GNG2101 Report Template

Gripply
Group B04 A

Submitted by

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Abstract

The goal of this project was to incorporate all the knowledge and skills taught in this course throughout the semester, and to be able to see how the design process can be applied in a real-life scenario. The process was started by meeting with our client to understand her needs and what was required to satisfy them while staying under budget. After the first meeting we created a problem statement that we would continually look back on throughout the process so we could ensure our group was on the correct path.

Later, the needs and wants of our client were applied to create our fundamental requirements, non-fundamental requirements and constraints. We used these to create our design criteria and did further research in able to complete benchmarking to compare our ideas to other products available. From the benchmarking we developed ideas and ultimately decided on our final solution. We then created prototypes based on this idea. With these prototypes, we were able to analyze and test different concepts to match the requirements of our client.

After completing testing, a final prototype was developed and completed. Gripply was able to meet all the requirements of our client, incorporate ideas learned in the course, and lastly stay on a budget and timeline. This project required teamwork to find a solution to a real-world issue and to be able to be able to create a physical product for our client.

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List of Acronyms

Acronym	Definition
CAD	Computer Aided Design
TOS	Thoracic Outlet Syndrome
SEM	Scanning Electron Microscope
NMES	Neuromuscular Electronic Stimulation
lbf	Pound Force
3-D	3-Dimensional
TELOS	T – Technical E – Expense L – Legal O – Organizational S - Schedule

1 Introduction

Many people struggle with everyday tasks because they have a severe lack of strength in their hands. The sources can range from a stroke to Thoracic Outlet Syndrome (TOS), a condition caused by the compression of blood vessels or nerves between the clavicle and the first rib. Restoring strength to and stabilizing the hands of these patients is the key to allowing them to live a life free of barriers. Our client, Adrienne, suffers from TOS which has left her unable to grip objects like knitting needles and dishes, which she uses in everyday life. Our goal is to create a device to help people with TOS or other conditions that result in reduced hand strength and mobility. Our device should stabilize and help move the thumb which will provide the necessary grip strength to allow a user to manipulate and pinch objects unencumbered by their condition.

Our product is going to continue the positive aspects of the previous attempts at this project. However, we are going to make some adaptations to our device so that we can satisfy our client, Adrienne, and her needs. Gripply differs from previously created products because this product presents casing into all our wiring and electrical system supplies. Despite so, our product is fully functional and is pleasing to look at. Overall, Adrienne has been pleased with the results of the previous groups although the size and look of the final design was a huge drawback for her. In an attempt to fulfill her request, our focus was to create something that is minimalistic and appealing, as well as still being fully functioning, in which we achieved for the most part.

1.1 Problem Statement

Our client needs a breathable, light, and wearable assistive device that can compensate for her low grip strength when manipulating or pinching objects during the completion of her daily tasks and activities.

2 Need Identifications

In order to avoid words like must and should, we can organize our findings into 3 categories that branch into the requirements of design [table 1]. These categories aid in deciding the importance of each metric and help us understand and realize what each metric is linked to in the design, and what is ideally more important to create within the time frame and constraints we have. It brings out the positive of the design criteria metrics as it leaves no room for any metric to be questioned or doubted, and precisely emphasizes what is needed to create a superior product that meets all kinds of requirements and specifications. For example, this helps organize thoughts and ideas into the importance rank. A functional requirement can be highly desired and is important for the functioning of the hand grip tool. While a non-functional requirement can take too much time or money and is not really essential to the functioning of the assistive device, thus, can be prioritized less.

Functional Requirements	Constraints	Non-Functional Requirements
- Rigid (support the thumb well) - Rechargeable option - Ability to generate forward and torsional force along the Ulnar Collateral ligament - Allow for thumb and finger movement precisely and easily	- Low profile (not too bulky) - Price (considerate of budget) - Quality (high-quality and high functionality) - Time (up to November 28th)	- Aesthetics - Breathable 100% cotton - Lightweight - Comfortable

Table 1 - Functional and Non-Functional Requirements and Constraints

Number	Need	Importance
1	The device needs to be rigid enough to support the thumb	5
2	Any batteries have the option to be rechargeable.	3
3	The device can generate forward and torsional force along the Ulnar and Collateral ligament.	5

4	The device allows the thumb and fingers to move precisely and easily.	5
5	The device has a low profile and is not bulky.	4
6	The device is affordable for the average person.	4
7	The parts of the device that cover the hand are breathable and comfortable.	5
8	The materials for the parts of the device that cover the hand are made from 100% cotton.	5
9	The device is lightweight.	3
10	The device is aesthetically pleasing.	2
11	The device is water resistant. It can be worn while washing dishes or gardening.	4
12	The device, including mechanical parts, can be easily maintained.	3
13	The device is easy to put on, take off, and use.	3
14	The device can be used for long periods of time.	3
15	The device has a long lifetime.	3

Table 2 – Client Need Statements

3   Metrics and Target Specifications

Design processes are important in solving many engineering problems. Every design process includes a design brief, consisting of a list of specific requirements that must be met in order to ensure success. Designing a hand grip system is a challenging task that requires certain design criteria to be planned out before prototyping the design. After meeting with the client, basic needs that were addressed are included.

Number	Metric	Unit	Acceptable Value	Ideal Value	Reason for values
1	Weight of Glove	g	<400	<250	- Compact, low profile - Not overly invasive or heavy - Typical comfortable glove weight one can handle

2	Aesthetics	size	= large size	= medium size	- Pleasant to the eye - Ideal for daily wear
3	Device Size	cm³	<18	<12	- Minimize motor and battery size
4	Water Resistant	Depth (m)	>0.5	>2	- Able to endure dishwashing, gardening activities - Depth ability to submerge in water
5	Gripping Strength Generated	kg	>15	>30	The average grip strength for females
6	Breathable	g/m²/24 hours	>3000	>6000	- Fabric or 100% cotton - Keeps hands clean - easy to wear in any weather condition https://shop.rockymountainskiandboard.com/waterproof-breathability-ratings/
7	Manufacturing Cost	$	<500	<100	Affordable and cost-worthy
8	Usage time	hour	>4	>6	The client will use this product daily, typically for over an hour to complete one certain activity
9	Maintenance	day	>30	>60	- Easy to clean -User can repair simple damages - Doesn't require a lot of maintenance
10	Practicality	minute	<2	<1	Ideally should take no more than the average time to tie both shoelaces

Table 3 - Target Specifications

4 Benchmarking

Product Name	Technology	Price	Product Image
GripMate	Arduino circuit, a MyoWare muscle sensor, and pressure sensors	N/A	Figure 1 – GripMate
Tenaci Hand Grip	Arduino microcontroller	N/A	Figure 2 – Tenaci Hand Grip

Design C	Arduino coding	N/A	
			Figure 3 – uOttawa Design Team
Saebo Glove	Electrical Stim (NMES)	$299	**Figure 4 – Saebo Glove**
Carbon Hand	SEM technology	N/A	**Figure 5 – Carbon Hand**

Benchmarking

Manovivo	9-axis IMU sensor, MCU, and a Bluetoothv2.0+E DR module	N/A	 **Figure 6 - Manovivo**
Gripit	Manual	N/A	 **Figure 7 - Gripit**

Table 4 – Benchmarking Designs

5 Chosen Concept

See Appendix II for Weighted Decision Matrix
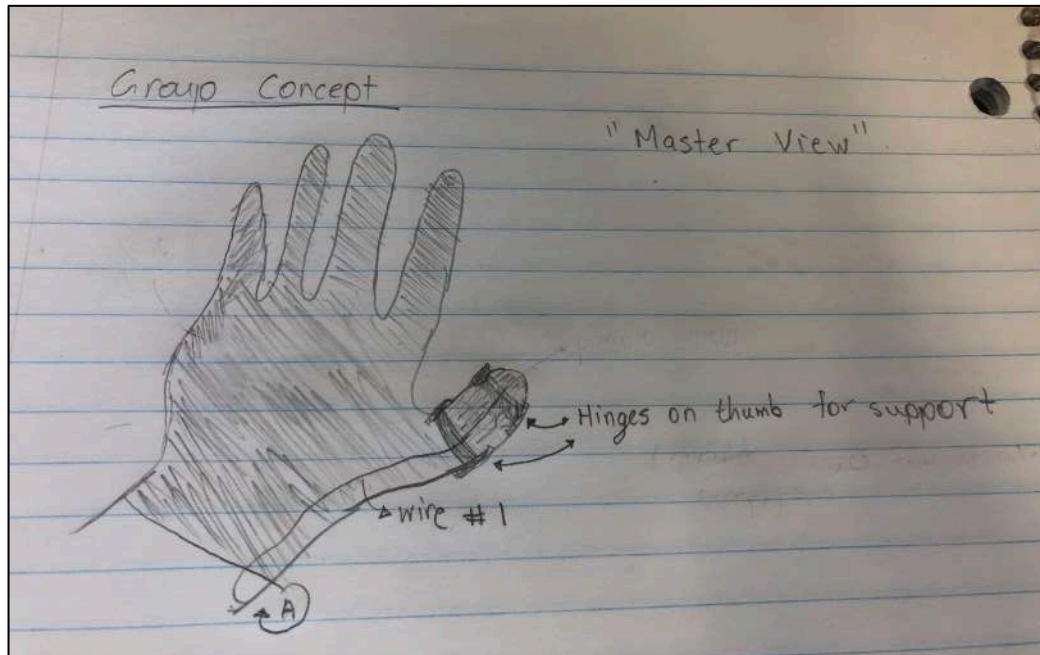
Figure 8 – Master View Sketch of Group Concept
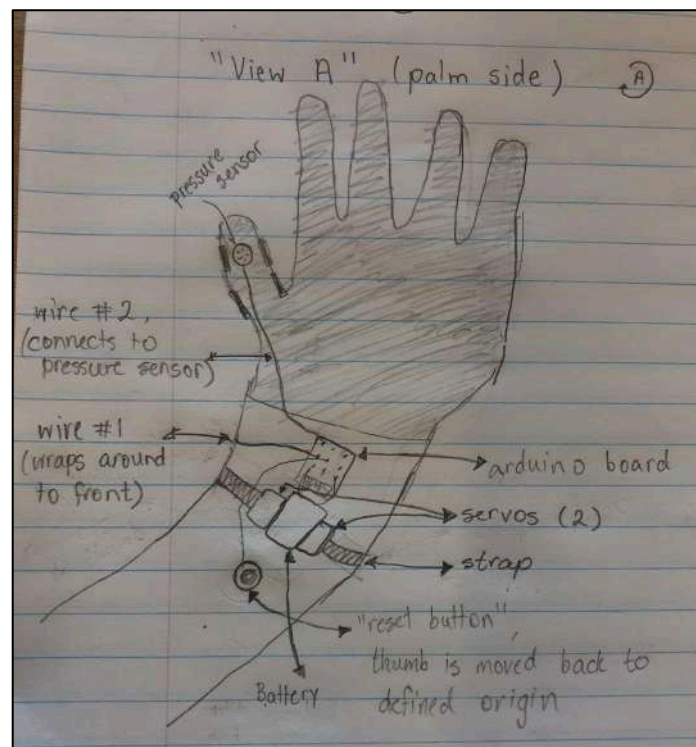
Figure 9 – Palm View Sketch of Group Concept

6 Prototyping, Testing, and Customer Validation

6.1 Prototype I

6.1.1 CAD Prototype I
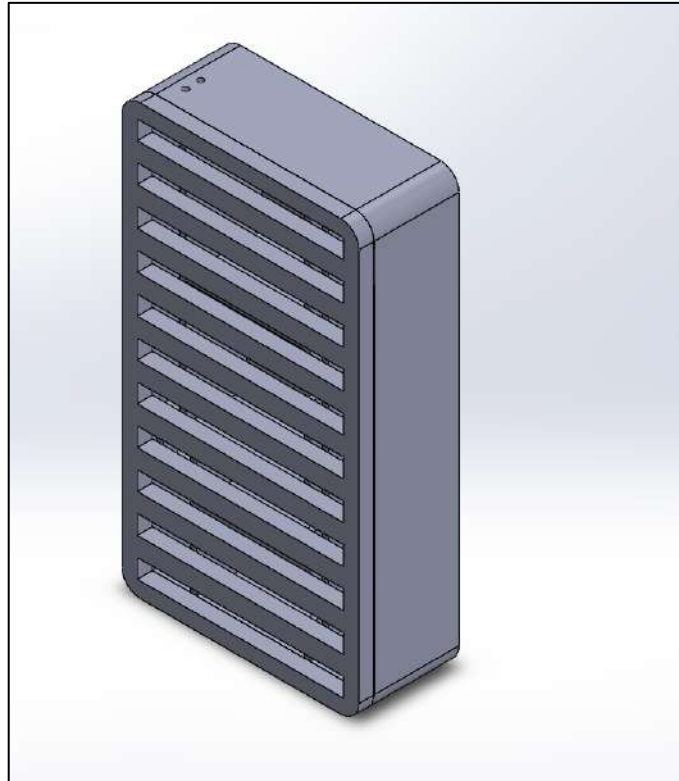
Figure 10 – Forearm-Mounted Electronics Case
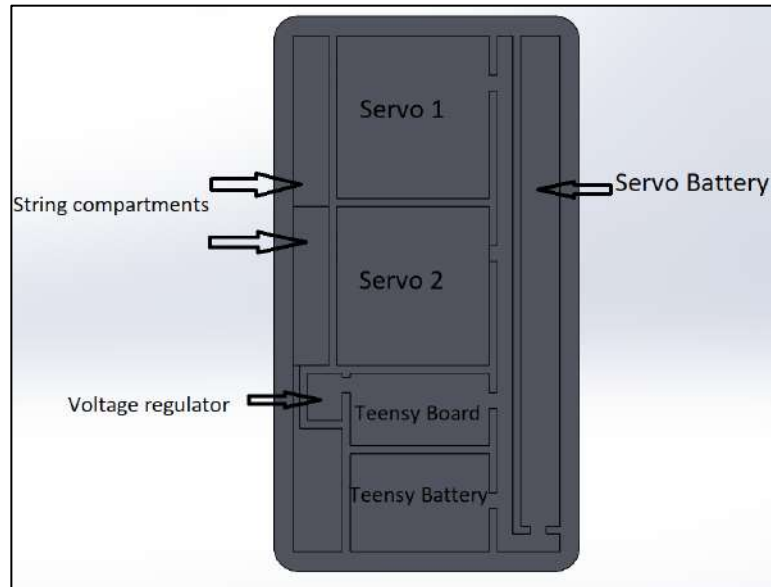
Figure 11 – Labelled Compartments of Electronics Case
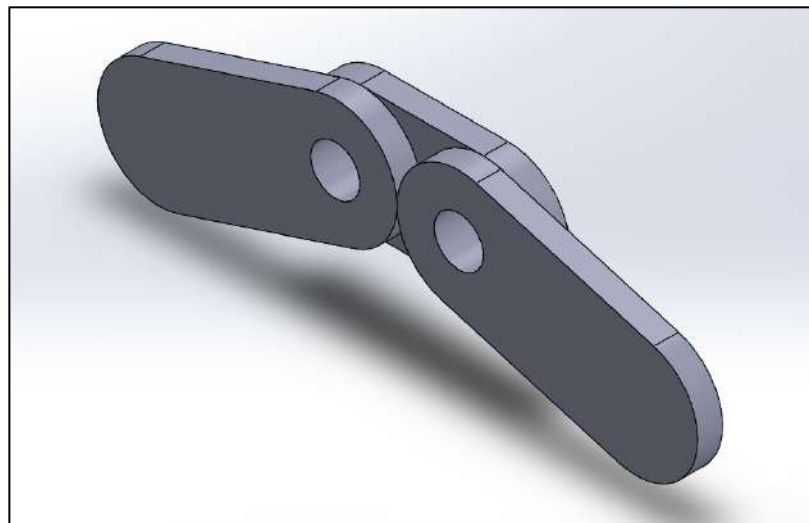
Figure 12 – Thumb Supports

CAD models were made for the thumb supports and the electronics case.

6.1.2 Software Prototype I
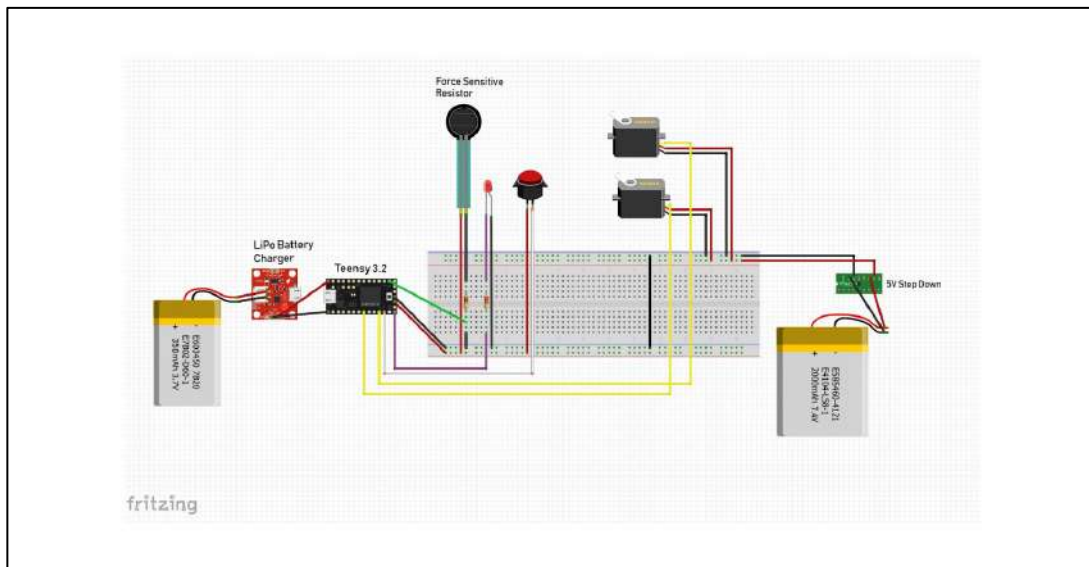
Figure 13 – Prototype Circuitry for Electronics

Table 5 – Prototype I

Prototype I	
 	The objective of this prototype is to simply demonstrate the layout of our electronics and how our subsystems will work together to support the thumb. 2 strings are attached to the thumb supports, which are then connected to the string compartment in the electronic glove case. The string will be tight enough to not tangle onto anything or break in any situation. The client quilting gloves will be used for the next prototype, but for testing purposes, disposable gloves were used in order to be thrown out if any glue or tape damages it during the process of making it.

This is a physical, focused prototype. The thumb supports are wrapped around the thumb tight enough to support any movement. The pressure sensor at the tip of the thumb will be activated once any movement is detected, where the client may flex her finger. This will trigger the string compartment and servo motors in which they will pull the strings and activate the power to keep the thumb supported and prevent it from collapsing. As the glove moves the thumb to grip the object, the object pushes back on the thumb, increasing the pressure measured by the pressure sensor. Once the measured pressure reaches a certain value the motors stop pulling the string and simply maintain the current thumb position. To return the thumb to a rest position the client can release the pressure by moving her other fingers or she can use the release button.

6.2   Prototype II

6.2.1   CAD Prototype II
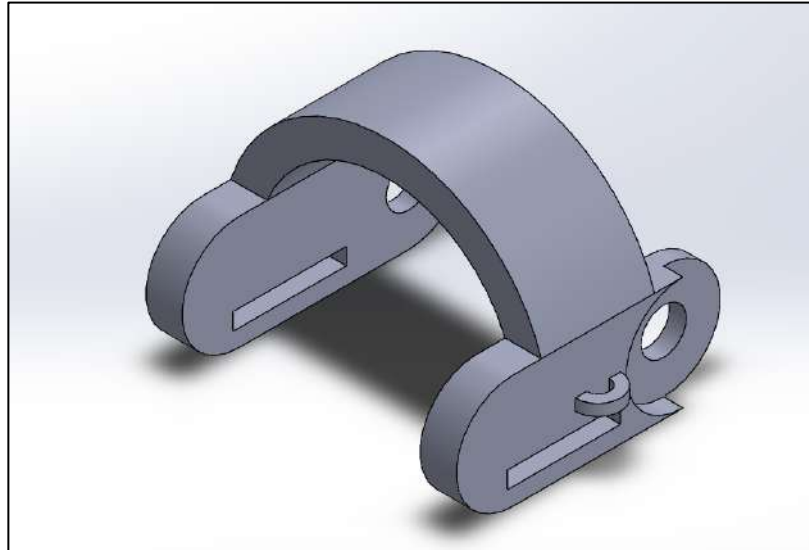
Figure 14 – Updated Thumb Supports

6.2.2   Software Prototype II
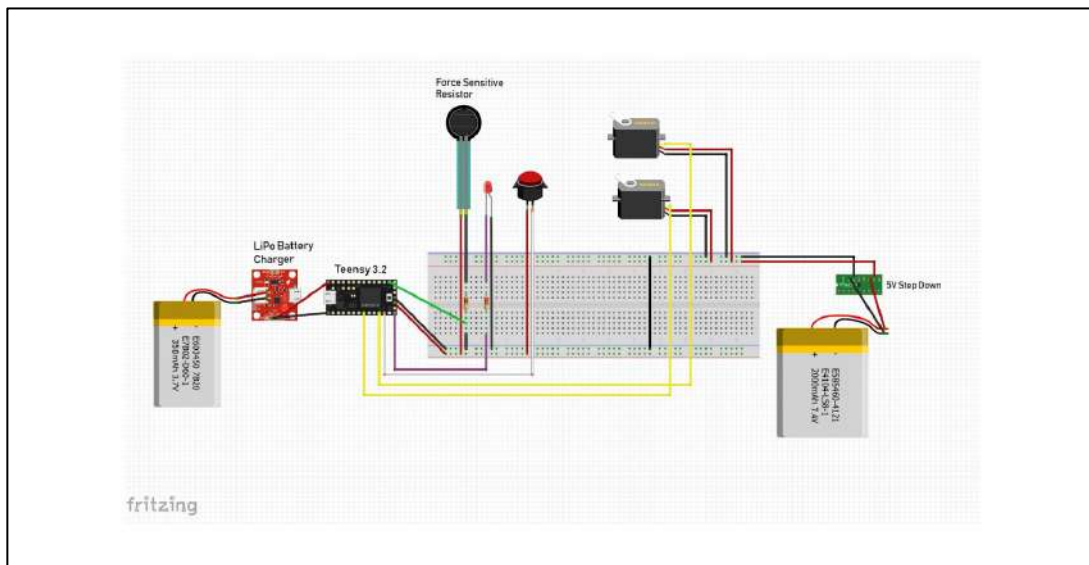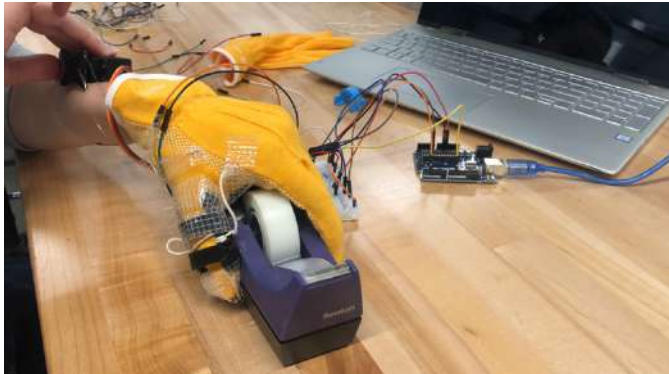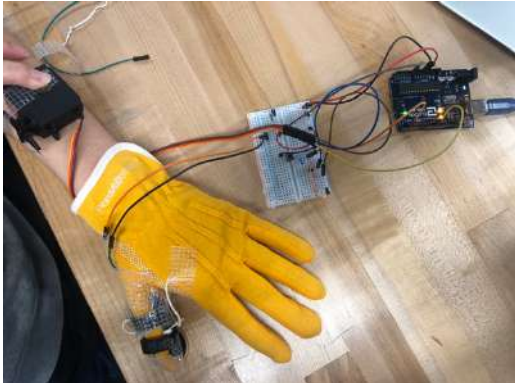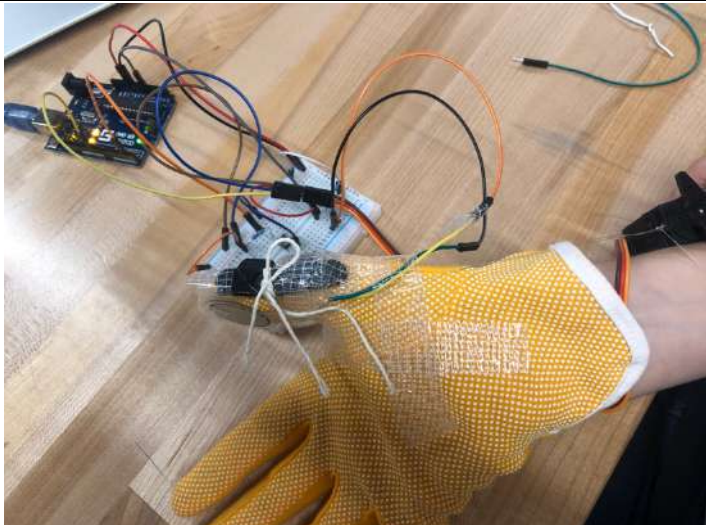
Figure 15 – Prototype Circuitry for Electronics

Table 6 – Prototype II

Prototype II

We have built a medium-fidelity prototype, in order to test the overall functionality of the designed system. Overall, the system is working and has proven our theory of functioning. The main issue to be solved and monitored is the powering of the system, which has set us back a little and is discussed in the testing section. This issue can still be solved within the next 2 weeks and will be ready for display on design day.

6.2.2.1 Prototype I and II Testing

Table 7 – Prototype I and II Testing Results

Testing Results			
Target Specification	**Method Conducted**	**Expected**	**Actual**
Device Size	The device size is measured through the electronics case, in which is drawn to scale on the forearm and CAD software. The dimensions are 141.5mm x 78mm x 33mm, in which come to a higher volume than expected. The expected value was not reasonable, so the actual value is accepted, and only minor dimensions changes will be made, but will remain in that range.	<12cm³	256.822cm³
Weight	Research of each component and gadget weight, and an estimation of total weight. The device is very compact and not overly invasive.	<250 g	220g
Cost of Prototype II	Built through the use of ideal materials that can be easily found and are practical enough to demonstrate the main idea of the prototype itself.		

Gripping Strength Generated	Servo Motor torque is 8.85 lbf-in. If an item is picked up over the range of 2 inches… $T = d \times F$ where T is the torque, d is the distance between the pivot and the acting point, and F is the force acting on it 8.85 lbf-in/2 in. = 4.425 lbf = 2 kg The expected value was very reasonable for a low budget, and motors that cannot support such force. The average grip strength generated is 30 kg by a female, and these motors are able to support a grip strength (force) of 19 N = 2 kg. The device will help Adrienne add to her grip strength, assuming she has half the grip strength of an average female. This means, she is able to acquire a total grip strength of 17kg.	>15kg	17 kg
Usage Time	Monitoring of batteries running the system after charging and testing upon usage.	>6 hours	Unable to be tested at the moment
Combination of electrical system and support system	This combination includes the testing of how the system will function as a whole and power up as planned, using light batteries.	Batteries and Nano to power system	USB laptop port was only able to power the system

6.3 Prototype III

6.3.1 CAD Prototype III
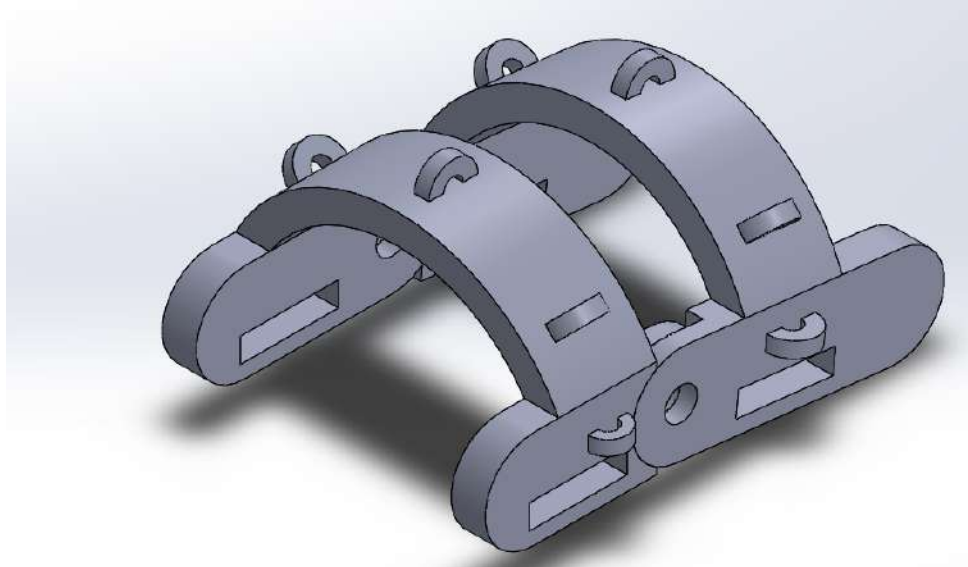
Figure 16 – Thumb Supports Prototype III
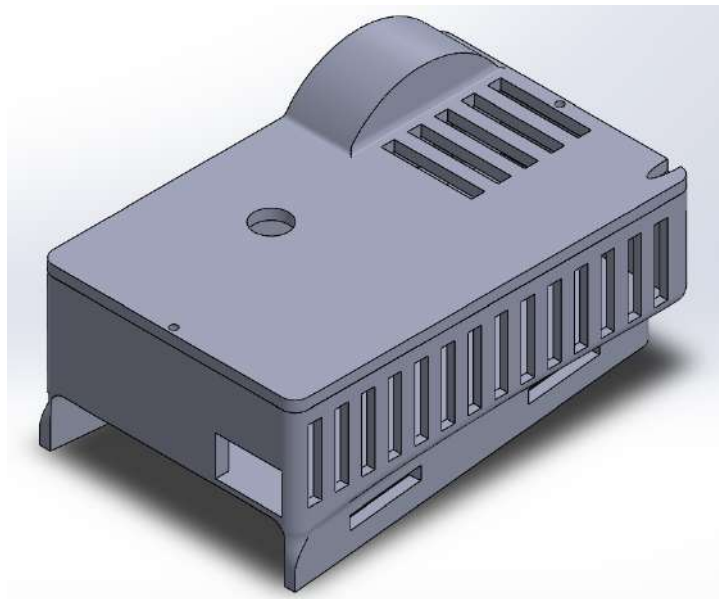
Figure 17 – Forearm Casing Prototype III

6.3.2　Software Prototype III
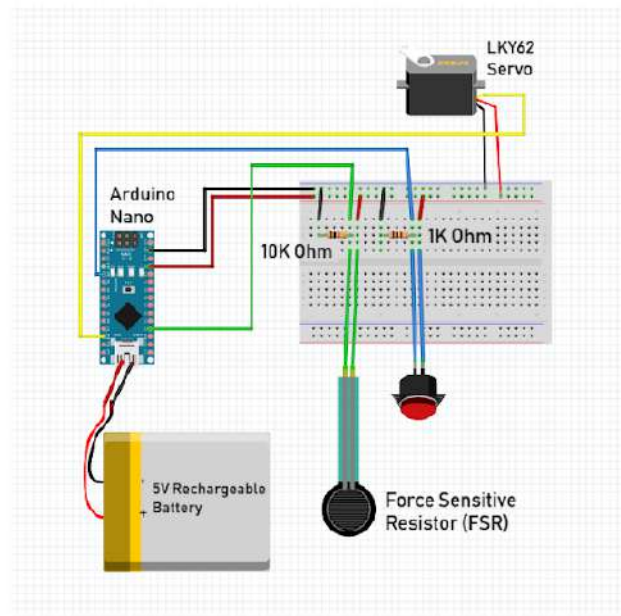
Figure 18 – Schematic Prototype III

**Table 8 – Prototype III**

Prototype III

The objective of this prototype is to present a full functioning product to demonstrate on Design Day. This product comprises of the full electrical system, 3D printing frames, wires, and sowed glove with all these components.

7   User Manual

7.1.1   Features

This product features a lightweight and breathable quilting glove, with an electrical system fastened to it to assist with movement and grip in the thumb. The electrical system uses an Arduino Nano as its microcontroller, a Servo motor that is activated by a force sensitive resistor, a portable phone battery to power the system, electrical wires, a 10K ohm resistor and a 1K ohm resistor. When the user is wearing the glove, the force sensitive resistor is positioned on the thumb so when gripping an object, it will be able to sense pressure. This will then send a signal to the Arduino Nano and the servo to assist the user to pull the thumb towards the object. For the user to release tension in the thumb, they simply need to release the object with their fingers so there is no longer pressure on the sensor. This product also features a button on the arm casing that is able to reset the thumb to a neutral position when pressed.

7.1.2   Function and Capabilities

The function of Gripply is to mimic the strength and gripping ability of a thumb by using an electrical and mechanical system. The product is aimed towards people who suffer from Thoracic Outlet Syndrome (TOS) or lack strength in their thumb and wish to recover mobility or grip strength. The Gripply has a sensor that is capable of sensing pressure of up to 20kg, a servo motor that can apply a maximum torque of 11 kg/cm, and is able to assist the user with a full range of motion in the thumb.

7.1.3 Parts of Gripply
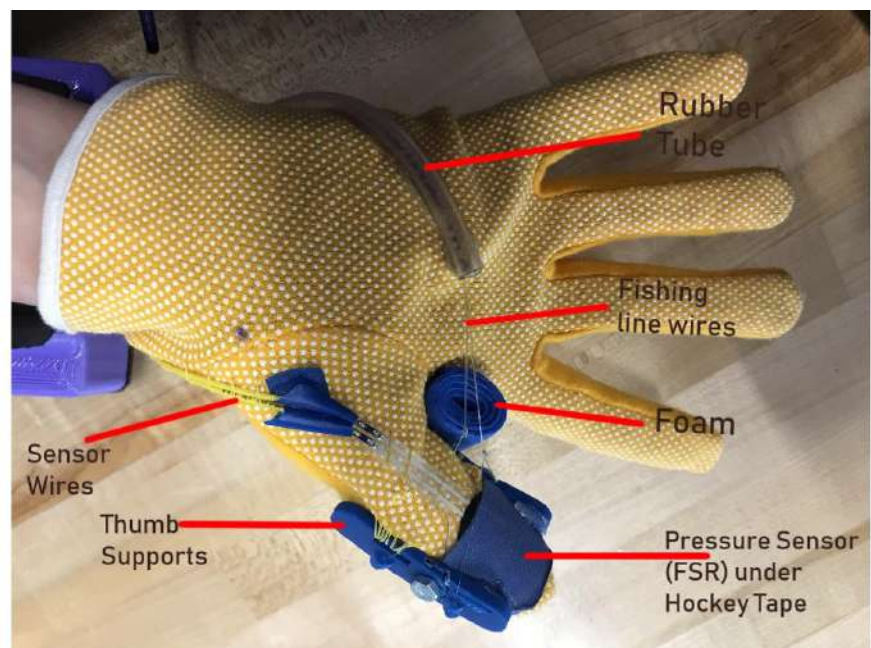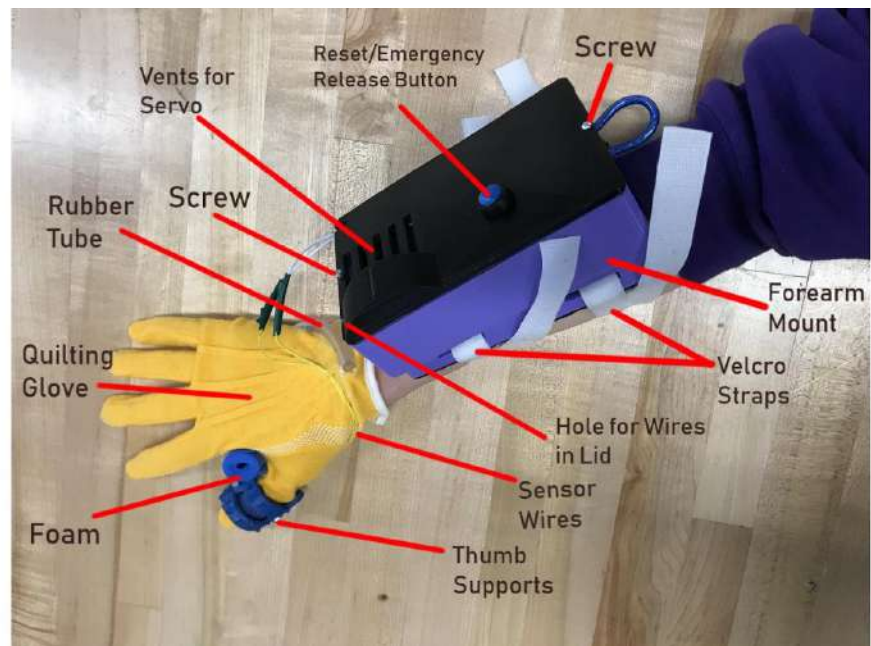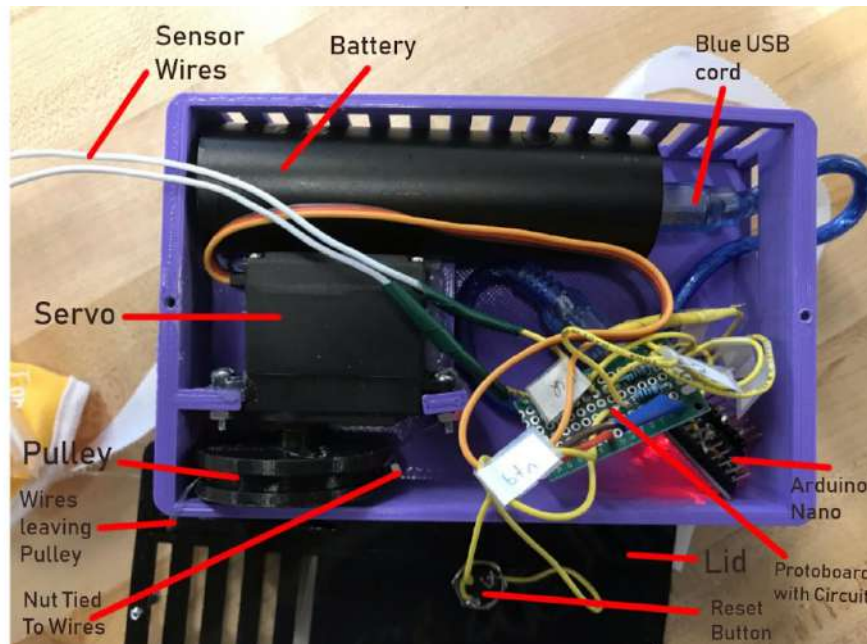
Reset Button: If for any reason Gripply malfunctions and does not release the thumb, the reset button can be pushed. This will force the servo to release the thumb.

7.1.4   Materials List:

- 1 pair of quilting gloves
- 15cm of small rubber hose
- 1 force sensitive resistor (FSR) that detects up to 20kg
- Hockey tape
- Electrical tape
- 54cm of velcro
- 3 sheets of craft foam
- Electrical wire
- Fishing line
- Needle and thread
- Button

- 4 4-40 x ½'' machine screws
- 4 4-40 x ¼'' machine screws
- 9 4-40 machine screw nuts
- 1 Arduino Nano with USB cord
- 1 proto board
- 1 LKY62 Servo with cross
- 10K ohm resistor
- 1K ohm resistor
- Portable phone battery (Anker)
- Hot glue and hot glue gun
- Liquid white glue
- Breadboard and jumper wires for testing circuit

7.1.5   Equipment List:

- 3D printer
- Soldering equipment
- Sewing machine
- Exacto knife

7.1.6   How Gripply is Made:

1. Use a 3D printer to print the forearm mount case and lid. Also print the thumb supports and pulley. The files can be found in CAD_files.zip on Makerepo. They are 'battery case v6.sldprt', 'Battery case top 5.sldprt', 'string spool.sldprt', 'Thumb Supports Front.sldprt' and 'Thumb Supports back.sldprt'.
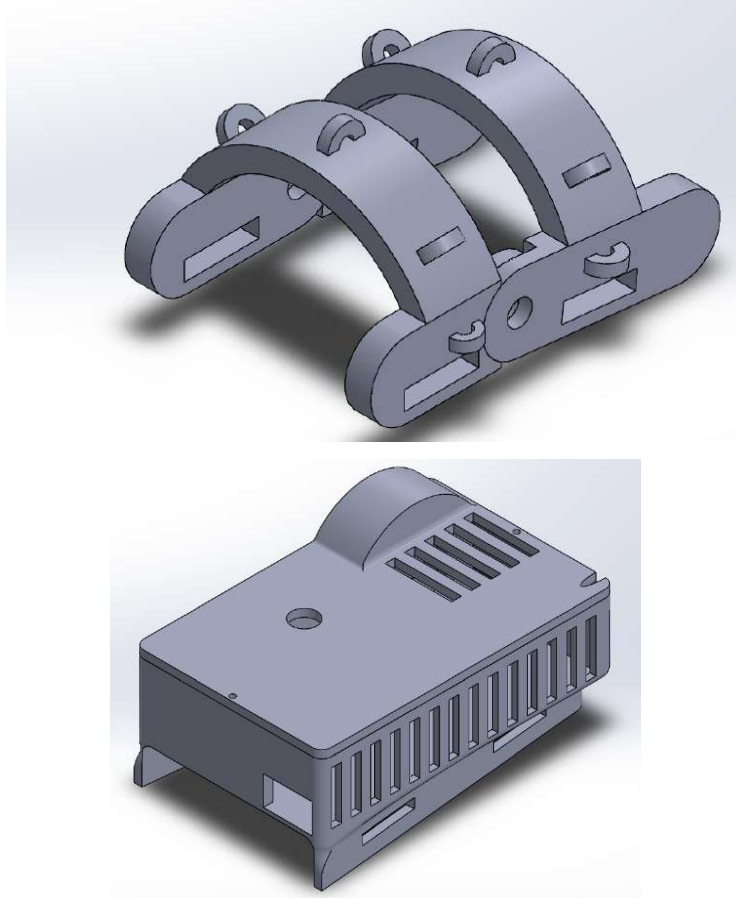
2.   Assemble the circuit based on the image 'circuit_prototype_3labelled.png' found in the project files on Makerepo using the breadboard and jumper cables. The pins for the Arduino can be found in the Arduino code at the top: The button should connect to D2, the sensor to A0, the servo to D10, the 5V pin will power the circuit and one GND must complete the circuit.

3.   Load the file 'gloveCode.ino' in the gloveCodeV2.zip onto the Arduino Nano.

4.   Test the circuit. Gently pressing the pressure sensor should activate the servo. Pressing the button should cause the servo to return to its origin.

5.   Use the soldering equipment to solder the circuit to the protoboard. Solder directly to the Arduino pins. Clip the connectors off the end of the servo and solder the servo wires directly into the circuit. About 7cm of wire (not including stripped ends) is all that is necessary for each connection, except for the button and FSR. Give the button about 12-13cm of wire (not including stripped ends) and the FSR about 35-40 cm of wire (not including stripped ends). Be careful

when soldering to the FSR, the metal pads will melt through the thin plastic of the sensor if the iron is left on it for too long. Make sure the button is attached to the lid before soldering it on.

6.   Put the glove on and position the sensor over the thumb pad. Use hockey tape to secure the sensor to the glove. Use two screws to act as the hinges in the thumb supports. Screw nuts onto the outside to keep the bolts in place. Make sure the bolts are on the outside of the thumb supports. Drop liquid white glue onto the bolts to prevent them from coming off.

7.   Position the thumb supports on the glove. Use a needle and thread to stitch the thumb support to the glove using the gaps on the lower supports only. The upper supports will be blocked by the sensor.

8.   Position the sensor and use hot glue to glue the thumb supports and the sensor to the glove.

9.   Run fishing line through the five loops on the back of each thumb support. Leave lots of extra line. Make sure the length of line on each side of the thumb support is equal. Tie a knot close to the finger to keep the wires together. Attach fishing line to both thumb supports.

10.   Position the rubber hosing on the glove so that it starts in about the center of the palm of the glove and loops around behind the hand and comes out at the base of the glove. Use hot glue to glue it to the glove.

11.   Run all four ends of the fishing line through the tube so that it comes out at the base of the glove.

12.   Check that the battery fits into case. You may need to file the edge off the servo pedestal so that the battery fits into the case without issue.

13.   Put hot glue into the indented cross in the pulley and push the cross from the servo into the pulley. Let harden and attach pulley to servo.

14.   Use hot glue to glue the servo with the pulley on it to the case and run the longer screws through and screw bolts onto the opposite end. Make sure the bolts are on the side of the pulley. Use a screwdriver to turn the bolt and needle nose pliers to hold the nut in place. It is important to have the pulley already on the servo when it is glued in because there is not enough room to put the pulley on the servo when it is glued in. It will not fit past the servo's gear.

15.   Pop the pulley off the servo gear so that it can rotate freely in the slot. Feed all four-fishing line ends through the hole in the lid then hole in the pulley and out the other side.

16.   Put the glove on and close the thumb across the hand. Turn the pulley so that the hole the lines leave the pulley out of is 90 degrees to the base of the case. Pull the lines tight and tie them to a spare nut.

17.   Turn the pulley so that the hole the lines enter through is just above the front wall of the case. This is the neutral position for the pulley and there should be no lines wrapped around the pulley at this point. Open the thumb. Test to see if the line is too tight or too loose. The lines tightness is crucial. The thumb should still be able to move freely but the lines shouldn't be loose. If the lines are not the correct tightness redo step 16 and 17 until it is.

18.   Once the lines have the correct tension. Turn the pulley so you can access the knot again and tie several more knots and add some white glue to the knots. Allow the glue to dry before turning the pulley again so that the entry hole is just above the front wall.

19.   Use a screwdriver to push the pulley back onto the servo gear by wedging it between the case wall and the pulley side. The angle the screwdriver to push the pulley towards the servo.

20.   Cut 24cm of velcro off the 54cm strip. This will yield a 24cm strip and a 30cm strip.

21.   Separate the 24 cm strip into the 'soft' piece and the 'sticky' piece. Overlap one end of the 'sticky' piece with one end of the 'soft' piece so that that section velcros together. The overlap should be about 3cm.

22.   Use a sewing machine to stitch over the velcroed together section to sew them together.

23.   Repeat steps 21 and 22 for the 30cm strip.

24.   Slip the velcro straps through the slits in the lower part of the forearm mount. The 24cm strip should go at the front of the mount and the 30cm strips should go at the back. Make sure the 'soft' side is facing inwards so that it will be facing towards the wearer's skin and the 'sticky' side is facing outwards.

25.   Use hot glue to glue the velcro straps to the bottom of the case. Make sure the overlapping section is in the center.

26.   Take one of the sheets of craft foam. Hot glue it to the underside of the forearm mount, covering the velcro and the sides of the part of the mount that rests against the wearer's arm.

27.   Use an exacto knife to cut off the extra foam.

28.   Place a second sheet of foam over the first. Use white glue this time as hot glue may form hard lumps between the two sheets. Make sure to cover the bottom, sides and up on the top of the sides that the velcro slips through.

29.   Use an exacto knife to cut off the extra foam.

30.   Use a needle and thread to stitch the sensor wire down on the glove to keep it from getting caught on things. Add extra stitches to the end where the wires leave the glove to go to the case. This is meant to reinforce the stitching on the wires incase the part that isn't stitched down does get caught on something. It should be stronger here with more stitches to distribute the force across so that the stitches don't get torn out.

31.   Tightly roll up the third sheet of craft foam to form a log. Use hot glue to secure the end. Cut off about 3cm from the log. Hot glue this between the thumb and the index finger with the edge of the foam facing inwards towards the hand so that it is less likely to get caught on something.

7.1.7   How to Use Gripply:

1.   Turn on Gripply

a.   Open the forearm mount by unscrewing the two screws located on the top of the lid. The longer screw belongs at the front of the case while the shorter belongs at the back.

b.   If not already not already done so, insert battery into compartment beside servo and electronics. Make sure the button on the side is accessible through the slots on the side and the three little LEDs underneath it on the battery are also visible.

c.   Plug blue USB plug into USB port on battery. A red LED on the Arduino should turn on and the servo may twitch, afterwards vibrations can be felt from the servo when touching it.

d.   Before closing the lid, test that applying pressure to the pressure sensor will cause the servo to activate.

e.   Make sure all wires are inside the forearm mount and that the pressure sensor wires run up on top of the battery to the corner.

f.   Replace lid making sure the pressure sensor wires exit through the notch on the lid for them.

g.   Screw the two screws back through the lid into the main case.

2.   Put on Gripply.

a.   Put Gripply upside down on a table and undo velcro straps.

b.   Put on the glove, making sure that the pressure sensor lines up with pad of thumb and joint of thumb-supports lines up with knuckle in thumb.

c.   Tighten velcro straps over forearm. Make them tight enough that Gripply will not slip but not too tight that they cut off circulation. When the arm is raised and the forearm mount is

flipped upside right, the forearm mount should not slide down. Gripply works best if the forearm mount is not separated from the forearm by a sleeve, however if a sleeve is necessary it should be pulled as far forward (toward the hands) as possible.

3.   Grab an object.

a.   Close hand around object, making sure that the pressure sensor is in contact with the object. The pressure sensor is how Gripply knows an object is being grabbed and without contact with the object Gripply will not activate.

b.   When enough pressure is applied Gripply will activate the servo and pull the thumb across the hand. Try to keep the pressure on the object. If pressure is lessened on the sensor Gripply may assume the object is being released and unwind the fishing line.

c.

4.   Set down the object when desired.

a.   To release the object, move the four fingers away from the thumb and the object to open hand. This will remove the pressure from the pressure sensor. There may be a delay of a few seconds before Gripply releases the wires attached to the thumb. This is because Gripply is checking to make sure that the loss of pressure isn't just the user adjusting their hand on the object. If the delay is too long, the reset button may be pushed.

7.1.8   Charging Gripply:

1. To charge the battery remove the lid of the forearm case with a screwdriver. As with step 1 of using Gripply.

2. Connect the battery to a power source via the input port using a standard USB cable. The input port is the smaller micro-USB port, not the larger USB port on the Battery.

3. The charging will be complete when the three lights on the side of the battery turn off. During charging they will flash to indicate the current battery level. The more LEDs light up the more charge in the battery.

4. Unplug the battery from the charging cord and plug Gripply's blue USB cord back into the battery.

5. Replace the battery into the forearm mount and use a screwdriver to close the lid.

7.1.9 Troubleshooting:

1. Gripply won't turn on. The red light from the Arduino isn't on and the USB is plugged in.

a. Has the battery timed out?

The battery Gripply uses times out after a certain amount of time when Gripply isn't used. The turn it back on push the button on the side of the battery. This can be done through the slots on the side of the case. This can be done with the end of your fingernail or other thin object.

b.   Is the battery charged?

Check the three little LEDs on the side of the battery. If they aren't on push the button on the side of the battery. This can be done through the slots on the side of the case. This can be done with the end of your fingernail or other thin object. This will turn on the LEDs. If they don't turn on or only the bottom one turns on, charge the battery.

c.   Is the other end of the cord plugged into the Arduino?

If the other end of the cord isn't plugged into the Arduino, nothing in Gripply will get any power. Plug it back in.

2.   Gripply won't work. The red light from the Arduino is on but the servo won't activate when I grab things.

a.   Is the pressure sensor making contact with the object?

The pressure sensor needs to be pressed against the object for Gripply to know something is being picked up.

b.   Is there enough pressure on the sensor? To much pressure?

Even if the sensor is touching an object, the sensor must register past a certain threshold before it will activate. It is recommended that the sensor be directly under the where the thumb presses against the object. As a way of adapting to different size objects Gripply will stop tightening the servo once it reaches a certain upper threshold. As such applying too much pressure will mean the servo doesn't activate.

c.   Has one of the wires broken off?

Check all the connections. Is one of the wires no longer attached to something? If a wire has become disconnected refer to the circuit diagram in How Gripply is Made to find where it should be attached and re-solder it.

3.   Gripply lets go of things as soon as I grab them.

a.   Is the pressure on the pressure sensor constant?

If the pressure on the sensor drops below a certain threshold for 5 measurements in a row Gripply will assume the object is being let go. You may need to adjust how you are gripping an object so that the pressure on the sensor remains constant and doesn't drop below the threshold.

4.   I can hear the servo activating but the line isn't being tightened.

a.   Has the pulley popped off the servo?

Sometimes after opening the lid the pulley may be pulled off the servo because it is attached to the wires on the glove. Before reattaching the pulley make sure that it is positioned so that where the wires come out of the pulley is at the front of the case (towards the glove) and just slightly above the wall of the case. The idea is that the wires are as close to being lined up with the hole in the lid they come out as possible. It doesn't need to be exact, but just aligning the pulley any which way will cause the wires to loosen before they tighten and Gripply will never reach its maximum grip. After the pulley is aligned, slip a screwdriver or other thin and sturdy object down in between the pull and the longer side wall. Use the screwdriver to push the pulley back onto the servo. Make sure it is firmly in place.
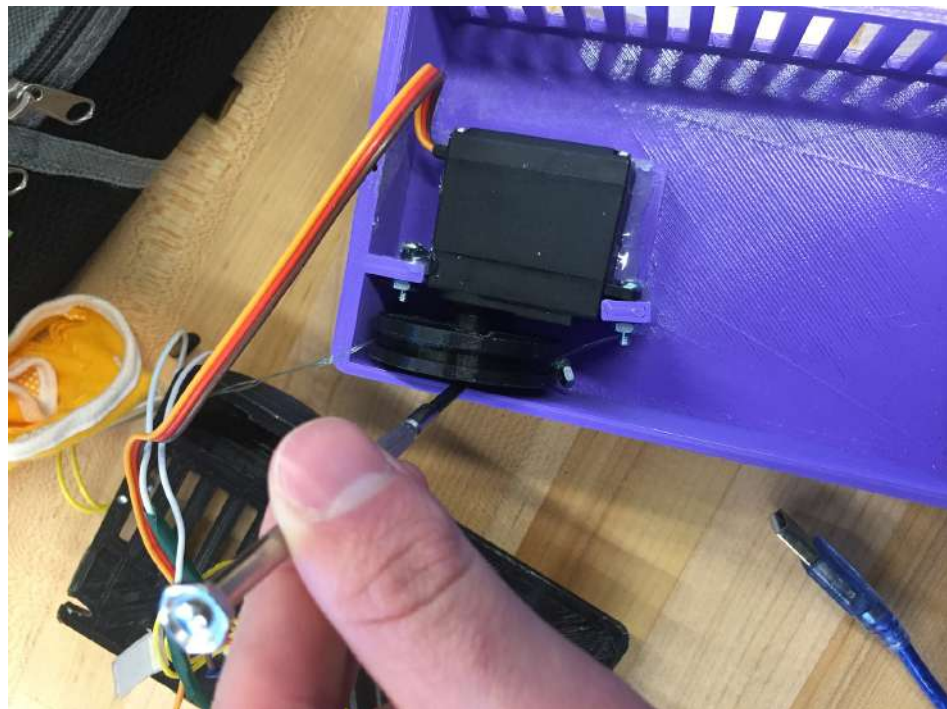
5.   Gripply is acting weird. It is randomly activating the servo randomly and randomly loosening it.

a.   Is the battery fully charged?

Gripply has been known to act strangely when it is low on power. It has been known to randomly tighten and loosen the wires connected to thumb, sometimes doing this repeatedly when there is nothing touching the pressure sensor. Charge the battery.

 b.   Check the circuit. Is there anywhere it may be shorting out? Is it heating up anywhere? Check that there are no parts of exposed wires that are touching. Since the circuit is in such a small place it is important that all parts of all the wires are insulated. If there is a part where the wire insulation has been stripped away, use some electrical tape to cover it up and insulate it from other wires. The rest of the circuit may have sustained permanent damage, Gripply may not function properly even after the circuit is repaired. If Gripply does function correctly, exercise caution when using it. Test that the reset button still works in many scenarios. It may be safer to replace the electronics in Gripply.

7.1.10 Health and Safety

- Gripply will release the thumb when the other four fingers are moved away. If the thumb is not released when the fingers are moved away or the fingers are unable to be moved, the blue button acts as an emergency release which will disengage the servo motor when pressed and return the thumb to rest.
- Gripply is powered by a lithium-ion battery so it is important to keep the device at room temperature and away from flammable materials.
- Gripply is not waterproof and electrical components will be damaged if the device comes into contact with water. If Gripply must be used near water it can be used with a waterproof glove over top.

8 Future Steps and Implementations

- Add a couple potentiometers to change threshold (at what point it engages and what point it goes to)
- Waterproofing electronics, more durable to withstand the elements
- Decrease the size of the forearm mount
- Make left-handed version done
- More accessible charging port

- Shrink the casing size in a more effective way (use armband)

We established a list of variables to consider for future work on this prototype, or similar prototypes. As of right now, our prototype is only functional on the right hand, hence we used a right-handed glove because the TOS was only affecting our client's right thumb grip. Therefore, it would be ideal to produce gloves compatible for both hands, rather than just one. Another

important variable to consider would be the size of the forearm mount. Rather than having a somewhat-bulky case strapped around one's forearm, it would be better to have a more compact casing, such as a strap similar to the type of a runner's strap for their cell phone when doing exercise. Another area of improvement would be to implement a more accessible charging point for the systems battery. The point of this would be to make the turn on/off option as easy as possible for a person struggling with grip strength within their hand(s). The concept of adding one or multiple potentiometers to change the threshold of the thumbs movement could further improve the current design since it would reveal the point of engagement and what point the design allows the thumb to move to, essentially increasing the range of motion of the thumb. Lastly, searching for strategies to waterproof the electronics would simply create a more durable product under different circumstances and environments.

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APPENDICES

APPENDIX I: Design Files

All videos, pictures, code, are uploaded in following link through MakerRepo:

https://makerepo.com/mkhal/gng-2101-group-b04-a

APPENDIX II: Concept Screening

All concepts represented are integrations of the quilting gloves given by the client, which are light, breathable, and highly preferred.

Figure 19 – Client Quilting Gloves

Table 9 – Weighted Decision Matrix

	Design Criteria	Weight of Glove	Aesthetics	Device Size	Water Resistant	Gripping Strength Generated	Breathable	Manufacturing Cost	Usage Time	Maintenance	Practicality	
	Weight	0.0857	0.0571	0.1143	0.1143	0.1429	0.1429	0.1143	0.0857	0.0857	0.0571	Total
M1		4	3	3	2	4	3	3	3	3	3	3.0569
		0.3428	0.171	0.3429	0.2286	0.5716	0.4287	0.3429	0.2571	0.2571	0.2571	
M2		4	1	1	4	2	3	1	3	3	1	2.2572
		0.3428	0.0571	0.1143	0.4572	0.2858	0.4287	0.1143	0.2571	0.2571	0.0857	
M3		3	3	4	2	5	3	4	4	4	4	3.6854
		0.2571	0.171	0.4572	0.2286	0.7145	0.4287	0.4572	0.3428	0.3428	0.3428	
A1		1	1	1	2	3	1	3	3	3	2	2.0286
		0.0857	0.0571	0.1143	0.2286	0.4287	0.1429	0.3429	0.2571	0.2571	0.1142	
A2		2	2	2	2	3	3	2	2	2	1	3.1413
		0.1714	0.1142	0.4572	0.4572	0.4287	0.4287	0.6858	0.1714	0.1714	0.0571	
A3		4	3	4	4	1	3	4	2	3	1	3.2
		0.3428	0.1713	0.4572	0.4572	0.1429	0.4287	0.4572	0.1714	0.5142	0.0571	
B1		4	3	4	3	5	3	3	3	3	4	3.5429
		0.3428	0.1713	0.4572	0.3429	0.7145	0.4287	0.3429	0.2571	0.2571	0.2284	
B2		4	3	3	3	4	3	4	3	2	4	3.3143
		0.3428	0.1713	0.3429	0.3429	0.5716	0.4287	0.4572	0.2571	0.1714	0.2284	
B3		3	2	2	1	3	3	2	4	3	4	3.3143
		0.2571	0.1142	0.4572	0.1143	0.4287	0.4287	0.6858	0.3428	0.2571	0.2284	
C1		3	1	1	2	2	2	1	3	3	1	2.0286
		0.3428	0.0571	0.1143	0.2286	0.2858	0.2858	0.1143	0.2571	0.2571	0.0857	
C2		4	1	1	2	2	3	1	3	2	1	2.1715
		0.3428	0.0571	0.1143	0.2286	0.2858	0.4287	0.1143	0.2571	0.2571	0.0857	
C3		3	2	2	1	3	2	2	4	3	4	3.1714
		0.2571	0.1142	0.4572	0.1143	0.4287	0.2858	0.6858	0.3428	0.2571	0.2284	
R1		1	2	1	1	3	3	2	4	3	4	2.8
		0.0857	0.1142	0.1143	0.1143	0.4287	0.4287	0.6858	0.3428	0.2571	0.2284	
R2		4	1	1	4	2	3	1	3	3	1	2.2572
		0.3428	0.0571	0.1143	0.4572	0.2858	0.4287	0.1143	0.2571	0.2571	0.0857	
R3		4	5	3	2	4	3	3	3	3	4	3.2856
		0.3428	0.2855	0.3429	0.2286	0.5716	0.4287	0.3429	0.2571	0.2571	0.2284	
R4		3	3	3	4	2	4	3	2	2	3	3.5431
		0.2571	0.1713	0.3429	0.4572	0.2858	0.5716	0.3429	0.6858	0.1714	0.2571	
R5		2	2	2	2	3	3	2	2	1	1	3.0574
		0.1714	0.1142	0.4572	0.4572	0.4287	0.4287	0.6858	0.1714	0.0857	0.0571	

Concept Options