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1 Introduction

Research in vehicle automation aims to solve road congestion issues and mitigate the risk of accidents. Generally speaking we can make the distinction between two classes of automated vehicles. The first being cooperative vehicles, which aim to improve traffic flow by means of communication, and the second being fully autonomous vehicles. These autonomous vehicles typically make use of a trajectory planner, which provides a reference for the vehicle's trajectory control system. In this work we attempt to include communication of cooperative vehicles into the framework of the trajectory planner of the autonomous vehicle.

2 Path Planner

We adopt the planner framework presented in [1], in which in frenet frame, $\vec{e}_2^{\,2}$, (Figure 1) is defined along a reference spatial path. The planning problem then reduces to finding trajectories $\{s(t), d(s(t))\}$ with respect to a reference trajectory, where s is the curvilinear distance along the reference path, and d, the lateral offset. To minimize jerk, a set of fifth order polynomials, trajectories is generated with discritized terminal conditions at terminal time, τ, for both coordinates, which are tested for feasibility and collisions. A cost function is then used to select the trajectory that will be executed.

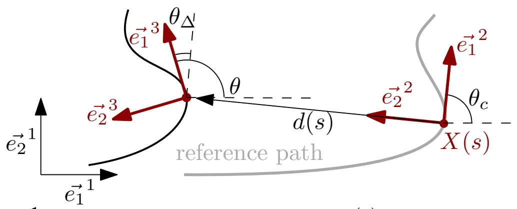

Figure 1: Reference path described by $X(s)$, and trajectory coordinates $s(t)$ and $d(s(t))$.

3 Communication

We focus on generating the path progression trajectory $s(t)$. In cooperative vehicles, typically a constant time gap spacing policy is used for the purpose of string stability [2]. This can be used to formulate a terminal constraint for the planned trajectory of $s(t)$,

$$s_i(\tau) = s_{i-1}(\tau) - c - h\dot{s}_i(\tau), \qquad (1)$$

where $s_{i-1}(\tau)$ and $s_i(\tau)$ denote the curvilinear position of the predecessor and host vehicle, c a standstill distance including vehicle length and h the time gap. Including V2V communication allows access to the planned trajectories of preceding vehicle $s_{i-1}(\tau)$. Minimum jerk trajectories for $s(t), t \in [0, \tau]$ are then generated such that $s(\tau) = s_i(\tau)$, $\dot{s}(\tau) = \dot{s}_i(\tau) = \dot{s}_{i-1}(\tau)$

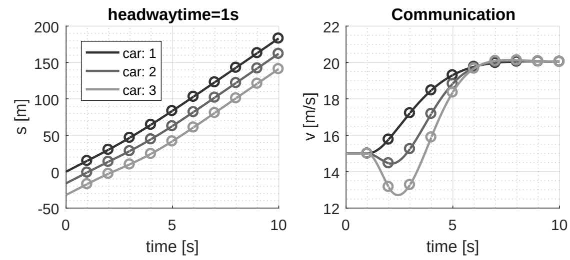

Figure 2: Trajectories $s(t)$, markers indicate planner update

This algorithm is implemented in a simulation environment in which the planner runs online at a frequency of 1Hz. The results for $s(t)$ are shown in Figure 2. The leading vehicle makes a change in forward velocity using a minimum jerk maneuver. The follower vehicles use spacing policy (1) with the described planning algorithm to generate trajectories. The minimum jerk nature of the trajectories results in an initial deceleration, which amplifies rearward in the string. This result demonstrates that the minimum jerk trajectories cannot be applied directly in the trajectory planner framework of the autonomous vehicle. Instead, the criteria for string stability should be explicitly included in formulating the functions for the longitudinal trajectory $s(t)$.

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References

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