Final Design Report

Lorem Ipsum

Project name?

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Is the Kate Enzler stuf
correct?

Make sure all names ar
spelled correctly.

Todo list

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Chapter 1

Introduction

Patients who have suffered from a stroke or traumatic brain injuries can develop a condition called left side neglect. This condition is caused by the inability of the right side of the brain to process information that comes from the left side of the body. Patients therefore struggle to engage with the left side of their body. Our project specifically addresses the patients who struggle to continue turning their head past the midline of the body. Our project partner, physical therapist Dr. Kate Enzler, stated during the client interview that the typical patient often forgets there is a whole world to the left side of the body. This lack of head rotation can cause everyday challenges for the patient as they may bump into things on the left side of them, miss information when reading, and many other problems. The solution to this problem is preferably wearable as per our client's request. Since left neglect patients span a wide demographic, the solution must be customizable to fit differently sized patients.

The research phase of this project consisted of both secondary and primary research. While researching the condition of left neglect, we also researched existing products for the condition and their shortcomings in order to avoid those elements in our design. Current methods of treatment include neck vibration therapy, prism therapy, eye patching, optokinetic stimulation, and the use of tangible stimuli to remind a patient to visually scan left. Many of these visual stimuli were effective in the moment but did not have long term effects. Additionally, many of the products, despite being effective, required a lot of work with the therapist in order to understand how the device worked or what its purpose was. Many of these solutions also place a heavy reliance of the patient onto their caregiver. Therefore, the patients are heavily reliant on others, and lose their autonomy. The goal of the product that we designed was to aid patients in regaining their autonomy while continuing to receive cues, in a haptic form, to visually scan left. Our solution is a haptic motor clip that attaches on a patient's hat or shirt to a point of skin contact on the right side of their body, which serves as a haptic stimulus to remind the patient to visually scan left. The motor will connect via bluetooth to an app, which will control the motor. The final part of the solution will consist of a pair of glasses that have cue lines on the left side that guide the patients towards the left. The glasses also have a gyroscope on them that track motion and will communicate with the app, and turn the motor off when the patient has turned their head to a certain degree.

Chapter 2

Users and Requirements

2.1 Main Users of the Design

Adults who are experiencing Left-Side Neglect: The user for our design will be patients at the Shirley Ryan Rehabilitation Center who have suffered a brain injury leaving them with the inability to turn their head past the midline of the body. They need cues/reminders from a caretaker in order to remember to continue turning their head all the way to the left past the midline. They would like a solution that does not rely on the caretaker in order to create more autonomy for the patient as well as just be overall easy to use.

2.2 Requirements

We identified the following requirements during the course of the quarter. The design had to be:

2.2.1 Lightweight:

The device will be attached to the pair of glasses and therefore must be light enough to comfortably fit on the glasses and not put too much weight on the patient. It must be small enough to fit onto the glasses and not make them lopsided.

2.2.2 Durable:

Since the device is attached to the glasses that will be worn frequently by the user, the device must be able to endure being worn as well as have a long battery life. The device must be element resistant since the patient must be able to wear the glasses outside and must be able to be dropped from a small height in case the glasses fall off the patients face or are dropped off a surface.

Chapter 3

Design Concept and Rationale

The [[name]] is a device that can track the degree to which the user turns their head and relay this data to the other components of the take-home kit. The [name] is intended to be mounted on the [name of glasses design], and sends data to the mobile app, the glasses and the haptic clip. The design has an accelerometer gyroscope that is able to track how far and how quickly the user is turning their head. This data is processed by the ESP 32 microcontroller, and then relayed to the other components using the communication protocols.

name of design

The following sections describe the components of the device—accelerometer/gyroscope, ESP32 microcontroller, and communication protocols—as well as the rationale for each component.

3.1 Accelerometer/Gyroscope

When creating this device, we needed some way of tracking movement and some way of processing the movement data and communicating it with the app. In order to track the users' movement, we decided to use a MPU6050 Six-Axis Gyroscope and Accelerometer. This device was chosen due to its simplicity, affordability, and great library support. The MPU6050 is a commonly used gyroscope/accelerometer. It features high resolution motion tracking with a built-in Digital Motion Processor to allow for high-resolution data capture ($+-2$g) with data-processing on chip. It is also very small (smaller than a fingernail), lightweight (less than 5 g), and affordable (costing around $3 for a development board). And most importantly, it is a very easy to use device with great library support through I2CDevLib on the Arduino framework.

3.2 ESP 32 Microcontroller

For communication purposes, we decided to use the ESP32 microcontroller from Espressif Systems, a battle-tested microcontroller used by hobbyists and professionals alike. Most importantly, it supports Bluetooth 5.0 (Low Energy) and the I2C communication protocol, needed for talking to the phone and MPU6050, respectively. It has two cores that can run at up to 240 MHz, deep sleep mode to lower power consumption, and a large online support base to allow for easy development. And as the chip is powerful enough to run a lightweight operating system, we are able to use multiple processes to speed up computation and also save energy.

3.3 Communication Protocols

One of the most important components of our design were the communication protocols. The I2C communication protocol was chosen due to its simplicity and unobtrusiveness, requiring only four wires for relatively high-speed communication. Bluetooth Low-Energy was chosen for its lower energy consumption, as our device should be able to run for long periods of time while on battery power. The tradeoff was the added complexity of Bluetooth Low-Energy, but low power consumption is a main requirement of our design. Similarly, we also will try to use the Deep Sleep mode of the ESP32 to reduce power consumption during idle periods to only 5 W.

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Chapter 4

Future Steps

There are four directions for future development with regards to [RotaSense]: app, data processing, electronics, and angle detection.

First, the app can be improved in three ways. One, some of the user interface design can be refined to be more user friendly, as some parts of the design can be confusing, especially for users who are less tech savvy. This improvement is quite straightforward, and requires rethinking some components of the design.

Two, and much more importantly, the account system needs to be rethought completely. Given that this app is a healthcare app, having an account system would require us to process data in accordance with HIPAA laws, which themselves are bundles of red tape. Though, for the sake of patient privacy, these laws ought to be respected. Having an account system means there is an increased chance of patient data leakage. The account system needs to be redesigned to eliminate this possibility, as otherwise there is a lot of grounds for legal action.

Three, the app can be set up to connect with Bluetooth. Due to constraints with Apple development, integrating the prototype app with Bluetooth would require a $100 Apple Developer License, which exceeds this project's budget. Instead, we created a Python proof of concept which works on a computer. While this is an okay substitute for now, it is not user-friendly as it requires extensive technical knowledge, making this a huge step for future development. Future development specifically can be done through using the user's phone's native Bluetooth library to interact with the microcontroller, which is a process that adds multiple layers of programming on top of what is already complex for a prototype project.

Second, data processing can be improved. As of now, data is sent from the gyroscope microcontroller to the app by creating a ten-number packet (yaw, pitch, roll, acceleration in all three axes, gyroscope movement in all three axes, time). This can be potentially improved by doing more data preprocessing on the microcontroller through applying things like the Fourier transform. More research is needed to decide the best form of data to transmit between controller and device as well as whether a change is necessary.

Third, the electronic components must be refined from the current prototypical form. The current microcontroller-gyroscope system takes up a lot of surface area, and this can be reduced. Reduction of surface area can be done by printing a custom circuit board, which is not overly expensive or complicated. This, however, would only be economically feasible if this product were to be mass produced.

Fourth, the angle-determination algorithm can be refined to be more accurate. Currently, the user will calibrate a gyroscope by using their mobile device, and any subsequent movement will be detected as a movement. However, if the user were to change positions, the gyroscope would need to be recalibrated altogether. A previous idea was to have two gyroscopes, one on the user's chest area and one on their head, and the difference in angle is the angle of head rotation. Further research needs to be done to determine which angle determination mechanism is the most effective and least intrusive for the patient.

The overall next step is to revise the current design to better promote user autonomy while preserving user privacy. These four ways are not extensive, but are the next steps with regards to improving [PRODUCT NAME].

Chapter 5

Conclusion

To summarize, our design and its function in the larger class solution meet the key needs of the users. The key components of our design are as follows:

an accelerometer gyroscope sensor that is capable of tracking the head movements of the user an ESP 32 controller that provides bluetooth capability, allowing the design to communicate information on the user's head movements to the mobile application and haptic clip

The users need a solution that is customizable and adjustable, and the feedback component provides this by collecting information on the user's movements so that the stimuli from the glasses and haptic clip can be modified to make sure the user is looking completely to their left. In addition, it was required that the solution be lightweight and ideally wearable, and the design meets this need because it is small enough to fit on a pair of glasses and the parts (the gyroscope and ESP 32) weigh only X g combined. Lastly, it was important that the solution be affordable, and our design is affordable, as it can be built for a total cost of X.

weight

cost

Appendix A

Project Definition

Write the project defin
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Appendix B

Bill of Materials

Write the BOM

Appendix C

Background Research

Write the background re-
search

Appendix D

Observations Summary

Get the observations summary

Appendix E

Interviews Summary

Get the interviews summary

Appendix F

User Feedback Summary

Get the user feedback summary