Seminar: Dr. Diego Deplano “Stability of Nonlinear Monotone Systems and Consensus in Multi-Agent Networks”

2023-09-18 at 16:00, Nyquist room or https://kth-se.zoom.us/j/62832892705

Welcome to a seminar by Dr. Diego Deplano, assistant professor at the University of Cagliari, Italy.

Title: Stability of Nonlinear Monotone Systems and Consensus in Multi-Agent Networks

Abstract: The study of how autonomous agents coordinate themself to achieve a desired global behavior, resulting solely from local interactions between agents, has spurred much interest within the control community. Systems composed of multiple interacting agents are often called Multi-Agent Systems (MASs). A compelling global behavior that has captured the attention of many researchers is the agreement or consensus among the agents. From a control system perspective, the consensus problem consists in the design of local interaction rules between agents to ensure their state variables converge to the same value, known as the consensus state. The scenario of agents modeled by linear discrete-time dynamical systems has been thoroughly investigated. The asymptotic behavior of a linear MAS is described by a matrix, typically assumed to be nonnegative (with all entries being zero or positive) and row-stochastic (with all row-sums equal to one), and its powers. Consequently, the theory for consensus in linear MAS has its roots in the theory developed by Perron and Frobenius for nonnegative matrices. The tightest result dictates that a MAS whose matrix is nonnegative and row-stochastic achieve consensus if and only if the graph associated to the matrix contains a globally reachable node, and the subgraph of globally reachable nodes is aperiodic. In this talk we discuss the case of a network of agents modeled by nonlinear discrete-time dynamical systems, whose asymptotic behaviour is fully described by a map assumed to be (type-K) monotone and plus-homogeneous, which are the nonlinear counterpart of nonnegativity (with positive diagonal) and row-stochasticity, respectively. The key findings are as follows:

1. We prove that nonlinear discrete-time dynamical system whose map is type-K monotone and plus-homogeneous asymptotically converges to a fixed point of the map, or equivalently, to an equilibrium point of the system, if any exists.
2. We derive necessary and sufficient conditions on the local agents’ dynamics and their reciprocal interaction in order to guarantee that the interconnected system falls into the above-mentioned class.
3. We provide the link between the above result and graph theory by proving that the existence of a globally reachable node in the communication network is sufficient to restrict the set of equilibrium points to those of consensus.
4. We discuss how these findings extend to continuous-time systems that are smooth and monotone.

The literature of nonlinear MASs mostly consists of ad-hoc solutions based on Lyapunov theory. In contrast, the innovative aspect of our approach is that it provides stability results and convergence to consensus as a special case without the need of exploiting Lyapunov theory. Thus, the range of possible applications is wide due to the general nature of the

approach, such as multi-robot coordination, distributed optimization, opinion dynamics, and many more.

Bio: Dr. Diego Deplano is Assistant Professor (RTD-A) at the Department of Electrical and Electronic Engineering, University of Cagliari, Italy. He received the B.S., M.S., and PhD degrees in Electronic Engineering “cum laude” from the University of Cagliari, Italy, respectively in '15, '17, and '21. He was awarded the best PhD Thesis defended in the area of Systems and Control Engineering at an Italian University by SIDRA. He spent visiting periods at the Nanyang Technological University (NTU), Singapore, at the Centre National de la Recherche Scientifique (CNRS), Grenoble, France, and at the University of Toronto (UofT), Toronto, Canada. His research interests include nonlinear multi-agent systems, consensus problems, distributed estimation, positive systems, and mobile robotics.

The organizers,

Nicola Bastianello, Karl H. Johansson