RME 40002
MECHATRONICS SYSTEM DESIGN
REFLECTIVE REPORT
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Range of Resources

During this MSD project, there are some resources which were hard to search for. Due to the current COVID-19, materials sourcing became one of the hardest task to carry out. I fail to push my teammates to carry out the material sourcing in a shorter period of time so that we could have extra 1-2 weeks to do the assembly task. During the material sourcing process, some of the available and cheap items are found to be under the category “Shipping From Overseas”. For this category of items, the date of arrival of the items may be delayed due to policies of some countries. Therefore, we need to try to source all the materials either through online shopping or go to the physical store to purchase the required materials. For some basic fasteners such as screws, bolts, nuts, and washers, they were easier bought based on their abundancy in the market.

For some complex mechanical components such as bearings and timing belts where the dimension needs to be specific and detailed so that the components can be fitted properly into the prototype. One of the scenario that we have encountered was the sourcing of timing belts for the stepper motor for y-axis direction, in which a closed-loop timing belt of a specific value of the minimum length is not available in the market. Therefore, the team had to spend extra 1-2 days to solve that issue.

In terms of the manpower, the team consists of members which are from different places physically. There are 2 members who are in Penang since the beginning of the project, and another one member from Kuching. Hence, the assembly of the system involved 2 person who are in Penang, in which tasks such as mechanical and electronic assembly were carried out by 2 person. In terms of mechanical fabrication, there were available tools which are used to carry out the assembly process such as drill set and riveting tool which greatly helps in the task. In terms of electronic fabrication and electronic components sourcing, there are many available resources that can be found in Penang. Hence, the task for circuit fabrication is not very tough.

However, due to the time constraint, some of the components were ended up not functioning properly due to lack of calibrating and testing. For example, the servo motor which is used to open the gripper claw to grab the item from the rack did not function properly. Another servo motor which was supposed to control the gripper arm swinging motion was later found to be defective and broken after the program has been loaded into the Arduino for calibration. The latter idea was scraped but the servo motor but the servo motor was already bought.

In terms of software programming, I was involved in minority of this part as the program needs to be written to operate the mechanism which was built in Penang. Hence, I found that there are a lot of resources for me to refer to when it comes to coding. Few of the websites include Stack Overflow and Arduino Forum, in which the problems we faced were similar to the one posted in any of these website forums.

Last but not least, in terms of resources for communication among team members. Thanks to the current technology where communication systems are well-developed, the team conveyed their messages through WhatsApp and Microsoft Teams. During the assembly process, 2 of the members from Penang have communicated with their team member in Kuching through video call, in which the member from Kuching can able to look at the real-time assembly process of the prototype and on the other hand, provides suggestions whenever the members faced any difficulties in assembling the prototype. Future works include the use of project management tools such as Trello should be used in order to allow all the members to present their updated tasks from time to time.

Level of Interaction

During the phase where idea proposing and development was carried out, there were mild conflicts between the team members as the prototype design kept changing a couple of times, mostly between Week 2-5. Based on the project we are required to do, there are a lot of parts in the design which the specifications and dimensions of the components became crucial for proper operation. This phase had some minor delays as I did not work with my current team members about the prototype finalising task before this. However, the team managed to come out a better design which can despite all these minor conflicts faced previously. As I know that effective conversation is important as it delivers key points among each other so that the updates can be progressed on track.

During the material sourcing stage, I have involved myself in sourcing most of the electronic components and some of the mechanical parts. For the mechanical components, I searched many places in Penang whether there are any physical shops which sell mechanical components. To ask for the specifications of the components, I managed to call the seller and asked them to provide a catalogue consisting of all the available components with different specifications and dimensions.

During the project development stage before assembling the prototype, I have involved myself in discussions to provide suggestions regarding the mechanical, electronic, and software planning and implementation which are improvised by my teammates. The suggestions include how to connect wiring from the Arduino Prototyping shield to the mechanical part which holds the electronic components and where to place the sensors so that the calibration can be done more easily. During the testing of sensors, I have informed my teammates about some requirements that must be fulfilled such that the minimum distance which proximity sensor can detect is 10 cm, the Arduino TX0 and RX0 pins must not be connected to any components as these 2 pins are responsible for serial communication.

During the project fabrication and assembly stage, I have involved partially in the mechanical assembly of the prototype, that I helped another team members who in charge of mechanical part to build the entire prototype. I have done some manual labour tasks such as drilling and riveting of the bar steel, in order to be connected to the L-brackets. My other involvements of mechanical task were:

- Using hot glue to secure end stop switches with the acrylic materials so that it can be properly attached to the prototype platform.
- Use drill to create holes and threads for the connection of aluminium bar and wooden board.
- Secure the screw connection in acrylics using nuts and washers, particularly at the x and y-axis roller section.

For the electronic part, I did most of the tasks due to my job scope chosen. However, another team member helped me in minority of this part, especially the tidying up of the wiring so that the project appearance looks more presentable. The electronic tasks that I have carried out were:

- Soldering of the header pins and wiring on the Arduino Prototyping Shield
- Soldering of the stepper motor driver circuit and calibration of the reference voltage for the stepper motor
- Crimping of the wires from the components into the connector housing
- Testing of the circuit connectivity and presence of short circuit using a digital multi-meter.

Innovation

In terms of innovation aspect, it can be seen more obviously seen during the project assembly stage. Throughout this stage, the team faced some hurdles and even conundrums which required critical thinking skills to be developed in order to overcome them. One of the conundrums the team faced is the dimension of the closed-loop timing belt which cannot be found in the market. Hence, the team managed to figure out a method which uses a double head pulley and two smaller closed-loop timing belts to connect the mechanism, although this solution requires fine calculation of the distance of placement of the timing belts as any miscalculation in the distance required would result in loosening of the timing belt connection, and eventually causes the mechanism to not work properly.

For electronic part, wiring is one of the main difficulty that I faced. For example, choosing the length of the wire is a difficult decision, especially when the components placed further from the connectors which is soldered on the prototyping shield. There were similar cases where the wiring is not long enough to connect the components and the connectors on the prototyping shield. Therefore, I came across an idea where 2 terminal block connectors were used to connect the shorter wires. Since the wires inserted between the 2 terminal connectors can be changed by removing the shorter one and replacing it with a longer one, hence this approach is able to solve the wiring length issue. Besides, to solve the issue of over-length wire, the wires are wrapped around the aluminium hollow bar which spirals down to the underneath of base board. Other than that, securing a sensor component onto the platform seems challenging when the hot glue could not hold the components securely with the aluminium hollow bar or aluminium profile. Hence, a combination of cable ties and hot glue are used to connect these sensor components to the mechanical part.

In terms of future work, instead of using the Arduino prototyping shield, we could design our own prototyping shield by cutting the appropriate size and dimension of a stripped board. After that, we solder two rows of header pins at the edge of the prototyping shield. One of the advantage of doing so is that we can customise our own connection by breaking up some of the stripped connection whenever necessary using a mini drill. By using a customized stripped board as prototyping shield, the connection for common ground and common Vcc connection can be greatly eased as less wirings are required, in turn also ease the process of troubleshooting the circuit in case any short-circuit or wire faulty occurs. Also, different colours of the wire must be chosen other than just red and black wire. For example, yellow wire can be used as wire connected from PWM output, blue wire should be used as wires which are input or output from digital pins, and orange wires can be used as wires connected to the analogue input. By doing so, troubleshooting seems easier as the type of connection can be identified immediately when there is a faulty occurs.

Consequences to Society and Environment

During this project, there are consequences to society and environment which can be either positive or negative. The positive impacts include:

- Increases efficiency of shopping in a convenient store

Due to current COVID-19 pandemic, social distancing becomes one of the most important aspect when it comes to shopping. Hence, this prototype helps customers to pick up the items purchased by them, so that customers do not need to stand so close to each other along the aisle when it comes to manual purchasing of goods.

- Reduces the risk of accident when searching for items in higher rack position.

For some items that are placed at a higher place, a ladder extension is required for the worker to get the items. The implemented solution can reduce the risk of workers falling down from the ladder when he/she tried to grab the item even though he/she has already stepped onto the topmost step of the ladder.

- Reduces the time taken for the items to be found and chosen.

Before getting the items from the rack, customer can access to the app created to order their items before their turn of purchasing. Hence, they do not need to spend additional time in finding the items on the shelf.

The negative impacts are:

- Reduction of job available

Since the machine can be able to help customers pick up the goods, additional worker which was initially assigned to do that is no longer needed, thus resulting in loss of jobs available.

- Potential of environmental harm

Some of the parts are made of 3D-printed materials, which is also made of plastics. Hence, proper disposal is required so that it does not harm the environment.

- Potential of risk of electrical hazard

Since the main power supply is connected underneath the base of the prototype, which is just a few inches above the ground. Hence, the prototype must be located at dry place as wet surface may cause the main power and the power plug connected to the socket to be short-circuited, thus creating risks of electrocution if the person in charge try to troubleshoot the circuit board at wet place.

Familiarity

From my previous studies in diploma, I have experiences with soldering and de-soldering components on stripped boards using the proper equipment, I also have used the flux liquid for better soldering on the board previously. Therefore, I found some of the soldering tasks very familiar. Based on the experience which I accidentally burned my fingers during the soldering task done previously, I am also aware that wearing safety gloves is required to minimize the risk of accident.

The only new thing when it comes to soldering is soldering wires and connector header pins on prototyping shield, where the board is a doughnut board type. Unlike stripped boards which there are rows of conductor strips mounted on the board, doughnut board consists of independent connection holes, and the only way to connection these two holes is to use soldering tool to do the job. In many cases where some of the connections such as common ground and common Vcc are to be joined together, soldering became harder to carry out, especially in a packed section.

For mechanical part, everything seems very new an unfamiliar to me. This is due to the fact that I just switched from different engineering course (EEE Engineering) to Robotics and Mechatronics Engineering course. Hence, my exposure to the mechanical skills and knowledge is somewhat limited. Therefore, I need to spend more time learning different skills which are related to the mechanical field, this might be one of the reason why the assembling of prototype stage took slightly longer than expected, as I need to familiarise myself with all types of connection such as screw and nut, rivet, and bolt connection. I also need to familiarise myself with different types of screws used in different materials.

In terms of programming, it's considered as 20% familiar and 80% not familiar. From my previous taken subject which is Embedded Microcontrollers, I have some basic knowledge of using some sensors such as ultrasonic sensor, therefore it is very familiar for use in integrating this sensor into the Arduino port. However, the rest seems unfamiliar to me initially. For example, the implementation of stepper motors and DC motors are not familiar to me as both of these motors require a driver circuit to operate. Hence, I have to spend a little time looking at the driver IC datasheet for the pinout diagram. For some algorithm, I had to find online resources for the sample code which can be modified and implemented into the software algorithm. Whenever I faced any difficulties, I would ask my team members, friends from other groups, or even lecturers about the issue.

Conclusions

In overall, I find the project very interesting as it integrates mechanical, electronic and programming knowledge together to develop a prototype that performs the required tasks. By involving in this Mechatronics project, I have gained a lot of relevant experiences, especially in the hands-on skills. Despite the COVID-19 which we were unable to use the lab equipment, nonetheless we still can use the available tools from our side to build out the prototype. From this project, I also learned a lot of testing and troubleshooting skills in which is necessary in developing out the prototype. I also learnt about the importance of testing the operation of each individual components before integrating it together with the software, so that immediate action can be taken when the component is found to be defective. After the project, the thing that I need to improve is the wiring planning, which some of the wiring are not planned properly, thus resulting in a messy circuit board. Besides, I also need to improve more on my mechanical knowledge and skills, so that I can handle other subjects such as Final Year Research Project 2, in which I need to assemble the prototype entirely by my own.