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OPTIMA

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Mathematical Programming Society Newsletter

Workshop on Computational Integer Programming

The first "Workshop on Computational Integer Programming" was held in November 1997 at the Konrad-Zuse-Zentrum in Berlin, Germany, and was organized by Bob Bixby, Martin Gröetschel and Alexander Martin (who was mostly in charge of the tedious and flawless organization) with the support of the "Gottfried Wilhelm Leibniz-Programm" of the German Science Foundation (DFG). More than 50 researchers and several practitioners from at least 10 countries followed a total of 19 talks and participated in the numerous discussions on the future of the field. SEE PAGE EIGHT ▶

Optimization: *An essential tool for decision support*

Plenary address by John Dennis at the XVIth International Symposium
(an edited version)

Tom Liebling asked me to give this talk. He said that I should give a talk that would appeal to our members, would motivate our official guests to support mathematical programming research, and would not bore anyone. Furthermore, I would share the podium with George Dantzig, the father of us all, as well as with our distinguished prize winners. So I said, "Sure."

Then, when I started to prepare the talk that would accomplish all these things, I remembered one of my favorite sayings from Mark Twain: A man is about to be ridden out of town on a rail, and he is asked if he has any last words. The man says, "If it weren't for the honor of the thing, I'd sooner walk."

This invitation certainly is an honor for which I thank the organizers and my fellow MPS members. Furthermore, I welcome a ride on this rail because it is a great opportunity to tell our story to our guests – and our story is ripe for the telling.

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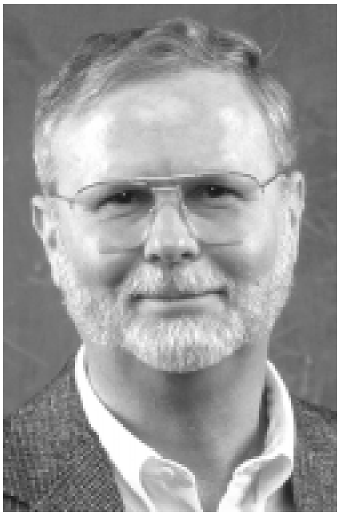
John Dennis' Address



You will notice that many of my examples are from the aerospace industry, as will be the case in my research talk later today. I spent last year at Boeing Research and Technology, and I owe a great deal to my Boeing colleagues for helping to crystallize these ideas.

We have distinguished guests among us who may wonder what Mathematical Programmers do and why we deserve support. I am including our spouses in this category.

For our guests, I will give a personal overview of the kinds of contributions we can make to computer-aided decision making. Key parts of the required technology are in hand, but much more research is needed to add crucial functionality.

For my colleagues, my message will be that there are some fascinating research issues we should address, and that interdisciplinary research is a fertile field for our talents.

The Mathematical Programming Society has about 1200 members with only about 35% from North America. Our symposia are unique among professional societies in that we always have more attendees and more lectures than we have members. This underscores our emphasis on research.

I hasten to add that our name does not mean that all members of MPS program computers. The research done by our members spans the spectrum in a healthy and appropriate way from purest to most applied. A major thrust of our members' research is in computer implementation of optimization algorithms. We have had a hand in all the most successful optimization software.

My thesis in this talk is based on the following assumptions: In the modern world, decisions must be made more and more quickly, and decision side effects must be understood in advance. Availability of high performance computing has caused common use of computers as decision aids (spreadsheets); huge progress in computational optimization; and a rich infrastructure of simulation models. People use computers in their work without any expectation that it will be necessary to learn programming or computer organization.

Spreadsheet applications are among the most widespread uses of computers because they allow decision makers to ask valuable "what-if" questions and examine the consequences of specific decisions.

My thesis is that the basic notion of a spreadsheet can be modified in fundamental ways by using optimization research to produce new tools required by a wide range of the most complex decisions.

A major reason we have such an exciting opportunity is because of the success of some other areas of applied mathematics. Interdisciplinary teams have provided us with a rich infrastructure of simulations of important phenomena.

Next, I will show how these simulations are being used now to support decision makers; then, I will introduce a more powerful paradigm made possible by incorporating optimization.

I visited a chemical plant where an analyst had been trying for two years to improve a process by manipulating two decision variables. He would choose values for the variables each evening before leaving work and start the process simulation program. The next morning he would see if he had made an improvement. He was a very patient man, and so was his boss.

I made a gentle suggestion - not in front of his boss - that pattern search methods could help. He did not take my suggestion. It was clear that thinking about how to set the variables for the nightly run had become an enjoyable part of his day.

It is common for decision makers to enjoy twiddling the decision variables, but they are no match for our algorithms at that piece of the problem. I will advocate tools that free the decision maker to concentrate on the essentially human part of the process: using judgement.

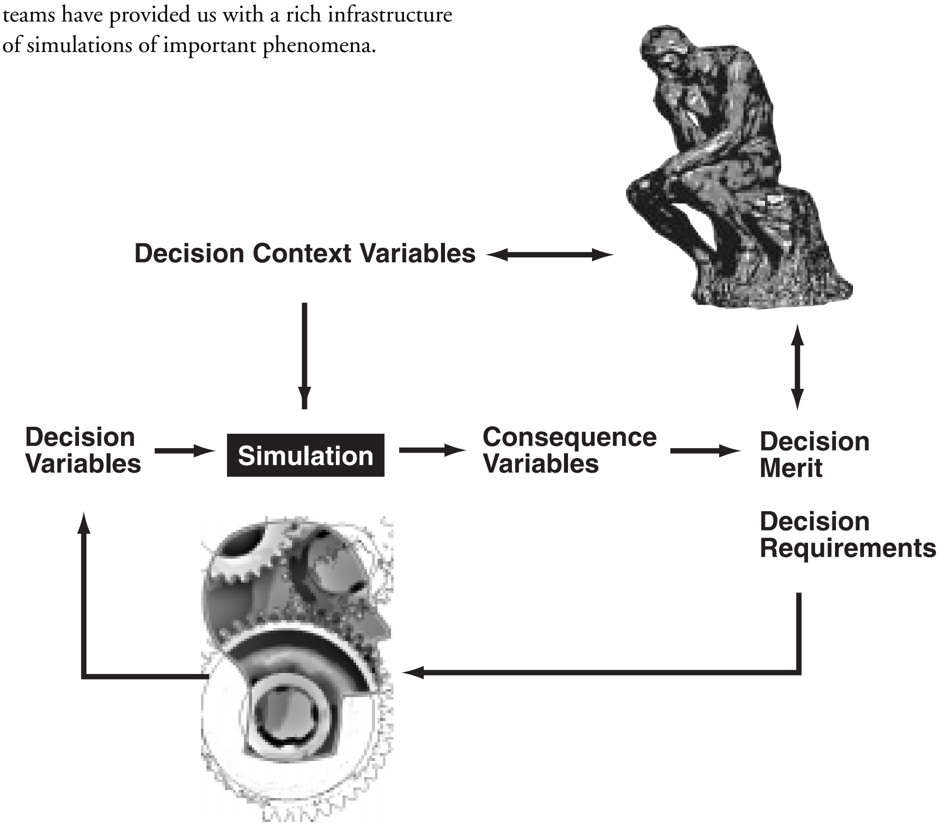


Figure 1. "Cut and Try" Optimization.

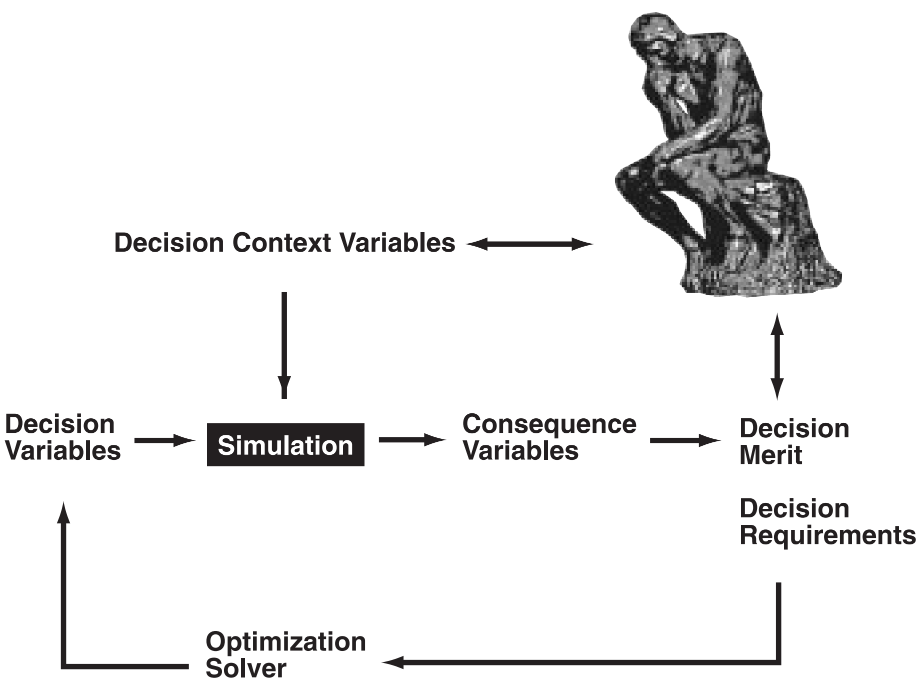
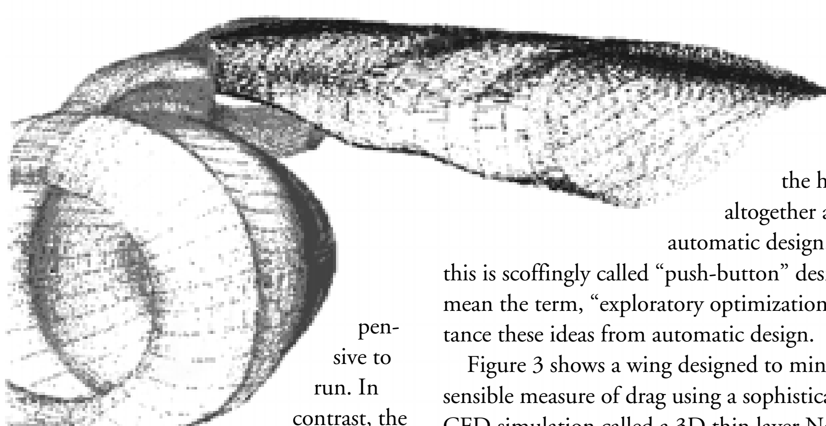


Figure 2. Exploratory Optimization.

Figure 3. Back to the Drawing Board.



Think of a fluid dynamics simulation as a formula attached to some cells on a spreadsheet. Fill in cells to specify design conditions like altitude, speed of flight, angle of attack for the wing; then fill in a couple of hundred cells with parameters that specify a particular wing shape, and after two hours of supercomputer time, the spreadsheet has calculated the airflow patterns around the hypothetical wing. It writes these in some cells connected to a formula to calculate the "drag" associated with the wing. That "drag" number is the figure of merit for the design. Less drag is better. Of course, there are extra constraints or requirements on the design. The aircraft should be able to fly a certain distance without refueling, etc.

The designer looks at these results and either alters the problem specifications or decides on some new design variables or, most likely, does both.

This approach was fine back when there was a lot of room for improvement and the simulations were not very accurate anyway. Wing design and many other engineering problems are at the point now where even small improvements are difficult and time consuming to make by "cut and try" (see Figure 1).

The point is to help you ask the right questions by showing you the answer to what you think is the right question. In simulation based decision support, the simulations can be complex and expensive to run. In contrast, the figure of merit is often simple and tentative. Important requirements may be omitted initially because they are so obvious to the decision maker that he forgets to specify them.

We should think of ourselves as providing tools for a client who is exploring decision variable space. The idea is to use optimization of these tentative formulations as a guide to where it would be interesting to look. Thus, we need to make it easy to change problem formulations and retain useful algorithmic information.

Notice that we have replaced the human decision maker only in the part of the process he wasn't suited for (see Figure 2). But only the decision maker is qualified to evaluate the decision context and specifications. A futile and misguided attempt was made in engineering 20 years ago to replace the human altogether and do automatic design. Now this is scoffingly called "push-button" design. I mean the term, "exploratory optimization" to distance these ideas from automatic design.

Figure 3 shows a wing designed to minimize a sensible measure of drag using a sophisticated CFD simulation called a 3D thin layer Navier-Stokes solver. It requires two Cray hours to run for a given wing in given operating conditions.

Look how wavy the surface is! So, the decision criteria were not the right ones to use, even if they do produce an efficient wing, because this wing would be too expensive to manufacture. Sophisticated designers did not know this would be the consequence of the design problem formulation they used.

How should the problem be changed? Does one change the way to calculate a single number that represents how good the particular design is, or does one add a requirement that bounds the manufacturing cost of the wing shape chosen? Both have their place. In this case the designer did the latter, but his calculation of drag also evolved, so really he did both.

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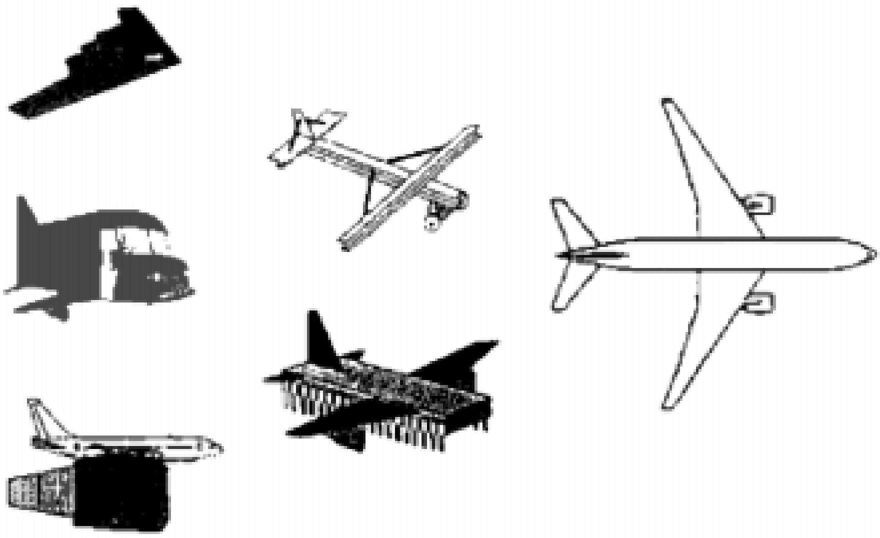

Figure 4.

Figure 4 (above) has been around Boeing so long that no one knows who produced it. It illustrates the different disciplines and notions of how to measure merit in a design.

This speaks to our point that the proper role of a decision maker is to make these compromises or "trade offs," not to twiddle design parameters.

In mathematical programming we have a notion of efficient frontier for a multiobjective problem that can help produce tools for the team making these trade offs. I expect wonderful cross fertilization from math programmers watching how real decision makers make these trades. Technology transfer is a two-way street.

The decision makers will want to know which design variables most influence which trades. They will want some notion of how the merit measures change globally with the most important variables.

In fact, it is common that the different disciplines involved in these trade offs will have their own simulations that must be coupled together to have a meaningful simulation-based tool.

As I begin my concluding remarks, I have one more new point to make. When the decision maker uses our tools to arrive at a decision, that decision has to be "sold" before it can be implemented. One can design a wing (or a transportation system), but there will always be an oversight group to convince that the right compromises have been made. In the case of the wing, the boss will want to be satisfied that the right trade off between manufacturing cost and aerodynamic performance has been made, and that the right trade off has been made between "cruise" performance of the wing and performance during take off, climb, and landing.

Tools that document the decision process would be invaluable not just here but in any open decision process. There will generally be the need to convince others that one has made a defensible compromise between competing concerns.

For the 50 years that linear optimization has been around, people recognized that integer programming was a powerful conceptual model. Until recently, many important problems could be formulated but not solved. The fact that they can be solved now is as much due to algorithmic improvements we have made as to faster computers. Of course, we would not have been able to make these improvements without faster computers, so it is a chicken-and-egg situation.

An oil company using a computer to control online optimization on one piece of equipment at a single refinery estimated a $5,000,000/year savings.

A Boeing problem involves designing an almost invisible part of an airplane to have less drag. They estimate that 0.1% improvement would save $60,000,000 in fuel for each airplane over its life; but, the client group would be quite happy with a tool that did no better than they can do now, but did it faster. This part has to be redesigned with every tweak of the airplane design. Time is money.

Airlines have built OR groups to schedule crews and planes.

Boeing has a large OR group and a sizable group building high level design tools. Both are busy and growing. The design tools group I work with is swamped with requests for help from manufacturing groups.

Optimization has reached the point in commerce where there are companies making silly claims about solving all the client's optimization problems.

When I speak of customers, I do not mean to imply that everyone should be interacting directly with users and doing immediately applied work. There is an interesting tradition at Boeing, and probably other companies as well, in which everyone has a customer whose needs one should meet. The point at Boeing is that not everyone builds airplanes, and a device of a chain of customer relations between oneself and the purchaser of the product is useful to help keep focus.

I think this interesting mindset could create a valuable sense of community in mathematical programming if we were to adopt it. It is always a good idea to keep in mind who will use our research and how they will use it. This leads to a better understanding of the state of the art and points to good research questions.

Interview

Don Hearn

Don Hearn founded OPTIMA in 1980 and was the editor until the Symposium in Lausanne. During this time period, OPTIMA has developed into a newsletter of high quality that reflects the characteristics of the Society. In the following interview, conducted in Lausanne and via e-mail, Don tells us about how he got involved in mathematical programming, his research interests through the years, and how OPTIMA has developed.

- KAREN AARDAL

OPTIMA: How did you get interested in Mathematical Programming?

DH: Manny Bellmore, a young professor at Johns Hopkins in the 1960s, got me interested in the field. He left academia for consulting many years ago, but at that time he was working on integer programming and network algorithms. I liked his course in optimization theory, and I became even more interested when I took nonlinear programming from George Nemhauser and Jack Elzinga. Then, I had the good fortune to spend a summer at IBM with Harlan Mills, who introduced me to a "transmitter location problem," which led to my dissertation topic. Mills, by the way, wrote one of the very early papers on optimal value functions for nonlinear programs.

OPTIMA: Tell us about your research interests and mention some of your papers of which you are particularly fond.

DH: The problem Mills posed was essentially that of finding a circle of minimum radius to cover a point set in the plane. Jack Elzinga and I came up with a geometrical algorithm for it and then we studied various extensions, to *n*-space, with weighted points, covering a polyhedron, etc. These topics made up my dissertation and were later published [1-4]. While working on the dissertation, I kept looking for the mathematical history of the minimum circle problem and finally found a reference in Fritz John's famous paper on optimality conditions. It turned out that the problem originated with the British mathematician J. J. Sylvester, who, coincidentally, had moved to Hopkins late in his career. The history included some algorithms that had been developed in the late 1800s, and I found them in the old journals that Sylvester had brought with him. Fortunately, our algorithm was new. The problem is still of interest; I continue to get papers for review and requests for computer codes. For those interested, my paper with Jim Vijay [6] gives a survey and synthesis of the algorithms up through 1980.

This got me into location theory for a few years, and there were other papers on, for example, multifacility location problems [5].

From location theory I moved to nonlinear networks, because in the mid 1970s Harold Kuhn recruited me to work on the Transportation Advanced Research Project (TARP) at Mathematica. (Mathematica, located in Princeton, was one of the first OR consulting firms; it was not related to the software of the same name.) Our part of the project was called "network aggregation," but I found that what transportation planners called "aggregation" was actually decomposition. I developed several decomposition methods based on simplicial decomposition and Benders decomposition with Russ Barton at Mathematica and later with Toi Lawphongpanich and Jose Ventura [8-11], both of whom won dissertation prizes. In looking at error bounds for these algorithms, I came up with the idea of a "gap function" for convex programs which led to a paper that I like a lot [7]. Those interested in nonlinear networks might want to read the survey that Mike Florian and I did for the *Handbooks in Operations Research and Management Science* [13].

More recently I have collaborated on continuous state DP algorithms for lotsizing [12] and continuous formulations of the maximum clique problem [14, 15]. This led to some very effective algorithms in both cases, thanks to the efforts of the two students, Hsin-Der Chen and Luana Gibbons. At the moment, I am working with

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Motakuri Ramana and a student on congestion toll pricing of traffic networks. The idea of congestion tolls has been around a long time, but we have new results on characterizing the set of all tolls that will force a user-optimal (equilibrium) solution to yield the system optimal solution of the untolled problem [16].

OPTIMA: How did you get involved in MPS and, in particular, what motivated you to start up OPTIMA?

DH: I joined MPS as a charter member. Starting a newsletter for the Society originated with Mike Held and Phil Wolfe, who were then chairman of the executive committee and chairman of MPS, respectively. George Nemhauser suggested that I be editor. The concern of all of us was that newsletters tended to come and go, and we wanted one that had some staying power while reflecting the quality emphasis of the Society. I'm happy to say we have achieved that. Another key factor was the financial support from our College of Engineering, which paid half the expenses for about 10 years.

OPTIMA: Which have been the key developments of OPTIMA?

DH: Key to the early development was the involvement of the College's publications group, particularly Elsa Drake, who has been the designer for a long time. She is very creative and we give her a free hand. The result is that OPTIMA won a local prize for best newsletter in its class in 1994.

Also important were the contributions of Phil Wolfe, Walter Murray, Bob Jeroslow and other leading researchers who wrote nice expository articles for the early issues. That helped define what OPTIMA was all about.

OPTIMA: What is your vision on how the field of Mathematical Programming is developing?

DH: Applications are exploding because computers and algorithms have evolved to the point that optimization models can be used everywhere, even in smaller operations. This demand will continue to justify the research, especially in algorithm development.

OPTIMA: How do you think OPTIMA can continue improving?

DH: I think it will remain low key and scholarly, like the MPS itself, and improvements should come since the council is providing more support, especially honoraria for associate editors and authors of feature articles. It would be good to have more news about individuals, especially as people take sabbaticals or start up research efforts.

OPTIMA: What did you like most about working with OPTIMA? What was the most difficult part of it?

DH: For me, it has just been the satisfaction of producing a newsletter that members like and working with staff here who also enjoy doing it. The most difficult part used to be getting feature articles – some issues were published without one – but now with the efforts you and the associate editors have been making, that has improved greatly.

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[15] "Continuous Characterizations of the Maximum Clique Problem," *Mathematics of Operations Research*, 754-768, 1997 (with L.E. Gibbons, P. Pardalos and M. Ramana).

[16] "Congestion Toll Pricing of Traffic Networks," *Network Optimization*, Springer-Verlag series *Lecture Notes in Economics and Mathematical Systems*, 51-71, 1997 (with P. Bergendorff and M. Ramana).

Editors

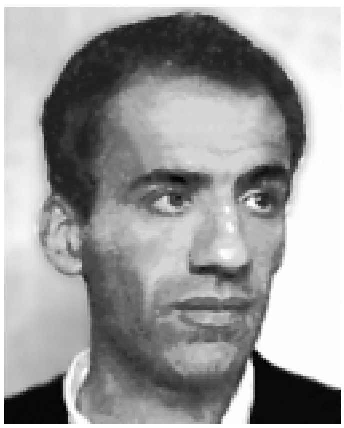
At the Lausanne Symposium, OPTIMA got an almost completely new editorial staff. Fortunately, Don Hearn, the founding editor, has agreed to continue giving advice and act as a link between the new staff and the publisher. Below, each editor introduces him- or herself briefly.

During the coming three-year period, we will try a slightly different structure of the board with a Continuous and a Discrete "area editor" to make it easier to cover the new developments of our field. We, of course, still have a Book Review Editor. The main responsibility for the Features articles will rest with the Editor, but all editors will assist in attracting feature articles.

We appreciate that the MPS members are very busy, but we still hope that you will take the time to provide OPTIMA with material and comments. The addresses and URLs of the editors can be found on the last page of OPTIMA.

Karen Aardal, Editor

I am working at the Department of Computer Science at Utrecht University as Associate Professor. I obtained my Ph.D. degree in 1992 from C.O.R.E., Université Catholique de Louvain, Belgium, under the supervision of Laurence Wolsey. The topic of my thesis, and some of my later projects, was the solution of various facility location problems using polyhedral techniques. Since then I also worked on frequency assignment and routing problems. My main current interest is algorithms for general integer programs. Some of these problems seem almost hopeless to tackle, even in low dimension, using standard branch-and-bound, so new methods are needed. In 1994 I became Features Editor of OPTIMA. As Editor, I will continue to be responsible for the Features Department, and with the help of the other editors I hope we will be able to attract a variety of



Sebastian Ceria, Discrete Optimization Editor

I have an appointment as Associate Professor in the Management Science/Operations Management Division of the Columbia Business School. I was born in Buenos Aires, Argentina. After obtaining a Licenciate in Applied Mathematics at the University of Buenos Aires, I attended the Graduate School of Industrial Administration at Carnegie Mellon University. In 1993 I completed my Ph.D. degree in Industrial Administration. In my Ph.D. thesis under the supervision of Egon Balas and Gérard Cornuéjols, I developed the "lift-and-project method," a disjunctive programming-based algorithm for tackling general mixed-integer programming problems.

I teach several courses in the MBA curriculum that are related to Operations Research and Management Science. My main research interest is the solution, both theoretically and computationally, of

Mary Elizabeth Hribar, Continuous Optimization Editor

I am currently a Research Scientist at Rice University in Houston, Texas. I was born in Detroit, Michigan, and received a Bachelor's degree in Mathematics at Albion College in Albion, Michigan. Inspired by an internship at Oak Ridge National Laboratory where I implemented algorithms on a hypercube, I decided to pursue an advanced degree in Computer Science at Northwestern University in Evanston, Illinois. I received a Master's degree and a Ph.D. under the direction of Jorge Nocedal. As part of my dissertation work, I developed software which solves the general nonlinear programming problem using an interior point, trust region method.

Currently, I am working in the area of multidisciplinary optimization (MDO). I am investigating methods as well as developing a solution environment for MDO problems. I am also looking forward to teaching my first course in the spring.

Robert Weismantel, Book Review Editor

I was born in München, Germany in 1965. After studying mathematics in the years 1984-1988 at the University of Augsburg, I moved to Berlin in 1991 and obtained my Ph.D. from the Institute of Technology in Berlin in 1992. In the years 1989-1991, I was an assistant of Martin Grötschel at the University of Augsburg. Since 1991 I have been working at the research institute ZIB in Berlin. In 1995 I was appointed at ZIB as an associate head of the Department of Optimization. I am currently acting professor at the University of Magdeburg.

My area of research is algorithmic discrete mathematics, in particular, theory and application of integer programming.

In 1993 I was awarded a Carl-Ramsauer prize for my dissertation. This year I received the Gerhard-Hess Forschungsförderpreis of the German Science Foundation (DFG).

Workshop on Computational Integer Programming *continued*

Karen Aardal, Editor

high-quality articles. At the Lausanne Symposium I became Council Member-at-Large of MPS.

Before arriving in Utrecht in the fall of 1995, I held positions at the University of Essex, Colchester; Erasmus University, Rotterdam; and Tilburg University.

Sebastian Ceria, Discrete Optimization Editor

general discrete optimization problems with a special emphasis on integer programming problems. I am developing new methodologies and practical implementations of efficient algorithms. For the last six years I have been working on the "lift-and-project method."

In 1994 I implemented a branch-and-cut code that uses Gomory cuts to solve general integer programs. I have also been working on crew-scheduling for the railways, cutting plane algorithms for general integer programs and a semi-definite programming approach for the clique problem in graphs.

There were a wide variety of topics, including theory of integer programming, computational implementation of efficient algorithms and practical applications of integer programming to difficult real-world problems.

Dan Bienstock opened the workshop with a discussion on how to solve difficult network design problems arising from various problems in the telecommunications industry. Dan seems to be able to keep finding relevant practical problems that lead to very difficult integer programming problems. Other talks that afternoon included the seminars by Denis Naddef on the traveling salesman problem and the semi-definite cluster, with talks by Michel Goemans, Franz Rendl and Christoph Helmberg. The natural question, "Is semi-definite programming useful for integer programming?" was raised, but it was very hard to find a general answer to this provoking question. The next day, Laurence Wolsey presented the latest results with bc-opt, a branch-and-cut system being developed jointly between CORE and XPRESS. He once again pleaded for more mixed-integer programming data, but in a model-form so that researchers can understand the constraints of the problem better (we will expand on this topic in a future article). Next, Alexander Martin talked about mixed integer cutting planes associated with mixed-integer (feasible) sets, and Rudiger Schultz showed us some interesting applications of decomposition for solving integer programs arising from Stochastic Programming.

In the afternoon we had a session on nonlinear approaches to integer programming problems, with talks by Kurt Anstreicher and John Mitchel, and a final cluster with speakers from industry. Ulrich Lauter from Siemens demonstrated how preprocessing can considerably help in speeding up computations in the calculations of shortest paths (with applications to traffic and vehicle guidance systems), and Jean-Francois Puget, from ILOG, described to us the world of Constrained Logic Programming and its relation to general integer programming.

The last day also included many interesting talks, like Ed Rothberg's description of mathematical programming from a computer scientist's viewpoint, Robert Weismantel's primal approach to integer programming, and Bernd Bank's description of real equation solving and integer polynomial optimization. Finally, Lex Schrijver presented some difficult integer programs arising from timetabling in the Dutch railways; I presented the latest computational results with the lift-and-project method, and Thomas Wintler an application in dispatching vehicles.

The social program included a wonderful party at Martin Gröetschel's house near Berlin. His wife delighted us with her cooking; but, nevertheless, we managed to generate some heated discussions on as varied topics as the traveling salesman problem, the future of integer programming, and the difference in the educational systems (especially for children) between Europe and the U.S. On Sunday morning, we visited "Sans Souci" (no problem), the wonderful summer castle of Friedrich the Great, where we were shown, among other amenities, various styles of Rococo decorations. On Monday night, some of us had the pleasure of finding an Argentinian restaurant, not recommended for vegetarians. For the last evening the organizers prepared a banquet at the "Café of 100 beers" where, unfortunately, the drinks were not included.

–SEBASTIAN CERIA

CONFERENCE NOTES

Algorithms and Experiments (ALEX98) Building Bridges Between Theory and Applications
Trento, Italy
February 9-11, 1998

Symposium on Combinatorial Optimization, CO98
April 15-17,1998
Brussels, Belgium
E-mail: bfortz@ulb.ac.be

Internation Conference on Interval Methods and Their Application in Global Optimization (INTERVAL '98)
April 20-23, 1998
Nanjing, China
URL: http://cs.utep.edu/interval-comp/china.html

INFORMS National Meeting
April 26-29, 1998
Montréal, Quebec, Canada
URL: http://www.informs.org/Conf/Montreal98/

Sixth Conference on Integer Programming and Combinatorial Optimization, IPCO '98
June 22-24, 1998
Houston, TX
URL: http://www.hpc.uh.edu/~ipco98

INFORMS International Meeting
June 28-July 1, 1998
Tel Aviv, Israel
URL: http://www.informs.org/Conf/TelAviv98/

Fourth International Conference on Optimization
July 1-3, 1998
Perth, Australia
URL: http://www.cs.curtin.edu.au/maths/icota98

Optimization 98
July 20-22, 1998
Coimbra, Portugal
URL: http://www.it.uc.pt/~opti98

ICM98
Berlin, Germany
August 18-27, 1998
URL: http://elib.zib.de/ICM98

Second WORKSHOP ON ALGORITHM ENGINEERING, W A E ' 98
August 19-21, 1998
Saarbruecken, Germany
URL: http://www.mpi-sb.mpg.de/~wae98/

INFORMS National Meeting
October 25-28, 1998
Seattle, WA

International Conference on Nonlinear Programming and Variational Inequalities
Hong Kong
December 15-18, 1998

Sixth SIAM Conference on Optimization
May 10-12, 1999
Atlanta, GA

19th IFIP TC7 Conference on System Modelling and Optimization
July 12-16, 1999
Cambridge, England
E-mail: tc7con@amtp.cam.ac.uk

Ninth Annual
ACM-SIAM Symposium on Discrete Algorithms
January 25-27, 1998
San Francisco, California
URL: http://www.siam.org/meetings/da98/da98home.htm

The plenary talks will given by:
László Lovász, Yale University: "Algorithms and Geometric Representations of Graphs;"
Arjen K. Lenstra, Citibank: "Factoring: Facts and Fables;"
Thomas L. Magnanti, MIT: "Four Decades of Optimal Network Design"

From the Nordic Section

The 5th meeting of the Nordic Section of the Mathematical Programming Society will take place in Molde, Norway, May 9-10, 1998. It is open to all Nordic members of MPS and, of course, to all others with similar interests.

For details, please look at the conference home page (http://www.himolde.no/~arnel/mpsnordic98). Also, the fourth issue of our newsletter, covering the time from July 1, 1995, to December 31, 1996, is in preparation. Once it is completed, it can be accessed via the Nordic MPS home page (http://www.mai.liu.se/Opt/MPS/index.html).

International Congress of Mathematicians (ICM'98)
August 18-27, 1998
Berlin, Germany
URL: http://elib.zib.de/ICM98

Plenary talks will be given by:
Jean-Michel Bismut: Differential Geometry and Global Analysis
Christopher Deninger: Arithmetic Algebraic Geometry, L-Functions of Motives
Persi Diaconis: Statistics, Probability, Algebraic Combinatorics
Giovanni Gallavotti: Dynamical Systems, Statistical Mechanics, Probability
Wolfgang Hackbusch: Numerical Analysis, Scientific Computing
Helmut H. W. Hofer: Global Analysis, Dynamical Systems
Ehud Hrushovski: Logic
I. G. Macdonald: Lie Groups, Algebraic Combinatorics
Stéphane Mallat: Applied Mathematics, Signal Processing
Dusa McDuff: Symplectic Topology
Tetsuji Miwa: Integrable Systems, Infinite Dimensional Algebras
Jürgen Moser: Dynamical Systems, Partial Differential Equations
George C. Papanicolaou: Applied Mathematics, Probability
Gilles Pisier: Functional Analysis
Peter Sarnak: Number Theory
Peter W. Shor: Computer Science
Karl Sigmund: Mathematical Ecology, Evolutionary Game Theory
Michel Talagrand: Probability, Statistical Mechanics, Functional Analysis, Measure Theory
Cumrun Vafa: String Theory, Quantum Field Theory and Quantum Gravity
Marcelo Viana: Dynamical Systems, Ergodic Theory
Vladimir Voevodsky: Algebraic Cycles and Motives

CALL FOR PRESENTATIONS
Mathematical Software Session
International Congress of Mathematicians 1998 (ICM'98)
Berlin, Germany
August 18-27, 1998

The International Congresses of Mathematicians, taking place roughly every four years since 1897, belong to the most important mathematical events in the world. One distinguishing feature, among others, is the award of the Fields Medals and the Nevanlinna Prize (the "mathematical Nobel Prizes") during the opening ceremony.

The ICM'98 will take place at the Technische University in Berlin, Germany, from August 18 to 27, 1998. In addition to the scientific program (with plenary and invited speakers chosen by the IMU-appointed ICM'98 Program Committee), a "Section of Special Activities" is planned. One of these activities will be a session on mathematical software, to be held on two afternoons during the congress. The focus of this session will be the presentation of a broad spectrum of mathematical software systems ranging from general purpose systems to specialized systems, e.g., systems from numerical analysis, computer algebra, optimization, mathematical visualization, or mathematical education. The presentations should include typical applications.

This session is planned to attract a broad audience including ICM attendees, students and teachers, with a special interest in mathematical software. The session will take place at the conference site.

Program Committee

A program committee for this particular session has been appointed. It will be chaired by Johannes Grabmeier of IBM Germany, who is speaker of the special interest group for computer algebra of DMV (German Mathematical Society), GAMM and GI.

Organization

Winfried Neun
Konrad-Zuse-Zentrum für Informationstechnik
Berlin, Germany
E-mail: neun@zib.de

Call for Presentations

The systems to be presented should meet the highest standards with respect to mathematical content. Mathematical originality, new solutions, or uncommon fields of application will be highly appreciated. The technical quality in design and implementation is also an important issue. Submissions for the Session on Mathematical Software are encouraged from all fields of mathematics where software systems are used. Systems which are available free of charge (e.g., public domain) are especially desired and will be given preference during the selection process.

There will be a software exhibition and a book fair in connection with ICM'98 too. This may be more suitable for the demands of vendors of commercial software systems. Please contact the chairman of the local arrangements committee, Professor Rolf H. Moehring (e-mail: moehring@math.tu-berlin.de), for details about the exhibition. Talks are also sought in which various commercial packages are compared from an independent viewpoint, pointing out particular strengths and weaknesses of the systems.

The program committee, a group of internationally renowned mathematicians and experts on mathematical software, will evaluate the entries and select a number of contributions according to quality and thematic balance. To aid the committee in judging the submissions, contributors should include material (either in paper form or an electronically readable format, e.g., a URL) which explains to the committee the mathematical background of the systems, the fields of application and the software design and techniques.

Submissions

Submissions should be sent, preferably by electronic mail, to:
ICM'98 – Session on Math. Software, c/o W. Neun, Konrad-Zuse-Zentrum (ZIB), Takustr. 7,
D-14195 Berlin, Germany
E-MAIL: neun@zib.de
and must be received by March 1, 1998. Submissions that arrive after this deadline will not be considered. Some guidelines that will help the program committee to review the submissions are:

1. For a first glance a URL is usually very helpful.
2. For each system it should be very clear where information about the mathematical content can be found. This is usually not trivial if the submission consists, say, of uncommented pictures.
3. The special features and the targeted user community should be identified.
4. The availability of the software and the terms and conditions for distribution should be easily accessible.

The scheduled length of the presentations including discussion is 30 minutes. This allows the organizers to put approximately 12 lectures into the time available for the session. Financial support for presentations is not available. Presenters are required to register for ICM'98.

Upon Acceptance

Contributors will be notified of the acceptance or rejection of their submission by the program committee. Based on this selection, the organizing committee will arrange a timetable in cooperation with the presenters.

Requests for special equipment needed for presentations can be discussed at this time, but the resources will be limited. Therefore, it is not advisable to rely on any special hardware and software support from the session organizers.

It is the contributor's responsibility to secure any necessary permissions and licenses for any material contained in the presentation or handouts. The organizers of ICM'98 would appreciate it if the commercial attitude of the system providers were modest.

Deadlines

Submission of Presentations:
March 1, 1998
Notification of Acceptance:
April 1, 1998

-MARTIN GRÖETSCHEL, PRESIDENT OF THE ICM'98 ORGANIZING COMMITTEE

FIRST ANNOUNCEMENT AND CALL FOR PAPERS

International Conference on Operations Research (OR98)
31 August - 3 September 1998
ETH Zurich, Switzerland

Up-to-date information on the conference can be found at the OR 98 web site (URL: http://www.or98.ethz.ch). The Program Committee invites papers of presentations in all areas of Operations Research. The conference will give particular attention to the following topics followed by chairperson of each section:

1. Mathematical Optimization
A) Continuous (Feichtinger, Horst, Vial)
B) Discrete (Burkard, Hertz, Reinelt)
2. Stochastic Modelling, Optimization and Simulation (Rieder, Stadlober)
3. Econometrics and Statistics (Deistler, Garbers, Schmitz)
4. Mathematical Economics, Game Theory and Decision Theory (Brachinger, Ulrike Leopold-Wildburger)
5. Banking and Finance (Buehler, Frauendorfer, Zechner)
6. Operations and Production Management (Guenther, Jammernegg, Tempelmeier)
7. Energy and Ecology (Haurie, Kalliauer)
8. Telecommunication (Martine Labbe, Mechthild Stoer)
9. Logistics and Transportation (Domschke, Fleischmann, Staehly)
10. Fuzzy Systems and Neural Networks (Rommelfanger, Brigitte Werners)

Conference Languages:
English and German

Deadlines:
Deadline for submission of extended abstracts: 15 January 1998
Notice of acceptance: 1 April 1998

Submission of Papers:
Authors wishing to contribute papers are requested to submit

a) full name(s), affiliation(s) and address(es) (including e-mail) of the author(s).

b) an extended abstract of two pages (indicating intended section).

The extended abstract should be submitted either as hard copy (four copies) or by e-mail as ASCII/TeX/LaTeX-file to:
Institut fuer Operations Research
der Universitaet Zuerich
OR 98
Moussonstrasse 15
CH-8044 Zuerich
E-mail: kall@ior.unizh.ch

Extended abstracts will be refereed and accepted papers will be subdivided for

a) presentation in a session (30 minutes including discussion)

b) presentation within special "poster sessions."

About 50 full papers will be selected for publication in the Proceedings of the Conference.

Conference Chairman: H.-J. Luethi
Chairman Program Committee:
P. Kall
Plenary Speakers:
M. Gröetschel, Berlin
Th. L. Magnanti, MIT
F. J. Radermacher, Ulm
F. Delbaen, ETH Zurich
F. Jensen, Aalborg

Reviews

Linear Programming: Foundations and Extensions

by Robert J. Vanderbei
Kluwer Academic Publishers
Boston, 1996

ISBN 0-7923-9804-1

Summary

This book presents a thoroughly modern treatment of linear programming that achieves a healthy balance between theory, implementation, computation, and between the simplex method and interior-point methods. Its most novel feature is that it is written in a delightful and refreshing conversational manner that bespeaks the author's teaching style and relaxed wit. It is a pleasure to read. Students will find the book to be friendly and engaging, while professors will find in the book a wealth of teaching material, nicely organized and packaged for classroom use. The book is also meant to be used in conjunction with a public-available website that contains software for various algorithms, additional exercises, and demos of algorithms.

The Need for New Linear Programming Textbooks

The world of linear programming has changed dramatically in the last 10 years. For one thing, the incredible changes in computer technology have made it easy to solve truly huge LPs, and routine LP problems solve in fractions of a second, even on a personal computer. As a result, the study of linear programming algorithms is of less interest to the casual student. (In a similar vein, we usually do not teach students how to efficiently compute square roots; we simply presume they can press the right buttons on their calculator.) On the other hand, because we can now solve truly gigantic linear programs, issues of computer implementation, numerical stability, and software architecture, etc., are as important for the serious optimizer as is, say, duality theory. Furthermore, the development and recognition of the importance of interior point methods has changed the landscape of linear programming significantly, so that linear programming is no longer synonymous with the simplex method, and a modern treatment of LP must also present an in-depth treatment of the most important interior point methods.

Vanderbei's Book Is Thoroughly Modern

Vanderbei's book is completely up-to-date. Aside from a nice treatment of the simplex method, it also contains a very up-to-date treatment of interior point methods, including the homogeneous self-dual formulation and algorithm (which might soon become the dominant algorithm in practice and theory). It contains extensive material on issues of implementation of both the simplex algorithm and interior point algorithms. A politician might call it a "book for the 21st century."

Vanderbei's Book Has Many Novel Features

This book is quite different from most other textbooks on LP in a number of important ways. For starters, the "standard form" of a linear program in the book is the symmetric form of the problem (max $c^t x$ | Ax £ b, ‡ 0), as opposed to the usual form (min $c^t x$ | Ax = b, x ‡ 0). This difference allows for an easier treatment of duality, and allows one to see the geometry of linear programming more easily as well. The symmetric form also makes it easier to set up the homogeneous self-dual interior point algorithm. However, this form has the drawback that discussions of bases, basic feasible solutions, and some of the mechanics of the simplex method are all a bit more awkward. (The book uses the language of "dictionaries" to describe the essential information in a simplex method iteration.) The book has more of a focus on engineering applications than does the more typical LP textbook (which tends to rely on business problems). For example, there is a nice chapter on optimization of engineering structures such as trusses. The book gives a very broad treatment of interior point methods, including several topics that are not usually found in textbooks, such as the homogeneous self-dual formulation and algorithm, quadratic programming via interior point methods, and general convex optimization via interior point methods.

These novel features are good in that the author has clearly tried to be innovative and to build an LP text from the ground up, without regard for past texts.

Some Nice Features

There are some particularly nice features in the book. The book contains a much-simplified variant of the Klee-Minty polytope that allows for a more straightforward proof that the simplex method can visit exponentially many extreme points. In addition to proving strong duality, the book also presents Tucker's strict complementarity theorem, which has become important in the new view of sensitivity analysis, optimal partitions, and interior point methods. The book also contains a nice treatment of the steepest edge pivot rule, which has recently emerged as an important component in speeding up the performance of the simplex algorithm. In the treatment of interior point methods, the author spends very little time on polynomial time bounds and guarantees (as a theorist, I like to see this material), instead adding value by discussing important computational and implemention issues, including ordering heuristics, strategies for solving the KKT system by Newton's method, etc. The book sometimes has an engineer's feel for the proofs, which is good for students but is a bit frustrating to hard-core math types such as myself. There are many instances where the "proof" is just a proof via an example. This is consistent with the conversational and informal style of the text, and this informality spills over into the mathematics on occasion.

This Book Has Style

As mentioned earlier, the book has a wonderfully appealing conversational style. While the author does not purposely go out of his way to be cute and corny, he succeeds in leaving the reader grinning with his humor. There are some passages that are downright funny, but the style succeeds mostly by default. One section on the issue of modeling the anchoring of truss design problems is called "Anchors Away." The subsection on updating factorizations to reduce fill-in is aptly called "Shrinking the Bump," and there is the hint of a racy discussion of an application of König's Theorem involving boys and girls that the curious reader might enjoy.

Overall, I greatly enjoyed reviewing this book, and I highly recommend it as a textbook for an advanced undergraduate or master's level course in linear programming, particularly for courses in an engineering environment. In addition, it also is a good reference book for interior point methods as well as for implementation and computational aspects of linear programming. This is an excellent new book.

- ROBERT M. FREUND, MIT

Geometry of Cuts and Metrics

by M. M. Deza and M. Laurent
Springer-Verlag
Berlin, 1997

ISBN 3-540-61611-X

This book is definitely a milestone in the literature of integer programming and combinatorial optimization. It draws from the interdisciplinarity of these fields as it gathers methods and results from polytope theory, geometry of numbers, probability theory, design- and graph theory around two objects, **cuts and metrics**.

Deza and Laurent do not only write but with their work actually prove the correctness of the statement, "Research on cuts and metrics profits greatly from the variety of subjects where the problems arise. Observations made in different areas by independent authors turn out to be equivalent, facts are not isolated and views from different perspectives provide new interpretations, connections and insights."

Every researcher in integer programming and combinatorial optimization will find his fields of research and interest represented in this book. This is one, but not the only aspect that makes the book unique.

The book has five parts, each of which is fairly self-contained.

Part 1 treats relations between cuts and metrics. Every generator of the cut cone (the generators of the cut cone are all incidence vectors of cuts of a given graph) defines a semimetric, i.e., a symmetric function *f* on the pairs of vertices, satisfying the triangle inequalities and $f(i,i) = 0$ for all vertices i. (Of course, not every semimetric is a cut.) Of major interest in this part are the characterizations of cuts by means of measure theory and ℓ_1-embeddability including, in particular, the following theorem: **a semimetric belongs to the cut cone if and only if it is isometrically ℓ_1-embeddable**.

Part 2 studies so-called hypermetric spaces. Hypermetric inequalities are inequalities of the form

$$\sum_{i\neq j} b_{ij}x_{ij} \leq 0 \text{ with } b \in Z^n, \textstyle\sum_i b_i = 1.$$

One can prove that every semimetric in the cut cone satisfies the family of hypermetric inequalities, yet not every semimetric satisfying the family of hypermetric inequalities is a member of the cut cone. Hypermetric spaces, the hypermeytric cone and the connections to point lattices and Delauny polytopes are the central issue in Part 2.

Part 3 is devoted to investigations of graphs whose path metric is ℓ_1-embeddable or hypercube-embeddable. It is shown in the book that a graph is ℓ_1-embeddable if and only if a non-negative multiple of its path metric is hypercube-embeddable. Of particular beauty is the fact that ℓ_1-embeddable graphs can be recognized in polynomial time.

Part 3 is directly connected to Part 4 of the book that treats questions of the form: given a distance function on a finite number of points, decide whether this distance function is hypercube-embeddable. There are some distance functions for which this problem is easy to solve. For others, the decision about hypercube-embeddability is *NP*-hard. For various other classes of metrics, there are conditions available that can be tested in polynomial time and ensure hypercube-embeddability.

Part 5 deals with the geometry of the cut cone and the cut polytope. It surveys extensively polyhedral material, including the fundamental facet-manipulating operations such as switching, the family of triangle inequalities and more general hypermetric inequalities. Very appealing is the detour to cycle polyhedra of binary matroids and the questions that the authors discuss in this context about linear relaxations by the triangle inequalities and Hilbert bases. Also very interesting are the discussions about the completion problem and the connections to geometric questions such as the partitioning of a set in the n-dimensional space into n+1 sets of smaller diameter.

The book is very nicely written, although it is quite dense and requires a lot of knowledge to understand the details. Starting with the important definitions that it resorts to, each of the chapters is self-contained. I found it helpful to read Chapter 1, the outline of the

►

book, in the beginning. It really helps in getting through the advanced parts. The book is also very well structured. With knowledge about the relevant terms, one can enjoy special subsections without being entirely familiar with the rest of the chapter. This makes it not only an interesting research book but even a dictionary. The material is up-to-date, and there are various sections that contain enough open questions for a couple of Ph.D. theses.

In my opinion, the book is a beautiful piece of work. The longer one works with it, the more beautiful it becomes.

- ROBERT WEISMANTEL, BERLIN

Lectures on Polytopes

by G. Ziegler
Springer-Verlag
Berlin, 1995

ISBN 0-387-94329-3

During the last 30 years, the theory of (convex) polytopes has drawn growing attention. As the convex hull of finite point sets in euclidean spaces, polytopes are very natural objects; therefore, it is not surprising that they have a great number of applications in such diverse mathematical areas as Linear and Combinatorial Optimization, Functional Analysis, Algebraic Geometry and Semialgebraic Geometry. This book does not concentrate so much on these fields of applications as on the theory of polytopes itself, which has by now obtained an enormous scope and depth. The reader, however, will still find numerous references to related areas. A very motivating and example-oriented introduction is presented in Chapter 0, which gives the reader a first impression of the interesting subject and introduces the basic terminology at the same time. This chapter explains in detail the different ways of representing polytopes which are important in Computational Geometry and Optimization.

Chapters 1 and 2 present the foundations of convex geometry and the most important facts about face lattices of polytopes. Chapter 3 studies the edge graphs of polytopes and extensively discusses the newest results on the diameter of such graphs. These are of particular importance for Linear Optimization as they reflect the worst possible behavior of best possible edge-following LP-algorithms. This chapter also includes Kalai's extremely elegant proof of the fact that the edge-graph of a simple polytope already determines its complete face lattice. The edge-graphs of 3-dimensional polytopes are characterized by planarity and 3-connectedness. This is the famous theorem of Steinitz which is the basis for many further results about 3-dimensional polytopes. A new proof of this theorem is presented in Chapter 4. This proof is based on a graph reduction technique due to Truemper, and it avoids some of the complications of earlier proofs.

The two following chapters are devoted to realizability problems for higher-dimensional polytopes. In analogy to the theorem of Steinitz, the question is whether cell-complexes with given geometric or combinatorial properties are isomorphic to the face-lattice of polytopes. For such problems, oriented matroids and Gale-diagrams have proven very useful. As an application of this theory, the reader is presented with a 5-dimensional polytope which has a 2-dimensional face whose shape cannot be arbitrarily preassigned. Meanwhile, Richter-Gebert have constructed a 4-polytope with this property, thereby solving a problem posed in the book. The part of the theory of oriented matroids that is needed in polytope theory is described very well.

In Chapter 7, this theory is studied in depth and is applied to zonotopes and other objects related to polytopes like arrangements of hyperplanes and tilings of space.

Chapter 8 introduces the spectacular results on the numbers of faces of polytopes, the "Upper-Bound-Theorem" and the "g-Theorem." The concept of shellability and the related h-vectors, which can be defined by it, are essential for these results. Both are explained in detail and applied to the first construction of a polytope having a partial shelling which cannot be extended to a complete shelling.

The last chapter studies fiber-polytopes which are important for Gröbner-bases. As an application, the author presents a construction of the permuto-associahedron. The book ends with an extensive list of references. All chapters contain a useful collection of problems, beginning with "warm-ups" and ending with important open problems. The book excels because of its lucid presentation, which is supported by many helpful illustrations. The careful descriptions of the results provide an excellent motivation for students and make the book a valuable basis for a course on polytopes.

The publication of the book has obviously led to the solution of some of the open problems described in it. The reader will be delighted to find that the author has established a web site (http://winnie.math.tu-berlin.de/~ziegler) which, in addition to the correction of minor errors, has all the information on these interesting new developments. These updates will be continued in a revised edition to appear soon.

As the book contains all important techniques of polytope theory and also many new results, it is most useful both for the expert and for other mathematicians and computer scientists who use polytopes in one of the application areas mentioned. I very much enjoyed reading it.

- PETER KLEINSCHMIDT, PASSAU

g a l l i m a u f r y

Deadline for the next

OPTIMA

February 28, 1998

Mathematical Programming on the Net

For the electronic version of MATHEMATICAL PROGRAMMING, please see: www.elsevier.com/locate/mp (USA mirror site) or www.elsevier.nl/locate/mp (European mirror site). It now contains the full text of articles (PDF) from Volume 77, the abstracts of articles from Volume 63, search facilities and indices.

- GERARD WANROOY

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