrystal.h> /*Include LiquidCrystal library */

#include "heartRate.h"
```

prototypecode | Arduino 1.8.12

File Edit Sketch Tools Help

prototypecode

```
MAX30105 oxygenSensor;
LiquidCrystal lcd(12, 11, 5, 4, 3, 2); //Parameters: rs, enable, d4, d5, d6, d7 (all for where pins are assigned on the LCD Display

const byte RATE_SIZE = 4; //Increase this for more averaging. 4 is good. const is nearly identical to #define (in C code)
byte rates[RATE_SIZE]; //Array of heart rates, 4 elements
byte rateSpot = 0;
long lastBeat = 0; //Time at which the last beat occurred

float beatsPerMinute; //self-explanatory
int beatAvg; //se

void setup()
{
  Serial.begin(9600); //set the data rate for serial data transmission for the arduino board

  lcd.begin(16, 2); //initializes the interface to the LCD screen, specifies the dimensions of the display.
  Serial.println("Initializing...");

  // Initialize sensor
  if (!oxygenSensor.begin(Wire, I2C_SPEED_FAST)) //Use default I2C port, 400kHz speed
  {
    Serial.println("MAX30105 was not found. Please check wiring/power. ");
    while (1); //boolean -> TRUE
  }
  Serial.println("Place your index finger on the sensor with steady pressure.");

  oxygenSensor.setup(); //Configure sensor with default settings
  oxygenSensor.setPulseAmplitudeRed(0x0A); //Turn Red LED to low to indicate sensor is running
  oxygenSensor.setPulseAmplitudeGreen(0); //Turn off Green LED
}

void loop()
{
  long irValue = oxygenSensor.getIR(); //assuming this is where the user places their finger on the sensor, ask TA for clarification
```

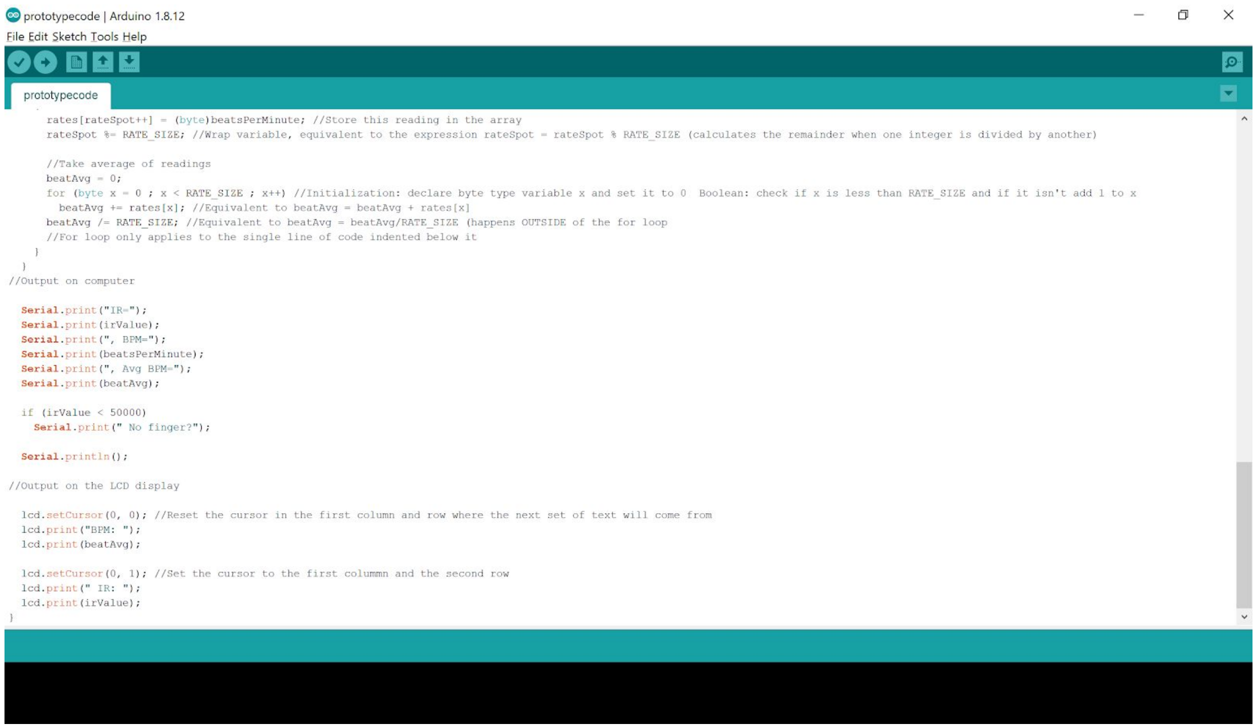
prototypecode | Arduino 1.8.12

File Edit Sketch Tools Help

prototypecode

```
void loop()
{
  long irValue = oxygenSensor.getIR(); //assuming this is where the user places their finger on the sensor, ask TA for clarification

  if (checkForBeat(irValue) == true)
  {
    //We sensed a beat
    long delta = millis() - lastBeat; //overall time - the last time at which a beat was recorded
    lastBeat = millis(); //the overall time in milliseconds, so that when the loop reoccurs, it hold the previous millis() which represents
    // the time at which the actual last beat was recorded

    beatsPerMinute = 60 / (delta / 1000.0);

    if (beatsPerMinute < 255 && beatsPerMinute > 20) //if the BPM is less than 255 and less than 20, proceed to the following instructions
    {
      rates[rateSpot++] = (byte)beatsPerMinute; //Store this reading in the array
      rateSpot %= RATE_SIZE; //Wrap variable, equivalent to the expression rateSpot = rateSpot % RATE_SIZE (calculates the remainder when one integer is divided by another)

      //Take average of readings
      beatAvg = 0;
      for (byte x = 0 ; x < RATE_SIZE ; x++) //Initialization: declare byte type variable x and set it to 0  Boolean: check if x is less than RATE_SIZE and if it isn't add 1 to x
        beatAvg += rates[x]; //Equivalent to beatAvg = beatAvg + rates[x]
      beatAvg /= RATE_SIZE; //Equivalent to beatAvg = beatAvg/RATE_SIZE (happens OUTSIDE of the for loop
      //For loop only applies to the single line of code indented below it
    }
  }
//Output on computer

  Serial.print("IR=");
  Serial.print(irValue);
  Serial.print(", BPM=");
  Serial.print(beatsPerMinute);
  Serial.print(", Avg BPM=");
  Serial.print(beatAvg);
```

Bibliography




```
      rates[rateSpot++] = (byte)beatsPerMinute; //Store this reading in the array
      rateSpot %= RATE_SIZE; //Wrap variable, equivalent to the expression rateSpot = rateSpot % RATE_SIZE (calculates the remainder when one integer is divided by another)

      //Take average of readings
      beatAvg = 0;
      for (byte x = 0 ; x < RATE_SIZE ; x++) //Initialization: declare byte type variable x and set it to 0  Boolean: check if x is less than RATE_SIZE and if it isn't add 1 to x
        beatAvg += rates[x]; //Equivalent to beatAvg = beatAvg + rates[x]
      beatAvg /= RATE_SIZE; //Equivalent to beatAvg = beatAvg/RATE_SIZE (happens OUTSIDE of the for loop
      //For loop only applies to the single line of code indented below it
    }
  }
//Output on computer

  Serial.print("IR=");
  Serial.print(irValue);
  Serial.print(", BPM=");
  Serial.print(beatsPerMinute);
  Serial.print(", Avg BPM=");
  Serial.print(beatAvg);

  if (irValue < 50000)
    Serial.print(" No finger?");

  Serial.println();

//Output on the LCD display

  lcd.setCursor(0, 0); //Reset the cursor in the first column and row where the next set of text will come from
  lcd.print("BPM: ");
  lcd.print(beatAvg);

  lcd.setCursor(0, 1); //Set the cursor to the first columnn and the second row
  lcd.print(" IR: ");
  lcd.print(irValue);
}
```

The libraries required for this code include:

- Wire.h - the communications library
- MAX30105.h - the library used for the oxygen sensor
- LiquidCrystal.h - used for the display on the LCD

setup()

- For the setup, we initialized the data rate for serial data transmission for the arduino board,
  - as well as initializing the interface to the LCD screen and specifying the dimensions of the display.
- oxygenSensor.setup()
  - Configure the oxygen sensor with default settings
  - Turn the Red LED to low to indicate that the sensor is running and turn off the the green LED

loop()

- Call the function to get a sensor reading from the user and assign it to a variable (in this case the variable is **long** irValue)
- Check to see if there was a reading (boolean if statement to check if true or false)
  - If true
    - Overall time - The last time at which a beat was recorded

        - Convert to millis(), so that the loop reoccurs, it holds the previous millis() value which represents the time at which the actual last beat was recorded
- If the BPM reading (formula used in the code) is within 20-255:
    - Store the reading within an array - **rates []**
    - **beatAvg** - Find the average of readings
- for loop
    - Declare byte type variable **x** and make it equal to 0
    - Check if x is less than **RATE_SIZE** and if it isn't, add 1 to x

Output on computer
- Overall outputs a display on the LCD to show the IR and BPM readings

Conclusion

In conclusion, this report discussed our prototype test plan, gave physical examples, and the results from each prototype. Based on the content in this report our group is keeping on track with the deadlines and should be continuing to do so. We have all of the outlined details necessary to make a successful second prototype.

Deliverable G: This was where we built and tested our second prototype. The file is below.

Prototype 2 - Deliverable G

Nathan Gaudaur (300138966), Brandon Joseph Broderick (0300128727), Michel Pellerin (0300131059), Andrew Bui (300116223), Matthew Yakubu (300123797), Cian Brushett (300128904)

March 9th, 2020

Table of Contents

Introduction

This deliverable contains within it the prototyping test plan for prototype II, as well as investigating the results that we have found so far. Additionally, we will analyze the feedback that we received from our customer based on our last prototype so we can further polish the final product.

Prototype test plan

Our goal with prototype II was to try and further polish our design to a point where the functional aspects of it were nearly ready for design day. Our two main focuses for this deliverable were to make the wiring of the device work and for us to create the final design for the encasement of the device on solid works.

The first part of the prototype was a physical model, we planned it to be a comprehensive prototype that will focus on the critical functionality of our product, we are doing this to measure the performance of the plan we devised in the last prototype. Our goal is to have the Arduino reading the blood oxygen saturation level and sending the measurements to the app we built. We plan to complete this by doing the following steps, building a function in the Arduino script that will take in real values from the sensor, build another function that takes the values that are read from the blood oxygen sensor and send them to the BlueTooth module. The BlueTooth module will be used to transfer these measurements to the app we built, which will be displayed to the user. This will be a high fidelity prototype, so if we can get this process working we will have completed a good portion of our prototyping goals and be very close to having the finished product.

The second part of prototype II was to design the case for the product. This part of the prototype was done so that we could get to testing how comfortable the device was to wear. As well as test that the device did not move around on the user's wrist too much when they were wearing the device, as the customer said this was one of the main challenges that were faced when designing an opioid detection device that was in the rough shape of a watch, and so as a result of the customer saying this we wanted to expedite the process of getting a physical model of the prototype to test this aspect of the device.

What is going on and how is it being done?

The two different parts of this prototype (physical model and case), were both tested with different parameters. For the physical model, we built code so the Arduino would function as we needed it to. Once we got the correct program we tested to see if it was functioning properly by touching the blood oxygen sensor to check if the device was reading values correctly, we verified that the values being outputted were correct by touching the device with our fingers multiple times and checking that the margin of error between each touch was within an acceptable range, which was roughly 2.5%, and that the values did not go below 95% or above 100%, as these values would be outside the normal range for a human who is healthy. This part of our prototype test plan was successful as we achieved our main goal.

The way that we tested that the solid works model of the case design was acceptable was by making a sketch of how big the device would be using a piece of paper, and finding out the dimensions of the sketch, then we took the dimensions and inputted them into our model on Solidworks, and as such the model on Solidworks should be big enough to incase all the components necessary for this device.

When is it happening?

For this deliverable the first test will be to make sure that the physical prototype of the device works, this will be done within one day, where multiple members of our group will get together and touch the blood oxygen sensor to test that the readings are accurate. The second prototype, which is the casing of the device does not require anytime to test at the moment and it is still just a Solidworks sketch. However, when the group ends up 3D printing the device, we will have one group member wear the device for a day to test its comfort, and then we will also put it through a series of more stressful test such as sleeping in it, jumping with it on, and falling down onto a padded surface to ensure that the device does not break connection with the skin throughout these tests, so it can still make accurate readings. These tests have been chosen to try and simulate both a working environment and also what someone who is overdosing might do when they are unconscious, so with all this testing, this will take approximately 3-4 days in total. Prototype III will be worked on between now and design day, we are hoping to have the final product done by the 20th of March, as we don't want to wait until the last minute in case there are any underlying issues with the device that are not initially apparent, so this should take around 12 days.

Customer feedback

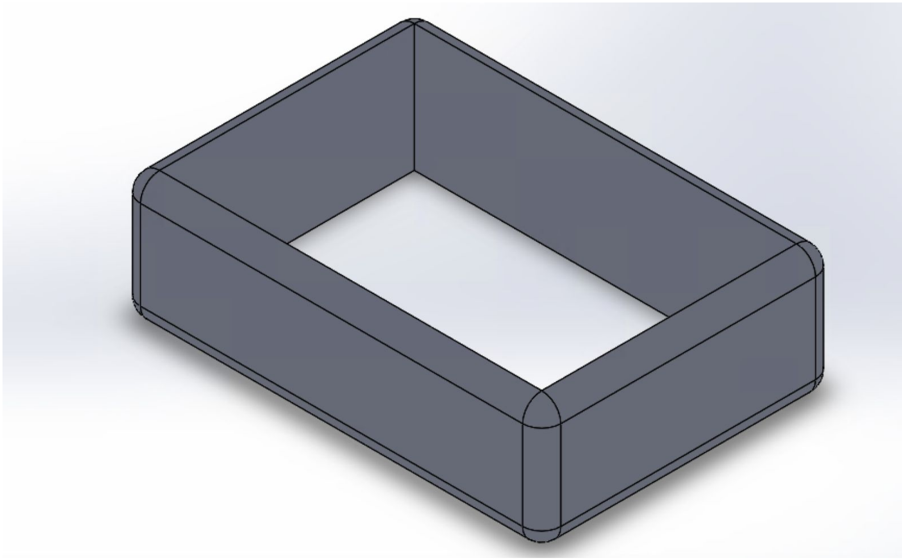
We showed the customer an overview of what the device will look like, as well as its more technical aspects, the following is her feedback, as well as what measures we will use to try and best ensure that it is addressed.

1. The customer was concerned that the device would move around too much, and as a result not make accurate readings of the user's blood oxygen levels.
    a. In order to try and address this concern, we will add a strap to the device with many size settings, as well as testing how good the device stays in one spot by performing a series of thorough tests. Another way that we will try to reduce the movement of the device would be to make the device out of a material that has more friction.
2. The customer was concerned that if the device was in the shape of a box that it could get caught on stuff.
    a. In order to address this concern, we have gone with a shape that has rounded corners that should hopefully not get caught on things as easily.
3. The customer was concerned about the overall battery life of the device, as she would like it to last for a full day of use.
    a. We have already done the calculations and our device should last a full day, however, we do have plans to add an on-off switch to the device in the future, to further increase how long it can last on one charge.

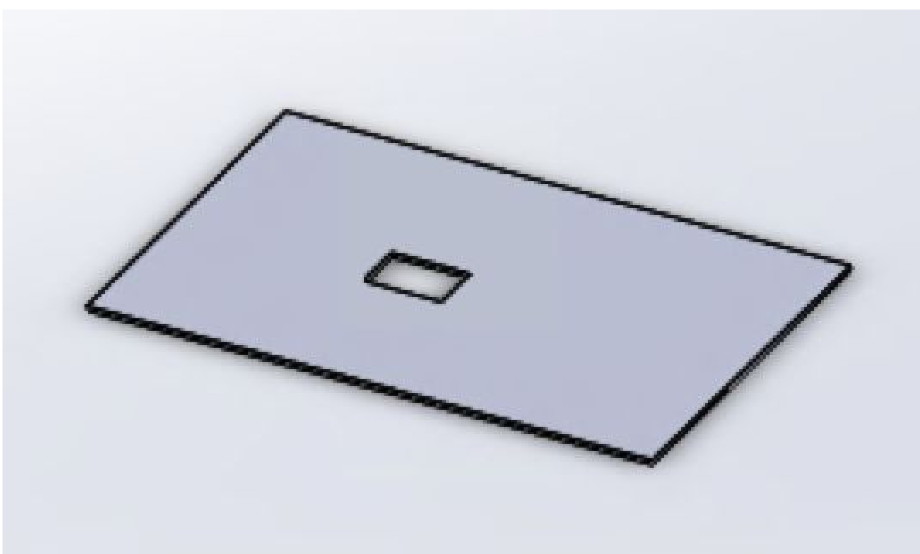
Device Design

We decided to print the design in three parts.

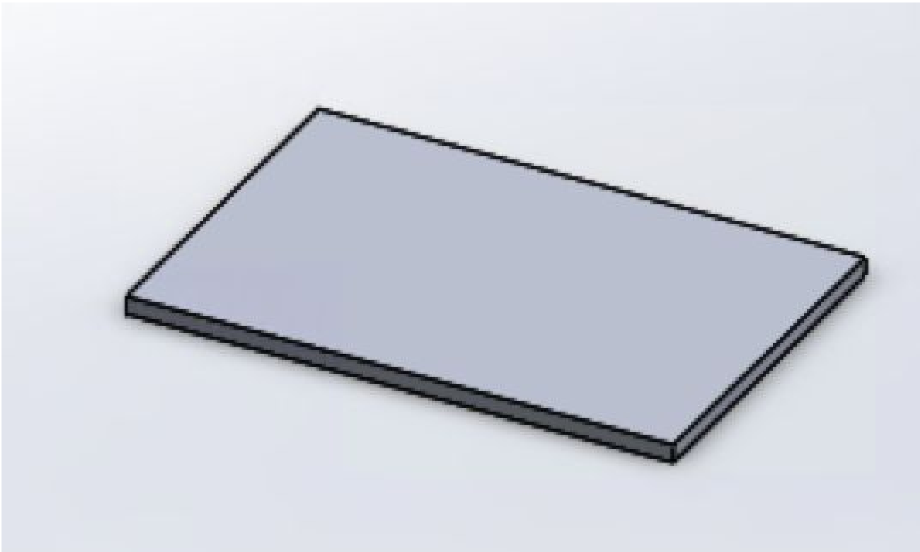
The first part is the sides, we made the sides slightly thicker than the rest of the parts so that we could have bigger curves. This would make it look less boxy and make it more aesthetically pleasing, as well as decrease the odds that the device will get caught on things, which was a concern of our customer.



The second part is the bottom of the device. The bottom has to be quite thin in order to allow the blood oxygen sensor to make contact with the skin. The bottom also needs a cutout for the sensor to allow it to make contact with the skin.



The third part of the device is the top. We decided not to make the top as thin as the bottom to increase durability. We still think it should be fairly thin in order to minimize the size of the device.



Further device refinement plan

- Make the app as simplistic as possible, while still having enough features as to not annoy potential future customers
    - Planned app features include adding emergency contacts, displaying blood oxygen levels and breathes per minute, adding a customizable phrase to send to emergency contacts when the device detects an overdose and having an option to cancel sending an alert in the case of a false reading from the device.
- Reduce movement of the device as much as possible when it is fastened on the user's wrist
    - Add a strap with multiple size settings in order to ensure the user has a wide variety of options so they can choose the one that best suits them
- Add an on-off switch to the device to save power
- Move the device away from a breadboard and onto a soldering board
- Install the battery pack to the device so that it will work away from a computer

Prototype results

We learned alot from our comprehensive prototype because this is the critical system of our device. We had to change the code multiple times to get the arduino and sensor functioning the way we needed it to. We also needed to keep critiquing our circuit. The main thing we realized is that our sensor needed to be adjusted so that it would work properly, the adjustment was we needed to connect two resistors with each other by a wire. Once we did this our sensor was working properly and displaying the proper results. This is a very big step towards the end of our project so we are glad to have completed this.

There were a couple of things we did not finish for the critical system analysis. The main feature we did not include is building the app that will display the sensor results. We just had our sensor measurements show up on the serial monitor so we knew it was working properly before worrying about sending the results to our app. The app has been started but will need more work to be completed. We will have the app completed by the end of this weekend. Once we have the app completed we just need to assemble the device on a pcb board and solder the components together. Therefore, based on the results from this prototype our group has made good progress and should have a completed product by the time our third prototype needs to be submitted.

Conclusion

This report consists of the tests and results that were found in prototype II, customer feedback and what we are doing to address it, and what we plan on doing in the future to improve the overall quality of the device.

Deliverable H: This was where we made the final design changes and concluded our final prototype for our device. **The file is below**.

Prototype 3 - Deliverable H

Nathan Gaudaur (300138966), Brandon Joseph Broderick (0300128727), Michel Pellerin (0300131059), Andrew Bui (300116223), Matthew Yakubu (300123797), Cian Brushett (300128904)

March 29th, 2020

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.

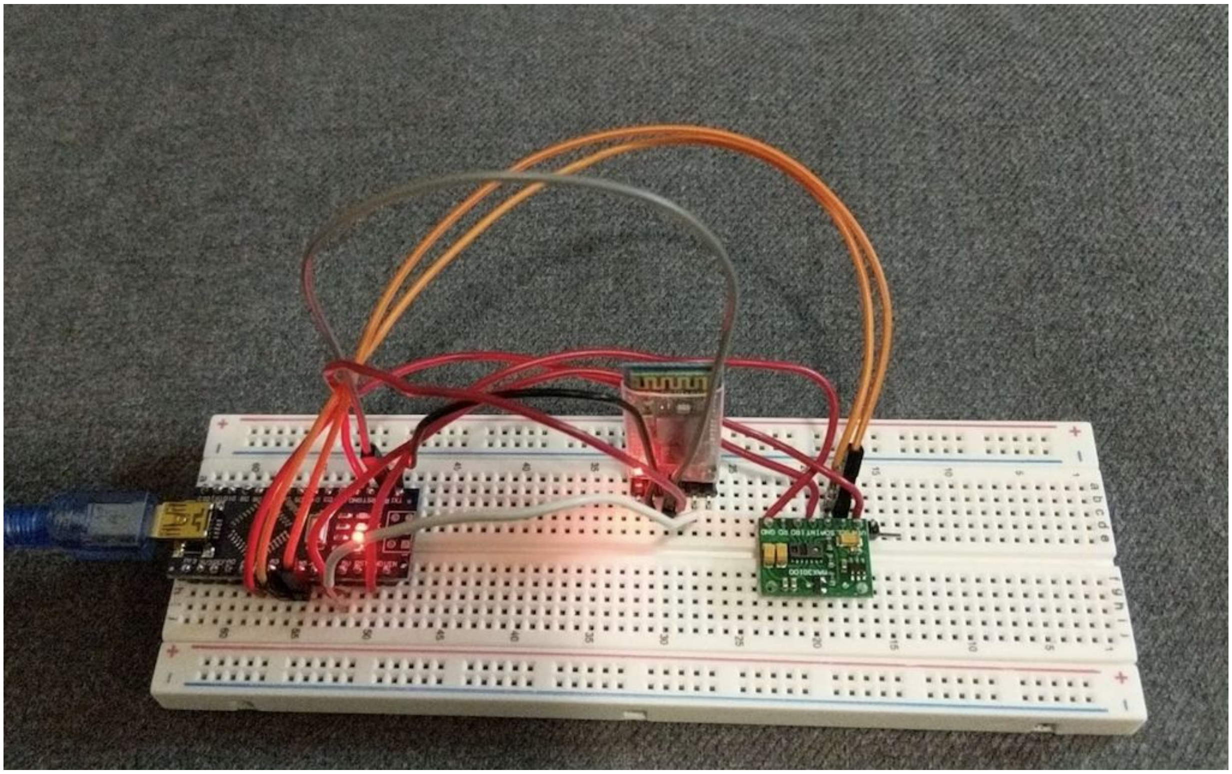
The elements of the design that we were able to complete despite the CEED facilities were the app design and adding a battery onto the device so that it could run without the use of a computer, this was completed on the 14th of March. Originally we wanted to include just one AA battery in order to reduce 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

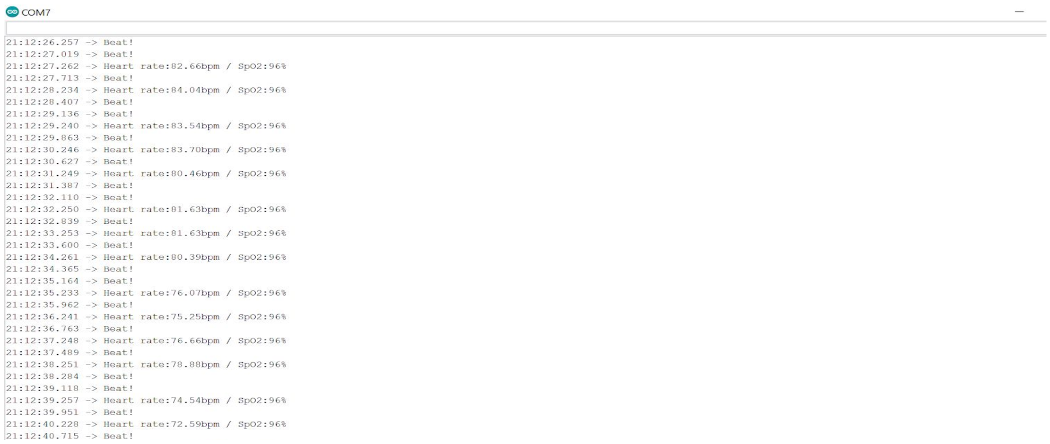
https://youtu.be/PQh93GcJ_-U

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.

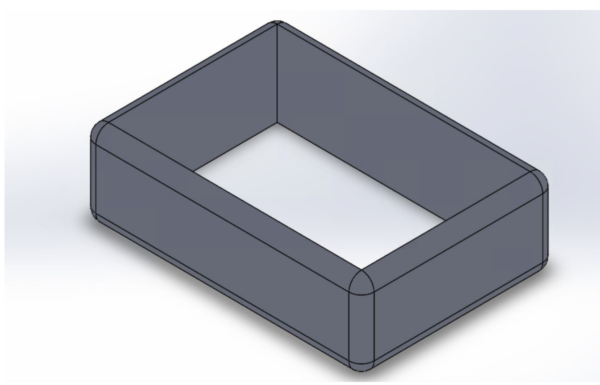
Over the course of the semester, we made good progress on building our device. The final status of our prototype is as follows. We have all of the components connected properly on a breadboard and reading the correct sensor values. Below is a picture of the circuit we built for the proper function of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

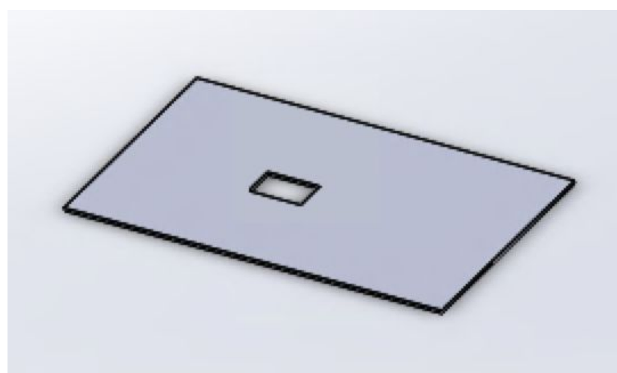


We connected this circuit to our computers so we can see the values being read by the sensor. When each of us touched the sensor it measured a blood oxygen saturation level between 95-100%, we know this is an appropriate range of values. Below is a picture of the sensor values being displayed on the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



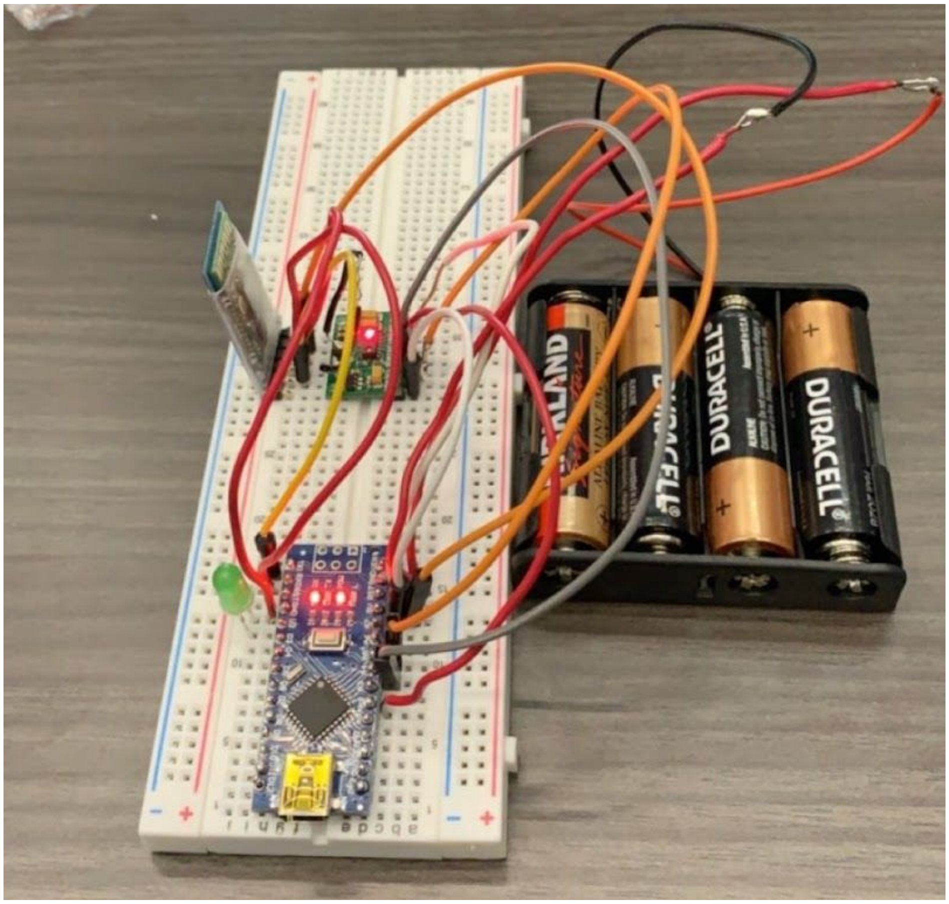
As you can see the SpO2 levels are between 95-100%, so we have our sensor functioning properly. As for the case that was supposed to hold all of the components on the breadboard, we made multiple designs on SolidWorks and picked the one we thought best suited our purpose for the device. Below is an image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



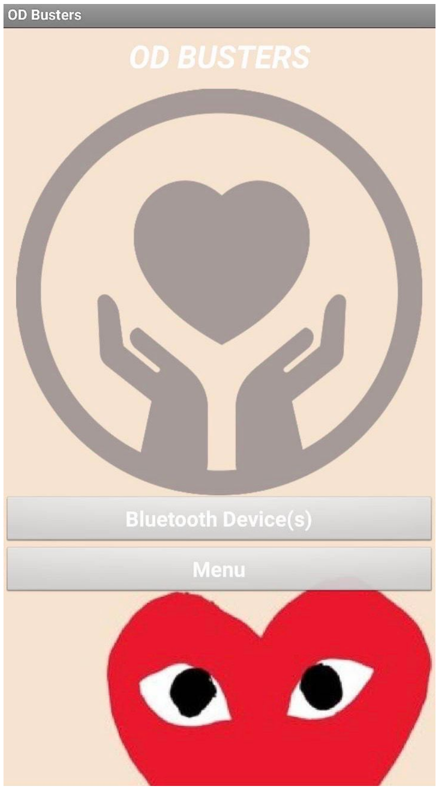


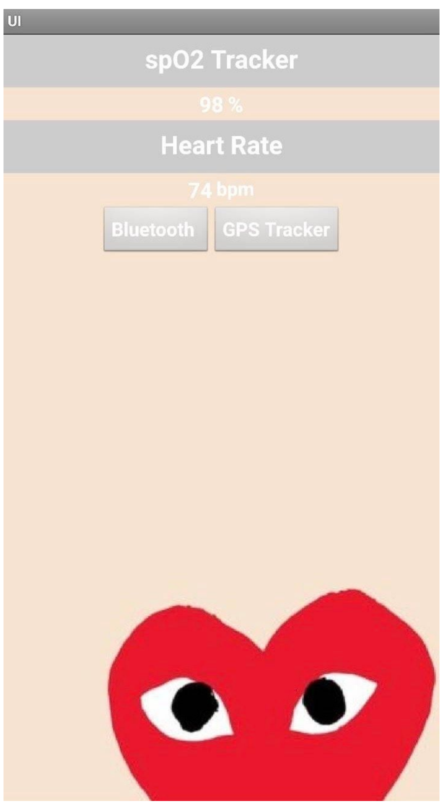
We planned to use this one because we analyzed it to be the most compact in size based on the other designs. We were planning to laser cut or 3D print this case last week, but unfortunately, the CEED facilities were closed so we didn't have the resources necessary to do this.

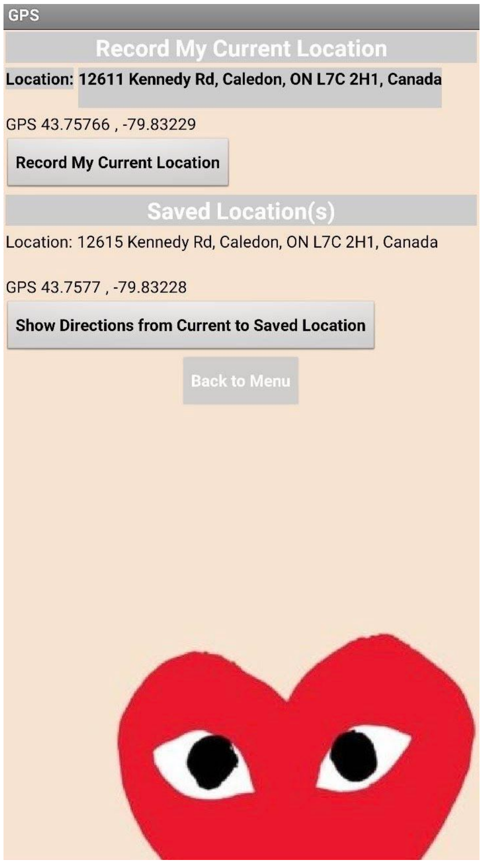
As time was running out and we had no luck on finding a battery that we believed to be suitable for our device, we ended up settling on four AA batteries for power. This was not ideal as it could end up being expensive to replace the batteries all of the time. We did have some ideas in mind to improve 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.

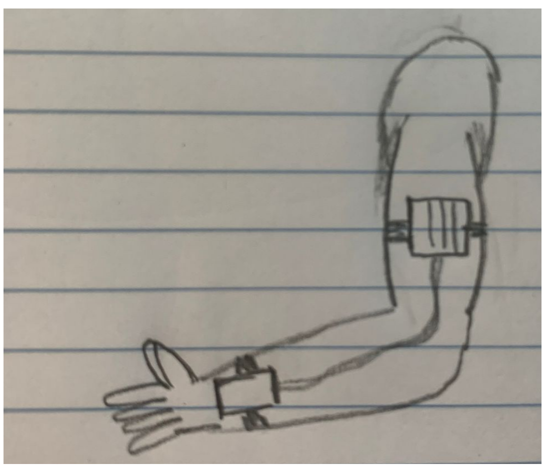
Plan to complete prototype

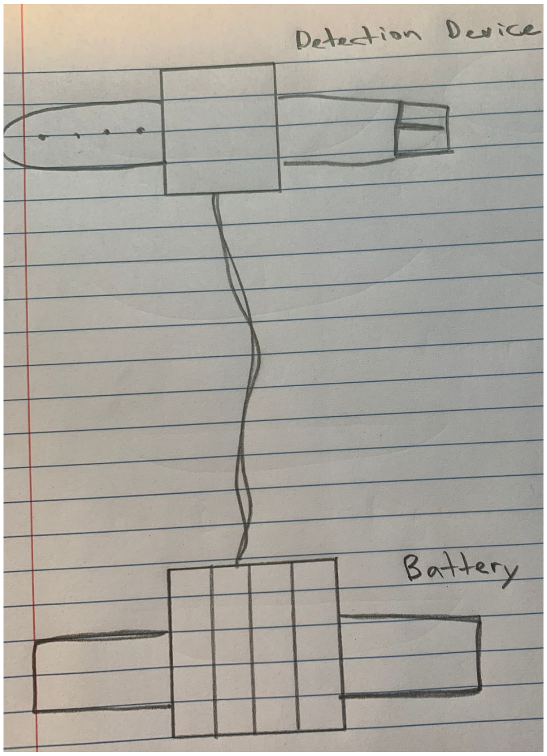
Battery

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.

APPENDIX II: Other Appendices

```
 #include <Wire.h>
#include "MAX30100_PulseOximeter.h"

#define REPORTING_PERIOD_MS     1000

// PulseOximeter is the higher level interface to the sensor
// it offers:
//  * beat detection reporting
//  * heart rate calculation
//  * SpO2 (oxidation level) calculation
PulseOximeter pox;

uint32_t tsLastReport = 0;

// Callback (registered below) fired when a pulse is detected
void onBeatDetected()
{
    Serial.println("Beat!");
}

void setup()
{
    Serial.begin(115200);

    Serial.print("Initializing pulse oximeter..");

    // Initialize the PulseOximeter instance
    // Failures are generally due to an improper I2C wiring, missing power supply
    // or wrong target chip
    if (!pox.begin()) {
        Serial.println("FAILED");
```

```
        for(;;);
    } else {
        Serial.println("SUCCESS");
    }

    // The default current for the IR LED is 50mA and it could be changed
    //   by uncommenting the following line. Check MAX30100_Registers.h for all the
    //   available options.
    // pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);

    // Register a callback for the beat detection
    pox.setOnBeatDetectedCallback(onBeatDetected);
}

void loop()
{
    // Make sure to call update as fast as possible
    pox.update();

    // Asynchronously dump heart rate and oxidation levels to the serial
    // For both, a value of 0 means "invalid"
    if (millis() - tsLastReport > REPORTING_PERIOD_MS) {
        Serial.print("Heart rate:");
        Serial.print(pox.getHeartRate());
        Serial.print("bpm / SpO2:");
        Serial.print(pox.getSpO2());
        Serial.println("%");

        tsLastReport = millis();
    }
}
```