MECH 6323 Project Proposal:

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Abstract

In this project a model of dynamics of the Autonomous Vehicle (NOVA) will be examined. The NOVA team aims to eventually develop an MPC-based control strategy, yet there still exists many uncertain and changing parameters that determine the dynamics of the system. The goal of the project is to develop and test the robustness for the simple mpc controller to maintain a straight and curved trajectory.
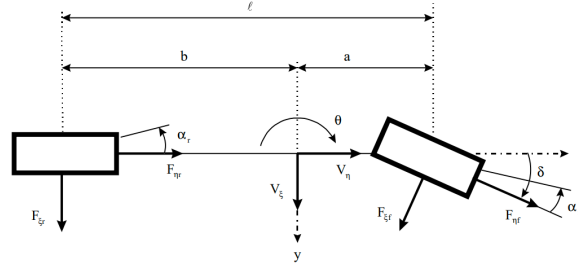
1 Vehicle Dynamics

Figure 1: 3 DOF Bicycle Model

The full nonlinear dynamics for the Bicycle model shown in Figure1 are given as:

$$I\ddot{\theta} = aP_f\delta + bF_{\zeta f} - bF_{\zeta r}$$
$$m(\dot{V}_\zeta + V_\eta\dot{\theta}) = P_f\delta + F_{\zeta f} + F_{\zeta r}$$
$$m(\dot{V}_\eta + V_\zeta\dot{\theta}) = P_f + P_r + F_{\zeta f}\delta$$
$$\dot{x} = -V_\zeta\sin(\theta) + V_\eta\cos(\theta)$$
$$\dot{y} = V_\eta\cos(\theta) + V_\zeta\sin(\theta)$$

where the global system coordinates are (x, y, θ), longitudinal (η) and lateral (ζ) velocities (V_η, V_ζ), longitudinal and lateral forces for the front and rear as $(P_f, P_r, F_{\zeta f}, F_{\zeta r})$, steering angle of δ, and with the following physical parameters that are uncertain:

	Parameter	Nominal
m	Vehicle Mass	1500.0 kg
I	Vehicle Yaw Inertia	12.0 kg m^2
a	CG Distance to Front Axle	1.228 m
b	CG Distance to Rear Axle	1.5618 m

There are additional complicated dynamics for how the tire forces are determined based on tire slippage and powertrain dynamics; however the simple plant model takes them as inputs. Within the actual system actuators are used that control the steering angle and the forces that the wheels excerpt on the ground.

Within this initial simulation many assumptions are taken that will be expanded upon when analyzing the robustness to these parameters.

Note: The page limitation has made inclusion of additional details from being included. If desired, I can provide even more details on the system dynamics but really the 'linear' model isn't beneficial outside a single time step, although can be seen in the attached MATLAB pdf.