OPTIMA

MATHEMATICAL PROGRAMMING SOCIETY NEWSLETTER

No 38 Nov 1992

New Optimization Centers at Cornell, Florida and Georgia Tech

CORNELL

The Cornell Computational Optimization Project (CCOP) — now in its sixth year — supports computational and theoretical activities in both discrete and continuous optimization through a computational facility, graduate student support, short-term visitors and seminars, and post-doctoral research associates. Funding is provided by the National Science Foundation, the Air Force Office of Scientific Research and the Office of Naval Research.

Faculty associated with the program are all members of Cornell's Center for Applied Mathematics, with primary affiliations in the Department of Computer Science and the School of Operations Research and Industrial Engineering, and include R.G. Bland, T.F. Coleman, D.B. Shmoys, É. Tardos, M.J. Todd, L.E. Trotter Jr., C.F. Van Loan and S.A. Vavasis. Among the visitors have been M. Gröetschel, L. Khachiyan, and L. Lovász.

Projects include a computational study of minimum cost network flow algorithms; heuristics for traveling salesman problems; investigations into crew scheduling, covering and packing problems; studies in interior-point methods; large-scale bound-constrained nonlinear optimization; complexity in nonlinear optimization; and parallel optimization and linear algebra.

FLORIDA

The recently established **Center for Applied Optimization** at the University of Florida is an informal center which encourages joint research and applied projects among faculty from different departments, especially in engineering, mathematics and business.

The initial list of affiliated faculty include R. L. Francis, S. T. Tufekci, C-Y Lee, Sherman Bai, Tom Kisko, and Don Hearn from Industrial & Systems Engineering (ISE); Bill Hager and Bernhard Mair from Mathematics; Kirk Hatfield from Civil Engineering and Harold Benson, Gary Koehler and Selcuk Erenguc from Decision and Information Sciences. Hager and Hearn are co-directors of the Center, and Panos Pardalos is currently visiting the ISE Department and the Center.

Individual and joint research includes acceleration of decomposition methods, new dynamic programming techniques for lotsizing models, network optimization methods, optimal control problems, optimization of elastic materials, inverse problems, multicriteria optimization, and global and discrete optimization. Current and pending applied projects include modeling and PAGE TEN ►

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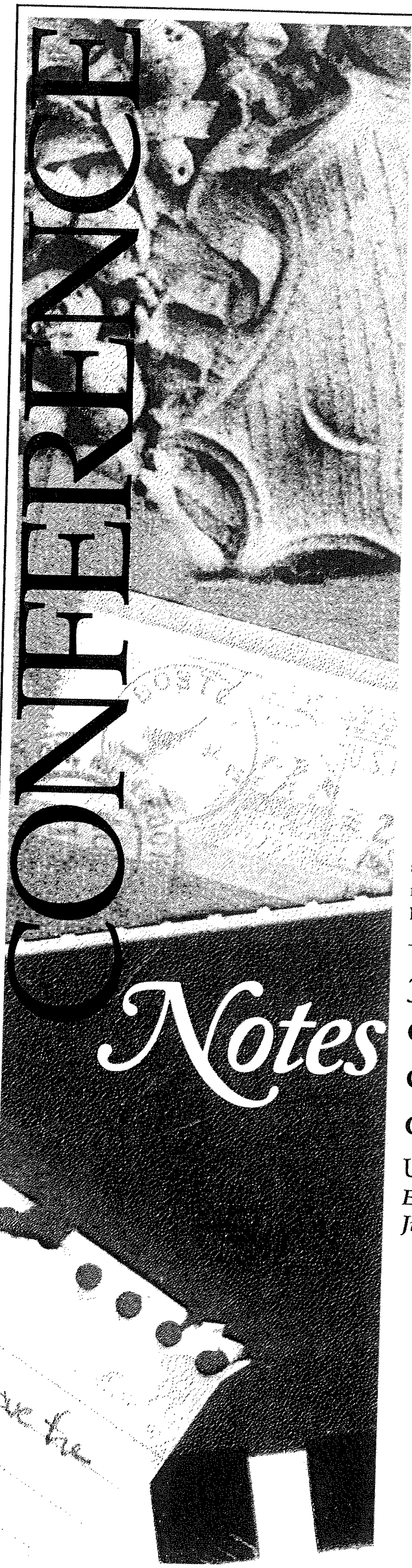

CONFERENCE ON LARGE SCALE OPTIMIZATION

University of Florida

Gainesville, Florida /Feb. 15-17, 1993

The conference will bring together researchers who are working on many different aspects of large scale optimization: algorithms, applications and software. It has been endorsed by the MPS, ORSA and SIAM. Currently, the list of invited speakers includes the following people:

Dimitri Bertsekas	John Birge	Christian Bischof	Andrew Conn
Jann Cook	Thomas Coleman	George Dantzig	Renato DeLeone
Joseph Dunn	Chris Floudas	Anders Forsgren	Masao Fukushima
David Gay	Philip Gill	Jean-Louis Goffin	Donald Goldfarb
Masao Iri	Narendra Karmarkar	C.T. Kelley	Hiroshi Konno
Leon Lasdon	S. Lawphongpanich	P. O. Lindberg	Robert Meyer
Jorge Moré	Walter Murray	Anna Nagurney	George Nemhauser
James Orlin	Michael Overton	P. Panagiotopoulos	Jong-Shi Pang
Roman Polyak	Aubrey Poore	Mauricio Rescende	K. Ramakrishnan
J. B. Rosen	Ekkehard Sachs	Michael Saunders	Robert Schnabel
David Shanno	Richard Tapia	Andre Tits	Philippe Toint
Yinyu Ye	Stavros Zenios		

ALTHOUGH only invited talks will be presented, everyone is welcome to attend the conference. Moreover, it is anticipated that some funds will be available for the support of graduate students and to support the participation of women, minorities and persons with disabilities; please contact the organizers. To obtain the latest information concerning the conference, send an e-mail message to "coap@math.ufl.edu" and in the body of the message, put the phrase "send meeting". The contact people for the conference are Bill Hager (fax: 904-392-6254), Don Hearn (e-mail: hearn@ise.ufl.edu), and Panos Pardalos (phone: 904-392-9011).

3RD TWENTE WORKSHOP ON GRAPHS AND COMBINATORIAL OPTIMIZATION

University of Twente

Enschede, The Netherlands
June 2-4, 1993

The 3RD TWENTE WORKSHOP on Graphs and Combinatorial Optimization will be held at the Faculty of Applied Mathematics, University of Twente, Enschede, The Netherlands.

The workshop will focus on recent results and developments in graph theory and combinatorial optimization as well as applications of operations research, computer science and economics. A proeedings volume devoted to the 3RD TWENTE WORKSHOP is planned.

Prospective participants are asked to register before Dec. 18, 1992. There is no registration fee.

For more information contact:

Prof. U. Faigle (0031-53-893462) or

Prof. C. Hoede (0031-53-893429:

Faculty of Applied Mathematics
University of Twente
P.O. Box 217
7500 AE Enschede
The Netherlands.

OPTI93

COMPUTER AIDED OPTIMUM DESIGN OF STRUCTURES

3rd International Conference

July 7-9, 1993
Zaragoza, Spain

Structural optimization is well-established as an important research field. The practical applications of optimization techniques are important in the design of aircraft, automotive design, civil and mechanical engineering and computing.

Computer aided structural design and optimization software provide a sophisticated means of finding solutions for certain engineering problems. The objective of this conference is to bring together researchers and engineers in this field.

The previous international conferences, OPTI 89 and OPTI91, were very successful with many international delegates representing universities, private and public research centers and industry.

Topics

Design Optimization;

Shape Optimization;

Knowledge Based and Heuristic Optimization;

Materials Selection and Topographical Changes in Optimum Design;

Design of FEA/BEM Adaptive Grids;

Design Sensitivity Analysis in Linear and Nonlinear Structures;

Expert Systems in Optimum Design;

Optimization in Reliability-based Design;

Optimization and Technical Codes;

Integrated Packages for Optimum Design;

Testing of Optimization Software;

Analytical Advances in Optimum Design;

Multicriterion Optimization;

Methods for Large and Continuum Structures, Optimization and Supercomputing;

Optimal Control Structures;

Approximation Methods in Structural Optimization;

Others falling within the scope of this conference.

Three copies of an abstract of no more than 300 words clearly stating the purpose, results and conclusions of the work to be described in the final paper should be submitted to the Conference Secretariat by Oct. 30, 1992, for review. A camera-ready manuscript of the final full-length paper must be received by March 5, 1993.

The published proceedings of the Conference will be available to delegates at the time of registration. The language of the conference will be English.

There is an airport in the city with 30-minute flights to Madrid and Barcelona and 90-minute flights to London and Paris. There are also several trains a day connecting Zaragoza with Madrid and Barcelona.

Conference Chairmen:

Dr. C.A. Brebbia, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton, S04 2AA, UK.

Tel: 44 (0) 703 293223; Fax: 44 (0) 703 292853;
E-Mail: CMI@uk.ac.rl.ib;
International E-Mail: CMI@ib.rl.ac.uk.

Dr. S. Hernandez, Department of Mechanical Engineering, University of Zaragoza, Maria de Luna, 50015 Zaragoza, Spain.

Tel: 34 (9) 76 516200; Fax: 34 (9) 76512932.

For more information contact:

Sue Owen, Conference Secretariat - OPTI 93
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E-Mail: CMI@uk.ac.rl.ib;
International E-Mail: CMI@ib.rl.ac.uk.

STRUCTURAL OPTIMIZATION 93

The World Congress on Optimal Design of Structural Systems

Rio de Janeiro, Brazil
Aug. 2-6, 1993

The purpose of this meeting is to bring together designers and researchers to present the latest advancements in Structural Optimization and Computer-Aided Structural Design. Topics ranging from the mathematical foundations of this field to software development and practical applications in mechanical, structural, aerospace, civil, chemical and naval engineering will be discussed. Closely related fields also are covered, provided that the treated subject is related to design optimization or automation.

Papers which consider Optimal Design of Multidisciplinary Systems, incorporating structural engineering interacting with other disciplines, are particularly relevant to the conference.

State-of-the-art tutorials and surveys which cover the broad spectrum of Structural Optimization will be given. Commercial and academic software of interest to the Structural Optimization community will be presented.

The conference will be held on the campus of the Military Institute of Engineering, located in one of the most charming parts of Rio de Janeiro, in front of Guanabara Bay and at the foot of the Sugar Loaf. Nearby is the famous Copacabana beach, where most of the major hotels, shops and restaurants are located. Bus transportation will be provided for participants.

Rio is a cosmopolitan city containing many lodging facilities, restaurants, shops and cultural activities. Rio has beaches, mountains, forests, parks, and islands. All of this beauty is flavored by the easy grace and natural hospitality of the inhabitants, the Cariocas, a people in love with life, music and dance.

A social program will be arranged for participants and their guests. A selection of pre- and post-meeting tours is planned. In particular, a very nice one-day cruise to beautiful tropical islands is scheduled for the Sunday before the conference.

Deadlines for authors:

Receipt of abstracts of about 500 words, **Oct. 30, 1992**; notification of acceptance, **Jan. 1, 1993**; receipt of final papers, **April 15, 1993**.

Mailing address:

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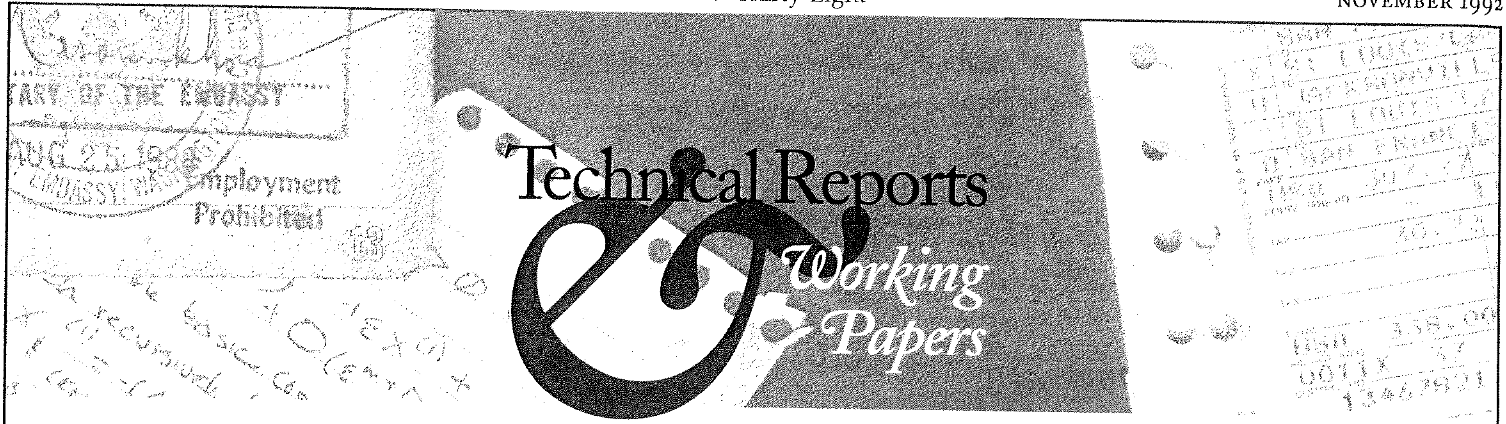

RUTCOR - Rutgers Center for Operations Research

Busch Campus
Rutgers University
P.O. Box 5062
New Brunswick, NJ 08903

P. Hansen and F.S. Roberts, *"An Impossibility Result in Axiomatic Location Theory,"* RRR 1-92.

L. Eeckhoudt and P. Hansen, *"Mean-Preserving Changes in Risk with Tail-Dominance,"* RRR 2-92.

P. Hansen and B. Jaumard, *"Reduction of Indefinite Quadratic Programs to Bilinear Programs,"* RRR 3-92.

I. Maros, *"A Practical Anti-Degeneracy Row Selection Technique in Network Linear Programming,"* RRR 4-92.

J.-M. Bourjolly, P.L. Hammer, W.R. Pulleyblank and B. Simeone, *"Boolean-Combinatorial Bounding of Maximum 2-Satisfiability,"* RRR 5-92.

P.L. Hammer and A. Kogan, *"Horn Functions and their DNFs,"* RRR 6-92.

E. Boros, P.L. Hammer, M.E. Hartmann and R. Shamir, *"Balancing Problems in Acyclic Networks,"* RRR 7-92.

P.L. Hammer and A. Kogan, *"Horn Function Minimization and Knowledge Compression in Production Rule Bases (Extended Abstract),"* RRR 8-92.

E. Boros, Y. Crama, P.L. Hammer and M. Saks, *"A Complexity Index for Satisfiability Problems,"* RRR 9-92.

P.-C. Chen, P. Hansen and B. Jaumard, *"Partial Pivoting in Vertex Enumeration,"* RRR 10-92.

I. Maros, *"Performance Evaluation of MINET Minimum Cost Netflow Solver,"* RRR 11-92.

P. Hansen, B. Jaumard and G. Savard, *"New Branch and Bound Rules for Linear Bilevel Programming,"* RRR 12-92.

P.-C. Chen, P. Hansen, B. Jaumard and H. Tuy, *"Weber's Problem with Attraction and Repulsion,"* RRR 13-92.

P.L. Hammer and A.K. Kelmans, *"On Universal Threshold Graphs,"* RRR 14-92.

Y. Crama and A.G. Oerlemans, *"A Column Generation Approach to Job Grouping for Flexible Manufacturing Systems,"* RRR 15-92.

E. Boros, P.L. Hammer and X. Sun, *"Recognition of Q-Horn Formulae in Linear Time,"* RRR 19-92.

E. Boros and P.L. Hammer, *"A Generalization of the Pure Literal Rule for Satisfiability Problems,"* RRR 20-92.

N.V.R. Mahadev and F.S. Roberts, *"Amenable Colorings,"* RRR 21-92.

CENTRUM VOOR WISKUNDE EN INFORMATICA LIBRARY

CWI Department of Operations Research, Statistics and System Theory Reports

Postbus 4079
1009 AB Amsterdam, The Netherlands

J.P.C. Blanc, P.R. de Waal, P. Nain, *"A new Device for the Synthesis Problem of Optimal Control of Admission to an M/M/c Queue,* BS-R 9101.

O.J. Boxma, *"Analysis and Optimization of Polling Systems,"* BS-R 9102.

M. Kuijper, *"Descriptor Representations without Direct Feedthrough Term,"* BS-R 9103.

H.J.A.M. Heijmans, J. Serra, *"Convergence, Continuity and Iteration in Mathematical Morphology,"* BS-R 9104.

H.J.A.M. Heijmans, *"Morphological Discretization,"* BS-R 9105.

C. MacDiarmid, B. Reed, A. Schrijver, *"Induced Circuits in Planar Graphs,"* BS-R 9106.

A.L.M. Dekkers, L. de Haan, *"Optimal Choice of Sample Fraction in Extreme-Value Estimation,"* BS-R 9107.

M. Kuijper, J.M. Schumacher, *"State Space Formulas for Transfer Poles at Infinity,"* BS-R 9108.

A.J. Baddeley, M.N.M. van Lieshout, *"Recognition of Overlapping Objects using Markov Spatial Processes,"* BS-R 9109.

B. Gamble, W. Pulleyblank, and B. Reed, *"Right Angle Free Subsets in the Plane,"* BS-R 9110.

O.J. Boxma, H. Levy, J.A. Weststrate, *"Efficient Visit Frequencies for Polling Tables: Minimization of Waiting Cost,"* BS-R 9111.

BOOK § REVIEWS

Evolution of Random Search Trees

Hosam M. Mahmoud
Wiley and Sons
Chichester
1992
ISBN 0-471-53288-2

This book is devoted to a small though important branch of probabilistic complexity theory, namely the behavior of random search trees constructed by insertion. Many of the results are fairly recent (from the second half of the 1980s to the present) and due largely to the authors, Devroye and Pittel.

Search trees are of obvious practical use as data structures, but the reader who enjoys the theoretical analysis of algorithms is well-served indeed. Which problems are addressed by the author? The elements of a randomly permuted ordered set of n objects are successively inserted into a labeled tree by following a simple combinatorial rule. For example, in the binary case, the familiar requirement is that an element in a node is larger than the elements in its left subtree but smaller than the elements in the right one. One may then ask for the expectations and (limiting) distributions of the number of leaves on a certain level (connected with expected search and insertion time), the height, the minimal path length, etc.

Recursive expressions for these parameters are not hard to find by elementary combinatorial and probabilistic arguments; some real fun starts when the resulting generating functions are solved or estimated. The means used are the combinatorial theory of generating functions and related topics in classical complex analysis. The book contains many useful exercises.

Chapter 1 contains a summary introduction to the tools used in the rest of the book. A few pages are devoted to the very basics of graph theory and order symbols. The next section is on generating functions and complex analysis. The author states in his preface that "... no special background, other than prior exposure to a general introduction to functions of complex variables, is assumed." This seems a bit optimistic however; a good familiarity with such subjects as asymptotic expansions, the Mellin transform and the analytic continuation of the Gamma function is certainly needed in order to appreciate this book.

Next, a short and clear overview is given of elementary probability theory up to and including some central limit theorems. The chapter ends with a few remarks on the computer representation of trees. The author adopts PASCAL as a universal programming language which makes his book less self-contained than it could be. The number of programs is small, however, and it is possible to read the book without the "background of one year in programming" the author assumes.

> ". . . the book can be highly recommended to researchers in complexity theory and discrete mathematics because of its many interesting applications of generating functions."

In Chapter 2 the basic binary tree algorithms (search, insert, traversal) are defined. The validity of the random permutation model for the data stream is demonstrated, and the probability distributions of (un)successful search time, height and path lengths are studied, culminating in the strong law of large numbers for the height by Pittel and Devroye.

Chapter 3 generalizes these results to m-ary trees, important in computer memory management (paging). The recursions become much harder now, and only partial results are known. Some theorems are really curious and inspiring. For example, the number of nodes has a variation which is linear in the number of keys for m-ary trees with *m* 26 but not for higher values. The remainder of the chapter, again, is devoted to the analysis of insertion depth and height.

Chapter 4 is relatively short and contains a similar analysis of quad trees and k-d trees. The distributions of random variables considered appear to be identical to their binary search tree equivalents.

Chapter 5 is devoted to faster search algorithms guided by the structure of the keys (radix search). The data structure used is the "trie". The actual keys now are stored in the leaves, and adding a key may increase the number of internal nodes considerably. Hence, the main point of interest is space requirement. Recent asymptotic results by Jacquet et al. are presented under the Poisson and Bernoulli data models. The chapter ends with an analysis of the key depth distribution and the expected height of a trie.

In the final chapter of Mahmoud's book, one studies digital search trees. These combine some advantages of binary search trees (storage in the internal nodes) and tries (digital search). The methods and results are analogous to those of the preceding chapters.

In summary, Mahmoud's book provides a clear, inspiring, and uniform presentation of a small yet useful branch of complexity analysis. Most of the book consists of fairly technical calculations, but the author gives ample attention to issues of practical motivation. From this point of view, the book is of interest to data engineers and probabilists. Even more so, the book can be highly recommended to researchers in complexity theory and discrete mathematics because of its many interesting applications of generating functions.

When used as a course text, the book requires, apart from some probability theory, a solid background in classical analysis. This makes it suitable for students in mathematics, rather than computer science (at least in Holland).

- D.C. VAN LEIJENHORST

Parametric Optimization: Singularities, Pathfollowing and Jumps

J. Guddat, F. Guerra Vasquez and H. Th. Jongen
Teubner and John Wiley & Sons
Chichester
1990

ISBN 0-471-92807-0

This is another significant research monograph coming from the "German school" of parametric optimization. Its style and quality will remind the reader of the classic book, *Nonlinear Parametric Optimization*, by Bank, Guddat, Klatte, Kummer and Tammer (Akademie-Verlag, Berlin, 1982). In the new monograph the authors study finite-dimensional optimization problems with one scalar parameter. Their approach is based on pathfollowing methods (also called continuation or homotopy methods). These methods are important in various situations ranging from solving nonlinear (single- and multi-objective) optimization problems to tracing dependency of the optimal solutions and the optimal values on a specific parameter in an economic or engineering system. (A group of power systems engineers at this reviewer's university has successfully implemented these methods in modeling real-life situations, a fact also reported in the monograph.)

The "paths" traced in the monograph are sufficiently fine discretizations of local minimizers, stationary points and generalized critical points (i.e., points in the decision variable x and the scalar parameter t, where the gradients of the objective function and active constraints are linearly dependent). The path following is based on the general predictor-corrector principle applied at every iteration: From a given point on the path, move t and construct a new initial point x (using, e.g., Euler predictor) that falls within the radius of local convergence of a corrector (e.g., a Newton, Robinson, Wilson or Garcia-Palomares and Mangasarian type method). In particular, an active index set strategy is proposed to follow a function of local minimizers. This strategy allows a change of more than one index at a time. An important feature of the proposed methods is that they include jumps from one connected component of local solutions or critical points to another (not necessarily of the same kind). The jumps are possible if certain types of turning points appear. For an identification of points along a path and for jumping criteria, the authors use a structure analysis and singularity theory of Jongen and relevant results of Kojima and several co-authors.

The theoretical background on the structure of various interesting points is reviewed in a self-contained introductory chapter (written by Jongen). In addition to a classification of critical points into five types (according to the so-called "characteristic numbers"), the chapter reminds the reader about general important facts, such as the role of the Mangasarian-Fromovitz constraint qualification in the local descriptions of the feasible set and its intimate relationship with bifurcation. All functions in the programs are assumed k times continuously differentiable, where k is raised according to the need. Several problems are actually solved numerically and some particular strategies, based on the experience of the authors, are suggested in some instances.

"This monograph...will be useful to the researchers in numerical optimization and mathematical modeling. For the experts in parametric optimization, especially in numerical parametric optimization, [it] will become a standard reference."

Titles of the chapters are: 1. Introduction; 2. Theoretical Background; 3. Pathfollowing of Curves of Local Minimizers; 4. Pathfollowing Along a Connected Component in the Karush-Kuhn-Tucker Set and in the Critical Set; 5. Pathfollowing with Jumps in the Set of Local Minimizers and in the Set of Generalized Critical Points; 6. Applications.

The monograph contains almost 250 references. The familiarity of the authors with a huge, and often technical, literature on numerical algorithms and various related topics in parametric and numerical optimization is impressive.

This monograph should be of interest to graduate students and researchers in every area of applied mathematics that requires optimization. In particular, it will be useful to the researchers in numerical optimization and mathematical modeling. For the experts in parametric optimization, especially in numerical parametric optimization, this monograph will become a standard reference.

-S. ZLOBEC

Handbooks in Operations Research and Management Science

Volume 2, Stochastic Models
Edited by D.P. Heyman and M.J. Sobel
North Holland, Amsterdam
1990

ISBN 0-444-87473-9

The book under review, *Stochastic Models*, is a collection of 13 rather independent chapters on stochastic topics which are useful in operations research and management science.

The chapter titles and authors are: 1. Point Process (R.F. Serfozo); 2. Markov Processes (A.F. Karr); 3. Martingales and Random Walks (H.M. Taylor); 4. Diffusion Approximations (P.W. Glynn); 5. Computational Methods in Probability Theory (W.K. Grassmann); 6. Statistical Methods (J. Lehocky); 7. Simulation Experiments (B. Schmeiser); 8. Markov Decision Processes (M.L. Puterman); 9. Controlled Continuous Time Markov Processes (R. Rishel); 10. Queuing Theory (R.B. Cooper); 11. Queuing Networks (J. Walrand); 12. Stochastic Inventory Theory (E.L. Porteus); 13. Reliability and Maintainability (M. Shaked and J.G. Shanthikumar).

It is not possible to review adequately the contents of each chapter here. Instead we concentrate on more general aspects. All in all, the expository level is high. General definitions are often motivated by examples and preceded by special definitions. The authors apparently have tried to write on a non-technical level. Each chapter has its own set of extensive references. An accumulated subject index helps to find specific topics. We conclude that *Stochastic Models* is valuable both as a reference book and as an introduction to each of 13 different topics. It should be included in any library of operations research, management science, mathematics or statistics.

The above conclusions are unaffected by the fact that *Stochastic Models* has several flaws. This is perhaps to be expected in a work of such size and scope, but it seems that many of these flaws could have been corrected during the editing process. We list some of them:

"*. . .Stochastic Models* is valuable both as a reference book and as an introduction to each of 13 different topics. It should be included in any library of operations research, management science, mathematics or statistics."

The prerequisites for reading and understanding most chapters are not stated. Not all chapters can be read assuming only "a calculus-based probability course and the rudiments of matrix algebra." For example, the concept of conditional expectation given a σ-algebra is used in Chapters 3 and 4 without explanation. No reference is given for the reader unfamiliar with this concept.

The subject index is incomplete. One example is the reference to the Ito integral (used without definition on page 436) is missing.

No cumulative author index or cumulative set of references has been provided.

Some misspellings occur which easily could have been found with an English language spell checker, e.g., invovled, on page 436.

In Chapter 1, E denotes expectations as well as some state space (see the first two formulas on page 11).

In Chapter 6, the book cited, Rao (1965), in the context of minimum variance unbiased estimation, should have been replaced by its second (1973) edition. A more recent book reference concerning this topic which I would have added is E.L. Lehmann (1983), *Theory of Point Estimation*.

The reported flaws are minor compared to the usefulness of *Stochastic Models*, but the book could have profited from a more careful editing process.

- L. MATTNER

Structural Complexity Theory Vol. I and Vol. II

EATCS Monographs on Theoretical Computer Science, 11 and 22
J. L. Balcázar, J. Diaz and J. Gabarró
Springer Verlag
Berlin
1988 and 1990
ISBN 3-540-18622-0 (VOL. I)
ISBN 3-540-52079-1 (VOL. II)

This pair of monographs, written by three authors from Barcelona, represents so far the standard textbook on the subject of structural complexity theory. As such, it has found its way into the classroom for our courses on structural complexity theory, and from this fact the readership of the OPTIMA newsletter may conclude that this reviewer will be biased in favor of these books. Still this will not prevent me from reviewing it from the perspective of the value of these books for those working in mathematical programming or combinatorial optimization.

First, we must look at the basic concepts of computational complexity. Researchers solving large-scale optimization problems by nature should be aware of the important differences between problems which are effectively solvable and problems which are solvable in principle, but are found to be intractable for all practical purposes. It was, in fact, a researcher in operations research, J. Edmonds, who presented the idea that tractability of a combinatorial problem should equate to having a polynomial time-bounded algorithm for its solution. The existence of a substantial class of problems, not known to be tractable, which can be solved in polynomial time using a non-deterministic guess and verify method, but known to behave as the hardest problem of this type, was verified by the fundamental work of S. Cook, D. Karp and independently by L. Levin. The results of these developments of the early 1970s are known as the P=NP problem and the concept of NP-completeness.

One reason these ideas are held to be fundamental is that they provide ways and means of talking about complexity and intractability without going into the details of a concrete machine model and the algorithms running on it. The notions of polynomial time and logarithmic, or polynomial bounded space consumption, are invariant for the reasonable sequential models of computation. Parallel models are a different story: the reasonable large-scale parallel models are known to have the power to do in polynomial time what sequential machines can do in polynomial space.

During the early years of complexity theory there existed two directions in the research: on the one hand, there was the more abstract line where the concept of complexity was investigated as a mathematical topic using tools primarily originating from recursion theory. On the other hand, a large amount of research was aimed at improving algorithms for specific concrete problems, designing new and efficient data structures or proving by difficult and complicated combinatorial arguments a lower bound showing that the known algorithms cannot be improved. In case the bounds are not tight, such a lower bound exhibits the gap between what has been achieved and what is known to be impossible. The two directions in complexity theory converged on the themes of NP-completeness, reductions and intractability proofs for various logical systems and decision problems. Still, in the 20 years that followed the P=NP? problem turned out to be the foremost unsolved problem in computational complexity theory, and this situation remains unchanged today.

Structural complexity theory finds its origins in work performed by Juris Hartmanis and his students in the late 1970s. Hartmanis and Berman observed that the combinatorial problems shown to be NP-complete turn out to be even more similar than what is expressed by the fact that they are interreducible by polynomial time many-one reductions; they are in fact interreducible by polynomial time bijections, which means that the corresponding combinatorial decision problems are isomorphic. Hartmanis and Berman went on to propose the conjecture that this isomorphism which holds for all known NP-complete problems in fact extends to all possible NP-complete problems. Having observed that this is a hard-to-prove conjecture (its truth would entail *P=NP*), they set out to disprove it by constructing an NP-complete problem which could not be isomorphic to a standard NP-complete problem like SATISFIABILITY, on behalf of its structural properties. Thus the quest for a sparse NP-complete set was initiated; this ended in failure when S. Mahaney proved that such sets could not exist, unless P=NP.

"The books provide a large collection of fundamental theory and tools which have been found relevant for this research."

These two results have set the tone for subsequent work in structural complexity theory performed in the 1980s and which by now has attracted an active community of researchers around the world; this community has its own series of annual conferences (IEEE Conference on structure in complexity theory, with a seventh edition in 1992), and a reasonable amount of coverage in general theory conferences and scientific journals. The topics involve the study of complexity hierarchies using recursion theoretical tools, the study of complexity classes defined using alternative modes of computation (among which the probabilistic models and the models based on interaction have become extremely important), and the ongoing

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study into machine models and the combinatorial study of characterizing their finite computations in terms of circuit models or descriptive complexity.

This brings me to the question of what this area has to contribute to operations research. It is evident that a theory which proclaims that all interesting operations research problems being worked on are in fact equal (even though researchers trying to solve those problems know quite different) risks losing credibility even before having been used. Still the structural framework has something to contribute to those working on practical problems. Over the past years I have been queried about the possibility that primality testing would be hard for NP or whether there could exist an NP-complete problem having unique solutions. In both cases the answer is negative, provided nothing bad happens. Here the bad thing that might happen amounts to the collapse of the polynomial time hierarchy which is generally believed to be infinite. Structural complexity theory yields constraints on how the actual state of the world of complexity may look, even if we do not know the real state of affairs. A more recent result which attracted much interest in the spring of 1992 shows that a number of well-known problems in combinatorial optimization cannot be solved approximately unless P=NP. This result, which is an unexpected consequence of the research on complexity classes based on interactive computation, clearly has a direct impact on operations research.

The two books present an extended introduction into a number of relevant concepts and results in structural complexity. The presentation is intuitive without unneeded formalisms. The readers must possess a reasonable amount of mathematical maturity and a general knowledge of the fundamentals of complexity theory. Previous experience up to the level of, for example, the textbook on automata theory and formal languages by Hopcroft and Ullman or the well-known monograph by Garey and Johnson is a must. Also, the exercises require a mathematical maturity.

The introductory sections are dense and concise: models of computation in Chapter 1; time and space bounded computations in Chapter 2; fundamental complexity classes in Chapter 3 and reducibilities in Chapter 4. Do not skip these introductions: some notions are defined here which will not be used until much later in the books. Part I continues with more specialized structural notions: non-uniform complexity in Chapter 5 and uniform diagonalization in Chapter 7. Extension of the modes of computation are presented in Chapter 6 dedicated to probabilistic models and Chapter 8 where the polynomial time hierarchy is introduced. This completes the contents of volume I which has provided the reader with a large collection of concepts and tools, all compared nicely with each other.

Volume II begins with more machine model theory: the parallel models are presented (Chapter 1) and the parallel computation thesis is discussed (Chapter 2). The alternation model in Chapter 3 and the uniform circuit complexity in Chapter 4 provide extensions of the class of computational models. The subject which originally motivated the whole research program (the isomorphism conjecture and Mahaney's proof of the non-existence of a sparse complete set) can be found in Chapter 5. The structural properties of bi-imunity and complexity cores are to be found in Chapter 6. Chapters 7 and 9 deal with ideas which have a clear origin in recursion theory, such as relativizations and high- and lowness concepts, which have been found useful for proving the sort of non-existence results on concrete problems mentioned in the introduction of this review.

The final chapters on resource-bounded Kolmogorov complexity and on interactive proof systems deal with areas which have become substantially more important since the books have appeared. Another indication of the time of completion is the fact that the 1987 result by Immerman and Szelepcsényi, showing the closure of nondeterministic space bounded classes under complementation (solving a problem from automata theory which had been open for 23 years!) has been included as an appendix. This result and the discovery of the collapse of various proposed hierarchies in the same year, 1987, indicate the real breakthrough of structural complexity theory. Other important, more recent results not mentioned are the full closure of PP under all Boolean operations (left as an open problem in Chapter 6) and Kadin's result that a collapse of the Boolean hierarchy implies that the Polynomial time Hierarchy collapses as well.

The two volumes contain a well-written introduction into an active research area which look at first sight only to be of indirect relevance for operations research, but the most recent developments seem to indicate otherwise. The books provide a large collection of fundamental theory and tools which have been found relevant for this research. However, publication came too soon in the sense that the theory has been expanded substantially following the completion of these books, therefore a large number of important results are not included. One should inspect the annual *Structure in Complexity Theory* proceedings in order to remain up-to-date. The books are suitable for use in a graduate course, but the course should include more recent material from journals and conference proceedings as well.

-P. VAN EMDE BOAS

OPTIMA

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CONTINUED

New Optimization Centers at Cornell, Florida and Georgia Tech

solutions of water management problems, evacuation modeling, and warehouse location problems. Sponsors include the National Science Foundation, the Army Research Office and the Florida Water Management Districts.

The Center is interested in promoting collaboration with researchers at other universities through visitors and student exchange. It administers a program for visiting students from The Royal Institute of Technology (KTH), Stockholm, in cooperation with P. O. Lindberg of the KTH Division of Optimization and Systems Theory and E. Rune Lindgren who has appointments at Florida and KTH.

A conference in Large-Scale Optimization, hosted by Hager, Hearn and Pardalos will be held Feb. 15-17, 1993, at the University of Florida. Many leading researchers will present papers (see announcement elsewhere in OPTIMA). The conference has been endorsed by the MPS, SIAM and ORSA.

GEORGIA TECH

The **Computational Optimization Center**, established with a grant from IBM, conducts research and education programs on the development, implementation and application of optimization methods. Housed in the School of Industrial and Systems Engineering, the Center draws upon the diversity of faculty with expertise in all areas of operations research and management science.

The principal faculty are Directors Ellis Johnson and George Nemhauser, Cynthia Barnhart, Roy Marsten and Martin Savelsbergh. The affiliated faculty are Faiz Al-Khayyal, Earl Barnes, John Bartholdi, Marc Goetschalckx, John Jarvis, Donna Llewellyn, Gary Parker, Don Ratliff, Alex Shapiro, Mike Shetty, Craig Tovey and John Vande Vate. Visitors for the academic year 1992-1993 include Lloyd Clarke and Ram Pandit.

The research of this Center focuses on large-scale optimization modeling and computation and the development of software using IBM's Optimization Subroutine Library (OSL). Recent projects include production scheduling in a manufacturing environment, optimization of a large distribution system, and airline crew assignment and fleet planning problems. Funding is provided by grants and contracts from the National Science Foundation, Air Force Office of Scientific Research, Army Research Office, AT&T, IBM, American Airlines, Delta Airlines and Northwest Airlines. NSF and AFORS fund basic computational research in mixed-integer programming, and NSF together with the airlines provide matching funds for a project on column generation methods and their applications to airline optimization problems.

Workshops to increase the technical and modeling skills of users of optimization software are conducted for executives, practitioners and researchers on a regular basis.

MPS
Nordic Section
R E P O R T

The Nordic Section of MPS held its second biannual meeting in Trondheim, Norway, Aug. 14-16, 1992. Twenty-seven people from all five countries (Norway, Sweden, Denmark, Finland and Iceland) took part. About one third were Ph.D. students. There was a decision to meet again during the winter of 1993-94 in Linköping. A new board was elected consisting of Stein W. Wallace (Trondheim, Norway), Jens Clausen (Copenhagen, Denmark) and Subhash Narula (Linköping, Sweden).

The number of MPS members in the Nordic counties has increased substantially over the last three years to about 45 at this time. Most of the members can be reached by sending e-mail to mps@iok.unit.no (automatic redistribution). The leader of the section can be reached via mps-request@iok.unit.no. All MPS members are encouraged to use this network if they wish to inform the Nordic members of some issue, be it a meeting, a visit to the region or some other subject.

-STEIN W. WALLACE

Enhanced Nonlinear Programming Code Available

VERSION 3.0 of FSQP has been completed recently. As was the case for previous versions, it is available free of charge to academic users, but may not be redistributed. If interested, please send e-mail to andre@src.umd.edu.

The main enhancement is that FSQP now also handles nonlinear equality constraints. "Semi-feasibility" for these constraints is maintained in the following sense: given a scalar constraint h(x)=0, if h(x0)<=0 (resp. >=0), then h(xk)<=0 (resp. >=0) for all k.

For those not familiar with previous versions of FSQP:

FSQP (Feasible SQP, developed by J.L. Zhou and A.L. Tits at the Institute for Systems Research at the University of Maryland, College Park) is a FORTRAN code for solving constrained optimization problems, including constrained minimax problems. Its main feature is that all the iterates it generates satisfy the constraints except for nonlinear equality constraints, for which "semi-feasibility" is maintained (see above). This is of value in many engineering-related problems. Extensive numerical tests show that the efficiency of FSQP is comparable to that of the most popular (non-feasible) codes. A detailed User's Manual is available.

Application for Membership

Mail to:

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Cheques or money orders should be made payable to **THE MATHEMATICAL PROGRAMMING SOCIETY, INC.** in one of the currencies listed below.
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Student applications: Dues are one-half the above rates. Have a faculty member verify your student status and send application with dues to above address.

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O P T I M A

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Margaret Wright (AT&T Bell Labs) has been re-elected vice president at large of SIAM and continues as chair of the Society's Major Awards Committee. ¶Early registration deadline for the **IFORS 93 Meeting** being held in Lisbon, July 12-16, 1993, is April 1, 1993. ¶**ADMOD93, a Symposium on Applied Mathematical Programming and Modeling,** will be held in Budapest, Jan. 6-8, 1993. Chairman is **István Maros**. It will be preceded by a one-day **Workshop on Interior Point Methods**. Contact the Secretariat, e-mail: h103hen@ella.hu. ¶E-mail address for OPTIMA is now: **optima@ise.ufl.edu**. ¶**Deadline** for the next O P T I M A is **Feb. 1**, 1993.

Books for review should be sent to the Book Review Editor,
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Journal contents are subject to change by the publisher.

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