Platforms and Algorithms for Autonomous Driving Planning and Control Module

Assignment 3: Motion Planning and Control

AA 2024/2025

Deadline: 13/01/2025, 23:59

Introduction

The purpose of this assignment is to experiment the Frenet-based planner. By completing this task, you will gain experience in tuning the planner and the controllers to track a path in order to avoid static obstacles.

It is highly recommended to read/study the paper Optimal Trajectory Generation for Dynamic Street Scenarios in a Frenet Frame and Kinematic and dynamic vehicle models for autonomous driving control design.

Instructions

- The assignment must be solved individually.
- A short report must be written for each assignment, describing the results, including motivations, observations from the simulations, and any conclusions.
- The report should be concise and clear, with all figures properly labeled, including axes and legends.
- The code should be well-commented to ensure clarity.
- Plagiarism will not be tolerated and will result in points being deducted.

- Submit your work sharing a private GitHub repository or as a zip file.
- Use the template shared. It is sufficient to complete the code with the requests below. You are free to extend it to improve the management of the plots, use different libraries for the control/planning algorithms, save the results in an external file and use the data for plots or something else in a different environment, etc.

Vehicle Parameters

Use the same simulation.py script produced for the Assignment 1 and 2, using the non-linear single track, RK4 and integration time of **0.05s** as it is already defined in the main.py template.

Outputs

For each exercise, you are required to plot the following outputs:

- Trajectory to track (global and local) and actual trajectory: x, y
- Longitudinal velocity: v_x
- Lateral velocity: v_y
- Front slip angle: α_f
- Rear slip angle: α_r
- Lateral tire force: F_y as a function of slip angle
- Steering angle δ
- Side slip angle β
- Lateral error
- Velocity error
- Longitudinal acceleration

as well as create a report in which for each exercise includes the most useful plots and describes the results.

Exercises

Exercise 1: Static obstacle avoidance at low speed (Points: 8)

In this exercise, you will complete the template code in order to generate a path by the Frenet-planner and track it. In particular:

- Track a speed of $10m/s$
- Use the Frenet Optimal Trajectory planner given. You are allowed to change all the parameters and weights but not the target/max speed which should follow the target speed requested here, and not the robot radius (3.0 m) used for checking the collision.
- Use one of the algorithms used in Assignment 2.
- Do it also tracking a speed of $15m/s$
- Calculate and plot the lateral error with respect to the Frenet path
- Bonus: Calculate the execution time of the Frenet planner using the parameters provided and then change them in order to reduce the time while keeping a good performance. Explain the reasons behind the choices made.

Exercise 2: Static obstacle avoidance at high speed (Points: 7)

Same as the previous exercise but:

- Track a speed of $20m/s$
- Produce the results using Pure Pursuit, Stanley, and MPC (kinematic model).
- Do it also tracking a speed of $25m/s$ with at least one of the controllers used in Assignment 1. You are allowed to extend the controller's capabilities (e.g. different model).
- Calculate and plot the lateral error with respect to the Frenet path.
- Bonus: Track the path at the highest speed you can respecting the maximum lateral error of 4m from the global path.

If you cannot track the path at $25m/s$, produce the results at the highest speed you achieved.

Deliverables

For the submission, you should provide the following:

- A clear and concise report in PDF format, including considerations and explanation of the plots you may consider useful.
- A well-documented code repository (via GitHub) or a zip file with all the source code.
- Any additional files necessary for the simulation (e.g., external files for saving results).