The synthesis and design of controllers and estimators for industrial systems is considered, assuming system models are represented in transfer-function or polynomial form. Most of the important optimal control design and signal processing problems, which are amenable to the polynomial systems approach and are of practical significance, are discussed. The catalogue of solutions and the summary of important results should be valuable to control and signal processing students or practitioners alike. The results are easy to implement in computer macros using standard commercially available software which contains Diophantine equation and spectral factorisation solution algorithms.

The applications chapters provide a range of realistic industrial control design studies based on industrial projects undertaken within the Industrial Control Centre at the University of Strathclyde. In most of the cases considered the transfer-function description is more appropriate than state-space models and hence the polynomial systems approach to the solution of the optimal control and filtering problems is a natural development. The physical significance of the terms within the optimal controllers or filters is more evident in the polynomial systems framework, where frequency-response characteristics can be linked directly to particular cost weighting or system characteristics.

The polynomial solutions of optimal control and filtering problems presented are very similar for the discrete-time and continuous-time cases. In fact, if the discrete-time results are obtained, it is a trivial step to derive the continuous-time filtering and control expressions. For this reason, the discrete-time case will be considered in most of the analysis and solutions presented. However, the simulation results for the industrial examples are often presented for continuous-time problems, since the frequency responses and time responses are easier to interpret in terms of the design requirements. The results for the equivalent discrete-time cases would be very similar for the type of sample rates used, but frequency-response diagrams, for example, repeat at the fold-over frequency, which is an additional complication. The decision to present all of the theoretical results in discrete-time form was mainly based upon the expectation that most industrial systems would be implemented digitally in future years.

New Edition

Much of the introductory material is based on the text M. J. Grimble, Robust Industrial Control; Optimal Design Approach for Polynomial Systems, published by Prentice Hall, Hemel Hempstead, 1993. We are much obliged to this company for the return of the copyright on this material. There are many new areas covered, including the very
important topic of nonlinear systems control and subjects such as: predictive control, multiple model control, restricted structure control, estimation and control in time-varying systems, performance assessment and benchmarking.

Mathematical Preliminaries and Notation

For convenience many of the fundamental mathematical concepts, results and notation needed within the text are collected and summarised in the Appendix. The reader is particularly encouraged to review the notation and results for polynomial systems before proceeding to the sections which include theoretical analysis.

Note

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