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BOOK REVIEWS

PROCESS CONTROL, THEORY AND APPLICATION, Jean-Pierre Corriou, Springer, London, U.K., 2004, xx + 752 pp, ISBN 1-85233-776-1

The contents of the book *Process Control, Theory and Application* written by Professor Jean-Pierre Corriou of *Ecole Nationale Superieur des Industries Chimiques* Nancy, France truly reflects its title. The book covers all the relevant topics in the control theory and contains a wide range of application topics. The book is organized in 6 parts. Parts I, II, III and some sections of Parts IV and V are appropriate for an undergraduate course in chemical process control. The rest of the book deals with the topics suitable for a rich graduate course in control theory. The book covers all the concepts of process control necessary for academicians and industrial practitioners. The concepts are clearly described to the extent necessary for easy comprehension and implementation of the topics. The book is replete with a host of very relevant and useful examples. The entire simulation examples are carried out in MATLAB. The only addition that would make the book ideal as an undergraduate and graduate textbook is a set of problems at the end of each chapter.

Part I of the book introduces the basic concepts in the chemical process modelling and control. Chapter 1 deals with the single-input single-output (SISO) systems and the dynamic modelling of such processes from a control engineer's viewpoint. First principle approach is used to develop models for typical chemical processes in the state space domain. The chemical processes considered are lumped-parameter processes, staged processes, and distributed parameter systems. The concepts of the degrees of freedom and stability are discussed. Reduction of the models to linearized models and their transformation into the Laplace domain are clearly demonstrated. The transfer function model is introduced next with an explanation of the effect and significance of system poles and zeros. The response of linear first- and second-order systems is discussed in detail and the concept of the state space modelling is generalized for the SISO systems. Chapter 2 introduces the concept of the linear feedback control. A brief discussion of the general hardware components in a typical PID feedback control loop is discussed. The effect of the various modes of a PID controller on the closed loop performance for first- and second-order systems is demonstrated. Stability analysis is expanded in Chapter 3 both in the s-domain and in the in the time domain. The direct method of Lyapunov is introduced. Routh Hurwitz criterion, root-locus diagram and a brief description of the stability in the frequency domain are discussed. Chapter 4 deals with the detail design criteria of the PID controllers, internal model controllers, pole placement, and linear quadratic control. A pH control system is discussed in detail as an example. The frequency analysis, first introduced in Chapter 3, is expanded in Chapter 5 and the Bode and Nyquist stability criteria are used as guidelines to design SISO feedback control systems. Some frequently occurring dynamic behaviours in chemical processes such as dead time and inverse response are discussed in Chapter 6 and the methods to compensate for them are described. Alternative control algorithms such as cascade control, selective control, split-range control and feedforward control and its realizability are also discussed in this chapter. Chapter 7 introduces the concepts of observability and controllability in the state space domain.

Part II of the book deals with the multivariable control and multi-input multi-output (MIMO) systems. Initially modelling of MIMO systems using the transfer function matrix is introduced and then Gershgorian circles, Niederlinski index, singular value decomposition and relative gain array are used for the analysis and design of the decouplers for the control of such systems. The concept of robustness of multivariable systems is concisely and elegantly covered in the frequency domain and applied to a distillation column. The discrete internal model control (IMC) is presented for multivariable systems.

Part III of the book is concerned with the discrete-time process identification techniques. A detail account of the Fourier transform in continuous and discrete modes is presented. The concept of sampling and the choice of the sampling period, and filtering are introduced. The discretization of continuous models to discrete models using the z-transform is covered. Preliminary properties of the z-transform and inverse z-transform are discussed. Non-parametric and parametric identification principles are discussed in Chapter 10. Both one-step and p-step prediction methodologies are introduced. Time series analysis of autoregressive moving average exogeneous (ARMAX) systems is discussed in Chapter 11. Parameter estimation in the state space domain is introduced and the discrete Kalman filter is introduced. Linearization of nonlinear models in the context of linear parameter estimation theory is discussed and the least squares method, weighted least squares method, the maximum likelihood method, and the instrumental variable method are discussed. Recursive parameter estimation techniques including the least squares, the generalized least squares, the maximum likelihood, and the instrumental variable methods are derived in Chapter 12. The robustness and validation of each technique is clearly demonstrated and a couple of examples are included to illustrate the highlights of each technique.

Part IV of the book deals with the discrete-time control. The discrete SISO pole-placement controller is described and its relation with the state feedback controller is elucidated in Chapter 13. Digital PID and IMC are described and the concept of adaptive controllers is introduced. Chapter 14 deals with the optimal control. The variational method is first introduced. Weierstrass and Hamilton–Jacobi conditions are described and the maximum principle of Pontryagin is introduced. Several examples are used to illustrate the application of the optimal control concepts and the numerical issues are discussed. The dynamic programming is described and the linear quadratic control is revisited. At the close of this chapter the discrete version of the linear quadratic control is presented. Chapter 15 presents an exquisite treatment of the generalized predictive control (GPC), considers an illustrative example and explores the relationship between the GPC and the pole placement control. The GPC with multiple reference and partial reference model is discussed and applied to a chemical reactor. The concept of model predictive control (MPC), widely accepted in the chemical industry, and its predecessors the dynamic matrix control (DMC), the quadratic dynamic matrix control (QDMC) in the state space domain are covered in Chapter 16. Nonlinear QDMC is introduced. The detail description of a fluid catalytic cracking process is presented and its model predictive control simulation is elegantly discussed.

Part V deals with the concept of nonlinear control. Initially the nonlinear geometric control is discussed and the concepts of the relative degree, zero dynamics and some notions of differential geometry are discussed. The principles of feedback linearization, input–output linearization, and globally linearizing control are described. The concepts are discussed in the context of both the monovariable and multivariable systems. In Chapter 18, the concept of state observers is described. The principal component analysis and the partial least squares are discussed. The various types of observers such as Luenberger, extended Kalman filter, globally linearizing and high-gain observers are described.

Part VI applies the concepts introduced in the book to a selection of well-chosen chemical processes with a wide variety of dynamic behaviours. This set of case studies is truly a very useful asset for both the academicians and practicing control engineers in industry. The nonlinear control of a chemical reactor with state estimation and of a biological reactor is discussed in Chapter 19. The dynamic modelling of a distillation column is presented in Chapter 20. Various control algorithms including a SISO feedback controller, a dual decoupling controller, the model predictive control and the nonlinear control are applied for the control of a distillation column. And finally in Chapter 21, the dynamic models of a series of chemical processes used as benchmark examples in the process control literature are presented.

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