Deliverable C: Detailed Design and Bill of Materials (BOM)
GNG 2101– Introduction to project management and development

Group Z25

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Submission date: June 1st, 2023

Introduction:

This document aims to outline several key components of the current proposed concept. First, the feedback received from client meeting two will be summarized and analyzed in order to optimize the current design so that it fulfills all needs and satisfies the key desires of the client. From this feedback, a highly detailed design will be produced. The detailed design will explore both the hardware and software aspects of the concept, in enough detail so as to allow someone to reproduce the product with minimal assistance. After this, a detailed list of skills and resources at the team's disposal will be constructed. This will include university provided services such as Makerspace, and an evaluation of the amount of time at each team member's disposal. Along with the schedule evaluation for individual team members, a time analysis of the concept implementation will also be provided. This will outline major aspects of the design, and the time and resources required to complete them. Furthermore, any assumptions that are critical to the implementation of the design will be listed and their impact on the product explored. Finally, a bill of materials will list all materials and software required for the project, along with their associated cost.

1. Summarize the client feedback that you received during your second client meeting and clearly state what needs to be changed or improved in your design.

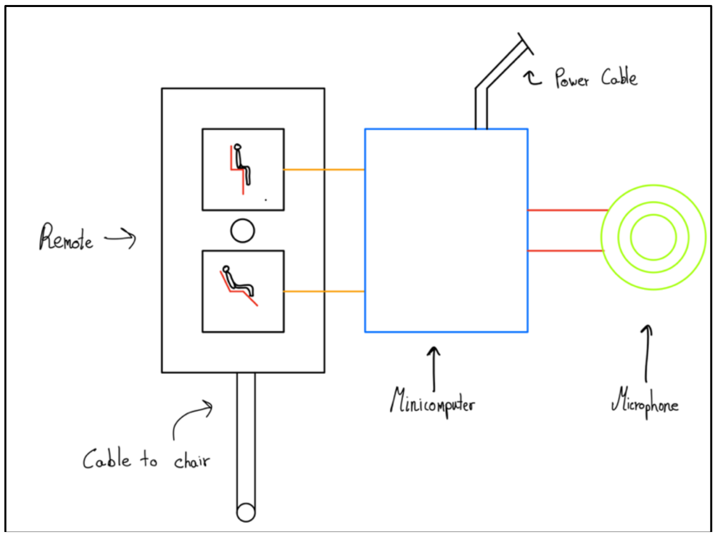
Overall, the client was pleased with the current proposed concept. They are relieved that the design is not reliant on an internet connection and allows for manipulation of the controller through normal means in addition to the raspberry pi. They did not protest the fact that there was a need for an additional electrical connection, and that we won't be able to power the prototype from the remote.

Some points brought up during the meeting include safety concerns with the presets and general movement of the chair. As it currently stands, there are no fail safes or monitoring systems built into the program. While this likely would not present an issue in implementation, it is an important aspect to keep in mind. One solution to this is to implement an emergency stop command as brainstormed with the TA. User protection is generally built into the chair and not directly into the remote, but having the ability to stop any action by the chair with a single command should be an easy to implement safety feature. A significant portion of the meeting was also spent discussing memory and other preset features of the prototype, highlighting the importance and convenience they will represent for the client.

Furthermore, there was some concern about the fact that a computer needed to be used. This is because the terminology used to describe the computer. We will be using a raspberry pi and the client thought we meant a full-sized desktop computer. This illustrates the need to use the most exact terminology possible to avoid adverse feelings in the client.

2. Develop an updated and detailed design of your concept, based on your client meeting, which includes:

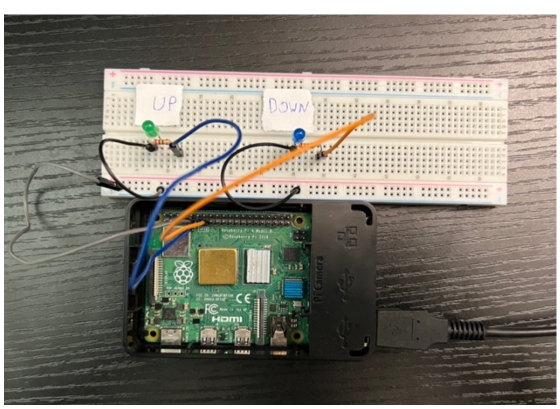
A. Physical Properties of Concept: Visual representations of the overall concept, as well as each subsystem. Clearly define how each subsystem is linked to other subsystems (including fasteners and electrical wires).

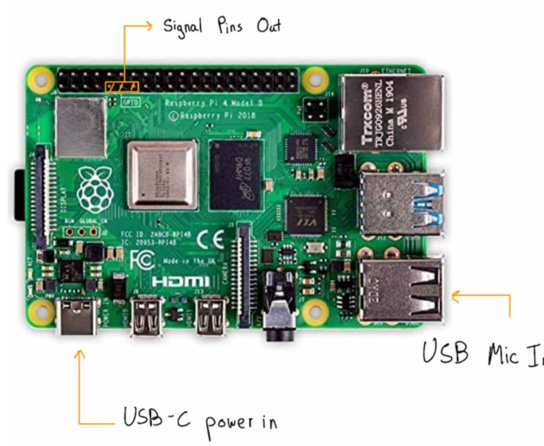


Overall, the proposed design can be divided into 3 main physical aspects:

1. Mini computer

This will be the brains of the concept. It will use software to process the voice into electrical signals, which will then manipulate the chair. It consists of a raspberry pi, which will need a mini-USB power inlet that will be connected to the wall, a micro SD card that will serve as storage, and outlet wires that will interact with the controller. The interaction will be made via the GPIO pins of the computer, which will be spliced with the remote by us. A diagram of the electrical connections can be found on the right, Note that as of right now we do not have access to the remote we'll be splicing, so for the prototype presentation the cables will be connected to LED to showcase its functionality.

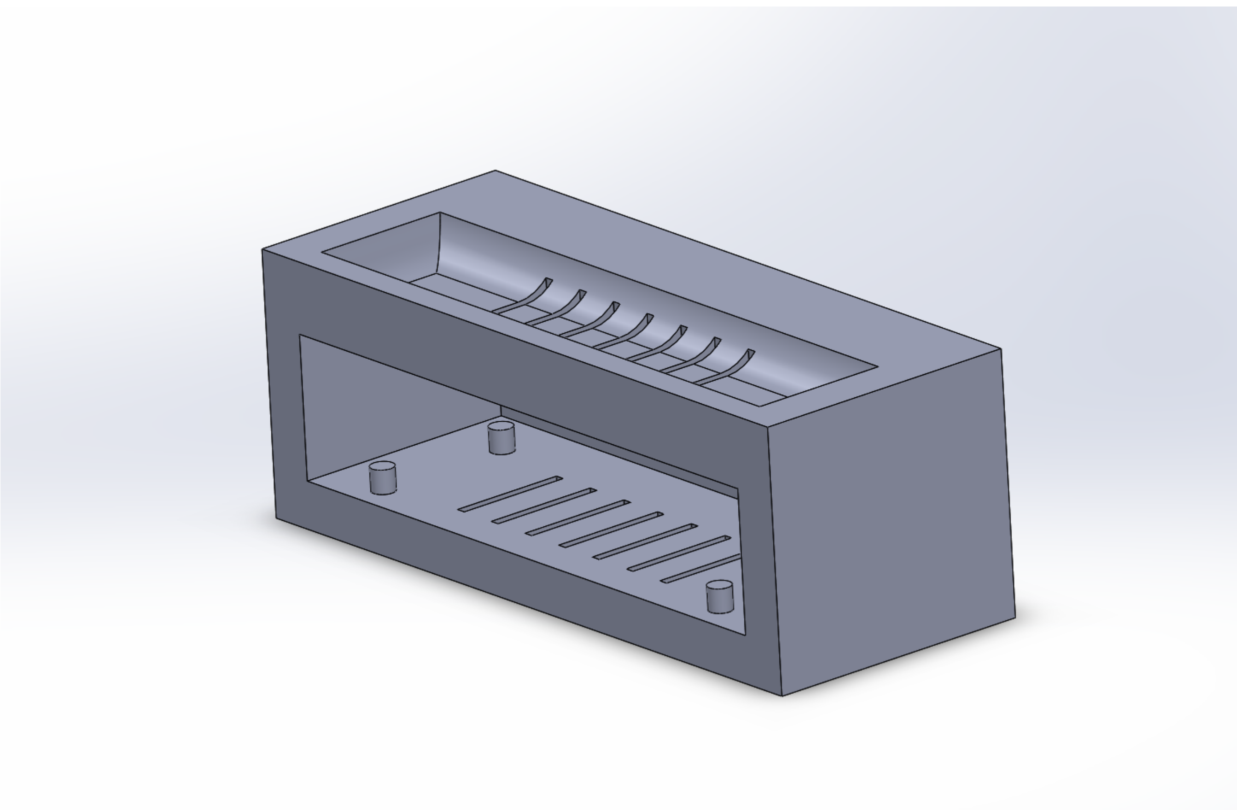




2. Universal Case (Control to Computer interphase)

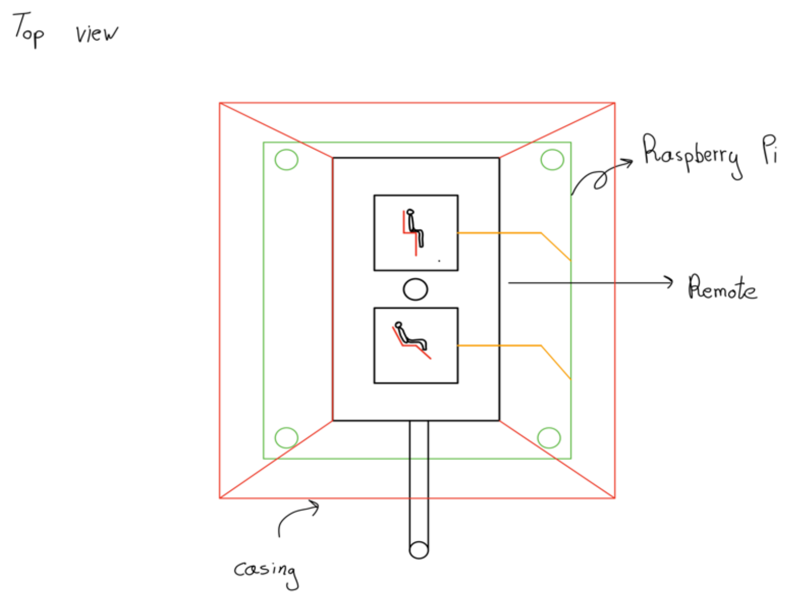
A 3D printed case will be the second main component of the concept.
It is critical since it will connect and keep together the controller and the raspberry pi. Too much movement or an imprecise design could result in the wires failing and detaching from the controller. It will need to have standoffs to help with cooling of the computer. It will use Velcro straps as fastening to the controller; this will allow for flexibility in the controllers it can be attached to as well as easy servicing of the device. A detailed diagram can be found below, the CAD files can be found in the Appendix. Further work is needed such as 3D scanning the controller to optimize the design of the case. Ideally, the final design would be made from laser cut plastic as it will enhance the aesthetics of the final product. Initial prototypes of the case will be 3D printed with PLA to quickly prototype improvement.

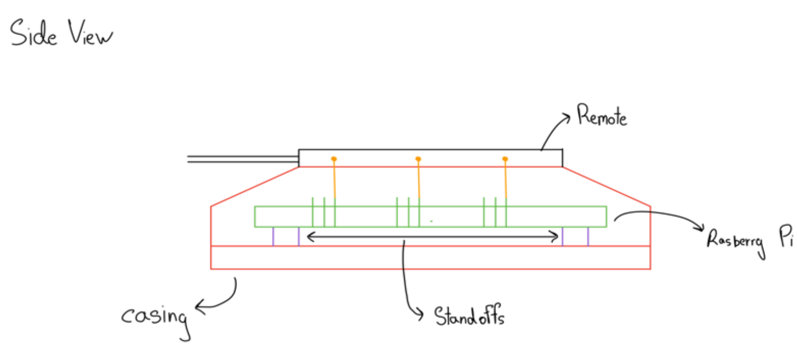
The video of a CAD design can be found with the following link:
Additional pictures can be found below:



At the moment, the simplest design possible has been chosen. This was determined to be a box with a hole on the side. This design allows the controller to just slide into its support case, where duct tape could be used to provisionally close the hole. It also removes any need for assembly other than splicing the wires, but since no controller is available as of yet we cannot provide instructions for doing so, but it will be included further down the line.
Using a single piece design reduces the possibility of mechanical failure, with the only option being the case integrity becoming compromised; it is however more costly on materials.

There are vent holes at the top and at the bottom of the box. The top holes serve 2 purposed, firstly they help air circulation in the case to prevent problems in the raspberry pi, secondly they serve as channels for the wires that will be spliced into the remote.
We also included directly 3D printed standoffs, which will reduce cost of materials. However thid could be reverted to normal metal standoffs if any problems are found.
Further steps down the line will be taken down the line to improve this design, such as adding a single piece lid that could be installed with bolts (using a threaded insert into the 3d piece), or switching some of the sides of the box to acrylic to enhance aesthetics. Some additional preliminary sketches of the design can be found below

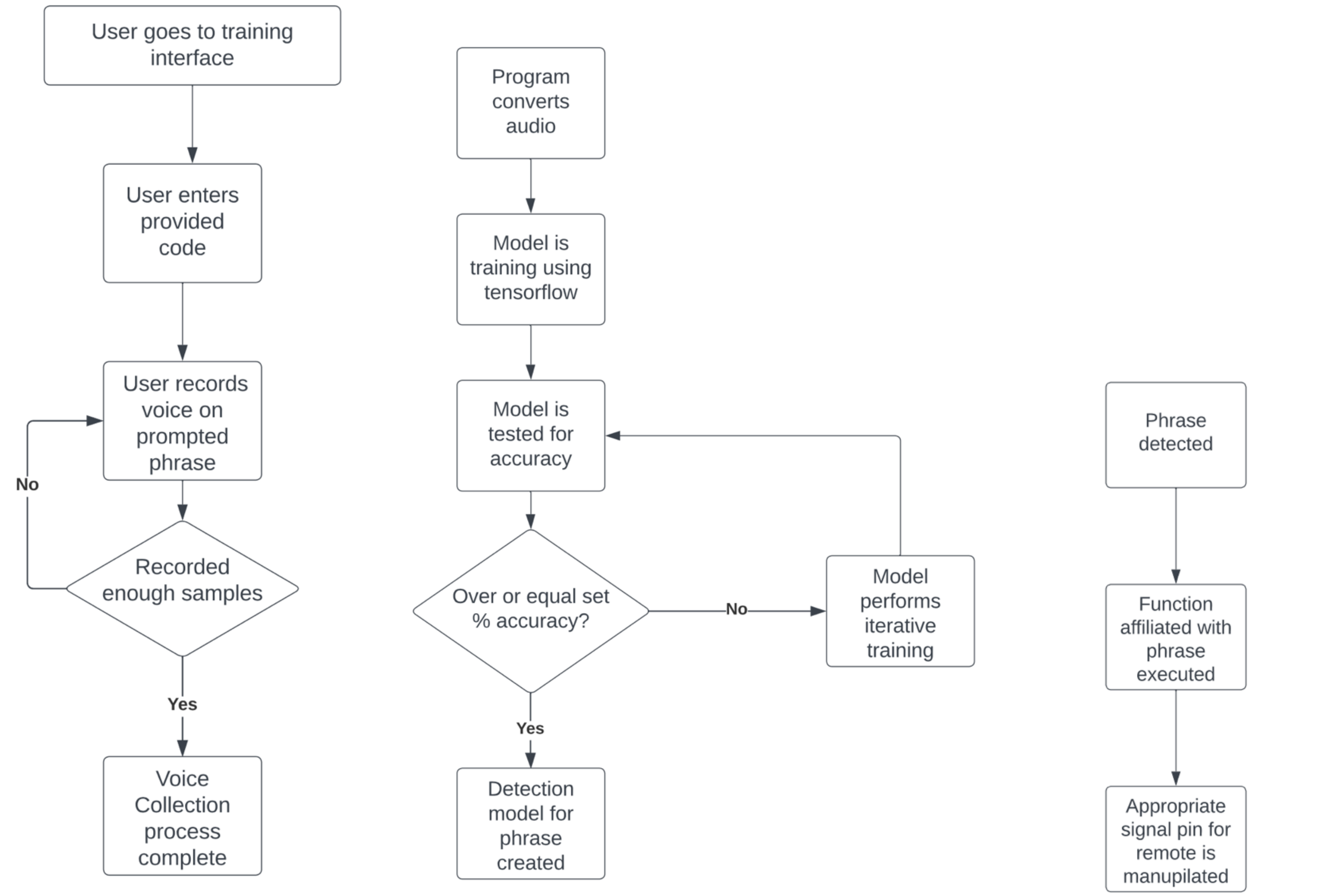




3. Microphone

The last and most important component is a microphone, this will be connected via USB to the computer. A detailed explanation of the functioning of the software can be found in the next section.

B. Software properties of concept: User interface and flow chart diagrams of the overall concept, as well as each subfunction. Clearly define how each subfunction is linked to other subfunctions.



User Voice Collection | Model Training and Generation | Phrase Detection

User Voice Collection – A web hosted site used to collect sample recordings.

User voice collection is essential for training a model. Sample collection can be done using a website. For our application a Nodejs website is hosted on which a user can submit their voice recordings. A user must first define the name of wake word they would like to train. A unique code is generated that links to a local database to store the incoming recordings. Users can share the code with others to also train a model. The code is entered on the webpage and then the user is navigated to the voice collection page where the entered code forwards all the voice recordings to the correct location.

Model Training and Generation – Scripts and executables running on a modern computer running on Linux.

To train and generate a model we are using a Recurrent Neural Network named [Precise](). For precise to work correctly it is recommended to have a Debian based Linux computer with a CPU that supports AVX (a runtime library that TensorFlow depends on). After following the setup guide for Precise based on your target architecture that you will be training on, collect the voice samples using your chosen method of data collection and convert the audio samples. The audio samples need to be converted to pcm_s16le format, following the detailed instructions available in the Precise training documentation. With the audio converted setup your folder structure based on the requirement for Precise and then start training. After the first round of training, a rudimentary model should be ready detection and testing.

Phrase Detection – Listening for a wake word and reacting accordingly.

Our implementation relies on detecting different wake words and executing functions accordingly. To detect wake words our implementation uses one top level Python file which runs an instance of the Precise listener Engine for each wake word. After a wake word is detected, a function is executed in which the appropriate GPIO pin is triggered to forward button commands to the remote.

3. Provide a detailed list of skills and resources you have at your disposal that will enable you to create your design. If there are skills or resources missing to complete your design, describe how you will obtain them.

Skills:

- Electronics: Fundamental understanding of electronics, including circuits, components, and soldering.
- Programming: Expertise in programming languages such as Python, C++, or Arduino.
- Voice Recognition: Knowledge of voice recognition technology as well as programming interfaces such as speech-to-text APIs or libraries.
- User Interface (UI) Design: Understanding the principles of UI design in order to create an intuitive and user-friendly interface.
- Prototyping: The ability to make physical prototypes with tools such as 3D printing and laser cutting.
- Troubleshooting: The ability to identify and resolve technical issues that may arise during the development process.
- CAD Design, one of the team members being a mechanical engineering student, they should have at the very least some skill in creating designs using CAD software.
- Project Management: the ability to organize and invest our time in useful things in order to advance to project in the most efficient way possible to be able to deliver a product that answers the client's needs.
- Interpersonal skills: Having the ability to empathize with the client, be able to ask the right questions to be able to further improve the prototype and be able to address his needs as best as possible.

Resources

These will be the building blocks of our project and will be combined in order to make the best possible product.

- CEED
- Maker Lab
- Makerspace
  - 3D printing: For making the case prototypes.
  - Laser cutting: For making the final version of the case.
  - Soldering: For splicing into the controller.
  - 3D Scanning: For scanning the controller.
  - Electronics: For connecting the controller to the computer
- Brunsfield center
  - Hand tools: To make any connections from the computer to the controller.

Hardware Resources Required:

- Microcontroller: A microcontroller board, such as Arduino or Raspberry Pi, to serve as the remote control's brain.
- A microphone module or sensor is used to capture voice commands.
- Power Supply: Batteries or power adapters for the remote control.
- Wires and Connectors: A variety of wires, connectors, and breadboards for making circuit connections.
- Tools: For assembling and troubleshooting, basic tools such as a soldering iron, wire cutters, pliers, and a multimeter are required.
- Resources for Software:
- Integrated Development Environment (IDE): A suitable IDE for programming the selected microcontroller, such as the Arduino IDE or the Raspberry Pi IDE.
- Voice recognition libraries and APIs: Precise
- Firmware Programming Tools: Microcontroller-specific programming tools, such as the Arduino programming environment or Raspberry Pi tools.
- 3D Modelling Software: If necessary, 3D modelling software such as Solid-works can be used to design custom enclosures or parts.

Additional Resources Required:

- Documentation and Tutorials: Electronics, programming, and voice recognition technology-related online resources, tutorials, and documentation.
- Online Communities: Platforms such as forums, Reddit, or Stack Exchange where you can seek advice from experts or enthusiasts.
- Supplier Networks: Access to dependable suppliers for the components and hardware needed for your project.
- Budget: Enough funds to purchase required components and equipment, as well as cover any unexpected expenses. (The Maker Lab can assist with keeping costs low, and the fact that we ourselves possess a raspberry pi helps.)

Skills or resources missing:

- Controller: Being able to modify and inspect the controller is something that has not been possible yet. The sample that the client sent in the mail is yet to get here. This complicates the design since it leaves uncertainties in the electrical interface side of things.

4. Provide a realistic assessment of the time required to implement your design and the actual time your group and its individual members have at their disposal.

Item	Description	Time necessary (Hours)
Software Construction	Creating the supporting software around the machine learning process. Adapting existing code to our purpose.	20 hours
Voice Training	Collection, sampling, and training of voice model along with basic testing	10 hours
Minicomputer set up	Setup of operating system (OS), software dependences and voice detection software	5 hours
3D Designing Attachment	Developing and printing 3D constructions of parts housing subsystems.	10 hours
Soldering to remote	Attaching wires from Raspberry Pi GPIO pins to remote PCB	2 Hours
Product Testing	Testing Voice and Controller Manipulation for all commands and operations	5 Hours
User Manual and Documentation	Develop a detailed user manual and other critical system documentation.	10 Hours

The time assessment totals to around 60 hours, which divided between the 4 members of our team equals about 15 hours of work per person. This is more than reasonable since there are 2 weeks before the prototype is due.

5. Critical Assumptions

In the process of designing a product, it is crucial to identify and address critical assumptions that can significantly impact the implementation and success of the design. These assumptions encompass various aspects such as functionality, material/component availability, and user interactions. By recognizing and considering these critical product assumptions, designers can make informed decisions and develop effective solutions. In this context, we will discuss three critical assumptions that need to be considered for our design project.

A. The ability for the client to speak in a semi-clear voice:

Our design project involves a voice-activated program that interprets spoken commands. However, an important assumption is that the client must be able to speak in a semi-clear voice for the program to accurately interpret the desired commands. Proper testing and validation of this assumption will be crucial to ensure optimal user experience and functionality, a way to reduces the implications of this assumptions would be to generate a script with prompts that the client would have to read out, this would result in the computer not having to interpret his words, and instead comparing them to an existing database.

B. Reasonable market value and availability of a Raspberry Pi:

Our design project incorporates the utilization of a Raspberry Pi, a popular and versatile single-board computer. An assumption here is that the Raspberry Pi will be reasonably priced and readily available in the market. It is important to consider the accessibility and affordability of this component since as of late prices have skyrocketed due to the aftermath of the covid pandemic and the global silicon shortage. If no board is found at an accessible price, alternatives with similar computing power would be necessary.

C. Remote control design and its interface to the computer:

As part of our design project, we require a remote control for testing and interaction with the system. This remote has a standard 9 pin connection and well-defined functions.
However, due to the current unavailability of a remote for testing, we need to make assumptions regarding its specific design and its interface to the computer. These assumptions will guide our design decisions and allow us to proceed with testing and development. However, they should be validated and refined as soon as the remote becomes available to ensure seamless integration and user satisfaction. Furthermore, the remote that the client will send is not as complex as the actual remote that he will need to use as it has a single two-way adjustable function. This is different to the three two-way adjustable functions present in the real remote. In principle, software and hardware modifications should not present a challenge to accommodate for this but it is still a critical aspect to consider.

6. Detailed preliminary bill of materials for final prototype

Item	Quantity / Notes	Cost (CAD)	Link
Wire	6	0.4	Ali Express
Soldering Equipment	From maker space	0	
Solder	From maker space	0	
PLA Filament	From maker space	5	
3D Printer	From maker space	0	
Raspberry Pi 3B	64Bit 8GB EMMC 2G RAM Bundle 6	84	Ali Express
SD Card	Included with Pi	0	
Mini USB Cable	Included with Pi	0	
Microphone	From maker space	22	Maker Lab
Screwdrivers	From maker space	0	
Fasteners (Velcro straps)	From maker space	1	
3D scanner	From maker space	0	
Python	Version 3.7	0	
TensorFlow	Version 1.18	0	
Precise	Version 0.3	0	Github
Generic computer	For training model	0	
SolidWorks	For case design	0	
Standoffs	Various sizes	16	Amazon

The total cost for this project will add up to roughly 130 CAD, which is below the established 150 CAD budget, and much lower than the market average of around 600 CAD for similar but worse performing products.

It is important to note that we already own a raspberry pi, a microphone, the required auxiliary equipment for the Pi such as an SD card and power cables, so the best market price found was quoted on the BOM as to obtain the same amount of equipment that we currently have.

A newer microphone will be obtained from the maker store, as to reduce the need to provide our own equipment for the project, if a compatible raspberry pi is found in the store, it will be obtained as well.

Conclusion:

In summary, this document focuses on a detailed description of the concept and the materials required to build it; This is achieved through summary and analysis of the second client meeting and an in-depth explanation of the current design. This detailed description will provide the ability for someone without inside knowledge of the project to replicate the design with little to no external input.

Additionally, a comprehensive list of skills and resources at our disposal was provided, along with a realistic time analysis for the implementation of the detailed design. This will allow the group to precisely plan out the implementation of the concept.

To conclude, a bill of materials is provided which details every item required for the successful implementation of our design. Upon approval of the bill of materials, we will possess all the items required to fully implement the detailed design.

Project Management:

Wrike link: https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=5JVLxVluzOzAJ4GsowFFZFtVbzIIh2cg%7CIE2DSNZVHA2DELSTGIYA