Arduino Controlled: Robotic Arm

Electronics 2211 Final Project Report

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***Abstract*—A final project was assigned by the Electronics 2211 course. This project allowed students to explore their own interests and create a project that would be presented at the end of the course. The project could incorporate previous knowledge, or the knowledge gained from the course.**

I. Introduction

At the start of the fall quarter, the team was advised that we were to design and create a final project for the 2211 course. Students were allowed to brainstorm ideas with a partner and present their final projects at the end of the quarter. This would be a well thought out project that would require lab time, as well as time outside of the lab to complete. A variety of ideas was introduced to the team during the design process. However, one idea stuck out to the team due to the level of interest in robotics. The team decided to design a robotic arm that would be able to pick items up. While it was only the beginning of the quarter, the team did not have any idea of what the final product would look like but they were eager to get started on it. The journey was not always perfect as the team faced many setbacks, but each member learned valuable lessons from their mistakes.

II. The Journey

A. Project Objectives

The primary goal for the project was to design a fully functioning robotic arm. Despite the team having to juggle others responsibilities, the team wanted to ensure the design would be considered fully functioning at the end of the course considering the amount of time that would be put into this project. The ideal robotic arm from the teams' vision was going to include three servos that would move different segments of the robotic arm. The very end of the arm would have a claw that would allow for items to be picked up. Lastly, the different segments of the robotic arm were to be controlled using either a keypad or potentiometers. The goal was also to have an Arduino board be used for the robotic arm to control all the different components at play. The team was unsure of how this would play out considering it would require refreshing the knowledge on how to program an Arduino board, as well as CAD designing the team's idea from scratch. In the end, the team decided this would be an exciting challenge to take on considering it would require critical thinking and allow teammates to sharpen their skills in CAD designing, 3D printing, and coding.

B. The Initation of the Project

Since the team has started college, they both have wanted to create a robotic arm as they are both passionate about robotics. The final project was a perfect opportunity for the team to get their first experience with robotics. The first assignment for the final project was to write an abstract for whichever idea the team decided to move forward with. The abstract was also to include a few of the components that would come into play when creating the final project design. This was a crucial part of the abstract assignment considering each design was to remain under a $50 budget. The team decided that no additional purchases would be necessary for the final project, as all of the pieces required for the design could be found in the innovation lab.

C. Project Challenges

The first challenge came from the CAD design. The team had to brainstorm how they would design the robotic arm. The first part of the project that was set to be 3D printed, was the base of the robotic arm. This base was to hold the potentiometers, wiring, Arduino board, and breadboard. The base was a simple design considering it was just a 3D printed box that would hold all components, with a lid that could open and close the base. The base lid, however, did carry some complexity as it would have to somehow connect to the robotic arm and allow for free movement of the arm. However, the team was able to find a way to make it all connect. While CAD designing the

lid, a pull tab design was being added to the lid to help remove the lid when needed. Despite that, the team decided to instead place a servo in the spacing inside the pull tab loop in order to connect the first segment to the base. The servo would be mounted to the lid of the base and the servo arm would be attached to the first segment. This was an exciting moment as the print had the perfect spacing for the servo. Nonetheless there was another issue at hand, the Arduino and potentiometers were colliding with each other inside the base. Thankfully, the team was able to instead use an Arduino Nano to fix this issue. The next part that was to be 3D printed was a long segment that would act as the main arm in the design. This segment resembled a thicker version of a popsicle stick. The team was creative and added holes in the shape of hearts for aesthetics, while also adding a rectangular hole at the end of the segment to insert the servo. The servo was to be mounted at the end of the first segment and the servo arm was to be attached to the second segment. The second segment would have the same shape but half the length of the first segment. The most time-consuming part of the project was designing and implementing the claw mechanism. The team had difficulty choosing whether to use one or two servos to work the claw. The claw would be made up of two segments pinching each other in order to pick up an item. The team decided to only go with one servo due to weight distribution and due to time constraints of the project. However, the second segment would also consist of an extending piece that would reach further outwards that would act as one of the fingers of the claw. The finger that was attached to the second segment would stay stationary. The fourth and final segment would be attached to the servo arm that is being held into place by the second segment. This segment takes a similar shape to the extra piece attached to the second segment. The project is set up this way so when the servo that is attached to the second segment is moved by the potentiometer. The third segment will press against the second segment, or in reverse move away from the second segment depending on how big the item is that the claw is trying to pick up. These last few segments that were discussed required a few reprints considering the printers failed a few times. Unfortunately, the failed prints created a few setbacks for the team as 3D printing of these segments would take a few hours.

The second challenge came from having to get the Arduino to be programmed in order for the potentiometers to get the servos moving accordingly. This required looking back into the teams old projects and getting inspiration for how to incorporate the potentiometers into the Arduino code. While these old projects did help the team get an idea for how to write the code, the code did not properly work the first time around. The Arduino code was first written and simulated on TinkerCAD allowing the team to ensure that the circuit was fully working before building it on the breadboard. This code was then uploaded to the Arduino Nano to test in real life. However, the working simulated code was not working the way it was in the simulation. The team then had to debug the code and resolve this issue. After troubleshooting the code, all servos were now reacting to the knob adjustment of each according potentiometer. Once the servos were reacting to the changes in the potentiometer, the team then needed to limit the angles that the servo was allowed to move to prevent the arm from colliding with itself. This all was done within the code of the Arduino by changing the degrees that the servo was allowed to sweep.

A few other minor challenges came up when finally putting the final product together. For starters, the holes that had been extruded when CAD designing the base did not fit the potentiometers. This was because the round body of the potentiometers was not taken into consideration when deciding the spaces between the holes that were made for the potentiometers. The team decided to instead drill a hole for the middle potentiometer in order to avoid the spacing issue. The next issue arose when placing all the servos inside there designated spaces. The excessive wiring attached to these servos was not taken into consideration either. This was an issue as the wiring could get in the way of moving segments. Nonetheless, the hearts that had been extruded into our segments for aesthetics ended up being a solution to this problem. The team was able to loop the excessive wiring through these holes to avoid the issue at hand. This also gave the final design a cleaner look. The wiring for the servos were also too short, so the wiring for each servo was extended using a soldering iron and extra jumper wires. The connections on the potentiometers needed to be soldered as well. This ended up working out, because it created a solid connection between the potentiometers and the jumper wires. The wiring under the lid can be found in Figure 1. In the end, the wires was a big issue considering they took up a lot of space in the base. The base already was limited on space due to the Arduino Nano, the breadboard that was also included, and the potentiometers. The lid for the base had to be shut with rubber bands in order for it to not pop off. The base also had no more space for the thick wire that was supposed to power the Arduino Nano, so instead the team decided to power the Arduino Nano with a 9V battery.

D. Results and Discussion

The final design was not exactly what the team had anticipated it would look like when they first started this project. Throughout the process, the challenges worried the team about being able to complete a fully function robotic arm. The team juggled a variety of other responsibilities, therefore not having enough time to

complete the project was something the team feared happening. Nonetheless, the team was able to create a robotic arm that followed the project objectives. The finalized assembly of the robotic arm can be found in Figure 2.

Each servo was programmed to be controlled by one potentiometer. The first potentiometer would move the long segment known as the "body." The second potentiometer would control the second segment which would give the arm more length and flexibility in reaching items. This segment in a way acts as a "wrist." However, this segment also has a pointer which is the "finger." Lastly, the third potentiometer controls the servo that has a third segment attached onto it in order to follow its exact movements. This potentiometer is in control of "picking items up," this is because it controls the third segment that will press upon the "finger" in order to pick up items as mentioned before. The schematic of the circuit can be found in Figure 3.

The team did not want to cause too much stress on the servos when first testing. Therefore, the robotic arm was first tested by picking up a light item such as a cotton ball. The robotic arm was able to successfully pick this item up. Next, the robotic arm was used to pick up a pencil and also succeed doing so. The item that was used for demonstration was a 3D printed owl. This item carried a little more weight than the previous items. After a few rounds of testing it, it was clear that the weight had begun to cause stress to the servos. The robotic arm still fully functions but it was clear the servos overtime make begin to not work properly due to the stress. The team also measured the voltage from the battery that was being used for the testing. After taking measurements, it was clear the project was using a lot of the battery to fully function.

While these are all minor things that can be fixed, the team would also like to take into consideration future possibilities. The team hopes to in the future use better servos to reduce the weight limitations for items that can be picked up. The team would also enjoy being able to create this design at a larger scale in order to help pick up bigger pieces. Lastly, the team would also like to use a fourth servo for the design. The "claw" part of this design only had one moving component, the team thinks it would be exciting to have to moving pieces for the "claw." Also, the team would have to implement a fifth servo the would allow the arm to swing 360 degrees instead of being stationary and only able to pick up objects in one direction. The controls being moved to an external control box is also a consideration that the team would like to implement. With the robotic arm free to swing 360 degrees, the controls would have to move away from the main body of the robotic arm.

E. Conclusion

The final project for the 2211 course proved to be a challenging and invaluable experience for the team. Despite the numerous challenges that were faced over the quarter, the team was able to successfully create a robotic arm prototype that was fully functioning and met all the required objectives that the team set at the beginning of the quarter. The process provides experience in CAD design, circuit design, Arduino programming, and being able to implement all of these experiences into one project.

With teamwork, the team was able to brainstorm, design, assemble and implement all the parts of a working robotic arm by showing that their design was able to function and pick up small things with the control of the potentiometer.

III. Figures and Tables

Fig. 1. Wiring of the Robotic Arm

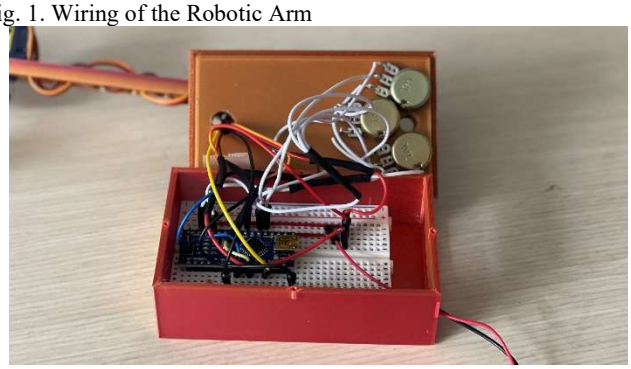

Fig. 2. Assembly of Robotic Arm

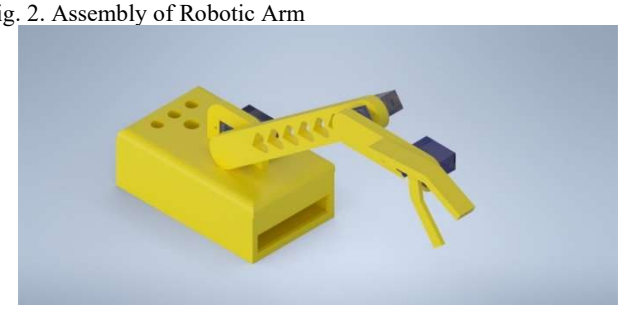

Fig. 3. Schematic of Robotic Arm