MSE 312 Individual Final Report

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Lab 2 Wednesday

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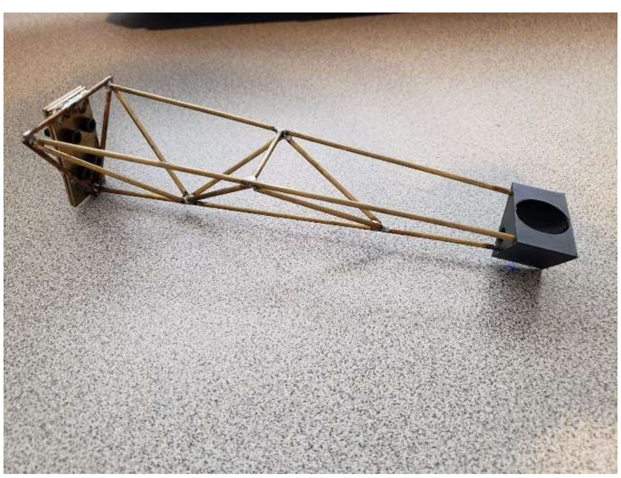
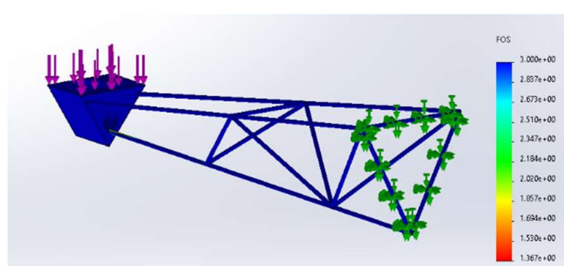
Reflection on Mechanics and Dynamics:

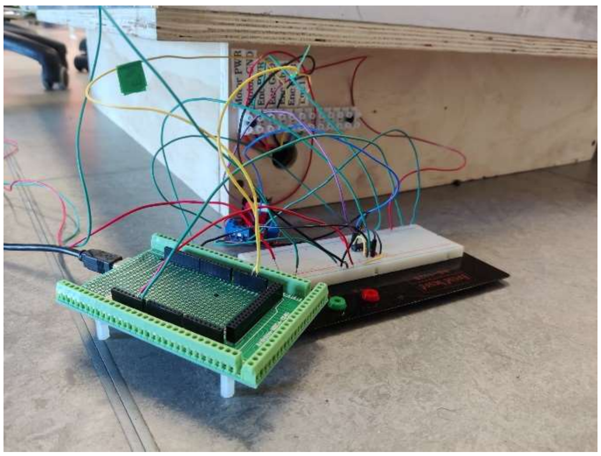
The mechanics of the truss arm structure and how it affected the performance of the throwing motion of the projectile. The low moment of inertia of the arm helped it to accelerate to the desired angular velocity in the desired time with the torque and speed output of the motor. Since we used the triangular truss design, it maintained the sturdiness with low deflection under that acceleration loading. This made our throws consistent. One lesson learned would be the effect of eccentric loading due to the arm on the position and speed control. Eccentric loading meant that the load on the motor would oscillate between positive and negative resting torque. A shorter arm or counterweight balance may have helped with this although it increases the moment of inertia it also increases the controllability of position and speed. The design of this truss arm allowed for better learning to create a controller scheme that works under the dynamic loading for this scenario.

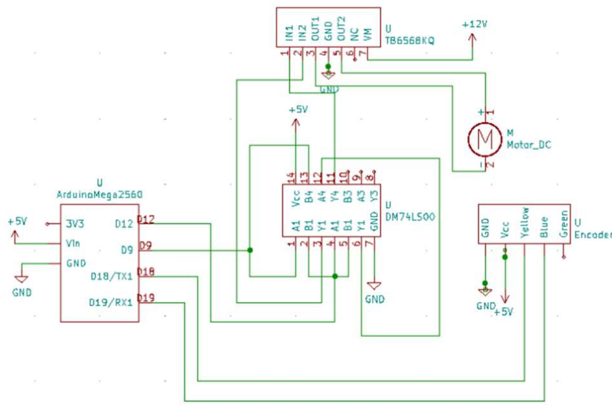




Reflection on Electronics, Electrical and Interface:

The electronics consisting of the H-bridge, NAND gates, Arduino, and power supply. Leading up to the demonstration, we encountered some difficulties assembling to the electronics hardware. The schematics were correct, but the connections and hardware components would either burn after soldering or disconnect. The H-bridge would overheat so we switched to a L298N Dual H Bridge Stepper Motor Driver Board. We also scrapped the protoboard and used the breadboard because we were running out of time and didn't want to risk trying to solder the NAND gate. One easy fix to enable soldering to protoboard with less failures is to use DIP sockets which can be soldered directly, and the actual components and IC's can be press fit. Regardless, our electronics design was successful as shown in the diagram and figure.



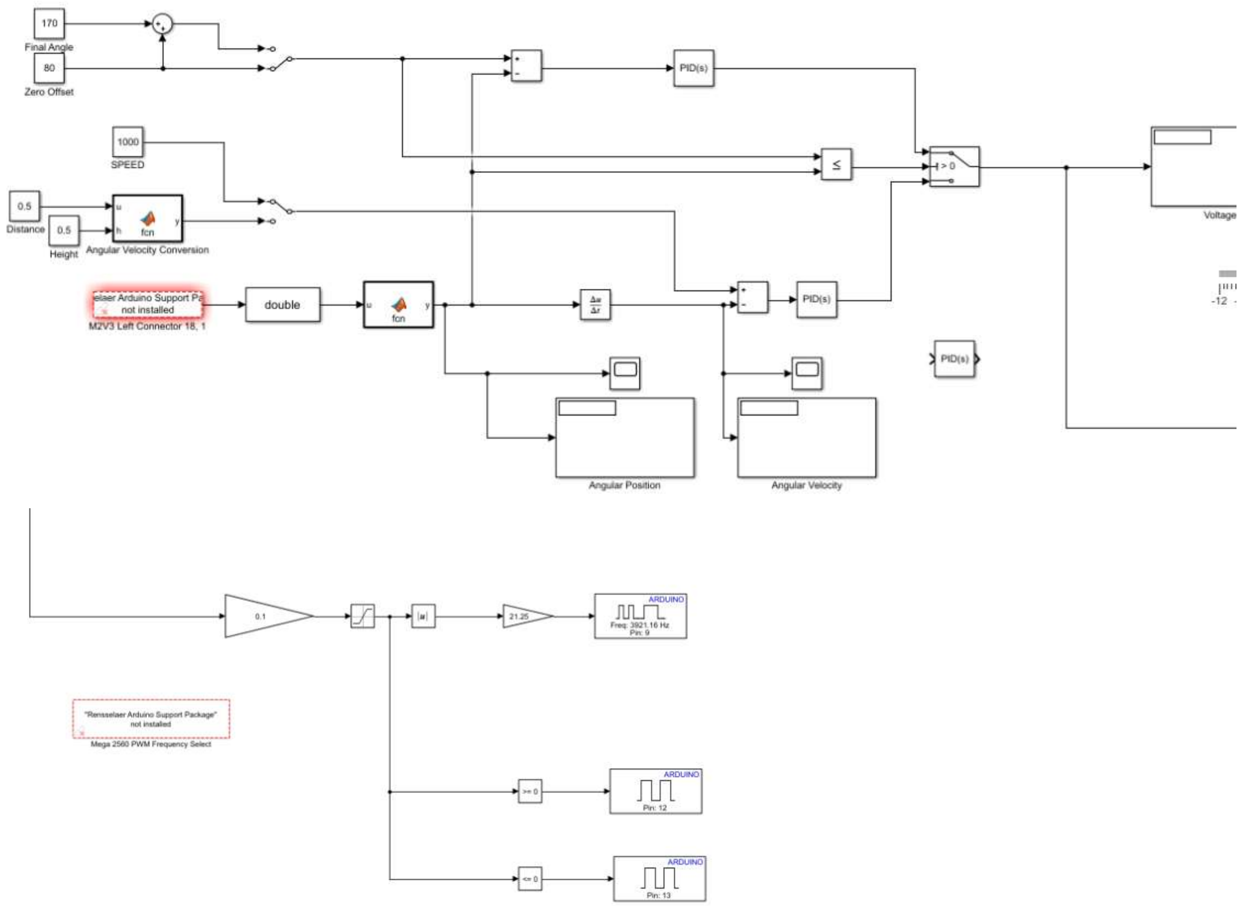


Control and Operation:

The algorithm on Simulink that we designed uses PID for speed and position control, The problem arises when PID causes slow settling time and oscillations. Since the output of the controller is a function of the input, input derivative and input integral there is an inherent problem with using this method to control a motor.

1. The convergence time and accuracy of the speed control
2. The convergence time and accuracy of the position control

We ideally would want the motor to reach the setpoint speed before reaching the setpoint position. Then we would want to maintain that speed until it gets to the position and then decelerate for the release stage. That is what this block diagram shows.



The switch controls which of the two inputs (input 1 or input 3) are used based on the condition on input 2. Input 1 is the position PID controller output and input 3 is the speed PID controller output. We made the conditions such that, if the desired position is less that the current position (if the arm swings past the desired position), the output of the switch will be input 1 which is position control.

The dynamic of the system is so that once it reaches the desired position, is slows down because of the position controller. One problem of this controller is that once the actual value of the encoder and the desired value of the encoder become very close to each other, the system creates a vibration. Therefore, we could hear vibration from the motor due to a fluctuation of the output from position controller to speed controller and it goes from positive gain to negative gain very quickly. To solve this problem, we proposed a method where there can be a tolerance within one or two encoder values of the desired position where the PID controller is not activated. This means that once we reach within the tolerance of the position, there is some space for the motor to settle between the positions where gain values are present.

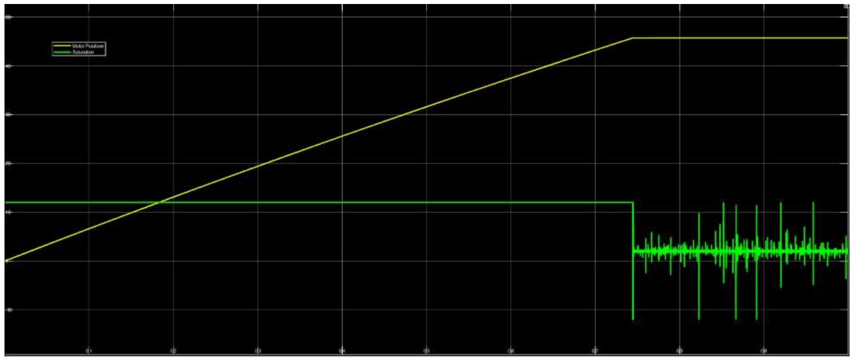


Figure 12: Graph of Position Control with Voltage to Motor

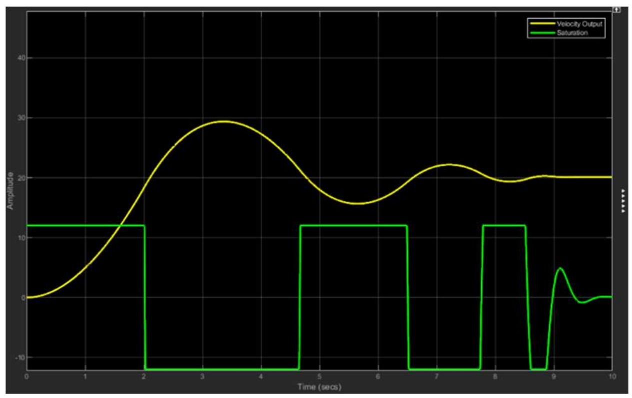


Figure 13: Graph of Speed Control with Voltage to Motor, P=100, D=10

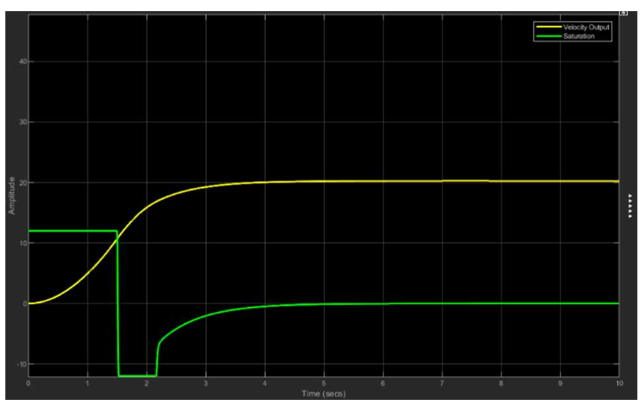


Figure 14: Graph of Speed Control with Voltage to Motor, P=100, D=70

Performance in the Competition:

The outcome of the performance during competition was using the position controller to land at the 200cm distance twice. We also attempted the 70cm throw and a distance between. While testing the system before the competition the 70cm and 100cm were also reliable but a short time before the competition we switched our software from speed and position control to purely position control. This change was because of some inconsistency with the speed and position combined. The software we used during the competition was good for position control and consistent for a 200cm throw.

Steps to make a product:

To make this a product, we would simply make the hardware connections on a PCB with uploaded software and package it. However, depending on the use case, the person who would want this product would also want the full ability to modify everything from hardware to software so it can simply be kept as a hardware kit and technical manual with Simulink software examples for testing and research purposes. Also, for a product, we may also try buying a DC motor and encoder separately if we wanted to swap motors while still using a high precision optical encoder. This would ensure the replaceability, repairability and cost efficiency of the system. Something great is how with this setup we can use a regular DC motor instead of a stepper motor. For applications like 3D printing, stepper motors are commonly used, it would be interesting to research on possibility of using the brushed DC motor or any of the other motors available in the market instead to achieve a similar level of position and speed control for large voltage or high torque applications.

Reflection on Teamworking

For effective teamwork in engineering design, we had everyone contribute and work together to deliver the project. When we are all aiming towards the same motivation then there is good thinking from the group and support. Overall, we had some fun testing and playing around with the design, testing software, sharing ideas, and we were able to meet the timelines as well. Methods to improve team effectiveness would be for everyone on the team to do documentation on progress consistently and having patience with positive communication with the group. Overall, we had successful teamwork and I hope to work on this type of research in the future as well.

The link to the files of this project for Simulink are in this google drive link

https://drive.google.com/drive/folders/1oQkBBSipBeBVBbPF8vsT_5XooL2UoC6z?usp=sharing