

# Worst-case performance analysis of autonomous vehicle platoons

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## Abstract

Autonomous vehicle platoons are aimed at increasing road capacity and reducing fuel consumption while increasing the level of safety. Among the difficulties in the analysis of vehicle platoons in this thesis the effects of communication delays are examined.

A vehicle platoon is a string of vehicles, where the lead vehicle is driven by a human driver and the drivers of the follower vehicle are replaced by automatic controllers. The goal of a vehicle platoon controller is to minimize the distance between the vehicles. Numerous control strategies are discussed in the literature, we consider a leader and predecessor following control architecture with constant spacing policy.

One important property of vehicle platoons is string stability, which ensures that the intervehicular spacing errors stay uniformly bounded along the platoon when a disturbance occurs. In this thesis we compute the worst-case (largest possible) gains of the system describing the controlled platoon between a disturbance input and spacing errors. The intervehicular communication network can be modeled with delays, or as a sampled data network. In this thesis the platoon model is described by a time-delay system.

For performance analysis of a time-invariant delay system different methods are presented based on delay-independent, simple delay-dependent and discretized complete Lyapunov-Krasovskii functional. For time-varying delays a method is demonstrated based on a Lyapunov-Krasovskii functional with triple integrals.

In the platooning problem disturbances and their delayed values simultaneously act on the system. Only a few paper investigate the performance of a system with disturbance input delay. By considering the actual and delayed inputs as two independent inputs gives a highly overestimated worst case gain. Two more methods are proposed, one transforms the input delay to state delay, and the other one is a scaling method. All these methods are considered for time-invariant and also for time-varying delays.

The contributions of this thesis are twofold: present different methods for worst-case performance analysis of state and input delay systems and test these methods in terms of accuracy and computational complexity when applying them to autonomous vehicle platoons.