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Model Predictive control and estimation of linear transport-reaction systems

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Abstract:

Distributed parameter systems (DPS) are ubiquitously present as models of fundamental conservation laws and in process control, manufacturing, transport systems and/or human society. The major drawback of DPS models is that they take form of partial differential equations containing higher order derivatives in space and time. The complexity of a partial differential equation (PDE) in the case of linear PDE models lies in necessity of modellers to account for model spatial characteristics by an approximating underlying model through some spatial approximation arriving to a finite dimensional model representation amenable for subsequent control, observer and/or monitoring device design.

This work provides foundation for systematic development of modelling framework for a linear DPS system which uses a finite and low dimensional setting for the controller/observer/estimator design without application of any spatial approximation or order reduction. In particular, we are interested in formulating control design methodology for a general class of linear DPS systems which in this work account for an optimal constrained optimization based setting. In addition to classical chemical process systems, we also address wave and beam equation system which accounts for a large class of distributed parameter systems. In this work, the discrete model of a distributed parameter system is obtained by using energy preserving Cayley-Tustin discretization. Discrete DPS models are low dimensional, energy preserving and do not dissipate numerically. In particular, discrete setting is amenable to an explicit, economic and/or a classical model predictive control setting realization, with emphasize on the different slight variations in realization of constrained finite dimensional controllers. Having this in mind, the model predictive control is designed by utilizing standard optimal control law with input or/and state/output constraints. The issues of stabilization, optimality and constrained stabilization are addressed for an infinite-dimensional system in this work. In addition, we also address the state estimation in this setting which allows practitioners to extend freely finite dimensional concepts to the PDE models. Finally, the controller performance is assessed by numerical simulation with application on different distributed parameter systems.

Biography:

Dr. Stevan Dubljevic received his Ph.D. in 2005 from the Henry Samueli School of Engineering and Applied Science at University of California in Los Angeles (UCLA), M.S. degree (2001) from the Texas A\&M University (Texas), and the B.Sc. degree (1997) from the Belgrade University (Serbia). He held independent post-doctoral researcher position at the Cardiology Division of the UCLA's David Geffen School of Medicine (2006-2009). He is the recipient of the American Heart Association (AHA) Western States Affiliate Post-doctoral Grant Award (2007-2009) and the recipient of the O. Hugo Schuck Award for Applications, from American Automatic Control Council (AACC) 2007. His research interests include systems engineering, with the emphasis on model predictive control of distributed parameter systems, dynamics and optimization of material and chemical process operations, computational modelling and simulation of biological systems (cardiac electrophysiological systems) and biomedical engineering. He is the reviewer for the IEEE Transaction on Automatic Control, IEEE Transaction on Control Systems Technology, Automatica, Industrial & Engineering Chemical Research, International Journal of System Science, American Control Conference, Conference on Decision and Control, and program coordinator for the AIChE Annual Meetings (2014).