
Distributed High-Gain Observer Design of Interconnected Nonlinear Systems for Vehicle Platoon Application

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Abstract

This paper addresses the state estimation problem for a class of interconnected nonlinear multi-agent systems, with a primary motivation from vehicle platoon applications. The triangular dependency inherent to platoons results in highly coupled estimation error dynamics. These coupled dynamics are difficult to analyze directly, presenting a significant challenge for constructive observer design. Our approach begins by decomposing the error into its average and consensus components. The innovation of this work lies in proposing a set of sufficient LMI conditions that enable the transformation of the coupled quadratic forms from the Lyapunov analysis into a tractable convex optimization problem. The obtained solution provides a constructive design of a distributed high-gain observer that ensures exponential convergence of the estimation error while providing explicit lower bounds on all observer gains. The effectiveness of the proposed design is validated through simulations on a nonlinear vehicle platoon model, confirming its relevance for practical automotive applications.

Keywords: Nonlinear observer, distributed observer, high, gain observer, vehicle platoons

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