

The Evolution of the Distributed Observer and Its Applications

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Abstract—A typical multi-agent system is composed of a follower system consisting of multiple subsystems and a leader system whose output is to be tracked by the output of each subsystem of the follower. What makes the control of a multi-agent system interesting is that the control law needs to be distributed in that it must satisfy time-varying communication constraints. A special case of the distributed control is where all the subsystems of the follower can access the full information of the leader. For this special case, one can design, for each follower subsystem, a conventional control law based on the information of the leader and this follower subsystem. The collection of these conventional control laws constitutes the so-called purely decentralized control law for the multi-agent system. Nevertheless, the purely decentralized control is not feasible as it violates the communication constraints. In this talk, we will elucidate a framework for designing a distributed control law by cascading a purely decentralized control law and a so-called distributed observer for the leader system, which is a distributed dynamic compensator capable of estimating the information of the leader and transmitting the estimated information to each follower subsystem over the communication network of the multi-agent system. Such a framework has found its applications to a variety of problems such as consensus, flocking, formation, cooperative output regulation, distributed Nash equilibrium seeking, and so on. The core of this design framework is the distributed observer for the leader system, which was initiated in 2010 for dealing with the cooperative output regulation problem and has experienced three phases of developments. In the first phase, the distributed observer only aimed at estimating the state of the leader over the communication network assuming that every follower subsystem knows the dynamics of the leader. In the second phase which started in 2015, the distributed observer was rendered the capability of estimating not only the state but also the dynamics of the leader over the communication network assuming that only the children of the leader know the information of the leader. Such a dynamic compensator is called an adaptive distributed observer for a known leader system. The distributed observer was further enhanced in 2018 for linear leader systems containing unknown parameters, thus entering its third phase of the development. Such a dynamic compensator is called an adaptive distributed observer for an unknown leader system as it not only estimates the state but also the unknown parameters of the leader. The talk will start with an overview on the development of the distributed observer and then highlight our ongoing effort on establishing the output-based adaptive distributed observer for an unknown leader system over jointly connected communication networks. The talk will end with some extensions and applications of the distributed observer.

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