Path Tracking Control of Model-Scale Vehicles

(Bachelor's Thesis)

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Motivation

Nowadays, the autonomous vehicles field is rapidly developing in both research and industrial sections. The Cyber-Physical Mobility (CPM) Lab provides an environment to easily test researched ideas. The vehicles in the lab are currently controlled by two techniques. The first technique is by providing control inputs from an external hardware, while the second is by transmitting a reference trajectory where an MPC controller determines the control inputs necessary to follow that given trajectory. Another technique for controlling a vehicle is by a path tracking controller. This controller will be designed in this work, allowing the external control of the motor commands. When changing the velocity of the vehicle externally, the vehicle's lateral controller adjusts the steering angle to keep the vehicle on the reference path and the vehicle's longitudinal controller will maintain the desired speed. This technique allows for separate path definition and then tracking. Also the tracking can be separated into steering and propulsion which is useful in applications where decoupling is needed.

State of the Art

The simplest path tracking controller is the Pure Pursuit controller, which calculates geometrically the steering angle from the curvature of a circular arc that connects the rear axle location to a goal point. The goal point is determined by a predefined look ahead distance. Another path tracking controller is the Stanley controller. It uses a steering control law that depends on the heading and cross-track errors, which are calculated from the center of the front axle to the nearest path point. It also uses a PI controller, to control the vehicle's speed. Since these are simple techniques they are limited to low-speed driving scenarios. Furthermore, there are other types of path tracking controllers. Adaptive PID controller overcomes the difficulty in guaranteeing performance and stability over a wide range of parameter changes and disturbances. Moreover, MPC can take into account the constraints of the system. Finally, there are newly developed deep learning path trackers, which perform more accurately in complex control problems and generalize previously learned rules to new scenarios.

Goal

The goal of this thesis is to implement a working longitudinal and lateral path tracker in the CPM lab environment. Each of the above techniques differs in simplicity, robustness, accuracy, and the various driving scenarios to which they are applicable. Therefore, starting with the simplest controller and after various testing a suitable technique will be chosen.

Planned Procedure

In this thesis a Stanley steering controller and a PI longitudinal controller will be implemented. The controllers will be evaluated by the sum of the cross-track error over time, and the settling time needed to settle within 5% of the required reference velocity. Finally, the path tracking controller will be evaluated against the currently available onboard trajectory following controller.

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