16681-A MRSD Project 1 | Individual Lab Report #3 March 7, 2019

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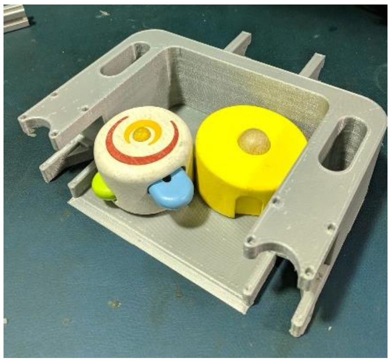
Teammates: Jorge Anton, Nithin Meganathan, Changshen Bobby Shen, Laavanye Bahl

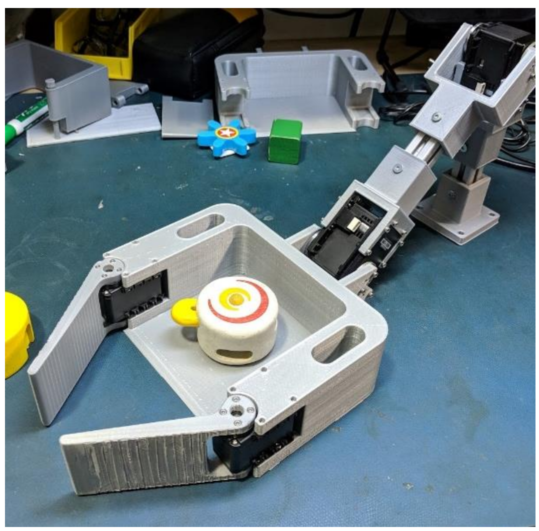
Individual Progress:

Manipulator: I have completed all the steps necessary for the manipulator sub-assembly and met the deadline as promised to my team.

I also took the chance to iterate the design of the tray and improve it further. A new tray was designed with an extended dimension of 20mm in depth to better accommodate two toys being picked together. The bottom of the tray was redesigned allowing a better access to the servo motor terminals and provisions for wire routing. The goals were to conceal the wiring and avoid interference with the operation when the tray will be seating flat on the ground.

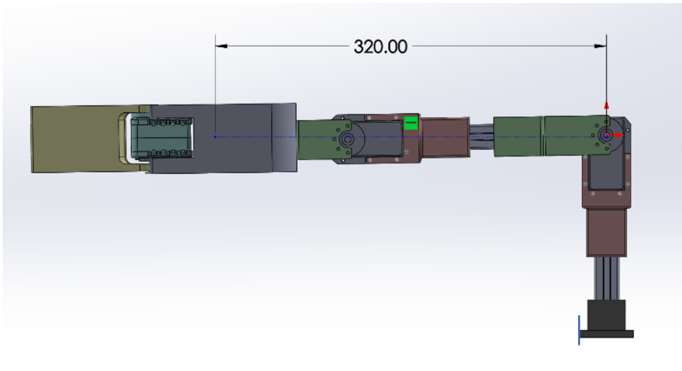


All the brackets for servo motor attachments were 3D printed and fit to the motors. I also added idler brackets on the opposite side of the driving horn to allow for the design of double supported brackets. The goal was to induce the torsional load to pass through the center-line of the bracket and motor, this way avoiding any possible binding of the brackets. I also replaced the malfunctioning Dynamixel 12-A with a new one from the stock. Finally, I finished the full assembly of the manipulator arm.



I went on to check actual weight of objects and the tray, including the Dynamixel servo motors. I then estimated a maximum weight of 500g for the tray plus two objects of 100g. totaling 700g, I then applied a safety factor to the weight of the toys, allow for 500 grams of payload. In that case, the total weight for tray plus objects might reach 1Kg, Here I considered the short straight section of the arm to have negligible specific weight.

I then calculated the torque necessary. At its extreme limit, we show the arm of force below, and torque which is T = payload * arm of force = 1.0Kg * 32cm = 32Kg.cm



Finally, I compared the required torque at the shoulder joint, against the Dynamixel MX-106 at 12V, which were available to us from stock. Stall torque = 8.4N.m = 85.6Kg.cm Our maximum torque required would be 32Kg.cm / 85.6Kg.cm = 37% of the stall torque. The manufacturer recommends that for smooth motion, that we should keep the required torque within 20% of stall torque which would equate to 17Kg.cm. That translates to 17Kg.cm / 32cm = 0.535Kg = 535g.

Conclusion, when carrying only one toy, we would be within the smooth action spec of the manufacturer, for larger loads we might experience “jerky” motion, but we would be well under the specified stall torque of the motor. We would like to try the manipulator with different weights and PID gains for the servo motors to assure that we will have a reliable and smooth operation.

Challenges: The whole mechanical assembly was very involving, and it took me a substantial amount of time. One of the main obstacles were the lack of availability of functioning 3D printers, both in our MRSD lab and at the Maker Space. Eventually I was able to have all the parts 3D printed in a few days longer than I expected. I also spent a considerable care in designing all of the holes for hardware with counterbores so that the socket head screws would seat flush with the surfaces of the brackets and tray both for functional—clearances—and aesthetical purposes. Also I had to order the proper metric hardware at the right length to interface with the servo motors. A 3d printed part is usually thicker than a metal bracket equivalent and so I could not use the hardware included in the motor kits.

Next Steps: I plan to design and mount the provisions for the robotic arm to be assembled on top of the Turtlebot mobile base. Care must be taken to not submit the top layer of the Turtlebot to excessive bending moment since it is made out of plastic. At this point, I believe the best design would be to attach the manipulator to the top and bottom layer of the Turtelebot which would create a proper support counter acting the torque generated by the arm—when looking at it from the side. I also plan to mount the camera and lidar on the mobile base at the proper height for visual efficiencies but also taking care to not obstruct the arm mechanism.

<u>Team Progress:</u>

Laavanye was able to achieve a good progress at segmenting objects. He is also working on a proper pipeline for our vision algorithm and functionality.

Jorge, Nithin and Bobby dedicated most of their time to integrate and control the Dynamixel motors

Challenges:

Laavanye is taking longer than we anticipated in classifying objects by their size since he had to spent more time than anticipated in the software architecture.

Jorge, Nithin and Bobby have experienced substantial problems to make the Dynamixel work. Eventhough that had succeeded in the task using the provided GUI in Windows environment, when trying to implement the same functionality in ROS, they lost connection with the motors and have not been able to access their IDs

Next Steps

Laavanye will focus on classifying objects by their size

Jorge, Nithin and Bobby will focus on making the Dynamixel work. They are contacting the manufacturer, searching expertise at the RI at CMU and continuing to find their own solutions.

This is critical to our project. If they are not able to make these motors work, we will have to search for alternatives, very likely having to order new motors, and Palo will have to adapt the current design, re-print and fabricate parts to assemble them to the new motors. For that reason, we will search for parts that will be as compatible as possible with the current one for a smooth retro-fit.