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Special Issue on Robust Stability and Control of Large-Scale Nonlinear Systems

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In a broad sense, large-scale systems theory is concerned with the analysis and design of often very high-dimensional systems that admit some kind of partition into smaller subsystems. Research in linear large-scale systems analysis and synthesis can be traced back to at least the 1970s. Recently, interest in this subject has been revived by new developments in nonlinear systems and control, which include but are not limited to dissipative systems theory, input-to-state stability, and various Lyapunov and small-gain design schemes.

Systems and control theory itself has seen many important advances since the 1970s, including for example concepts like control Lyapunov functions, effective implementations of nonlinear model predictive control, or entire emerging areas like hybrid systems and cooperative multi-agent systems. Naturally, these developments also leap into the area of large-scale systems. It is hence to be expected that the interest in this area will continue to increase, ultimately also due to, e.g., current research efforts in distributed model predictive control, next generation smart electricity grids, incorporating green and renewable energy sources, or bio- and neuro-engineering.

Many questions are associated to the theory of large-scale systems. A quite central one is about sufficient conditions on interconnections of a number of stable systems such that the composite system is also stable. Another one is how individual subsystems must be designed or controlled to achieve some common control objective in a decentralized way. Intricacy is added when

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stability is supposed to be robust against loss of information exchange among subsystems, model and input uncertainties, or in the presence of saturation, quantization, or time-delays. Conceptually related are problems referred to as flocking, synchronization and desynchronization, as well as consensus finding.

This special issue showcases some of the recent advancements in the field, concentrating on robust stability notions. A recent theme in large-scale systems is *generalized small-gain conditions*. Roughly speaking, they provide *sufficient* conditions for a network of stable subsystems to be stable, and they come in a variety of shapes, including cyclic contraction conditions over cycles in the interconnection graph of a network, conditions on the image of an operator describing the interconnection structure, and also comparison principles via lower dimensional artificial systems describing the dynamic interconnection topology of the network, see the references given in individual articles.

In "Numerical construction of LISS Lyapunov functions under a small gain condition" by Geiselhart *et. al.* such a small-gain approach is taken, with the added advantage of a numerical scheme that aids the practitioner in the stability analysis. A related stability problem for interconnected time-delay systems, with interconnections also subject to delays, is investigated by Gielen *et. al.* in "Input-to-state stability analysis for networks of difference equations with delay." In contrast to these sufficiency results, the question whether or not such small-gain type conditions are also necessary is pursued in "Necessary conditions for global asymptotic stability of networks of iISS system" by Ito.

While the analytic perspectives provided by the aforementioned contributions could also be used to find new design tools, this special issue also addresses the issue of stabilization. In "Quantized stabilization of strict-feedback nonlinear systems based on ISS cyclic-small-gain theorem" by Liu *et. al.* a quantized nonlinear control design of systems in strict feedback form is performed. A quite different scenario is considered in "ISS Lyapunov functions for time-varying hyperbolic systems of balance law" by Prieur *et. al.*, where partial differential equations are stabilized by selecting suitable boundary conditions. A special backstepping procedure to find a stabilizing control that guarantees the ISS property for an interconnection of switched systems in a generalized triangular form was achieved by Dashkovskiy *et. al.* in "Global uniform input-to-state stabilization of large-scale interconnections of MIMO generalized triangular form switched systems." A seemingly opposite objective, namely desynchronization of coupled oscillators is rigorously investigated in "Desynchronization and inhibition of Kuramoto oscillators by scalar mean-field feedback" by Franci *et. al.* for the case of Kuramoto-oscillators.

We do hope that while collecting the latest theoretical achievements and highlighting contemporary applications in the area of large-scale systems theory, we were also able to motivate and enable readers, in particular younger graduates, to join this newly revived research direction. Finally, we thank all the authors of this special issue, and in particular the reviewers who did a fantastic job by assessing quite long and intense manuscripts in a comparatively short time. We would also like to extend these thanks to the Editors-in-Chief of *MCSS* for giving us the opportunity to organize this special issue.