EECS 461 Final Report - Aiden Ascioti, Susan Zhao

Introduction

For this project, we were asked to develop a Simulink model to implement a simple vehicle with Adaptive Cruise Control (ACC) and an Automatic Steering controller. The vehicle was operated as stable as possible along a predetermined coordinate path via the NXP, Haptic Wheel Interface, and IOBoard used for each lab in the class. To visualize the vehicle driving, we were provided with a VR Driving Sim run via another Simulink program and the Unreal Engine. Our vehicle was implemented following a bicycle model to simplify the differential equations in the vehicle model.

Pick Lead Logic

To determine the vehicle ahead of us, we looped through the s-coordinates of every other vehicle on the road, setting a variable equal to the index of the vehicle ahead and closest to our own car. This variable was set to a default value of -1, so that we were able to clearly determine if our own vehicle was the leading car. With no lead car, the function would return the current position and velocity of our car, and set the ACC Mode boolean to True for “velocity”. If not, the function would return the parameters of the indexed lead car, and set the ACC Mode boolean to align with “position” if the distance to the lead vehicle was less than 20 meters, and “velocity” if the distance was greater than the following distance. This logic was implemented within an S-function to simplify debugging.

Once we extracted values from the S-Function, a set of logic gates was used to implement the ACC state determination. This was necessary since the ACC Mode boolean output from the S-function did not account for whether the ACC system was actually enabled, only which state the vehicle would be in assuming ACC were enabled. We used AND and NOT gates to combine the S-function’s ACC Mode boolean with the ACC enable input to produce a trio of independent output signals that were set high if that mode was chosen. These signals were then combined with a merge block to pass the appropriate throttle command to the vehicle model.

Automatic Steering Controllers

We implemented two Proportional plus Derivative (PD) controllers to autonomously steer our vehicle on the driving simulator. These PD controllers were structured as two loops, one inner loop to control the haptic wheel position, and an outer loop to control the position of the car relative to the road centerline. The gains we initially used were dictated by a natural frequency of 30 and a damping ratio of 0.7. This resulted in successful automatic steering, but we observed quite a bit of jitter and instability from the haptic wheel. To tune our controllers, we chose to explore two cases. The first was a critically damped case. By modifying the damping ratio to 1, the outer loop Kd term increased from 0.0875 to 0.125 whereas the inner loop Kdm term also increased from 137.43 to 198.9. In the simulink model there was a decrease in both the amplitude of the negative response in road position and overshoot in the step response to road angle change, which is desired. When tested empirically, there was only a slight improvement to the oscillations. The second case was the overdamped case. Both damping terms, Kd and Kdm, increased to 0.15 and 239.88 respectively. Theoretically and in simulation, this further smoothed out the response to any changes in road angle. In practice, we still observed some instability but ultimately chose to select the overdamped set of gains for automatic steering.

Encountered Problems

Over the course of this project, we encountered numerous setbacks, many of which were self-introduced errors in logic and interfacing. Our vehicle model had a number of incorrect block placements which we did not initially catch with test cases, causing delays in the development of Milestones 2 and 3. We originally failed to account for the angle Delta being measured as the steering deviation to the right of the vehicle centerline, which opposed the physics equations in the model that defined Delta as being the steering deviation to the left of the vehicle centerline. Furthermore, we incorrectly used the Right coordinate transform block instead of the Forward transform, which introduced heavy and asymmetric self-align torque. In our ACC and Steering control systems, our issues were primarily based on improper interfacing with inputs and outputs. Previous iterations included incorrectly indexing through the CAN-supplied class vehicle data, and a parameter swap in our outer control loop. Once these were addressed, each subsystem worked reliably.

Workload Distribution

A majority of this project was done collaboratively, with only a few exceptions. Aiden correctly implemented the S-function block used within the Vehicle Model subsystem, as Susan incorrectly used a continuous-time solution in the prelab. As for the controllers, both team members created solutions separately as required in homework. Susan's controller was the better design and was integrated into the simulation. Both members then collaborated on making modifications, fixes, and exploring making changes to the gains. All other aspects of the lab were worked on together.

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