Politecnico di Torino
Department of Control and Computer Engineering

IEEE CSS Italy Chapter
Seminar Series

A step towards decarbonization: the role of distributed coupled constraint optimization in energy systems

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Abstract: This talk is divided into two parts. In the first part, we consider constraint-coupled optimization problems where agents in a network aim to cooperatively minimise the sum of local objective functions subject to individual constraints and a common linear coupling constraint. To solve this problem, we propose a solution that embeds a dynamic average consensus protocol in the parallel Alternating Direction Method of Multipliers (ADMM) to design a fully distributed scheme for the considered setup. Convergence to the optimal solution is proved using recent advanced results in the theory of time-scale separation in nonlinear systems. The rate of convergence is shown to be linear under standard assumptions on the local cost functions. Interestingly, the algorithm is amenable to direct implementation to deal with asynchronous communication scenarios that may be corrupted by other non-idealities such as packet loss. In the second part of the talk, we show how the considered optimization scenario often arises in the modelling and control of energy systems. In particular, we focus our attention on the optimal management of the distributed resources populating Energy Communities (ECs). The concept of ECs was introduced by the European Community in the Clean Energy for all Europeans (CEP) package in 2019, as a means to enable citizen-driven energy actions to support the clean energy transition. We envisage that the smart design and management of ECs could pave the way for significant actions to decarbonise our planet.

An opinion-dynamics framework for resilient multi-agent systems

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Abstract: Multi-agent control systems span a wide range of applications such as multi-robot swarms, energy and distribution networks, wireless sensor networks. While autonomous agents with no centralized coordination are motivated by enhanced robustness and scalability of operations, distributed coordination exposes the system to vulnerabilities caused by cascading failures and cyberattacks by external intruders. This talk proposes a solution approach inspired by opinion dynamics and progresses along three steps. First, focusing on the relevant problem of distributed consensus, a resilient consensus approach that uses the Friedkin-Johnsen model is proposed. The key takeaway is that the resilience of standard consensus protocol can be significantly enhanced by adding a small competition term that makes normal agents a little selfish, mitigating the effects of faulty and malicious agents. Second, we extend this approach to distributed learning, where the agents aim to learn a common machine learning model. In this scenario, the proposed approach enhances both resilience and personalization of learned local models; that is, each agent has the flexibility to tailor its local model to its local data distribution. Finally, we consider the scenario where additional information, provided by a physical channel used by agents to exchange data, such as the physical layer of a wireless network, can be exploited to provide cues about the trustworthiness of received transmissions. In this case, by designing a vanishing competition term, we prove that the agents recover a resilient consensus under mild conditions. Further, their performance exhibits a tradeoff between speed of convergence and the optimality of the final consensus value (with respect to the nominal attack-free system), which can be tuned through the scalar competition parameter.

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