Transient One Dimensional Vehicle Simulator

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Kellogg Honors Capstone Project

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Objective

- Produce a simple one dimensional lap time simulator for a rigid body car accounting for both weight transfer and transient forces
- Institute a car control algorithm to allow for repeatability and eliminate human driver bias
- Create an easy platform for vehicle parameter and control characteristic change

Motivation

- In previous experiences in motorsport and even commercial vehicle design, there has been a lack of design feedback correlating 3 broad factors
  - change of vehicle parameter (i.e. weight)
  - change of driving style and habit (smooth vs sharp braking)
  - the necessary effort to implement change
- This project is a preliminary step to relate a simple change in vehicle to any changes in driving habit. The effort to make these changes can be evaluated against the changes in performance (i.ei lap time)

Assumptions

- Tires provide constant friction in all conditions. The grip changes with normal load on the tire
- Tires do not slip
- Aerodynamics properties dependent only on the drag coefficient and velocity of the vehicle
- Aerodynamic loads only occur in the tangential direction of the vehicle
- DC motors are idealized and can be characterized by max rpm, max voltage, no load voltage, and damping value.
- PID controller perfectly controls and supplies current to the DC motors

Method

- Design a car with the mass, dimension, tire, and motor properties of a commercially available RC car
- Input a track of xy points and get an ideal estimate of vehicle velocity at any given point on the track
- Have the vehicle, with transient forces considered, try to match that ideal estimate while being controlled by a PID
- Return lap times

Future Plans

- Overhaul the simulator into 3D to provide the following characteristics
  - Improve accuracy of forces going through the tires, and correlate the available grip due to turning forces
  - Improve the visualization of the vehicle to a working animation as opposed to a position vs. time plot
- Build a physical car that will be able to execute the laps based on the input control variables
- Alter vehicle parameters and compare the accuracy of performance

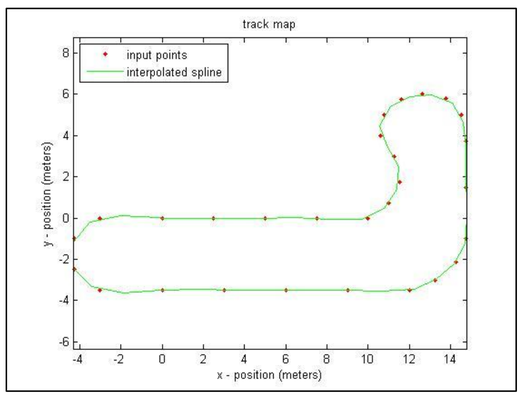
Special Thanks to:

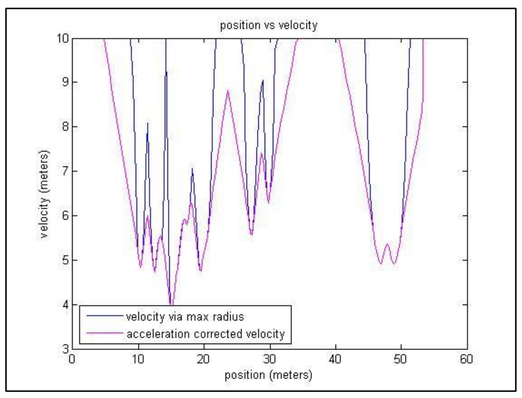
- The now Dr. Nolan Tsuchiya for his advice and hands on approach to problem solving within Matlab and Simulink
- Eric Schwartz for hardware development advice and sourcing of electronics for future testing and plant development

In Memory of:

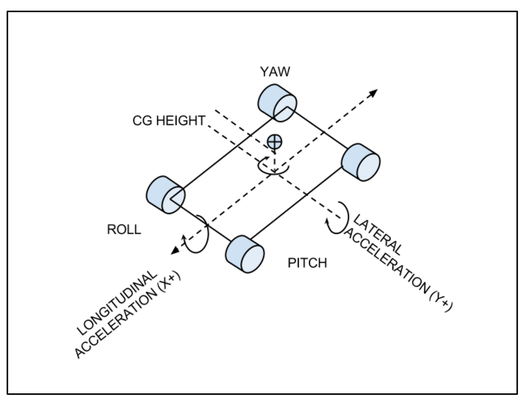
- Hao Nguyen, Eric Savengrith, and John Cone whose influence and inspiration to others will be missed

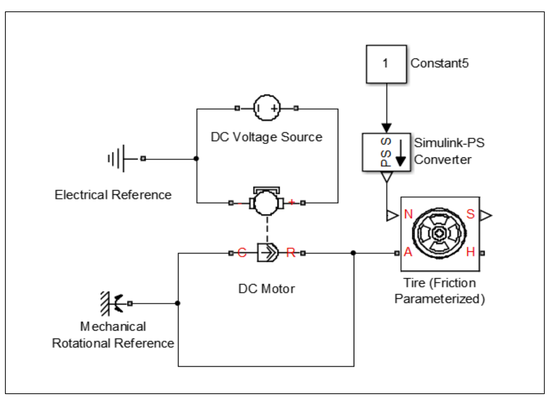
Step 1: Track Map



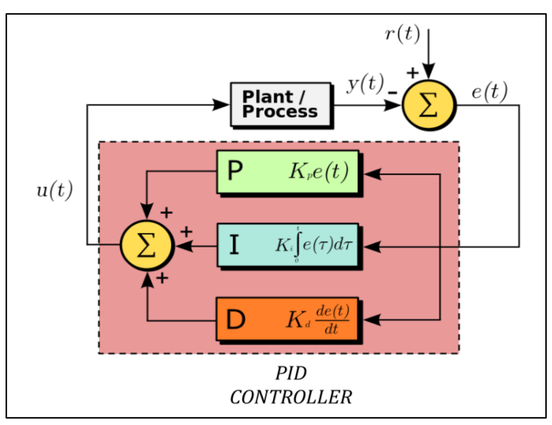


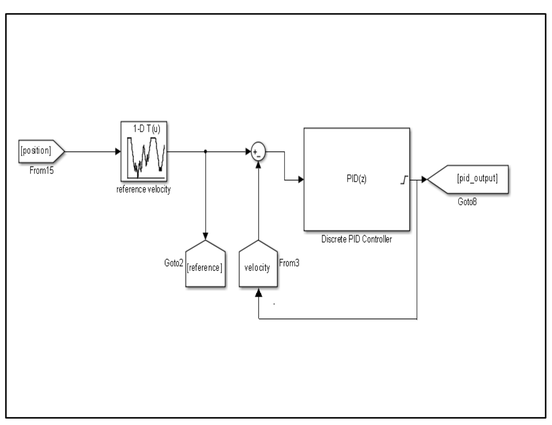
Step 2: Vehicle Model





Step 3: PID Controller





Step 4: Lap Results