Preface

Traditionally, process control systems rely on control architectures utilizing dedicated, wired links to measurement sensors and control actuators to regulate appropriate process variables at desired values. While this paradigm to process control has been successful, we are currently witnessing an augmentation of the existing, dedicated control systems, with additional networked (wired and/or wireless) actuator/sensor devices which have become cheap and easy-to-install. Such an augmentation in sensor information, actuation capability and network-based availability of data has the potential to dramatically improve the ability of process control systems to optimize closed-loop performance and prevent or deal with abnormal situations more effectively. However, augmenting dedicated control systems with real-time sensor and actuator networks poses a number of new challenges in control system design that cannot be addressed with traditional process control methods, including: (a) the handling of additional, potentially asynchronous and delayed measurements in the overall networked control system, and (b) the substantial increase in the number of process state variables, manipulated inputs and measurements which may impede the ability of centralized control systems (particularly when nonlinear constrained optimization-based control systems like model predictive control are used), to carry out real-time calculations within the limits set by process dynamics and operating conditions.

This book presents rigorous, yet practical, methods for the design of networked and distributed predictive control systems for chemical processes described by nonlinear dynamic models. Beginning with an introduction to the motivation and objectives of this book, the design of model predictive control systems via Lyapunov-based control techniques accounting for networked control-relevant issues, like handling of asynchronous and delayed measurements, is first presented. Then, the book focuses on the development of a two-tier networked control architecture which naturally augments dedicated control systems with networked control systems to maintain closed-loop stability and significantly improve closed-loop performance. Subsequently, the book focuses on the design of distributed predictive control systems, that utilize a fraction of the time required by the respective centralized control systems, to cooperate in an efficient fashion and to compute optimal manipulated input trajectories that achieve the desired stability, performance, and robustness for large-scale nonlinear process networks. Throughout the book, the control methods are applied to large-scale nonlinear process networks and wind–solar energy generation systems and their effectiveness and performance are evaluated through detailed computer simulations.

The book requires basic knowledge of differential equations, linear and nonlinear control theory, and optimization methods and is intended for researchers, graduate students, and process control engineers. Throughout the book, practical implementation issues are discussed to help engineers and researchers understand the application of the methods in greater depth.

In addition to our work, Prof. James F. Davis, Dr. Benjamin J. Ohran, doctoral candidates Mohsen Heidarinejad and Xianzhong Chen, and doctoral student Wei Qi, all at UCLA, contributed substantially to the research results included in the book and in the preparation of the final manuscript. We would like to thank them for their hard work and contributions. We would also like to thank all the other people who contributed in some way to this project. In particular, we would like to thank our colleagues at UCLA and the Universidad de Sevilla for creating a pleasant working environment, and the United States National Science Foundation and the European Commission for financial support. Last, but not least, we would like to express our deepest gratitude to our families for their dedication, encouragement, and support over the course of this project. We dedicate this book to them.

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