Control of platooning vehicles: separating path following from tracking

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1 Abstract

We consider a new approach for solving the vehicle platooning problem incorporating both lateral and longitudinal control. To that end, we deal with the lateral and longitudinal control problems separately. We consider the lateral control problem as a path following problem. That is, for the following vehicle we determine a path which converges to that of the preceding vehicle. We solve the lateral control problem by assuming that a virtual vehicle is driving along the trajectory of the preceding vehicle, adjusting its velocity for the follower to catch up with it. By associating the position of the following vehicle with the position of the virtual vehicle, we obtain a diffeomorphism from a point on the path of the following vehicle to a point on the path of the preceding vehicle, and vice versa. Subsequently, this diffeomorphism is used when solving the longitudinal control problem. By means of this diffeomorphism we can translate the position of the preceding vehicle to a position on the curve of the follower. As a result, we can consider the longitudinal control problem along the planned path of the following vehicle, effectively reducing it to a standard CACC problem of controlling two points on a straight line towards a required inter vehicle distance, as studied in [1]. An advantage of our approach is that once the following vehicle is on the path of the preceding vehicle, it stays on that path. In particular this implies that for curved paths corners are not cut. We illustrate the benefits of our approach by means of simulating a platoon consisting of five vehicles, see Figure 1.

Next step is to implement our controller in an experimental setup. A special point of interest will be the communication of planned trajectories to downstream vehicles. In our simulations we communicate all points generated by the ODE solver and use splines for fitting the intermediate points required downstream. How to obtain satisfactory results while keeping the required communication to a minimum is in particular worth investigating. Another point of interest is to improve the lateral controller. Similar to tracking control of marine vessels, we could define a desired orientation of the following vehicle pointing towards the virtual vehicle. By controlling the orientation of the following vehicle towards this desired orientation we focus even more on first converging towards the desired path and only then on following the path. Next, we want to improve the longitudinal controller by incorporating constraints on velocity and acceleration. A final point of interest is in updating the mapping between the paths of preceding and following vehicle based on relative position measurements.

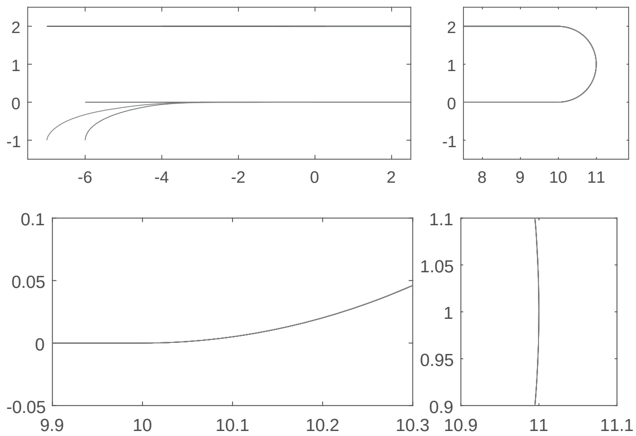

Figure 1: Resulting paths for platoon of five vehicles. Zooming in to the transition point from straight line to circle clearly shows that paths remain indistinguishable: corners are not cut. The same holds halfway the circle.

References

[1] J. Ploeg, N. van de Wouw, and H. Nijmeijer. Lp string stability of cascaded systems: Application to vehicle platooning. *IEEE Transactions on Control Systems Technology*, 22(2):786–793, 2014.