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International Symposium on Mathematical Programming

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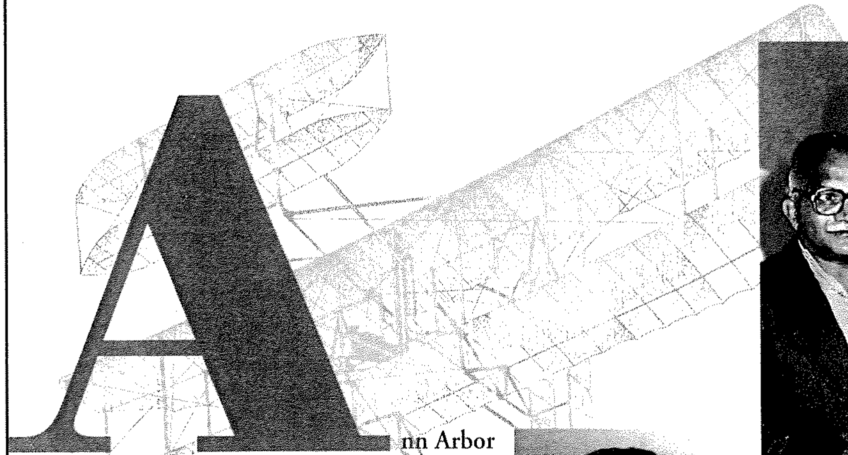

KATTA MURTY (l.) WITH DICK COTTLE

Ann Arbor and the University of Michigan hosted the XV International Symposium on Mathematical Programming, Aug. 14-19, 1994. The meeting began on Sunday night with opening remarks from Dean Peter Banks of the Michigan College of Engineering, Mayor Ingrid Sheldon of Ann Arbor, and Jan Karel Lenstra, Chair of the Society. Katta Murty, program chair, and Pulitzer Prize-winning composer William Bolcom then described the background of Bolcom's original composition, "Haunted Labyrinth," based on the solution of a linear complementarity problem. Noted pianist Robert Conway performed the piece exquisitely to an enchanted audience, who intently followed the musical path through a haunted house to the complementary solution (see accompanying article).

LENSTRA

JOHN BIRGE, general chair of the symposium, called the meeting to order for the Monday morning session, which included the Society's prize presentations. The names of the winners and reports of the prize committees are carried in this issue of OPTIMA.

BIRGE

In celebration of George Dantzig's 80th birthday in 1994 and his vast contributions to the field, Lenstra presented Dantzig with a special award from the Society. Roger Wets delivered an address on what Dantzig has called "the real problem" of optimizing under conditions of uncertainty. Professor Wets displayed the broad tree of student descendents that George Dantzig has had in this area and gave insights into the origin of stochastic programs and the real possibilities for practical computation with today's technology.

Bill Cook then took the stage, giving a colorful plenary lecture on "Large Scale Combinatorial Optimization," which referred significantly to his work with David Applegate, Robert Bixby and Vasek Chvátal in solving the largest traveling salesman problem ever.

Parallel sessions, including more than 1,000 talks, began after the opening session and lasted throughout the week. The parallel sessions were broken up with 20 tutorial lectures on topics across the realm of mathematical programming. Among the many sessions were particularly fascinating talks on Economics and Mathematical Programming, featuring Ralph Gomory of the Sloan Foundation and Herb Scarf of Yale University; a special session for Richard Cottle, in honor of his 60th birthday; and a special session on the TSP with Applegate and Chvátal.

Many sessions attracted record numbers of observers and great interest. Of particular note were the sessions on semidefinite programming and talk of the variety of new problem areas opened by this research: the stochastic programming sessions spurred by new computational experience, the nonsmooth optimization sessions featuring links across areas of mathematics, and the variety of practical combinatorial optimization and integer programming sessions.

Wednesday afternoon featured the Society Business Meeting and the announcement of the next symposium site at Lausanne, Switzerland, in 1997 under the direction of Thomas Liebling. More than 300 participants then attended a banquet picnic at the historic Greenfield Village in Dearborn, Michigan, featuring visits to the laboratories of Thomas Edison and the Wright brothers.

Overall, the meeting attracted more people than any previous symposium, with more than 1,070 registered attendees from 53 different countries. Of that number, fewer than half came from the United States, with more than 80 participants each from Canada and Germany, and more than 30 participants each from Italy, Japan, The Netherlands and the United Kingdom.

Complete rosters and addresses of participants, updated final program schedules, and additional abstract books are available for a U.S. $5 handling and postage charge by writing to: XVISMP, Department of Industrial and Operations Engineering, 1205 Beal, University of Michigan, Ann Arbor, MI 48109-2117, USA. Additional copies of the proceedings book of tutorial papers also are available at this address for U.S. $20. All checks should be made payable to University of Michigan.– JOHN BIRGE

O P T I M A

Haunted Labyrinth:

Symposium Invocation Music by W.E. Bolcom

FOR the first time, the world premiere of a musical composition has taken place at an inauguration ceremony of an International Symposium on Mathematical Programming.

William E. Bolcom, a Distinguished University Professor at the University of Michigan, composed the piece, "Haunted Labyrinth," especially for the Symposium. The music was performed by pianist Robert Conway.

The composition, based on B.C. Eaves' ghost story interpretation of complementary pivot algorithms for the linear complementarity problem (LCP), followed the path of iterates for an LCP of order 5 from a paper by Katta Murty.

Bolcom, born in Seattle, entered the University of Washington at age 11, where he studied piano and composition. He has earned many honors - including the 1988 Pulitzer Prize for Music - for compositions written in every period of his life. Commissions have come from orchestras such as the New York Philharmonic and the Vienna Philharmonic. Chamber music and concerti composed by Bolcom include a sonata for cellist Yo Yo Ma and pianist Emanuel Ax, and a flute concerto for James Galway and the St. Louis Symphony Orchestra.

Bolcom has taught composition at the University of Michigan School of Music since 1973. He has been a full professor there since 1983. In 1994, he was named the Ross Lee Finney Distinguished University Professor of Music.

–K. AARDAL

The PRIZES

Beale/Orchard-Hays Prize

After a very close competition involving many excellent nominations, the Beale/Orchard-Hays prize committee is pleased to announce the award of the 1994 prize to Andrew R. Conn of IBM, Yorktown Heights; Nicolas I.M. Gould of the Appleton Rutherford Laboratory, Oxfordshire; and Philippe L. Toint of the Facultes Universitaires Notre-Dame de la Paix, Namur, for their book titled: *LANCELOT: A Fortran Package for Large-Scale Nonlinear Optimization*, Springer Verlag, Berlin, 1992.

As the authors say in their introduction, LANCELOT (Large And Nonlinear Constrained Extended Lagrangian Optimization Techniques) was created out of the necessity for accurate modeling of physical, scientific, statistical and economic phenomena, which led to ever-larger and more challenging nonlinear optimization problems. However, necessity needs to be recognized, and complemented by the courage, determination and ability to undertake a major research effort spread over several years and nations.

To summarize briefly several of the achievements in the course of this project:

i) Significant work on the structure of large-scale nonlinear optimization problems, and on algorithmic approaches for large problems, i.e. their joint paper, "A globally convergent augmented Lagrangian algo-

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rithm for optimization with general constraints and simple bounds," *SIAM Journal on Numerical Analysis*, No. 28, pp 545-572, 1991.

ii) The development of a uniform input representation for nonlinear programs. The authors were not enamored of the MPS format, but were convinced by the user community that if LANCELOT were to get the widest possible use on real problems, total compatibility with the mps format was required. Thus they deserve commendation.

iii) The development of a code sufficiently robust that it efficiently solves, without tuning, the widest range of nonlinear programming problems of any code yet devised.

iv) The creation and distribution of the CUTE test environment, which is a major asset to the field.

v) The quality of the documentation provided by the book.

vi) The decision to distribute LANCELOT in return for a new problem from the user, thus making the software easily available and simultaneously promoting research.

In conclusion, the committee hopes and believes that LANCELOT is only a beginning, and, given that necessity has received such a helping hand, many others in the field will be encouraged to tackle the many problems crying out for a solution.

ROBERT R. MEYER, DAVID F. SHANNO, ROBERT VANDERBEI AND LAURENCE A. WOLSEY (CHAIR)


CONN (l.) AND TOINT RECEIVE THEIR PRIZES FROM WOLSEY.

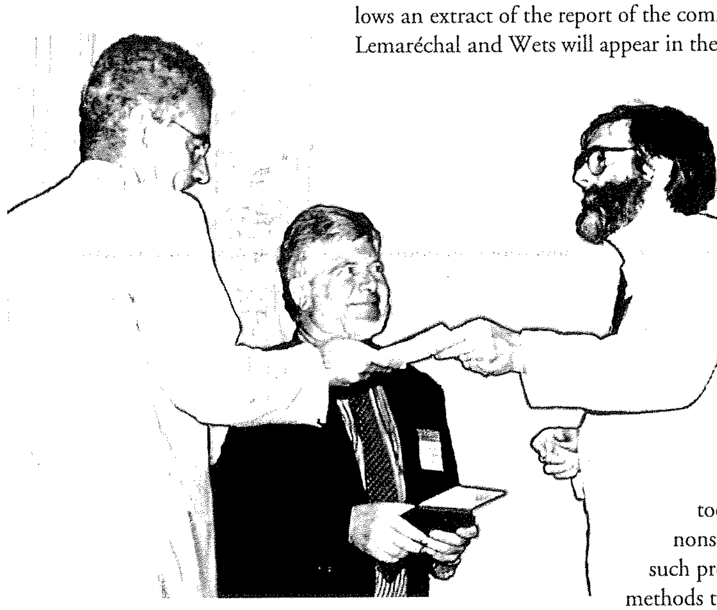
The PRIZES

The 1994 Dantzig Prize

The 1994 Dantzig Prize was awarded jointly to Claude Lemaréchal, INRIA, Rocquencourt, for his exceptional work in developing and analyzing numerical methods in nonsmooth optimization; and to Roger J.-B. Wets, University of California at Davis, for his outstanding contributions to all aspects of stochastic programming, and to variational convergence in the approximation of infinite-dimensional problems.

The George B. Dantzig Prize, jointly administered by the Mathematical Programming Society and the Society for Industrial and Applied Mathematics, is awarded to one or more individuals for research which, by virtue of its originality, breadth and depth, is having a major impact on the field of mathematical programming. The 1994 prize committee consisted of M. Gröetschel, E.L. Johnson, R.T. Rockafellar and M.J. Todd (chair). Below follows an extract of the report of the committee. Interviews with both Lemaréchal and Wets will appear in the next issue of OPTIMA.

LEMARÉCHAL (l.) AND WETS RECEIVE THEIR AWARDS FROM TODD.



Claude Lemaréchal:

Lemaréchal is the individual most responsible for the state of the art in computational nonsmooth optimization. This is a significant area not only because of the existence of nondifferentiable functions arising directly in applications, but also because decomposition methods for solving very large scale smooth problems (for example, those treated by stochastic programming) lead directly to the need to solve lower-dimensional nonsmooth problems. The tools of convex and, more generally, nonsmooth analysis are necessary to study such problems, but also needed are numerical methods that try to emulate the attractive behavior of methods for smooth optimization. Starting with some key papers, (e.g. "An extension of Davidon's methods to nondifferentiable problems," in *Math. Prog. Study 3* (1975) and "An algorithm for minimizing convex functions," in *Proceedings of the IFIP 74*) Lemaréchal has been the central figure in this new branch of mathematics. He initiated or participated in most of the significant developments in this area, especially in the algorithmic sector.

The *bundle* concept certainly is his decisive contribution to numerical nonsmooth optimization. In a series of papers, he thoroughly investigated and rigorously developed this idea and its variants (e.g. "Bundle methods in nonsmooth optimization," in *Nonsmooth Optimization*, Lemaréchal and Mifflin (eds.), Pergamon Press, 1978; "On a bundle algorithm for nonsmooth optimization," in *Nonlinear Programming 4*, Mangasarian, Meyer and Robinson (eds.), Academic Press, 1981). Until recently, the corresponding code M1FC1 was the only mathematically rigorous and efficient method for the minimization of general nonsmooth nonconvex functions. This code has been used successfully by numerous scientists and practitioners all over the world. More recent codes (by Kiwiel and Schramm/Zowe) are based on the same philosophy, with only minor additions to the bundle concept.

O P T I M A

Lemaréchal's work is also very imaginative and sometimes even speculative. He has not hesitated at pushing new ideas, which are currently far from practical realization, but which might open the way for future progress in nonsmooth optimization. Lemaréchal clearly realized that 'second-order elements' (whatever this means for nondifferential functions) are a must for any further substantial computational progress. A series of papers is devoted to this subject, e.g., "Some remarks on the construction of higher order algorithms in convex optimization," *J. of Applied Math. and Optim. 10* (1983), "The eclipsing concept to approximate a multivalued mapping," *Optimization 22* (1991).

He recently has published, with J.-B. Hiriart-Urruty, the two-volume book *Convex Analysis and Minimization Algorithms* (Springer-Verlag, 1993), giving a comprehensive and accessible account of these developments. Further, he has been involved in significant work on forcing global and fast local convergence of algorithms for nonlinearly constrained problems and on quasi-Newton methods.

Lemaréchal always has been concerned with the practical use of mathematical programming algorithms. He has long been the president of MODULOPT, which provides a library of computational methods and test problems, most from real-life applications. He has worked on solving problems arising in fields as diverse as flight trajectories; transonic fluid mechanics; meteorology; and molecular biology, leading to discretizations with hundreds or thousands of variables.

Roger J.-B. Wets:

Wets is recognized as the leading figure in the area of stochastic programming. His studies on the theoretical underpinnings of the subject include fundamental investigations into the geometry of the solution set, the properties of the value function, conditions for existence and stability of optimal solutions, and the structure of dual problems (see e.g., "Programming under uncertainty: the solution set," in *SIAM J. Appl. Math. 14* (1966), "Stochastic convex programming: basic duality," in *Pacific J. Math. 63* (1976), and "Stability in two-stage stochastic programming," in *SIAM J. Cont. Opt. 25* (1987)). One of the key insights is that stochastic programs have an additional multiplier type that does not arise in deterministic models: multipliers associated with *nonanticipativity* of the decision structure.

On the algorithmic side of stochastic programming, Wets' contributions include the basic and fundamental L-shaped method, a very efficient method for the simple recourse problem, and the recent progressive hedging algorithm (see "L-shaped linear programs with application to optimal control and stochastic programming," in *SIAM J. Appl. Math. 17* (1969), "Solving stochastic programs with simple recourse," in *Stochastics 10* (1983), and "Scenarios and policy aggregation in optimization under uncertainty," in *Math. of O.R. 16* (1991)). These methods have been used effectively in a variety of applications, and their use is expanding as computational power to handle such large models grows. The last method cited exhibits considerable scope for exploiting parallel computing. Nonanticipativity multipliers are crucial in it.

Through the analysis of statistical properties of optimization problems depending on random variables - including generalized laws of large numbers - Wets has laid the foundation for discretizing or otherwise simplifying the probability distribution in a stochastic programming problem. The central concept here, which he has spent a substantial part of his career in developing, is *epi-convergence*. This refers to a kind of convergence of optimization problems or subproblems, feasible solution set and objective function together, that ensures convergence of solutions, thus fitting into a larger subject known as variational convergence. From early theoretical work (see "Convergence of convex functions, variational inequalities and convex optimization problems," in *Variational Inequalities and Complementarity Problems*, John Wiley, 1980) he has proceeded to use epi-convergence to answer questions in the design of numerical methods that rely on random sampling or partitioning of the probability space to reduce dimensionality in the representation of a problem's stochastic structure (see "Epi-consistency of convex stochastic programs," in *Stochastics 34* (1991)). The epi-convergence approach is emerging as a basic tool also in other areas of optimization where the underlying problems have an infinite-dimensional aspect.

Wets also has been very active in applications ranging from the environment (lake pollution) to finance (asset/liability management). He has done consulting work for the Frank Russel investment system, which received the runner-up award in the 1993 Edelman Prize for Management Science Achievement, on the management of Lake Balaton eutrophication (see "Stochastic optimization models for lake eutrophication management," in *Operations Research 36* (1988)), and on the World Bank model for developing countries. He has been a driving force more generally in promoting the use of stochastic programming models by others in applications where deterministic modeling can lead to unsatisfactory results. A theme in this effort has been his close involvement in recent years with the ongoing development of stochastic programming codes at IBM.

In addition to their own research, both Lemaréchal and Wets have very successfully nurtured and inspired their areas, encouraging and working with younger scientists, organizing conferences, editing proceedings, and writing survey papers introducing the field to other researchers. Both nonsmooth optimization and stochastic programming have substantial literatures from East Europe, and Lemaréchal and Wets have done much to make this work known and appreciated in the West, through conferences, joint authorship or editing, their extended participation in the programs of IIASA, and their extensive visits throughout the world.

Dantzig Prize Fund

George B. Dantzig, ***one of the founders of the field of mathematical programming, celebrated his 80th birthday on Nov. 8 of this year. One possibility to honor George Dantzig on his birthday is to contribute to the George B. Dantzig Prize fund. The Dantzig Prize was established in 1979 by the Mathematical Programming Society and the Society for Industrial and Applied Mathematics (SIAM). The prize is awarded to recognize original, broad and deep research making a major impact on the field. The Dantzig Prize represents a continuing tribute to George - not only to his distinguished work, but also to him as an esteemed colleague, teacher and friend. If you wish to contribute to the fund, please send a check payable to "SIAM-Dantzig Prize Fund" to:***

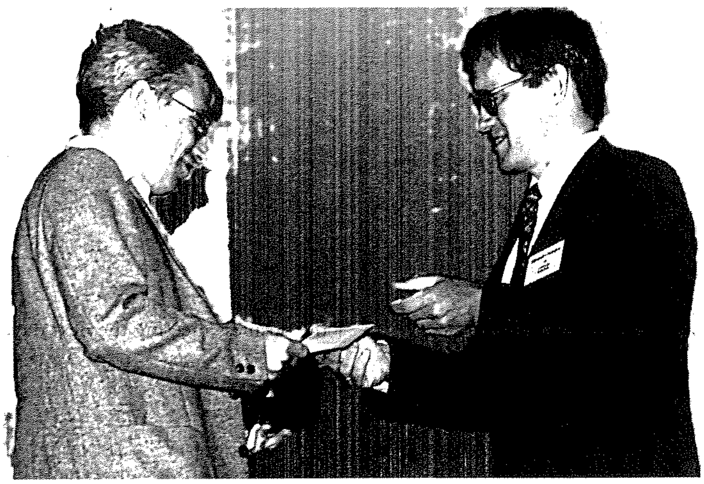
Professor Richard W. Cottle
Department of Operations Research
Stanford University
Stanford, California 94305-4022
USA

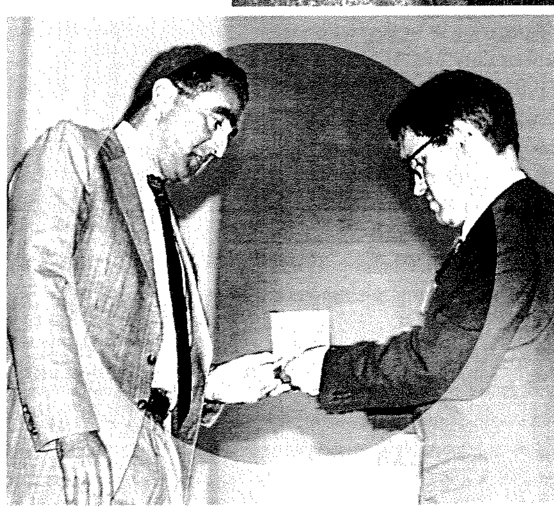
Checks in foreign currency also are welcome! Contributions are tax-deductible under the tax laws of the United States.

O P T I M A

(l. to rt.) THOMAS, SEYMOUR, ROBERTSON.

KALAI AND BILLERA (below) RECEIVING THEIR PRIZES FROM SCHRIJVER.





1994 Fulkerson Prize Citations

The 1994 Fulkerson Prize Committee consisted of: Alan J. Hoffman, Alexander Schrijver (chair) and Eva Tardos.

The committee was appointed by the American Mathematical Society and the Mathematical Programming Society to submit a recommendation of the paper(s) that should be awarded a 1994 D. Ray Fulkerson Prize.

The specifications read:

"Papers to be eligible for the Fulkerson Prize should have been published in a recognized journal during the six calendar years preceding the year of the Congress. The extended period is in recognition of the fact that the value of fundamental work cannot always be immediately assessed. The prizes will be given for single papers, not a series of papers or books, and in the event of joint authorship the prize will be divided. The term "discrete mathematics" is intended to include graph theory, networks, mathematical programming, applied combinatorics and related subjects. While research work in these areas usually is not far removed from practical applications, the judging of papers will be based on their mathematical quality and significance."

This Committee considered papers published in one of the six years from 1988 through 1993. Calls for nominations were published by *Notices of the American Mathematical Society, OR/MS Today, OPTIMA, Mathematical Programming* and *SIAM News.* Moreover, several researchers (including most members of editorial boards of journals in discrete mathematics) were requested directly (by mail or in person) to submit nominations.

The committee reviewed 13 eligible articles, including some nominations consisting of a set of papers, and found most of high quality. Extensive discussion between the three members of the committee and consultation with some specialized experts led to the unanimous conclusion that the following three papers should be awarded a 1994 D. Ray Fulkerson Prize:

L. Billera, "Homology of Smooth Splines: Generic Triangulations and a Conjecture of Strang," *Transactions of the American Mathematical Society,* pp 325-340, No. 310, 1988.

Citation:

For a long time, numerical analysts have studied vector spaces of splines, or piecewise polynomial functions. Billera's paper gives a new approach, expressing the spaces in question as graded components of a commutative ring or module. This leads to a proof of Strang's conjecture of 1973 concerning the dimension of the space of differentiable functions on a plane two-manifold that are piecewise polynomial of degree at most r. Billera's highly unexpected techniques solve several problems that stuck others attempting to solve the Strang conjecture. Not only did Billera's techniques prove Strang's conjecture, they also yield lower bounds for dimensions larger than two, and it opens up a new field of algebraic techniques (modules instead of vector spaces) to be used for splines. The article is exemplary in its effectiveness of creating bridges between pure mathematics (commutative algebra, Groebner basis methods) and a central field of applied mathematics (the computation of splines).

G. Kalai, "Upper Bounds for the Diameter and Height of Graphs of Convex Polyhedra," *Discrete and Computational Geometry,* pp 363-372, No. 8, 1992.

Citation:

In Kalai's paper, an $n^{(2 \log d + 3)}$ upper bound on the diameter of a d-dimensional polytope with n facets is proved. It is a completely unexpected breakthrough in the long-standing and important Hirsch conjecture of 1963, which states an upper bound of n-d. Despite considerable efforts by several researchers over more than three decades, the best known upper bound was until recently exponential in the dimension. Kalai's methods are of a surprising elegance and simplicity, and will stimulate further important research on the complexity of linear programming and on understanding the structure of polyhedra.

N. Robertson, P.D. Seymour and **R. Thomas**, "Hadwiger's Conjecture for K_6-Free Graphs," *Combinatorica*, pp 279-361, No. 13, 1993.

Citation:

This paper gives a proof of Hadwiger's conjecture (1943) for K_6-free graphs, stating that every graph not containing K_6 as a minor is five-colorable. It thus forms a breakthrough in the area of graph-colorability. The proof is very deep and ingenious, and it provides a lot of techniques applicable to other problems on graph colorings, paths and minors (while the proof is quite independent of the graph minors project). The proof consists of a reduction to the four-color theorem, thus giving several interesting tools for understanding Hadwiger's conjecture beyond planarity. The lucid and transparent style of presenting deep and original arguments adds to the quality of the paper as a masterpiece of pure and hard combinatorics.

The 1994 Fulkerson Prize recipients were honored in an award ceremony held at the opening the 15th International MPS Symposium in Ann Arbor, MI, August 1994.

–ALEXANDER SCHRIJVER, CHAIR

The PRIZES

1994 Tucker Prize Citations

The A.W. Tucker prize is awarded by the Mathematical Programming Society for an outstanding paper authored by a student. The 1994 prize committee consisted of Andrew Conn, William Cunningham, Clovis Gonzaga, Thomas Liebling (chair), and Jean-Philippe Vial. The committee proposed Dick den Hertog, Jiming Liu and David Williamson as the three finalists. All finalists presented their work at a special session of the symposium. At the business meeting the next day, David Williamson was announced as the winner. The committee's motivation follows. An interview with Williamson starts to the right. Interviews with Dick den Hertog and Jiming Liu will appear in the next issue of OPTIMA.

David P. Williamson, Massachusetts Institute of Technology, "On the Design of Approximation Algorithms for a Class of Graph Problems."

Williamson's extremely well-written thesis presents new, interesting and creative techniques that have implications for rather broad classes of problems. It presents an original application of duality for heuristics design with guaranteed performance for a family of problems that, aside from the (easy) matching problem, includes notoriously hard ones such as the generalized Steiner problem and the prize-collecting traveling salesman problem. While the performance bounds given are the best known, they underestimate the actual performance of the heuristic, which turns out to be very robust for practical problems. Several associated papers already have had wide influence.

Dick den Hertog, Delft University of Technology, "Interior Point Approach to Linear, Quadratic and Convex Programming - Algorithms and Complexity."

The candidate worked in a particularly active and competitive area in which many well-known researchers keep making contributions that are difficult to follow and classify for the non-specialist. His beautifully written thesis represents a reconciling and unifying treatment. It also includes a generalization of those contributions, bringing out the simplicity of the underlying ideas. Also noteworthy are the results produced by the candidate in the area of large step methods for convex programming. It is quite remarkable that it should have been a graduate student, like den Hertog, rather than a more senior researcher, who uncovered such basic results and treated the subject in such breadth and depth. His texts have become a standard reference in the area.

Jiming Liu, The George Washington University, "Five Papers on Stability and Sensitivity Analysis of Generalized Equations and Variational Analysis."

Liu has obtained highly original results related to perturbed variational problems; in particular, some of the results on growth condition in variational inequalities are real extensions of what was known before. His work on sensitivity of solution points (not optimal values, a much easier problem) to local perturbations will be helpful for improved design of models and algorithms, for a better understanding of their asymptotic behavior. For instance, in bilevel programming, Liu's results on some form of differentiability may prove very useful in the design of algorithms. His work already has found its way to the scientific literature, with five singly authored publications in first-rate journals.

interview

The Winner of the 1994 Tucker Prize

David P. Williamson *received his Ph.D. from Massachusetts Institute of Technology in September 1993. The thesis, "On the Design of Approximation Algorithms for a Class of Graph Problems," was supervised by Michel X. Goemans.*

The research lies in the intersection between computer science and combinatorial optimization, an area that has been particularly active in the last couple of years. The main result of the thesis is the development of a unifying framework for designing approximation algorithms for combinatorial problems. Until recently the design of such algorithms has been done ***ad hoc****, by using the specific structure of the considered problem. When Williamson speaks of an 'approximation algorithm,' he means an algorithm that runs in polynomial time, and that generates a feasible solution that is within a factor* α *of the value of an optimal solution. The factor* α *is usually referred to as the 'performance guarantee' of the algorithm.*

Currently Williamson holds a post-doc position at the School of Industrial Engineering & Operations Research at Cornell University.

OPTIMA

interview

OPTIMA: *All your university degrees are from MIT. How did you chose MIT?*

DW: When I looked for colleges, I applied to five places; among others Cal Tech, Stanford and MIT. It ended up that I got accepted everywhere. I was accepted early to MIT, so I had a couple of months to think about going there. I didn't think I was going to get in, so it was really nice when I did. Then it came down to thinking about MIT versus Cal Tech. Cal Tech was too narrow and too high-pressure, and then MIT versus Stanford. I decided in the end I wanted to go to a technical school, because in high school I was tired of people not understanding that I liked science. So, I went to MIT.

OPTIMA: *Were there any specific events or people that influenced your choice of working in combinatorial optimization and computer science?*

DW: MIT had this nice program that combines mathematics and computer science in the mathematics department, and since I liked both, that's what I went into. But the person who really influenced me for working on combinatorial optimization was David Shmoys. He was my undergraduate advisor as well as my Masters thesis supervisor. MIT assigns undergraduate students to people in their areas arbitrarily, and I ended up with David. It turned out that he also taught a course in complexity theory that I took the first semester he was my undergraduate advisor. So I took courses with him and during one summer I started working for him doing research that eventually led to my Masters thesis. David then left MIT just as I was entering graduate school.

OPTIMA: *And then you met Michel Goemans?*

DW: No, I actually didn't meet Michel until a couple of years later. David had been in touch with Michel, so I had heard of some of the things Michel did through him. It wasn't until some time later that I met Michel, and a little later that I decided that I'd better start working with him!

OPTIMA: *At the time you started working with Michel Goemans, did you already work on similar topics?*

DW: One of the reasons I wanted to work with him was that I had already duplicated some of his results, done special cases of things that he had done in greater generality. We were thinking of similar things, so I thought that it would be better to "join forces" than to keep duplicating someone else's research.

OPTIMA: *One major problem on designing approximation algorithms has been the lack of a unifying framework. You have successfully developed a framework into which many combinatorial problems fit. What was the main idea leading to your developments?*

DW: It was a particular paper by Agrawal, Klein and Ravi (*Proceedings of the 23rd Annual ACM Symposium on Theory of Computing*, pp 134-144, 1991) in which they use a kind of primal-dual technique for solving a specific problem, except they were not using linear programming. Michel and I thought we should try to make the linear programming part of it explicit and see what happened. Then we also saw it was possible to generalize the algorithm, to do more than what they were trying to do, and also make it conceptually simpler. That is really where everything started.

OPTIMA: *The combinatorial problems you consider are viewed as graph problems, and they are modeled as a special type of covering problem. You then consider the linear programming relaxation of that model, and its corresponding dual. One of your key results is the development of a primal-dual approximation algorithm with a performance guarantee of two. Could you explain the logic behind the "two"?*

DW: What's happening here is that you are trying to construct a forest, and you do so by increasing dual variables to determine which edges to add next. The cost of the edges in your final forest can be shown to be no more than twice the sum of all the dual variables: The main intuition here is that the relation between the cost of the forest and the dual variables has to do with the average degree of the forest, and the average degree is always no more than two. The sum of the dual variables is a lower bound on the integer program you are trying to solve, so you know that your solution is always no more than two times optimal.

OPTIMA: *What do you think is going to be the main impact of your results?*

DW: The hope is that people will be able to take this idea of applying the primal-dual method to solve integer programs approximately. It's not that it wasn't done before, but we give a new way of thinking about it. The other thing is that some of the problems considered in my thesis are problems people are really interested in, such as the survivable network design problem. The approximation algorithm we give for that problem has already been implemented by people at Bellcore, and is used in one of their software packages.

OPTIMA: *I guess there are still combinatorial problems that do not fit into your framework. Do you think it is possible to generalize your method even more to handle more general classes?*

DW: The ideas I wrote about can still be applied to other problems. People are thinking more about coming up with other, different, unifying frameworks, and they have been more successful in doing that in the past couple of years. There is a little bit of overlap in the sense that people have been using linear programming duality to help them solve other types of problems.

OPTIMA: *For many problems, you see quite a big gap between the best known worst-case bound and the known limit of approximability. Do we lack tools for developing approximation algorithms with a sharp bound, or to prove tight limits of approximability?*

DW: I think that a lack of tools on both sides is part of the problem. It was only in the past few years that the result by Arora, Lund, Motwani, Sudan, and Szegedy came up (*Proceedings of the 33rd Annual Symposium on Foundations of Computer Science*, pp 2-13, 1992) and people were able to prove any substantial bounds on approximability on a number of problems. Well, even the bounds that are known now are not always so substantial - they are along the lines of 'you can't approximate such-and-such a problem to within 1 percent of optimum unless P=NP.' Still, no one was able to prove any constant gap before for many of these problems, so it is a tremendous result. In terms of being able to prove sharp bounds, probably some new tools are needed. However, new tools also are necessary for designing algorithms. For instance, Michel and I wrote a paper right after I finished my thesis in which we made a big step forward for the maximum cut problem. That was by using the tool of semidefinite programming, which people in computer science hadn't used at all before then, and showing that it really helped in terms of being able to approximate the maximum cut problem, and some of the satisfiability problems.

OPTIMA: *Mathematical programming and operations research receive a lot of input from other fields such as computer science and mathematics. What is your opinion on the direction of development for mathematical programming?*

DW: It is hard for me to say because my training was mostly as a computer scientist, so I don't have the perspective of someone who has been in operations research. But, because of where I am, I tend to see the cross fertilization between mathematical programming and computer science, which is very lively! Since I am a computer scientist, I think there are a lot of great ideas from mathematical programming and operations research that can be used in computer science, and which computer scientists are not so familiar with.

OPTIMA: *In your particular area, what is the main open question?*

DW: Is P=NP? If P=NP, I am needless! The Arora paper was the last thing that got everybody in the field excited, although it is not clear how that result can be applied to take the next step to proving that P is not equal to NP. Actually, there was a recent result on something a bit lower down in the complexity hierarchy. Mulmuley showed that one could separate strongly polynomial time from NC, for an appropriate definition of NC that allows only arithmetic operations (*Proceedings of the 26th Annual Symposium on Theory of Computing*, pp 603-614, 1994). It sounds like a nice result, but I find it hard to evaluate.

OPTIMA: *What are your plans for the near future?*

DW: I am going to start at IBM in January. I will be doing research and working on applied problems within. My job is in an optimization group headed by Bill Pulleyblank. There is a computer science group nearby, so I will probably be working a bit with some of them as well.

–KAREN AARDAL

OPTIMA

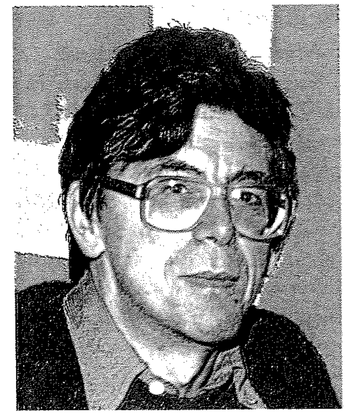
Working Group on Generalized Convexity Formed

The recent International Symposium on Mathematical Programming in Ann Arbor included for the first time an entire track of sessions on *generalized convexity*, with more than 25 lectures.

During the conference, the international **Working Group on Generalized Convexity** (WGC) was formed. Its activities will be guided by the International Scientific Committee, consisting of the following members: C.R. Bector (Canada), B.D. Craven (Australia), J.P. Crouzeix (France), J.B.G. Frenk (The Netherlands), S. Komlosi (Hungary), J.E. Martinez-Legaz (Spain), P. Mazzoleni (Italy), and S. Schaible (USA, Chair).

The committee will attempt to guide the generalized convexity community in establishing itself within worldwide academia. It will engage in proposing future events, such as international and regional conferences, and it will try to improve communication among its members. Anyone interested in participating in WGC should contact its chair, Siegfreid Schaible, Graduate School of Management, University of California, Riverside, CA 92521, USA; fax to (909) 787-3870; or e-mail to schaible@ucrac1.ucr.edu.

Laurence Wolsey Receives the EURO Gold Medal



MADY DE DEKKER

Laurence A. Wolsey, C.O.R.E. Université Catholique de Louvain, a distinguished member of the Mathematical Programming Society, received the EURO Gold Medal at the EURO meeting in Glasgow in July 1994. The medal was jointly awarded to Jean Pierre Brans, Vrije Universiteit Brussel.

The EURO Gold Medal is conferred on a prominent person or institution either for a remarkable role played in the promotion of operations research (OR) in Europe, or for an outstanding contribution to the OR science.

Wolsey has been one of the main contributors to the development of the theory and the computational aspects of polyhedral combinatorics. His work on polyhedral solution methods has led to the development (with T.J. Van Roy) of the software package, MPSARX, for general mixed-integer programming.

The work on MPSARX was awarded the Orchard-Hays (now the Beale/Orchard-Hays) prize in 1988 for "excellence in computational mathematical programming" by the Mathematical Programming Society. Wolsey's book, *Integer and Combinatorial Optimization,* Wiley, 1988, co-authored by G.L. Nemhauser, was awarded the 1989 Lanchester Prize by the Operations Research Society of America.

Wolsey is coordinator of the research project, "Algorithmic approaches to large and complex combinatorial optimization problems," within the Science and Human Capital and Mobility programs of the European Community, involving many of the leading research groups in Europe. Since 1986, he has been responsible for the European Doctoral Programs in Quantitative Methods in Management, which is an exchange program for graduate students between eight European universities.

Wolsey has long been an associate editor of *Mathematical Programming Series A,* and is, since 1990, a co-editor. He also has been a member of Council, and a Publications Committee Chairman of the Mathematical Programming Society.

–KAREN AARDAL

New Society Officers Elected

At the Mathematical Programming Symposium in Ann Arbor, Chairman Jan Karel Lenstra reported on the recent MPS elections. The new officers and council members are:

John Dennis (Vice-Chairman until August 1995; Chairman, 1995-1998);

Clyde Monma (Treasurer, 1995-1998);

Aharon Ben-Tal, Bob Fourer, Toshihide Ibaraki and **Eva Tardos** (Council Members-at-Large, 1994-1997).

O P T I M A

Obituaries

Stepan Karamardian (1933-94)

On July 10, 1994, Stepan Karamardian died in Oakland, CA, from a sudden heart attack. He was 61. Stepan received his Ph.D. from the University of California, Berkeley, in 1966 under G.B. Dantzig with a thesis titled "Duality in Mathematical Programming." He then joined the faculty of UC Irvine and later UC Riverside, taking on increasingly more administrative duties.

FROM 1982-90, Stepan served as Dean of the Graduate School of Management at UC Riverside. He oversaw the enlargement of the faculty and student body and the establishment of an undergraduate degree in business administration and the MBA degree, at the same time improving the research environment of the school. After having taken an early retirement in 1990, Stepan joined a UC team that was to establish the American University of Armenia, where he held administrative positions until his death. His Armenian background, as well as his administrative and academic experience, were of great value in his last assignment. He is survived by his wife, Seta, of San Francisco, and three daughters.

Stepan became internationally known early in his career through his contributions to nonlinear complementarity theory, which he studied in the broader context of mathematical programming, fixed-point theory and variational inequalities. He also worked on problems related to generalized convex functions and generalized monotone operators. In his last two published articles, Stepan focused on generalizations of monotonicity for operators (Karamardian and Schaible, *JOTA* 1990; and Karmardian, Schaible, Crouzeix, *JOTA* 1993). Together, we opened up a new area of research which has stimulated several research groups abroad within a short period of time. Such results relate back to generalized convexity as well as to complementarity problems and variational inequalities.

In the mathematical programming community, Stepan will be remembered as a mathematician of high caliber, whose contributions have significantly broadened the theoretical basis.

–SEIGFRIED SCHAIBLE
Sept. 20, 1994

In Memoriam: Eugene L. Lawler

Eugene L. Lawler died on Sept. 2, 1994, aged 61, after an eight-month battle with cancer. He is survived by his wife, Marijke, his son, Stephen, and his daughter, son-in-law and granddaughter, Susan, Matthew and Janna Rose Surprise. He will be dearly missed by his students, colleagues and friends.

GENE obtained an A.M. at Harvard University in 1957 and was a Senior Electrical Engineer at Sylvania Electric Products in Needham, MA, from 1959 until 1961. He went back to Harvard to obtain a Ph.D. in 1962. Gene then taught at the University of Michigan in Ann Arbor from 1962 until 1970, and at the University of California at Berkeley since 1971. He combined an illustrious career of highly influential research with a history of dedicated service to both universities.

For more than 30 years, Gene has been studying algorithmic issues in combinatorial optimization. His contributions have been fundamental in giving the discipline the breadth and depth it has now attained. Of all of his work, his textbook, *Combinatorial Optimization: Networks and Matroids* (1976), has had the most pronounced impact. It brought the most important results in the area together and is notable for its lucid writing style. It gave new clarity to well-understood results, brought the reader to the forefront of the field, and made the challenges of the future both apparent and accessible. It is one of the classics of the area. The book, *The Traveling Salesman Problem: A Guided Tour of Combinatorial Optimization* (1985), which he edited with three younger colleagues, also became a benchmark reference.

It is hard to separate Gene's contributions as an expositor and as a researcher. His great gift in investigating a computational approach to a problem was his ability to extract the essential difficulty, achieve a deeper insight, and then solve a more general problem in a simpler way. To some extent, his expository talent came from the relative difficulty he had in absorbing new ideas. For him to understand other people's work, especially when it was written in a complicated way, he often had to wrestle with it to arrive at a better understanding and a simplification of the result.

Gene's papers on branch-and-bound (with D.E. Wood) and dynamic programming (with J.M. Moore) are classics; the former, in fact, was selected as a citation classic in 1987. Both papers, rather than introducing radically new techniques, brought a new level of usefulness and understanding to important algorithmic paradigms. Since the mid-70s, Gene was particularly interested in sequencing and scheduling. Prior to his work, the area was a rather unmathematical hodgepodge, with little systematic understanding of the types of methods and techniques. Gene's work stimulated and unified the area greatly. Most recently, he had turned his attention to combinatorial problems in computational biology, which is an area of growing importance.

Gene was a phenomenal educator, providing the intuition that made difficult results easily accessible. He was constantly available for every new idea and always ready to interest his students in whatever he currently was thinking about.

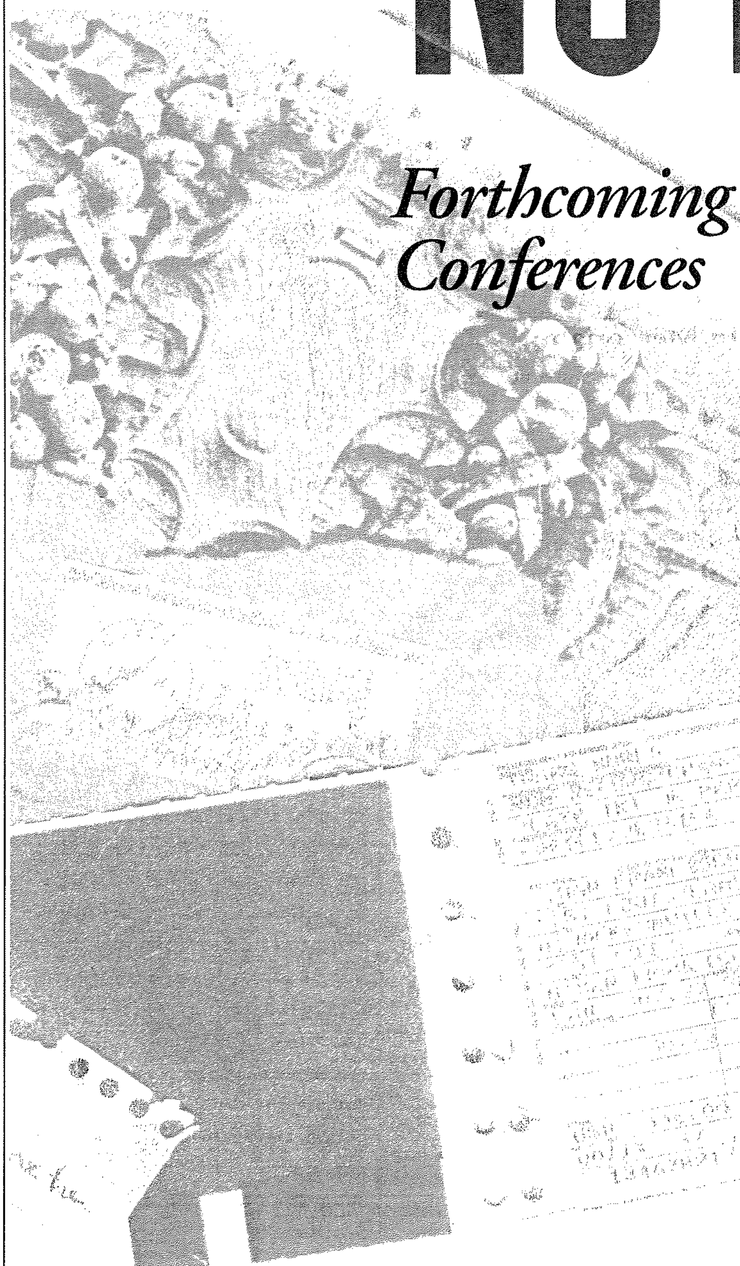
Gene had an enormous influence on the atmosphere of the Computer Science Division at Berkeley. He never lost sight of the mission of a university and never backed away from difficult tasks. Gene was the social conscience of the Division. He helped the individual student fight the bureaucracy, reformed what the university taught and to whom it taught, and made the university a more humane and stimulating place to study. This year he was awarded the Berkeley Citation, the campus's highest accolade.

Gene Lawler was a remarkable man who was ready to discuss intelligently nearly any current issue and did so in a thought-provoking way. We will all miss him very much.

Gene's family welcomes donations to the **Eugene L. Lawler Fellowship for Disadvantaged Students.** Checks, payable to UC Regents, can be sent to: Chairman's Office, Computer Science Division, 387 Soda Hall, University of California, Berkeley, CA 94720.

OPTIMA

CONFERENCE NOTES



Forthcoming Conferences

- APMOD95 - International Symposium on Applied Mathematical Programming and Modeling, Brunel University, Uxbridge, Middlesex, U.K., April 3-5, 1995
- The Fourth Conference on Integer Programming and Combinatorial Optimization, Copenhagen, Denmark, May 29-31, 1995
- The Hebrew University of Jerusalem International Conference on Game Theory and Applications, in Honor of Robert J. Aumann on his 65th Birthday, Jerusalem, June 25-29, 1995
- VII International Conference on Stochastic Programming, Nahariya, Israel, June 26-29, 1995
- The Fifth Conference on Integer Programming and Combinatorial Optimization, Vancouver, Canada, June 1996
- International Workshop on Parallel Algorithms for Irregularly Structured Problems, Lyon, France, Sept. 4-6, 1995
- XVI International Symposium on Mathematical Programming, Lausanne, Switzerland, Aug. 1997

OPTIMA

VII International Conference on Stochastic Programming

Nahariya, Israel, June 26-29, 1995

First Announcement and Call for Papers

The VII Conference on Stochastic Programming, sponsored by the Committee for Stochastic Programming of the Mathematical Programming Society, will be hosted by the Technion-Israel Institute of Technology, and held in Nahariya, Israel (near Haifa). A number of tutorial and state-of-the art reviews will be presented by invited speakers.

For more details, please contact: Nilly Schnapp, Faculty of Industrial Engineering and Management, Technion, Haifa, Israel. fax: 972-4-235-194; e-mail: ierns01@technion.ac.il.

The Hebrew University of Jerusalem International Conference on Game Theory and Applications in Honor of Robert J. Aumann on his 65th Birthday

Jerusalem, June 25-29, 1995

The academic committee includes Kenneth J. Arrow, Jacques Dreze, John C. Harsanyi, Sergiu Hart, Michael Maschler, Andreu Mas-Colell, Abraham Neyman, Ariel Rubinstein, David Schmeidler, Eytan Sheshinsky and Menahem Yaari. Partial financial support may be available. If you would like to participate and/or to receive further announcements, please write to:

Center for Rationality and Interactive Decision Theoralem
Feldman Building, Givat Ram
91904 Jerusalem, Israel.

Phone: +972-2-584135/6; Fax: +972-2-513681; e-mail: RATIO@VMS.HUJI.AC.IL

APMOD95 - International Symposium on Applied Mathematical Programming and Modeling

Brunel University, Uxbridge, Middlesex, U.K., April 3-5, 1995

APMOD95 is the third in a series of successful events. This year's symposium will be held at Brunel University from April 3-5, 1995. This series of events compliments the triennial Mathematical Programming Society Symposia and has built up a good tradition: in particular, the APMODs are followed by refereed publications and have been well-liked by the participating scientists. The main topics will be Large-Scale Linear Programming, Integer Programming, Nonlinear Programming and Modeling Systems. Contributions from America and Eastern countries are invited and solicited. The symposium is set up to attract specialists with different backgrounds, such as hardware manufacturers, industrial research workers, software houses and academic researchers.

The deadline for abstracts is Jan. 14, 1995. Notice of acceptance of papers will take place by Feb. 14, 1995. For more information and more deadlines, contact Molly Demmar, Department of Mathematics and Statistics, Brunel University, Uxbridge, Middlesex, UB8 3PH. Tel: +44 895 274000 ext. 2421.
Fax: +44 895 203303; e-mail: molly.demmar@brunel.ac.uk.

International Workshop on Parallel Algorithms for Irregularly Structured Problems

Geneva, Aug. 29-Sept. 2, 1994

Extensive research has been carried out concerning different ways for the automatic extraction of parallelism of several problems. Efficient solutions have been found to many problems, but others still lack efficient and automatic methods for their solution and remain open to research in parallel algorithms. Among this latter category, often are seen irregularly structured problems that resist parallelization by both automatic and manual manipulation.

To discuss such issues, the first international joint workshop on Parallel Algorithms for Irregularly Structured Problems was held at the University of Geneva from Aug. 29-Sept. 2, 1994. The workshop was organized by Afonso Ferreira (LIP, Lyon) and José Rolim (University of Geneva). This meeting consisted of presentations of the state of the art in research concerning irregularly structured parallel algorithms, and surveys of potential research areas. It provided a collaborative working and research environment. Talks included such topics as scheduling, parallel data structures, branch and bound, randomized algorithms, discrete optimization, load balancing, automatic synthesis and approximated methods.

The list of speakers included:

A. Gerasoulis, Rutgers University
T. Haagerup, Max Plank Institut, Saarbruecken
G. Kindervater, Erasmus University
L. Kucera, Charles University, Prague
V. Kumar, University of Minnesota
R. Lueling, University of Paderborn
G. Megson, New Castle University
P. Pardalos, University of Florida
V. Prasanna, University of Southern California
C. Roucairol, University of Versailles

This workshop was sponsored by IFIP, EATCS, 3eme Cycle Romand d'Informatique, Fonds National Suisse de la Recherche Scientifique, IBM Switzerland, Centre Universitaire d'Informatique de l'Universite de Geneve, and by the Laboratoire d'Informatique Theorique de l'Ecole Polytechnique de Lausanne.

Proceedings of the workshop will be published. The next workshop will be held in Lyon, France, Sept. 4-6, 1995.

Call for Papers

***Mathematical Programming Series B* special issue on Applications of Computer Science Techniques in Combinatorial Optimization, edited by Jan Karel Lenstra, Alexander Rinnooy Kan, and David Shmoys.**

With this special issue we intend to honor the memory of Eugene L. Lawler, who died in September 1994. We solicit papers that illustrate the application of concepts and methods from computer science to problems in combinatorial optimization. These problems may find their origin in a diversity of areas, such as distribution and production planning, computer system design and control, and computational biology. Computer science techniques for the design, analysis and implementation of combinatorial algorithms include polynomial-time optimization methods, data structures, issues of problem complexity, the derivation of guaranteed and probabilistic performance guarantees, and the study of local search methods.

All papers will be reviewed in accordance with the standards of *Mathematical Programming*. Please submit contributions to this issue following the submission guidelines of the journal before June 30, 1995 to:

Jan Karel Lenstra
Department of Mathematics
and Computing Science
Eindhoven University of Technology
P.O. Box 513
5600 MB Eindhoven
The Netherlands
jkl@win.tue.nl

or

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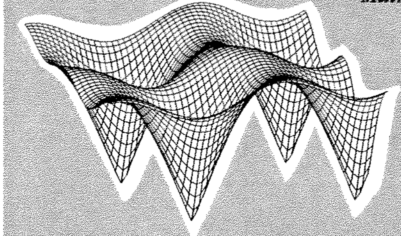


Nonlinear Programming

Olvi L. Mangasarian

Classics in Applied Mathematics 10

This reprint of the 1969 book of the same name is a concise, rigorous, yet accessible account of the fundamentals of constrained optimization theory. Many problems arising in diverse fields such as machine learning, medicine, chemical engineering, structural design, and airline scheduling can be reduced to a constrained optimization problem. This book provides readers with the fundamentals needed to study and solve such problems.

Contents

Preface to the Classics Edition; Preface; Chapter 1: *The Nonlinear Programming Problem, Preliminary Concepts, and Notation;* Chapter 2: *Linear Inequalities and Theorems of the Alternative;* Chapter 3: *Convex Sets in R^n;* Chapter 4: *Convex and Concave Functions;* Chapter 5: *Saddlepoint Optimality Criteria of Nonlinear Programming Without Differentiability;* Chapter 6: *Differentiable Convex and Concave Functions;* Chapter 7: *Optimality Criteria in Nonlinear Programming with Differentiability;* Chapter 8: *Duality in Nonlinear Programming;* Chapter 9: *Generalizations of Convex Functions: Quasiconvex, Strictly Quasiconvex, and Pseudoconvex Functions;* Chapter 10: *Optimality and Duality for Generalized Convex and Concave Functions;* Chapter 11: *Optimality and Duality in the Presence of Nonlinear Equality Constraints;* Appendix A: *Vectors and Matrices;* Appendix B: *Resume of Some Topological Properties of R^n;* Appendix C: *Continuous and Semicontinuous Functions, Minima and Infima;* Appendix D: *Differentiable Functions, Mean-value and Implicit Function Theorems;* Bibliography; Name Index; Index.

November 1994 / xv + 220 pages / Softcover
ISBN 0-89876-341-2 / List Price $28.50
OPTIMA Reader Price $22.80 / **Order Code CL10**

Interior-Point Polynomial Algorithms in Convex Programming

Yurii Nesterov and Arkadii Nemirovskii
with a foreword by Stephen Boyd

Studies in Applied Mathematics 13

In this book, the authors describe the first unified theory of polynomial-time interior-point methods. Their approach provides a simple and elegant framework in which all known polynomial-time interior-point methods can be explained and analyzed.

Contents

Chapter 1: *Self-Concordant Functions and Newton Method;* Chapter 2: *Path-Following Interior-Point Methods;* Chapter 3: *Potential Reduction Interior-Point Methods;* Chapter 4: *How to Construct Self-Concordant Barriers;* Chapter 5: *Applications in Convex Optimization;* Chapter 6: *Variational Inequalities with Monotone Operators;* Chapter 7: *Acceleration for Linear and Linearly Constrained Quadratic Problems;* Bibliography; Appendix 1; Appendix 2.

1994 / ix + 405 pages / Hardcover / ISBN 0-89871-319-6
List Price $68.50 / OPTIMA Reader Price $54.80 / **Order Code AM13**

Optimization Software Guide

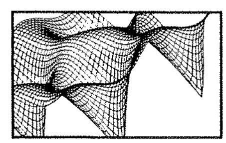
Jorge J. Moré and Stephen J. Wright

Frontiers in Applied Mathematics 14

Here is a reference tool that includes discussions of developments in optimization theory, and names software packages that incorporate the results of theoretical research. After an introduction to the major problem areas in optimization and an outline of the algorithms used to solve them, a data sheet is presented for each of the 75 software packages and libraries in the authors' survey.

For a complete table of contents or excerpts available in uncompressed PostScript form access gopher.siam.org *or contact SIAM Customer Service.*

1993 / xii + 154 pages / Softcover
ISBN 0-89871-322-6 / List Price $24.50
OPTIMA Reader Price $19.60 / **Order Code FR14**



Also of INTEREST

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BOOK REVIEWS

A Course in Computational Algebraic Number Theory

by Henri Cohen

Springer-Verlag, Berlin, 1993

ISBN 3-540-55640-0

Algebraic numbers are numbers such as the cube root of two, the golden ratio, or roots of unity. Algebraic number theory is the study of arithmetic properties of number systems that consist of such numbers. It first came up in the first half of the 19th century, in connection with generalizations of Gauss' *quadratic reciprocity law.* Algebraic number theory has important applications to the solution of diophantine equations, such as Fermat's equation $x^n+y^n=z^n$; to arithmetic algebraic geometry; and, to mention a recent development, to the problem of decomposing large numbers into prime factors, which is related to cryptography.

Cohen's book offers, in more than 500 pages, far more than the title promises. In addition to algorithms in algebraic number theory, one finds algorithms in elementary number theory, algorithms for polynomial factorization and algorithms related to elliptic curves.

There is a thorough and up-to-date treatment of primality testing and factorization. The second chapter is probably closest to the interests of the reader of OPTIMA: it contains the algorithms in linear algebra that the author needs, including lattice basis reduction algorithms.

"The second chapter is probably closest to the interests of the reader of OPTIMA: it contains the algorithms in linear algebra that the author needs, including lattice basis reduction algorithms."

The book can be used in several ways. The minimum prerequisites are a basic knowledge of elementary number theory and a feeling for algorithms. In principle, one can learn algebraic number theory from the book, since the algorithms presented often yield proofs of important results that usually receive more conceptual, but less constructive treatments. The student who likes to learn by example acquires the proper tools for numerical experimentation. At the same time, the expert will be able to use the book as a compendium of algorithms in number theory; what cannot be found here most likely is yet to be developed.

The attitude of the book is that of the pure mathematician for whom algorithms are tools rather than objects of study. Thus, the emphasis is on the practicality and the mathematical justification of the algorithms, rather than on complexity issues, which are hardly addressed at all. Also, while the author spells out all algorithms that he treats, he knows that his readers skip passages printed in quasi-algol or in typewriter font, and he has been wiser than many in avoiding both.

The style of the book is lively and informal, rather than polished, with many asides, exercises and stimuli for further research. It is highly recommended to anybody interested in knowing what is going on in this area.

–H.W. LENSTRA JR.

Optimization in Industry, Mathematical Programming and Modeling Techniques in Practice

edited by Tito A. Ciriani and Robert C. Leachman

John Wiley and Sons, Chichester, 1993

ISBN 0-471-93492-5

In 1991, the IBM Europe Institute held a seminar on Optimization in Industrial Environments, aiming at an overview of new achievements in mathematical programming modeling and its implications for optimization technology. Seventeen presentations held at that seminar are documented in this book.

"This book presents an illustration of present-day use of optimization techniques in industry and demonstrates the economic impact these techniques have, despite the difficulties encountered during practical implementation."

How should one review this diverse collection of articles? I admit I found it difficult to answer this question. Should I attempt to characterize each individual article? Or is a grouping according to optimization techniques used more interesting? Or a categorization according to industry? At any rate, the sequence as presented in the book seems completely arbitrary; I could not find any logic behind it. So let me group the articles in my own way and that is by industry application.

The first group is about the computer industry. These papers are the following: "Modeling Techniques for Automated Production Planning in the Semiconductor Industry," by R.C. Leachman. He describes the information flow and production planning in a semiconductor industry (Harris Corp.) The 20 time-period planning model covers a horizon of 18 months and, if formulated as a single linear program, would involve half a million constraints and variables. Instead, a heuristic decomposition scheme is proposed, including five modules, in which three use LP, the largest LP involving 100,000 rows. A model for material requirements planning with uncertainties in demand is studied in "MRP Modeling via Scenarios," by L.F. Escudero and P.V. Kamesam. The main goal is to determine the production schedule as well as the volume and location of stock levels in such a way as to hedge against uncertainty in demand while meeting specified service-level requirements. A scenario approach is used, leading to a stochastic programming model. Computational results are said to be quite encouraging. "Optimization in Microelectronics Manufacturing," by H. Fromm, C. Dillenberger and A. Wollensak, describes optimization of a drilling center using linear combinatorial optimization. Next, they discuss the loading of batches of parts on processing equipment using queuing models, which is treated in more detail in "Real-Time Scheduling of Batch Operations," by C.R. Glassey, F. Markgraf and H. Fromm. They conclude from simulation results that a decision process based on arrival forecasts (look ahead) can lead to substantial inventory and waiting time reductions. "The Job Sequencing Ordering Problem on a Card Assembly Line," by L. Escudero and A. Sciomachen, presents a 0-1 algorithm for a job sequencing problem, and reports on computational experience with it. "A Linear Approach to Planning the Production of Mainframe Computers," by C. Monvoisin, advocates an LP approach with two objectives (maximize production, minimize inventory) for production planning of IBM mainframes.

Three articles deal with problems in the oil industry. "Optimization in Refinery Scheduling: Modeling and Solution," by K. Ballintijn, deals with a multiperiod LP model for refinery scheduling to which integer variables are added to reduce the number of unnecessary switches in production modes on the refinery plants. The other two articles deal with the so-called pooling problem in refinery scheduling: If several different refinery streams are flowing into a single tank from which material also is taken for various destinations, and if each flow possesses distinct qualities satisfying mixing rules when brought together, then the production model becomes nonlinear. "In the Pooling Problem," M. Fieldhouse proposes a recursive method for solving such problems. R. Main, in "Large Recursion Models: Practical Aspects of Recursion Techniques," warns, however, that some recursion techniques which work for small models give poor results when applied to larger models. He adds that at present there does not appear to be a technique better than recursion.

The consumer product industries are represented in two articles. The first one is by A. Gascon, R.C. Leachman and A.A. DeGuia and is titled, "Optimal Planning and Control of Consumer Product Packaging Lines." It describes a hierarchy of computer-based decision supports systems for the planning and control of household product inventories. The highest level computes forecasts of monthly shipments, based on multivariate regression of seasonality and promotional activity data. In the second level, an LP model is used to translate the demand forecasts into monthly production. An in-house developed heuristic does the scheduling of production cycles on individual packaging lines at each plant. Benefits from, and difficulties with, the introduction of this system are briefly mentioned. Some pages of this paper are missing, describing the LP. The other article, "Mixed Integer Programming in Production Scheduling: A Case Study," by R. Ashford and R. Daniel, gives an MIP model for the scheduling of the production of cartons for the storage of liquid products. The authors point out the big improvements of the model outcomes over manually produced schedules and emphasize the important role of a modeling language in exploring various MIP formulations.

Two studies represent the aerospace industry. "Crew-Pairing Optimization at American Airlines Decision Technologies," by R. Anbil, C. Barnhart, L. Hatay, E.L. Johnson and V.S. Ramakrishnan, describes the problem of partitioning a flight schedule of an airline into sequences of flight legs beginning and ending at a crew base with an overnight rest period in the middle. Using LPs with a few million columns, the company saves an estimated $6 million for both the domestic and long-haul crew-pairing models. "Nonlinear Optimization Algorithm for Mixed Integer Programming Problems: Applications and Results," by G. Fasano, develops an approach for solving linear 0-1 programming problems by reformulating the problem as a quadratic nonlinear optimization problem and solving this in a branch-and-bound manner. It claims successful application to satellite optimal configuration layout problems containing 3,500 0-1 variables.

Finally, there remain four theoretically oriented papers. In "Monte Carlo (Importance) Sampling within a Benders Decomposition Algorithm for Stochastic Linear Programs," G. Infanger gives a complete presentation of the use of Benders decomposition and importance sampling for solving two-stage stochastic linear programs with recourse. He has tested the approach on problems, such as expansion planning of electric utilities and portfolio management, and states that the technique can handle 26 or more stochastic parameters. "Combinatorial Models for Manufacturing: Optimizing Flow Management in Flexible Production Systems," by A. Agnetis, C. Arbib and M. Lucertini, shows the correspondence between flow management problems in FPS and optimization techniques, such as dynamic, linear and integer programming, and cost-flow problems in networks. In "Solution of Large-Scale Linear Programs: A Review of Hardware, Software and Algorithmic Issues," R. Levkovitz and G. Mitra discuss sequential and parallel computing platforms, sparse simplex and interior-point algorithms, and the suitability of these algorithms on the various computer architectures. They conclude that the challenges now seem to be the seamless integration of simplex and interior-point methods, and the exploitation of parallel and novel computer architectures in future generations of solvers. This paper presents a fine overview of the current state of large-scale LP. T.A. Ciriani, in "Model Structures and Optimization Strategies," tests MIP preprocessing capabilities of MPSX/370 and OSL on various large models. He observes that model structures are important for solution efficiency and concludes that MIP preprocessing techniques can efficiently reduce optimization time.

This book presents an illustration of present-day use of optimization techniques in industry and demonstrates the economic impact these techniques have, despite the difficulties encountered during practical implementation.

–A.T. LANGEVELD

Discrete and Combinatorial Mathematics, an Applied Introduction, Third Edition

by R.P. Grimaldi

Addison-Wesley, Reading, USA, 1994

ISBN 0-201-54983-2

The author writes in the preface that the major purpose of this book is "to provide an introductory survey in both discrete and combinatorial mathematics. . . intended for the beginning student." In 17 chapters, which are divided into four parts, he introduces the reader to various areas of discrete mathematics.

The first part consists of seven chapters discussing some fundamentals of discrete mathematics. As in just about every book of this type, the first chapter is about the fundamentals of counting: permutations, arrangements, binomial coefficients, the binomial theorem and distributions. Also, Chapter 5, "Relations and Functions," is mostly about counting different types of functions from finite set A to some finite set B, yielding, for example, the Stirling numbers. The last two sections of this chapter, about the order of complexity of algorithms, have only the notion of a function in common with the preceding sections. Some chapters are just about formalizations of intuitive notions, such as Chapters 2 and 3, about logic (explaining what a proof is) and set theory (some basic definitions), respectively. Chapter 6, on languages and finite state machines, is an isolated chapter and seems to be superfluous. Chapter 4, about the integers, actually discusses two different subjects, namely mathematical induction (including recursive definitions and harmonic, Fibonacci and Lucas numbers) and some

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ring properties of the integers: division algorithm, prime numbers, gcd, lcm, Euclidean algorithm and factorization. Finally, Chapter 7 introduces partially ordered sets, including lattices, and equivalence relations.

Part 2 of the book treats some more advanced methods of counting, such as the principle of inclusion and exclusion (Chapter 8, recalling some results of Chapter 3 and the Stirling numbers and discussing derangements and arrangements with forbidden positives in general), generating functions (Chapter 9), and recurrence relations (Chapter 10) on finding and solving different types of recurrence relations, Catalan numbers and the complexity of divide-and-conquer algorithms.

The third part consists of the topics found in every book with a title like "Introduction to Graph Theory." It starts with some generalities about graphs: some basic definitions, Euler circuits, planarity, Hamilton cycles and graph coloring (Chapter 11). Chapter 12 is about trees and Chapter 13 discusses some optimization problems in graphs such as Dijkstra's shortest-path algorithm, the minimal-spanning tree algorithms of Prim and Kruskal, the max-flow min-cut theorem and the theorem of König-Hall.

Part 4 discusses some further algebraic structures such as rings and fields (Chapter 14, especially the integers modulo n) and Boolean algebra (chapter 15). Chapter 16 introduces the notion of a group, with coding theory and Polya's method of enumeration as applications. Finally, in Chapter 17, the finite fields are constructed and combinatorial designs such as latin squares and block designs (including affine and projective planes) are discussed.

There are a large number of examples with detailed explanations in the text. Maybe it is a matter of taste, but I think the number of examples is a bit overdone, totaling more than 600. As a consequence, the text looks at first sight like an agglomeration of examples and the pace is somewhat slow. At the end of each section and each chapter there is an abundance of exercises, totaling more than 1,700. The solutions of the odd-numbered exercises are given at the end. In each chapter, the last section provides a rough summary and a historical review of the topics treated and gives up-to-date (U.S.-oriented) references for further study.

The book has three appendices which discuss exponential and logarithmic functions (A1), matrices, matrix operations and determinants (A2), and countable and uncountable sets (A3). It is not clear to me why these appendices were added. It seems more natural to assume that these subjects are treated in other courses.

Except for the three appendices, 87 extra examples and more than 300 extra exercises, the differences between this edition and the second edition are marginal.

Because of the many examples, the book is extremely suitable for private study. Almost no foreknowledge is needed to read this book, which has a very nice and clear layout. I think the book is especially suitable for beginning students in mathematics and areas related to mathematics, such as computer science and management science, although I prefer a more concise treatment of the subjects for mathematics students.

–RENÉ PEETERS

OPTIMA

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OPTIMA Expanding with new Editors

OPTIMA will be expanding in 1995, by decision of the MPS Council. Joining **Don Hearn**, Editor, and **Dolf Talman**, Book Review Editor, will be: **Karen Aardal**, Features Editor; and **Faiz Al-Khayyal**, Software & Computation Editor. ¶Karen will have primary responsibilities for feature articles and Faiz will solicit and prepare articles on computational news. ¶Karen has made several contributions to this issue and Faiz will start a column in OPTIMA 45, the spring 1995 issue. MPS members are encouraged to submit articles and general interest items to the editors. ¶Deadline for the next OPTIMA is Feb. 1. 1995.

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