Deliverable E: Design Constraints and Prototype 2

GNG 2101– Introduction to project management and development

Group Z25

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Introduction:

This document focuses on the project's design constraints and the creation of prototypes. We identify two non-functional design constraints that have a significant impact on the prototype development process in the first section, these are reliability and usability. Furthermore, we explain at length how to address this constraints to obtain the best performance possible, some calculations and research to justify our ideas and lastly a new detailed design hat reflect the aforementioned changes.

Moving on to section 2, we summarize the new client feedback, highlighting specific aspects of the design that need to be changed or improved. In addition, the document defines the critical product assumptions that have yet to be tested, which in our case is the connection from the raspberry pi to the controller. A second set of prototypes is created to address these assumptions, with the goal of progressing towards the final prototype while testing the critical product assumptions along the way. The changes include improvements to the case, the sogtware and the interphase between the controller and the computer.

The document documents the continuous improvement of our design through a variety of sketches, diagrams, and pictures, while also explaining the purpose and function of each prototype and presents the results in an organized way explaining the impacts of each change in the overall functioning of the prototype.

1. Design constraints:

A. Identify two non-functional design constraints that play an important role in the development of your prototypes. Justify your reasoning

1. Reliability

The performance and reliability of the program itself is probably the most important aspect of this project. In order to meet specifications, the remote must action the desired command within the first or second time asked and do so in a timely fashion. The former is important because if no command is understood, or if it executes the wrong command, the result could vary from annoying to potentially dangerous for the user. Without being able to function properly, the voice activated system is basically an electronic paperweight. Furthermore, it must be able to understand a variety of voices and tones and understand even if the tone isn't perfectly clear. To address this critical aspect of the project, constant variations and improvements to the code, hardware, and base functionality of the program have been made, additional details of which will be discussed later in this document. Another key aspect in the scope of this constraint is the design of the case, which must protect the computer and the connections to the remote, be snuggly fit, provide ventilation, among other things in order to achieve other physical reliability and endurance metrics

2. Usability:

This term can be defined in how easy a system is to use, for this project, having the ability to mark a variety of presets and commands that trigger specific chair movements; this results in an increased ergonomics for the user and make the product easier to live on the day to day. In other words, it's simpler to ask for the chair to go into sit position than individually adjust the settings for 3 different controllable aspects of the chair. To this end specific timings and functions can been added to the code so that it can follow the commands and execute them efficiently.

B. For each design constraint, explain in detail what changes would need to be made to your design to satisfy the constraint.

1. Reliability:

Voice Recognition Register and Accuracy:

Enhance the voice recognition capabilities by replacing the monodirectional microphone with an omnidirectional one, which will be able to pick up sounds from any direction. Additionally, more samples can be recorded to broaden the pool of samples and be able to match up to a command more quickly.

Connection with the controller:

To be able to connect with the controller, relays in the form of a 4-channel relay module will be implemented to be compatible with the architecture. It requires a peak voltage of 63 volts as and a current of 9A as measured with a voltmeter in order to operate the chair.

Case design:

To improve ergonomics and longtime durability, a lid design can be implemented as well as the use of Velcro as fastener for holding the lid in place and at the same time securing the controller to the raspberry pi unit.

Response Time:

To enhance the response time of the prototype, several avenues can be explored. Firstly, more voice samples for commands, non commands, and background noise can be recorded. This would enhance the local library of content and allow for the computer to more easily.

2. Usability:

New voice samples website

One of the best attributes of our project that make it very user friendly is the fact that we have a website dedicated to collecting voice samples. Using a series of links, the user can access the website and be prompted to record samples. This is good because is allows for constant updating of the voice as the clients voice might change with time and the progression of the disease. The website is still very rough looking and requires some introduction before understanding its functioning. It needs some additional design improvements to be at its best and be more user friendly.

Better timing / Actuation length

A design issue that we had had thus far was the fact that deciding a time interval for the commands had been done by saying the command accompanied with a time duration. Whilst this is easily put on paper, it requires more speaking by the user and several entries in order to obtain the best position adjustment possible. After the client meeting, it was decided that it would be easier to only need to speak the command, which would actuate the chair for half the movement of the axis that wants to be adjusted, and then the user can just say stop once the desired position is achieved to stop the movement of the chair.

More presets

More words linked to presets can be added to the code and their respective voice samples recorded to meet target specification

C. Provide proof (e.g. analysis, simple calculations and/or simulations, research) to demonstrate the effectiveness of your changes in satisfying the constraints. Justify the process and methods you used.

Mic comparison

	Blue Snowball (old)	ANSTEN Conference mic (new)
Reliable Range	7 ft	10 ft
Direction	Unidirectional	Omnidirectional
Accuracy	83%	92%
Time to actuate	3 seconds	2 seconds

Actuation time:

The new model of microphone demonstrates a greatly improved response time to the original mic. Along with increased voice samples, the response time decreases from 3 seconds to 2 seconds.

Range and direction:

Voice commands can now be accurately detected and understood from a greater distance, irrespective of where the sound originates. This significantly increases the reliability of the system.

Accuracy:

The accuracy of the system increased by approximately 9% with more voice samples.

Case:

Design requires only Velcro as a fastener now instead of Velcro and bolts. Furthermore, the microphone is smaller than the original, streamlining the design.

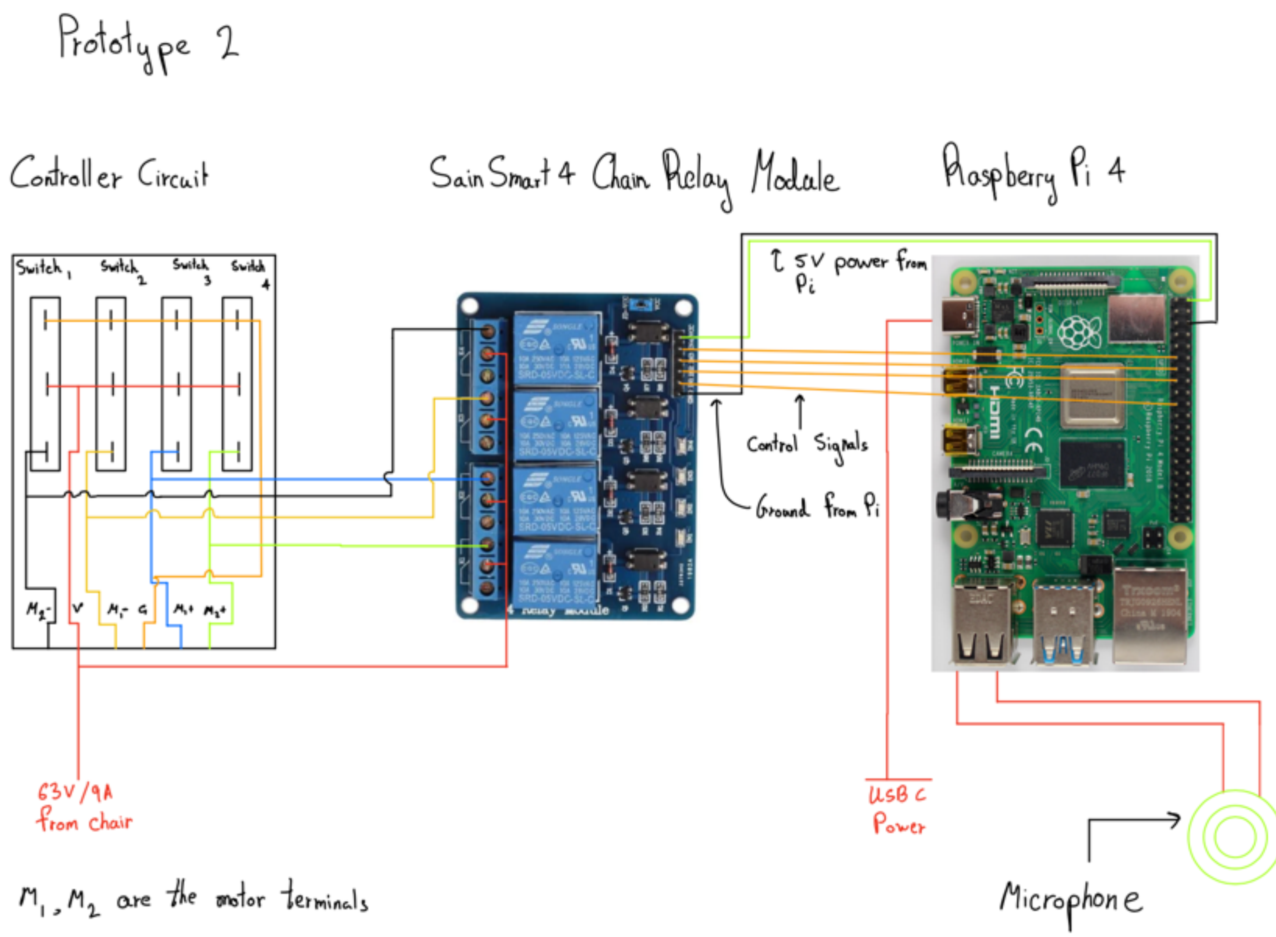
Actuating the remote:

With the relays (per our electrical design and sources) we should be able to control the chair, so a solution has been found for that problem.

D. Update your detailed design accordingly.

a. Electrical Design

The newest prototype will use a 4 channel relay module in order to actuate the controller. It will be connected between the raspberry pi and the controller, and will allow for the pi to interphase with the chair seamlessly.

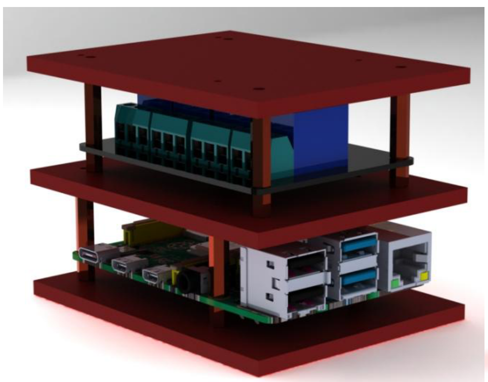
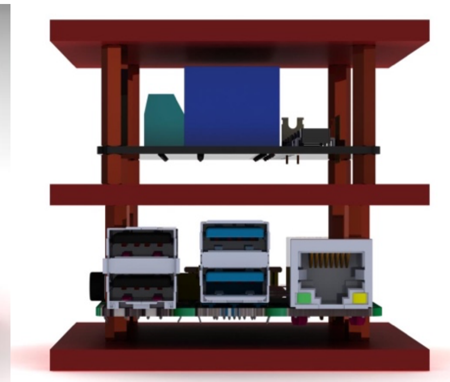


b. Physical Design

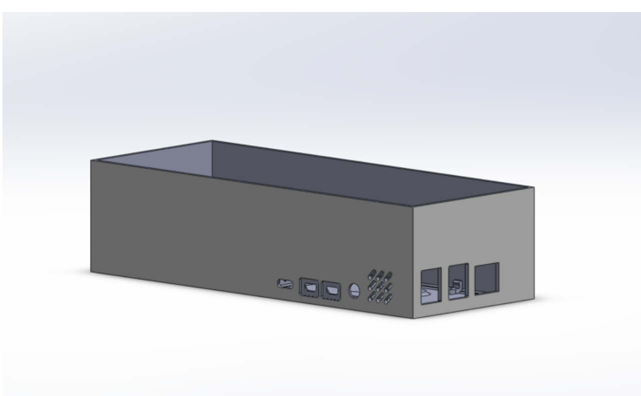
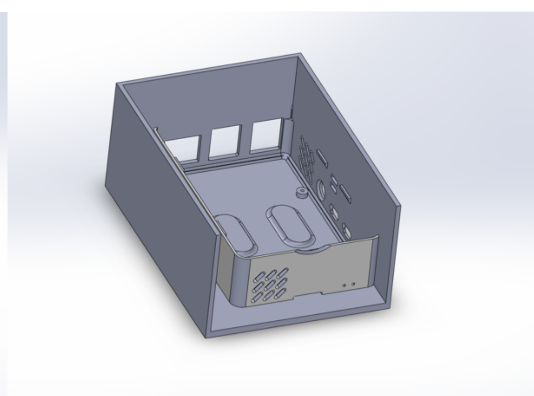
The newest prototype will use a newly designed case that will feature a lid to keep the raspberry pi inside, standoffs, space for the relay module, and Velcro as fasteners to secure both the lid and the remote to the raspberry pi. It will feature an omnidirectional microphone instead of a monodirectional one, and updated code that will allow for more presets, as well as faster receiving and interpretation of voice commands.

Detailed video of case here: https://youtu.be/H92uFyxzEqw

Inner case layout

Inner and outer case

2. Prototype 2

A. Summarize any new client feedback that you have received and clearly state what needs to be changed or improved in your design. Update your detailed design accordingly.

Priorities:

We should focus on obtaining a fully functioning prototype before concerning ourselves with the efficacy and reliability of the design. These aspects can be further refined after making a working product.

Safety stop:

The option for the client to stop the chair's movement at any stage with a voice command was very well received during the client meeting. Safety is an important consideration, and this alleviates any concerns the client harbored about the design.

Updating voice:

Another concern raised by the client during the most recent meeting was the possibility of the user's voice deteriorating over time. Due to the nature of ALS, a client's ability to control their voice will decline, meaning that the original recordings that the program was trained on may not work anymore. This problem is resolved by the fact that the design allows for a user to re-record their voice, which can bring the reliability back to an optimal level.

Movement:

Another facet of the design is the degree of movement resulting from an individual command. Originally, we were considering making the Pi move the chair in discrete intervals. However, upon receiving feedback from the client, we are looking at updating the design so that it moves continuously until receiving either a "stop" command or reaching its limit. This will decrease the number of commands required and allow for a more precise degree of control.

B. Define the most critical product assumptions that you have not yet tested

At this stage in the project, our most critical untested assumption lies in connecting the Raspberry Pi to the chair controller. The current design relies on a direct connection between the Raspberry Pi and the controller via splicing of the controller. This will be achieved through soldering the Pi to the pins. This method, if successfully implemented, will allow the Pi to rapidly manipulate the chair in response to the interpreted commands. However, if the architecture of the remote does not allow for any form of direct connection between it and the Pi, then we will be forced to completely re-evaluate the current design of the project. Essentially, the most critical assumption at this stage lies in the design of the remote. Due to the significance of this assumption, we must devote substantial effort into obtaining a remote that allows our design to be realized, or if the architecture of the remotes proves to be incompatible, updating the design to be able to work regardless.

C. Develop a second set of prototypes that will help you on your way to creating your final prototype and test the critical product assumptions along the way.

Prototype 2a: Case improvement 1

- Improvements to the ergonomics and functionality of the case.
- Added Velcros as securing mechanism, a lid to improve ergonomic, sized it to new Raspberry Pi Model, designed to accommodate standoffs

Prototype 2b: Microphone change

- Substituted the monodirectional microphone for an omnidirectional one

Prototype 2c: Design update

- Added a relay in order to be able to operate the remote: Given the electrical architecture of the remote, a relay will be necessary to accommodate for the high voltages necessary to operate it.

Prototype 2d: Case improvement 2

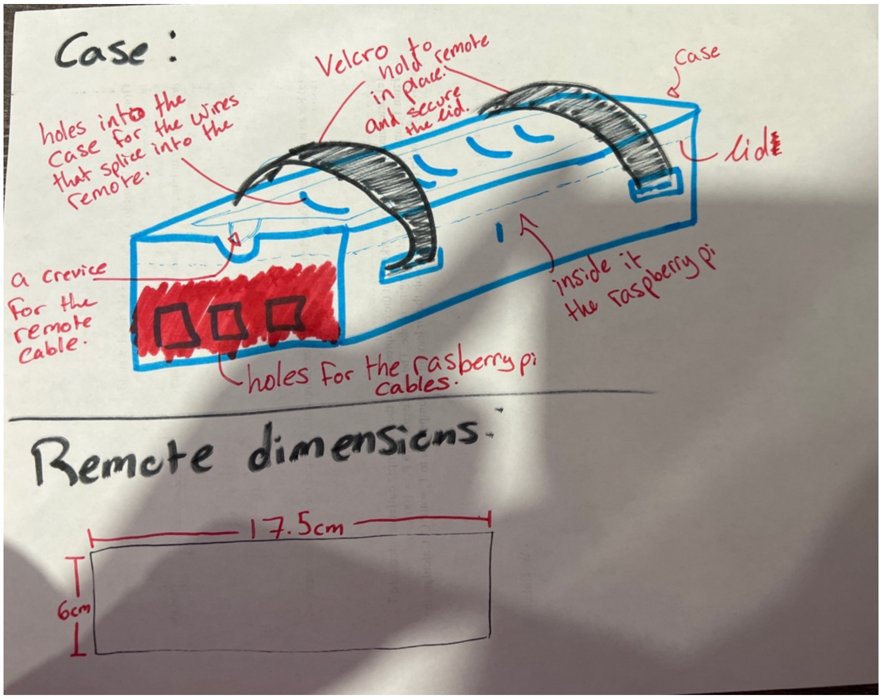
- Updated the CAD to fit the relays in prototype 2c.

Prototype 2e : Code and audio file revision

- Re-took all the audio samples and recorded new code words in order to implement additional presets and increase sample pool.
- Optimized the code to improve efficiency and response time.

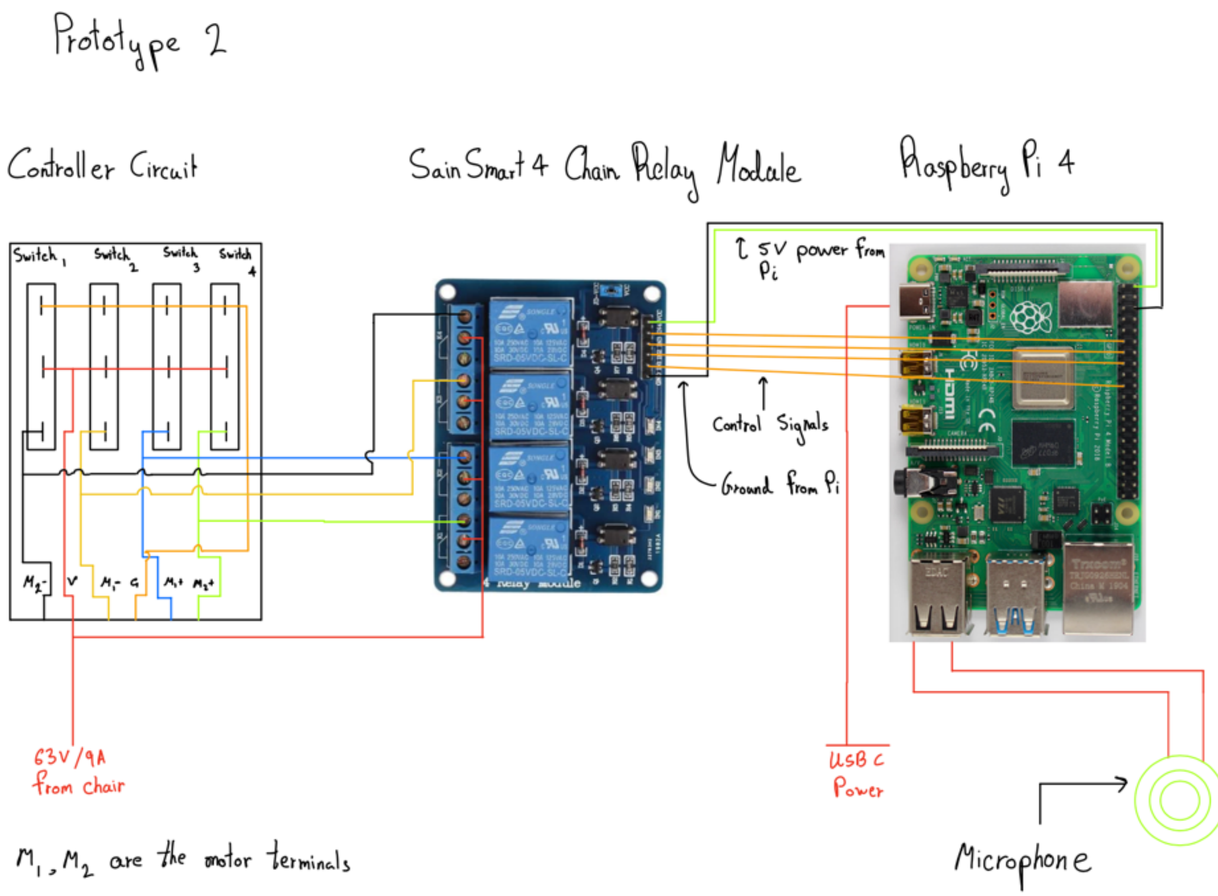
D. Document your latest prototype(s) using as many sketches/diagrams/pictures as required and explain the purpose and function of your prototype(s).

a. Prototype 2a Case sketch



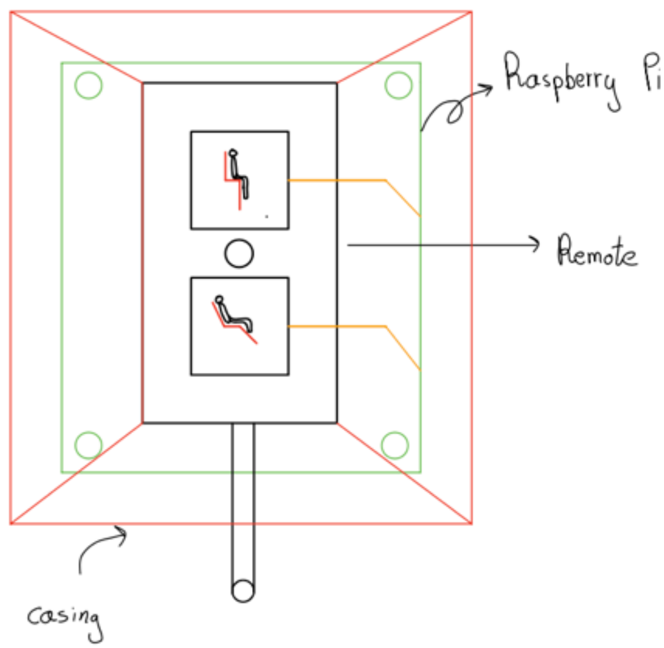
b. New microphone picture

c. Prototype 2c electrical diagram

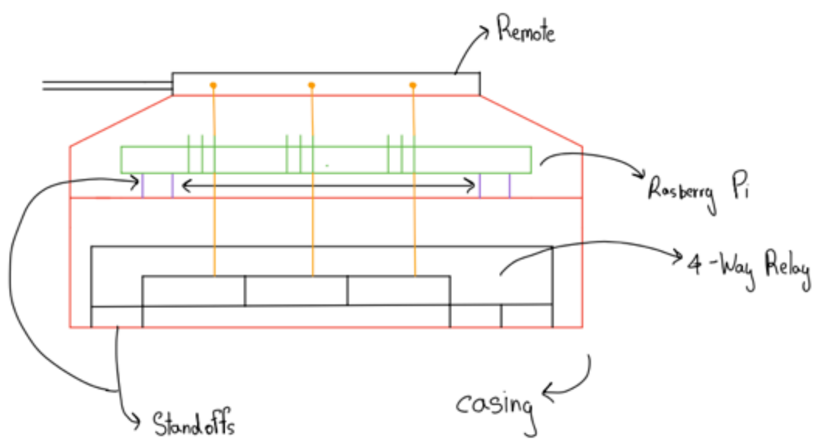


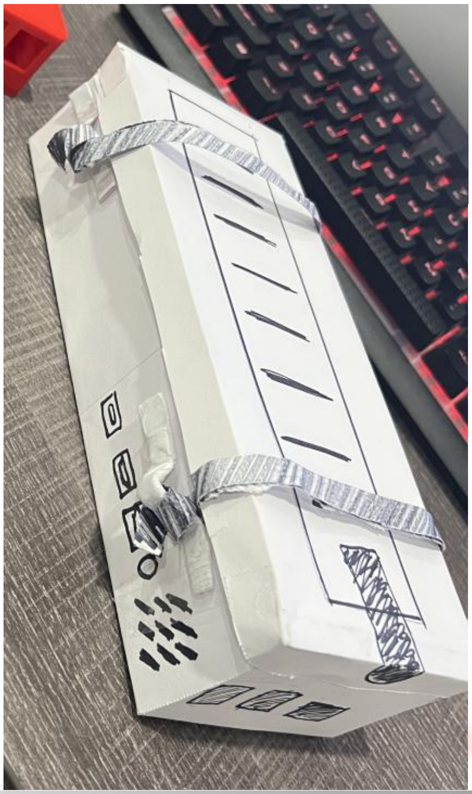
d. Prototype 2d updated case sketch.

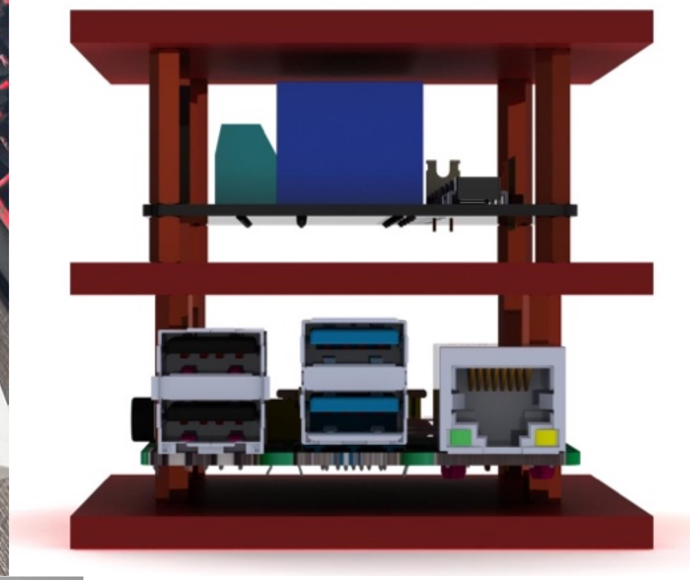
Top view

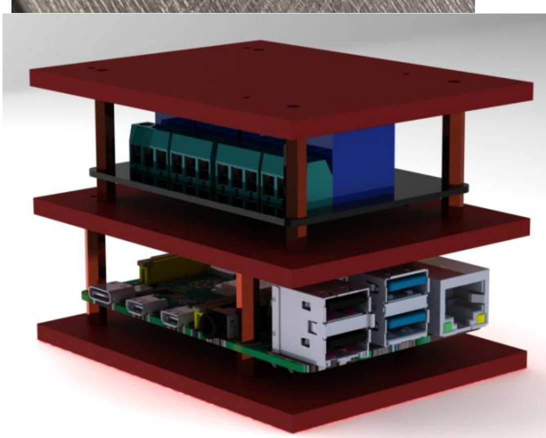


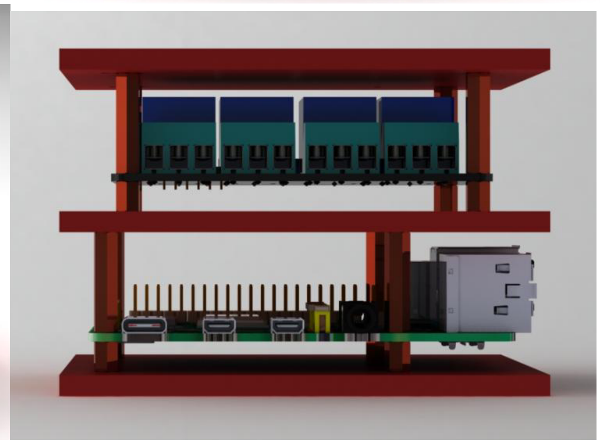
Side View











E. Carry out prototype testing, analyze and evaluate performance compared to the updated target specifications first developed in Project Deliverable B and document all your testing results and prototype specifications. Present your testing in an organized, tabular format that shows expected versus actual results (i.e. compare your measured prototype specifications to your target specifications by including both in a similar table to the one your developed for Project Deliverable B).

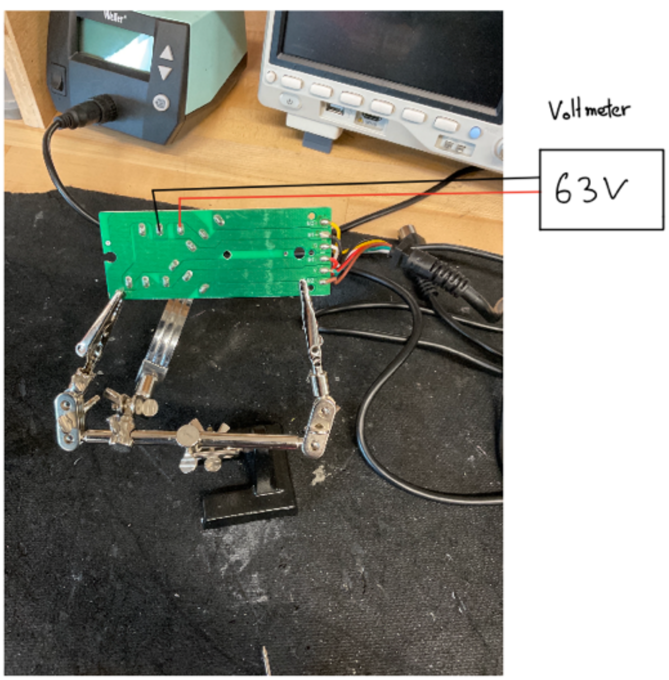
Accuracy and Voice Register Improvement:

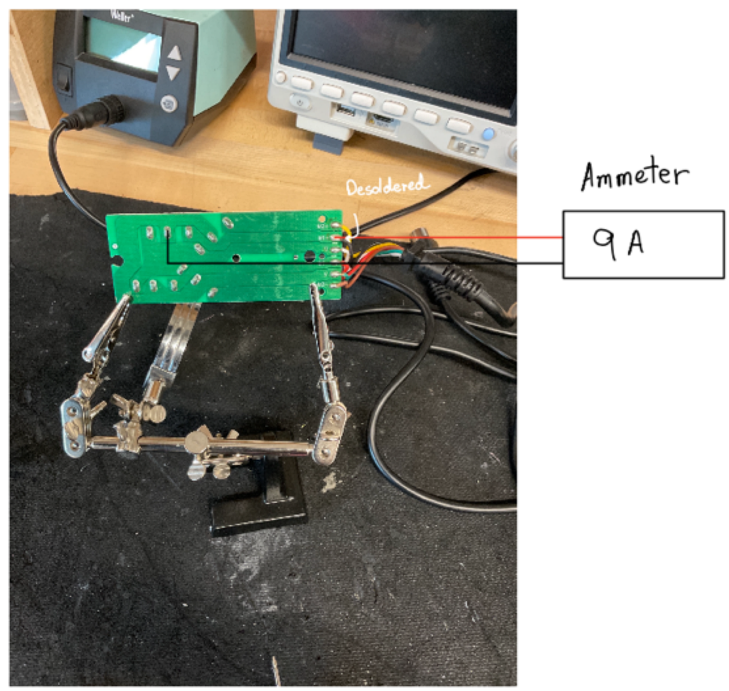
After adding over 20 new voice samples per person, and 50 background noise samples in different environments, the accuracy of the voice detection software has increase by 9%. We are now at around 92% accuracy, determined by a series of 20 tests per person (totaling 100). With the addition of an omnidirectional microphone, the voice can now be picked up from anywhere in a room, even if its placed in the edge of the room and the person speaking is on the other end. This is a notable improvement from the other monodirectional microphone which would only pick up voices from one direction, and it needed a better intonation of the words.

After the improvements, the performance is still marginal since it does not understand the commands 100% of the time, however it is still good enough for a second iteration of the design.

Remote Control Architecture

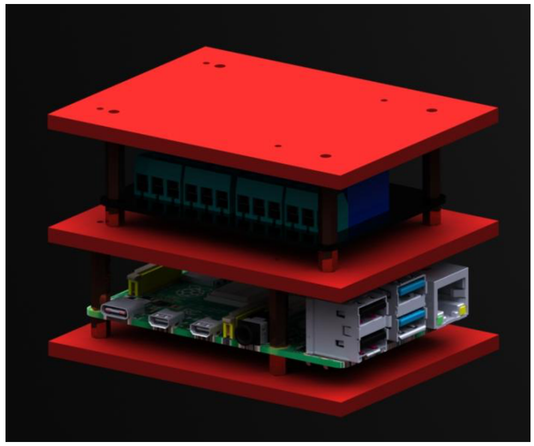
The pin connector of the remote has 5 pins that split into 6 terminals. Motor 1+, Motor 1-, Motor 2+, Motor 2-, Ground, Voltage. The controller works by having a button connect the physical connection of the Voltage to the appropriate motor leads. When measured with a voltmeter the controller receives an input of 63V from the chair. When measured with the ammeter the motors draw 9A of current under peak load. The controller does not handle any logic in understanding if the motor is at the max level. When tested by directly connecting the voltage to a motor lead, it was discovered that the chair would still move to its max possible position and then stop without any damage being done to it.





New Case:

The newest design of the case is much better in every way than the previous one. Chiefly, the previous design was not correctly sized for the Raspberry Pi, and there was no space for standoffs, attachment of the case or the controller, and it would have required some manual modifications to work at all. In comparison, the new design will not only be able to fit the Raspberry Pi, but also the rest of the pieces perfectly, includes a robust fastening mechanism and additionally requires no further work or adaptation from the team in order to work. Furthermore, the lid design should be able.



Conclusion:

In conclusion, this document has identified key design constraints, including reliability and usability as well as their impacts on our prototyping thus far. Next, the feedback received from the third client meeting was summarized and analyzed, with the current design updated according to their concerns and questions. From these new guidelines, necessary updates were made to the target specifications of deliverable B. Finally, a new According to these updated specifications, a new stage of testing was carried out on the most recent iteration of the project.

Project Management:

Wrike

Snapshot:

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=idwUhzDBWnRr0bsHkj07TO8EIiybpM5r%7CIE2DSNZVHA2DELSTGIYA