PTSD Detection and Service Dog Alert System

Design Document

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Table of Contents

1 Problem Statement 2

2 Project Goal 2

3 Client Requirements 2

4 Revised Design 2-5

5 Requirements 6-7

5.1 Functional Requirements 6

5.2 Non-functional Requirements 6

5.3 Standards 6-7

6 Engineering Constraints 7

7 Security Concerns 7

7.1 Physical Security Concerns 7

7.2 Cybersecurity Concerns 7

7.3 Countermeasures 7

8 Implementation 8

9 Testing 8

9.1 Testing Process 8

9.2 Testing Results 8

10 Context of Related Products and Literature 9

10.1 Related Products 9

10.2 Related Literature 9

Appendix I. Operation Manual 9-12

Appendix II. Alternative Designs 12-13

Appendix II.I Pre-client Specifications Designs 12

Appendix II.II Pre-further Research Designs 13

Appendix II.III Designs That Failed Specifications 13

Appendix III. Key Takeaways 13

Appendix IV. Code 14-15

Appendix V. Parts List 15

1. Problem Statement

Service dogs aid veterans and others with severe PTSD. These highly trained dogs can detect the physical symptoms of PTSD attacks as they happen and help stop an attack in progress. They help service members regain their life, but they can only detect PTSD attacks once visual symptoms arise. This in turn requires an external solution that can aid the dog in its response to said PTSD attacks.

2. Project Goal

Our goal is to create a system that will use a smartwatch to detect a PTSD attack as it begins by utilizing the heart rate data from the watch. When the attack is detected, a signal will be transmitted to a device attached to the dog's service vest. That device will then vibrate, giving the dog a non-audible cue to perform its duty to comfort the user and help stop the PTSD attack. We hope this device will give the user an improved quality of life and a sense of security to go to places they had trouble visiting in the past. Additionally, we hope our device will be able to cut the gap between dog natural detection and response time.

3. Client Requirements

- Must track and send data to the dog device
- Must be comfortable for the dog
- App must be able to run on any mobile operating system
- Devices must be able to turn off during exercise
- Battery life must be of reasonable usable length (approximately a day)
- Dog alert and device must be reasonably discrete

4. Revised Design

For our design, the system at a high level consists of 4 major components/subsystems: dog device, smartphone, software application and smartwatch. For the dog device, we created a device that consists of a few electrical components fit inside of a 3D printed enclosure that becomes fixed to the dog vest via velcro. This subsystem is responsible for receiving alerts of PTSD attacks from the smartphone and alerting the dog via vibration when flagged. The components that reside within the enclosure are an Arduino Nano 33 Iot, portable phone charger, vibration motors, and bluetooth module. Fixed externally to this enclosure is velcro on the bottom of the base and motors that connect to the Arduino inside of the enclosure.

Figure 1: Dog device with power supply removed

Figure 1 shows that the dog device subsystem is a modular system in which the enclosure can be removed from the vest and the electronics can be taken out or tweaked if needed. The image also shows that the motors are internal and both the power supply and bluetooth module are not present. This is because the system was complete as far as we have been able to get with our financial allotment and time and tested for demo of our progress at the time the picture was taken. One may note there are copious amounts of space in the enclosure but once all hardware is installed the free space begins to dwindle. The open space allows for further module additions as this device is to be continued being worked on.

The smartphone device is assumed to be owned by the user in order to utilize our product. The device we use for harboring and running our software is the Google Pixel 6A but other Android devices can be used as well. The smartphone's main function is to serve as a data processing and storage unit as well as user interface. The heart rate data is taken from the smartwatch then logged and processed on the smartphone through an algorithm to see if there is a PTSD attack in progress through a peak in heart rate. Once the increase in heart rate is detected, the smartphone sends a signal to the dog device utilizing the smartphone's internal bluetooth system. For the software run on this smartphone, it serves two major functions. The first function is to run the algorithm and processing as stated previously. The second major function is for it to act as a UI in the smartphone which is meant to be simple and allow the user an option of customizability and control over their device. Elements such as data history, connectivity, vibration strength, etc. can all be controlled by the user in this UI.

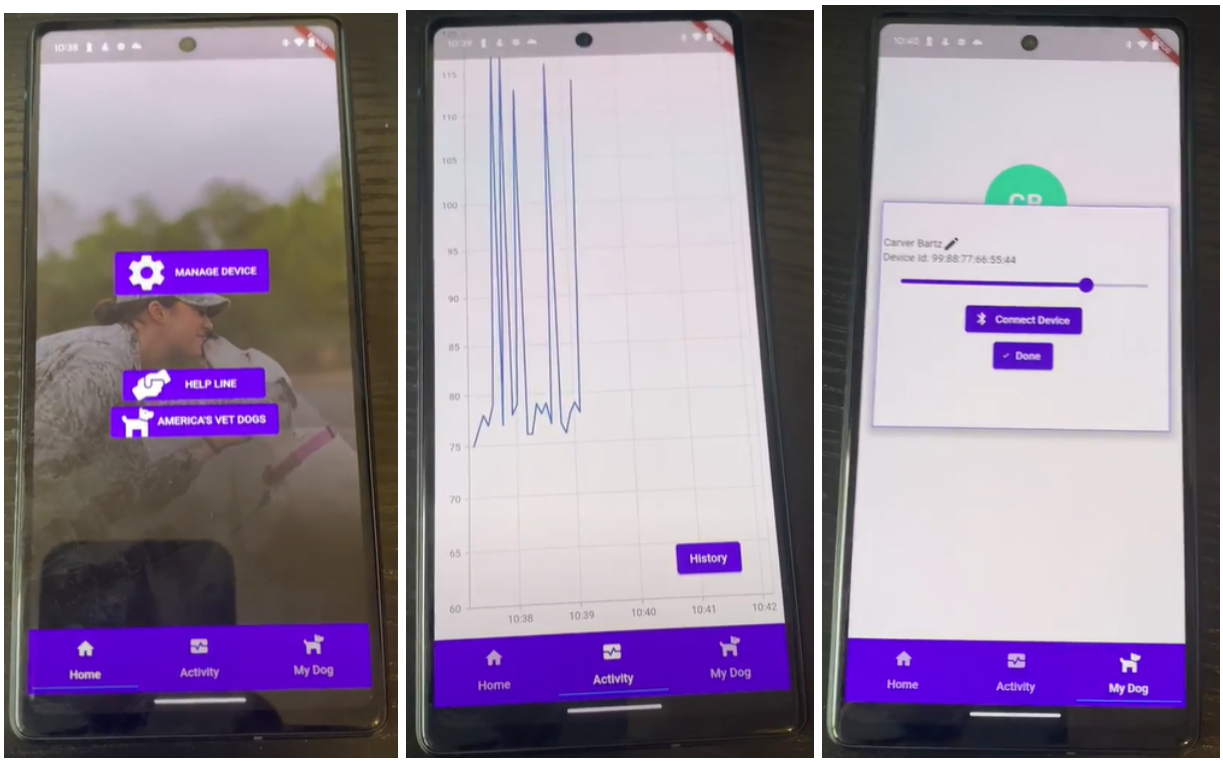


Figure 2: Smartphone application UI (main menu, activity page, bluetooth connection page)

The last subsystem is the smartwatch. The watch we use for testing is a Samsung Smartwatch which collects the user heart rate and sends it to the smartphone. This device is similar to the smartphone in that it is implied that the user will already have this device to have the system work as a whole. With respect to the dog device hardware, we had two system ideas in mind with a hard and soft form factor.

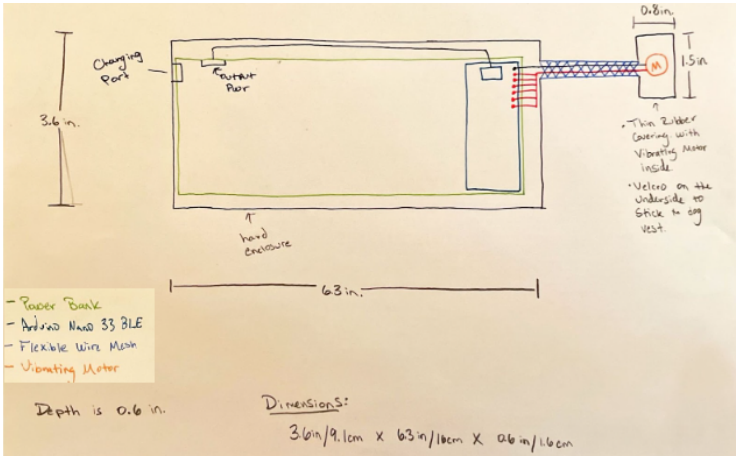


Figure 3: Soft Form Factor Concept

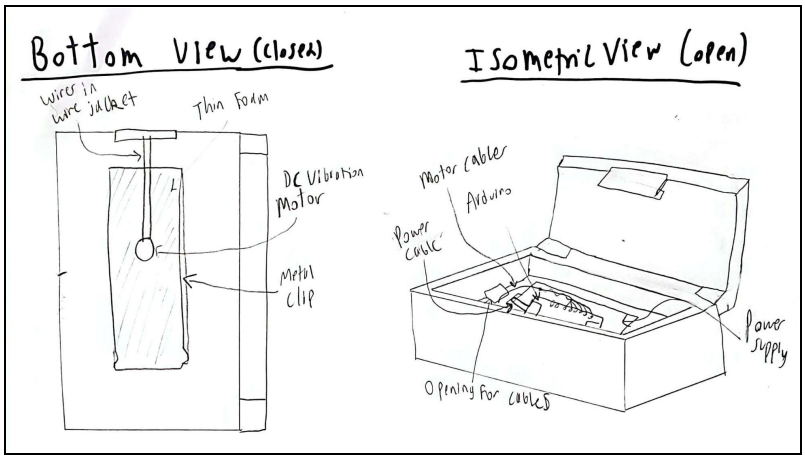


Figure 4: Hard Form Factor Concept

Overall, we decided to use the hard form factor concept since it provided strength and, compared to the soft form factor, was more feasible to create. The main difference from the hard concept to our actual design is that the enclosure is of a different form and the motors are housed inside the device compared to the external application on a clip which is also not used in our final design.

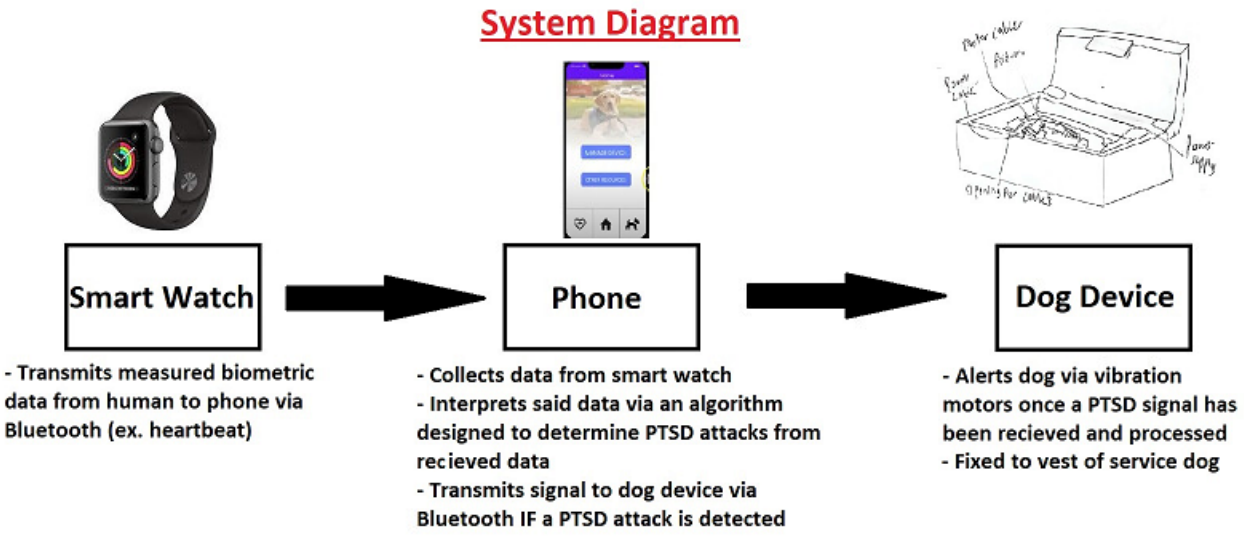


Figure 5: System diagram with a summary of the components

5. Requirements

5.1 Functional Requirements

The app must quickly detect onset symptoms of PTSD episodes by checking the heart rate data collected from the user's smart watch. Once an episode is detected, the service dog must be alerted though the device on its vest in the form of vibration. The device on the service dog must be configurable through the app to increase or decrease the intensity of the vibration motor for more or less sensitive dogs. In addition, the app must have the option to turn off the detection system for when the user is exercising. It also needs to be easy to navigate and be able to run on any common mobile operating system.

5.2 Non-functional Requirements

Various non-functional requirements needed to be addressed in the design, some of which were brought to the team's attention by potential users. One requirement was that the device could not be disruptive to surrounding individuals or other dogs in the area which is why the design uses a vibration motor over a sound frequency only dogs can hear. In addition, accessible to any person with PTSD and therefore affordable to the average person.

5.3 Standards

- IEEE 802.15.6: Wireless Body Area Network (WBAN)

  The WBAN will apply to our project because the application (Program) in the veteran wearable device will collect his or her vitals and send a signal to the service dog device.

- IEEE 802.15.1-2005 : Bluetooth and Bluetooth Low Energy (BLE)

  This standard will apply as both wearable devices will communicate through bluetooth.

- IEEE 1725-2006: Rechargeable Batteries for Cellular Telephones

  These standards also will apply to our project as our program will run in the background of the veteran wearable, and the device on the service dog will require a battery that lasts longer to keep the veteran safe.

- IEEE 12207 : Systems and software engineering – Software life cycle processes

  This standard applies as we went are software components as we want to meet the

  quality management and quality assurance requirements for our software.

- IEEE 7002-2022: Data Privacy Process

  This standard may apply to our project because we collect data about veterans. Data collected will be things like vitals, time of PTSD detected attack, date, location, etc. Since this data may be stored for the user to look over and interact with, we may want to consider this standard to ensure privacy for the user's data.

6. Engineering Constraints

- Quick Signaling
- Relatively lightweight
- Comfortable to both human user and dog
- Financially affordable
- Follows antenna radiation regulations
- Power must last within a days time minimum (~24 hours)

7. Security Concerns

The development of a PTSD detection device raises potential security concerns related to the privacy and protection of sensitive medical information, the protection of the device itself and the safety of individuals using the device.

7.1 Physical Security Concerns

When it comes to physical security, the design of the device requires physical contact with the individual or the dog. It also involves the use of sensors and other equipment that could cause discomfort or injury.

7.2 Cybersecurity Concerns

Our device does not have a cybersecurity concern as the data collected is protected by the manufacturer of the watch.

7.3 Countermeasures

To address these physical concerns, it is important to consider the intended use of the device by using durable materials, incorporating security features, and test the device under various conditions to ensure its reliability and safety.

8. Implementation

The system we have devised consists of 3 subsystems. The first subsystem is the smartwatch which reads heart rate data from a user and transmits said data to the second subsystem being a smartphone. Once the smartphone receives the data via bluetooth, it then logs the data in our own app which processes said data by running an algorithm for PTSD detection. In this algorithm, it looks for a peak of heart rate when compared to the users normal heart rate. Additionally, this app allows user interface capabilities like turning the notifications off while exercising and viewing their data. Finally, if an attack is detected, the smartphone will then send a signal to a device attached to the dog's vest with velcro to alert the dog via vibration. This system consists of a custom enclosure, Arduino Nano 33 Iot, power supply, bluetooth module, and vibration motors.

9. Testing

With respect to the electrical hardware of the dog device, all testing was done physically. When the device was being soldered, all interconnections of pins in parallel and between pins and the vibration motors were tested for continuity with multimeters. The vibration motors due to this testing were guaranteed to have the full power supply necessary for maximum performance and the best chance a notification is received by the animal. When testing physically, we ensured that the vibration is not only felt, but heard through the housing containing electrical hardware for the guarantee that our device will notify the animal no matter how thick their hair, or how distracted the animal may be.

Due to limitations with the watches that were available to us, as well as issues with the bluetooth communication, we had to test everything with mock data. This data was simulated and processed within our app as if it was collected by the smart watch. We were able to successfully show that the app works great. The app could in theory work with the proper smart watch, but due to Samsung and Apple’s limitations with Android applications, we could not demonstrate this fully.

10. Context of Related Products and Literature

10.1 Related Products

On the market there are similar devices to ours. One specific device is called the "Wearable PTSD Therapy Device" by MUSC Health Medical University of South Carolina. This device has a similar but more accurate wrist component that measures the veterans vitals like our smartwatch. For our device we just used the heart rate to determine whether the veteran is about to have a PTSD episode while the device that is made by the MUSC records and watches the heart rate, breathing and emotional distress of the veteran. With that extra information they can more accurately detect a PTSD episode occurring. With this device by MUSC it also alerts a therapist instead of a dog. If their device detects the symptoms of an episode it alerts a therapist that is available to walk them through some exercises that will bring them back to a better place. For our project the dog was alerted via the vibration motors and then the dog would go over and help relax the veteran. Both devices watch the vitals of the individual and then when triggered alert either a dog or therapist to service the individual experiencing the PTSD episode.

10.2 Related Literature

The article that talks about the device in the related products portion of this document can be found at the following link:

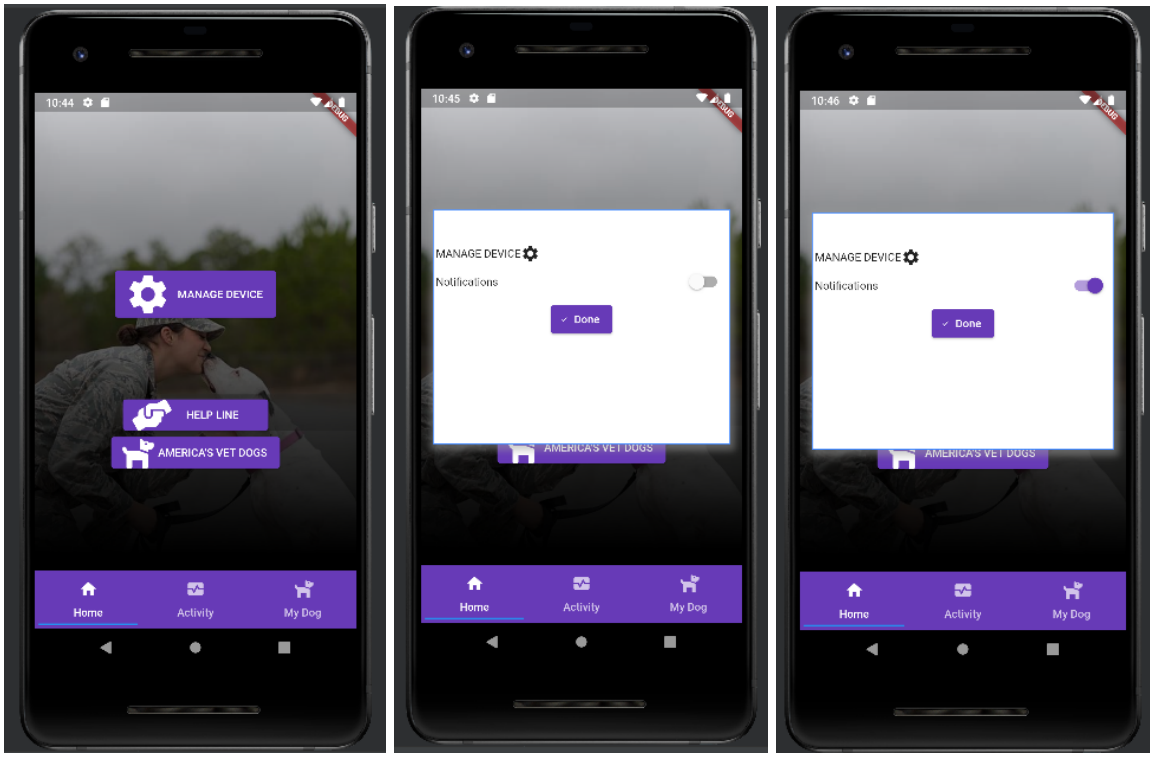
https://musc.bcst.md/news/wearable-ptsd-therapy-device

Appendix I. Operation Manual

With respect to the electrical hardware, in our current mode of operation, as soon as the dog device is powered by the power supply, it will vibrate at maximum notification power. We have it configured in this mode of operation with bluetooth capabilities next in line for development, and had we more time and resources, bluetooth mode would be enabled and the code would be in pairing mode and notify only when a data packet is received over bluetooth. We were unable to utilize the code for this because the bluetooth radios are unable to sustain connections despite our best efforts and trying several different fixes and two iterations of bluetooth modules. To power the dog device first ensure that the power supply is properly charged in order for full vibration. Next connect the micro usb to the power supply and the arduino. When this connection is made, vibration should start immediately. If vibration doesn't start immediately, locate the button on the side of the power supply and press it. If it doesn't start vibration, and no lights light up next to the button, the power supply is dead. In this case ensure the device gets charged and when it is charged, try again. If the supply is now lighting up when pressed, but the dog device is not vibrating, it is malfunctioning. Contact supplier for support on repair or replacement.

For the software there are 3 main pages.

On opening the app, you will see the Home Page. Here you can click manage your device and see “Notifications” next to an on off switch. The positioning of this switch determines if notifications or off or on, simple click to change, and hit done when finished.

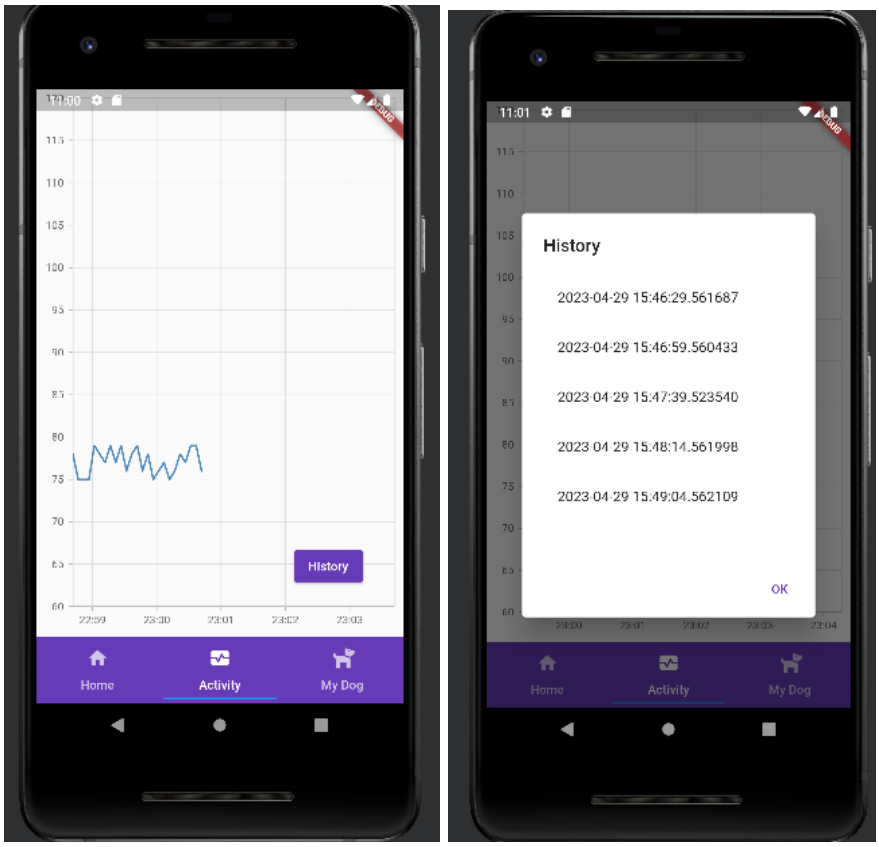


The Help Line button will redirect you to https://www.veteranscrisisline.net

And the America’s Vet Dog will redirect you to https://www.vetdogs.org

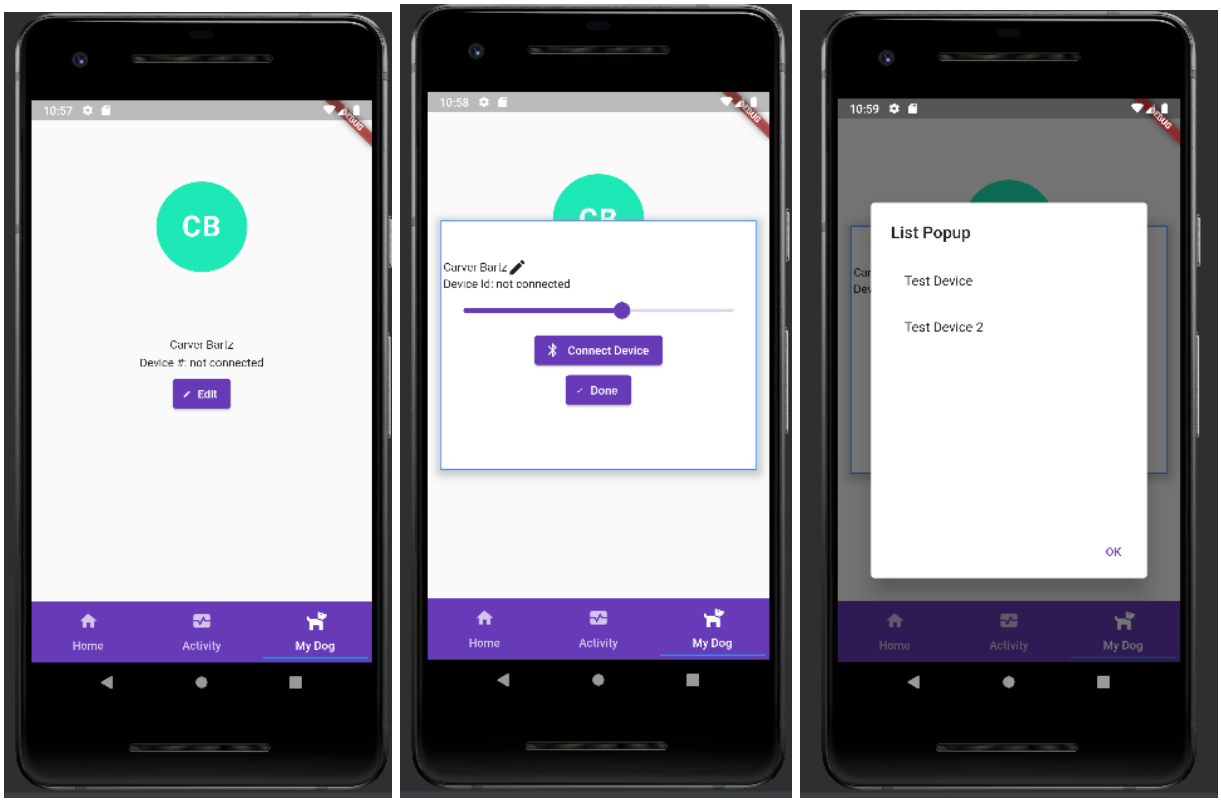
To navigate to the Activity Page, use the tabs located at the bottom and click ‘Activity’.

The activity page is just a live update of your current heart rate. You can use this to gauge your average heart rate, if the rate rate goes up to a certain threshold, the app will assume you are entering a PTSD episode and start sending alerts to and your dog. To view this activity you can click history to see the most recent episodes, this may be helpful information for a healthcare professional.



To navigate to the Dog Page, use the tabs located at the bottom and click ‘My Dog’.

The dog page is where you will connect your dog’s device to your phone. Simply click ‘edit’ and a pop up will appear. You will see a slider, this slider is to turn up and down the strength of the vibration of the dog’s device. Below is the ‘Connect Device’ button, click it and you will soon see another pop-up. Scroll through the list on the provided pop-up and click your Dog’s Device, then hit ‘Ok’ to finish. You are now connected to your dog, you should see the device id number change.

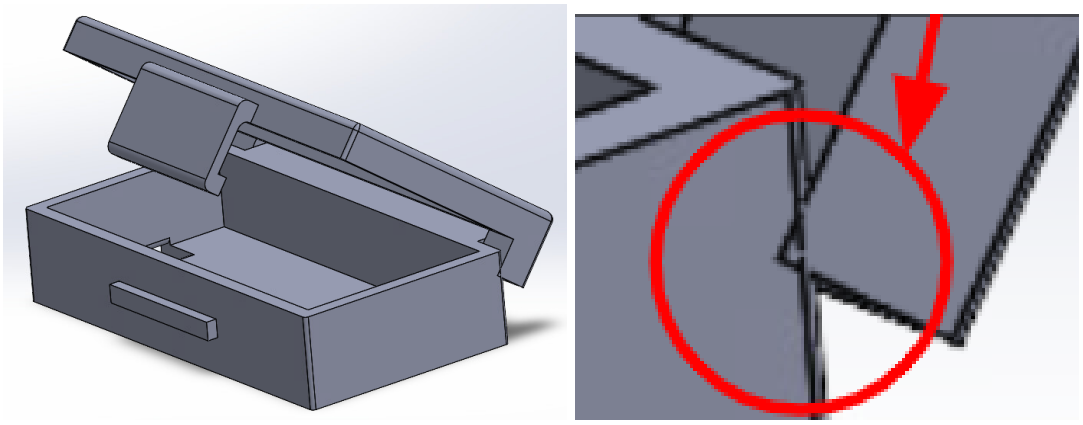


If any pop-up come up to request permission for bluetooth services, you must approve them to connect to dog's device.

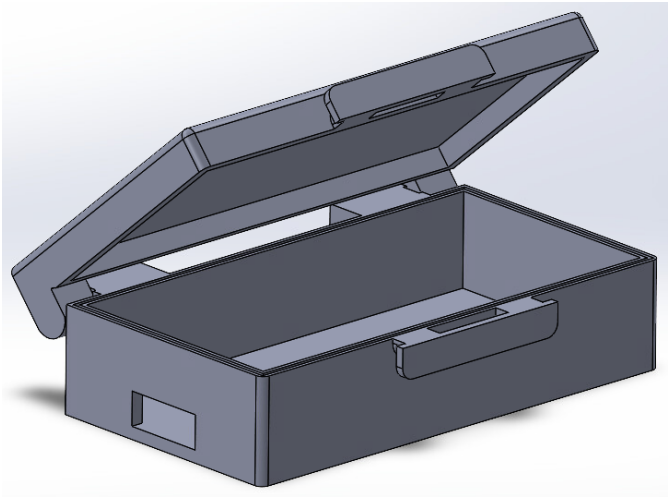
Appendix II. Alternative Designs

Enclosure Alternative Design

Our enclosure went through rigorous testing through trial and error in order to physically see dimensions and functionality with our design. The original design was to utilize a clasping tab that connected to the ridge of the base as shown below...



This design was flawed in 2 ways. The first flaw was the hinges being too rigid and not allowing the design to rotate properly due to there being no room for the lid to rotate. Additionally, when we finally had the parts printed and assembled, the clasp was too thick and inflexible to lock into place therefore making the locking mechanism useless. In order to remedy both of these issues, we were able to create another CAD model which beveled the hinges and revised the closing mechanism by replacing the old system with 2 identical ridges that close one a rubber band was fixed around both pieces. The final design was as follows...



Appendix III. Key Takeaways

In this semester's time, we were able to create and test all the subsystems successfully in a controlled environment. However, when connecting all components as a whole, the system was unable to work correctly due to bluetooth communication complications. With more time, we could most likely continue to fight the bluetooth connectivity issues and eventually come to a resolution to have the communication up and running. Aside from the issues we faced, we all learned an incredibly useful skill transferable through many important things in life which is teamwork. Throughout this project, we were all

able to communicate, conceptualize, and construct a system that works all at the submodule level and satisfy our clients expectations. While the entire design is not perfect, we were able to learn and work with each other effectively.

Appendix IV. Code

https://git.ece.iastate.edu/sd/sdmay23-08/-/tree/dogpage-carver

(dogpage-carver is the most updated branch)

Hardware-electrical code:

```
#include <Arduino.h>
void setup() {
  pinMode(2,OUTPUT);
  pinMode(3,OUTPUT);
  pinMode(4,OUTPUT);
  pinMode(5,OUTPUT);
  pinMode(6,OUTPUT);
  pinMode(8,OUTPUT);
  pinMode(9,OUTPUT);
  pinMode(10,OUTPUT);
  pinMode(11,OUTPUT);
  pinMode(12,OUTPUT);
}

void loop() {
     digitalWrite(2,HIGH);
     digitalWrite(3,HIGH);
     digitalWrite(4,HIGH);
     digitalWrite(5,HIGH);
     digitalWrite(6,HIGH);
     digitalWrite(8,HIGH);
     digitalWrite(9,HIGH);
     digitalWrite(10,HIGH);
```

```
    digitalWrite(11,HIGH);
    digitalWrite(12,HIGH);
    delay(10000);
}
```

Appendix V. Parts List

- Dog vest
- Arduino Nano 33 Iot Microcontroller
- 3 V Vibration Motors
- Power supply (Mobile phone power bank)
- 3D Printed Enclosure
- Velcro strips
- Rubber band
- Bluetooth module (HC-05)