Low cost prosthetic limb translator

[redacted]

Global Context: Scientific and Technical Innovation

Goal: To create a low cost muscle controlled prosthetic arm with a sense of touch. That is also able to translate text to sign language.

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Criterion A: Investigating

Strand 1: Define a clear goal and context for the project, based on personal interests.

- **Goal and Global Context**

  Goal

The objective for this personal project is to make a low-cost 3D printed prosthetic arm, based on InMoov by Gael Langevin's design. Concentrated on the issue of cost, durability, and function, as these 3 are novel issues concerning prosthetic arms. For example, as per a Bioengineering Center for Neuroprosthetics, at the Worcester Polytechnic Institute, the expense of a cosmetic arm and hand may go up to $3,000 - $5,000, and a fully functional arm would cost in the low ~$200,000 according to Mobius Bionics (See appendix 2a). This subject intrigues me because as far back as I was a kid, I have had the excitement to make an innovation that could fulfill my interests, and yet for the benefit of others. I have furthermore done some personal research and was astounded of the expense of even a cosmetic arm would go to an extraordinarily high rate.

Though there are plenty of organizations such as Open Bionics, Bebionic, Mobius Bionics, and Arm Dynamics; these companies still charge a very high rate in the range of $5,000 to a whopping $200,000, and last for an average of three years. For example, through the research that I had conducted, out of 3 companies, none of them sold their prosthetic arms below $5,000.

Thus, in short, my personal project goals are:

1) Making use of InMoov's arm design as a basis for my 3D printed prosthetic arm.
2) Increase my knowledge on electrical engineering.
3) Implementing ChipRobot's copper capacitive sensor idea, and improve it, so the hand will have more functions.
4) Implement an EMG sensor to have more practical use of the prosthesis.
5) Keep the budget below $1000, with every variable included.
6) Make an app that can translate text to sign language.

Global Context

Due to the scientific nature of the project, the global context that will be explored is Scientific and Technological Innovation; this project will further discuss into the subtopic, the impact of scientific and technological advances on society and the environment. This particular subtopic will help me delve deeper into my project.

This subtopic will also help me to focus on the two terms, "Society" and "Environment." The first term guiding me to find a way to make a prosthetic arm that is cost-effective and practical at the same time. The second term will help me look into how I can create the 3D prosthetic arm that is environmentally friendly.

Strand 2: Identify prior learning and subject-specific knowledge relevant to the project.

- **Prior Learning**

I am confident to say that before this project, I had a general understanding of electrical engineering and could apply it on practical use. Although in school they don't teach this, even in physics, I have gathered quite a lot of experience ever since I joined robotics in 4th grade. Robotics does not generally teach how to create PCB boards, coding robots, making circuits, but they do give a general idea on how robots mechanised and how they are structured. Reflecting to past MYP experiences, though we never did any practical electrical engineering or any form of robotics. I have learned a lot through my MYP years, primarily on how to research (Science, History, and math), how to plan projects (Digital Design, Criterion B Science, and Business), making reports and essays (English, BI, Math, and Science), and basic practical skills (Science, Business, and Math).

After a few years of robotics, I eventually started to branch out into coding, starting with HTML later on going into C++. In design class, 9th grade, on term two there was a unit where we were tasked to create an educational application. The unit went as expected, doing Criterion A, B, C and D. Improving every fundamental skills about app building. But late that year, there was a competition hosted by SGU to create an app; I ultimately thought this to be an opportunity to expand my knowledge in app making. Didn't win, but managed to get 3rd place and more insight regarding the topic. It was not until the late 9th grade that I have started to dive further into electrical engineering. While I never did have a mentor, I consider my books to be them, one of my favorite books that taught me about electrical engineering is "Getting started in electronics" by Forrest M Mims. It showed me a lot, from the necessary circuits to some of the more complex ones.

Strand 3: Demonstrate research skills

Within this project, research skills had been an integral part of this project. In-depth research was conducted to ensure that every information and knowledge needed is fully understood. This particular skill was demonstrated through vast analysis of sources such as the problem, PCB builds, InMoov's arm design, electrical components, wiring individual motors and sensors, to hardware, and coding. These sources are found through online resources and some primary resources. These raw data are later on compiled for the prosthetic arm to be built. (See appendix 3a, 3b, 3c, 3d for research)

Criterion B: Planning

Strand 1: Develop criteria for the product/outcome

- **Product Criteria** *(See appendix for product criteria)*

The product criteria that was used in this particular project was made to be challenging but, at the same time attainable. This product criteria further explain my goal, global context, my design specifications, and evaluations. In the product criteria, the goal and global context are also restated to clarify how I would want to achieve my goal and which aspect within the global context I would like to explore further.

In the product criteria, it gives an overview of the outcome of the product. Specific aims and guides are also inputted to be used throughout the project, (See appendix 1c for product criteria) the following, are given a more detailed explanation: appearance, cost, target, environmental considerations, safety, size & weight, function, manufacture, and materials.

Details are also specified such as the goal of having a realistic looking arm ,so it will be easier to measure the product's success. The product criteria are also made to fit the timeline (See appendix 1a) and the budget plan (See appendix 1d), to ensure that it is achievable. The product criteria will be measured by comparing the final product with its product criteria.

Strand 2: Plan and record the development process of the product

- **Process Journal**

To ensure that my supervisor can monitor my progress, a google drive folder was made to give my supervisor the right to access my files and progress, as well as to provide his inputs and critiques. The process journal that I created explicitly assist me in keeping the record and steps of everything I did throughout the project in one specified folder. Another process journal was also made in the form of text to keep track of the progress, every time there is any, the purpose of this is so it will help me reflect on what I did wrong if there are any problems with the product. (See appendix 4a for few of them)

Strand 3: Demonstrate self-management skills

- **Timeline**

Self-management had always been one of my flaws ever since I entered the MYP programme, always tried but eventually procrastinate. However, I am confident that this personal project will help me improve it. To ensure that I can manage my time correctly, a timeline was made, and since this project is conducted throughout school days, it should be a weekly timeline, rather than a daily timeline. So it will not hinder any school tasks. The timeline that was made is a six-month timeline that will give a general overview of things that is expected to finish per week and when the product should be finalized. The timeline will also help in making the product; although it was not written to every detail, the timeline still gives a general overview on what needs to be done (See appendix 1a). Ex. On the first week of February, all circuit schematics and layout plans should be finished. The timeline should always be reexamined to observe whether the project is on track or falling behind.

Criterion C: Taking Action

For objective C, making a 3D printed prosthetic arm was chosen, the arm which would be based on InMoov by Gael Langevin, a French designer. The arm would feature the essential functions of a regular prosthetics, also a capacitive sensor to detect touch and an application that can translate text to sign language. The process began with the research stage, by finding the most suitable prosthetic arm model for this project. Circuits, example codes, battery outputs, servos, and any technical data sheets were also researched thoroughly in this stage (See appendix 3c). By using numerous sources to identify how the product will function was also done during this stage (See appendix 3d). This stage is considered to be vital since it would give an insight into how the project would be done.

After the research stage, the second stage is all about communication. Professional prosthetic makers were contacted during this stage for further insight regarding the project. They were contacted through email for an email interview, some of the questions being how prosthetics can revolutionize the world? Also, some technical questions regarding prosthesis functions, battery life, usage period and cost. Since many companies were being interviewed, to give a more controlled environment, an email interview questions and template was made (See appendix 1b and 2b). Gael Langevin was also contacted for copyright permission to use his InMoov arm model (see appendix 2c for copyright). The only issue with this type of communication method is that most of the companies do not have any spare time to fully answer all the questions, out of seven that was contacted only three replied, and one of them just answered one question.

The project was initiated with research regarding useable prosthetic arm models that are copyright free. While there was a debate on whether I should design and model my own prosthetic arm, due to the time limit of six months I concluded that an arm model would be used. That is how the InMoov arm model came into view. Many of the data gathered came from the use of Stack Exchange, a community of makers (See appendix 3e), Google, and the book "Getting started in electronics" by Forrest M Mims. The research that was conducted was beneficial because it gave a better understanding of how the arm would help the community and how it should be made.

After completing the research, a product criterion was made (See appendix 1c product criteria), its purpose is so the project can be divided into multiple strands/subgoals that would be achieved by the end of the product. An email template was also made to be sent out to numerous well-known prosthetic makers, some being Open Bionics and Arm Dynamics. Even though, I admit that this method of communication is not the most conventional. However, it seems to be the most plausible, since most of the companies did not input their phone numbers or any other method of communication, other than their email addresses on their contact page (See appendix 2b full email interview).

For logistics, it was split into two different parts, electrical components, and 3D printed parts. For the electrical components, a list of components that would be bought was made, the purpose of this is so that it will be easier to keep track of what to buy ahead of time since some components are challenging to get. A budget plan was also made to create an estimated cost of the product

(See appendix 1d for budget plan). For the 3D printed parts, a timeline was established to keep track on what should be printed on which day, since with the time limit of 1 month all 3d printed parts need to be finished by that period. While theoretically, one month is enough to print all the parts, there were some problems with the print settings which made the prints to be very brittle, so some parts are needed to be reprinted.

Once the parts are bought, finished with the digital circuit (See appendix 4b), and all parts printed, I then started assembling all the printed parts. Firstly, the printed parts are layered with epoxy clay, and once they hardened, they were smoothed out, so there were no blemishes on the outer shell. Then the forearm and the wrist was attached. The servo bed was also attached during this stage, and the servos were screwed and glued into place. After everything had dried and fixed together, a test code was made to test the servos to see if they function or not (See appendix 4e for progress). After the forearm is finished, the palm and the fingers are next. Firstly, each finger parts are glued together to avoid the joints falling off. Each finger hinge is connected using a 2mm aluminum wire. Secondly, a 0.8mm braided fishing lines were cut at 75cm each, and the ribbon wires were cut at 100cm. Lastly, 2 ribbon wires and 2 fishing lines are runned through to each finger, the only problem faced here is that the holes are incredibly minuscule making it hard for the lines to pass through (See appendix 4f for progress).

After the linings and wires are attached, the lining is made into knots on the servos and the fingertips. With that, the finger mechanism is finished. For the fingertip sensors, each of the electrical wires will be soldered to a tiny piece of copper foil, and there will be a single anti-static foam on top. The idea here is that since the foam contains carbon it acts as a bridge between the two contactors, so when the foam is pressed against the copper, the carbon lets the current flow between them, and the more the foam is squeezed, the more current goes through (See appendix 4g for progress).

With the arm finished, I then moved on to the coding and circuit aspect of the project, which is where my thinking skill was applied. I first started by investigating how many degrees does it take for different fingers to contract and retract. With the data gathered, I could then code the specific data needed to move the fingers. I then followed my custom circuit that was made beforehand, although there are bugs it is easily fixed (See appendix 4b circuit). Firstly, the muscle sensor is attached, and similar to the fingers, the data values are gathered first to obtain a fixed value. Secondly, a code for the finger sensors are made into a boolean value, if data >10 pressed = true, when <10 pressed = false. Lastly, an app was created to translate text to sign language, by utilizing the ASL dictionary. With this, the code is later on compiled into a single file, which took a few days of brainstorming since both the finger sensor and muscle sensor is using analog pins, which in turn made them affect each other's values. In the end, all the problems are solved. So with everything done, the product was tested using the app, the sensors, and all the motors, which is successful. (See appendix 4c, 4d, 4h for code, app, final product)

Criterion D: Reflecting

- **Appearance**
  6/8, in the product criteria it was mentioned that the product must look modern, realistic and smart. While the final product may look brand-new, the color schemes are quite dull, and it seems robotic with wires and strings seen in between the fingers. However, due to layering the arm with epoxy clay and smoothening it out, the epoxy clay already gives a more natural color of a human arm. Application looked simple, but it is easy to understand.
- **Cost**
  7/8, even though the modules, filament, circuit boards and necessary materials that were bought amounts to a total of below IDR 5,000,000. The product was not sold, and can't give a general view of how much consumers would pay for the product. Secondly, electricity usage was not accounted for, despite being specified in the product criteria and the goal, that all variables should be included. (See appendix 1d total expenditure)
- **Client-Target Market**
  6/8, The product criteria specified that the product was meant for all ages, but for someone with a limb loss. So since the product worked and is usable, this strand is a success. What brought it to six is that the product was not publicly tested on anyone with a limb deficiency so I could not say whether the product was effective. App is also both available for IOS & Android.
- **Environmental Issues**
  8/8, this strand was a major success, since all the parts are successfully printed with PLA, which is a biodegradable polyester and is friendly to the environment. Secondly, the electrical components are only screwed in, so it is detachable and reusable.
- **Safety**
  6/8, sharp corners and anything that can pose a potential threat is smoothly sanded, and wires are neatly tucked under the arm. The circuit had also been tested multiple times, but the chances of short-circuiting are still there. Although the chances are relatively small, short-circuiting is not that uncommon in electrical components over some time.
- **Size & Weight**
  8/8, the arm's mass weighs below 5kg, which is considered a success since the product criteria mentioned it needs to weigh below 5kg. The size of the arm is also proportional to a real arm, having approximately equal length with an average forearm.
- **Function**
  6/8, all requirements that were specified in the product criteria worked to some extent, the reason this strand was given a 6 is that, even though the fingers worked, muscle sensor detected, touch sensor responding, the app worked, and able to grip objects. When the arm grasps an object, there is a slight chance for the object to slip from its grip due to the lack of any adhesive surfaces on the palm. Lastly, while the muscle sensor

worked, the data values still sometimes fluctuate making the fingers jitter. The tiny vibration in our arm most likely causes this problem, and since the muscle sensor is easily susceptible, the problem occurs.

- **Manufacture**
  8/8, all the materials that were specified in the product criteria was entirely used to its maximum potential. So there will be no additional materials that will cause a hindrance, everything was taken into account For example, all screws are Philip-head screws, so there will be no confusion on what screwdriver to use to tighten and untighten the screws.
- **Materials**
  8/8, materials was a success since everything specified in the product criteria such as PLA, jumper wires, epoxy clay, and the rest are used, and no changes were made.

Through creating this prosthetic arm, I have gained a more in-depth knowledge of electronics. My research, communicating, and thinking skills have been improved drastically. In research, I now understood that arranging my findings into a single file will make things more comfortable for me to look through when I needed it. For communicating, I had learned how to create a more formal email to contact executives for an email interview, and how to persuade them to answer my email. Through this skill, I had also learned other's perspective and how they perceived the occurring problem. For thinking skills, since throughout this project, I had encountered numerous faults and bugs that have proved to be challenging, but due to my ability to think critically, I was able to overcome these mistakes. Practically, I have learned more about how my project could be beneficial to the environment and society, as stated in the global context. From the project, I can also relate how my project will have a positive impact on both society and the environment. I have also learned numerous new skills and techniques that I can apply for future projects regarding electricity.

By learning from my successes and faults; I have grown to be a more balanced learner as I have carefully managed my downtime, and stick to the existing timeline. With almost weekly summative tasks, managing my time have proved to be somewhat overwhelming. However, by creating a process journal and timeline, it had helped. This is beneficial for my MYP years and my upcoming DP years. Reflecting towards the IB learner profile, this project had shaped me into a more confident student, by helping me be more open-minded since this project requires me to think critically. Communicators, since this project had taught me how to write formal interview requests. A thinker, since I need to think hard to achieve my product criteria and goals. A risk-taker, since there was no time to create a prototype for the product I decided just to go with the flow. Lastly balanced, since I need to balance my time so I can still relax, do my homework, study for my test, and do PP at an equal pace.

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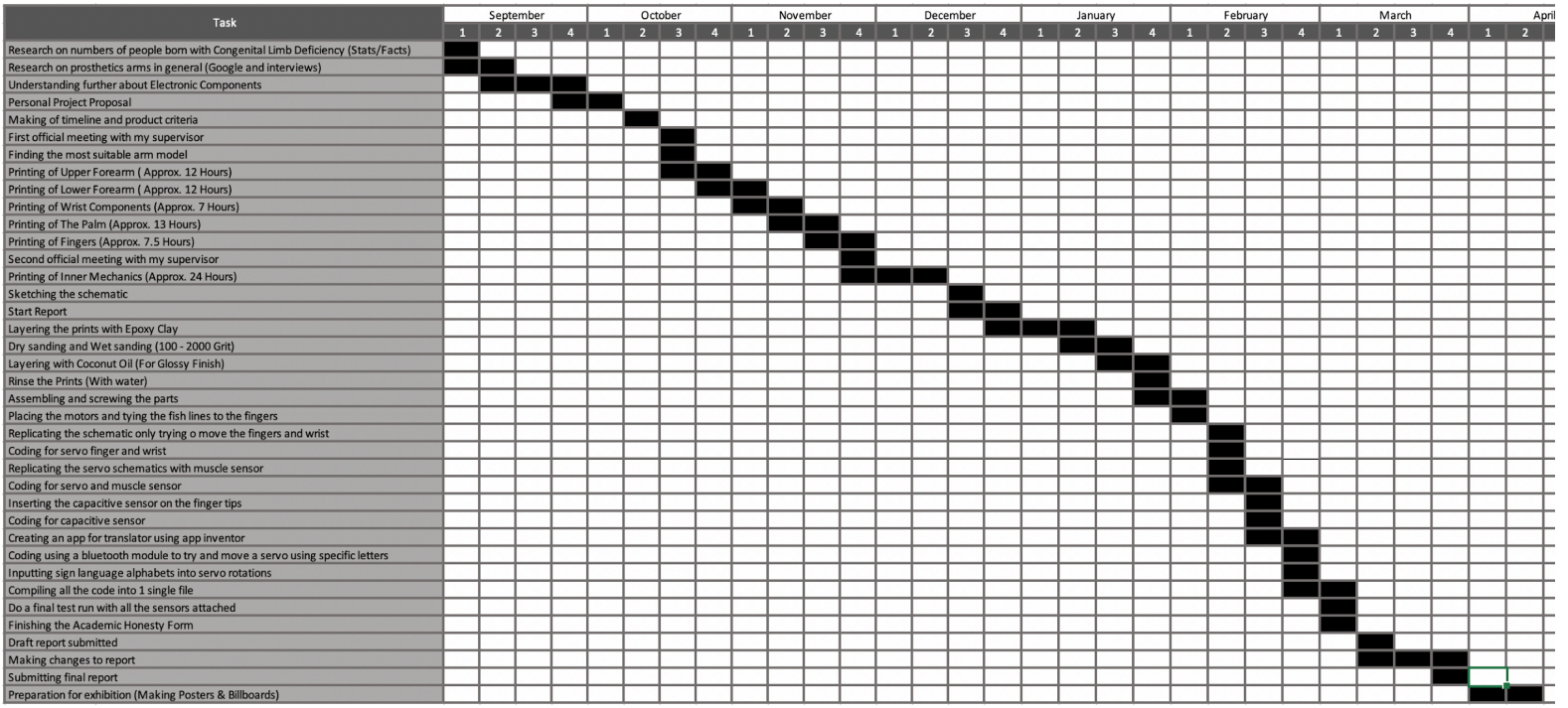
Appendices

Appendix 1. Planning

- Appendix 1a) Timeline



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- **Appendix 1b)** Interview Questions Criteria

1. In your own words, what is a Prosthetic? How can it revolutionize today's world?
2. Theoretically speaking, is controlling Prosthetic Limb through EEG (Electroencephalography) signals much more efficient than using EMG (Electromyography) signals? Why?
3. In terms of cost, would it be cheaper if we used an external power source (NiMH Battery, Solar Panel) rather than using a Myoelectric to power the arm? Why?
4. If you were allowed to make your own prosthetic arm with any material you want? Would you still go for an alloy, or a 3D printed one? Do you think casting an alloy limb will last longer than that of the 3D printed one?
5. Is it really possible to make an arm that could replicate the feeling of a real arm, with a real sense of touch and with incredibly fluid movements? If so how do you think will it work?
6. If I were to apply my idea on making a Prosthetic arm that could translate text to sign language, in a day to day basis how useful do think it will be? (Please answer in your own opinion)
7. As a philanthropist, do you think building cheaper less durable (Usage of 1 year) prosthetics, are the solution to children with loss limbs in third world countries? Or do you have a solution for it?

- **Appendix 1c)** Product

Goal:	3D printed prosthetic arm, based on InMoov by Gael Langevin's design, that can translate text - sign language, detect touch on fingertips, and muscle controlled.
Global Context:	Scientific and Technological Innovation; The impact of scientific and technological advances on society and the environment
Descriptions	Criteria
Appearance (How will the product outcome look like?)	The appearance of the prosthetic arm will look modern, realistic and smart. It will be covered with epoxy clay, to give a somewhat realistic look, and will also be sanded to provide a smooth feeling. The design of the arm will not be modified from InMoov's design. The custom application should also look simple, yet beautiful
Cost	Manufacturing cost will be below IDR 5,000,000, the Arduino, motors, and sensors included. The product is a prototype and will not be sold. If sold, retail cost will be approximately below IDR 10,000,000 cheaper than most prosthetics on the market.
Client-Target Market (Who is the product targeted to?)	The target market for the product is for all ages, but only individuals that have a limb loss. Application should be easy to understand, for childrens and elders.
Environmental Issues	The product will be environmentally friendly, With its main components made out of PLA/Polylactic Acid, which is a type of Biodegradable polyester. The inner parts such as the Arduino board, wires, and motors can be reused.
Safety	For the safety of others, the prosthesis will be smoothly sanded to avoid any rough parts. Wires will also be hidden to prevent any electrocution. All circuits and wires will also be tested before use to prevent any short circuits.
Size & Weight	The ideal weight will be below 5 kg since if the prosthetic is too heavy, it will be hard to mount to the upper limb. The arm should also be approximately proportional with a real arm, having the same length and width of an average arm.
Function (What is the product used for?)	The function of the prosthetic is to be able to open and close its fingers, twist the wrist, detect a touch at the tip of the finger, capable of gripping onto objects, translating text to sign language, and muscle controlled.
Manufacture (ex. the hardware, software, materials, tools, and parts necessary to create the product)	To manufacture the prosthetic a bunch of equipment will be used. A 3d printer to print all the necessary parts. Sandpaper to smoothen out all the parts, Screwdrivers to screw in any essential elements, and a laptop to upload the code and program the arm. App inventor will also be used to create the app since app inventor is free of use.
Materials	PLA will be an ideal material since it is lightweight and cheap. Wires will be used to communicate and transfer data, from the board to the motors and sensors; epoxy clay to cover the arm, and give its natural color. A smartphone should be use to run the application.

- **Appendix 1d)** Budget Plan

No.	Product Name	Store	Unit Price (IDR)	Quantity	Total
1	AA Alkaline 1.2v Battery	Tokopedia	Rp3,000	4	Rp12,000
2	Arduino MEGA 2560 Clone	Tokopedia	Rp118,000	1	Rp118,000
3	Myoware Muscle Sensor	Tokopedia	Rp760,000	1	Rp760,000
4	Convidien EMG Electrodes H124SG	Tokopedia	Rp14,000	3	Rp42,000
5	Bluetooth HC-05 Module	Tokopedia	Rp41,800	1	Rp41,800
6	PE Pioneer Eco Fishing Braid (100m)	Tokopedia	Rp83,000	1	Rp83,000
7	0.5mm Diameter Extension Spring (Custom)	Tokopedia	Rp12,000	10	Rp120,000
8	5mm ESD Antistatic Foam	Lazada	Rp61,000	1	Rp61,000
9	1mm Copper Foil	Tokopedia	Rp67,000	1	Rp67,000
10	1kg White PLA Spool	Tokopedia	Rp285,000	1	Rp285,000
11	MG996R 5v Servos	Tokopedia	Rp52,000	6	Rp312,000
12	Jumper Wires	Tokopedia	Rp100	100	Rp10,000
13	Epoxy Clay	Tokopedia	Rp110,000	1	Rp110,000
14	2mm Aluminium Wire (10m)	Tokopedia	Rp36,500	1	Rp36,500
15	PTFE Tube (50cm)	Tokopedia	Rp6,000	1	Rp6,000
16	AA x4 Battery Holder Series	Tokopedia	Rp15,000	1	Rp15,000
17					
				Total	Rp2,079,300

Appendix 2. Investigation

- **Appendix 2a)** Email to MobiusBionics on average price for a prosthetic

Re: Prosthetic Arm Cost Inbox ×

Jarrett Porter support@mobiusbionics.com via freshdesk.com
to me

[redacted]

Good Morning Brilliant,

Thank you for your interest in the LUKE arm. Just so you are aware, at the present time the arm is available only for domestic sale here in the US. However, there is the potential to be fit with the prosthesis here in the US and self-import it back home. Please note, we have not yet confirmed this is legal to self-import to Indonesia.

There are many variables that must be determined by the prosthetist that include the level of amputation, fitting of the socket, training, follow up care and ongoing support. Therefore, an estimated cost can only be determined when a specific patient's case is under review by a certified prosthetist. That being said, I can give a rough estimate of the Shoulder Configuration in the high ~$200k range and Humeral Configuration would likely be in the low ~$200k range.

The first step would be to put you in touch with a LUKE certified prosthetist. They would be best suited to answer most questions regarding fitting, cost/coverage and the potential for an evaluation to see what prosthetic options might be best. With your permission, I could provide your contact information to the nearest LUKE certified office and have them reach out directly to you. Otherwise, I will be here if you have any further questions and will be more than happy to help.

Best Regards,

Jarrett Porter
Technical Support Engineer
www.MobiusBionics.com

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[redacted]

- **Appendix 2b)** Email to Arm Dynamic executive regarding prosthetics

Arm Dynamics
Redefining Possibility

Dan Conyers, CPO, FAAOP
National Clinical Director

Arm Dynamics
dconyers@armdynamics.com

P: (503) 869-7202

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From: Dan Conyers, CPO, FAAOP
Sent: Thursday, January 24, 2019 12:37 PM
To: 'tryan@armdynamics.com' <tryan@armdynamics.com>
Subject: RE: your inquiry attached.

Mr. Brilliant,

I have been heavily scheduled at work with many meetings and travel, so my reply is somewhat delayed. See answers from me and my colleagues written in red to address the questions where I feel we have some perspective to share.

All the best,

Dan

1. In your own words what is a Prosthetic?
   A human prosthetic solution is intended to replace a missing or damaged anatomical structure.

   How can it revolutionize the today's world? Well thought out and well-designed human prosthetic solutions attempt to restore a useful degree of the missing function of the absent or damaged anatomical structure. When careful consideration is given to mating the man/machine solution, when proper training is provided, when the user has resources to support the integration of a prosthetic solution into their life, the outcome can revolutionize an individual's life, and subsequently create a positive effect on the world around that individual's ability to contribute to family, community, workplace and society.

2. Theoretically speaking is controlling Prosthetic Limb through EEG (Electroencephalography) signals much more efficient than using EMG (Electromyography) signals? Why?
   An EEG control input would provide a theoretically more robust signal, as well as a more focused signal for both control and also to potentially provide a return pathway for sensory feedback. Current research EEG input devices remain less than ideal from the standpoint of bulk, reliability and comfort for the user.

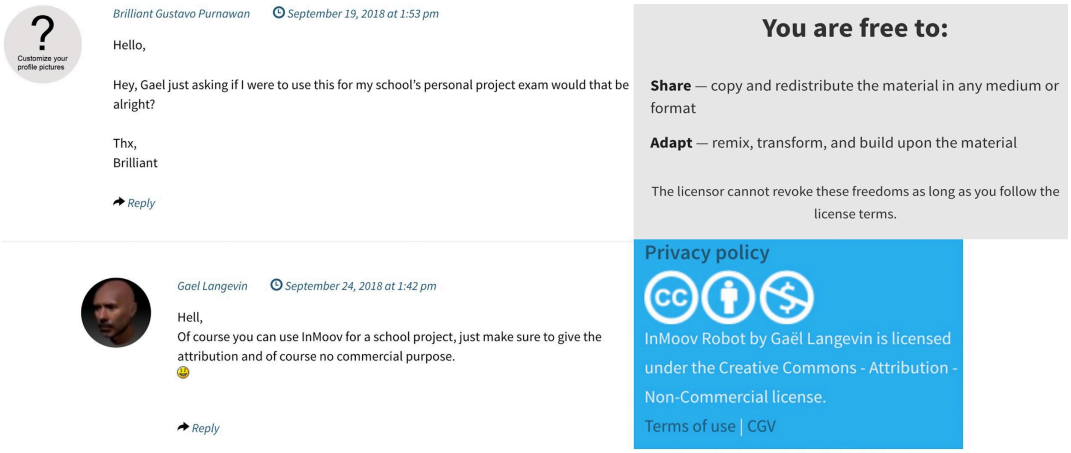
3. In terms of cost, would it be cheaper if we used an external power source (NiMH Battery, Solar Panel) rather than using a Myoelectric to power the arm? Why?
   NiMH has been questioned in the U.S. as a power source for upper limb prosthetic use secondary to newer, stronger and more reliable battery materials being used. New battery technologies that are lighter, stronger and which can maintain a charge for longer periods of time, are desired in nearly all applications reliant on battery power, included upper limb prosthetics. Your question seems to mix the power required to operate a prosthesis, with the control input to control the prosthetic arm, so I cannot be certain that I understand where your actual focus is with this query.

4. If you were allowed to make your own prosthetic arm with any material you want? Would you still go for an alloy, or a 3D printed one? Do you think casting an alloy limb will last longer than than the 3D printed one? Additive manufacturing processes are quite capable of "printing" in metal and alloy, and offer the distinct advantage of speed and cost saving for prototype work over traditional mold making and manufacturing techniques. As printing machinery and software become more sophisticated, there is a growing opportunity for manufacturers to create products for market with additive manufacturing methods. Two of our suppliers now use additive manufacturing to create parts to meet our specifications for patients needing upper limb prosthetic components. Other manufacturers have entered the market with printable versions of their designs that can be tailored to the individual, but many of these still lack the robustness required to be used in heavy duty applications.

5. Is it really possible to make an arm that could replicate the feeling of a real arm, with a real sense of touch and with an incredibly fluid movements? If so how do you think will it work?
   No comment at this time.

6. If i were to apply my idea on making a Prosthetic arm that could translate text to sign language, in a day to day basis how useful do think it will be? (Please answer in your own opinion)
   My initial thoughts on this would be to take a look at the intersection between hearing impaired persons who use sign language to communicate and persons who rely on an upper limb prosthetic device to restore function to an absent or damaged upper limb. While my estimate is that there is a very small number of individuals who may benefit from this technology….there may be other applications for the hearing impaired population, who rely on sign language for communication. I can imagine robotic hands with enough "sign-vocabulary" that they could become an additive part of programming for learning, entertainment and other visual communication platforms. That being said, a communication application could probably be more rapidly developed in a software based tool with digital imagery to mimic hand signs on a screen, rather than a 3 dimensional robotic application.

- **Appendix 2c)** Inquiry to Gael Langevin regarding using his model arm (License)



Brilliant Gustavo Purnawan September 19, 2018 at 1:53 pm

Hello,

Hey, Gael just asking if I were to use this for my school's personal project exam would that be alright?

Thx,
Brilliant

Reply

Gael Langevin September 24, 2018 at 1:42 pm

Hell,
Of course you can use InMoov for a school project, just make sure to give the attribution and of course no commercial purpose.

Reply

You are free to:

Share — copy and redistribute the material in any medium or format

Adapt — remix, transform, and build upon the material

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Appendix 3. Research

- **Appendix 3a)** List of acronyms and terms used in report

Definitions & Acronyms

- **Prosthetic**: An artificial body part.
- **Electromyography**: Recording of electrical activity within the muscle tissue, often displayed through a visual display or audible signal.
- **Polylactic Acid / PLA**: A biodegradable and bioactive thermoplastic aliphatic polyester derived from renewable resources varies from its continent. (Ex. Asia [Starch], America [Corn Starch], Rest of the world [Sugarcane])
- **3D Print**: Action of creating a physical object from a three-dimensional digital object, by laying down multiple layers onto a surface.
- **Forearm**: The region between the elbow and the wrist.
- **InMoov**: A project by a French sculptor and designer, Gael Langevin, it was initiated in January 2012 as the first Open Source prosthetic hand. Easily replicable for Universities, Laboratories, Hobbyist and Makers.
- **Split Hook**: A type of prosthesis that utilizes elastic bands to close the arm and generate grip force
- **Baud**: Unit of transmission
- **Torque**: A twisting force that causes a rotation
- **Analog**: Relating to or using signals or information represented by a continuously variable physical quantity such as spatial position, voltage, etc.
- **PWM / Pulse Width Modulation**: A square wave, a signal switched between on and off

- **Appendix 3b)** Personal research regarding the problem

Personal Research

- **Congenital Limb Deficiency**

1. One of the major issue of having Congenital Limb Deficiency as an adult is because of they have limb reduction defects as a baby.
2. CDC (Center for Disease Control) estimate that approximately 1,500 babies in the US are born with upper limb reduction and 750 with lower.
3. In simpler terms, 4 out of 10,000 babies will have upper limb reduction, and 2 out of 10,000 will have lower limb loss.
4. Potential difficulties if the have lim deficiency
    a. Difficulties with normal development such as motor skills
    b. Needing assistance in a daily basis
    c. Limitations with certain movements and sports
    d. Emotional and Social issue due to physical appearance
5. Causes of limb defects
    a. Exposure of the mother to hazardous chemicals
    b. Exposure of the mother to dangerous viruses
    c. Exposure of the mother to certain medications
6. Solution to lim defects
    a. Surgery
    b. Prosthetics

- **Prosthetics in 2019**

  1. Prosthetic with a sense of touch

     a. From a team of engineers in John Hopkins University they created an electronic skin. When layered on top of prosthetic hands, this e-dermis brings back a real sense of touch through the fingertips. This idea is based on the human skin which contains a complex network of receptors that relay a variety of sensations to the brain. It works by using the e-dermis to convey information to the amputee by stimulating peripheral nerves in the arm.

  2. 3D printed prosthetic

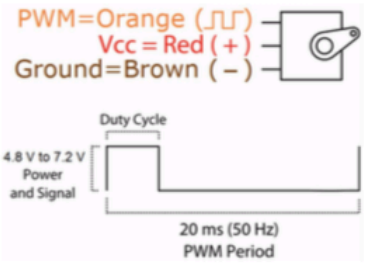
     a. As per a Bioengineering Institute Center for Neuroprosthetics, at the Worcester Polytechnic Institute, the expense of a prosthesis may shift contingent upon the patient's inclination. For instance, a cosmetic arm and hand may go up to $3,000 - $5,000, and a fully functional arm will cost about $11,000 - $13,000 according to Open Bionics. Due to this 3D printed prosthetics has been very popular, which in contrast a 3D printed arm would cost less than $100. Besides it being very cheap, 3D printed prosthetics can also be made much quicker; with a team of trained professionals a limb can be made in a day. Another pros is that the arm is fully customizable, an example can be seen from open bionics with their Hero Arm. But with all the benefits 3D prosthetic are also less durable and have a shorter life span. In conclusion 3D prosthetic arm are easier to make, cheaper, customizable, but less durable.

- **Appendix 3c)** Technical details of the sensors and processors used

Technical Data

- **Servo MG996R**

  1. Stall torque: 9.4 kgf·cm (4.8 V), 11 kgf·cm (6 V)
  2. Operating speed: 0.17 s/60º (4.8 V), 0.14 s/60º (6 V)
  3. Operating voltage: 4.8 V a 7.2 V
  4. Running current 500mA to 900 mA (6V)
  5. Temperature range : 0 ºC - 55 ºC

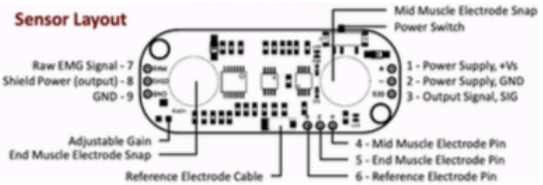


- **Arduino Mega 2560**

  1. Microcontroller : ATmega2560
  2. Operating Voltage : 5V - 6V
  3. Input Voltage : 7V - 12V
  4. Digital I/O Pins : 54 (14 provide PWM output)
  5. Analog Input Pins : 16
  6. DC Current per I/O Pin : 40 mA
  7. DC Current for 3.3V Pin : 50 mA
  8. Flash Memory : 256 KB of which 8 KB used by bootloader
  9. SRAM : 8 KB
  10. EEPROM : 4 KB
  11. Clock Speed : 16 MHz

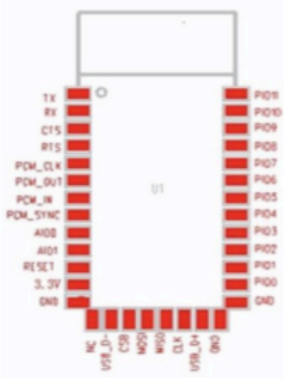
- **Myoware Muscle Sensor**

  1. Single Supply : +2.9V to +5.7V
  2. Two output mode : EMG Envelope & Raw EMG



- **Bluetooth HC-05**

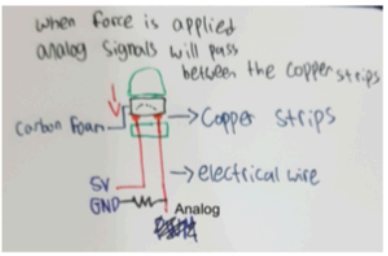
  1. Default Baud rate : 38400
  2. Data bits : 8
  3. Stop bit : 1
  4. Supported baud rate: 9600, 19200, 38400, 57600, 115200, 230400, 460800.
  5. Up to +4dBm RF transmit power
  6. Low Power 1.8V Operation ,1.8 to 3.6V I/O
  7. Integrated Antenna
  8. Typical -80dBm sensitivity



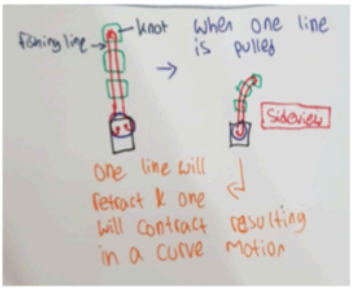
- **Appendix 3d)** How the product will work

How it will work

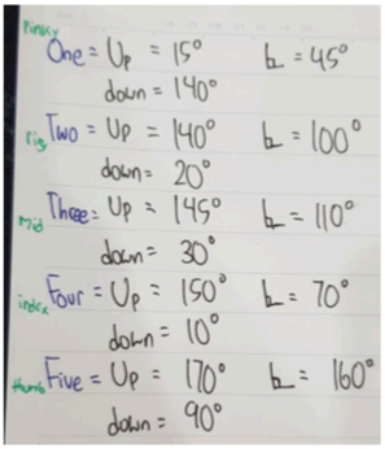
- **Capacitive sensor**
  1. Based on Chiprobot's idea (https://www.youtube.com/watch?v=SFLLjkhvsYs). Since carbon and copper are good conductors of electricity, the carbon foam acts as a bridge that will connect the 2 copper strips sending analog signals through them.



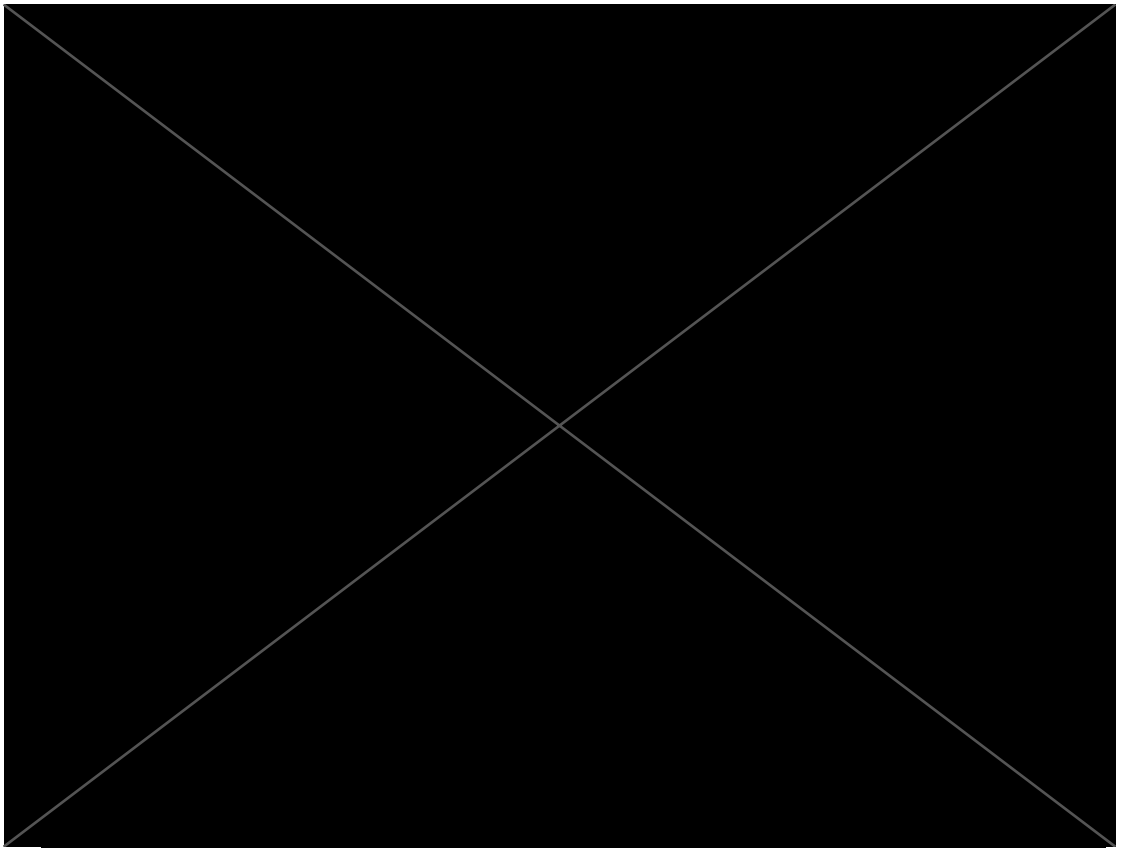
- **Finger movement**
  1. Called the string theory by Gael Langevin. It utilizes two braided fishing line to contract and retract the finger. As seen on the image when two braided line will be pulled to a knot on top of the finger and on the servo. When one string is contracted the other will retract, and vice versa.



- **Servo rotation**
  1. On the right is an image that shows how many degrees is needed for each finger to move up, down and 90 degrees.

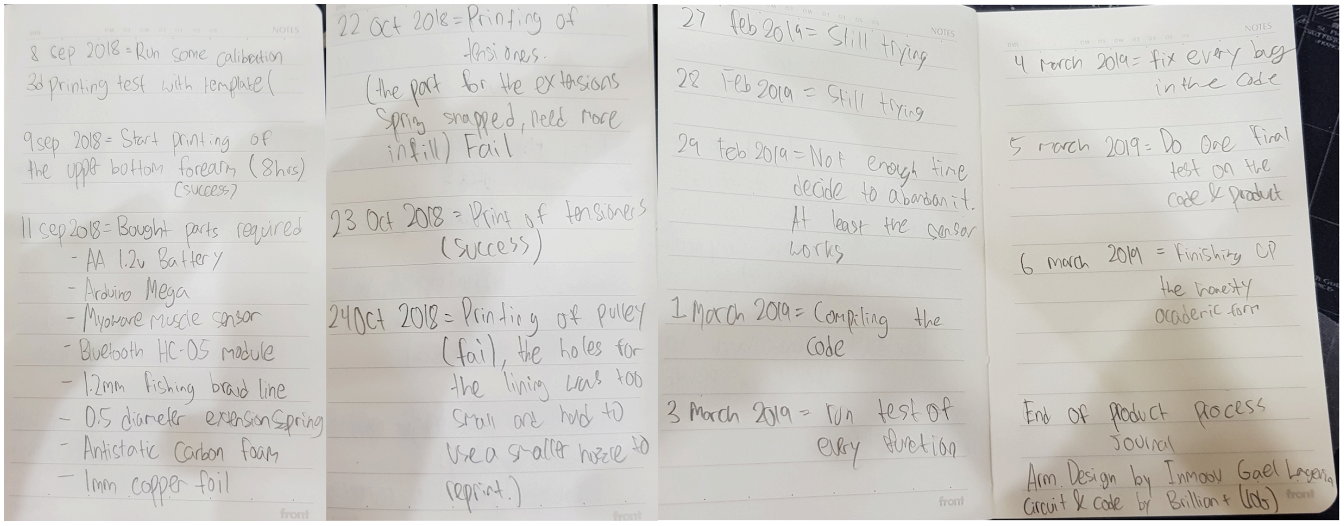


- **App translation**
    1. By using a alphabet dictionary from ASL we can use the "if else" code, in the application made, if in the text box there is letter "a" send text through bluetooth "a". In the Arduino code, we can replicate sign language A using the servo rotation technique.



Appendix 4. Taking action

- **Appendix 4a)** Process journal entries



8 sep 2018 = Run some calibration 3d printing test with template (

9 sep 2018 = Start printing of the upper bottom forearm (8hrs) (success)

11 sep 2018 = Bought parts required
- AA 1.2v Battery
- Arduino Mega
- Myobore muscle sensor
- Bluetooth HC-05 module
- 1.2mm fishing braid line
- 0.5 diameter extension spring
- Antistatic Carbon foam
- 1mm copper foil

22 Oct 2018 = Printing of tensioners. (the part for the extensions spring snapped, need more infill) Fail

23 Oct 2018 = Print of tensioners (success)

24 Oct 2018 = Printing of pulley (fail), the holes for the lining was too small are hard to use a smaller nozzle to reprint.)

27 feb 2019 = Still trying

28 Feb 2019 = Still trying

29 feb 2019 = Not enough time decide to abandon it. At least the sensor works

1 March 2019 = Compiling the code

3 March 2019 = run test of every function

4 march 2019 = fix every bug in the code

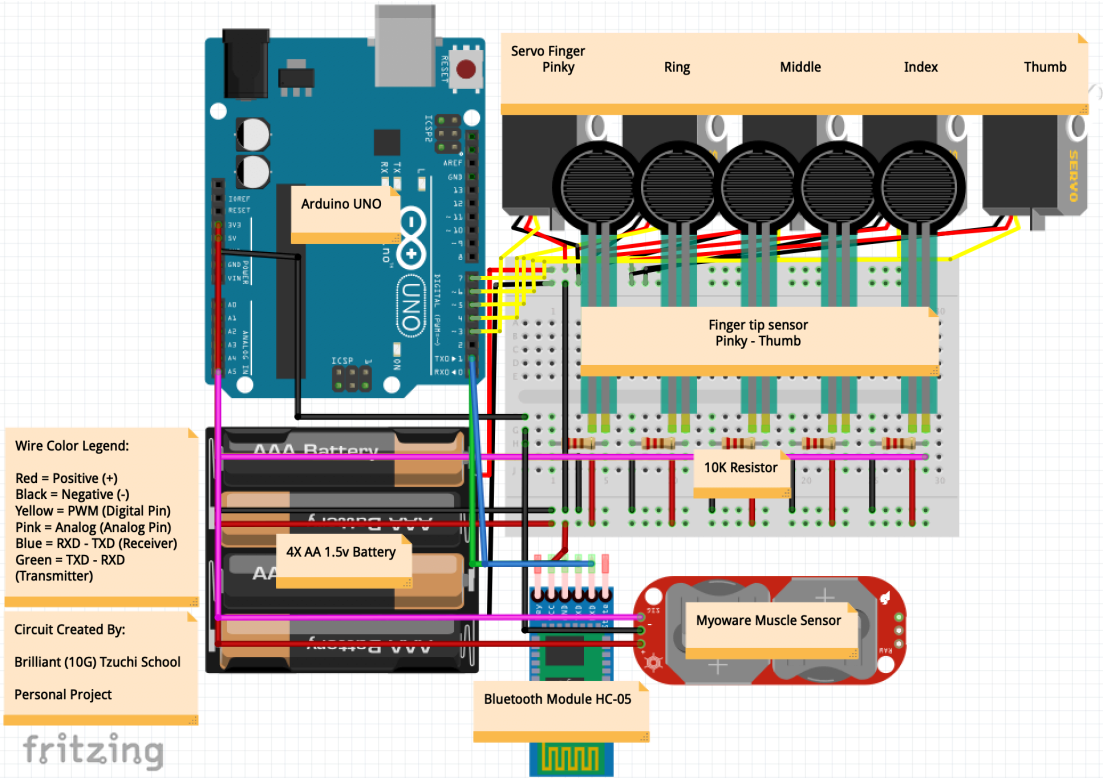
5 march 2019 = Do one final test on the code & product

6 march 2019 = Finishing up the homestyle academic form

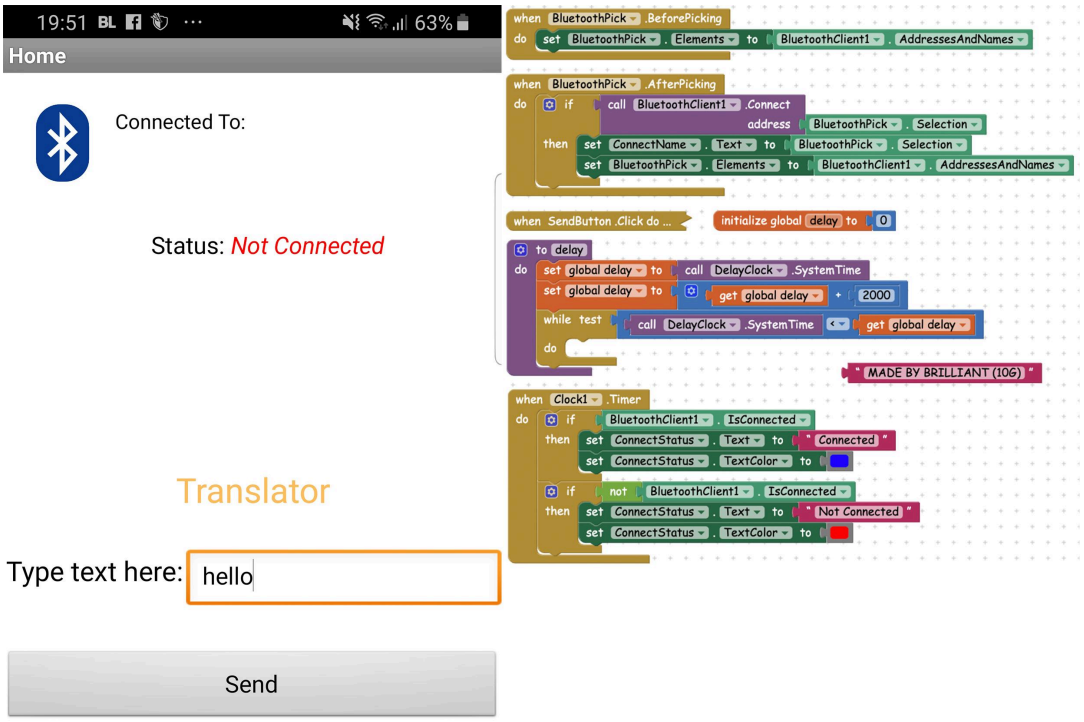
End of product process journal

Arm Design by Inmoov Gael Langevin
Circuit & Code by Brillian + (Me)

- **Appendix 4b)** Schematic



- **Appendix 4c)** Final app

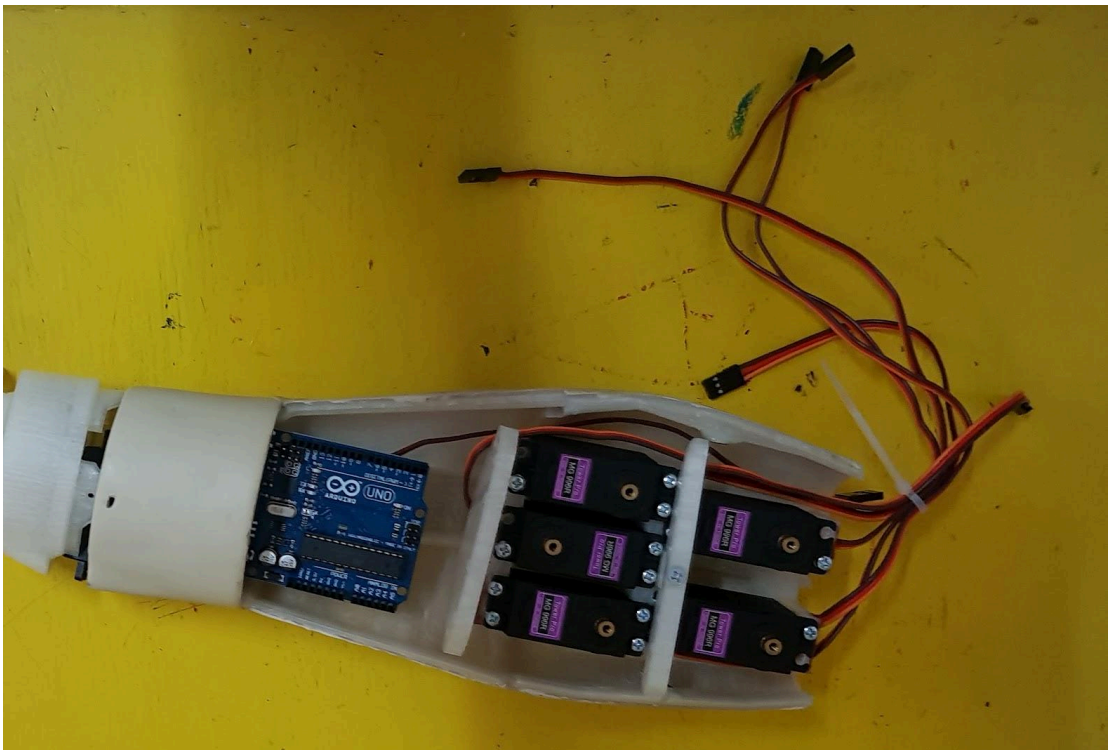


- **Appendix 4d)** Final Code

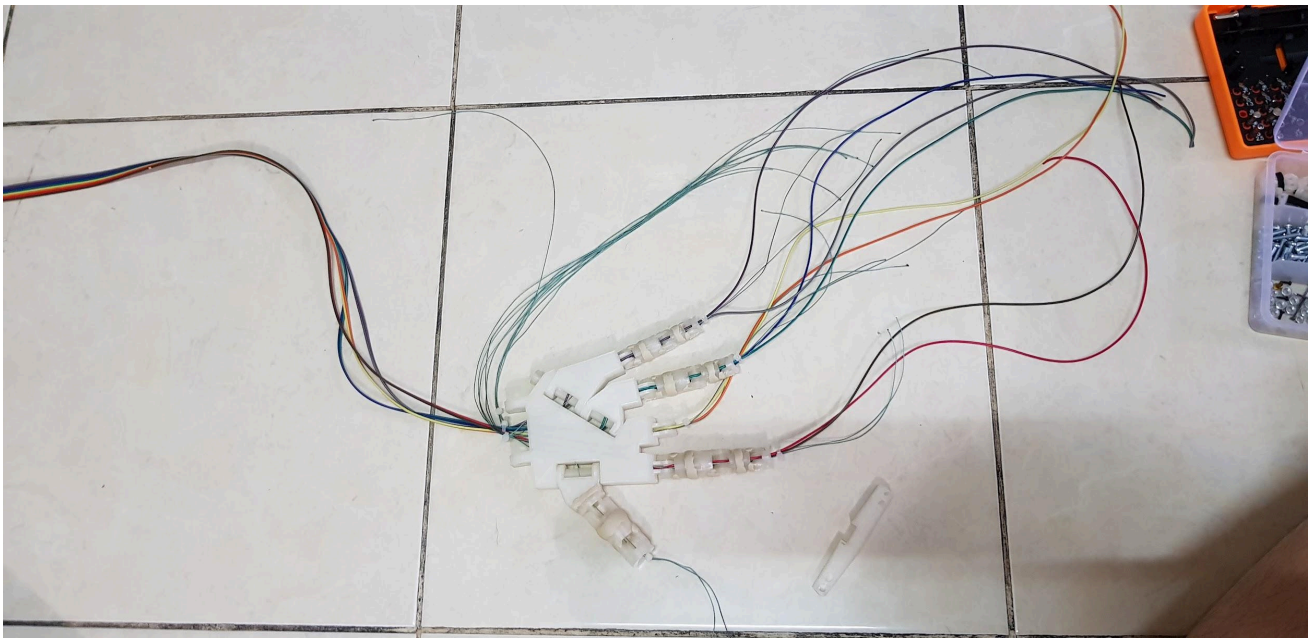
Code-Finger_App §

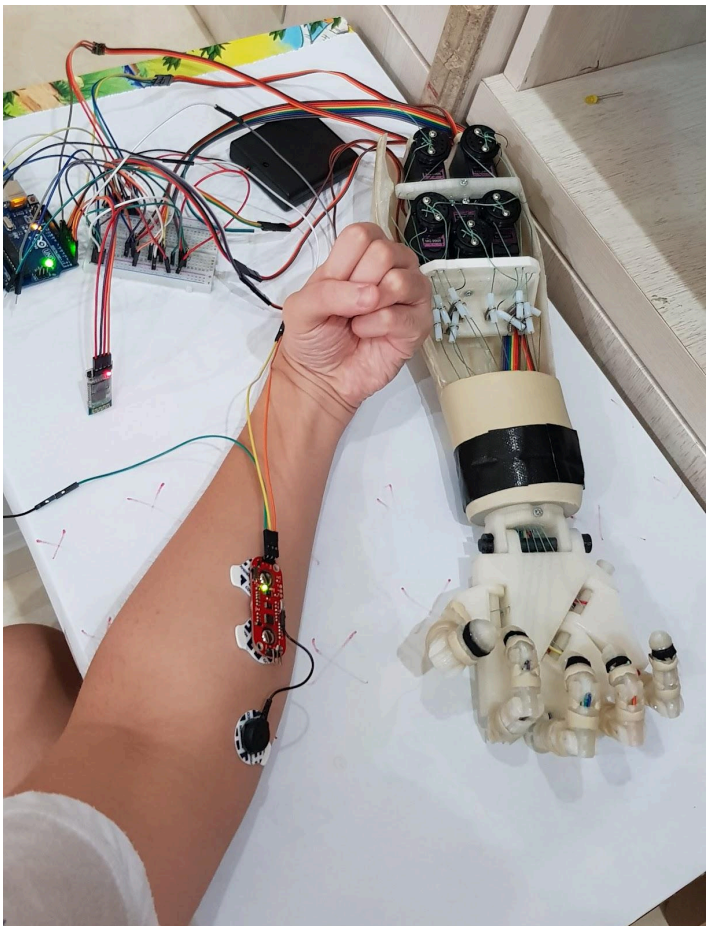
```
1 /////Code created and compiled by Brilliant(10G) TzuChi School/////
2 /////Finger Tip Sensor code modified from Adafruit FSR/////
3 /////Muscle Sensor code modified from MyoWare/////
4
5
6 #include <Servo.h>
7
8 /////Declaring Servos, Variables and Servos/////
9
10 Servo one;
11 Servo two;
12 Servo three;
13 Servo four;
14 Servo five;
15
16 const int sensorOne = 0;
17 const int sensorTwo = 1;
18 const int sensorThree = 2;
19 const int EMG_PIN = 3;
20
21 int sensorReadingOne;
22 int sensorReadingTwo;
23 int sensorReadingThree;
24
25 int Received = 0;
26
27 #define THRESHOLD 100
28
29 /////Declaring Servos, Variables and Servos/////
30
31 void setup() {
32
33 /////Declaring Data Rate & Attaching Servos/////
34
35   Serial.begin(9600);
36
37   one.attach(3);
38   two.attach(4);
39   three.attach(5);
40   four.attach(6);
41   five.attach(7);
42
43 /////Declaring Data Rate & Attaching Servos/////
44
45 }
46
47
48
49 /////App Translation/////
50
51   if (Serial.available() > 0)
52   {
53     Received = Serial.read();
54   }
55
56   if (Received == 'a')
57   {
58     one.write(15);
59     two.write(140);
60     three.write(145);
61     four.write(150);
62     five.write(90);
63   }
64   else if (Received == 'b')
65   {
66     one.write(140);
67     two.write(20);
68     three.write(30);
69     four.write(10);
70     five.write(170);
71   }
72   else if (Received == 'c')
73   {
74     one.write(100);
75     two.write(90);
76     three.write(100);
77     four.write(60);
78     five.write(120);
79   }
80   else if (Received == 'd')
81   {
82     one.write(15);
83     two.write(140);
84     three.write(145);
85     four.write(10);
86     five.write(170);
87   }
88   else if (Received == 'e')
89   {
90     one.write(45);
91     two.write(100);
92     three.write(110);
93     four.write(70);
94     five.write(170);
95   }
96   else if (Received == 'f')
97   {
98     one.write(140);
99     two.write(20);
100    three.write(30);
101    four.write(150);
102    five.write(170);
103  }
104  else if (Received == 'g')
105  {
106    one.write(45);
107    two.write(100);
108    three.write(110);
109    four.write(10);
110    five.write(170);
111  }
112  else if (Received == 'h')
113  {
114    one.write(140);
115    two.write(20);
116    three.write(145);
117    four.write(150);
118    five.write(90);
119  }
120  else if (Received == 'i')
121  {
122    one.write(140);
123    two.write(140);
124    three.write(145);
125    four.write(150);
126    five.write(160);
127  }
128  else if (Received == 'j')
129  {
130    one.write(140);
131    two.write(140);
132    three.write(145);
133    four.write(150);
134    five.write(160);
135    delay(1500);
136    one.write(15);
137    delay(1500);
138    one.write(140);
139
140  }
141  else if (Received == 'k')
142  {
143    one.write(15);
144    two.write(140);
145    three.write(30);
146    four.write(10);
147    five.write(170);
148  }
149  else if (Received == 'l')
150  {
151    one.write(15);
152    two.write(140);
153    three.write(145);
154    four.write(10);
155    five.write(90);
156  }
157  else if (Received == 'm')
158  {
159    five.write(170);
160    delay(1500);
161    one.write(15);
162    two.write(140);
163    three.write(145);
164    four.write(150);
165
166  }
167  else if (Received == 'n')
168  {
169    one.write(15);
170    two.write(140);
171    five.write(170);
172    delay(1500);
173    three.write(145);
174    four.write(150);
175  }
176  else if (Received == 'o')
177  {
178    one.write(45);
179    two.write(100);
180    three.write(110);
181    four.write(70);
182    five.write(120);
183  }
184  else if (Received == 'p')
185  {
186    one.write(15);
187    two.write(140);
188    three.write(100);
189    five.write(120);
190    delay(1500);
191    four.write(60);
192
193  }
194  else if (Received == 'q')
195  {
196    one.write(15);
197    two.write(140);
198    three.write(145);
199    four.write(70);
200    five.write(170);
201  }
202  else if (Received == 'r')
203  {
204    one.write(15);
205    two.write(140);
206    five.write(170);
207    three.write(145);
208    delay(1500);
209    three.write(30);
210    four.write(150);
211  }
212  else if (Received == 's')
213  {
214    one.write(15);
215    two.write(140);
216    three.write(145);
217    four.write(150);
218    delay(1500);
219    five.write(170);
220  }
221  else if (Received == 't')
222  {
223    one.write(15);
224    two.write(140);
225    three.write(145);
226    delay(1500);
227    five.write(170);
228    delay(1500);
229    four.write(150);
230  }
231  else if (Received == 'u')
232  {
233    one.write(15);
234    two.write(140);
235    three.write(30);
236    four.write(10);
237    five.write(170);
238  }
239  else if (Received == 'v')
240  {
241    one.write(15);
242    two.write(140);
243    three.write(145);
244    four.write(150);
245    five.write(170);
246    delay(1500);
247    three.write(30);
248    four.write(10);
249  }
250  else if (Received == 'w')
251  {
252    one.write(15);
253    two.write(20);
254    three.write(30);
255    four.write(10);
256    five.write(170);
257  }
258  else if (Received == 'x')
259  {
260    one.write(15);
261    two.write(140);
262    three.write(145);
263    four.write(70);
264    five.write(170);
265  }
266  else if (Received == 'y')
267  {
268    one.write(140);
269    two.write(140);
270    three.write(145);
271    four.write(150);
272    five.write(90);
273  }
274  else if (Received == 'z')
275  {
276    one.write(15);
277    two.write(140);
278    three.write(145);
279    five.write(170);
280    four.write(10);
281  }
282
283 /////App Translation/////
284
285 /////Finger Tip Sensor/////
286
287   sensorReadingOne = analogRead(sensorOne);
288   Serial.print(sensorReadingOne - 975);
289   Serial.print(" ");
290   sensorReadingTwo = analogRead(sensorTwo);
291   Serial.print(sensorReadingTwo - 975);
292   Serial.print(" ");
293   sensorReadingThree = analogRead(sensorThree);
294   Serial.println(sensorReadingThree - 975);
295   delay(100);
296
297 /////Finger Tip Sensor/////
298
300
301   int value = analogRead(EMG_PIN);
302
303   if(value > THRESHOLD){
304     one.write(15);
305     two.write(140);
306     three.write(140);
307     four.write(150);
308     five.write(155);
309   }
310
311   else{
312     one.write(140);
313     two.write(30);
314     three.write(30);
315     four.write(10);
316     five.write(60);
317   }
318
319   Serial.println(value);
320
321   /////Muscle Sensor/////
322 }
```

- **Appendix 4e)** Progress of product 1



- **Appendix 4f)** Progress of product 2



- **Appendix 4g)** Progress of product 3

Appendix 4h) Final product