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Editorial

Chemical Process Control

Model uncertainties and nonlinearities are prevalent in chemical process control problems. As a consequence, the majority of industrial applications of robust control and nonlinear control algorithms are found in chemical process operations. The list of successful application examples is extensive, including semiconductor processing, materials manufacturing, electrochemical, pharmaceutical, and biological/biomedical processes, as well as most processes for the production and consumption of energy, such as oil refining, fuel cells, and combustion. This Special Issue features design methods for chemical process control problems, with a focus on key issues such as model uncertainties, nonlinearities, discrete decision-making, and constraints.

The Special Issue consists of five contributions with motivating applications ranging from the high-speed adaptive control of micro-array reactors to the scheduling of research and development pipelines to the control of gas flow networks and of blood glucose in humans. Control methodologies cover a wide range of techniques for nonlinear and robust control including adaptive control, robust nonlinear control, nonlinear model predictive control, run-to-run control, and Q-learning. The content of the individual papers are summarized below:

- Schweickhardt and Allgöwer combine robust control theory and nonlinearity measures to develop a linear controller design procedure for mildly nonlinear processes, and illustrates the approach for a reactor for producing cyclopentenol.
- Srinivasan proposes a real-time adaptive control algorithm with very fast adaptation for dynamic systems with multiple units, suitable for parallel units used in flexible manufacturing as well as for micro-array reactors in microchemical systems.
- Palerm, Zisser, Jovanovic, and Doyle propose a new run-to-run control algorithm to adjust the meal-related insulin dose based on blood glucose measurements, and analyse the robustness of the algorithm to the sources of uncertainty typically encountered in clinical use.
- Choi, Realff, and Lee propose a Q-learning method for solving stochastic resource-constrained project scheduling problems in which the candidate projects evolve with time, and apply the approach to a research and development pipeline problem. Markov chains are used to model the key uncertainties which include the duration, cost, and result of a task.
- Long, Polisetty, and Gatzke develop a global optimization algorithm for solving nonlinear model predictive control problems for systems exhibiting nonlinear hybrid dynamics, and apply the approach to a gas flow network.

The contributions are representative of the current status of the field of chemical process control, which has steadily increased its efforts to address broader issues such as the inclusion of discrete decision-making as part of the control problem (see the papers on scheduling and hybrid systems), and to shift much of its focus towards new applications areas such as microchemical systems and biomedicine. A consistent theme throughout these applications problems is the need to address nonlinearity and robustness, often within contexts beyond the standard feedback controller design problem. It is the hope of the Guest Editors that these contributions will motivate the development of further control theory for addressing these problems.

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