Réalisation, Réduction et Commande des Systèmes Linéaires

by Ahmed Rachid and Dris Mehdi
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Well-written as it is this book is a self-contained and concise presentation of modern control theory for deterministic systems, and focusses on some most important results. Linear continuous- and discrete-time finite-dimensional systems are dealt with. The reviewed book summarizes many theoretical results in control system analysis and synthesis, offering to the reader some guidance to effectively using these results.

The book consists of six Chapters and four Appendices.

Chapter 1, entitled *Réalisation des systèmes linéaires* (*Realization of Linear Systems*), deals with structural properties of linear systems, controllability/observability canonical forms, and realization theory based on transfer function matrices, Markov parameters, or impulse response.

Chapter 2, entitled *Réduction de modèles* (*Model Reduction*), describes several time-domain techniques for finding reduced-order models: aggregation, singular perturbations, Schur decomposition, balanced realizations, Padé approximations, and optimal reduction.

Chapter 3, entitled *Commande optimale* (*Optimal Control*), deals with classical optimal regulator problems, mainly for a quadratic performance criterion over a finite or infinite time interval. The essential role of the differential or algebraic matrix Riccati equations is emphasized. The main properties of linear optimal regulators, including the performance degradation due to state observers, are discussed. Integral action, prescribed stability degree, and the inverse problem of optimal control, are also described.

Chapter 4, entitled *Placements de pôles* (*Pole Assignment*), presents several techniques for pole placement: dyadic regulators, Brogan's method, optimal pole allocation (specifying the performances or spectra), etc.

Chapter 5, entitled *Approche entrée-sortie* (*Input-Output Approaches*), is devoted to the polynomial approach for finding adaptive control laws, based either on optimal control, such as (generalized) minimum variance, and generalized predictive control, or on pole assignment.

Chapter 6, entitled *Invariance positive et commande contrainte* (*Positive Invariance and Control with Constraints*), discusses a recently proposed approach to pole assignment for systems with state and/or input constraints.

Four Appendices deal with matrix computations, controllability, solution of Riccati equations, and Diophantine equations, respectively.

Each Chapter can be read as such. A large number of (low-order) illustrative numerical examples is present throughout the text. Each Chapter ends with several proposed exercises, and hints at their solution are given in a special Section of the book. There is a Bibliography Section including many references (grouped by chapters), but not all items include full information. The book ends by a two-page subject index.

While the book describes techniques with theoretical appeal, it lacks the very important, in practice, feeling of numerical issues. None of the methods presented can solve real-world, large-scale problems. For instance, determining the controllable part of a state-space realization based on the controllability matrix (page 19) is a poor numerical method. Likewise, the use of (generalized) eigenvectors is not advisable in practical computations; (generalized) Schur vectors should be preferred. Unfortunately, the authors offer no guidance or bibliographic references to sound numerical techniques which can actually be used in practice. Some methods are not general enough. For example, the pole assignment method based on solving a Sylvester equation (page 120) cannot be directly used if the desired spectrum has a nonempty intersection with the open-loop spectrum; an inefficient approach that solves two pole assignment problems is proposed. Other methods (for instance, Munro's method, page 115) are not well justified. No clear references are made to additional reading where the interested reader could turn to.

There is a number of errors and misprints. For instance, one should add the condition $x \neq 0$ in the stated definition of positive definite matrices (page 206). The matrix W should also be invertible to compute the inverse of the partitioned matrix (page 207). Duality is wrongly defined (page 208): the matrices B^T and C^T should be interchanged. One should replace $i = 0$ by $i = 1$ in the formula for $G(s)$ for simple poles (page 10). One should use ellipsis in the expansions for g_{11}, g_{12}, and g_{22} (page 24). The transposes of the matrices $J_i, J_{i+1}, \ldots, J_{i+q-1}$, should be used on line 5, page 29. On line 6 of the proof of (41) (page 88), one should multiply on the left, and on the right, respectively, by the specified matrices, and not conversely, as stated there, etc.

By its concise, but comprehensive coverage, good organization of the material, the readability of the exposition, the included theoretical results, and by its interesting examples and exercises, the reviewed book can be recommended as an introductory course to control theory or for self-study. The intended audience is formed by control engineers and researchers, as well as students in control engineering and related domains. The assumed background includes basic linear algebra, differential equations, calculus, and classical control theory.

Vasile Sima

Dr. Vasile Sima was born at Lita, Romania, on the 21st of October, 1949. He graduated from the Polytechnical Institute of Bucharest in Control Engineering in 1972, and from the Department of Mathematics at the University of Bucharest, in 1978. He obtained his doctoral degree in Control Engineering (adaptive control) from the Polytechnical Institute of Bucharest, in 1983. Since 1972 he has held several research positions at the Research Institute for Informatics in Bucharest. He is senior research worker and vice-chairman of the Scientific Board of the institute. He is also an Associate Professor at the "Politehnica" University of Bucharest. Dr. Vasile Sima has published more than 100 scientific papers (about half of them were published in international journals and symposia proceedings). He co-authored three books: "Computer-Aided Optimization Practice", "Adaptive and Flexible Control of Industrial Processes", and "Computer Aided Control Systems Engineering: Design Algorithms and Software" (in Romanian), and authored other two books "New Methods in Applied Mathematics" (in Romanian), and "Algorithms for Linear-Quadratic Optimization" (Marcel Dekker, Inc., New York). He is a member of the AMS (American Mathematical Society), WGS (Working Group on Software), and an affiliate member of IFAC (International Federation of Automatic Control). His research interests include automatic control theory, adaptive and optimal control, computer-aided control systems design, nonlinear programming, numerical linear algebra and scientific computations.