Project Deliverable C: Detailed Design and BOM

GNG 2101 - INTO PROD DEV & MGMT FOR EN/CS

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Group C3.1

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Table of contents

Introduction

On February 1st 2023, we had the opportunity to meet with our client and present the information that we learned along with the designs that we came up with. During our meeting, we discussed the need statements that we created based on the information that we received from our last client meeting. We also discussed our problem statement, along with some details on our solution's three subsystems which are the folding actuators, accessibility and control system, and housing and frame. Our client agreed with what we showed her during our meeting. We also asked our client some questions at the end of our meeting. For example, we asked about the dimensions of the final product, and about the importance of the app integrated into our t-shirt folder.

After this client interview, we were able to develop physical CAD representations of the overall concept and for each subsystem. We also developed a flowchart that describes the overall flow of the use of the t-shirt folder, whether it is used physically or through our software app. In addition, we developed a medium prototype of the mobile app that will be used to control the t-shirt folder. We also provided a detailed list of skills and resources that will enable us to create our design. For example, in terms of resources, it is important that we have the ArduinoBLE bluetooth library, to connect the switch adapted t-shirt folder to the app. In addition, it is important that we have the 9g servos, because it is what allows for the movement of the flaps of the t-shirt folder. In terms of skills, it is important that we have programming skills in Arduino because that is what is going to allow us to control the movements of the t-shirt folder's flaps. These skills will also be needed to connect to the mobile application that we are going to develop as well. We also provided a realistic assessment of the time required to implement our design and the time that our group has at our disposal. We also defined other critical product assumptions that could affect our ability to implement our design. For example, we discussed what would happen if a particular material was not available. We also provided a detailed preliminary bill of materials and parts for our final prototype. For example, we noted that we needed the 9g servos and the 3.5 mm audio jack. We also included materials that will cost nothing, like the ArduinoBLE library and the Arduino Nano. The Arduino Nano won't cost us anything because Ryan is providing it to us. Finally, we updated our project plan to include any missing tasks, task responsibilities, milestones, and dependencies.

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.

Within our second client meeting, we discussed need statements that we made from the first client meeting. After going through each of our client's need statements, we asked her if she had any issues with them, and were told that they were all acceptable. After telling our client about the need statements, we showed her our problem statement. Our problem statement is, "There is a need for an easy & accessible switch system that would allow patients at the Bethany Children's Health Center, some of whom have motor & speech impediments, to activate an automatic T-shirt folder. The device should not be overly robust, not slide easily while in use, but should be easy to install and need minimum assistance from caretaker staff to use." We asked her if she had any issues with this problem statement, but she said that she had no issues with our problem statement. After this, we told her our solution system, and discussed how it could be broken down into 3 different subsystems. The 3 subsystems are folding actuators, accessibility and control system, and housing and frame. We made sure to discuss the phases of motion for the t-shirt folder, and the underlying mechanisms behind it. For example, we described to our client that we were using a 2-bar linkage for folding the sides of the t-shirt folder, and using the sliding surface/string drive for the bottom flap of the t-shirt folder. For the folding actuators, we described the mechanical concepts we thought of, like the sliding slot drive, sliding surface/string drive, 2 bar linkage, and inline drive. We also described the motor drive possibilities for the folding actuator subsystem, like stepper motors, DC motor with limit switches, and servo motors. In terms of the accessibility and control system, we described the accessibility concepts, like the 3.5 mm audio jack adaption and the mobile device connection. We also gave our client a high level summary of the control system. For example, telling our client how the t-shirt folder will be powered by a 5V USB power bank, and the programming being done on Arduino. Finally, we described to our
client , the housing and frame of the product, and explained general concepts like it being a contained box or even having stilt supports. We also showed our client sketches of our final solution. After showing our client all of these details, she agreed with all of them, and did not recommend any changes. After our presentation, we asked her questions like whether we should add straps or rubber feet to our final solution. She said that she was okay with either straps or rubber feet. We also asked her how important the app was to the project as a whole, and she said that she is happy with just the physical buttons and said there was not a

real need for the app. However, she still encouraged us to try and develop an app, if we wanted to. We also asked her about the dimensions of our final solution and she said that the height did not matter because she has adjustable tables at the health center. Also, for the width and length, it just has to be the size of the t-shirt folder. We also asked her if the children have any uncontrolled hand movements because they could accidentally hit the LCD and get hurt. For this our client informed us to just add a bumper or frame around the LCD and to just cover the LCD with plastic.

Skills and resources

Skills at our disposal

- Programming Languages
    - C++
    - Python
    - React
- Electronics hardware prototyping skills/expertise
    - General hardware design etiquette
    - Knowledge of common electrical components/concepts
- Front-end app design
- Mechanical design skills
    - Understanding of material selection process.
    - Knowledge of common hardware/fasteners.
    - Ability to design linkages
    - 3D Printing experience
    - Laser cutting experience
    - Experience with aluminum extrusions (80/20)
- CAD design skills
    - Solidworks
    - Fusion360
    - Cura
        - Exporting to slicer/creating gcode files
        - Adapting prints to exotic filaments
- ECAD design skills
    - Altium
    - Autodesk Eagle
    - Experience with executing PCB orders

Resources at our disposal

- MakerSpace
    - 3D Printing
    - Laser cutters
    - Hand tools
    - PCB mill

- Arduino libraries
    - RGBLED driver
    - BLE I2C library
    - EEPROM I2C library
    - LCD I2C Backpack library
- Internet experience
    - Stack exchange
    - Arduino forums
- Github
- Brunsfield Centre
    - Mills/Lathes
- Makerstore
    - Selection of parts that can be reimbursed
- Electronics Store
    - High quality soldering stations
    - Solder reflow oven
    - Selection of simple parts that can be reimbursed

Skills and resources missing

Skill/Resource missing	How we will obtain them
Arduino bluetooth to iphone connection	Research online
IOS app development	Research online
Finite Element Analysis	Youtube
Duel platform app development	Research online
Performing mechanical calculations	Read Mechanism and Mechanical Devices Sourcebook
Experince designing laser-cut enclosures	Prototyping and research online
EEPROM Libray use	Reading doccumentation

Table 1: Skills and resources missing and how we will obtain them

High-level on functionality

Flow state of the T-shirt folder

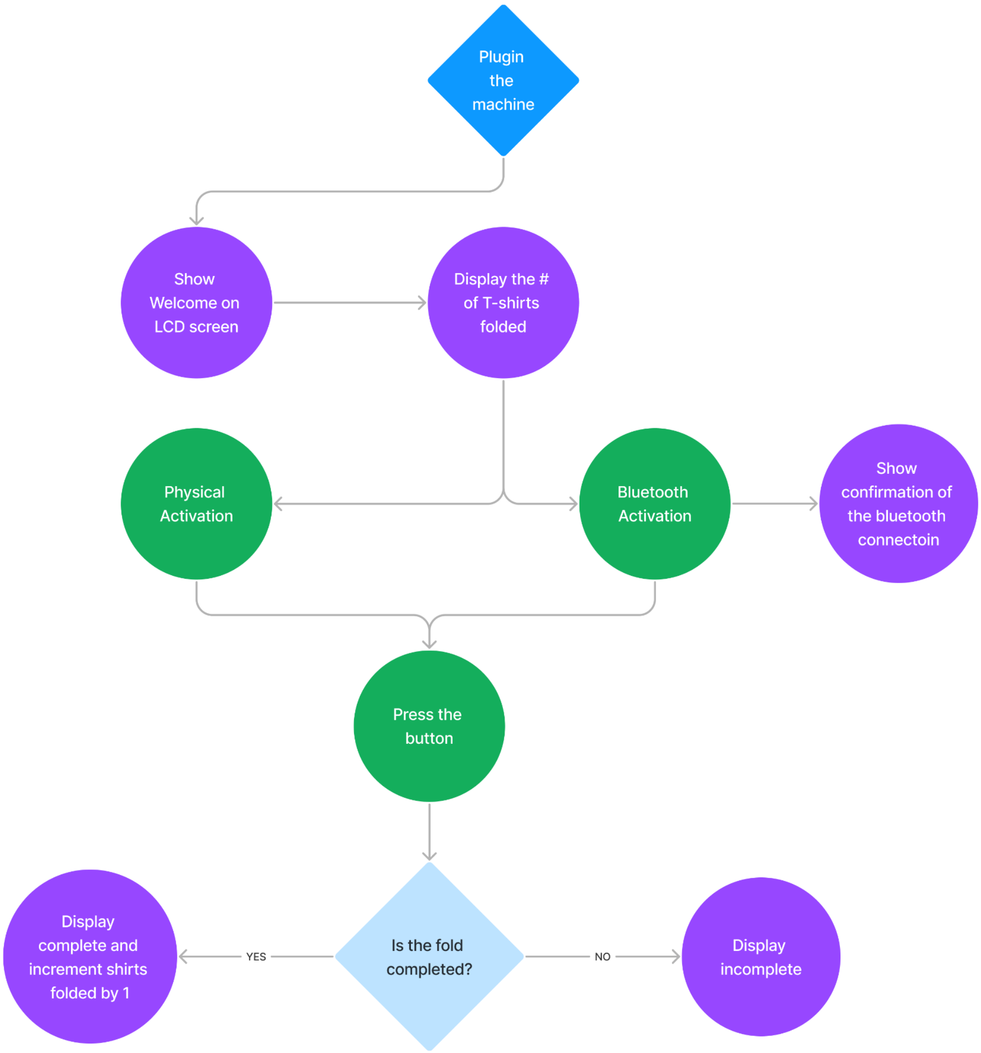

Plugin the machine
Show Welcome on LCD screen
Display the # of T-shirts folded
Physical Activation
Bluetooth Activation
Show confirmation of the bluetooth connectoin
Press the button
Is the fold completed?
YES
NO
Display complete and increment shirts folded by 1
Display incomplete

Figure 1: Flow state diagram for the T-shirt folder

T-Shirt Folder Mockup Prototype

The prototype can be accessed via this link

For each state of the mockup prototype, it is designed with an iPad Pro screen. The reason for this is because during our client meeting, our client mentioned that there are mostly only Apple products like iPads that are used by the children.

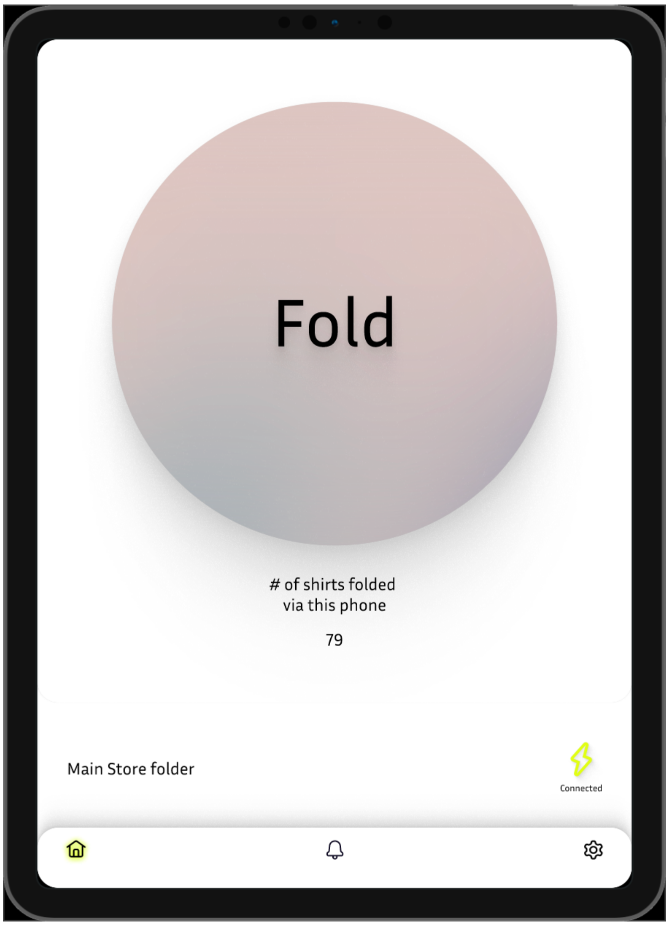


Figure 2: home page when app is launched

Home page: The homepage features a prominent button that takes up most of the screen and, when pressed, initiates the fold with an automatic t-shirt folder. The homepage also displays the connection status of the t-shirt folder with an iPad and the number of t-shirts that have been folded using the iPad. This design aims to provide a user-friendly experience for folding t-shirts, allowing for efficient and streamlined processing. The integration of the iPad and the t-shirt folder makes it easy for users to keep track of the folding process and ensure that the task is completed efficiently.

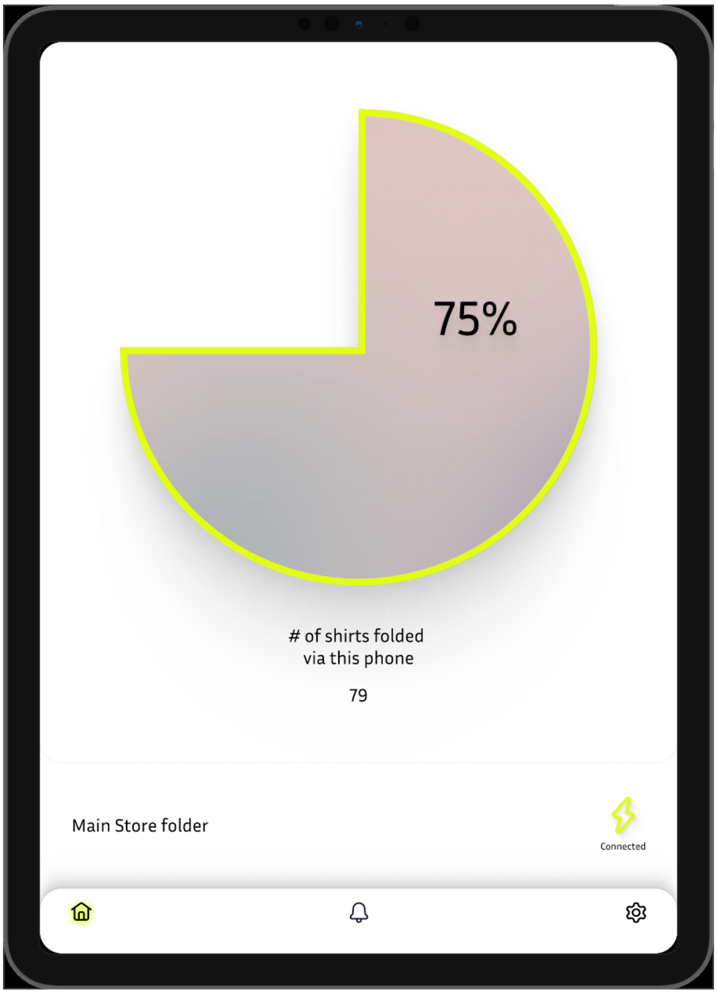
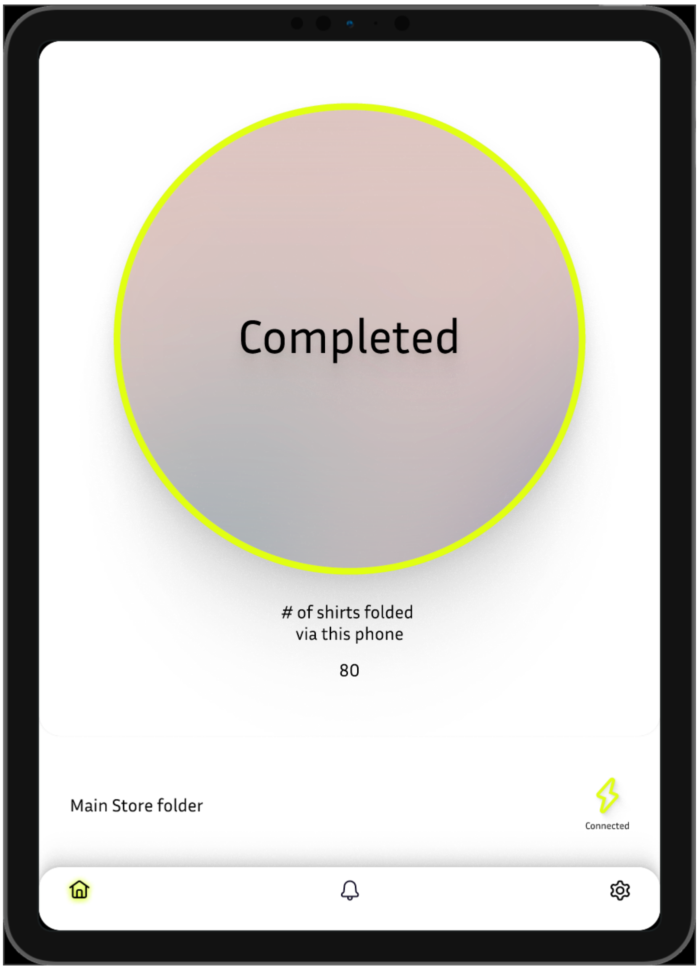


Figure 3: Process visualization of folding the t-shirt

After pressing the fold button, the homepage will provide users with a visual representation of the folding process by displaying the percentage of the t-shirt that has been folded. For example, if the t-shirt is 75% folded, the display will show "75% complete." This provides users with real-time information on the progress of the folding process, allowing them to gauge how much longer it will take to complete the fold. The use of a percentage indicator also helps to create a more intuitive and user-friendly experience, as users can easily see the progress of the fold and know exactly when it will be completed. This feature will also help users to quickly identify any potential issues or delays in the folding process and make any necessary adjustments.



Completed

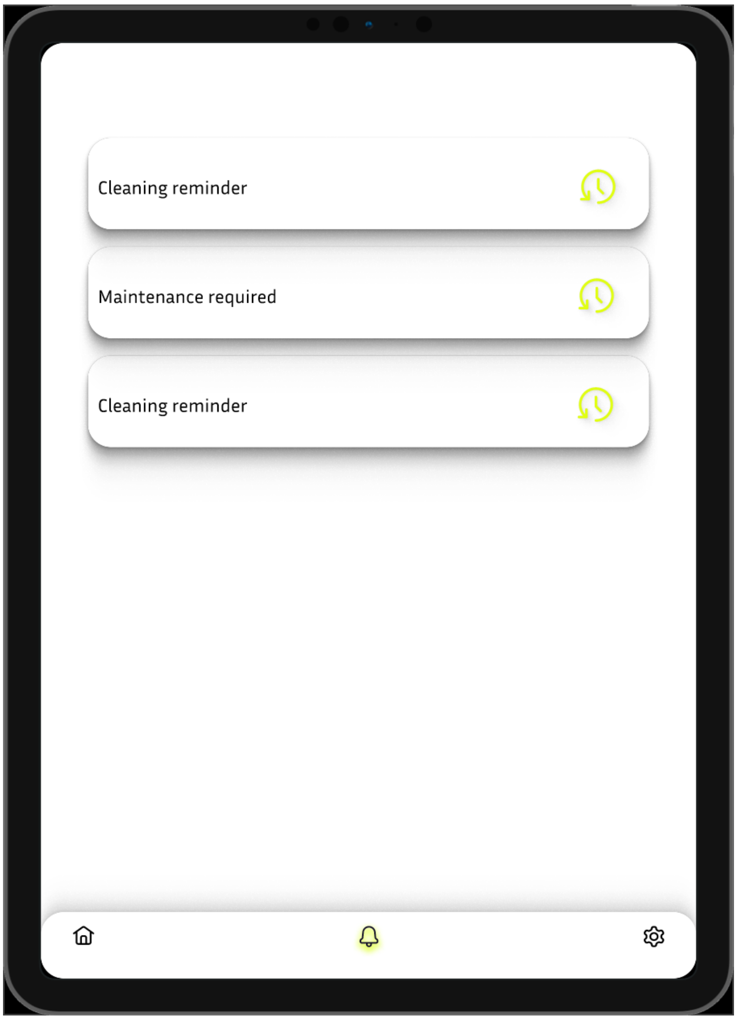
# of shirts folded
via this phone

80

Main Store folder

Figure 4: Confirmation of completion

Upon completion of the t-shirt fold, the homepage will transition to a completion page. This page will display the total number of t-shirts folded and updated in real-time as each t-shirt is folded. This information will be stored on the iPad, allowing users to track the total number of t-shirts folded over time. The completion page will also provide users with the option to start another fold, return to the main homepage, or log out of the system. Additionally, the number of t-shirts folded will increment with each successful fold, providing users with a clear and accurate record of their progress. This information can be used for tracking purposes, or for setting goals for how many t-shirts a user wants to fold in a given day, week, or month.



Cleaning reminder

Maintenance required

Cleaning reminder

Figure 5: Notification page

In addition to the main homepage and completion page, the deliverable also includes a notification page, which provides users with important reminders and notifications related to the t-shirt folding process. This page will be used to inform users of any maintenance requirements for the t-shirt folder, as well as to provide important updates or alerts. For example, if the t-shirt folder requires routine cleaning or replacement of parts, the notification page will display a reminder for the user to take action. Additionally, if there are any software updates or bug fixes available for the iPad, the notification page will provide users with a notification to download and install the update. The notification page is designed to be user-friendly and easy to understand, with clear and concise notifications and reminders.

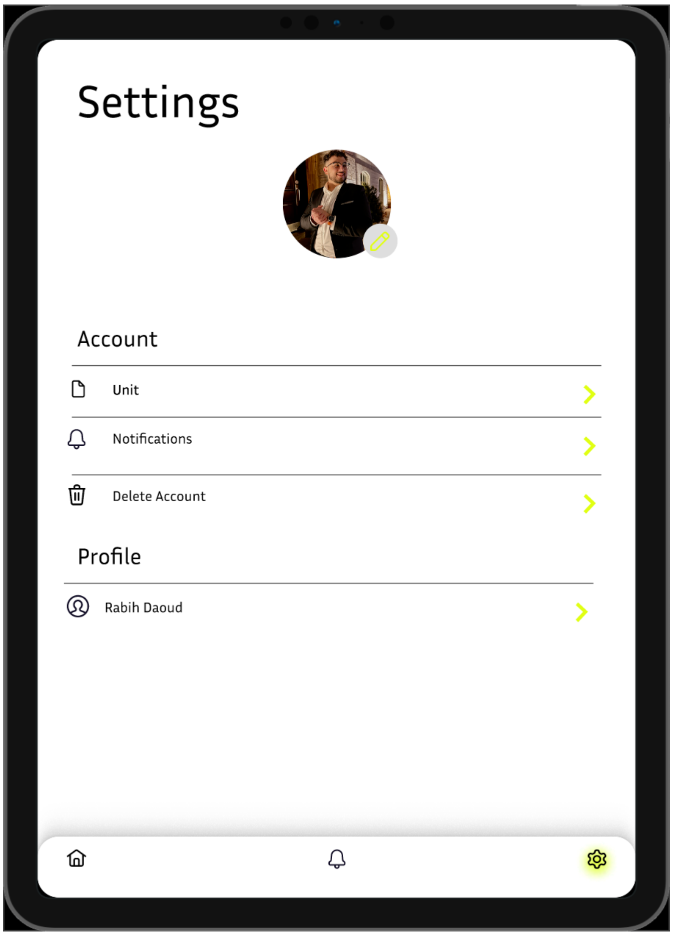


Figure 6: Setting page

On this page, users can set the unit of measurement for their t-shirt folder, such as inches or centimeters, to ensure that the folding process is accurate and meets their specific needs. Additionally, users can set their notification preferences, such as choosing which notifications they would like to receive and how they would like to receive them (e.g. email, push notification, or in-app notification).

The settings page also includes a profile setup feature, where users can create a profile with their personal information and preferences. This information can include their name, contact information, and any other relevant details. The profile setup feature allows users to quickly and easily access their information and preferences each time they use the t-shirt folder, streamlining the overall experience and making it more convenient for users.

Electronics Design

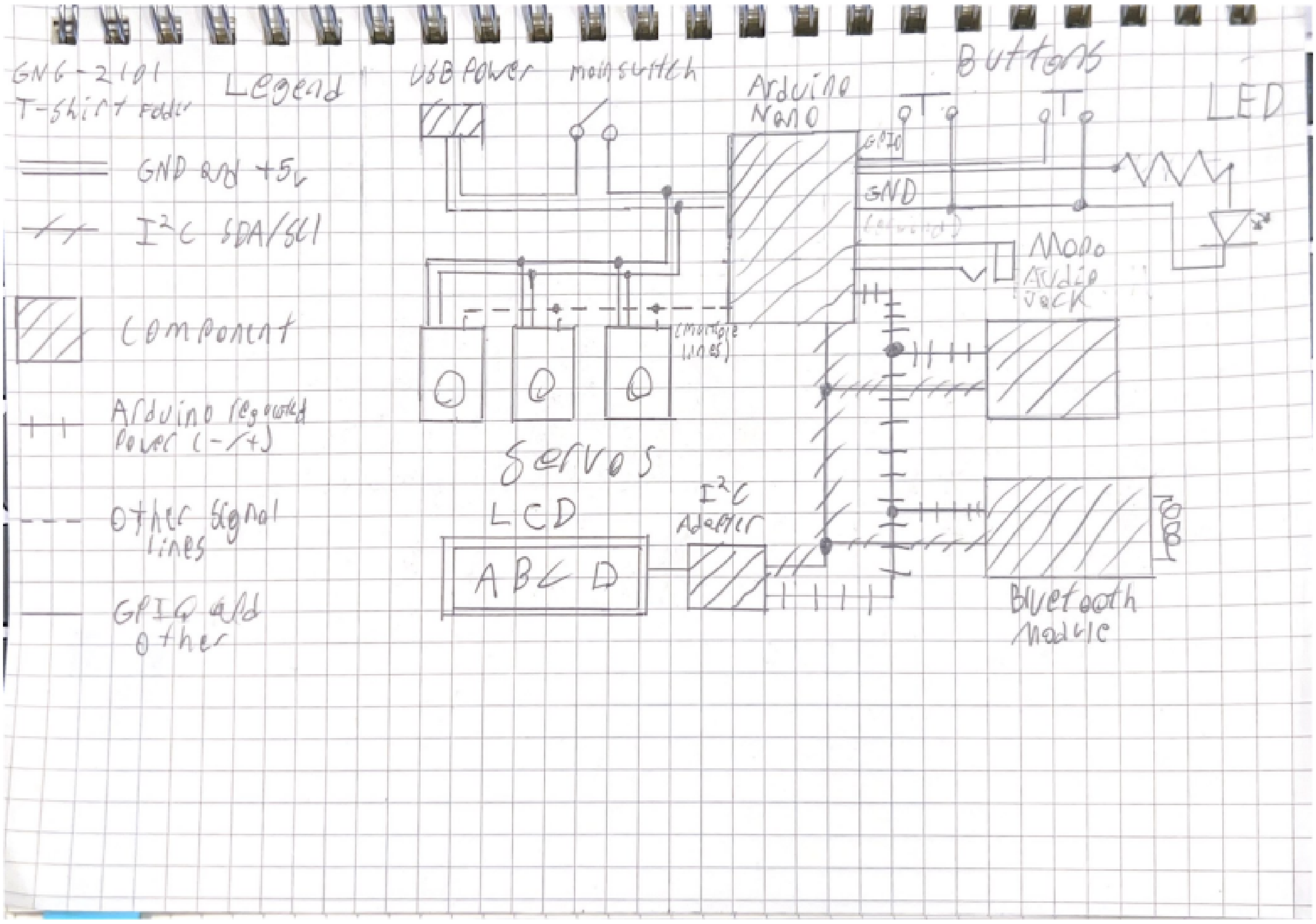


Figure 7: Electronic design sketch

Time required for design

Mechanical

The mechanical side of the project will likely take one to two weeks to complete. The reason behind this is because it would take approximately one week to wait for the materials to arrive, and then build the 2-bar linkage, and sliding surface/string drive. The additional week is used for making calculations for the design, such as calculating moments of inertia. The extra week will also be used to attach the servos, 2-bar linkage, and the sliding surface/string drive onto the t-shirt folder, and to experiment with folding the flaps of the t-shirt folder, to determine the best method to fold the shirt. This could include changing the angle at which the t-shirt folder stops its folding, as well as trying to modify the speed at which the servos fold the t-shirt folder's flaps.

Software

The software side of the design will consist of programming an arduino microcontroller to rotate servo motors in a pattern that will result in moving the flaps of the t-shirt folder so that a t-shirt is folded. This will take three to four days to implement as we will likely have to do many alterations to the program to get the servo motors aligned and turning in a way that results in the t-shirt being folded.

There will also be an LCD display showing the current state of the t-shirt folder as well as some statistics. This will also likely take three to four days meaning the software part of the project will take around a week in total.

A lot of the software side depends on the mechanical side of the project. If part of the physical t-shirt folder breaks and has to be fixed, then the software development will be delayed and may take longer.

Mobile Application

For now we are treating the mobile application as a bonus that will only be done if we have more time remaining after we have created a working automated t-shirt folder. Should we get around to working on the application, it should take no longer than a week to develop and test. The front-end of the application should take no longer than a day or two whereas the back end may take three to four days to complete. A large amount of our time with the back end will likely come from trying to figure out how to get information sent from the t-shirt folder to the application via bluetooth. We will also need a day to test the application.

Individual availability

Jeyason: 8 hours during weekdays, and 9 hours of the weekend.
Jordan: 11 hours during weekdays, and 10 hours of the weekend.
Rabih: 10 hours during weekdays, and 12 hours of the weekend.
Ryan: 8 hours during weekdays, and 12 hours of the weekend.
Joshua: 14 hours during the weekdays, and 10 hours of weekend

Critical Product Assumptions

Here are some critical product assumptions that may impact our ability to develop our product:

- A possible scenario in which our materials do not arrive in time would impact the mechanical assembly time frame.
- The materials and parts that we purchase do not work as intended.
- The mobile application does not work on multiple different platforms.

- Difficulties getting the mobile application on the app store. The Apple review process may take some time.
- The servo motors cannot support the weight of a t-shirt.
- Any of our materials or our device breaks or malfunctions at any point.
- If the servo motors do not have enough torque meaning they do not move the flaps of the t-shirt folder fast enough, then there is the chance that the t-shirt may fall off before a fold is complete preventing the t-shirt from folding properly.

Bill of Materials

Item Name	Part Type	Description	Quantity	Unit Cost	Bulk Cost	Source	Link
Arduino Nano	Electronics	Microcontroller	1	$0.00	$0.00	Ryan	n/a
9 Gram Servo	Hardware	Motor	3	$0.00	$0.00	Jordan	n/a
Breadboard	Electronics	Wiring	1	$0.00	$0.00	Jordan	n/a
3.5mm Aux Female	Electronics	Audio Jack	1	$1.25	$1.00	Adafruit	link
Piezo Buzzer	Electronics	Buzzer	1	$1.50	$1.13	Adafruit	link
USB Wall Adapter	Electronics	Adapter	1	$0.00	$0.00	Team Member (any)	n/a
USB-A Male to Male	Electronics	USB	1	$6.99	$6.99	Amazon	link
Rocker Power Switch	Electronics	Switch	1	$5.99	$5.99	Amazon	link
USB-A Femal Panel Mount	Electronics	USB	1	$3.95	$3.16	Adafruit	link
MDF Board	Hardware	Board	5	$0.00	$0.00	Makerstore	n/a
24LC32 I2C EEPROM	Electronics	Memory	1	$3.95	$3.16	Amazon	link
Pushbuttons	Electronics	Button	2	$0.00	$0.00	Electronics Store	n/a
16x2 LCD and I2C Backpack	Electronics	LCD	1	$17.18	$17.18	Amazon	link
Wires/Dupont Connectors	Electronics	Wiring	Unknown	$0.00	$0.00	Ryan/Electronics Store	n/a
HC-06	Electronics	Bluetooth	1	$16.99	$16.99	Amazon	link
M4 20mm Hex Bolts	Hardware	Bolts	20	$0.00	$0.00	Ryan	n/a
M4 20mm Hex Nuts	Hardware	Nuts	20	$0.00	$0.00	Ryan	n/a

M4 20mm Hex Washers	Hardware	Washers	10	$0.00	$0.00	Ryan	n/a
3D Printed PLA Parts	Hardware	3D printed parts	Unknown	$0.00	$0.00	Makerspace	n/a
RGB LED	Electronics	LED	1	$9.95	$7.96	Adafruit	link
300 Ohm Resistors	Electronics	Resistors	12	$0.00	$0.00	Ryan	n/a

Table 2: Bill of materials

Closing remarks:

Conclusion

To conclude, the second client meeting confirmed to our team that the steps are going in the right direction in terms of designing our product. Although our client told us that she does not require a mobile app to be developed, our group is still going to develop an app, because it allows us to utilize and improve our software skills, and it helps make the t-shirt folder more usable. It makes the t-shirt folder more usable because now the children could activate the t-shirt folder through a physical button and through the actual app, and pressing a button there. Through working on this deliverable, our team learned more about the importance of making detailed designs and prototypes, as that helps us to actually assemble the final product. This deliverable also allowed for us to assess our skills, realize what skills we are missing, and figure out how to obtain them. For example, our group needs to have good Arduino skills, however this skill is missing. So in order to obtain good Arduino skills we decided to watch youtube tutorials, and do the Arduino lab for lab #5. We also realized the importance of creating the BOM, as it lets us see the list of materials that we need to produce our final solution. It also allows us to actually do research and choose our products wisely to stay within the $100 budget. The next step for deliverable C, is to actually do the design review, where our group will meet with our PM/TA/Prof, and present our detailed design and BOM to get feedback about the quality of our design and its feasibility. Then using the information that we gathered from the design review, we will work on deliverable D, where we have to develop our first prototypes.