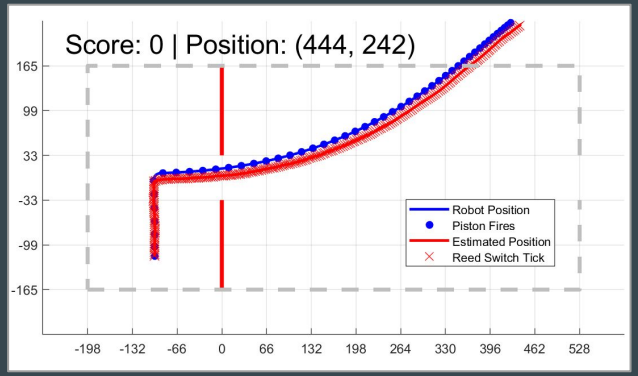
MAE 106 Robot Project: Controller Design

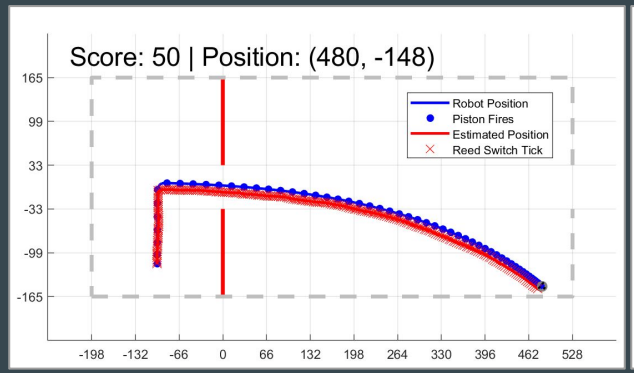
By: Kelsey Lawson

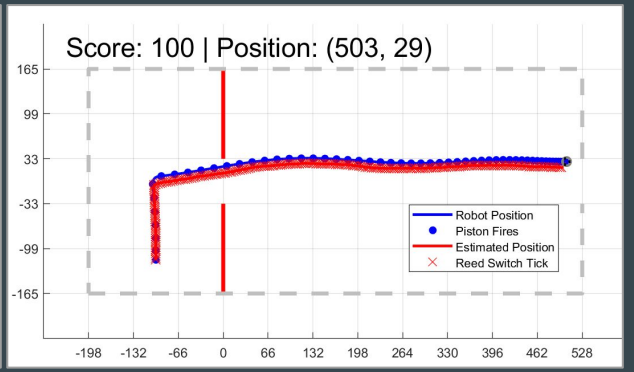
Simulation: Open-Loop Control

Altered Control Parameters

- Piston time ON: 0.5 seconds
- Piston time OFF: 1 second
- Ticks before turn: 35
- Total time before turning: 0.60 seconds



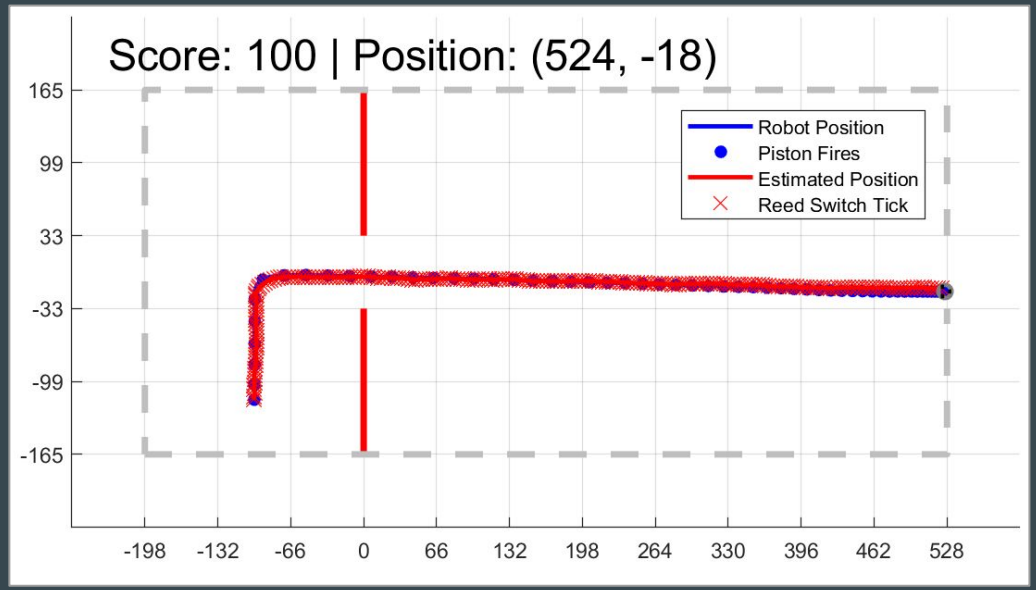




Simulation: Hybrid Control

Altered Control Parameters

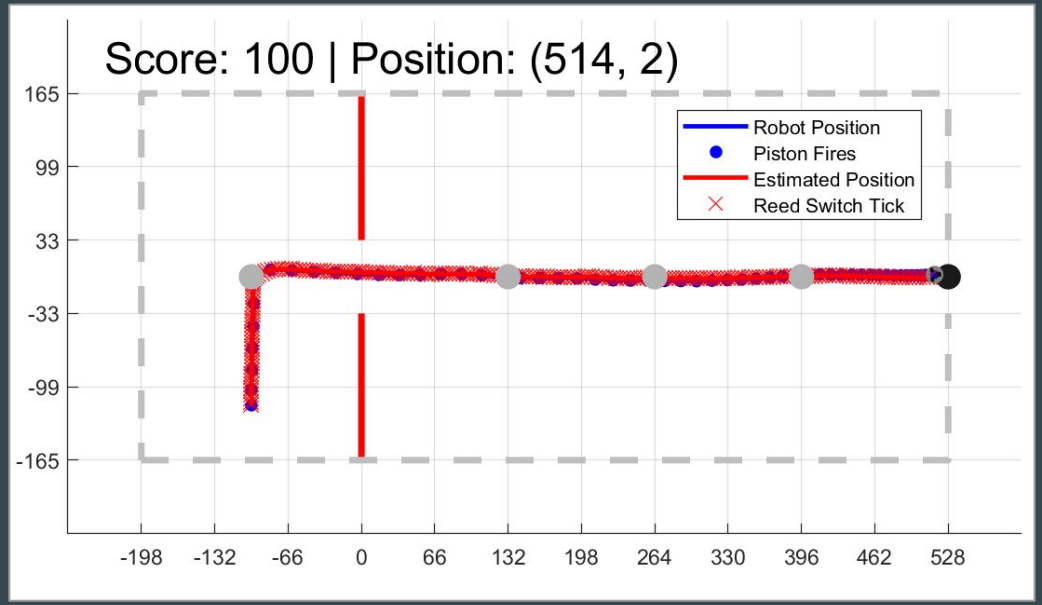
- Piston time ON: 0.5 seconds
- Piston time OFF: 1 second
- Ticks before turning: 30
- Total time turning: 0.6 seconds
- Kp: 0.6



Simulation: Closed-Loop Control

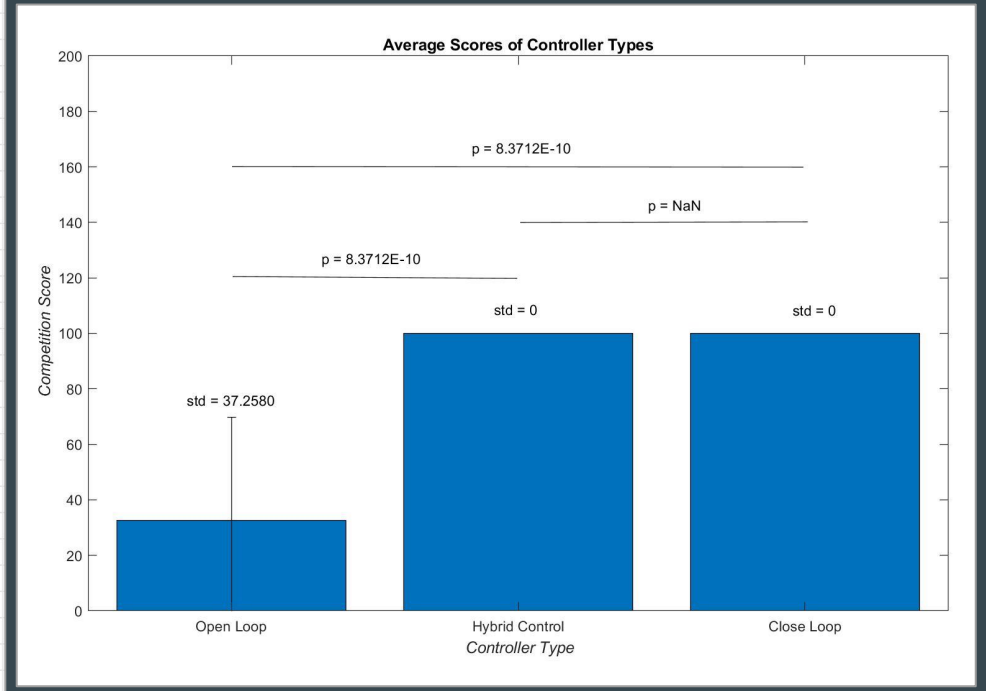
Altered Control Parameters

- Piston time ON: 0.5 seconds
- Piston time OFF: 1 second
- Kp: 0.6
- Target Distance: 10
- Position of waypoints: (-1.5,0), (2,0), (4,0), (6,0), (8,0)



Results of Each Control Type

Run	Open Loop Control Scores	Hybrid Control Scores	Close Loop Control Scores
1	100	100	100
2	0	100	100
3	50	100	100
4	50	100	100
5	0	100	100
6	0	100	100
7	50	100	100
8	50	100	100
9	100	100	100
10	0	100	100
11	50	100	100
12	0	100	100
13	0	100	100
14	50	100	100
15	100	100	100
16	0	100	100
17	0	100	100
18	50	100	100
19	0	100	100
20	0	100	100
Mean	32.5	100	100
Standard Deviation	37.25799102	0	0
Compared Control Types	**P-Value**		
Open & Hybrid	8.37E-10		
Open & Closed	8.37E-10		
Hybrid & Closed	#NUM!		



Outline for Using Closed-Loop Control Technique

Connect the Magnetometer & Reed Switch to the Arduino

Establish Variable for the **Magnetometer**
Establish Variable for the **Reed Switch**
Establish Variable for the **Car's Direction**
Establish Variable for the **Proportional Gain, K_p**
Establish Variable for the **Servo Angle**
Establish Variable for the **Distance to Target**

Setup: *(Starting Position of Car)*
State value for proportional gain, K_p
State the piston timing
    The piston is ON for how long and OFF for how long
State the angle of the servo
    What is the maximum angle the servo can attain to
State the distance between each target along the path
    List the target distances between each checkpoint the car makes
    Verify the maximum distance that the last target will be at
    Verify the first point through the magnetometer readings so that the car can establish its initial position

Loop: *(Determines Moving Position of Car)*
Verify the robot's direction by using the magnetometer readings
    If the car is following the correct direction of the target no adjustments are needed

    Otherwise the servo angle needs to change based off the proportional gain using this equation:
    $\Delta\theta = K_p$*(Current Position of Car - Desired Position of Car)*
    until the direction aligns with the target

Verify the distance of the car to each target using the reed switch
    If the distance made by the car has not surpassed the second to last target, keep firing the piston

    Otherwise, start to limit the amount of time the piston is ON and lengthen the amount of time the piston is OFF so that at the last target the car makes a complete stop

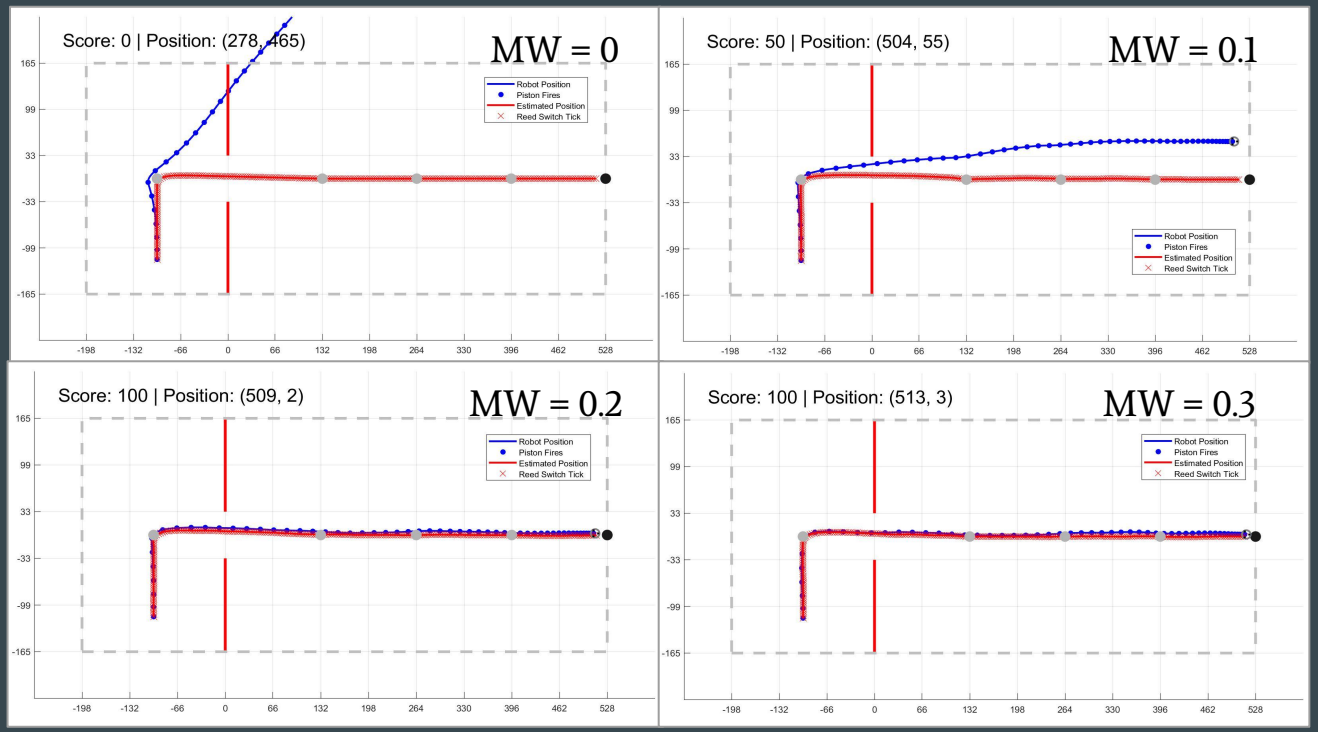
Save the most current target made by the car to keep it aligned on the intended path

The Effect of Magnetometers on Closed-Loop Control

Altered Control Parameters

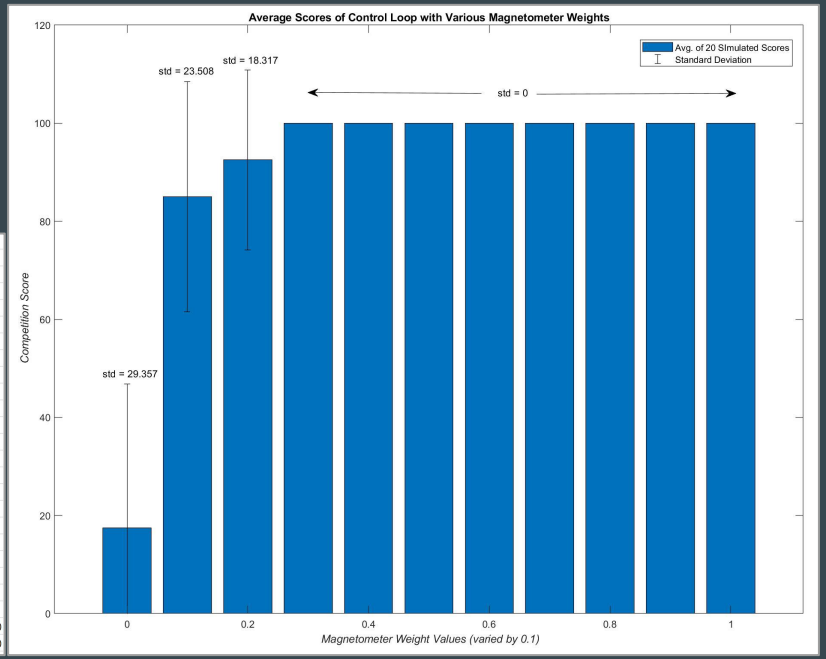
- *Piston time ON: 0.5 seconds*
- *Piston time OFF: 1 second*
- *Kp: 0.6*
- *Target Distance: 10*
- *Position of waypoints: (-1.5,0), (2,0), (4,0), (6,0), (8,0)*

Changed the Magnetometer Weight (MW) Value by 0.1 from 0 to 1. For each, 20 simulations were run. When MW = 0 the magnetometer is not being used and when MW = 1 there is full reliance on the magnetometer (no estimations).



The Effect of Magnetometers on Closed-Loop Control

When the magnetometer is not being used by the car, the score values drop significantly to only a 17.5 average. Further, the lowest weight of the magnetometer that can be used while still maintaining a score of 100 is at 0.3.



Closed-Loop Control											
Run	**0 MW**	**0.1 MW**	**0.2 MW**	**0.3 MW**	**0.4 MW**	**0.5 MW**	**0.6 MW**	**0.7 MW**	**0.8 MW**	**0.9 MW**	**1 MW**
1	0	50	100	100	100	100	100	100	100	100	100
2	0	100	100	100	100	100	100	100	100	100	100
3	100	100	100	100	100	100	100	100	100	100	100
4	0	50	50	100	100	100	100	100	100	100	100
5	0	50	100	100	100	100	100	100	100	100	100
6	0	100	100	100	100	100	100	100	100	100	100
7	50	100	100	100	100	100	100	100	100	100	100
8	0	100	100	100	100	100	100	100	100	100	100
9	0	100	100	100	100	100	100	100	100	100	100
10	0	50	100	100	100	100	100	100	100	100	100
11	50	100	50	100	100	100	100	100	100	100	100
12	0	100	50	100	100	100	100	100	100	100	100
13	50	100	100	100	100	100	100	100	100	100	100
14	50	100	100	100	100	100	100	100	100	100	100
15	50	100	100	100	100	100	100	100	100	100	100
16	0	100	100	100	100	100	100	100	100	100	100
17	0	50	100	100	100	100	100	100	100	100	100
18	0	100	100	100	100	100	100	100	100	100	100
19	0	100	100	100	100	100	100	100	100	100	100
20	0	50	100	100	100	100	100	100	100	100	100
Mean	17.5	85	92.5	100	100	100	100	100	100	100	100
Standard Deviation	29.35714743	23.5081173	18.31737743	0	0	0	0	0	0	0	0