DOI: 10.1002/oca.2842

GUEST EDITORIAL

WILEY

Optimal control of networked and transportation systems

This special issue is concerned with the optimal control of systems over networks and the use in transport system applications. Among the many available control techniques, optimal control presents several advantages, as it allows one to formalize the control problem as the maximization of a given performance criterion. Furthermore, optimal control can deal with nonlinear dynamics and constrained systems. The main downside of optimal control is the computational complexity of solving a constrained maximization problem. Additionally, in order to introduce feedback, the problem is solved online repeatedly, such that the computations must be real-time feasible. This feedback strategy is referred to as model predictive control and is nowadays one of the most successful approaches. A large research effort has been devoted to the derivation of various problem formulations and algorithmic frameworks which yield reliable controllers with a good trade-off between optimality and computation time. This made it possible to apply Optimal control and MPC to a wide spectrum of applications, ranging from the classical process control of industrial plants to vehicle dynamics, robotics, power systems and biological systems. Recently, particular interest has been devoted to the design of optimal control strategies for networked and transportation systems, which are typically spatially distributed large-scale systems, therefore posing severe challenges in terms of computational reliability and burden.

Networked systems are multi-agent systems, where each agent is connected via a communication medium which allows the exchange of various signals. This setting is very promising as it opens the possibility to control increasingly complex and spatially distributed systems, but is also particularly challenging due to the presence of, e.g., constraints to access the medium, the occurrence of delays, and losses over the communication lines, which can deteriorate the performance and even cause instability. The challenges, however, are not restricted to the control side of the problem, but also involve the optimization algorithms which must be adapted to the networked setting. One important class of networked systems is that of transportation systems, which has recently attracted increasing interest. In this specific context, the unprecedented rise in traffic of the last decades further poses additional issues such as, e.g., congestion, accidents and pollution.

This special issue aims at providing novel insights in how optimal control strategies can be applied to networked control systems, by covering both system theoretical and algorithmic aspects while also providing relevant applications related to transportation systems. A first group of papers [1–3] focuses on algorithms and theoretical guarantees. A toolbox for efficient networked nonconvex optimization is proposed which is able to exploit the structure present in the problem to distribute computations while guaranteeing fast convergence [1]. An algorithm that yields approximate optimality for control and communication schedule co-design is developed with guarantees of robust constraint satisfaction [2]. A clustering algorithm combined with MPC is also proposed for large-scale networks, e.g., of electric type with the goal of efficiently coordinating distributed generators to balance unexpected load variations with respect to nominal forecasts [3].

A second group of papers [4,5] considers transport systems applications of networked optimal control theory. A scenario-based optimized controller tuning is proposed to maximize the throughput while accounting for the current traffic situation and, therefore, optimize the infrastructure utilization [4]. A double-layer predictive control for hybrid powertrain, using currently available vehicle-to-everything information and cloud computing, is developed and assessed on a real case study [5].

In summary, this special issue provides a fresh view on the most recent developments in optimal control of networked and transportation systems, by considering theory, algorithms, and applications.

Gian Paolo Incremona[1]
Mario Zanon[2]

[1]*Dipartimento di Elettronica, Informazione e Bioingegneria Politecnico di Milano, Piazza Leonardo da Vinci 32, 20133, Milan, Italy*
[2]*IMT School for Advanced Studies Lucca, Piazza San Francesco 19, 55100 Lucca, Italy*

REFERENCES

1. Engelmann A, Jiang Y, Benner H, Ou R, Houska B, Faulwasser T. ALADIN-α – An open-source MATLAB toolbox for distributed non-convex optimization. *Optimal Control Applications and Methods*. 2022.
2. Bahraini M, Zanon M, Colombo A, Falcone P. Optimal scheduling and control for constrained multi-agent networked control systems. *Optimal Control Applications and Methods*. 2022.
3. La Bella A, Klaus P, Ferrari Trecate G, Scattolini R. Supervised MPC control of large-scale electricity networks via clustering methods. *Optimal Control Applications and Methods*. 2022.
4. Pasquale C, Sacone S, Siri S. Optimization of time-varying feedback controller parameters for freeway networks. *Optimal Control Applications and Methods*. 2022.
5. Deng J, Adelberger D, Del Re L. Communication-based predictive energy management strategy for a hybrid powertrain. *Optimal Control Applications and Methods*. 2022.