Team: sdmay24-15

Introduction

Many people who suffer from Post Traumatic Stress Disorder (PTSD) also suffer from PTSD-induced episodes, which can lead to self-injury and a general lack of ability to function on a day-to-day basis. PTSD, formerly known as ‘shell-shock’ and ‘war neurosis,’ is a common disorder among veterans of World War I and World War II. The disorder stems from the witnessing of horrific events and the near-death experiences these veterans experienced in their time of service. PTSD is not limited only to veterans, as people outside of war can experience PTSD episodes through reliving past trauma. These PTSD episodes can cause the person being impacted to experience flashbacks to these traumatic events, disassociate from other people around them, and resort to alcohol or drugs to cope with the pain.

Service animals are trained to recognize such episodes. Dogs can smell changes in blood chemistry, observe behavior, and much more. This makes dogs very useful for responding to many different biological conditions. However, the training of service animals takes several years and is quite expensive. Additionally, some veterans may have dog allergies.

1.1 Problem Statement

If a discrete and wearable device existed that is capable of detecting PTSD episodes, support for veterans with PTSD would become much cheaper, accessible, and faster than it currently is. Veterans could either wear the device and respond accordingly, or the device could notify a service animal, then the animal would respond. These devices could also prove to be a good tool for trainers to train service animals.

American Vetdogs proposed a potential solution to this problem. We are challenged with designing and building a prototype for a device that monitors the veteran’s physiological data, detects PTSD symptoms in advance, and alerts a service animal that an episode is imminent.

1.2 Requirements & Constraints

Functional requirements:

- Reliably monitors the user's physiological data.
- Accelerometer provides information about the user’s movement.
- Detects any abnormal behavior (spikes) in blood pressure/heart rate consistent with a PTSD attack.

A project funded by Texas A&M University used cardiovascular and acceleration data from commercially available smartwatches to identify onset of PTSD episode symptoms using machine learning. They

identified episodes with (83% accuracy and 0.70 AUC). As such, we should attempt to provide detection with similar accuracy. Our goal is **80% accuracy and 0.65 AUC**.

- Communicate with the device on the service animal's collar that a PTSD attack is imminent.
- The user should be able to dismiss the device before the dog is notified
- The device on the dog's collar should alert the service animal that a PTSD attack is imminent
- The user should be able to power off and on the device.

Qualitative aesthetics:

- Must be discrete. It was emphasized in the project proposal that the device should not disturb anybody in the vicinity.
- Dog notification is quiet (or at least subtle/non-disruptive) **(constraint)**
- The device worn by the user should be comfortable and non-invasive

Economic/market requirements:

- We are given a budget of $5000 for designing a prototype **(constraint)**
- The end product should have a lower cost than smart watches and other biological monitoring devices on the market. Our end-users are commonly disabled and may have a fixed income. This may limit their ability to purchase expensive products. Cheaper manufacturing techniques will be a consideration after our initial design.

UI requirements:

- The interface with the user should be accessible for various disabilities. We must take into account motor function, vision, hearing, and any other disabilities we discover common among our primary users, veterans.
- The interface should be simple to use so notifications can be easily dismissed before alerting the service animal. Our primary clients are also commonly members of an older generation, commonly less skilled at using technology.

Performance requirements:

Algorithm performance: The PTSD detection device should be more tolerant of false positives than true negatives (we would rather have the device alert the service animal when there is no PTSD symptoms than not provide a notification when there is an episode). The receiving operating characteristic (ROC) graph for classification algorithms. This graph provides intuition about how a classification algorithm performs. A higher value means a higher portion of the output is correct. We can also look at the False positive rate, and true negative rate (portion of episodes missed).

- The device must have a minimal number of missed PTSD episodes. Upon further study, we should determine a goal metric for this requirement. This means we have low tolerance for the true negative rate. We should shoot for a rate of under 0.2 (20%).

- We should have a reasonably low number of false-positive notifications for the dog. The dog being alerted that they need to respond is a low-damage situation, while the dog not being alerted during a PTSD attack is potentially embarassing to the veteran, and disruptive to the situation. This can be measured with the false-positive rate.

Combined algorithm performance::
These first two performance requirements can be quantified using the area under the curve (AUC) of the receiving operating characteristic (ROC) graph. An AUC value of over 0.65 would assert that most of the positive outputs are correct.

Durability: The device should be durable since it is intended to be worn everywhere the user goes.

- Should be drop/impact resistant
- Should be water-resistant
- The battery/device for the monitoring device should last at least 24 hours.

Legal and Ethical requirements:

- We are storing, processing, and moving medical vitals from our clients. In order to allow this prototype to be on the market, we would need to follow local laws for computer-based records. These laws vary by state and country. This considered the legal consideration of medical information is outside the scope of our prototype, and we will **not** be putting significant efforts into following these standards and requirements.
- The materials used in the dog collar and the device worn by the user should be made of materials with no potential to harm the users.
- The collar should use an ethical mode of communication for notifying the service animal

Maintainability requirements:

- We want the devices to be modular, so each component can be easily updated and replaced
- Backward compatible, so updating different components doesn't require a replacement of the entire system.

Security Requirements:

- End-to-end encryption of vitals
- In-place encryption of stored vitals and information (Not necessary for prototype).
- Authentication/identity verification for accessing information
    - (Not necessary for the prototype.)

Testing requirements:

- The system should have a minimal false positivity rate.
- The device should be tested with our partner company, VetDogs, to ensure the subtleness of the alerts and the comfortability of the devices on both the user and the dog.

1.3 Engineering Standards

- IEEE 802.15.1: WPAN / Bluetooth - We plan on using Bluetooth to connect separate devices (phone and wearable) in our design.
- IEEE 802.11: WiFi - Future iterations may use WiFi.
- ISO/IEEE 11073: Medical / Health Device Communication Standards - We will be designing/using a wearable device that collects health data and communicates it to another device.
- IEEE 360-2022: IEEE Standard for Wearable Consumer Electronic Devices - We are planning on designing a wearable device to collect heart rate/blood pressure.
- IEEE 370-2020: IEEE Standard for Electrical Characterization of Printed Circuit Board and Related Interconnects at Frequencies up to 50 GHz - We will be doing some PCB design and testing
- Revised 508 Standards and 255 Guidelines https://www.access-board.gov/ict/ - accessibility standards are used on government and official user interfaces to ensure access for people with physical, sensory, or cognitive disabilities. Section 255 covers telecommunications and customer-premises equipment While 508 covers information and communication technology.
- Web Content Accessibility Guidelines https://www.w3.org/WAI/standards-guidelines/wcag/ WCAG documents explain how to make web content accessible to people with disabilities. If we are designing any interfaces on screens, this standard can ensure usability for our clients.

1.4 Intended Users and Uses

Use cases:

- Veterans and non-veterans with a history of PTSD episodes need to be able to prevent these episodes before they happen. (Currently, veterans are the main testing group for this project.)
- Service dog trainers need to be able to determine when a PTSD attack is happening so they can train service animals more effectively.

Who benefits from the project:

People with PTSD episodes benefit from the prevention of PTSD episodes before they happen, reducing their stress and pain and thus improving their quality of life.

The families of people with PTSD indirectly benefit from the improvement of their family member's quality of life. Seeing a loved one routinely suffer and relive unimaginable trauma significantly affects the psyche of everyone witnessing the attack.

Service dogs of people with PTSD episodes benefit from the alert of a PTSD attack, which makes it easier for them to know when they need to assist their owner.