Guest Editorial - Innovative control approaches for smart transportation systems

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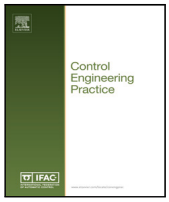

Editorial

Guest Editorial: Innovative control approaches for smart transportation systems

1. Introduction

Transportation systems are a broad research area that has brought in the past and still brings many relevant challenging issues to be studied for the control community. The importance of transportation systems in the daily life and the need for efficient, synchronized, safe and sustainable mobility systems has led, indeed, to a higher interest by the research community towards the development of automatic control methods and tools for the analysis, supervision and management of transportation systems. The research in this field has been further revitalized in recent years, thanks to the development of new technological advances towards autonomous and connected vehicles, smart mobility, and unmanned aerial vehicles, which represent new challenges for researchers all over the world.

In this Special Issue we include 9 papers that propose innovative control methods for managing transportation systems of different types, showing, on the one hand, the prominent role of transportation systems for real-life applications and, on the other hand, important challenges for the development of theoretical investigations for systems and control engineers.

2. Contents of the Special Issue

This Special Issue includes 9 contributions selected among the papers accepted to the 16th IFAC Symposium on Control in Transportation Systems, held virtually in 6–8 June 2021 and organized by the University Gustave Eiffel, France.

The topics addressed by these papers cover a wide variety of problems arising in transportation systems, such as:

- vehicular traffic control, both in freeways and in urban areas;
- control of vehicles, including autonomous vehicles and platoons;
- control of railway systems;
- air traffic management and control;
- control of robotic systems for transportation applications.

All these contributions are characterized by a common goal, i.e. devising innovative control approaches for real-life large-scale applications, with a strong focus not only on the efficiency of the proposed algorithms but also on their computational burden, showing that these two aspects are essential for the effectiveness of transport systems engineering practice.

Among the papers on *vehicular traffic control*, Jeschke, Sun, Jamshidnejad, and De Schutter (2023) propose a parameterized Model Predictive Control approach for urban traffic networks that uses Grammatical Evolution to construct continuous parameterized control laws on the basis of a simulation-based training framework. The main goal is to guarantee high performance of the controller and, at the same time, computational efficiency for the real application in large-scale traffic networks. Malekzadeh, Yanumula, Papamichail, and Papageorgiou (2023) consider instead highways and arterials, in which lane-free vehicle driving is considered for connected automated vehicles. In order to apply the control in large traffic systems, two different overlapping decentralized control schemes for internal boundary control are applied, which can be deployed in real-time.

The control of *connected and autonomous vehicles* is addressed by Liu, Zhou, Wang, and Peeta (2023) who consider a mixed traffic scenario with autonomous vehicles and human-driven vehicles coexisting in the same road. Specifically, deep reinforcement learning-based proactive longitudinal control is proposed for connected and autonomous vehicles to counteract disruptive lane-change behaviors of human-driven vehicles. Németh and Gáspàr (2023) investigate collision-free motion control strategies for automated road vehicles that have to interact. Such strategies have a hierarchical structure, composed of a high-level learning-based control, a low-level robust control and an optimization-based supervisor. Automated vehicles are also studied by Kapsalis, Sename, Milanes, and Molina (2022) for a path-following system, in which a Linear Parameter Varying controller based on the polytopic approach is introduced. The proposed steering system is based on the reduction of the initial three-dimensional polytope by reducing the number of vertices and the volume of the polytope that includes the parameter variations, i.e. the longitudinal velocity of the car, its inverse and the look-ahead distance of the steering algorithm.

A relevant application of connected and autonomous vehicles is related with *platooning*, as treated by Miekautsch, Seeland, Horn, and Fay (2023), considering heterogeneous platoons composed of different vehicle types or brands in which disturbances, such as the cut-in of a foreign vehicle or the emergency braking of the entire platoon, must be handled. The paper presents a mechanism for switching the communication topology depending on the current driving situation in order to prevent collisions within the platoon.

Railway control is another important topic in transportation systems, addressed by Marlière, Richard, Pellegrini, and Rodriguez (2023). The authors of this paper tackle the real-time railway traffic management problem, in which the optimal choices for train schedules and routes must be found to minimize delays due to conflicts. They propose a constraint programming algorithm exploiting the concept of conditional time-interval variables and applying specific constraint propagation techniques for increasing the efficiency of the algorithm.

Toratani, Yoshihara, and Senoguchi (2022) examine another important area of transportation systems control, that is *air traffic control*,

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with specific attention to arrival spacing of aircraft. Indeed, one of the tasks of air traffic controllers is to maintain appropriate longitudinal separation between the leader and the follower aircraft to avoid the effects of wake turbulence. The support algorithm proposed in the paper is based on a trajectory estimation that is generated by applying Gaussian Process Regression.

Many *robotic applications* can be found in transportation systems, often involving contacts with humans, thus requiring that safety and task requirements are satisfied. Torta, Reniers, Kok, van de Mortel-Fronczak, and van de Molengraft (2023) investigate supervisory controller synthesis for applications based on Robotic Operating Systems. They present a formalization of the mapping between concepts from supervisory control theory and Robotic Operating Systems addressing the development of event-driven controllers for generic robotic applications based on the inter-process communication protocols provided by the Robotic Operating System.

Declaration of competing interest

The authors have no conflict of interest to declare.

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