Bachelor/Master Thesis

Trajectory Planning for Autonomous Vehicles with Spline Curves

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Trajectory planning for autonomous vehicles is one of the main components of all autonomous driving stacks. It is responsible for generating a local trajectory which considers the kinematics of the vehicle, obstacles in the environment, and the properties of the vehicle platform. There are many existing methods for generating local trajectories, such as DWA, Elastic Bands, and MPC.

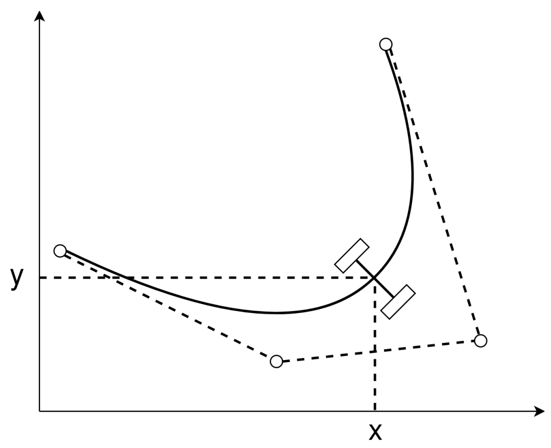

Figure 1: Trajectory planning with B-splines.

The local trajectory is represented by a curve, which can be represented implicitly, explicitly, or by a parametric curve. These have different properties, which effect the computation time, how they can be modified, and more. Two types that are of interest are Bézier and B-Spline Curves, which use different polynomial functions for the curve representation (see Figure 1). Each of them has different properties, such as the convex hull property, global/local control, and more. For the navigation of mobile robots, such properties can be exploited in order to guarantee a safe and efficient trajectory generation for the vehicle.

For example, the convex hull property guarantees that, the generated trajectory is located in the area that is defined by the control points. This property can be combined with information about the environment in order to determine whether or not the trajectory is feasible with regards to the obstacles in the vehicle's path. Another key point is the velocity, acceleration, and steering that is required for the vehicle and which depends on the planned trajectory during navigation.

The implementation should be done using ROS2, which is a software stack for creating complex robot systems that consists of many modular components. Each component represents one module of the system that communicate via the DDS-communication architecture. ROS2 provides packages, such as the Nav2 navigation stack and AuNa-Framework [2], that provide the basic components for autonomous navigation and the simulation of the vehicles, so that the local planner can be replaced with a custom solution that is based on spline curves.

In this thesis, at first students should get familiar with ROS2 and the general architecture of the current navigation stack that is used for the simulation of the vehicles. After that, a local trajectory planner should be added to replace the currently implemented solution. It should be based on Bézier or B-Spline curves to determine a feasible trajectory of the vehicle and guarantee obstacle avoidance, while optimizing the driving behaviour of the vehicle. Students should note that the involved source code of this thesis will be publicly released and should be fully documented to comply with the rationale of open-source software development.

Required Skills:

- Knowledgeable of C++ and Python
- Knowledge in robotics and ROS2

Acquired Skills after the thesis:

- Knowledge about the required navigation system components of autonomous vehicles
- Knowledge about trajectory planning for dynamic environments

References:

[1] Gloderer, Martin et al., "Spline-based Trajectory Optimization for Autonomous Vehicles with Ackerman drive", 2010

[2] Teper, Harun et al., "AuNa: Modularly Integrated Simulation Framework for Cooperative Autonomous Navigation", 2022, https://github.com/tu-dortmund-ls12-rt/AuNa