Prototype II and Customer Feedback

Project Deliverable G

GNG1103

Team 13

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1.0 Introduction

In the previous deliverables, a problem statement was created which states the need for a non-intrusive, wearable device that monitors oxygen levels of an opioid user and detects overdoses. The device must be affordable, lightweight and compact; it must alert emergency responders of the location of the person affected. Each member then created three conceptual designs using the list of prioritized design criteria, and benchmarking. From the various designs, three fully-functional subsystems were put together. The three designs include a watch, a patch that can be placed on multiple locations of the body, and an earpiece. Through careful consideration of the pros and cons, the watch design was determined to be the most feasible.

The previous deliverable included an analysis, list of tasks, and a bill of materials. The analysis included a brief summary of the client meeting from which we gathered feedback and applied it to our existing concept. We decided to add an app that connects through Bluetooth to the watch so that all of the information that the sensors collect can be displayed in one place. Then a general plan and list of tasks were made for each of the three prototypes to ensure that we stayed on track. The bill of materials included all of the items that had to be purchased for this device. These items include the following: watch strap, MAX30100, Arduino Nano, and bluetooth. Prototype I was a physical prototype which was made out of cheap material (paper). A base for the app was already created which is able to track the location of the user.

For this deliverable, the Team first filled out the Prototyping Test Plan which outlines the objective of the second prototype, test objectives (specific test objectives, what is being learned/communicated, possible results, select concepts, test success/failure), how the testing will be done (testing process, information measured, what's being observed/how is it recorded, materials needed/estimated costs, what work needs to be done), and lastly, how long would the testing take (estimated time/dependencies, when are the results required by). After completing the test plan, a 3D model of the prototype was created on SolidWorks which was then will be 3D printed. We also made additional purchases for the prototype which includes a LED, batteries/charger and a watch strap. We primarily focused on getting the code that tracks the heart rate and oxygen saturation levels to work properly. We also plan on testing the bluetooth on the app to check that the information from the sensor and arduino is being properly and accurately displayed on the app. For the third and final prototype we will try to get the code to detect an overdose and be able to send the location and user information to the listed emergency contacts.

2.0 Analysis

2.1 Prototype Test Plan

Why are we doing this test?

The objective of this test is to ensure the prototype is properly functioning and able to communicate with the app via bluetooth. The app will also be developed in this prototype and any issues we might have such as connection reliability and contacting authorities will be addressed in our third and final prototype.

Test Objectives Description

*What are the **specific** test objectives?*

- Ensure that the device is functioning and tracking oxygen readings accurately
- The app will be developed so as to communicate with the device effectively.
- Ensure that the device accurately communicates blood oxygen readings with the app via bluetooth.

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

- We must find where our sensor best measures blood oxygen levels around the wrist area.
- The priority of this prototype is to ensure that the device can effectively communicate blood oxygen levels with the app.
- The app will be developed to track location and act if abnormal blood oxygen levels are detected.

What are the possible types of results?

- The best possible results would be that the blood oxygen levels can be measured on the outside wrist so the device can remain as discreet as possible, looking like a watch or bracelet.
- In the case that the sensor measures data better from the underside of the wrist, the sensor would need to be moved and might slightly alter the design of the device from the first prototype.

- The android app can accurately track location and effectively communicate emergency services if an overdose is detected.
- The app and device must also communicate seamlessly.

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

- The placement of the sensor could possibly affect the design of our device, depending on which part of the wrist blood oxygen levels are most accurately measured.
- Because location of the device is easily accessible in the app, we can choose who to contact in the case of an overdose to ensure quick and reliable actions.
- The app and device must communicate seamlessly because a break in connection could mean that an overdose goes undetected.

What are the criteria for test success or failure?

- Because we already know the sensor already measures blood oxygen levels, the test is already successful. We will just be measuring levels to find the best placement of the sensor on the wrist.
- Test success with the app will be if the device can accurately measure a user's location.
- Test success with communication is if the device and app communicate effectively with little to no break in connection.

What is going on and how is it being done?

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

The blood oxygen sensor will be placed on various parts of the wrist and measured to find which part of the wrist allows the sensor to measure blood oxygen levels most accurately. The app shows current location, so the test will ensure that the app shows current location and can update when the user moves. Finally, the app must receive constant measurements from the device to ensure that connection is not interrupted or broken.

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

- Blood oxygen levels are being measured for accuracy.

- Location accuracy is being measured on the app. We must ensure that the app can measure current location and any movements.
- We will also measure how often data is sent to the app and how well the app measures changes in blood oxygen levels.

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

- A pulse oximeter (MAX30100), bluetooth (HC05), arduino nano, breadboard, and some wires are required to create Prototype II.
- The estimated cost of these materials was approximately $60.

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

- The physical design of the device might need to be altered based on where the sensor most accurately measures blood oxygen levels.
- The app needs to be properly developed to accurately measure location and seamlessly communicate with the device.

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 testing will take place at our team meeting where the sensor can be placed on a team member's wrist and measured for accuracy.
- The app will be measured at various parts of campus to ensure that location data is accurate and can measure changes in location.
- Seamless communication will be measured on the app as it can sense changes in heart oxygen levels that we can test with the sensor.

When are the results required (i.e. what depends on the results of this test in the project plan)?

- The device must remain discreet even if the sensor must be moved from the position chosen in our original device.
- The app must accurately measure location so that emergency services can effectively know where to respond in the case of an overdose.
- The device must communicate with the app over short periods of time, tracking fluctuations in blood oxygen levels and possible overdoses.

2.2 Prototype II

Figure 1: Compartment that hold all the components

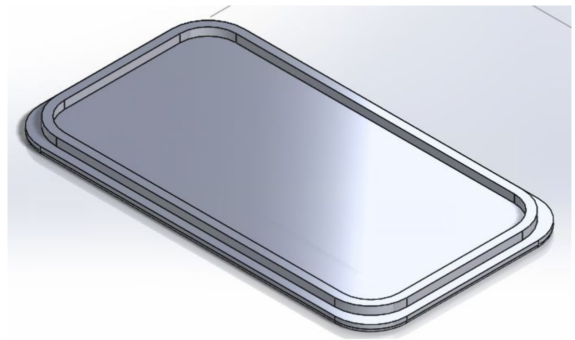

Figure 2: Lid for Figure 1 Compartment

Figure 1 is a 3D representation of the main compartment of the casing on the watch which is 45.7 *25.4mm. The arduino nano, bluetooth, and pulse oximeter will all be placed within the compartment. This part is going to black and will be open at the bottom, Figure 2 will be the lid. The final design of the lid will have a whole at the bottom so the pulse oximeter sensor can be in direct contact with the skin.

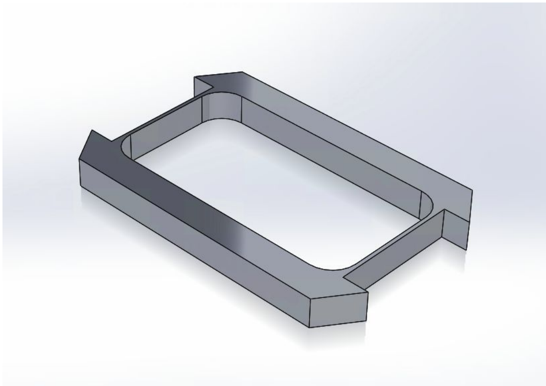

Figure 3: Part that attaches to watch strap

Our design idea is a watch, for that we need straps. This is going to go around the watch casing, and it will help with the attaching of the watch straps to the final product. The size and casing design will be altered depending on the straps we decide to buy.

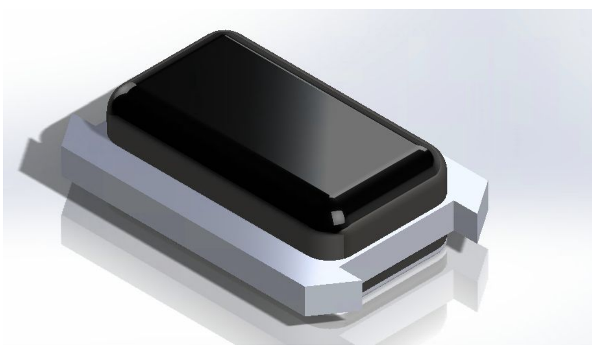

Figure 4: Final model of casing

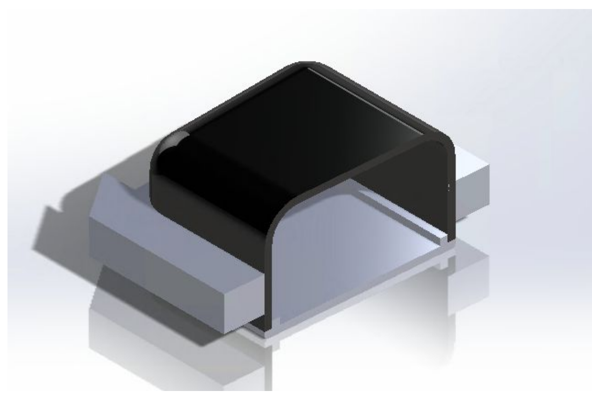

Figure 5: Model cut in half. Components will be placed within the compartment.

Figure 4 shows that final model of the casing for the watch with all the components fit together. As you can see from Figure 5, it is hollow and it has enough space to contain all the components that the watch needs to function.

2.3 App

Figure 6 : Main screen

Figure 7: Location

Figure 8: User information

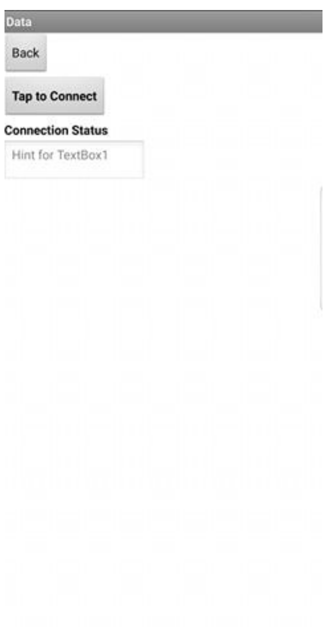

Figure 9: Data

Figure 10:Bluetooth connection

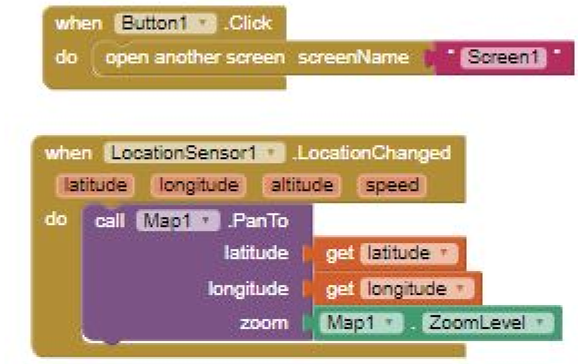

Figure 11: Code blocks

The app is being created using MIT App Inventor 2 which already has the base coding done. As seen in Figure 11, the program works in blocks to make it easier to put the app together. Each block is composed of codes written in Java. The way this works is whenever a component is added onto the screen, they each must be assigned a set of functions/statements which act as instructions. For instance, Figure 11 displays the code blocks for the location screen. This states that whenever the location sensor is activated, it will call the map and pan it to the corresponding latitude and longitude location.

So far, the basic layout is made for the front page, location, and bluetooth. The data, user information, and emergency contacts pages are not yet designed. The front page consists of four buttons which lead to alternate screens: Data, User information, Location, and Emergency contacts. The Data page, Figure 9, is also a basic layout which includes a button that leads to another screen that lists all available bluetooth devices (Figure 10). Once the bluetooth device is selected it should display the heart rate and oxygen levels on the screen updating frequently. The next screen is Location, this page consists of a map which locates the user using the location sensor embedded on the phone. The location updates every second as long as the device location is active and the user is connected to Wifi or data. Lastly, the setup for user information was started. On this page, the user will be able to input his/her information such as name, age, gender, allergies, home address, phone number, etc. The emergency contacts page has not yet been started but it will contain a list of contacts which includes their name and phone number.

For Prototype III, all the pages will be complete and when an overdose is detected the app should be able to take the users location and send it via text/call to the listed emergency contacts.

One obstacle that we have encountered was that getting the location sent to other contacts might not be possible using this program as it does not allow us to change the code itself. We will attempt to do this using this program but if it seems to not be working then we will have to migrate to another software called Android Studio which involves us coding everything from scratch which is very time consuming. Since there is still two weeks before Design Day, we will try to get the app done as soon as possible.

2.4 Arduino Setup

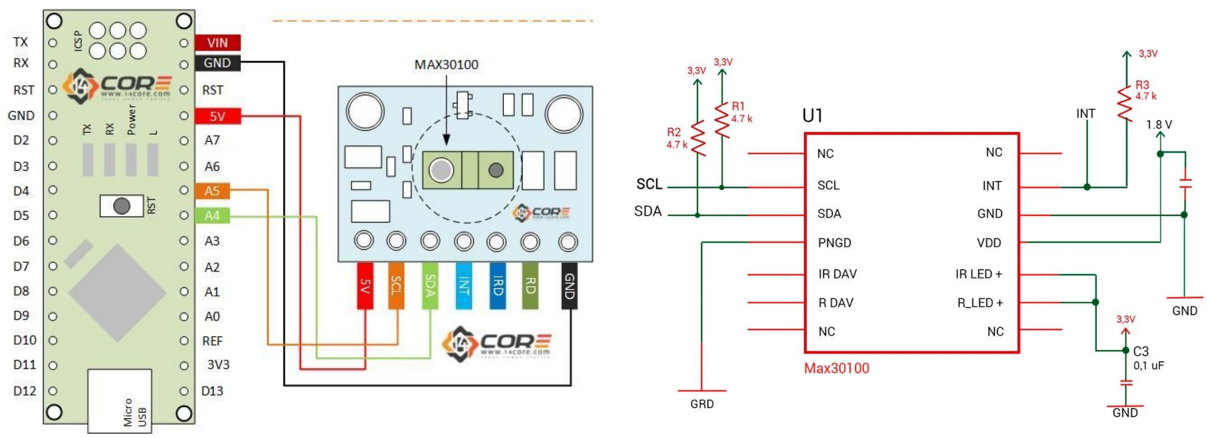

Figure 12: Block and circuit diagram for MAX30100 and Arduino Nano

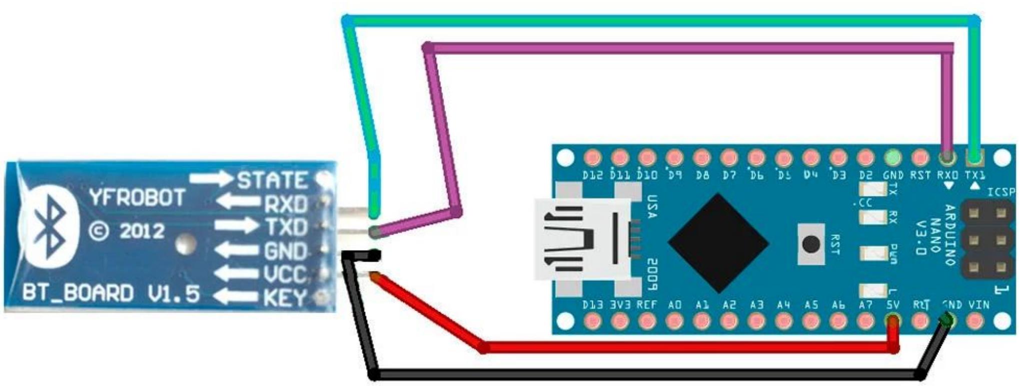

Figure 13: Block diagram for Bluetooth and Arduino Nano

Figure 12 and 13 show the block diagrams for the connections between the MAX30100, Bluetooth, and Arduino Nano. We were able to follow these diagrams and position everything on the breadboard. Once everything is positioned correctly and double checked, we will solder all the wires in their appropriate locations. This will allow the components to be as compact as possible so that they can fit, along with the battery, in the watch casing.

Also, a battery supply will be needed to provide power for the arduino nano and the pulse oximeter. The arduino nano power consumption is 19mA, the MAX30100 has a power consumption of 20mA, and the bluetooth has a power consumption of 30mA. The three components give a total power consumption of 59mA. We are looking to purchase a battery with at least 1400mA giving the device a battery life of 24 hours. Although the device will not be tracking the heart rate and oxygen levels every second, but more so on a 30 second or one minute interval allowing the battery to last longer before recharging.

2.5 Code

```
#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.println("Initializing MAX30100");
    // Initialize the PulseOximeter instance and register a beat-detected callback
    pox.begin();
    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.print("% / temp:");
        Serial.print(pox.getTemperature());
        Serial.println("C");

        tsLastReport = millis();
    }
}
```

Figure 14: Code

This is a sample code that we are working with. This is the main code but it refers to others that are in a common folder. This code simply initializes the sensor first, once there is an active connection the sensor begins recording the data and displaying it on the serial monitor. Through this code, the bluetooth becomes activated which can then be located on the app. Once the app connects to this bluetooth device, it should display the same information as the serial monitor but instead on the app. The goal for Prototype III is to create a code that sends out an alert whenever the heart rate and oxygen levels drop below a certain point. Once they do, the location of the user must be sent to their emergency contacts.

3.0 Client/User Feedback

During our Friday class we presented our prototype 2 to our client. The powerpoint we presented outlines our decision making process that led to our prototype design as well as our future plans for the device. Between our many ideas we decided to choose a watch design that would monitor the users blood oxygen levels and send this information through a bluetooth connection to the users phone app. In the event of an overdose the app would send a text to a pre-recorded number with the users location. Our client has known about watch designs before and brought up known issues with us. The main issues she mentioned was the watch sliding around causing a loss of monitoring and batteries losing power fast. To counter the watch moving around we will purchase a silicon watch strap online to ensure a better grip than a 3D printed one. To counter the battery loss we will purchase a high mAh battery that is rechargeable. We are currently looking at a few batteries and watch straps within our budget.

4.0 Conclusion

Our problem statement asks for a wearable and non-intrusive device that can detect opioid overdoses by monitoring blood oxygen levels of an opioid user. The device must be affordable, lightweight and compact. We focused on this part of our problem statement for this second prototype, creating a 3d model of the casing to 3D print that can comfortably fit on the wrist but also contain all the components of our device. We also tested some codes that would be able to track the users heart rate and oxygen levels. The development of the app has begun, but we will finalize it by the third prototype and ensure that the device seamlessly communicates with the app via bluetooth. So far, the app displays the user’s information, emergency contacts, and location. In the application part of the watch, we also need to determine the automatic maintenance function of the system to ensure that no crashes occur during the connection process. And also need to better display the data on the display to ensure that personnel can read; on the app to ensure that it can be tracked in real time and there is no possibility of crashes For the third prototype, the app should be able to display the information gathered from the sensors and send the location to the listed emergency contacts once an overdose is detected. This second prototype was beneficial to ensure that all our components function well and fit in a discreet casing on the wrist, allowing us to continue with the current design.