Development of a Route Planner for Autonomous Driving

Background

Autonomous driving (AD) has seen a spike of interest in recent years. In AD, the pipeline usually consists of sensing, perception, prediction, planning and control [1]. As a joint research cooperation, several chairs of TUM are currently developing EDGAR, a fully autonomous research car. As the initial project owner, our chair is responsible for the planning part, using our own CommonRoad eco-system [2, 3].

Figure 1: Autonomous Vehicle EDGAR

One central pillar of planning in AD is the route (aka mission) planner as the highest level planner for the specific scenario. In our context, the route planner takes the information from previous parts of the pipeline, i.e. perception and prediction as input. It computes one or more reference paths from the initial state to the goal position. Subsequently, the behavior and trajectory planners generate trajectories based on the reference path and control aims to follow the generated trajectory [4, 5, 6].

Since our goal is to run our entire planning stack on EDGAR, we aim to further enhance our route planner, as it is used in most of the planning software from our chair and FTM.

Description

The central goal of this thesis is to improve our existing route planner by developing new, robust algorithms. Although the definitions are not always used coherently in the literature, the route planner is usually responsible of finding one or more paths from the initial state to the goal position using the information of the road network [4, 5, 6, 7].

Our route planner, as many others, employ graph search for finding the path(s) to the goal [7, 8, 9]. Additionally, the planner must be capable of choosing the best option out of the found routes. Moreover, it is also responsible of generating actual reference paths. A reference path can be seen as the (optimal) drivable and smooth path from start to goal in the road network without considering traffic. This includes, most notably, lane-changing maneuvers.

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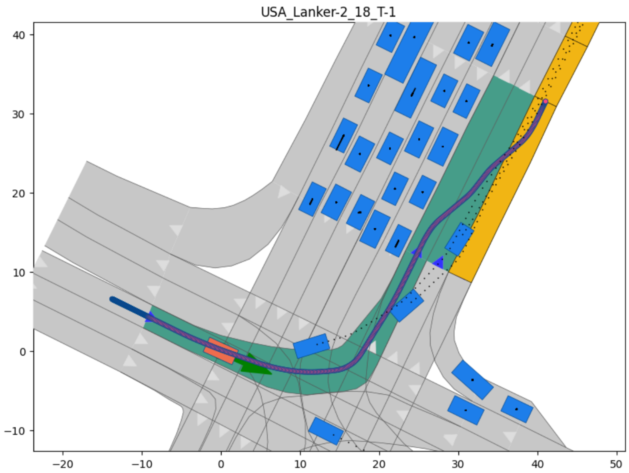

Figure 2: Exemplary Reference Path

Generating a well-defined reference path has become increasingly important, as state-of-the-art behavior and trajectory planners oftentimes entirely depend on the Frenet-Frame (also known as curvilinear coordinate system), which is computed from the reference path [10]. However, generating a well-defined reference path for arbitrary road networks is a non-trivial task, especially for lane-changes. A commonly encountered problem is that the algorithms are not adaptable enough for the vastly different real-world scenarios, leading to unrealistic results (e.g. abrupt lane-change sequences on highways, not entering a better lane, completely missing a feasible goal state, ...) or failure to produce any.

Tasks

This thesis focuses on developing and integrating new algorithms (from the literature, maybe with your own spin on them and/or own ideas) for improving our generated reference path, especially for adaptable, possibly user-defined, lane-changes.

The underlying project focuses on real-world scenarios and use-cases, therefore, the developed algorithms must be tested and evaluated accordingly. As planning on arbitrary, real-world scenarios is notorious for having edge-cases, one key factor is the robustness of the developed algorithms. We provide several hundred different scenarios from mostly real road networks, some with real recorded data, some with simulated traffic in our CommonRoad benchmark for testing (the current software already passes all tests).

Additionally, as this software is already used by many other parties, this thesis requires a well-documented and thought-through object-oriented implementation in readable code and possibly the rearrangement of the existing code base whilst also not changing the main interface. I will give you an overview and frequent advice on this part, if desired.

Your tasks are:

1. Understanding the shortcomings of the current implementation and desired improvements
2. Solution for adaptive lane-changes, with optional user-defined high-level parameters
3. Solution for reference path reliably going through goal state
4. Solution for sorting the generated reference paths according to their usefulness
5. (optionally) reliable initial-state lane determination in edge-cases
6. Testing on CommonRoad benchmark and (optionally) EDGAR's simulation
7. Making your solution work with the currently used interfaces

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