GNG 2101 Final Report

Group B3B - Hand Grip

Submitted by:
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Abstract

The purpose of our project was to create a hand grip. Our client was diagnosed with thoracic outlet syndrome which caused a pinch in her nerves that lead to loss of muscle in the hands. This means that client is unable to grip objects with much force which in turn, impacts her everyday life. Our client has done prior research from a company in Switzerland but had no response from them. The focus of our hand grip project is to help people that have disabilities in the hand and are hindered in their everyday lives because their disabilities.

The final goal for this project would be a glove that focuses on giving the client finger strength in the thumb and index finger. This design will allow the client to pinch her thumb and index finger together and hold them with a certain amount of pressure while reducing the amount of bulk on the client's hand and arms. The functional prototype will provide finger strength to the client's index and thumb through the actuation of an bike brake cable via a servo motor powered by a USB(universal serial bus) power bank. The motor's movement will be connected to the finger's motion by a glove which will have wires that run along the palm of the glove and into the index finger and thumb.

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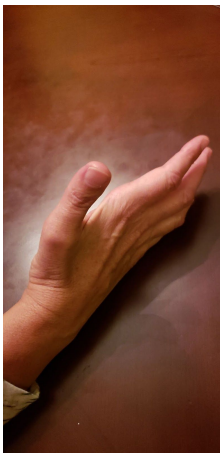


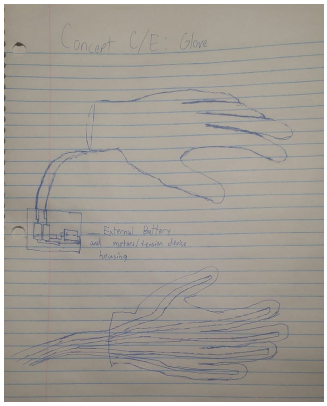
Figure 1.A

Figure 1.B

Figure 1.C

#	Task	Start Date	Due Date	Who?	Completed?	Completion Date	Timeline
	PROJECT	9/7/2018	12/20/2018	Everyone	☐		
A	Team Contract	9/7/2018	9/16/2018	Everyone	☑	2018-09-16	
B	Needs Identification & Product Specifications	9/18/2018	9/23/2018	Everyone	☑	2018-09-27	
C	Design Concepts	9/26/2018	9/30/2018	Everyone	☑	2018-10-04	
D	Project Plan, BOM, Feasibiliy	10/4/2018	10/12/2018	Everyone	☑	2018-10-12	
D-1	*Project Plan*	10/4/2018	10/12/2018	Jarod	☑	" "	
D-1.1	Construct the Project Plan sheet	10/7/2018	10/11/2018	Jarod	☑	" "	
D-1.2	Inital Population of the Project Plan	10/7/2018	10/12/2018	Everyone	☑	" "	
D-2	*Bill of Materials*	10/8/2018	10/12/2018	Everyone	☑	" "	
D-3	*Feasibility Report*	10/8/2018	10/12/2018	Everyone	☑	" "	
E	Prototype 1 & Client Meet Prep	10/12/2018	10/17/2018	Everyone	☑	2018-10-17	
E-1	*Building the first Prototype*	10/12/2018	10/17/2018	Everyone	☑	" "	
E-1.1	Obtain hand/finger analog (3D printing?)	10/14/2018	10/16/2018	Jarod	☑	2018-10-16	
E-1.2	Test force transfer system on a finger analog	10/16/2018	10/17/2018	Everyone	☑	2018-10-17	
E-2	*Client Meet Prep*	10/12/2018	10/17/2018	Everyone	☑	" "	
F	Project Progress Presentation	10/12/2018	10/18/2018	Everyone	☑	2018-10-18	
G	Business Models	10/17/2018	10/21/2018	Everyone	☑	2018-10-21	
H	Economics Report + 1 min Pitch	10/21/2018	10/28/2018	Everyone	☑	2018-10-28	
I	Prototype 2 & Customer Feedback	10/17/2018	11/18/2018	Everyone	☑	2018-11-18	
I-1	*Second Prototype (First glove iteration)*	10/17/2018	11/16/2018	Jarod	☑	2018-11-16	
I-1.1	*Obtain Missing Materials*	10/17/2018	10/23/2018	Everyone	☑	2018-10-23	
	Buy Brake Cables	10/12/2018	10/15/2018	Jarod	☑	2018-10-15	
	Obtain suitable gloves	10/17/2018	10/23/2018	Sein	☑	2018-10-23	
I-1.2	*Design Force Transfer System*	10/12/2018	10/28/2018	Jarod	☑	2018-10-28	
I-1.3	*Construct Force Transfer System*	10/23/2018	11/3/2018	Jarod	☑	2018-11-03	
I-1.4	*Construct Finger Control System*	10/23/2018	11/3/2018	Jarod	☑	2018-11-03	
I-1.5	*Assemble components onto glove*	10/28/2018	11/7/2018	Jarod	☑	2018-11-07	
I-1.6	*Test Glove functions as intended*	11/7/2018	11/18/2018	Jarod	☑	2018-11-18	
I-2	*Customer Feedback Report*	11/1/2018	11/18/2018	Everyone	☑	2018-11-18	
J	Design Day	11/18/2018	11/25/2018	Everyone	☑	2018-11-25	
K	Intellectual Property Search	11/25/2018	12/2/2018	Everyone	☑	2018-12-02	
L	Final Project Presentaion with Functional Prototype	11/20/2018	12/4/2018	Everyone	☑	2018-12-04	
L-1	*Functional Prototype (Improving our second prototype)*	11/18/2018	11/29/2018	Everyone	☑	2018-11-29	
					☐		
L-2	*Presentation Prep*	11/20/2018	12/3/2018	Everyone	☑	2018-12-03	
M	*Final Project Report*	11/25/2018	12/20/2018	Everyone	☐		

Figure 2. Project Plan



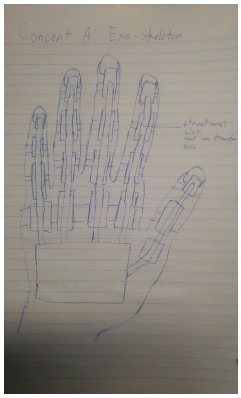


Figure 3.A **Figure 3.B**

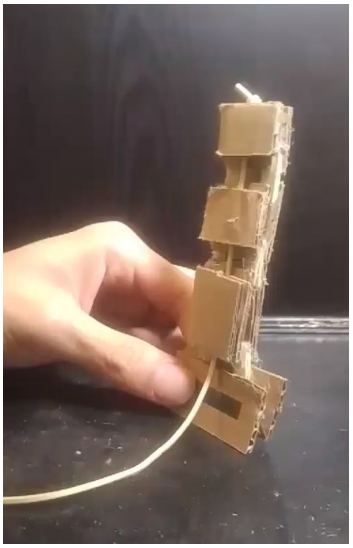


Figure 4.A **Figure 4.B** **Figure 4.C**

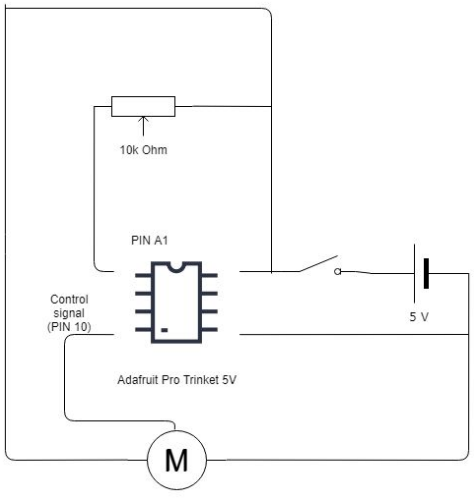


Figure 5. Circuit of the System

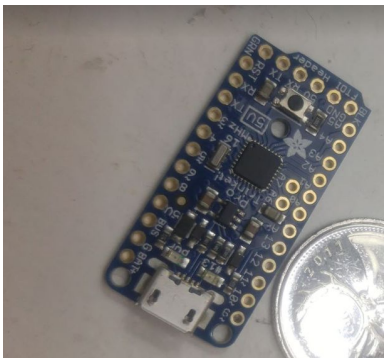


Figure 6. Adafruit Pro Trinket 5V

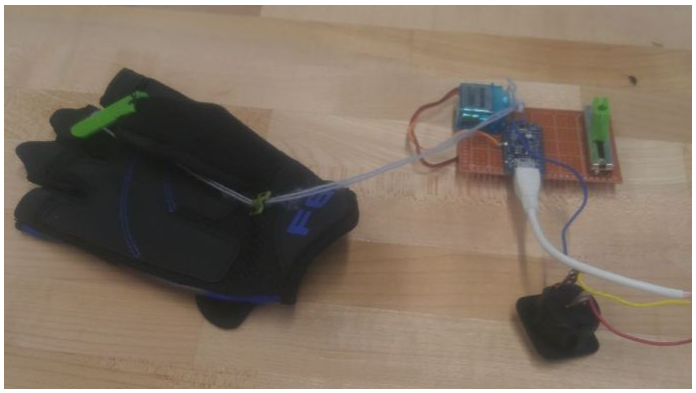


Figure 7. Final Prototype

ii - List of Tables

Statement	Importance (1 Important to 5 unimportant)
The product will be able to perform dexterous movements (ie. knitting, typing)	1
The product transfers grip strength to the fingers or otherwise allows for a strong grip	2
The product is battery powered or is portable through some means.	3
The product is lightweight and convenient	4
Preferred color is turquoise	5

Table 1. List of Client Statements/Observations

Product	Cost	Complexity	Dexterity	Grip Strength	Ease of use
Exo-skeletal glove	High	High	High	Medium	High
External Glove/claw device	Medium	Medium	Low	High	Medium/Low

Table 2. Design Concepts and their Characteristics

How?		***What?***	***Who?***	
Key Partners -Supply Chain for Materials - Distributors (ie Amazon or healthcare providers) -Customers; give very important feedback and insight to improve the product	***Key Activities*** -Sales -Research and development -Customer service -Helping people with hand disabilities with their grip	**Value Propositions** -Better quality of life -Gain independence because they will be able to perform more tasks on their own	***Customer Relationship*** Business to Customer relation Business to Partner (distributor/investor) relationship	***Customer Segments*** -People that have hand disabilities are the users, and possible customers. -Healthcare providers are also a major customer segment that we have to market towards.

	Key Resources -Warehouses -Manufacturing Centres -Office Space -Online Presence		***Channels*** -In person -Digital distribution (Online store, online contact, delivery) -Through Distributors	
Cost Structure			***Revenue Streams***	
Types of Cost: Materials - Fixed R&D - Variable Economy of Scale: Probable but depends on the design of the product.			- Commissions from distributors and direct sales to customers. - Investment funds (Universities and investment firms)	

Table 3. Business Model Canvas

COMPONENT	**PRICE PER UNIT**	**QUANTITY**	**PRICE**
Fingerless Glove	14.99	1	14.99
Brake Cable	8.49	1	8.49
Servo (Continuous 360)	16.11	1	16.11
Adafruit Trinket Pro 5V	15.03	1	15.03
Toggle switch	1.98	1	1.98
Linear Slide Potentiometer	4.05	1	4.05
Thin Inner Brake Cable	5.49	1	5.49
Servo (Angular 90)	12.40	1	12.40
9v Battery	3.99	1	3.99
Protoboard	1.20	1	1.20
PLA Filament	25/kg	0.06	1.50
SUBTOTAL BEFORE TAX			85.23

Table 4. Bill of Materials

iii - List of Acronyms

Acronym	Definition
IEDP	Iterative Engineering Design Process
USB	Universal Serial Bus

1 - Introduction

The project assigned to our group (B3B) was the hand grip. Our client suffers from Thoracic Outlet Syndrome. This disease has caused some of the muscle tissue in the hand to degrade to nearly nothing. This means that the clients fingers can still move, but, the client has poor fine motor skills in the fingers and poor grip strength. The client has done some of their own research into possible solutions and has even gone through a surgery but their condition has not changed. Our client has a difficult time doing simple daily tasks such as washing dishes and crochet. Although we were tasked with designing a device to help our client, this device could also help anyone who has difficulty gripping objects with their fingers.

Our product started as a very complex design and through iteration, became very simple and straightforward. It is connected to the hand using a fitness type glove which is light, comfortable and breathable. All of the electronic components are housed in a separate location to help with portability. When the glove is activated, it curls the thumb into a “pinching” motion with the index finger. Although prosthetics and bionics may be able to recreate hand movements more in depth, our product recreates this motion in a very simple way that allows the client to grab objects easily and efficiently. Our product runs on a rechargeable power bank, so it can be recharged easily for daily use. The glove is also a fingerless fitness glove for comfort and breathability, especially for extended use.

2 - Engineering Design Process

For our project, we decided to use the Iterative Engineering Design Process(IEDP). This was the design process that all members were familiar with since we learned about it in class. Also, this fit the scope of our project. Since as a group we had to go through many iterations to decide on many parts of the project, such as the problem statement and prototyping, it was convenient for us to use this design process.

3 - Need Identification and Product Specification Process

We inferred from the initial information that we were given that the hand grip was going to used for strength purposes, however, after our first client meeting it was clear that dexterity was a much more important feature for the product. We stated our client needs and specifications as seen in *Table 1*. With our clients needs recorded and ranked. We then referred back to the IEDP’s problem refinement loop to see if we were answering the question “Are we solving the right problem?” until we were satisfied with our problem statement. Our final problem statement was: “Client has a disability in the hand which reduces strength and dexterity in her hands. The thumb, middle finger and index finger are all affected and the disability continues to spread to other fingers. Product will be something which can assist in replacing lost dexterity and strength in the hands.”

4 - Conceptual Designs

After our first client meet, we were able to start brainstorming about how we wanted to design our project. We thought of as many ideas as possible from the start and then decided to refine and reduce our options after. Some initial ideas included: exoskeletons, pistons, pulleys, motors, and claws, etc. After coming up with many ideas, we decided on the two ideas that were the most feasible: an exoskeletal glove*(Figure 3.2)* and an external glove/claw device*(Figure 3.1)*. We then did some research and benchmarking of similar products as seen in *Table 2*.

5 - Project Planning and Feasibility Study

The project plan we used throughout the semester is seen in *Figure 2*. It includes the tasks to be completed, the start and end dates, who will be doing it, and the timeline relative to the whole project. Due to communication errors a group, we found it difficult to assign tasks to certain people and therefore unable to use the project plan effectively. However, we believe with proper and constant communication that this project plan could be used very effectively.

6 - Analysis

After multiple client meets, we decided that our initial solution was more technically complex than anticipated with the given time we had for our project. Due to these constraints, we simplified our solution to focus on a specific movement rather than moving the hand as a whole. This meant focusing on the gripping motion between the thumb and the index finger.

7 - Prototyping, Testing and Customer Validation

Our first prototype was a physical proof of concept for articulating a finger utilizing wires. To replicate the closing motion of a finger using wires, we created a cardboard finger, as shown in *Figures 4.1, 4.2 and 4.2*, attached to which is a wire along the top of the finger that when pulled perpendicularly to the finger, caused the finger to close like a real finger.

With our proof of concept complete, we presented our idea to our client, who in turn was receptive of the idea, but raised several concerns, namely the potential bulk of the system and the fact that the fingertips were covered by the ring that attached the wire to the cardboard finger which reduced the dexterity of that finger. With this feedback we got the idea of using a finger plate that sat on top of the finger that would apply force on the finger when the system pulled the wires, this plate would then be connected to a fingerless glove that would serve as a barrier between the wires and the hand.

8 - Final Solution

When we began work on our prototype, we had planned to have the thumb, index and middle finger be controlled by the glove; however, as we worked on the final prototype, we decided that a simpler approach was better and more realistic for the time that we had. Thus, As a group we decided that we should focus on the simple motion of pinching of the thumb and index fingers.

Our final assembled prototype as shown in *Figure 7* consists of a glove worn by the user, and a module that is attached to the user's arm using a strap. The glove was to be operated using a control ring on the user's middle finger however that control method couldn't be implemented fully before the project deadline.

We first created the circuit as seen in *Figure 5* to accommodate the motion for both fingers. The circuit consists of a 5V power source, an adafruit pro trinket to serve as the microcontroller, a slide potentiometer attached to the adafruit and the servo that is controlled by the adafruit. As the potentiometer changes resistance, the trinket outputs a related angle to the servo, causing the servo to move to the specified angle.

We then began modelling the thumb plate and thread guides that would be attached to the glove through sewing them onto the glove's fabric. We also made a small finger ring with a hole that would control the potentiometer using a wire. Having modelled each part, we began printing and adjusting each model until they were of the proper dimensions and durability.

9 - Business Model

The business model canvas that we used for our product is seen in *table 3.* Our main customer relations were business to customer and business to enterprise. This means that our customer was also our end user. This creates the opportunity to create a personal relationship between the customer and our business, ensuring that there is a level of trust and loyalty included. The main value that our product will offer is that it will be able to offer a better quality of life to those that have disabilities in the hand. Our channels will include in person consultations and online purchases with our main customers being people have hand disabilities and healthcare providers.

10 - Economic Analysis

Creating a product with many electronic components increases the price of the product as a whole. As seen in *Table 4,* the total cost of production for our prototype was approximately 85 canadian dollars. We assumed a low volume of product sold because the hand grip is a specialty product that targets a relatively small niche. The Product has a relatively high cost to price ratio because the product requires a moderate degree of personalization to ensure that the product fits and is usable by the user. The

sales expenses come from a estimation for the shipping and packaging of a single unit of product and the customization needed to make it right for the user. The general and administrative expenses come from the deprecated costs of any equipment we require as well as rent or other long term expenses that are unlikely to change.

11 - Conclusions and Recommendations for Future Work

In conclusion, we were able to learn many different concepts throughout the duration of this project. For all of the group members, it was the first time working in a group environment throughout the entire semester, so we were able to learn how to work with people that you have never worked with before. This also gave us the opportunity to learn about how important communication is in a group setting. Creating a hand grip gave us the opportunity to teach each other different skills and abilities due to the project being technically complex.

APPENDICES

APPENDIX I: User Manual

Contents:

- A right Hand Grip glove and Motor module
- A USB Power Bank
- 1m USB charging cable

Setup:

1. Plug cable from the module into the USB port on the power bank labelled “OUT1A”
2. Attach USB battery bank to Motor module
3. Wear the finger glove on the right hand.
4. Strap the Motor module and battery bank onto the right forearm, ensure wire is resting tight while your hand is open.
5. Wear the control ring on the middle finger, the fit should be snug
6. Flip the power switch of the module to the on (|) position

Control:

1. To close the thumb and index finger, close the finger that the control ring is on. The amount that the fingers close is proportional to the amount the control ring is moved.
2. To release, open the finger that the control ring is attached to.

Maintenance:

- Charge the USB power bank every day to ensure continuous operation, the charging port of the power bank is labelled “IN5V”
- You can change the included power bank for another USB powerbank of your choice, however we do not guarantee that the power bank will function with the motor module as intended.

APPENDIX II: Design Files

Design files and arduino compatible microcontroller code can be found at: https://makerepo.com/JarJarThinks/hand-grip