PTSD Detection and Service Dog Alert System

DESIGN DOCUMENT

sdmay23-08
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Executive Summary

Development Standards & Practices Used

List all standard circuit, hardware, software practices used in this project. List all the Engineering standards that apply to this project that were considered.

- Embedded Programming
- IEEE 1725-2006: Rechargeable Batteries for Cellular Telephones
- IEEE 802.15.1: Bluetooth Communication Standard

Summary of Requirements

List all requirements as bullet points in brief.

- Must track and send data to the Dog's 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 much be of usable length

Applicable Courses from Iowa State University Curriculum

List all Iowa State University courses whose contents were applicable to your project.

CPRE 288 : Embedded Systems I: Introduction
EE 201: Electric Circuit
COMS 309: Software Development Practices
ENGL 250: Written, Oral, Visual, and Electronic Composition
ENGL 314/309: Technical Communication /Proposal and Report Writing
SP CM 212: Fundamentals of Public Speaking

New Skills/Knowledge acquired that was not taught in courses

List all new skills/knowledge that your team acquired which was not part of your Iowa State curriculum in order to complete this project.

- Mobile Development
- Flutter Development
- Bluetooth Communication
- Project Management
- PCB design and manufacture
- Arduino programming API for embedded systems
- The use of CAD to develop container for the hardware

Table of Contents

List of figures/tables/symbols/definitions (This should be the similar to the project plan)

Team

Team Members

- Jonathan Pixler
- Sam Brang
- Comlan Bocovo
- Steven Trinco
- Carver Bartz
- Maisy Millage

Required Skill Sets for Your Project

Knowledge of UI, CAD, Bluetooth communication, Electrical components, and Embedded programming.

Skill Sets covered by the Team

UI - Carver Bartz and Maisy Millage

CAD - Steven Trinco and Sam Brang

Bluetooth Communication - Carver Bartz and Jonathan Pixler

Electrical Components - Jonathan Pixler, Comlan Bocovo, Steven Trinco, and Sam Brang

Embedded Programming - Jonathan Pixler

Project Management Style Adopted by the team

Agile

Initial Project Management Roles

- Jonathan Pixler - Embedded Systems and Hardware Design Lead
- Sam Brang - Team organization, Electrical and CAD Design
- Comlan Bocovo - Client Interaction and Software Design

- Steven Trinco - Discord Admin, Hardware and CAD Design
- Carver Bartz - Software Design
- Maisy Millage - Writing and upper-level software

Introduction

Problem Statement

What problem is your project trying to solve? Use non-technical jargon as much as possible. You may find the Problem Statement Worksheet helpful.

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. Our system will use an apple watch 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.

Intended Users and Uses

Who will use the product you create? Who benefits from or will be affected by the results of your project? Who cares that it exists? List as many users or user groups as are relevant to your project. For each user or user group, describe (1) key characteristics (e.g., a persona), (2) need(s) related to the project (e.g., a POV/needs statement), and (3) how they might use or benefit from the product you create. Please include any user research documentation, empathy maps, or other artifacts as appendices.

Our device is intended to be used by veterans with PTSD. However, the device also has the potential to be expanded to help others, including active-duty service members, first responders, and anyone else who has experienced PTSD induced by traumas.

There are a few possible characteristics to help define and understand our users, specifically veterans. They most likely value independence and the ability to serve others. They also might enjoy being active members of society, physically active people, and protecting others from danger. These values are important to recognize because PTSD attacks can affect their ability to comfortably exemplify these values due to the symptom of avoidance.

The user needs the device to detect the first signs of PTSD symptoms so that the dog can help calm the user quickly before the attack worsens. The user would also need this device to be

relatively comfortable on both them and their dog, given that this device will most likely be on them most of the day.

One of the many benefits of this product, if it works as we hope, is that it will shorten the response time for the dog to assist the user. In addition, if the dog is not near or is asleep, the dog will be notified of the PTSD attack and can assist the owner. Lastly, having a device like this can help track when, where, and perhaps why PTSD symptoms are occurring. This information can help further research and understand the specific individual's triggers

○ Requirements & Constraints

List all requirements for your project. Separate your requirements by type, which may include functional requirements (specification), resource requirements, physical requirements, aesthetic requirements, user experiential requirements, economic/market requirements, environmental requirements, UI requirements, and any others relevant to your project. When a requirement is also a quantitative constraint, either separate it into a list of constraints, or annotate at the end of requirement as "(constraint)." Ensure your requirements are realistic, specific, reflective or in support of user needs, and comprehensive.

Functional requirements

- Device detects PTSD episodes through checking user vitals
- Device on dog's collar is alerted when a PTSD episode is detected
- Device(s) are configurable through an app
- App must be able to run on any mobile operating system
- Devices must be able to turn off during exercise
- Quick Signaling (constraint)

Resource Requirements

- Bluetooth connection
- Power supply
- Mobile device to run app
- Fitbit/Apple Watch (device to read vitals)
- Vibration Component

Physical Requirements

- Device is comfortable to wear for both dog and human
- Adjustable for differents types of people and dogs
- Device does not hurt the dog
- Light (as in weight) (constraint)

Aesthetic Requirements

- Device is discrete on user's wrist
- Device is discrete on dog's harness

- Device looks like and/or is comparable to other modern watches (fitbits, apple watches, etc)

User Experiential Requirements

- Device is not disruptive to user's everyday tasks
- Device does not make PTSD episodes worse
- Can be configured to user's needs
- Simple and easy to use
- Ability to look over data
    - Track frequency of PTSD attacks
    - Time of PTSD attack
    - Vitals logged for PTSD attack

Economic/Market Requirements

- Affordable to the average person
- Accessessable to any person with PTSD
- Energy efficient components

Environmental Requirements

- Device is not disruptive to surrounding individuals
- Dog's device is not disruptive to other dogs

UI Requirements

- Navigability
- Simple
- Consistent
- Helpful in emergency situations

○ Engineering Standards

What Engineering standards are likely to apply to your project? Some standards might be built into your requirements (Use 802.11 ac wifi standard) and many others might fall out of design. For each standard listed, also provide a brief justification.

- 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.

3 Project Plan

3.1 Project Management/Tracking Procedures

Which of agile, waterfall or waterfall+agile project management style are you adopting? Justify it with respect to the project goals.

Our group is following an agile management style. Our project will go through multiple iterations as we develop, an agile methodology will be the best practice for this kind of development cycle. Given that our product will be interacting with 2 users (Human and dog users), we will be going back and forth between these two on comfort, utility, convenience, etc. Agile rather than waterfall has flexibility in accommodating between these 2 users criticisms between prototypes and testing.

What will your group use to track progress throughout the course of this and the next semester. This could include Git, Github, Trello, Slack or any other tools helpful in project management.

We are using Github to manage our sprints and keep track of milestones and progress. We have been dividing up tasks and keeping track of completed/incomplete tasks. Meeting notes and discussions are done within discord.

3.2 Task Decomposition

In order to solve the problem at hand, it helps to decompose it into multiple tasks and subtasks and to understand interdependence among tasks. This step might be useful even

if you adopt agile methodology. If you are agile, you can also provide a linear progression of completed requirements aligned with your sprints for the entire project.

App

1. **User Interface**
    a. Design Theme
    b. Main Page
        i. Device Management Pop-up
        ii. Other Resources Pop-up
    c. Activity Page
        i. Graphs
        ii. Other Analytics
    d. Dog Management Page
        i. Dog Manager
2. **Backend**
    a. API/Send-Receive Data
    b. Connecting to devices
    c. Cache Info (Flutter Hive??)
    d. Database? (Firebase??)
    e. Machine Learning Algorithms

Dog Device

1. **First Iteration**
    a. Device Build
        i. Breadboard/jumper wires for connectivity
        ii. Arduinos for central processing and control
        iii. Vibration motor for dog alert
        iv. Bluetooth module for communication between watch and device
        v. 5V source for power
        vi. 3D printed enclosure for structure
    b. Establish connection between Flutter app, phone, and watch
2. **Additional Iterations**
    a. Change enclosure based on how fits
    b. Add PCB to get rid of cumbersome jumper wire/breadboard connection

3.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

What are some key milestones in your proposed project? It may be helpful to develop these milestones for each task and subtask from 2.2. How do you measure progress on a given task? These metrics, preferably quantifiable, should be developed for each task. The milestones should be stated in terms of these metrics: Machine learning algorithm XYZ will classify with 80% accuracy; the pattern recognition logic on FPGA will recognize a pattern every 1 ms (at 1K patterns/sec throughput). ML accuracy target might go up to 90% from 80%.

In an agile development process, these milestones can be refined with successive iterations/sprints (perhaps a subset of your requirements applicable to those sprint).

Since our group is using an agile management style, we anticipate our project will go through multiple iterations as we develop. We will be going back and forth between improving comfort, utility, convenience, etc. Agile as opposed to waterfall has flexibility in accommodating new features or modifying current features during development between prototypes and testing, as opposed to in version 2 of the product.

We will use Github to manage our sprints and keep track of milestones and progress. We will divide up tasks and keep track of completed/incomplete tasks. Meeting notes and discussions are done within discord.

Milestones

- UI allows user to reach 100% features (design/theme is beyond this milestone)
- Machine Learning algorithms are 80% accurate
- Response time from PTSD episode recognized and sent to dog device is less than a second
- Dogs are 99% responsive to device
- Design of sensors and hardware finalized

3.4 Project Timeline/Schedule

• A realistic, well-planned schedule is an essential component of every well-planned project

• Most scheduling errors occur as the result of either not properly identifying all of the necessary activities (tasks and/or subtasks) or not properly estimating the amount of effort required to correctly complete the activity

• A detailed schedule is needed as a part of the plan:

– Start with a Gantt chart showing the tasks (that you developed in 2.2) and associated subtasks versus the proposed project calendar. The Gantt chart shall be referenced and summarized in the text.

– Annotate the Gantt chart with when each project deliverable will be delivered

• Project schedule/Gantt chart can be adapted to Agile or Waterfall development model. For agile, a sprint schedule with specific technical milestones/requirements/targets will work.

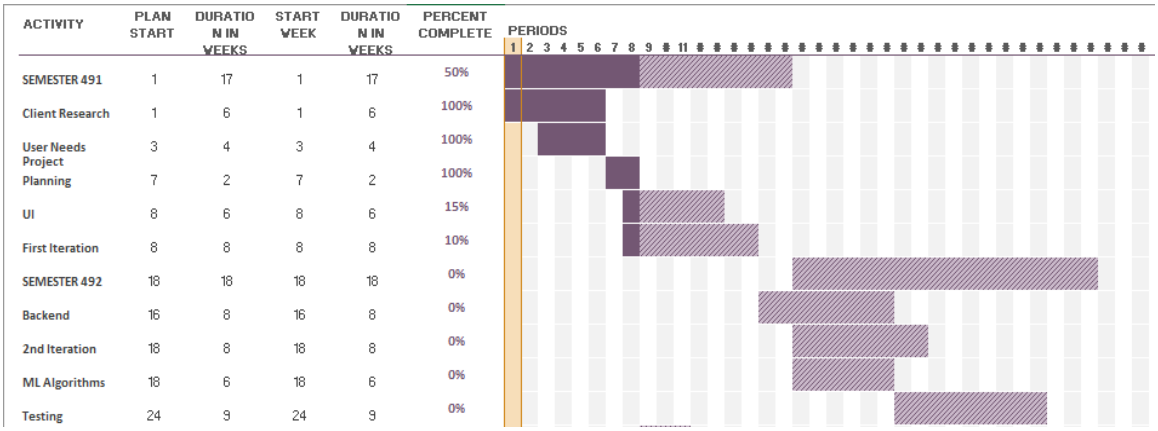

Figure 1 : Project schedule/Gantt chart

3.5 Risks And Risk Management/Mitigation

Consider for each task what risks exist (certain performance targets may not be met; certain tool may not work as expected) and assign an educated guess of probability for that risk. For any risk factor with a probability exceeding 0.5, develop a risk mitigation plan. Can you eliminate that task and add another task or set of tasks that might cost more? Can you buy something off-the-shelf from the market to achieve that functionality? Can you try an alternative tool, technology, algorithm, or board?

Agile project can associate risks and risk mitigation with each sprint.

Agile project management can associate risks and risk mitigation with each sprint. When implementing this style, we will be able to adapt to issues that come up in real time and retarget more efficiently.

Risks (and mitigation):

- Machine learning algorithms will have to be unsupervised (unless further research suggests otherwise) so there is a chance the algorithm will not find anything helpful. To mitigate this risk, we will not completely rely on the algorithm, if vitals are clearly suggesting a possible PTSD attack we will assume it is. (Risk Rating 0.6)
- Users may feel our system is intrusive. To mitigate this risk we are making our system as configurable as possible, allowing them to turn features off and on, even customizable, so the device is comfortable and non-intrusive for all users and dogs. (Risk Rating 0.7)
- Dogs may find the device too uncomfortable or may not respond to the stimuli we provide. This would hinder the dog's ability to respond and be trained using the vibration stimuli. To mitigate this risk we are including buffer room for multiple iterations of the Dog's device design as well as time for testing on dogs. Additionally, the configurability of the device should allow the user to adjust the vibration motor to best suite the individual dog. (Risk Rating 0.3)

- Hardware may not be capable of meeting our requirements. To mitigate this risk we our ordering multiple versions of our hardware modules so that we can figure out which is best fit for our system (Risk rating 0.3)
- Devices may incorrectly detect PTSD attacks (false positives). To mitigate this risk, we are offering the user the ability to turn off and on the device if they anticipate doing an activity that may raise their heart rate (exercise, roller coasters, etc). (Risk Rating 0.7)

3.6 Personnel Effort Requirements

Include a detailed estimate in the form of a table accompanied by a textual reference and explanation. This estimate shall be done on a task-by-task basis and should be the projected effort in total number of person-hours required to perform the task.

Personal Effort Requirements	
Task	**Time (hours)**
UI-Main Page	4
UI-Activity Page	4
UI-Dog Management Page	4
Backend-Main Page	5-7
Backend-Activity Page	5-7
Backend-Dog Page	5-7
Backend-Machine Learning (Learning Curve)	10-15
Backend-Caching User Info	4
Create Schematic and find compatible parts	5
Order Parts For Device	0.5
Connect Core connections to Arduino (Power and communication)	0.5
Program Arduino for core functions	5
Test Core Connections/Functions	3
Connect peripherals to Arduino (vibration device)	0.5
Program Arduino for Peripheral Function	0.5
Test Peripheral Function	2
Create Enclosure and Holding Device	10

Test on Dog (Multiple types of service dogs with different size vests)	20
(After First Iteration)	
Create PCB Add on To Arduino	8-15
Reconnect Devices	0.5
Create Enclosure for Device (CAD)	2
3D Print Enclosure and Integrate (Hours include printing time)	8-15
Reiterate Enclosure Design for Comfortability and Utility	Indeterminate
TOTAL	~115

Table 1: Effort Requirement

3.7 Other Resource Requirements

Identify the other resources aside from financial (such as parts and materials) required to complete the project.

We want to meet with a veteran with PTSD and their trained service dog. The veteran will serve as a knowledge base for answering our questions regarding what they want the device to look like, feel like, and how they want it to work. Once we have built a device, we want to test it on the service dog in conjunction with the watch on the veteran to determine that its responsiveness and accuracy is enough to effectively detect the user's PTSD and quick enough for the dog to react faster than it normally would.

4 Design

4.1 Design Context

4.1.1 Broader Context

Describe the broader context in which your design problem is situated. What communities are you designing for? What communities are affected by your design? What societal needs does your project address?

List relevant considerations related to your project in each of the following areas:

Area	Description
Public health, safety, and welfare	Our system will reduce the response time for a service dog to recognizing their owners PTSD episode, meaning the user's will experience less traumatic PTSD episodes resulting in an improved quality of life for our users.

Global, cultural, and social	The development of this device has the potential to change cultural and societal stigmas associated with PTSD by improving possibilities for people suffering from PTSD. The development of this device brings awareness about PTSD without bringing attention to an individual during a PTSD attack due to the design of discreet detection.
Environmental	Much of our product is just an application for user's to download on their phones, meaning production and usage of our product will have limited impact on the environment
Economic	Our product has the possibility to reduce the cost of training a service dog, thus making them more affordable for our customers.

4.1.2 Prior Work/Solutions

Include relevant background/literature review for the project

– If similar products exist in the market, describe what has already been done

– If you are following previous work, cite that and discuss the advantages/shortcomings

– Note that while you are not expected to "compete" with other existing products / research groups, you should be able to differentiate your project from what is available. Thus, provide a list of pros and cons of your target solution compared to all other related products/systems.

Detail any similar products or research done on this topic previously. Please cite your sources and include them in your references. All figures must be captioned and referenced in your text.

Relevant Prior Work for Dog Device:

Market Products Available:

1. Haptic Vibration Collar for dog training [1]

   Uses vibrations to alert a dog to problematic behavior. These devices are widely used for correcting bad behavior in dogs. This device is a collar that has prongs for sending vibrations directly to the skin on the dog's neck. These prongs allow for better sensation transfer from the haptic collar to the dog [1].

   Pros: Does not need a vest to be attached to the dog

   Cons: Somewhat uncomfortable for the dog depending on proper adjustment

Additional Research on Haptic Devices for dog training:

1. A Vibrotactile Vest for Remote Human-Dog Communication [2]

Research on developing and implementing a haptic vest for training dogs via vibrational motors and various programmable stimuli associated with certain commands. This literature highlights some design considerations for implementing haptic feedback inside a worn vest. The paper highlights issues when sending vibrations to certain areas on the dog's back that may be less sensitive to haptic feedback and how to adjust for issues like these [2].

Relevant Prior Work for User (Human) Device:

Market Products Available (Disclaimer: These devices do not detect PTSD and is not intended to do so but in relation to our project, we will be using pre existing technology for the human user and compare them on a basis of their functionalities relevant to what we want to do and other devices/products that do them.):

1. Apple Watch

   An Apple Watch tracks biometric data and gives the user a visual interpretation of it either with numbers or diagrams. It has software and hardware to detect any critical abnormalities and learn from users in normal states. However, it is not made to detect PTSD but can detect states that PTSD triggers. [3]

   Pros: Best fitness companions; has both electrical and optical heart rate sensor; can warn the user of any abnormalities, either high or low beats per minute.

   Cons: Cannot detect if it is PTSD episode

2. Fitbit

   A Fitbit can track the user's biometric data and can give the user a visual interpretation of it with numbers and diagrams. It also can detect fight or flight response triggers. While this is not entirely made to function as a PTSD device, it can track stress levels,heart rate, etc. which all contribute to PTSD. [4]

   Pros: Can track biometric data and warn you in the case of critical abnormalities.

   Cons: Does not warn service dogs of this biometric data in the case it is critical to a PTSD attack. Not made to track PTSD episodes.

Relevant Prior Work for Detection Algorithms:

Heart Rate and Body Acceleration

One study tested whether smart watches could detect PTSD events using the heart rate data. The researchers found that it could track the event, but with some error during movement or physical activity. However, they deduced that while using heart rate data and body acceleration data together, the accuracy improved and “enable[ed] algorithms to

distinguish between heart rate fluctuations due to physical activity and heart rate fluctuations due to mental stress." [5]

Pros: Able to distinguish between physical activity and stress.

Cons: 0.7 AUC (fair to poor accuracy)

Heart Rate Variability

Another study was able to use a watch which tracked both heart rate variability and actigraphic data— sleep parameters and average motor activity over a period of days—to classify and predict PTSD events. In addition the researchers were able to develop a method that " automatically detect[ed] rest and activity periods of the day using the cosinor analysis." [6]

Pros: Able to detect rest and activity. With user input, AUC increased to .77 (fair accuracy), showing that user input can be helpful to improve data and the results

Cons: Without user data, 0.7 AUC (fair to poor accuracy)

4.1.3 Technical Complexity

Provide evidence that your project is of sufficient technical complexity. Use the following metric or argue for one of your own. Justify your statements (e.g., list the components/subsystems and describe the applicable scientific, mathematical, or engineering principles)

1. **The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles –AND–**
2. **The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.**

1. Our App is built using Flutter as a framework and an MVC design pattern.

2. Machine Learning elements will require further technical research as well as statistical analysis knowledge.

4.2 Design Exploration

4.2.1 Design Decisions

List key design decisions (at least three) that you have made or will need to make in relation to your proposed solution. These can include, but are not limited to, materials, subsystems, physical components, sensors/chips/devices, physical layout, features, etc. Describe why these decisions are important to project success.

Key Dog Device Design Decisions:

1. Arduino Nano BLE (Decision Made)

The Arduino our team chose has a built-in Bluetooth module capable of 5.0 Bluetooth connectivity and low power consumption. This is an important design decision because it allows us to maintain small dimensions for the circuitry of the dog's device and implement IEEE standards for Bluetooth connectivity.

2. Vibration Motors (Decision Made)

   The vibration motors will provide a form of feedback to a dog. It is an important feature to allow us to give a stimulus to the dog without hurting or hindering it. Configurability of these vibration motors is another important feature which will allow for adjustments to be made individually depending on the dog's size and weight or his hair.

3. Design of Device Attachment

   After discussing it with the veterans, our team has decided to use the dog's service vest to attach the device. The vest will allow for a slightly larger device than what a collar would allow. In addition, it can be attached more securely in a way that will not be at risk to fall off or be too far away from the dog's body to work effectively.

4.2.2 Ideation

For at least one design decision, describe how you ideated or identified potential options (e.g., lotus blossom technique). Describe at least five options that you considered.

	Made with 3d printing filament and metal clip			Integrated ports for motors, enclosure, and wiring			Made with 3d printing filament and Velcro (with adhesive connection)	
Made by connecting 3 parts excluding the electronics	Clamshell Container with Clip	Rigid and robust to physical contact	Flexible and fitted custom to the dog	Vest with Fixed Clamshell Container	Fixed to the dog over the entire body	Made with connecting 2 parts and fixing velcro to device and dog vest	Clamshell Container with Velcro	Flexible connection with velcro attaching device to vest
	Fixed to vest via clip						Enslosure is rigid and robust to physical cotact	
			Clamshell Container with Clip	Vest with Fixed Clamshell Container	Clamshell Container with Velcro			
				Design of Device Attachment				
			Collar Fixed Design		Collar Hanging Design			
	Made from 3d printed enclosure with metal clip						Hangs from dog collar for easy on and off attachment	
Rather than hang, this design is more static and closer to sensitive area in dog	Collar Fixed Design	Fixed to the collar of the dog via clip				Made from clip and 3d printed enclosure	Collar Hanging Design	Made more for audio alert rather than vibration
	Made from clip and 3d printed enclosure							

Table 2: Ideation

As shown in the lotus blossom, for our design of device attachment, we had many different options on how we wanted to house and fix our device to the dog. Out of all the options, we are currently focused on the clamshell container with a clip given that it is not only economically feasible, but also easy to test, use and design. For the rest of the designs, some required dog alert styles that we no longer use such as the collar hanging design or were too difficult to make like the vest with integrated clamshell container.

4.2.3 Decision-Making and Trade-Off

Demonstrate the process you used to identify the pros and cons or trade-offs between each of your ideated options. You may wish you include a weighted decision matrix or other relevant tool. Describe the option you chose and why you chose it.

We chose to go with the lotus blossom method because it gave us a clear view of the characteristics of each design decision. From there, we talked every time we met to work on the technical components. During these talks we kept the comfort of the dog as the highest priority. As more of the design came along, we crossed off several of our ideas because of how difficult they'd be to make comfortable for the dog. In the end we found our slim under vest design to be the most optimal for both comfort and functionality.

4.3 Proposed Design

4.3.1 Overview

Provide a high-level description of your current design. This description should be understandable to non-engineers (i.e., the general public). Describe key components or subsystems and how they contribute to the overall design. You may wish to include a basic block diagram, infographic, or other visual to help communicate the overall design.

Our system involves 3 main components; a fitness watch, mobile application, and a custom produced vibrating dog collar. Our goal is to create a system that detects PTSD episodes from a human user and alert their service dog through a vibrating collar. The fitness watch's role in this system is to gather the vitals that will be necessary to conclude the user is having a PTSD attack. The mobile application will be installed on the fitness watch and will be responsible for handling the information gathered by the watch and determining if the vitals are showing a clear sign of PTSD. The mobile app will also be connected to the dog collar via Bluetooth and send a message to the dog collar to inform the collar to vibrate in order to alert the dog of an attack.

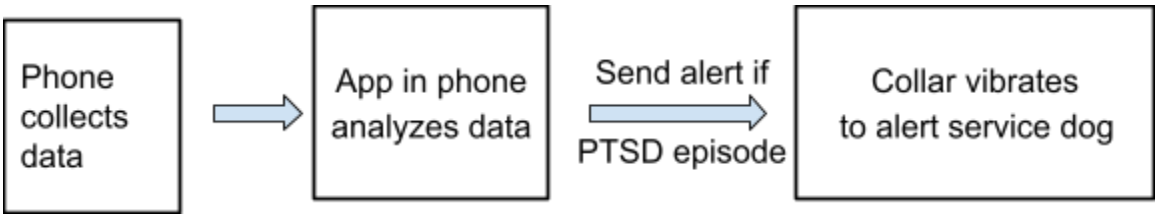

Figure 2: Functional diagram

4.3.2 Detailed Design and Visual(s)

Provide a detailed, technical description of your design, aided by visualizations. This description should be understandable to peer engineers. In other words, it should be clearly written and sufficiently detail such that another senior design team can look through it and implement it.

The description should include a high-level overview written for peer engineers. This should list all sub-systems or components, their role in the whole system, and how they will be integrated or interconnected. A visual should accompany this description. Typically, a detailed block diagram will suffice, but other visual forms can be acceptable.

The description should also include more specific descriptions of subsystems and components (e.g., their internal operations). Once again, a good rule of thumb is: could another engineer with similar expertise build the component/sub-system based on your description? Use visualizations to support your descriptions. Different visual types may be relevant to different types of projects, components, or subsystems. You may include, but are not limited to: block diagrams, circuit diagrams, sketches/pictures of physical components and their operation, wireframes, etc.

The dog device consists of an arduino, a custom pcb. and a vibration motor. We will design the pcb in a way that allows the arduino controller to be slid into place, connecting all the proper GPIO pins, and allowing for mounting screws to slide through holes in the board to secure the controller. From here, we have a 3D printed rectangular housing that will have slots to slide the board in and secure it inside. It will also have a mounting area to securely attach the vibration motor to the housing to reduce vibration noise. There will be space to slide in and secure a battery before closing the housing after everything has been secured with a binding agent to further reduce vibration noise. The arduino will have C code running onboard that will be transmitting and receiving data over the bluetooth connection to the apple watch application that is written in flutter.

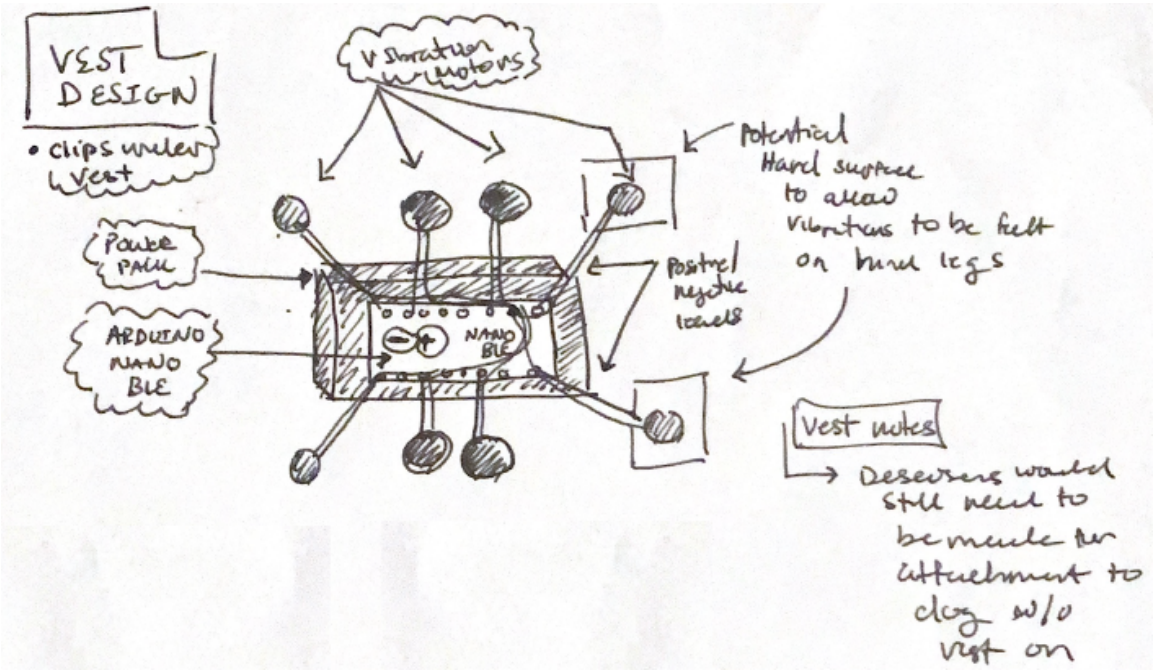

Figure 3: Initial Dog Device Model Without Enclosure On

Flutter app:

Our software app follows an MVC design. We will implement a service to receive data from the user's fitness watch either via fitbitter or Apple watch's flutter package. We will update the backend components of this which will call listeners to update the views (main screen, Home Screen, activity screen, dog screen, etc). The service will also allow us to send a notification to the user upon the detection of a PTSD attack as well as a signal to the Dog's collar via Bluetooth module.

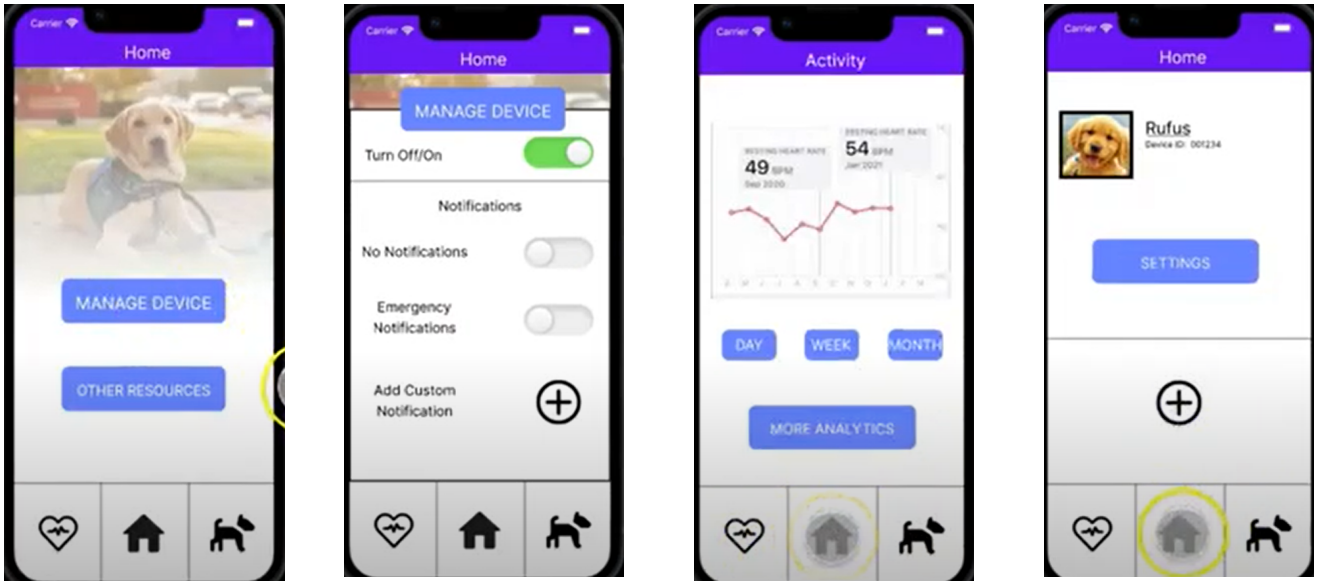

Figure 4: User Interface

4.3.3 Functionality

Describe how your design is intended to operate in its user and/or real-world context. What would a user do? How would the device/system/etc. respond? This description can be supplemented by a visual, such as a timeline, storyboard, or sketch.

In the real world, this device will be used on the service dog and the veteran worn smart watch. These platforms will be linked over bluetooth, and will be installed on the wrist and under the service dog vest. During operation, the watch will monitor the user's heart rate for irregular heart rates. When it detects an irregular heart rate, it will cross reference the heart rate information with the other gyroscopic, altitude, and gps sensor data to determine if the user is having a PTSD attack, or if they are performing a physically demanding task triggering a false positive. When a positive PTSD attack is determined, the device will send a message over bluetooth to the dog worn device to alert the dog of the attack in progress. The dog will require some training to recognize what the vibration sensation indicates, but once trained it will know this means it needs to focus on the user to bring them out of that attack.

4.3.4 Areas of Concern and Development

How well does/will the current design satisfy requirements and meet user needs?

Based on your current design, what are your primary concerns for delivering a product/system that addresses requirements and meets user and client needs?

What are your immediate plans for developing the solution to address those concerns? What questions do you have for clients, TAs, and faculty advisers?

Currently our design will satisfy the requirements and meet user needs as best as we are able to on the budget we are provided. The task of determining a psychological condition based solely off of physiological symptoms is incredibly difficult, and is limited extremely by the design requirements of not having anything but a smartwatch sized device. We cannot add any sensors onto this apple watch sensing device, which leaves us the activity detection and heartbeat monitoring alone to detect. We believe that this can provide a function and usable prototype, but further funding and technical resource knowledge from apple level user device design and manufacturing is required to make a device that will function faster than a $75,000 trained animal. We believe that this prototype will aid in adding more detected PTSD attacks by reminding the dog to look at the user when an attack is detected. If for any reason the dog was distracted or preoccupied, this device will detect attacks that the dog isn't aware of and refocus the dog on its job to stop the attack faster than if the device wasn't present.

4.4 Technology Considerations

Describe the distinct technologies you are using in your design. Highlight the strengths, weaknesses, and trade-offs made in technology available. Discuss possible solutions and design alternatives.

Flutter Framework:

Our team is choosing to use a flutter framework to build our mobile app for a variety of reasons. The first being, flutter allows easy cross-platform development, regardless of the operating system we are developing on, this means we can develop for web, iOS, and android all within our Windows machines. Secondly, flutter provides a host of libraries that will make development significantly easier, including libraries to integrate with Bluetooth modules, arduinos, Apple watches, fitbits, and more. Finally, their is experience in developing with flutter in our team, making it an easy choice. Only weakness we anticipate is there are still some limitations to iOS development specifically, but flutter will meet around 90% of our needs.

Fitness Smart Watch

Our team is choosing a fitness smart watch such as the Fitbit or Apple Watch given that making a device such as the ones provided would be costly in both time and resources. Competing with devices that have already been out and honed in monitoring biometrics of humans would be incredibly difficult and is the reason we chose an already existing device to begin with. The strengths as mentioned before is the fact that this device already has algorithms and measurement systems built into them and all we have to do is interpret them. A weakness of this device is the fact that they are quite costly when purchased brand new. For our prototype, we will be buying a preowned device in order to cut costs.

Arduino

Our team is choosing the Arduino Nano 33 BLE as our microcontroller that goes on to the dog. The strengths of such a device is good processing power, small power use, bluetooth connection, and small form factor that are all desirable traits for our dog device. A weakness of this device is that interfacing with the pins requires lots of wiring which will require cable management and ways to minimize said cable mess. There have been other alternatives such as the Raspberry Pi

but this device we are all familiar with and has similar features therefore we choose the Arduino Nano 33 BLE.

PCB Breakout Box

This piece of technology is a PCB board customly designed by our team in order to declutter the cables on top of the Arduino. The strength of doing so is the fact that it minimizes space our device takes up by routing wires and components via a small/thin PCB. The weaknesses of this is the fact that we will have to create a custom board which requires a learning curve of PCB design which not many of us are experienced with.

4.5 Design Analysis

Discuss what you have done so far, i.e., what have you built, implemented, or tested? Did your proposed design from 4.3 work? Why or why not? Based on what has worked or not worked (e.g., what you have or haven't been able to build, what functioned as expected or not), what plans do you have for future design and implementation work? For example, are there implications for the overall feasibility of your design or have you just experienced build issues?

So far we have been able to design, code, and deliver a flutter coded application for prototyping communications between hardware and software. This has been the only thing thus far that we have been able to test because we have been chasing down how to get approval to order parts for most of the semester. We have successfully gotten approval, and have successfully ordered the parts necessary for the first prototype of our system. So far our proposed design from 4.3 for the flutter application has worked. Based on my previous experience in embedded systems and hardware design, I am confident that the parts we ordered with the dog device will produce a functional prototype. So far the overall feasibility of our design is intact, remaining solid. We will need to set out on building our hardware prototype next in our future design and implementation work. Once these two systems are functioning independently, we will need to design and implement a bluetooth communication API for our device.

5 Testing

Testing is an extremely important component of most projects, whether it involves a circuit, a process, power system, or software.

The testing plan should connect the requirements and the design to the adopted test strategy and instruments. In this overarching introduction, given an overview of the testing strategy and your team's overall testing philosophy. Emphasize any unique challenges to testing for your system/design.

In the sections below, describe specific methods for testing. You may include additional types of testing, if applicable to your design. If a particular type of testing is not applicable to your project, you must justify why you are not including it.

When writing your testing planning consider a few guidelines:

- **Is our testing plan unique to our project? (It should be)**
- **Are you testing related to all requirements? For requirements you're not testing (e.g., cost related requirements) can you justify their exclusion?**
- **Is your testing plan comprehensive?**
- **When should you be testing? (In most cases, it's early and often, not at the end of the project)**

5.1 Unit Testing

What units are being tested? How? Tools?

For our testing, we will be testing several metrics. One of the major metrics is the response time of the dog to the PTSD signal sent to the dog device. The response time can be measured by timing the delay with a stopwatch from when the signal is applied to when the dog shows a physical reaction. The forced signal will be applied via phone or watch and connected to the dog device. Once this has been proven, we then plan on testing the dog's reaction time to go from the forced signal to going to assist the veteran. Again, this can be tested by forcing a signal via phone or watch to the dog device and beginning measurement via a stopwatch from when the signal is sent to when the dog goes to do its routine with the veteran. Both these tests will be measurements of time (in seconds, most likely), measuring the time it takes our device to function as intended when interfacing with the human and dog. When it comes to the dog device battery life, we plan on testing the lifetime of this device by using a voltmeter to measure the battery's nominal voltage throughout a given time interval. The reason for such a test is to ensure that our device's lifetime is sustainable over a reasonable period of time that this device will be utilized. We will use time functions and battery voltage sampling with different sample rates of refresh, checking the heart rate of the watch device to ensure we dial in the proper battery life specified by the client. We will run manual tests on hardware to test vibration for physical feel to ensure the vibration motor is properly soldered to the device

We plan to implement multiple dart unit tests for the software to test various use cases and functionality. To test a use case, our test will simulate a user and ensure that the flow of the use case can be accomplished. For example, if a user wants to navigate to the home page from the dog's setting page, we will provide our test case with the setting page and have it simulate tapping the necessary buttons that would navigate the user to the home page. We will also use mock objects to test various functionality, such as sending and receiving, and storing data between all three devices involved in our system.

5.2 Interface Testing

What are the interfaces in your design? Discuss how the composition of two or more units (interfaces) are being tested. Tools?

Our interface testing will be testing how the devices interact with each other. The tests for the user fitness device have already been tested through their respective manufacturers. Our app will use mock objects to test (in flutter/dart this done with Mockito) to test edge cases (the data is smaller or greater than expected data), and test various workloads (large/small amounts of data coming in or sending out). When the hardware device is being tested, we will verify the physical impulse of vibration motors. We will test bluetooth connection by pinging back and forth over the bluetooth connection, as well as executing all functions that are supported over our bluetooth protocol to ensure all sensors are functioning properly. We will also send tests to the battery to send

it under load by engaging all vibration motors to draw current and measure how hard the voltage sags under load. If the battery doesn't pass the test, it will indicate if it needs to be replaced. We will also test the optimal sampling of the heart rate to not kill the battery of the watch too quickly. This will be done using time functions to save time differences and testing different sampling rates and the value of the battery voltage before and after these sample rate tests.

5.3 Integration Testing

What are the critical integration paths in your design? Justification for criticality may come from your requirements. How will they be tested? Tools?

Our plan for this is to emulate the app within android studios (if possible run on an actual device), and attempt to connect to our prototyped hardware. We will provide both the devices with various debugging tools, to ensure that we can see the connection is established, and data can be sent and received between the two devices. The most critical point of integration is on the bluetooth protocol. To begin, we will write mock response code and testing on each device to test when coding that nothing breaks before integration. During integration we will make tests of every function in our API that will test communication between the two devices fully to validate it is up to spec.

5.4 System Testing

Describe system level testing strategy. What set of unit tests, interface tests, and integration tests suffice for system level testing? This should be closely tied to the requirements. Tools?

All functions will have mock responses for each function testing to ensure that code doesn't break when changes are made when not connected to a hardware device. There will be a similar test protocol for the hardware device that will run through all functions provided by the hardware API with mock instructions and responses from the watch. There will be a final system level protocol that will test everything while connected with real commands and responses for full system testing coverage.

5.5 Regression Testing

How are you ensuring that any new additions do not break the old functionality? What implemented critical features do you need to ensure they do not break? Is it driven by requirements? Tools?

Our unit tests will be responsible for ensuring working functionality does not break as we continue to add new additions. We are aiming for a code coverage of 80% (this final number will be provided by client), a strong code coverage will ensure that if a faulty change is made, a unit test will fail indicating that the change has broken something. With all functions being tested, we can make changes and test them before pushing any code to the repository. This will keep our software functioning as expected over multiple iterations of refactoring and adding new functions.

5.6 Acceptance Testing

How will you demonstrate that the design requirements, both functional and non-functional are being met? How would you involve your client in the acceptance testing?

We will be noting our requirements being met by physically/electronically keeping a testing document on us with written requirements from both our team and client noting our progress, success, and details of said requirements. We could also potentially record or take pictures of us testing the requirements to enhance our proof even more. We plan to involve our client in this acceptance testing by notifying them when they have been met at the next meeting via sharing our documentation of said testing and also verbally explaining it to them. Given that we will require service dogs for our training, we also will be involving them physically by having them with us when we test our device on the dogs to make sure we are handling them properly.

5.7 Security Testing (if applicable)

We have a closed loop system containing non-sensitive data, so this isn't a high concern. Functionality is of highest importance.

5.8 Results

What are the results of your testing? How do they ensure compliance with the requirements? Include figures and tables to explain your testing process better. A summary narrative concluding that your design is as intended is useful.

The result of our testing is a prebuilt code base to test all usage cases of our system at the press of a button. This can be ran at any time when coding, providing instant feedback to errors, reducing problems from faulty code being unchecked. The requirements will be programmed into the testing to ensure if anything breaks and a requirement is not being fulfilled, it will be caught and handled before becoming an issue. Our testing will ensure that the design of the arduino based vibration system, and the apple watch based sensing mechanism, will be able to catch cases of PTSD attacks whenever the dog isn't focused or aware. This will dramatically reduce the number of flare ups, and the severity of their impact when they do occur. It will provide our users with a better mindset everyday knowing they have an extra layer of protection from their disease when going throughout their day. This will profoundly improve the mental health of our users and dramatically improve the quality of life of our users by reducing all of the negative impacts of PTSD more effectively than any other available solution on the market.

Test first approach:

Determine function to add → Write test of function output → Write code to implement function →
← Repeat ← Refactor ← Run Test Code ←

6 Implementation

Describe any (preliminary) implementation plan for the next semester for your proposed design in 3.3. If your project has inseparable activities between design and implementation, you can list them either in the Design section or this section.

We have currently designed the flutter application and coded most of the front end of the phone and watch application. We have also acquired the parts for the dog device and developed a vibration controlled by the arduino microcontroller. Moving forward, we will be implementing bluetooth communication between the dog device and the user device. We will be designing a custom PCB and housing for the dog unit in the next semester.

7 Professional Responsibility

This discussion is with respect to the paper titled " Contextualizing Professionalism in Capstone Projects Using the IDEALS Professional Responsibility Assessment", *International Journal of Engineering Education* Vol. 28, No. 2, pp. 416–424, 2012

7.1 Areas of Responsibility

Pick one of IEEE, ACM, or SE code of ethics. Add a column to Table 1 from the paper corresponding to the society-specific code of ethics selected above. State how it addresses each of the areas of seven professional responsibilities in the table. Briefly describe each entry added to the table in your own words. How does the IEEE, ACM, or SE code of ethics differ from the NSPE version for each area?

- Work competence, IEEE 6 states to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience or after full disclosure of pertinent limitations.
- Financial Responsibility, IEEE 2 states to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems.
- Communication Honesty, IEEE 4 states to avoid unlawful conduct in professional activities and to reject bribery in all its forms.
- Health safety and well being, IEEE 1 states to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to promptly disclose factors that might endanger the public or the environment.
- Property ownership, IEEE 5 states to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, to be honest, and realistic in stating claims or estimates based on available data, and to properly credit the contributions of others.
- Sustainability, IEEE 1 states to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to promptly disclose factors that might endanger the public or the environment.
- Social responsibility, IEEE 2 states to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems.

7.2 Project Specific Professional Responsibility Areas

For each of the professional responsibility area in Table 1, discuss whether it applies in your project's professional context. Why yes or why not? How well is your team performing

(High, Medium, Low, N/A) in each of the seven areas of professional responsibility, again in the context of your project. Justify.

1. High - Our team is combining the skills we have learned and has a design that is in the progress of being assembled that will effectively meet the requirements

2. High - Our team has managed to keep the overall cost of the device below $200 even if they have no watch device and must purchase that in the package.

3. High - Our team has effectively communicated design difficulties with our client and come to satisfactory solutions for all parties.

4. High - Our team has placed the utmost importance on the comfort of the end design and has ensured there will be no danger of components shorting to create fire hazards if the device is jostled during normal use.

5. High - Our team has listened to and performed the tasks, and design specifications asked of us by our client.

6. High - Our team has considered the implications and found there is nothing further we can do to reduce impact.

7. High - Our team has made sure to design this device out of commonly available parts so it will not be affected by the parts shortages, and we have effectively designed something that will be safe with little disturbance to the animal in alerts of PTSD attacks in progress.

7.3 Most Applicable Professional Responsibility Area

Our team has taken property ownership into the largest level of account during our design. Initially, it was difficult for the client to work with us to find an effective way to design the device that would perform most of the functions they wanted, with no trade-offs in the difficulty of design and requirements for comfortability. In the end, we successfully took their views in mind and never told them we could not or would not do something; we only asked them for advice on how to meet their requirements. By following their advice and asking for more when needed, we laid our concerns out to them respectfully, allowing them to maintain their position in control as the owner and putting us successfully on track to deliver our product.

8 Closing Material

8.1 Discussion

Discuss the main results of your project – for a product discuss if the requirements are met, for experiments oriented project – what are the results of the experiment, if you were validating a hypothesis – did it work?

Our product will provide a faster response time for the service dog to aid the user at the start of a PTSD attack. There will be a phone app with a simple UI for the user to configure their dog's device to suit their needs and remain non-invasive. Additionally, the device will be discrete so it will not attract any unwanted while being worn, dormant, and functioning. We aim to meet these requirements which our current concept design successfully accomplishes.

8.2 Conclusion

Summarize the work you have done so far. Briefly re-iterate your goals. Then, re-iterate the best plan of action (or solution) to achieving your goals. What constrained you from achieving these goals (if something did)? What could be done differently in a future design/implementation iteration to achieve these goals?

We have come to a general conclusion about our product's prototype regarding its purpose, function, design, and potential future builds. Concerning hardware, we have created schematics for our circuit design and tested components to ensure they function properly. We have also drawn up enclosure prototypes with approximate dimensions to be created in CAD software and 3D printed in the future once the circuitry is solidified. For software, we currently have most of the UI implemented for our app built in Flutter. Some of the backend components have also been implemented, including a caching system and the skeleton of a service.

For our goals, we hope for this semester to have a solid foundation of our design and implementation that fulfills our client's needs and wants. We also aim to create a solid prototype before the semester ends, which will give us a jumpstart in the coming semester. We are working on and revising schematics, code, and team chemistry to achieve these goals. We have done this by meeting weekly with our advisor, client, and team to ensure client expectations are met, and our work is completed based on our Gantt chart.

A constraint that held us back initially was getting our components. Although it took time for the parts to get to us, we decided to fill that time by continuously honing our hardware design ideas and continuing software development, closing the gap on wasted time. We should have started our hardware design and ordered parts sooner to avoid that issue. If we had received the parts earlier in the semester, we would have been able to experiment and test our design more.

8.3 References

List technical references and related work / market survey references. Do professional citation style (ex. IEEE).

WILL FINISH CITATIONS LATER

https://store.arduino.cc/products/arduino-nano-33-ble

https://www.digikey.com/en/products/detail/seeed-technology-co-ltd/316040001/5487672

8.4 Appendices

Any additional information that would be helpful to the evaluation of your design document.

If you have any large graphs, tables, or similar data that does not directly pertain to the problem but helps support it, include it here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics, layout etc,. PCB testing issues etc., Software bugs etc.

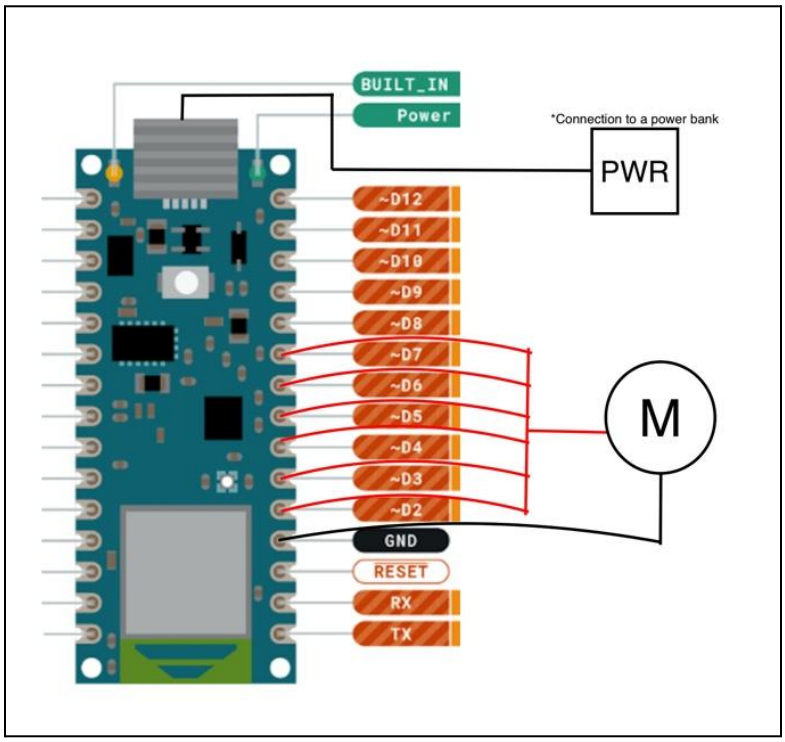

Figure 5: Schematic Dog Device

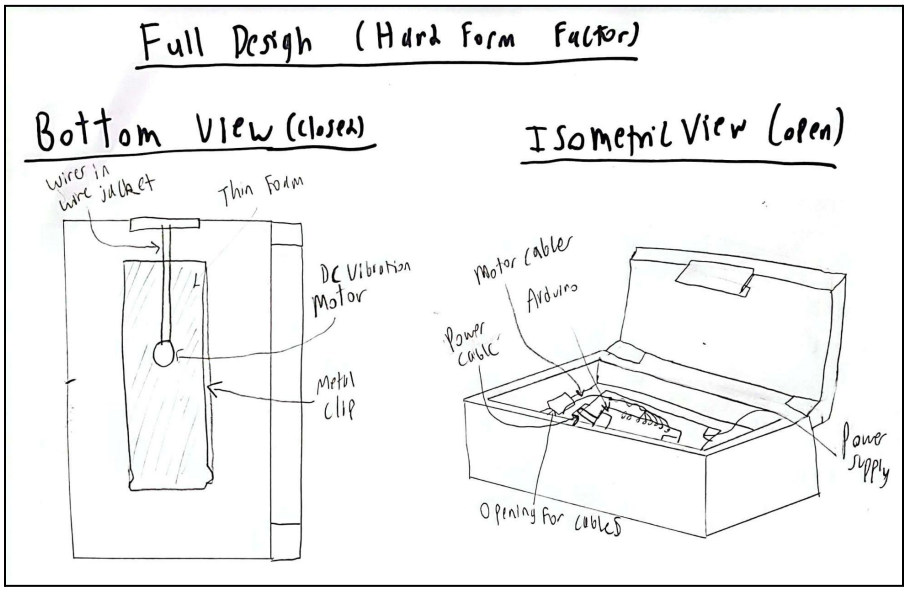

Figure 6. Full Design

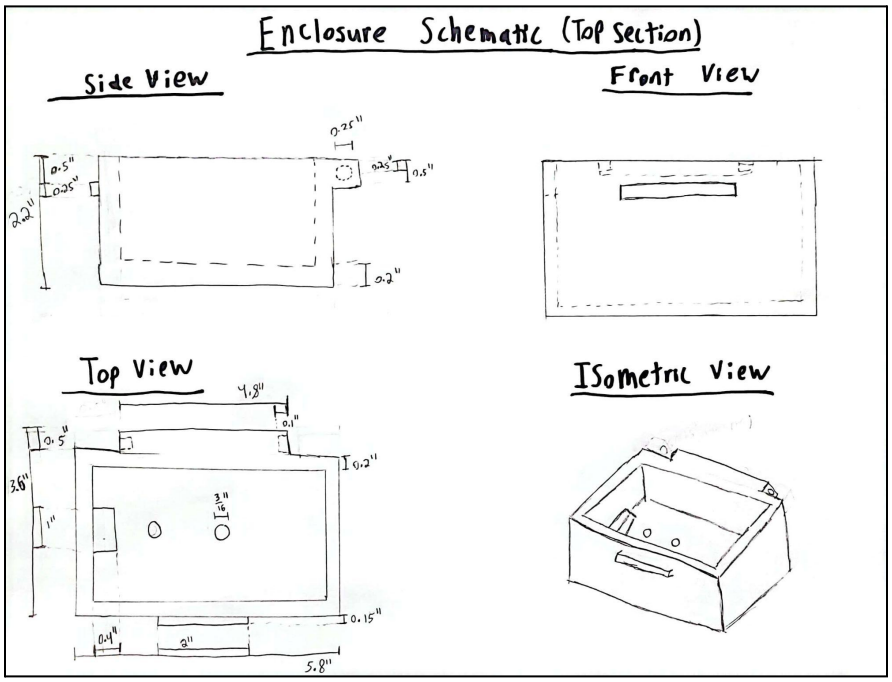

Figure 7. Enclosure Schematic (Top Section)

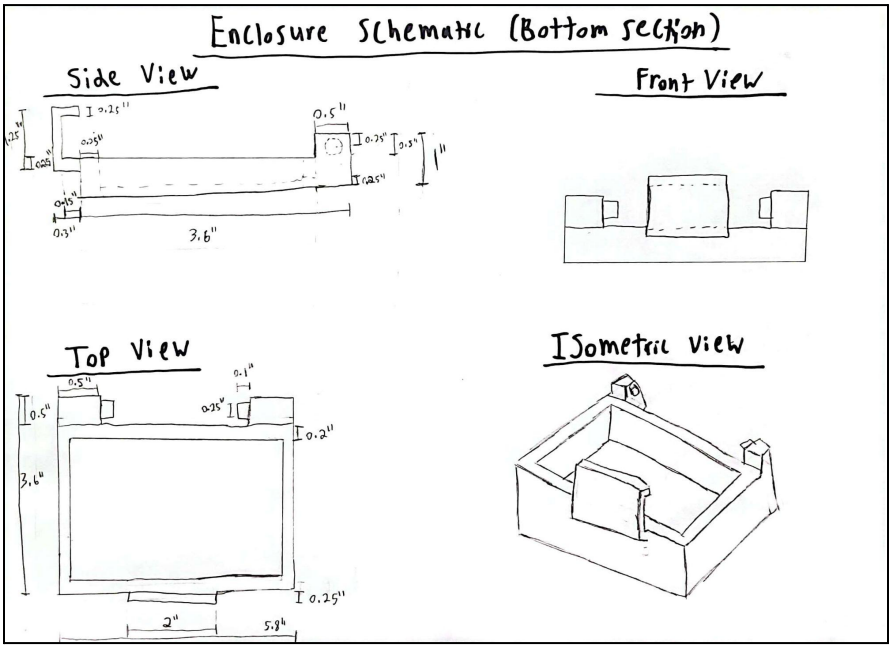

Figure 8. Enclosure Schematic (Bottom Section)

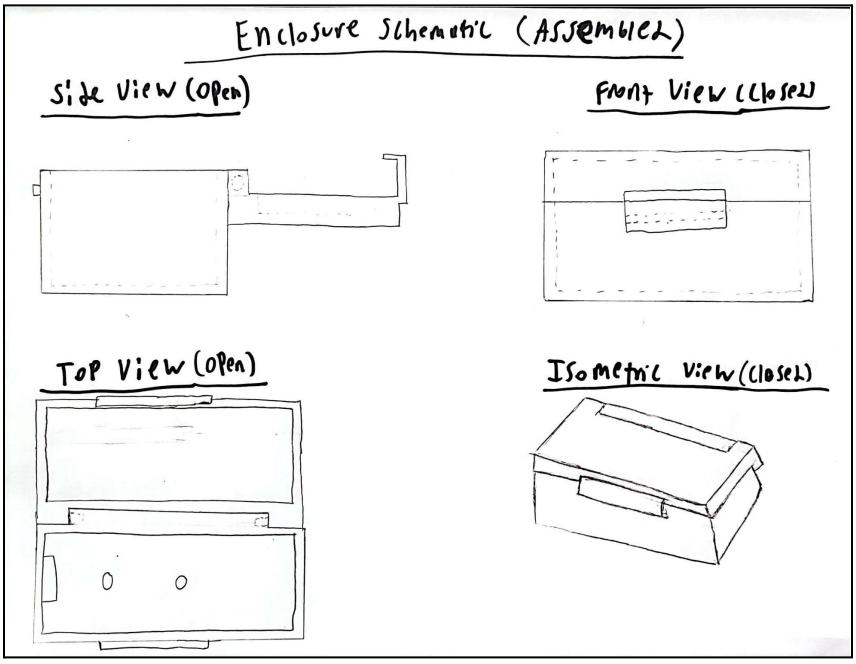

Figure 9. Enclosure Schematic (Assembled)

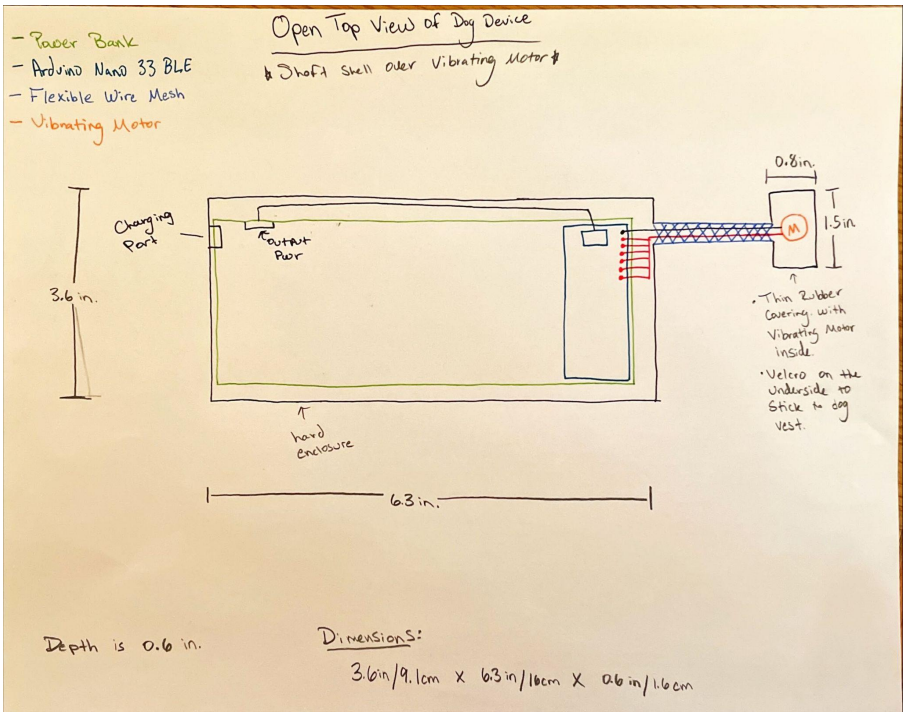

Figure 10. Softshell Vibrating Motor Schematic

8.4.1 Team Contract

Team Members

1) Maisy Millage 2) Carver Bartz

3) Samantha Brang 4) Jonathan Pixler

5) Steven Trinco 6) Comlan Bocovo

Team Procedures

Day, time, and location (face-to-face or virtual) for regular team meetings:

- Client Meetings: Mondays 2:00pm to 3:00pm (discord)
- Advisor Meetings: Wednesdays 10:00am to 10:30am (In-person at Durham Hall)
- General Meetings: Twice a month (Discord/ In-person when needed)

2. Preferred method of communication updates, reminders, issues, and scheduling (e.g., e-mail, phone, app, face-to-face):

In class or on Discord

3. Decision-making policy (e.g., consensus, majority vote):

Consensus unless we can't make a decision then majority vote.

4. Procedures for record keeping (i.e., who will keep meeting minutes, how will minutes be shared/archived):

Keep notes on Discord, the members in a meeting

Participation Expectations

1. Expected individual attendance, punctuality, and participation at all team meetings:

- Except for advanced notice with group approval
- Individuals will be expected to take on responsibility that makes the group feel they are pulling equal weight

2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:

- Team members will be expected to complete the work they take on by the deadline determined by the group or assignment due date.

3. Expected level of communication with other team members:

- Communicate with team members whenever possible especially if you run into problems or finish something.
- Let everyone know if you have something coming up and can't meet a deadline, meeting or anything else pertaining to the project.

4. Expected level of commitment to team decisions and tasks:

- Full commitment is expected without advance notice or significant negative event that prevents the level of commitment the team member was fully expecting to perform, but for the hard circumstances.

Leadership

1. Leadership roles for each team member (e.g., team organization, client interaction,

individual component design, testing, etc.):

- Sam - Team Organization, Electrical and CAD Design
- Carver - Software Design
- Jon - Hardware-software bridge, embedded systems leader
- Steven - Discord Admin, Hardware and CAD Design
- Maisy - Writing and upper level software
- Comlan - Client interaction, Software design and time management

2. Strategies for supporting and guiding the work of all team members:

- Keep each other updated in our meetings, request help when needed, consult team members who are more experienced with certain aspects of the project.

3. Strategies for recognizing the contributions of all team members:

- Recognize work in team meetings, weekly/monthly demos of work we have completed individually, keep tabs

Collaboration and Inclusion

1. Describe the skills, expertise, and unique perspectives each team member brings to the

team.

- Our team has a good mix of electrical, computer, and software engineers with a variety of intern/general work experience. Some skills include design/management, artificial intelligence programming, machine learning, embedded systems design, pcb design, as well as project and team management.

2. Strategies for encouraging and support contributions and ideas from all team members:

- Pool all ideas during the team meetings and include all ideas in the meeting notes. When it comes to implication, documentation, and planning, all areas of expertise should be consulted before continuing with any plans.

3. Procedures for identifying and resolving collaboration or inclusion issues (e.g., how will a team member inform the team that the team environment is obstructing their opportunity or ability to contribute?)

- Inform them of this during a team meeting, and discuss ways they can be included in the project. Consult the advisor if the team is unsure of ways to improve the environment for struggling team members.

Goal-Setting, Planning, and Execution

1. Team goals for this semester:

- To develop a working strategy that utilizes all of our strengths to build a quality product and forward our skill set for use in the workplace.

2. Strategies for planning and assigning individual and team work:

- At our 3 weekly group meeting times we will determine and discuss the work needed to be completed for the week and divide up the work equally amongst ourselves.

3. Strategies for keeping on task:

- Have a predetermined set of tasks to make sure the focus is clear
- Speak up when focus shifts too out of subject

Consequences for Not Adhering to Team Contract

1. How will you handle infractions of any of the obligations of this team contract?

- First give a warning or indicate to a team member that you feel they should pull their weight a little more, offer ways they can help/assign them tasks.

2. What will your team do if the infractions continue?

- If they continue to break the contract, this will result in a poor peer review from the rest of the team, possibly consulting the advisor if necessary.

****

a) I participated in formulating the standards, roles, and procedures as stated in this contract.

b) I understand that I am obligated to abide by these terms and conditions.

c) I understand that if I do not abide by these terms and conditions, I will suffer the consequences as stated in this contract.

1) __Maisy Millage_____ DATE _____11/29/2022_____

2) __Jonathan Pixler_____DATE ____11/29/2022_____

3) __Carver Bartz_____ DATE ____11/29/2022_____

4) __Samantha Brang_____DATE ____11/29/2022_____

5) __Steven Trinco_____ DATE _____11/29/2022_____

6) __Comlan Bocovo_____ DATE _____11/29/2022_____