Purdue ECE Senior Design Semester Report
(Team Section)

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Fall 2018
Advisors	Prof. Thottethodi, Todd Wild
Team Number	7
Project Title	Handi_glove

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Yaodong Shen	EE	PCB & Firmware	May 2019
Jia En Chua	CE	Embedded C Firmware	December 2018
Carol Lo	EE	Electrical Mechanical design & assembly	May 2019
Yao Chen	EE	Embedded C Firmware	December 2018

(a) Provide a general description of the product to be delivered by this design project.

The Handi-Glove is a two-part system consisting of a user-controlled glove and a robotic hand. The user-controlled exoskeleton glove is a wearable device that will provide temperature, motion, and force feedback to users according to the data sensed on the robotic hand. When the user wears the exoskeleton glove, they are able to control the movements on the robotic hand. In addition, temperature and pressure data will be relayed from the robotic arm. For example, if the robotic arm were to pick up a cold can of soda, the user would be able to immediately feel the coldness through the Peltier cooling modules installed on the fingertips of the user-controlled glove. At the same time, the user would also be able to feel pressure on their fingertips that is caused by the expansion of a mini-airbag inside of the fingertip holder of the user-controlled exoskeleton glove. There also exists a pressure sensor intended to detect whether or not there is a hand inserted in the glove-- this information is then relayed back to the robotic arm. On the robotic hand, there are temperature and pressure sensors installed in order to detect data and relay the information to the user-controlled glove.

(b) What is the purpose of this product? For whom is it intended?

Researchers and industry professionals are constantly exposed to hazardous environments in modern research, the project that our team aims to develop consists of using a glove to control a robotic hand that aids the experimental process while protecting the operators. We are aware that similar technology already exists in the modern world; however, researchers are unable to receive real time feedback from the experiment's result. Interaction is important in certain experiments and the opportunity to physically interact with elements within the experiment is sometimes not easily realizable. With our project, scientists and researchers would be able to overcome this obstacle in a safe and efficient manner. Temperature and pressure feedback are crucial because the ability to detect changes of temperature or pressure can speed up experiments from time to time. More importantly, the temperature and pressure feedback systems emulate the physical environment in which experiments are being conducted. This allows researchers and scientists to physically yet remotely interact with the experimental environment. Our project serves the purpose of improving experiment efficiency and preserving the safety standards within industrial and commercial environments.

(c) Describe how the engineering design process used to create your product was utilized in this project. Include how you were able to develop and conduct appropriate experiments, analyze and interpret data, and use engineering judgment to draw conclusions related to the development of your product.

The first step is to set criteria that correspond to our objective. In the process, feasibility and practicality need to be taken into consideration. Firstly, we want to use the metal touch button to reset and initialize the mechanical hand. However, the metal exists lots of shortcomings like conductivity and hard to manufacture. Therefore, we finally decide to use the pressure film sensor bottom to reset our hand and finish our PSSC. In the analysis and synthesis stages, both software and hardware designed need to be considered since our project needs a lot of sensors and external devices like feedback airbags. The layout of our PCB needs to consider many factors for the sensors. Besides, PCB PIN also needs to be considered for the implementation of different peripherals. When construct and test the project, every peripheral should be written and tested separately before being integrated.

Furthermore, the method to connect the microcontroller to external devices should be chosen appropriately. To achieve the temperature feedback system, we need to use H-bridge to control Peltier cooler and according to the sensor, value to give the real temperature feedback for users. After finishing all peripherals, we should evaluate the results of the test and make changes accordingly in construction and then re-do the testing again.

(d) Describe the design constraints, and resulting specifications, incorporated into your product (list a minimum of 3).

Size factor: Because different people have different size of hands, it is tough to decide the control glove size to fit everyone. At first, we want to use 3D printed glove module to fix the exoskeleton. However, it is fixed hand size, and the size is not friendly for most small hand users like female and children. Finally, we decide to use the knitted glove and tailor the exoskeleton on the glove to meet most user expectation that they can control the mechanical hand much more flexible.
Safety factor: It should come as no surprise that safety is an essential issue in the design of any electrical equipment which is liable to come into contact with a human operator or servicing individual. For human safety, we decide to use low power supplies to control our

project. Besides, all areas inside the control glove containing hazardous voltages have been protected from access by the user, including through any openings in the enclosure. Finally, we decide to use pressure film bottom and give up the metal bottom to reset the mechanical hand.

Aesthetics factor: There are lots of different sensors need to fix on the fingertip. Therefore, we design a fingertip holder which can be placed on the user's fingertip. It contains a pressure sensor, temperature sensor, Peltier cooler, aluminum heat sink, and airbag. It is an aesthetic design for our project and cut off the weight of the user wearing the glove.

(e) Describe how each of the following factors influenced your design specifications and constraints.

Health, Safety, Safety, and Welfare: The design is aiming to improve the safety level of workers in industrial and research area. The design also minimized safety concerns that arise when a user interacts with temperature and touch feedback system. For example, we set a threshold for both heat generator and linear actuator so that user's safety is never compromised.

Global: The design has no global constraints in this stage.

Cultural: The design has no cultural constraints in this stage.

Social: In order to make the design suitable for different people's hand, it includes controlling gloves with two different sizes. User with different gender and age can pick glove that suits them the most.

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Environmental: The device is designed to be environment-friendly because it requires relatively low power consumption. We purchase parts that produce least amount of pollution to manufacture and make sure the end product is high-quality so that the product will last long and avoid parts replacement.

Economic: The device was designed to ensure the affordability of target population. Some components can be replaced by cheaper one that also incorporate with the project. The overall cost is designed to be affordable for average user and we make sure the product will last long enough so that it worth the money that user spent.

(f) Describe the appropriate engineering standards incorporated into the creation of your product.

The CE certification [1] certifies that products have met EU health, safety, and environmental requirements that ensure user safety. This certification is required for electronic devices. The CE marking is affixed not through approval, but by us after we ensure that all required standards have been met. There are a number of tests that can be run

in order to determine whether each standard is met or not. Typically, it takes about a month to complete CE certification.

The FCC [2] is required within the US. It pertains to intentional or unintentional radiation caused by the product in question. In our project, since we use a chip, we would be required to have FCC certification to ensure our radiation is within safety limits. FCC certification happens through a third-party FCC lab that has the necessary equipment to perform certification. It typically takes about a month for this to be completed.

The RoHS [3], Restriction of Hazardous Substances Directive, is a certification that ensures none of the materials used exceeds the safety threshold. There are many RoHS testing labs that our product can be sent to for RoHS certification. The process will take around 1-2 weeks. The PCBs used in our project do meet the RoHS standards.

The WEEE [4], Waste Electrical and Electronic Equipment, certification ensures that electronic waste will be collected in a safe and responsible manner. This certification requires the equipment to be environmentally-safe even after its lifetime, while RoHS ensures that nothing used to construct the device is too hazardous, to begin with. WEEE, together with RoHS, will similarly take about 1-2 weeks at a third-party lab. WEEE, similar to RoHS, is something that pertains to our use of PCBs.

(g) Describe the final status of your product.

The final status of our product successfully met all of our initial goals. We have 3D printed the exoskeleton which is installed on the glove. Potentiometer is installed on each finger and there is mechanical design which turns the potentiometer when finger moves. Besides we invent a fingertip holder that holds the Peltier Module and airbag which provide touch and temperature feedback. There is a cable holder that holds all the cable and pipe that connect the electronics and airbag on the glove to the microcontroller and linear actuator. Microcontroller and linear actuator reside in a package box that sits beside the user. Then the glove's microcontroller will have a wire connection to the robot hand's microcontroller. Similarly, the robot hand's microcontroller resides in a box as well. Touch and temperature sensors are placed on a small 3D printed fingertip plate. Each robotic finger has a touch and temperature sensor installed on the tip of finger. Then all cables are tidied up in a net-like container. The final product provides an organized and user-friendly system that meet our desired functionalities which simulate touch and temperature feedback and mimic finger's movement.

(h) Describe the makeup of your project team and how you were organized to establish goals, plan tasks, and meet the objectives of this project.

Our team comprises of three electrical engineers and a computer engineer. Our project requires a wide range of electrical engineering fundamental from selecting electronics like capacitor and MOSFET to designing PCB. Therefore, having a higher ratio of electrical engineers on our team brings an advantage at succeed in the course. We distribute tasks by first learn about each team member's knowledge and ability. Then we assign weekly goal for each member and we also have a weekly meeting that requires all member to report their progress outside of class. We draw a timeline at the beginning of the semester to guide us throughout the semester in completing each goal. We also constantly communicate in the group chat to discuss problems and help each other to solve everyone's difficulties. We provide suggestion and listen to other's opinion and then vote for an optimal solution.

(i) Did your project require the production of any written documentation other than this document (i.e., manuals, educational materials, etc.)? If so, describe the types, composition, and nature of the audiences for whom these materials were intended.

Our final product will require a user-manual in order to help users better understand the operation of our device. Although the use of our device is fairly intuitive, to avoid any potential safety concerns, it is advised to follow our guidelines in the user-manual for fair use. The nature of our audiences is industry professionals as well as highly-educated scientists. In the production of our product, we also produced other documentation such as functional specification, software overview, electrical overview, mechanical overview, legal analysis, reliability and safety analysis, and ethical and environmental analysis. Although the previously mentioned list of documentation is not necessary for the users of the device to view, they could be potentially helpful for the users to understand how the project came to be.

(j) Describe the types, composition, and nature of the audiences in attendance for the final oral design review. Discuss how you prepared for this audience.

In the final design review, it is expected that the same audience as the midterm design review will attend. The audience will consist of a group of audiences knowledgeable in ECE, but not necessarily familiar with our particular project. It is important to give a clear overview of what the product specifically does and cover all the functions it is expected to perform. Since there may be a lot of information to remember, we will prepare handouts (i.e. user-manual, photos of the product, functional overview documentation).

[1]RoHS Guide 2019 [Online]. Available http://www.rohsguide.com/ [Accessed: 30-Nov- 2018].

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Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Yaodong Shen	EE	PCB & Firmware	2019 May

Individual Reflection: Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

(a) Describe your personal contributions to the project.

My main contribution to the project is the PCB design. In the design, we implemented 4 separated PCBs to fulfill the functionalities and power separations of the project. The schematic of our project contains different designs of 4 different switching regulators, a linear regulator, a DC motor driver, a Peltier cooler driver with H-bridge and 3v3 to +-12V logic level shifter, and I/O and sensor peripherals. All the circuitries are either my original designs or designs that are recommend by the datasheet, no third-party module has been used. I prototyped and verified all the modules before finalizing the PCB with my teammates. The most challenging part in the circuit design is the Peltier cooler driver. Since we are using 5 small Peltier coolers that only works below 0.8V, no one on the internet has shared a usable circuit for these special coolers. I came up with 4 different design concepts and chose the one we are now using with the help of ECE 477 instructors and teammates. The H-bridge is chosen among tens of different H-bridges and with the help of one failure design prototyping. I also designed the logic level shifter with voltage inverter and comparator given that there is no such circuit available on the internet. I also completed most of the PCB soldering and debugging work, and helped my teammates improving their soldering skills. On the firmware side, I developed a temperature control algorithm and help my teammates with their algorithms. The temperature control algorithm is implemented with the concept of PID feedback control system. In my algorithm, I first linearize the thermistor data read by ADC with a table that generated by a two-stage logarithm equation derived from my experiments on the thermistors. With the assumption that the Peltier cooler has a linear cooling performance, the output PWM signal to the cooler is related to the feedback error with the PID equation. However, due to the inert delayed response time of the Peltier cooler system, the differential part of the PID control is not implemented in our design. Additionally, I also made some contribution to the mechanical system with the fingertip sensor holder, touch feedback system and some peripheral components.

(b) Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

I learned basic embedded system design concepts from ECE 362. With that knowledge, I was able to choose the most suitable microcontroller for our project and design the circuit for it. Although we used 9S12C in the course, the basic microcontroller knowledge and

programming experience shorten the learning curve of stm32 and enabled me to draw the firmware skeleton before getting familiar with the stm32 chip. In the process of choosing H-bridge, the semiconductor knowledge that I learned from ECE 255 and ECE 305 helped me to have a good understanding of its properties. And the knowledge from ECE 202 helped use comparator in my logic level shifter design. ENGR 131 also taught me to use Excel regression functions in temperature data analysis.

(c) Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

I learned to use Fusion 360, PID control and STM32. All the information was acquired online from Youtube tutorial videos and product datasheets. I used two different strategies. For Fusion 360 and PID control I first generate the idea on what is needed for the project, then I watch the tutorials with those needs in my mind. After I understand the basic knowledge, I explore them by myself. On the other hand, in the learning process STM32, I divided my needs into small items, and use the online resource to solve them one-by-one and only continue to the next item after completing the former ones.

(d) Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

The ethical responsibilities are mostly related to the user safety issues. Since our design provide temperature and touch feedback to user's hand, in the process of developing our algorithms we need to consider the possibilities that the heat and force would hurt the user and minimize those possibilities even when user mishandling our design. As an engineer, it is our responsibility to carefully consider every possibility that would happen to our design and eliminate the possible shortcomings in the design stage.

(e) Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product's impact in each of these four contexts?

Since our product is aiming at the industry and research areas, our product would largely improve the safety level for people in those areas working under unhealthy situations or handling dangerous materials. Based on the design we have now, the market of our product is not big enough and the product itself is not cheap enough to have a noticeable impact on economic, societal and global contexts. On the environmental side, we minimize the use of environmentally unfriendly materials. All the components and PCBs fulfill the RoHS compliant and the plastic used in our product is primarily degradable.

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Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Jia En Chua	CE	Firmware	Fall 2018

Individual Reflection: Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

(a) Describe your personal contributions to the project.

I wrote most of the software parts except temperature feedback system. However, I do work with one of the teammates to merge the temperature feedback program with the overall software system. To be specific, I first started by getting ADC value from potentiometer by using different methods. There are 'standard poll' method and also 'direct memory access' method which allows reading of multiple ADC channels. After I successfully read the ADC value, I used these ADC values to generate PWM duty cycle that control servos. To let servos, work properly, I need to determine an appropriate frequency and a duty cycle range for it to work. Once the clock frequency is determined, I then need to calculate the prescaler value and clock period to achieve such frequency and to generate a reasonable timer interrupt for modifying PWM duty cycle. After getting servo to work, I move on to pressure feedback system. I verified the reading of touch sensor value and used that value to manipulate linear actuator to generate air expansion in the air bag. I have spent a good amount of effort to setting linear actuator to work efficiently because the linear actuator is controlled by two GPIO input signals and I need to set the period of high time based on touch sensor value. However, I can't use loop to set the high time because that would slow down the overall system. Thus, I need to utilize timer interrupt and several arrays of integers to calculate the amount of interrupt that equates the expected time period. After that, I shift to working on communication between two boards through UART. I need to make sure the data is transmitting correctly and efficiently between two boards in a 'two-way' fashion. There are many problems occurred when I worked with two boards. For example, the receiver program will terminate if the transmitter program started sending value before the initialization of receiver's code and sometimes there are noise being transmitted in the communication channel. After getting all major and minor issues solved, I finally come to last phase of setting the robotic finger back to default position once the glove is empty. This is relatively easy because I planted a touch sensor on the glove and make sure the servo moves to its default position when there's no pressure detected on the sensor.

(b) Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

In ECE 362, I learned about the fundamental of microcontroller. I was exposed to basic knowledge of several most important microcontroller's module. I learned about their functionality, limitation, resource requirement, and how to use them. These hardcore knowledges allow me to setup a metric that let our team visualize the best decision of selecting project ideas, microcontroller selection and PSSCs. In addition, the knowledge that I gained from several C programming class in earlier course work allows me to work efficiently and confidently at creating the overall software for the entire project. I was able to discuss about the logic flow and system's efficiency trade-off with teammates and course staff. I have also utilized the knowledge from earlier course work to help on power management, waveform verification and so on. In this project, we need to step up/down incoming/outgoing voltage and change the polarity of current using H-bridge. I would not be able to help without the knowledge from earlier course work.

(c) Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

The core of my contribution is writing the overall software and a lot of new knowledge were gained through online resources. I learned from online tutorial video, datasheet, and several technology blogs to achieve various parts of the project. I employ the strategy where I start by setting a goal and figure out way to achieve it. I have realized that the beginning of each task is the hardest part and once I achieve the first small goal, the rest of the goal would be relatively easier. In addition, by breaking down a complicated task into several bits help debugging which part of the project causes specific issue. Therefore, when an issue suddenly occurs, and the team have no clue what is causing the issue, I usually break down the project and trace back to each phase and this way we can narrow down the problem.

(d) Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

I have learned the importance of designing product from the aspect of ethical and professional responsibilities in this project. For example, we need to be very careful about the heat and force generated in the feedback system to ensure the safety of user. Also, we need to have a good heat dissipation system to avoid the burning of chip or any other electronics. There is also discussion among our team about the selection of materials and parts to ensure a high-quality user experience and most importantly the safety of user. In addition, I learned to communicate better with other engineers to convey my idea and listen to other's opinion. I learned that it is definitely vital to ensure good communication between teammates and ensure good progress from everyone on the team.

(e) Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product's impact in each of these four contexts?

Our project would have great impact in the manufacturing industry and research field, but it is going to take time for the industry to recognize the advantage of our product. The reason of my statement is because there are statistic showing that there a lot of talented researcher and professional got injured or harmed badly in a hazardous working environment. For example, chemistry expert is commonly diagnosed with lung cancer and mechanical engineer often got injuries from their work. We know that the current industry treasure talent but there is no feasible way to protect these talents. Thus, our product would be an affordable solution for company that truly cares about their employee. In addition, we limit the parts that we use in this project to be minimal and environment-friendly. Therefore, the product is going to last for a long period of time and the value it brings to the industry will be well over its cost.

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Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Carol Lo	EE	Electrical and Mechanical design and assembly	May 2019

Individual Reflection: Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

(a) Describe your personal contributions to the project.

In this project, my primary focus is the user-controlled exoskeleton glove. Earlier in the project, I mainly focused on the electrical overview and the design of the temperature feedback system. I designed the user-controlled exoskeleton glove using Fusion360 and 3D printed all the components for assembly. The components are then sewn onto a fabric glove for better user experience. Overall, I was in-charge of the user's system including mechanical and electrical components.

(b) Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

Originally, I had wanted to tackle the software side of the project since I am a 362 TA and 477 is the direct extension of the 362 course. However, since my teammates had more experience in programming in addition to 362, I decided to take on the hardware side. During the earlier stages of the project, I spent my time on the electrical components, in particular, the temperature module. The temperature module was initially based on an H-Bridge design, which is something that I was learning at the time in ECE 455. Although the design went through several drastic changes, I still used a lot of my knowledge in ECE 255, 305, and 455 in the process. In terms of designing the entire exoskeleton, I used a lot of my knowledge from my first internship. In my first internship, I extensively used AutoCAD to design substations and am therefore familiar with AutoCAD. Instead of using AutoCAD, due to access of the application, I used Fusion360.

(c) Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

Although I was familiar with the application used to design the exoskeleton, I was not familiar with the workings of the actual mechanical movements of the exoskeleton. I looked through many different designs of existing projects and tried to decipher why each design is different and what elements I could take reference from. I printed numerous designs and experimented with them physically. I am aware that there exist functions that will simulate movement for me virtually, but I felt that given the time constraint, it was more realistic and efficient to 3D print the components and actually work with them in real life. In the earlier

stages when I was working with H-bridges, I had to read quite a few papers and see many other designs and do hand calculations in order to understand what I am trying to work with. Even though my ECE 455 class is highly relevant to this component, it still isn't directly taught to me in class. My learning strategy in general was trial-and-error as well as reading as much material as I could.

(d) Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

Working in a team comes with many professional responsibilities and working on a project like this comes with many ethical responsibilities. I felt that the ethical responsibilities that came with this project was properly investigated when we wrote the documentation for ethical responsibilities. The only ethical concern with our product comes with every single other electronic product on the market-- the materials used. On the professional side, I learned that it is important to keep documentation carefully. Without proper documentation every week, it is impossible to keep track of what is done each week and keep progress up-to-date. It is also important to keep professional communication between team members in order to ensure that the correct work gets done and there are no misunderstandings between teammates.

(e) Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product's impact in each of these four contexts?

I believe that this product will have little impact in terms of economic, environment, societal, and global contexts. This is because it is such a niche product that would not be widely advertised in the popular culture. In contrast, it may have a significant impact in the manufacturing research and industrial environment. There are many applications that our product can be applied to. It could significantly speed up some experiments for researchers and could be very popular in the manufacturing/research environment. I made this educated judgement based on the purpose of our product and the expected environment it is to be used in.

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Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Yao Chen	EE	Firmware	Fall 2018

Individual Reflection: Provide a brief (1-2 page) individual reflection of the design project, as outlined below:

(a) Describe your personal contributions to the project.

In the first half of semester, I contributed to use UART communication module to transmit and receive data with two different board. I set up two separate committees to send the ADC signal from transmitter board to receiver board and then confirm on the computer that both sides have transmitted and received correctly via the buffer status. The transmitter sends the real-time ADC value to the receiver on the other board to finish the communication process. Therefore, we can monitor transmitter and receiver activities on two separate computers. Then, I mainly contributed to the temperature feedback part of the project. I created a function which can transfer the ADC value to the real temperature value. The temperature reading function also has the logic to restrain temperature reading to be under 100 degrees Celsius, to protect the user from burning the skin. Yaodong helps me to test the H-bridge and incorporated it in the temperature feedback block to form the feedback loop. The H-bridge is used to control the Peltier cooler to produce whether actual temperature or negative temperature.

(b) Describe how your contributions to this project built on the knowledge and skills you acquired in earlier course work.

I learned the basic concept of microcontroller from ECE362. ECE362 imparts me the knowledge of both the internal structure of STM32 as well as its peripherals. In ECE362, we were assigned an assignment to control the motor via PWM module. I transferred that part of the algorithm into our application of using PWM to control the Peltier cooler. Besides ECE362, my prior C programming courses also lies a good foundation for my firmware development skills. I gained lots of hands-on experience of oscilloscope from ECE207/208, and this enables me to efficiently debug the program by looking at the waveform as well as some crucial parameters.

(c) Describe how you acquired and applied new knowledge as needed to contribute to this project. What learning strategies did you employ to do so?

I believed that I maximized the online resources about the STM32L152. Unlike STM32F4, the L1 series only has limited tutorial or resources online that we can read about. But since the general concept between them are quite the same, I learned not only the articles about the L1 series but also the F4 series. Also, I utilized forums such as StackOverflow to ask for the solutions to the problem that I have struggled for days.

(d) Discuss your ethical and professional responsibilities as they relate to this engineering design experience.

Working as a team requires professional responsibilities for each team member. I learned from the design project that two significant factors that have great impacts on teamwork are communication and documentation. Documentation is essential because team members can keep not only tracks of their individual contributions but also other team members' progress. Without knowing how far other teammates has gone, it is highly possible to have work conflicts. A good communication enables each teammate to take vital advice from others. It can also build up the team spirit. Working with a design project like this also requires each team member to have ethical responsibilities. Since the goal of our design project is to employ a protective mechanism to researchers/workers working in a hazardous environment, we cannot tolerate any pitfalls that may cause safety problems. We cautiously selected the materials and ensured that it is human-friendly. We also take all kinds of safety factors our team can think of, such as heat and pressure, during the design process.

(e) Consider what the impact of the product of this engineering design experience could have in economic, environmental, societal, and global contexts. Discuss how you would make (or did make) an informed judgement as to your product’s impact in each of these four contexts?

I believe that our product can have great potential in the manufacturing industry. Annual workplace injuries and illness are always reported at a relatively high rate, and most of them are either caused by direct damages or toxic chemicals constantly diffused in the factory. With the help of our design product, the direct costs can be significantly decreased because the robotic hand can detect potential hazards and employ the protection mechanism. Not only that, but our product can also improve the efficiency and performance of researchers working with corrosive or dangerous substances.