Therapalz Collar

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1 Introduction

1.1 Objective

‘Therapalz’ was a project pitched in class by Ms Fiona Kalensky. It is a a smart therapeutic companion animal which provides both comfort as well as company to patients suffering from Alzheimer's. The original animal has a realistic heartbeat, calming vibrations and makes a purr sound to replicate the behavior of a real cat. However, Ms Kalensky wanted certain external controls on the animal like an on/off button. She also wanted to improve the battery life of the animal. She also wanted a way for caregivers to adjust the settings of the animal as well as have a way to track the animal as Alzheimer's patients have a tendency to hide things. Hence, we propose to work with the existing design to design a smart collar which will have on/off and mute buttons, a tracking mechanism, light sensors which will put the animal to sleep when it is dark in the patient’s room, an accelerometer which will sense the patient’s activity level, a microphone sensor which will change the behavior of the animal based on the loudness/softness of the patient’s voice, and finally a rudimentary app which will help the caregiver adjust the settings of the animal based on his/her need and preference.

1.2 Background

Alzheimer's is the most common form of dementia which causes problems with memory, thinking and behavior. It is a progressive disease with symptoms usually developing slowly before getting worse over time. Patients in early stages, have mild memory loss but as they get older, they begin to lose their ability to respond appropriately to their environment or even carry a conversation [1]. Alzheimer’s affects about 5.5 million people older than 65 every year in the United States. Additionally, about 200,000 people under the age of 65 are affected with early-onset Alzheimer's in the United States. One in ten people age 65 and older have Alzheimer's disease and about one-third of people age 85 and older (32 percent) have Alzheimer's disease [2]. Alzheimer's is also the sixth leading cause of death in the United States [1]. Despite these startling numbers, there is currently no medical cure to Alzheimer's. This is the

reason why several organizations and people have dedicated their lives to develop non medical methods to improve the quality of life of these patients to the maximum extent they possibly can.

There are several studies that have proven that pets have a positive impact on patients suffering from Alzheimer's. Pets are a great companion for patients with dementia as they help reduce anxiety, agitation, irritability, depression, and loneliness [3]. However, it is not always feasible or practical to have and look after a pet in a long-term care facility. This is why when Ms Fiona Kalensky proposed the idea of 'Therapalz', a stuffed animal that replicates certain behavior of an actual pet, our team thought this was a perfect solution to the problem.

1.3 High level Requirements List

- **Concealability** : We would like for the buttons to be concealed in such a way such that the patient cannot accidently turn them on or off and mess with the settings of the animal. We propose to have some sort of mechanism similar to that of a locket so the buttons can only be accessed when actually intended too.
- **Sensors :** We would like to make sure that the sensors are strategically located such that they behave as intended. For example, we want the light sensors to be able to detect when the entire room is dark so it can put the animal in sleep mode to both conserve battery as well as to go mute so it doesn't disturb the patient while he or she is asleep.
- **Tracking :** We want to make sure that the animal can be tracked relatively accurately within a room even when faced with obstacles. We also want to make sure that the speaker installed on the collar makes a noise when called so it can help the caregiver locate the animal easily.

2 Design

2.1 Block Diagram

For the collar to work successfully, the power unit, the control unit and the communication system need to work harmoniously. The battery provides the collar with power. The control unit contains all the sensors along with the microcontroller which will behave as described in pre-programmed settings. The bluetooth with the help of beacons will be used to locate the animal as well as to communicate with the app and others part of the animal. Finally the app will be used to track the animal as well as adjust different settings of the animal.

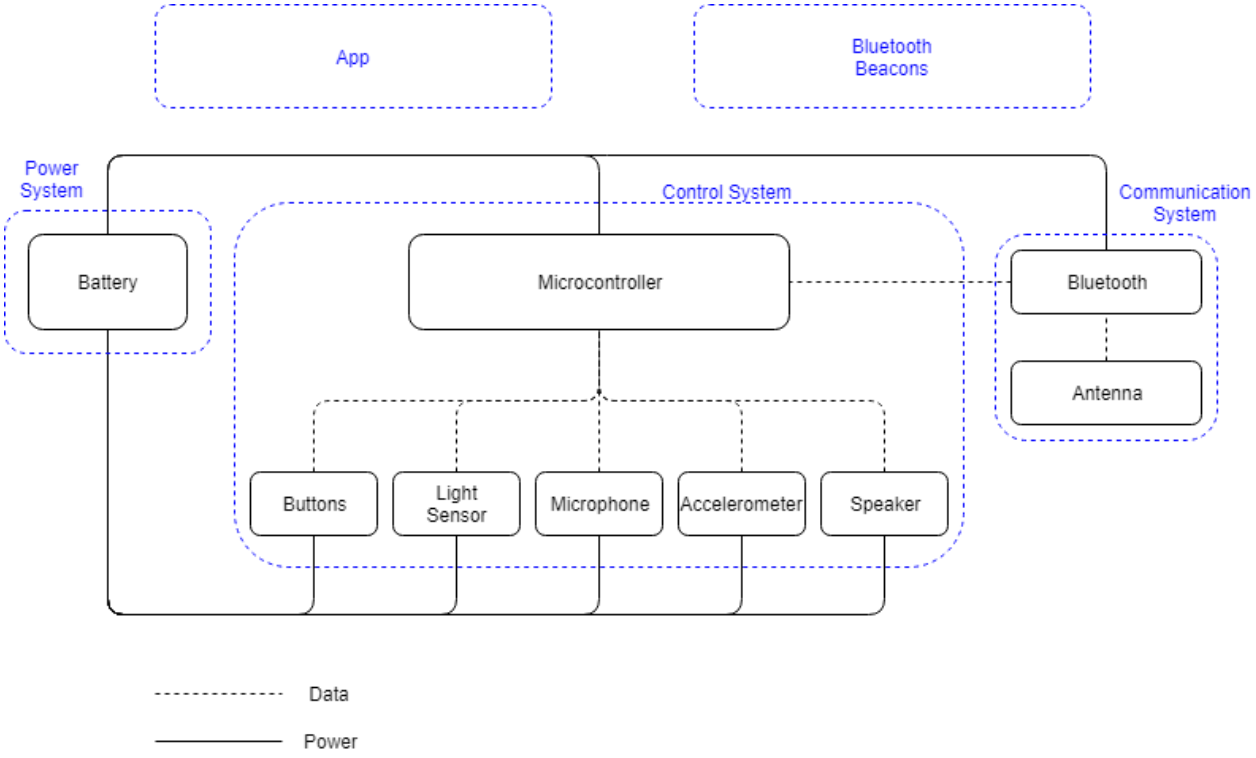

Figure 1: Block Diagram

2.2 Physical Design

This is a schematic representation of what we hope the outer casing of our device will look like.

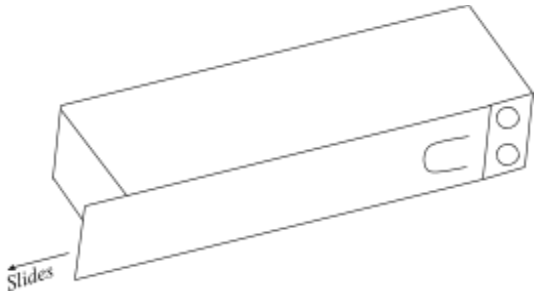

Figure 2: Outside casing of device

2.3 Function Overview and Requirements

2.2.1 Battery: The battery supplies power to all of the components of the collar through its daily use.
Requirements: Must power keep the device powered for minimum 12 hours.

2.2.2 Microcontroller: The microcontroller will receive inputs from buttons and sensors, as well as use Bluetooth through SPI to communicate with the app.
Requirements: Can be used with SPI protocols.
Requirements: Can interface with all sensors used.

2.2.3 Bluetooth module: The Bluetooth module will be used to track the location of the stuffed animal as well as send/receive data from caregiver through associated app.
Requirements: Can be used with SPI protocols.
Requirements: Can successfully send and receive data from up to 6 devices (beacons, app, other sections of pet).

2.2.4 Antenna: The antenna used by the Bluetooth module will be used to send and receive signals from the Bluetooth beacons used for tracking as well as communicate with the app
Requirements: Has an effective range of minimum 30 ft. to cover a whole room

2.2.5 Bluetooth beacons: The Bluetooth beacons will be used to triangulate the location of the stuffed animal within a room
Requirements: Has an effective range of minimum 30 ft. to cover a whole room
Requirements: Has a battery life of >1 week actively broadcasting signal

2.2.6 Power/Mute buttons: Allow caregivers to easily change important settings, must not be easily accessible to patients (turn on/off and mute).
Requirements: Can be quickly accessed by caregivers, but not accidentally pressed.

2.2.7 Light sensor: The light sensors, of which we plan to use photo conductors, change their resistance in response to varying levels of light hitting them. Our intentions are to use these sensors for the sake of battery conservation, placing the product into a rest mode when the collar detects a substantially low level of light as is expected in a night time scenario.
Requirements: The light sensors are able to actually detect distinct changes in light levels.

2.2.8 Microphone: The microphone is intended to work in tandem with the microcontroller and the Therapalz' vibration and purring settings. Depending on noise levels the microphone receives the pet is to use one of a set of pre-programmed settings for vibration and purring.
Requirements: The microphone is able to successfully receive noise levels.

2.2.9 Accelerometer: The accelerometer measures acceleration in three dimensions. We intend to use this sensor to determine periods of inactive use of the pet, mainly the time when the patient(s) are asleep. After a few minutes of no activity, the pet is to enter a idle mode.
Requirements: The Accelerometer data is successfully recorded and analysed.

2.2.10 Speaker: The speaker is intended to work in tandem with the app. Should the pet be lost or hidden, the caretaker is given the option of pressing a distress button on the app, which triggers the speaker to emit a sound which would help locate it.
Requirements: The speaker has to emit a sound that is both not harmful to the patients physically or mentally, and useful for location.

2.2.11 App: The app is going to have sliders which can be used to adjust the frequency of the heartbeat, the frequency of the vibrations and the loudness of the purrs based on the wishes of the caregiver. It is also going to have a feature to track the animal. On pressing a button the animal will emit a sound through the speaker helping the caregiver locate it.
Requirements: The app has to successfully change the behavior of the animal based on settings adjusted in it. It must also be able to set of the speaker when the animal needs to be located.

2.4 Risk Analysis

The Bluetooth connection will be an important part of the project because it is a central part of the location tracking feature, as well as being the sole connection for sending and receiving data. Its success depends on a functional implementation of SPI protocols as well as access to sensor

data and the location tracking algorithm through the microcontroller.
The collar must also be able to pick up bluetooth signals accurately as this is necessary to track the location of the animal. If there is a hindrance or an obstacle blocking the signal then the collar will not work as intended. Furthermore, if the collar is not able to communicate with the internal box of the animal accurately, it will not be able to adjust the settings of the animal. It will also not be able to mute it or turn it off thus making the buttons useless. Lastly, bluetooth is also important for the sensors to work as they are intended too. If the sensors are unable to communicate data to the internal box, they will not be able to serve their purpose.
Given the above reasons, we think it is safe to conclude that the improper working of the bluetooth module poses the biggest risk of failure to our project.

3 Ethics and Safety

We plan to conform to and follow the IEEE Code of Ethics in order to preserve the health of our product's users and their privacy, as well as to disclose potential dangers our project might pose to the users.

3.1 Potential Hazards

Alzheimer's, also known as senile dementia, is a form of dementia. A common consequence to this is that there is often an increased sensitivity towards noise that is often overlooked. Our feature of using noise to locate the pet in the case that it becomes lost is similar to that of an alarm or a pager, sources of noise that are recommended to keep at a minimum [5]. In order to try to keep the emotional health of our intended users in mind, we have incorporated the idea of using tracking via Bluetooth, so that resorting to the noise method is only applicable in extreme scenarios.

In addition to this we must take care to develop the noise we use for locating the pet to be distinct yet unobtrusive. As such it is important to understand a certain constraint on the decibel levels of said sound. Nearing dB levels of 100, exposure for longer than 15 mins can cause possible damage to the patient's hearing [6].

Another potential hazard is as a result of having a battery in a product where the stuffed animal is in part sufficiently flammable, it is a concern to make sure the battery is never damaged in such a way that could lead to it catching on fire. Care must made to make sure the battery is not put into conditions that might result in extended overheating, which could also lead to fires.

3.2 Potential Privacy and Security Infractions

The use of accelerometer and Bluetooth data in tandem can be used to track the motion the user as they move throughout their rooms, and as such poses a significant breach of privacy. This is especially a concern considering this data will be sent through Bluetooth to the phone app. What we propose to do is to encrypt the data being sent and received with private keys for the sake of the prototype.

References

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[6] “Decibel Exposure Time Guidelines” *Dangerous Decibels.* [Online]. Available: http://dangerousdecibels.org/education/information-center/decibel-exposure-time-guidelines/. [Accessed September 19, 2018]