BOOK REVIEWS

Computational Systems Analysis Topics and Trends

edited by **Achim Sydow**
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Powerful interactive software tools for analysing and understanding complex systems are now available for supporting the modelling process and simulation experiments. Advanced simulation environments, including graphical abilities and user friendly interfaces, have been developed. They can get an insight into the complex systems behaviour. Computational Systems Analysis is viewed as systems analysis by means of such advanced tools. It connects systems theory, applied mathematics, control sciences, applied sciences, etc., based on computing techniques, for investigating or constructing various systems and finding control strategies.

Topics like those mentioned above are explored in the reviewed book. The book contains an introductory keynote, 24 papers grouped in five parts and an index.

In his introductory remarks, A. Sydow presents a state-of-the-art of the field. The analysis and design of complex systems need a complex procedure and sophisticated software tools for performing each procedural step: modelling, model simplification, model analysis, optimal structure or control strategy design, etc. Simulation systems attempt to automatize the simulation process, as well as data and model handling for experimentation. They include specialized computer languages, model bases, data bases, result storage abilities and graphical visualisation.

The first part, **Methodology, Basic Methods and Models**, includes five papers authored by H. P. Schwefel, W. Ebeling, G. Jumarie, L. Budach and V. V. Kalashnikov, respectively. The first paper deals with natural organic evolution and collective learning and optimum-seeking. Ebeling's paper analyses the dynamics of competition and valuation in non-physical systems using deterministic and stochastic (birth and death) models. Applications to economic, biological and social processes are described. Jumarie proposes an information theory for deterministic data and discusses its possible applications to systems analysis: measuring the complexity of networks or engineering dynamic (linear or nonlinear) systems, reduction of large scale systems minimizing the loss of relevant information, image processing and pattern recognition, parameter estimation (without probability distribution assumptions). He uses the *entropy* of deterministic (possibly continuous) functions and *quantum entropy* of non-probabilistic matrices, as measures for uncertainty (or information), which are fully consistent with Shannon's entropy (contrary to Kolmogorov's entropy). Budach's paper deals with mathematical investigation of recursive VLSI-designs and shows that each such design defines a contraction functor that admits a finite number of invariants, which are fractals with computable Hausdorff-dimension. The

RELACS language has been developed for describing the recursive design procedure. Kalashnikov's paper reviews some results obtained for a rather general type of discrete-time models, called *aggregative models*, which can serve as a basis for simulation software and support sophisticated simulation experiments.

The second part, **Systems Theory**, includes six papers. The first paper, by G. Wunsch, elaborates a general process theory, which can be specialized to many laws of conventional systems theory, classical and statistical mechanics, etc. The concept of processes and general process types are defined (with emphasis on Markov processes) and used to elaborate state representations and parametrizations. The second paper, co-authored by P. Borne, J. P. Richard, N. E. Radhy and W. Perruquetti, proposes a methodology for estimating attractors and attraction regions of nonlinear non-autonomous dynamic systems, based on the use of vector norms and an optimization procedure for obtaining better estimates. Both local and global attractors are analysed and numerical examples are given. The methodology is useful since such systems often have complex asymptotic behaviours, including locally stable equilibrium points or periodic orbits, which can be acceptable if they are not too far from the expected operating point and can be reached for sufficiently large regions of the state space. Moreover, the exact calculation of attractors and attraction regions is generally impossible. Some results are based on the *overvaluing systems* concept and, consequently, they are robust with regard to the modelling errors. The paper of Dj. Petkovski and Z. Gajic develops a recursive algorithm for solving the nonlinear equations of an optimal static output feedback control problem with small parameters. Using decomposition, only low-order systems are involved in the calculations. Two real world examples (a fluid catalytic cracker and a twelve plate absorption column) are used to illustrate the effectiveness of the algorithm. An advantage over the singular perturbations theory is that the approach can be applied even if the small parameter ϵ is not "small enough"; moreover, it can efficiently produce accurate results (of the order $O(\epsilon^k)$, $k = 2, 3, \cdots$). The paper co-authored by K. H. Fasol and H. G. Gehre is a survey of model order reduction methods and includes a discussion of a multi-purpose software tool, applicable to order reduction, identification, and controller design for SISO systems. Both time domain and frequency domain methods are described. Numerical examples illustrate the capabilities and effectiveness of the approach. The paper by J. Lunze is devoted to symmetric composite control systems, with similar structural properties of subsystems dynamics and symmetric interconnections. These bring about conceptual simplifications of the model and solution. Control theoretic properties (observability, controllability, stability and connective stability, input-output behaviour of the subsystems, etc.) can be investigated by models of the order twice the subsystem order. The results hold for arbitrary number of subsystems and arbitrarily strong interactions among them. An application to a multiarea power system is described. The paper by I. Troch investigates the decoupling of composite linear systems consisting of partially decoupled subsystems (series, parallel, and feedback connections). As subsystems can often be locally decoupled with no difficulty, it is of theoretical and practical interest to know whether this local property is also a global one, and how the local decoupling laws can be modified for becoming global ones.

The third part, **Knowledge-Based Methods**, includes eight papers. Most of them deal with the use of advanced software tools, including decision support systems (DSS), expert systems (ES) and knowledge-based systems (KBS). The first paper, co-authored by S. Tzafestas, G. Kapsiotis and S. Reveliotis, provides a unified overview of the generalized network (GN) approach to optimized decision making and planning. Real-world application problems, such as ship scheduling, optimal lot sizing, machine-loading, financial budgeting, file merging, and distribution planning, are outlined. A GN DSS tool — GENET OPTIMIZER — and its enhancement to a knowledge-based DSS — GENETEXP — developed by the authors in PASCAL language under DOS on an IBM PC compatible computer, are described. The paper by M. G. Singh addresses the information processing and decision making issues in large private enterprises, operating within competitive environments. Such tools as ES, DSS, and hybrid KBS, are regarded as ways of adding value to the different information. The most promising area for their use is at the tactical and strategic decision making levels. Several tactical tools developed by the author (PriceStrat, BS-opt, Resource-opt, and TAPS) are outlined. The paper by E. J. H. Kerckhoffs deals with parallel processing in model-based problem solving in a broad perspective, including simulation systems, KBS, connectionist systems (neural networks), and their combinations. These correspond to the human problem solving paradigms: by calculation, by reasoning, by learning and subsequent generalization, or by combination of these. A key issue for future problem solving is *integration* of various tools and techniques. The paper by F. G. Filip surveys some new results in combining traditional systems analysis and ES approach for building effective DSS for operative control. The concept of the model of an expert decision maker is introduced, for supporting or performing several functions in a goal oriented activity concerning the plant model construction, testing and experimentation. A multilevel modelling approach for both continuous process industries and discrete part manufacturing systems is discussed, and trends in building expert DSS, including a sample set of production rules incorporated in the X-DISPATCHER system, developed by the author and his colleagues, are presented. A numerical example for solving a scheduling problem in a pulp and paper mill is given. The paper by A. Häuslein and B. Page shows various opportunities for the use of KBS within the framework of modelling and simulation. These opportunities let additional knowledge required by the modeller be provided, and modeller's knowledge be processed more adequately. A complete realization seems not to be possible and useful now, with the existing limitations of the Artificial Intelligence (AI) field. But coupling simulation systems with ES may be a suitable first step towards the KBS. The paper by F. Stanciulescu substantiates a methodology of the so-called *mathematical-heuristic modelling and simulation* for large-scale systems, using AI concepts in connection with a dynamic (nonlinear) simulation and control model. A specialized knowledge base, containing a set of heuristic rules, and an inference engine, both included in the knowledge-based controller, are employed. The methodology is applied for simulation and control of hydrological and ecological systems of the Danube Delta. The paper by T. H. Hoang presents a fuzzy system and fuzzy logic theory for research and applications in advanced computer technology (like DSS and AI). For instance, fuzzy entropy evaluation is useful in DSS for assessing the conflict or conformed situations (by extremizing entropy criteria), or in neural networks for information processing classification. The paper by A. Javor describes a new methodology, based on *demons*, for the distributed control of simulation experiments during dynamic simulation including the modification of experimental conditions, model parameters and model structure. This enhances the effectiveness of investigations by simulation, as well as the possibility of building adaptive models. The proposed methodology is implemented in CASSANDRA system, developed by the author and his colleagues, and used to solve some practical examples.

The fourth part, **Computer Architecture, Simulation Tools**, includes three papers, authored by W. K. Giloi, W. Ameling, and B. Page, respectively. The first paper gives an overview of parallel computer architectures: array and vector SIMD (single instruction - multiple data) machines, shared memory MIMD (multiple instruction - multiple data) machines, and distributed memory MIMD machines, as well as the associated programming models: sequential programming, vector processing, loop parallelization, cooperating processes and virtual processor models. Ameling's paper deals with the evaluation of performance of modelling and simulation of distributed functions and systems, which are of great interest due to the increasing use of multiprocessor systems and network structures. The simulation of parallel processes can be accomplished using evaluation nets and Petri-nets. Several software tools developed by the author and his colleagues, like OSCAR — for processing of queueing networks — and P3 — Parallel Petri net Processor — are described. Page's paper reviews the main concepts of the Modula-2 programming language and its use for the implementation of simulation software. A discrete event simulation package — DESMO — is described; it allows for different simulation styles, and offers various powerful functions, such as internal simulation sequence control, combined discrete-continuous simulation, statistical distributions, data collection and data analysis, deadlock control, tracing and reporting. A comprehensive job shop simulation is used as example model, and the corresponding Modula-2 procedures are listed.

The fifth part, entitled **Applied Systems Analysis**, includes two papers, authored by G. Spur, and R. W. Shaw, respectively. The first paper discusses the planning process of Computer Integrated Manufacturing (CIM) structures and the support of this process by modelling. The models should be complete (all functions, objects and resources), and applicable to any phase of planning and operation. The approach enables faster, more rational and economic systems design and operation. The last paper uses integrated assessment models for developing and assessing emission control strategies to reduce regional acidification of the environment in Europe. The importance of the careful identification of the elements to be included in these models (emissions, control costs, atmospheric transport and ecological effects), the linkages among them, as well as the estimation of the effects of uncertainties in these linkages, are emphasized. The use of the Regional Acidification Information and Simulation (RAINS) model, developed at the International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, indicates that strategies for reduction the acidic deposition in specified areas of Europe are much more cost-effective than uniform emisssion reductions, provided the environmental targets are carefully selected.

In conclusion, the book is a valuable reference for the latest achievements in the systems analysis domain, and could be useful for a large readership. The book is available from Elsevier · North-Holland · Excerpta Medica (Postal Address: P. O. Box 1991, 1000 BZ Amsterdam, The Netherlands), or in the USA and Canada from Elsevier Science Publishing Co., Inc. (P. O. Box 882, Madison Square Station, New York, NY 10159, U.S.A.).

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