INTERNATIONAL JOURNAL OF ADAPTIVE CONTROL AND SIGNAL PROCESSING, VOL. 11, 167–170 (1997)

BOOK REVIEWS

FEEDBACK CONTROL OF LARGE-SCALE SYSTEMS, Jan Lunze, Prentice-Hall, International Hemel Hempstead, 1992, ISBN 0 13 318353 X, xiv + 344 pp., £56·50.

This book describes the application of control theory to large-scale systems. It is commonplace in industry that the total plant to be controlled consists of a large number of interacting sub-systems. The interactions take the form of material and energy flows and information exchange. Usually the control of the plant is designed in a decentralized manner with local control stations allocated to individual subsystems. Two primary reasons why a decentralized control design is preferred over a single global controller are as follows: (i) the sheer size of the problem to be solved in terms of the number of decision variables and outputs to be regulated is prohibitive to solution by a single controller; (ii) for the improvement of integrity and security of operations, i.e. if one local controller becomes faulty then the global stability of the whole plant may be preserved and partial production may be maintained.

The large-scale system control design task is to achieve the desired closed-loop performance taking full account of the various subsytem dynamics, the interactions between subsystems and the constraints on the information exchange permitted between local controllers.

Chapter 1 introduces the main concepts and the basic problems relevant to large-scale systems. The main concepts include decomposition of systems into hierarchical multilayer and multilevel architectures, as is adopted in modern DCS. The book restricts the theoretical analysis primarily to linear continuous-time systems, although extensions to the non-linear case are often discussed.

Chapter 2 provides a review of standard multivariable control theory, where it is assumed that a global model and all measurements are available to a single controller. The chapter enables comparisons to be made with the results of decentralized control developed in the remainder of the book.

Chapter 3 introduces the methods by which interconnected systems may be modelled. The different methods are distinguished from one another by the way in which the subsystems and their interactions are represented mathematically. The analysis of system structure is a natural application of graph theory. Two main decomposition strategies involve consideration of the physical layout of the plant and of the different time periods over which various subsystems operate.

Chapter 4 is concerned with decentralized stabilization and pole assignment. The analysis is based around the concept of decentralized fixed modes. These fixed modes are independent of any output feedback control law that may be applied. How decentralized fixed modes depend upon the large-scale system structure and the information constraints is investigated.

In Chapter 5 the theoretical development is extended to the decentralized asymptotic tracking problem.

Chapter 6 provides further theoretical results on decentralized stabilization and pole assignment. The practical design example of the load–frequency control of a multi-area power system is included.

Chapter 7 extends optimal control theory to the decentralized case. An example of how the problem complexity is increased for decentralized control is given by LQ optimal control. In the centralized case the optimal feedback control is linear for a quadratic cost function and a linear model; however, when the control is decentralized, the optimal control solution becomes non-linear even though the subsystem models are linear and the global cost function is quadratic.

Chapter 8 introduces stability test algorithms for large-scale systems. The approach known as 'the composite system method' aggregates the subsystem models and the interconection relations and establishes stability for incompletely known systems and/or systems subject to structural perturbations. The method is multilayer, where at the lower level the stability of isolated subsystems is considered and at the upper level the global stability is checked via Lyapunov theory.

Chapters 9 and 10 focus upon the decentralized control of large-scale systems which exhibit strong and weak interactions between the subsystems respectively. Relevant results from the disciplines of decision theory and game theory are reviewed. Following this, design methods based upon multilayer decentralized pole placement and LQ theory are developed. The issue of robustness is also discussed.

Chapter 11 is concerned with the design of decenrtalized PI controllers. A sequential tuning algorithm is included.

Chapter 12 develops the design theory for a particular class of large-scale system where each of the subsystem dynamics is the same or similar and where the interactions possess structural symmetry.

The book closes with a survey of the open research issues that currently exist in large-scale systems theory.

The book is well written and the mathematical development is clear and concise, avoiding overburdening the reader with excessive detail. Included at the end of each chapter are valuable bibiliographical notes. The subject appears to be one for which there is currently a shortage of published books. It is recommended to professional engineers from many disciplines, particularly those from control, chemical, transportation and power industries. It is also suitable for post-graduate students with an interest in these areas.

ANDREW PIKE
Special Analysis and Simulation Technology Ltd.
Brentford, Middx, TW8 8HQ, U.K.

ADVANCED CONTROL WITH MATLAB AND SIMULINK, J. Moscinski and Z. Ogonowski, Ellis Horwood, Hemel Hempstead, 1995, ISBN 0 13 309667 X, xiv + 251 pp., £39.95.

MATLAB has evolved from being a research software into a comprehensive set of toolkits for analysis, design and simulation in a wide range of engineering and scientific disciplines. The extensive linear matrix features of MATLAB have ensured its particular success for the analysis of linear control systems and filters. The addition of SIMULINK, enabling system simulation using linear and non-linear block constructions, greatly enhanced the utility of the software for the control engineering and signal processing community. Today it is not uncommon to find industrial engineers using MATLAB/SIMULINK to solve everyday engineering problems. With this type of success it is not surprising to find university courses incorporating MATLAB/SIMULINK exercises and teaching modules. Some educationalists have even constructed complete control or signal processing courses using the software, and books documenting these courses have already appeared.

Moscinski and Ogonowski's book introduces advanced control using MATLAB/SIMULINK exercises. The book gives an overview of several areas of control and signal processing: (i) basic system dynamics, (ii) control system design, (iii) process identification, (iv) neural networks in identification and control and (v) adaptive control. Basic system dynamics covers the common linear models adopted in control, concepts of and tests for stability, controllability and observability and an introduction to feedback control and estimation.The section on control system design gives a whistle-stop tour of many popular control strategies and methods/measures for testing the efficacy of designs, such as gain/phase margins and sensitivity functions. It considers designs of SISO and MIMO cases, for transfer function and state space models, from a classical (say Nyquist/root loci), a linear quadratic and an H_∞ point of view. In a similar vein the identification chapter gives the reader a quick overview of typical practice in process identification. It discusses the various models that can be adopted, such as transfer function, frequency domain and impulse response to name but a few, and follows this by including identification algorithms for each type of model. As expected, however, the greatest emphasis is on least squares identification. Neural nets have become very popular in recent years and hence rightly enjoy a prominent place in this book. Again the reader is treated to a brief but complete overview of the important concepts and principles. For example, what are neurons, multilayers, learning (training) rules, different types of nets and activation functions and how are neural nets used for control? The book is completed with a chapter on adaptive control which covers what adaptation is, what type of control laws can be used in an adaptive scheme, coupling identification and control and measures of performance.

To look in more detail at the exercises, it was felt that the reader needed a little more help than is offered in *quick help*, notably in Chapter 1. The excercises are often presented as if the reader is expected to know what is in the writers' mind. Thus a reasonable expertise in MATLAB/SIMULINK (as well as control) as a minimum was needed; this perhaps should not be assumed, especially if students are to use the exercises as a learning aid. Where available, being able to access the authors' *files* is excellent and largely circumvents this problem. However, this reviewer found that the files could not be collected by *ftp* without several problems in translation. It is thought that the authors have stored the files as PC files on a SUN server without translating them first to SUN format and hence *ftping* the file produces either spurious line spaces or puts the whole file on one line. Obviously the files will not then run without substantial editing. Moreover, it would be preferable if each exercise (not just each chapter) carried an explicit statement of which MATLAB toolboxes are required, since most users will not have access to all toolboxes.

In general I am quite positive about this book. On the one hand I felt that the overview of control offered by the various chapters was very well done and would serve as an excellent summary of the field for a Master's programme, although it is perhaps a little too brief to learn