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Book reviews

G.P. Liu, J.B. Yang, J.F. Whidborne, Multiobjective optimisation and control, Series: Engineering Systems Modelling and Control, Research Studies Press, 2003, ISBN 0 86380 264 8

1. Introduction

This book covers the central concepts of multiobjective optimisation and control techniques. Multiobjective optimisation models and methodological approaches are increasingly applied to the design of control systems. The authors justify the need to consider explicitly multiple objectives in control system design based on the common “realistic” argument: multiple and conflicting design objectives are at stake and inevitable trade-offs arise (for example, between output performance and stability robustness). Besides theoretical foundations, the book presents a large range of design algorithms and describes applications of multiobjective optimisation and control to several areas.

The book can be used for classroom work at the undergraduate or postgraduate levels, provided the students possess a technical background in linear control systems, linear algebra and calculus. The book can also be useful to researchers, control system designers and professionals of several engineering disciplines from which practical optimisation and control applications emerge.

The book has 320 pages and it is priced at £65 at the publisher web site www.research-studies-press.co.uk (an electronic version is available at £60). The authors are G.P. Liu (University of Nottingham, UK), J.B. Yang (UMIST, UK), and J.F. Whidborne (King’s College London, UK).

2. Content of the book

The book comprises 12 chapters. In the Introduction (Chapter 1), a brief review is made of multiobjective optimisation, encompassing “traditional” mathematical programming based approaches and genetic algorithms (GAs). A review of multiobjective control is also made, including references to trade-offs arising in control systems, robust control, critical control, eigenstructure assignment, PID control, nonlinear system identification, and fault diagnosis. These are the main topics developed in the subsequent chapters.

Chapters 2 and 3 introduce the basic concepts and methods for unconstrained and constrained nonlinear optimisation, respectively. These chapters, as it is understandable in the scope of the book, do not develop these topics in-depth, but they offer the reader a comprehensive review of concepts and methodological approaches which are necessary for the following chapters. In Chapter 2 one-search dimensional methods such as Fibonacci’s and golden section search are presented as well as unconstrained methods such as steepest descent, Newton’s and quasi-Newton’s methods. In Chapter 3, Kuhn–Tucker necessary conditions and sufficient conditions (both based on Hessian matrices—second order derivatives—and saddle points) are introduced. The presentation divides the approaches in primal methods (sequential linear programming and sequential quadratic programming) and dual methods (sequential unconstrained minimisation techniques: exterior penalty, interior penalty; and Lagrangean). The authors justify the interest of these approaches on the basis of their utilisation in optimisation software packages and GA-based procedures.

The basic concepts and methods in multiobjective optimisation are introduced in Chapter 4. Particular attention is paid to methods based on L_p norms and interactive methods. In the first category the following approaches are mentioned: reference point methods (for which the min–max, minimizing the maximum distance to the ideal solution can be considered a particular case), goal attainment and goal programming. In the second category four interactive methods are presented: Geoffrion's, STEM, ISTM and an interactive procedure based on the (utility) gradient projection method. In the framework of the interactive methods described, it is discussed how the design engineers' preferences can be elicited and used in the operational framework of the procedures.

Chapter 5 makes an introduction to GAs in the realm of optimisation, spanning the basic structure of GAs, population representation, computation of fitness functions to assess the performance of individuals, and the role and working of the operators selection, crossover and mutation. Some approaches to multiobjective optimisation using GAs are then described.

Chapter 6 presents a hybrid approach to multiobjective robust control system design combining the flexibility of numerical (parameter) optimisation techniques (method of inequalities) with analytical optimisation (H_∞ , LQG). This combined approach is illustrated using two design case studies (reported elsewhere in the literature) concerning a control system for a high purity distillation column and the suspension controller for a magnetic levitated vehicle. Pointers to MATLAB routines are given. The combined approach enables to include desirable features such as making explicit the design trade-offs and the closed-loop performance, including time domain and frequency domain performance indices.

Chapter 7 introduces critical control systems and discusses robust control design of critical systems with external uncertainties (environmental conditions, disturbances, etc.) and internal uncertainties (in the mathematical models). The robust control design problem for critical systems is formulated considering explicitly a set of performance criteria, including output performance in the time domain and robust performance in the frequency domain.

Chapter 8 discusses multiobjective robust control design for multivariable systems using eigenstructure assignment (a design technique which may be used to assign the entire eigenstructure of a closed-loop linear system via a constant gain full state or output feedback control law). The individual eigenvalue sensitivities and the sensitivity functions of the closed-loop system in the frequency domain, and the controller gain constraint have been considered as the multiobjective performance criteria (expressed as a set of inequalities).

Chapter 9 presents a PI controller design using multiobjective optimisation (addressing the ALS-TOM benchmark challenge on gasifier control). The parameters of the multi-input multi-output PI controller must satisfy a set of performance criteria derived from the system specifications on outputs, inputs and input rates. The nonlinear gasifier is linearised in three load operating points (100%, 50% and 0%) at which the degree of satisfaction of specifications is measured. Results are provided comparing the multiobjective optimal-tuning PI controller with fixed parameter controllers regarding computation effort, stability and performance.

In Chapter 10 a multiobjective GA is presented to compute optimal Finite Word-Length structures for PI digital controllers. The method is illustrated through its application to the implementation of PID controllers for a steel rolling mill and a benchmark problem. Parameterisation issues linked to Finite Word-Length implementations are relevant because of the degradation (even instability) experienced by closed-loop control systems when infinite precision controllers are implemented by using fixed-point digital processors (due to the finite precision of the parameters representation). The method exploits the use of binary numbers in both the implementation of Finite Word-Length controllers and representation in GAs. The method requires the solution of a linear system similarity completion problem, which is illustrated for the case of a two state single-input single-output system.

Chapter 11 addresses the problems of model selection and identification of nonlinear systems (a nonlinear functional approximation problem) using neural networks and GAs. Multiple

performance criteria based on the L_2 and L_∞ -norm distances between the actual system and the nonlinear model are considered, as well as a model complexity indicator (number of nonlinear units in the model). The method is based on GA optimisation, involving computing solutions to the linear system completion problem, to obtain the nonlinear function units associated with the simplest model required for approximation. A neural network is used for model representation, which is the Gaussian radial basis function. An illustrative example is reported regarding the identification of a large pilot scale liquid level nonlinear system.

Chapter 12 deals with the design of optimal residuals for diagnosing incipient faults. Performance indices are incorporated into the fault observer design to reduce false and missed alarm rates. Five performance indices are expressed in the frequency domain, thus accounting for the frequency distribution of faults, noise and modelling inaccuracies. Even though the problem is recognised as multiobjective in nature, the authors transform the performance criteria into a set of constraints. The problem becomes then finding a solution (parameter set) with all performance indices within the acceptable region defined by the constraint set. A GA is used to compute that solution. An example is given concerning the fault diagnosis of a flight control system.

3. Discussion

The main merit of this book is to present in a consistent manner multiobjective optimisation in the realm of control problems. Most books on multiobjective optimisation are too mathematical or management-oriented and this book contributes to fill the gap regarding engineering applications of multiobjective optimisation models and methods, namely in the scope of control systems. Moreover, it reflects both theoretical and practical insights of multiobjective optimisation and control.

The book content is mainly based of work carried out by the authors and already published elsewhere. However, I found the chapters well inte-

grated and the book can be read sequentially or only the relevant chapters, which are reasonably self-contained for someone with technical background on control system theory. Nevertheless, in some parts of the book this generates sections that are too condensed (which is understandable in the scope of journal or conference papers), but that the authors could have developed further, namely having in mind the use of this book for classroom work specially at undergraduate levels.

Although this strongly depends on the orientation given by lecturers to the courses, I have serious doubts the book could fulfil the purpose of supporting undergraduate students unless it is a strongly control-oriented undergraduate degree. However, I found the book a valuable tool for graduate students in control related topics in several engineering disciplines.

In my opinion, the review of interactive methods in Chapter 4 is somewhat poor. Despite the authors claim that attention is paid to interactive methods, there are several interactive procedures which are not even mentioned or listed in the reference list. The same happens in Chapter 5 regarding the introduction to GAs. This section is surprisingly short and the reference list does not include some important review papers and books on multiobjective optimisation using GAs, which is an exciting and active area both regarding research and applications, including in control as it is clearly shown in this book.

Section 7.5 on multiobjective critical control is also too condensed. A generous expansion of this section in the context of this chapter would be welcome in future editions of this book. In Chapter 8, I also found the description of the controller design using GAs too scarce to be really useful for students and design engineers. Again, the authors should have complemented and expanded the texts published elsewhere to make them more readable and self-contained.

In summary, I think this book is a very interesting and useful reference offering a broad view of the range of problems and approaches in multiobjective optimisation and control. Moreover, up-to-date references are provided (except for the criticisms I made above) which enable the reader

to develop further his/her own specific interests in this field.

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Saul I. Gass, Arjang A. Assad, *An Annotated Timeline of Operations Research, An Informal History*, Kluwer, 2005

1. Introduction

This volume is a new contribution to the growing literature on the history of OR. The authors have tried to organize the development of our discipline on a timeline, emphasizing a number of “key events”. For each of these events, the authors provide a brief explanation of why it is important (from 10 lines to one page) and a number of references. For most events, a picture of the authors of the discovery is also available together with a short biographical sketch and/or representative quotes.

This book is authored by Saul I. Gass and Arjang A. Assad. The name of Saul Gass will probably be familiar to all readers of this Journal through his many papers and books and, in particular, his *Encyclopedia of Operations Research and Management Science* (co-edited with C.M. Harris, and published by Kluwer). He is currently Professor Emeritus at the University of Maryland at College Park. Saul Gass is a past president of ORSA and a past vice-president of both INFORMS and IFORS. Arjang Assad is professor of Management Science at the University of Maryland at College Park. He has published two books and numerous research papers. His interests include Total Quality, vehicle routing and operations management.

This volume has 210 pages and is priced at 79.95€ (ISBN 1-4020-8112-X). A cheaper paperback edition is also available at 29.95€ (ISBN 1-4020-8116-2).

2. Content of the book

The title of the book accurately reflects its content. The annotated timeline is divided into eight periods:

- (1) Operations research precursors from 1564 to 1873 (18 pages).
- (2) Operations research precursors from 1881 to 1935 (25 pages).
- (3) Birth of operations research from 1936 to 1946 (15 pages).
- (4) Expansion of operations research from 1947 to 1950 (19 pages).
- (5) Mathematical, algorithmic and professional development of operations research from 1951 to 1956 (31 pages).
- (6) International activities, algorithms, applications, and operations texts and monographs from 1957 to 1963 (29 pages).
- (7) Methods, applications and publications from 1964 to 1978 (29 pages).
- (8) Methods, applications, technology and publications from 1979 to 2004 (33 pages).

The book ends with a very useful index of acronyms, names, and subjects.

The timeline for the prehistory of OR (up to 1936) reveals a rich picture, including many great names: in Probability (Cardano, Pascal, Huygens, Jakob, Nicolaus and Daniel Bernoulli, de Moivre, Buffon, Bayes, Laplace, Poisson, Galton, Bachelier, Markov, Erlang, Lévy, de Finetti, Chapman, Kolmogorov, Pollaczec), Statistics (Bosovich, Graunt, Legendre, Gauss, Quételet, Neyman,