Open Invited Track Proposal
,,Recent trends in modeling, estimation and control with PDEs"

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1 Abstract

Although analysis of distributed parameter systems has a long history and tradition, they have in recent years evolved as one of the fundamental mathematical descriptions of many technical processes and scientific observations. The distributed parameter description in terms of partial differential equations (PDEs) is an essential ingredient of the modeling and analysis process if the spatial or property-related distribution of the process variables can no longer be neglected. As a result, control and observer design has to explicitly take into account the resulting spatial-temporal system dynamics. With the proposed open invited track entitled ,,Recent trends in modeling, estimation and control with PDEs" the organizers aim to realize a joint forum addressing the very recent developments in this field. To foster the methodological developments it is desired to also include application papers that provide case studies illustrating and confirming the increasing interest in modeling, estimation and control approaches for systems governed by PDEs.

2 Association to Technical Committee

IFAC Technical Committee 2.6 Distributed Parameter Systems

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3 Description of the Topic

The topics of this open invited track are the *mathematical modeling and the development, design and evaluation of control and estimation concepts for distributed parameter systems* governed by partial differential equations (PDEs).

The analysis and the control of distributed parameter systems has in recent years gained increasing attention and importance. This is on the one hand driven by the availability of methods and tools enabling the detailed resolution of the temporal and the spatial dynamics even of complex multi-physics systems. On the other hand, new application areas evolve, which rely on the study and utilization of the spatial-temporal system dynamics. Selected examples include smart, flapping, and flexible structures and their interaction with fluids in aerospace applications, reaction processes and devices in chemical engineering and biotechnology, fusion reactors, energy generation, storage and distribution, quantum systems and quantum computing, or interconnected multi-agent systems. The dynamic operation of these systems essentially relies on sophisticated control and observer strategies that explicitly address the spatial-temporal system dynamics. Moreover, the ever stringent environmental regulations, increasing safety requirements and technological progresses for key technologies such as semiconductor manufacturing, space and aerospace, biotechnology and nanotechnology have motivated extensive research on analysis and control of complex distributed systems across all engineering disciplines. For this, infinite-dimensional systems and control theory has been developed and is continuously refined to provide a unifying mathematical framework to address the arising analysis and design tasks.

Model-based feedback control for distributed parameter systems can in general be classified in terms of early and late lumping. In the early lumping approach, the process model is approximated using, e.g., finite-difference or finite-element techniques, proper orthogonal decomposition, or weighted-residual methods prior to the control design. As a result, well-developed methods from linear and nonlinear finite-dimensional control theory can be applied for control and observer design. However, depending on the order of approximation, the early lumping approach does lead to high-dimensional and complex feedback control structures. In addition, the neglected dynamics may lead to a degradation of the control performance or even result in the destabilization of the closed-loop system due to the well-known control and observer spillover. Furthermore, for nonlinear distributed parameter systems the validity of the finite-dimensional approximation and hence the determined controller is usually restricted to a certain subset of the state space. Contrary, in the late lumping approach the control and observer design is directly based on the distributed parameter model to cope with the infinite-dimensional system description while retaining implementable control laws. Besides its theoretically appealing nature this in particular enables a rigorous extension of finite-dimensional systems and control theory to systems governed by partial differential equations, see, e.g., the monographs Curtain and Zwart (1995); Luo et al. (1999); Tröltzsch (2005); Tucsnak and Weiss (2009); Jacob and Zwart (2012); Meurer (2013) for modern and comprehensive treatises.

In this open invited track it is desired to provide a well-balanced combination of state-of-the-art theoretical results and their applications for mathematical modeling, structure-preserving approximation, model-based analysis, and control as well as observer design for distributed parameter systems. Researchers will be brought together who employ distributed parameter methods for modeling, control and approximation, to present to the control community the benefits of the numerous uses of distributed parameter systems and to further stimulate activities in this important research area. The proposed track will provide a forum for presenting and discussing the latest developments on theoretical, applied and computational aspects of the control of distributed parameter systems by leading researchers. The organizers aim to include contributions from both junior and senior faculty across different academic disciplines, i.e.,

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electrical engineering, mechanical engineering, chemical engineering, applied mathematics, and representing different geographic regions. While all contributions will center around the track theme, they should cover a wide range of theoretical topics and applications that are great interest to control researchers from academia and industry.

4 Measures

The track organizers are chair and co-chair of the IFAC Technical Committee 2.6 Distributed Parameter Systems and have jointly organized the first edition of the newly established workshop series IFAC CPDE (Control of Systems Modeled by Partial Differential Equations). In addition, both have served as organizers of numerous invited sessions at IFAC conferences, symposia and workshops as well as at the IEEE ACC, IEEE CDC or the ECC. The TC internal newsletter and several international mailing lists will be used to propagate informations about this open invited track. The corresponding IEEE CSS Technical Committee on Distributed Parameter Systems will be actively involved. In addition, researchers in industry will be actively approached to increase the number of contributions considering applications of control and observer design techniques for distributed parameter systems.

References

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