Nº45 MARCH 1995

OPTIMA

MATHEMATICAL PROGRAMMING SOCIETY NEWSLETTER

OPTIMA EXPANDS WITH NEW DEPARTMENTS

FEATURES

THE MAIN ACTIVITY of the Features Department is to provide high-quality feature articles on topics covering all areas of mathematical programming. Our goal is to publish at least one article in every issue of OPTIMA. Feature articles have always been welcome and several have appeared. They have, however, appeared less frequently during the last few years. Given the very rapid development in many areas of mathematical programming, the increased interaction with other areas, and the vast number of new successful applications, it is felt strongly among members that feature articles should again constitute a prominent part of OPTIMA. In order to stimulate this activity, I have solicited articles by leading experts in various fields of mathematical programming. In the coming year articles on combinatorial optimization used in railway planning, Gröbner bases and integer programming, randomized algorithms, and structural optimization are expected to appear. It is our hope that many people will be inspired by these contributions and submit articles for forthcoming issues.

AS A GUIDELINE TO AUTHORS, I want to point out that a feature article should be written in a way that is understandable to the general MPS member. It could typically present a new technique, the state-of-the-art of an area, provide historical perspective, or describe an application. Formulae are allowed but should be used sparingly. Illustrations are most welcome. Below is a complete list of feature articles that have appeared so far in OPTIMA. Prospective authors can request any of those from me. The recommended way of submitting an article is by e-mail using the address given below. The format should be a plain text file with TeX commands wherever needed. Figures or photos can be sent by ordinary mail. Articles will be subject to limited editing but will not be refereed.

PAGE TWO ▶

SOFTWARE & computation

The SOFTWARE & COMPUTATION Department of OPTIMA is the new home for readers interested in computational activities. It is an outgrowth of activities of the former Committee on Algorithms (COAL) and is intended to serve the entire community of readers with regard to computing and software issues.

The material published in this space will be largely reader driven. In other words, any plans I have are flexible and subject to change without notice. At the moment, the plan is to prepare articles (either written or solicited by me, or contributed by members) on computational issues and mathematical programming software, compile and maintain information on test problems and problem generators (including evaluating same), compile and maintain a list of recent technical reports related to computation, and compile and maintain a list of available commercial quality software (including evaluating same). Obviously, some of the more lengthy information is best transmitted through a directory accessible via anonymous ftp, with OPTIMA guiding readers to what is available on the Internet.

In order for this column to be successful and responsive to reader views, I herein announce a general call for contributions to this Department. This is to include material to support the activities outlined above as well as related news items about conferences, workshops, appointments, awards, and personal achievements that you would like to communicate to your peers.

MORE ON PAGE NINE ▶

NUMBER 45

OPTIMA

A SECOND RESPONSIBILITY of the Features Department is to collect and compile news. I am currently building a network of news reporters to assist me in this task. We welcome news about conferences, workshops and other activities as well as personal news, such as appointments, awards and other achievements. News regarding software should be sent to the Software and Computation editor, Faiz Al-Khayyal. Anyone willing to serve as a news reporter is encouraged to contact me as quickly as possible. News should preferably be submitted to me by e-mail using the same format as the feature articles.

OPTIMA exists to provide service to the members. Any ideas on topics for feature articles or any other activities are, of course, most welcome!

Karen Aardal
Features Editor
Department of Econometrics
Tilburg University
P.O. Box 90153
5000 LE Tilburg
The Netherlands
e-mail: **aardal@kub.nl**
Tel.: +31 13 663254
FAX: +31 13 663280

Feature articles published in earlier issues of OPTIMA:

- *The ellipsoid algorithm*
  (P. Wolfe, Number 1, June 1980)
- *Algorithms: The influence of finite precision arithmetic*
  (W. Murray, Number 2, Oct. 1980)
- *Mathematical programming at Oberwolfach*
  (A. Bachem, Number 3, March 1980)
- *Some roads hardly taken*
  (R. G. Jeroslow, Number 4, July 1981)
- *Mathematical programming activities in the USSR*
  (B. Korte, Number 6, March 1982)
- *At play in the fields of scheduling theory*
  (E.L. Lawler et al., Number 7, June 1982)
- *Testing the theory of evolution*
  (L.R. Foulds, Number 10, Aug. 1983)
- *The programming of (some) intelligence: opportunities at the OR/AI interface*
  (R.G. Jeroslow, Number 14, Jan. 1985)
- *Are you all salesmen here?*
  (E.L. Lawler et al., Number 19, Sept. 1986)
- *Highlights of Mike Todd's research*
  (L.E. Trotter, Jr., Number 26, April 1989)
- *Some comments on notation for quasi-Newton methods*
  (W.C. Davidon et al., Number 32, March 1991).

interview

CLAUDE LEMARÉCHAL

Claude Lemaréchal *received the 1994 Dantzig Prize, mainly for his work in developing and analyzing numerical methods in nonsmooth optimization. The prize was jointly awarded to Roger J.-B. Wets, who will be interviewed in the next issue of* OPTIMA. *The Dantzig Prize is awarded once every three years by the Mathematical Programming Society and the Society for Industrial and Applied Mathematics to recognize original, broad and deep research making a major impact on the field. Among Lemaréchal's many important contributions to nonsmooth optimization is the so-called bundle method. Next to his theoretical work, he has been involved in numerous collaborative projects on applied optimization problems. He recently published, with J.-B. Hiriart-Urruty, the two-volume book, Convex Analysis and Minimization Algorithms (Springer Verlag, 1993).*

Lemaréchal graduated from the engineering school in Toulouse (part of the French "Grande Ecole" system) and received his Ph.D. degree from Université de Paris IX, Dauphine. In 1971 he received an appointment at INRIA (Institut National de Recherche en Informatique et Automatique) le Chesnay, France, where he is still working.

OPTIMA: *How did you start your work on nonsmooth optimization?*

CL: I went to INRIA just as I had graduated. It was an institute created in 1967 for work in applied mathematics, and more specifically, on problems coming from industry. At the start it was a very small institute. We were about 10 people, including the housekeepers and the concierge!

I first worked on partial differential equations and ordinary differential equations. Then I moved to optimization, and I was lucky enough to get an application from the glass company, Saint Gobain. It concerned the management of a glass oven and could be interpreted as a multi-product, multi-machine lot-sizing problem. It was very well formulated. All the equations of the model were present, so for me it was "only" a matter of finding an appropriate algorithm. However, it was a nonlinear programming problem for which classical methods were not really suitable. It took me a while to analyze it since I was quite fresh in optimization. The problem was decomposable, so Lagrangian relaxation was, in principle, suitable, but it was not convex, so the Lagrangian dual was nondifferentiable. At that time I didn't know that nonsmooth optimization existed. I was, however, lucky to find Lasdon's book, *Optimization Theory for Large Systems*, MacMillan, 1970), which has got a very good introduction to elementary convex analysis in an appendix. This appendix contained all the material necessary to understand what can be done in this subject.

The glass company project was the origin of the development of bundle methods. It took me about one year to find the appropriate solution scheme, and when I had finished, I went back to Saint Gobain and told them very proudly "OK, I have got the solution," but they told me, "What? We don't care about this problem anymore. First it is too old, and second, there was a mistake in the formulation anyway." If the mistake had not been present, the problem would have become perfectly convex with a nice dual, so all this research would not have been carried out. So, it was a "happy mistake!"

OPTIMA: ***One of your most important contributions to nonsmooth optimization is the* bundle method. *Could you describe the principle behind this technique?***

CL: There are two ways of describing bundle methods. The way to explain it that appeared at that time, i.e., about 20 years ago, is as follows. If you minimize a smooth function, you first need to find a descent direction. If the function is smooth, i.e., if the gradient exists, it suffices to move in the direction opposite to the gradient, or even anywhere in the half-space opposite to the gradient. If, however, the function is nonsmooth, instead of having one gradient, you have a bunch of generalized gradients–or subgradients–which form the so-called subdifferential. If you generate a subgradient (by an oracle), you are ***not*** sure that the direction opposite to this subgradient is a descent direction. What you need to do to find a descent direction is to consider the set that forms an obtuse angle to ***all*** subgradients, which is a set much smaller than the half-space opposite to the subgradient. In the bundle method you start by computing one subgradient. If the opposite direction is a descent direction, it is all right, but if it is not, there is a way of forcing the oracle to compute a new, different subgradient that forms an acute angle with your direction. You then pivot your direction so as to have an obtuse angle with ***both*** subgradients, and so forth. You can prove that either your starting point is optimal, or eventually, after enough such pivots, you really get a descent direction.

One more comment: this approach was "invented" simultaneously by Phil Wolfe and myself, but Phil behaved wonderfully towards me. While I was very young and totally unknown, he immediately moved aside, and then he started to put my own work continuously to advantage, advertising it at every occasion. I am also very grateful to Michel Balinski, who had a decisive influence on my career, helping me and encouraging me from the very beginning. Then Bob Mifflin was the "worker of the first hour." Later on, K.C. Kiwiel, J.J. Strodiot, J. Zowe joined us (in alphabetical order!), as well as several others. It is my pleasure to acknowledge the important role they all played in the development of the field.

OPTIMA: ***In which direction did your work proceed after the Saint Gobain application?***

CL: What happened then, in the mid-'70s, was that we quite rapidly found appropriate algorithms which were rather satisfactory for optimization of convex functions. We were also able to generalize these algorithms to nonconvex functions. On the other hand, my point was, and this I feel very strongly about, that work in nonsmooth optimization should keep close to smooth optimization. You should not become an expert in a difficult subject before you are an expert in the easy subject in which the difficult one is contained. Therefore, I did work on smooth optimization. Furthermore, I considered the research in nonsmooth optimization to have reached a kind of equilibrium, by the development of appropriate software that can solve significant problems, and on top of this, applications were coming that involved "ordinary" optimization. However, I did not totally abandon my specialty; I kept an eye on the nonsmooth world.

OPTIMA: ***Which are currently the main issues in nonsmooth optimization?***

CL: On the purely theoretical side, a really challenging question is how to properly generalize the concept of second derivative to the case of functions which are convex but which have no first derivative. The motivation is to design algorithms that are really ***extremely*** fast (those existing at present may be slow; there is a reason for that). I have been asking myself this question for about 20 years, and I must confess that no substantial progress has been made.

On the application side there are several issues. It would, for instance, be a good thing to develop computational codes especially tailored to Lagrangian relaxation, enabling the resolution of large-scale real-life problems (Lagrangian relaxation is one of the main applications of nonsmooth optimization). This is, however, fairly difficult since large-scale problems involve broad expertise, almost by definition. Developing such codes involves joint work, not only between applied mathematicians but also with people from the application world as well. This is why there has been very little development of software for decomposable systems so far. For instance, I have for several years been in contact with EDF (the French Electricity Board), and progress is very slow.

OPTIMA: ***If you look at the real-world problems that you have studied, would you say that there are tools available for solving them?***

CL: I would say that the tools are not too bad. What I would like to have is ***excellent tools,*** which is much more demanding.

OPTIMA: ***What is the major deficiency of the present tools?***

CL: Speed of convergence. From the theoretical point of view it is very difficult to develop excellent tools. It has actually been proved that it is impossible! The complexity theory of Nemirovskii (Nemirovskii and Yudin, ***Problem Complexity and Method Efficiency in Optimization,*** Wiley, 1983) tells you that there does not exist any fast algorithm to minimize a general convex function. Therefore, if we really want "excellent tools," we are forced to use heuristic methods. This negative theoretical result is extremely important as a safeguard to prevent people from trying to prove theorems that have got to be wrong. Unlike the traditional theory of computational complexity where it is still not known whether P is equal to NP, Nemirovskii's result tells you that ***for sure*** such algorithms do not exist! The same theory tells you also that one particular variant of a bundle method is optimal in a certain sense: its rate of convergence cannot be made faster independently of the number of variables. These results are true only if you consider the general class of convex functions; for some particular subclasses, the situation may change.

OPTIMA: ***Does the community aim at developing a general-purpose code for solving generic nonsmooth problems?***

CL: As far as solving generic nonsmooth problems, the existing codes are all right, at least theoretically. On the other hand, it is extremely difficult to develop codes for ***specific*** problems. The reason is simply that we do not know how to classify convex functions. Let's consider the generic problem of minimizing convex functions given the oracle

interview

that computes the subgradient. We don't know right now which subclasses of convex functions are easy in the sense that they can be minimized quickly with the help of this oracle. Maybe some day we will know what kind of functions are easy, but right now it is impossible to say.

OPTIMA: ***In this way it is hard to know exactly what you are developing for.***

CL: Right! We have got to develop general codes, but we have no idea what particular problem will be more amenable to a specific method. Therefore, we cannot develop the specific method.

The big open question is the one that I mentioned earlier.

OPTIMA: ***You mentioned earlier that a very important open question is how to generalize the second-order concepts from classical calculus. If you had such a generalization, what would the consequences be?***

CL: The aim would be to have algorithms that, due to Nemirovskii's result, would not be superlinear, but at least, based on some serious grounds, *likely* to be very fast. Alternatively, this generalization might help us to say which problems are easy, i.e., amenable to fast convergence.

OPTIMA: ***Which areas provide input to, or interact with, nonsmooth optimization?***

CL: The introduction of convex analysis into the field, more deeply than has been the case before, is one of the new inputs that can be useful. Here I think more of the introduction of convex analysis in numerical optimization, rather than on the theoretical side. Convex analysis is, of course, well-known on the theoretical side for optimality and stability conditions, but for *algorithmic* development it is relatively new. I also feel strongly about the harmony between smooth and nonsmooth optimization.

OPTIMA: ***What is your feeling about possible future developments in nonsmooth optimization?***

CL: For the future, there is another field of application of nonsmooth optimization, which has just been born but is growing very fast, namely, eigenvalue optimization. You have a symmetric matrix that depends on certain parameters and you want to adjust these parameters such that the maximal eigenvalue becomes as small as possible. This is a nonsmooth problem occurring in both so-called robust control, which is an extremely expanding subject in optimal control, as well as in combinatorial optimization (see, e.g., C. Delorme and S. Poljak, "Laplacian Eigenvalues and the Maximum Cut Problem," ***Mathematical Programming*** 62 (1993) 557-574, or L. Lovász, "On the Shannon capacity of a graph," ***IEEE Trans. Information Theory*** 25, (1979) 1-7). There are already some approaches available for this problem, such as a very recent one by Nemirovskii based on interior point methods; see also the work by the team of S. Boyd at Stanford (Information Systems Laboratory). This technique is extremely powerful but rather heavy. Convex optimization would, hopefully, result in a more flexible and versatile method even though the speed of convergence would be more modest.

I also think that there will be an extreme need for development of algorithms for quadratic programming, and this leads me to a second way of describing bundle methods. Think of the Dantzig-Wolfe algorithm where you solve a sequence of linear programming problems. The bundle principle can be viewed along the lines of just adding a quadratic term to the Dantzig-Wolfe master programs. This has the beneficial effect of stabilizing the Dantzig-Wolfe mechanism, which is highly unstable. Each master program will now be a quadratic problem instead of a linear one. So, the more we want to have software for large problems, the more we will need efficient software for solving quadratic problems.

OPTIMA: ***What is, in your opinion, the situation in the field of general nonlinear programming?***

CL: I feel that nonlinear programming in general needs fresh blood. One proof to me that this is the case was, for instance, that when the ellipsoid method was developed, it created a lot of noise. Next, it was the development of interior point methods, which now very much dominate the literature in the field. This was to me a sign that the community was in need of a new idea and that new fresh blood is needed which, in a sense, is a bad sign for the nonlinear community.

Moreover, I think that the general work that has been done in nonlinear programming the last 40-50 years has basically come to an end. There are few important theoretical developments to foresee. I feel that the only really important developments are going to be at the computational side, like the improvement of the simplex method for linear programming over the last decades. I also believe that for the field to revive, new ideas are needed; one is the use of convex analysis, which is why I am so excited about it.

I agree with John Dennis who says that we should work closer to the applications because research in this field ***has to be*** motivated by applications. I am extremely proud that my own research has started with a specific application. I consider myself very lucky for this reason. In general, it is difficult because these applications, of course, come from people who are totally outside our world, and we have no common language. They express themselves in a way that is extremely hard for us to understand and conversely, of course. Therefore, it requires a lot of generosity from both sides–and, in particular, from our side!

interview

DICK DEN HERTOG & JIMING LIU

Dick den Hertog *and* **Jiming Liu** *were two of the three finalists for the A.W. Tucker Prize which is awarded by the Mathematical Programming Society for an outstanding paper by a student. The third finalist, and winner, was David P. Williamson who was interviewed in the previous issue of* OPTIMA.

Dick den Hertog received both his undergraduate and his Ph.D. in computer science and applied mathematics from Delft University of Technology, Delft, The Netherlands. His thesis "Interior point approach to linear, quadratic and convex programming-Algorithms and complexity" was supervised by Kees Roos. He currently has an appointment with the consultancy firm Center for Quantitative Methods (CQM), Eindhoven, The Netherlands.

Jiming Liu received his undergraduate degree in combinatorial optimization from Beijing Institute of Technology. He is completing his Ph.D. thesis at George Washington University, Washington D.C., supervised by Anthony Fiacco. His submission to the Tucker Prize competition consisted of five papers on stability and sensitivity analysis of generalized equations and variational inequalities.

OPTIMA: *How did you choose your Ph.D. topics?*

DDH: I also worked on interior point methods for my Engineering degree, and I really liked it, so I continued the work for my Ph.D.

JL: After I got my bachelor's degree, I went to another institute for three years as a computer programmer. After a while I got tired of computers, so when I decided to take a master's degree, I wanted to choose a topic between computer science and applied mathematics. That is why I chose computational mathematics. In 1990 I tried to apply to some schools in the U.S., and eventually I got financial support from George Washington University. I already knew of Anthony Fiacco since I had studied his book with McCormick (A.V. Fiacco and G.P. McCormick, *Nonlinear Programming, Sequential Unconstrained Minimization Techniques*, Wiley, 1968) already in China. When I came to Washington, Professor Fiacco was interested in stability and sensitivity, so he asked me to write some papers with him. So I started very early, just after beginning my Ph.D., to write papers. Later on, I started to write on my own. Some of this work is following new directions and some is extending my work with Fiacco.

OPTIMA: *Within your field of research, what is the most central result?*

DDH: Of course, Karmarkar's work is the most important one. It was the root of all developments in the field of interior point methods. Besides that, I think the book of Fiacco and McCormick was very stimulating for me. My research mainly concentrates on the path-following methods, which forms a subclass of the interior point methods, and the path-following techniques go back to the book of Fiacco and McCormick. Also, the book of Nesterov and Nemirovskii (Y.E. Nesterov and A.S. Nemirovskii, *Self-concordant Functions and Polynomial Time Methods in Convex Programming*, Central Economical and Mathematical Institute, USSR Academy of Science, Moscow, USSR, 1989), published later, was an important milestone for me. Here I also want to mention that the work by, for instance, Anstreicher, Gonzaga, Ye and, last but not least, my supervisor Kees Roos has all been very important to me. When I started to work on interior point methods, Kees Roos gave me his articles, and they stimulated me to start working in this field. For me, Karmarkar is the "father" of the interior point methods, but I should be careful here! Some of the interior point methods go back to the '60s, but at least he gave the impetus that started an important development.

JL: Can I say something here? As I see this whole development, I think a main contribution of Karmarkar is that he in some sense pointed out that the simplex method is not the only way.

DDH: But Khachian had already pointed that out, so I don't think it is as simple as that.

JL: But Karmarkar was the first one to really challenge the simplex method.

DDH: If you look at the implementation of interior point methods today, they are very different from Karmarkar's. So, it's still difficult to check if the claim that Karmarkar made at the time is really true, at least for the variant that he proposed.

OPTIMA: *So, let me ask you, Jiming, what the central results are in your area.*

JL: I think that Fiacco and Steve Robinson pioneered this field. At the beginning they made very important contributions. Fiacco proved some very basic sensitivity results, but these results do not take care of the nonsmooth case. I believe that Steve Robinson was the first one to come up with a very nice idea about how to deal with the nonsmooth characteristics of the Karush-Kuhn-Tucker conditions.

OPTIMA: *What would you consider to be your own biggest contribution?*

DDH: I developed a machinery to prove complexity results for path-following methods, also for long-step methods, which could easily be extended to the nonlinear convex case. To obtain these results I used many results of others.

JL: I think I wrote a couple of papers. In three years there were about 20, and these papers cover a lot of areas, but most concern stability and sensitivity analysis.

OPTIMA: *Can you give an example of such a result?*

JL: Actually, it's kind of technical! For instance, Steve Robinson proved a very beautiful result which says that if we have the MFCQ and general second-order sufficient conditions, then the perturbed solution is up-Lipschitz continuous, which is the basic property we want. Since my background is half computer science and half applied mathematics, I al-

interview

ways want to deal with something we can compute, so I developed a theory trying to estimate the Lipschitz coefficient. I believe this work is important in practical situations. Another important contribution is that I proved a very nice result for variational inequalities. I provide a necessary and sufficient condition for strong stability and I think that result is very cute.

OPTIMA: ***Which are the research questions that you would like to study next?***

DDH: Concerning interior point methods, I would like to try to get some further complexity results. For linear programming problems, the most efficient methods are the primal-dual ones. If you look at the nonlinear programming problems, then we can get good complexity results only for the path-following methods. So, I think it is a nice area here to prove some complexity results for the primal-dual methods for nonlinear problems. In practice these methods have proved to be very efficient, but the theory is not yet there.

JL: I am trying to integrate different algorithms in optimization. My general point of view on optimization is that here, I talk about nonlinear programming problems since I wrote most of my papers on nonlinear programming; this subject has reached maturity. But one development would be the following: Suppose we are dealing with some kind of general nonlinear programming problem–because my feeling is that users usually don't want to provide special structure. Then assume that for a given algorithm this problem has got a good complexity result. Maybe for another class of problems this algorithm's complexity is very high. For a second algorithm we probably have another distribution of complexity results, and so on. So, the point here is first of all: How can we identify which type of algorithms are suitable for which class of problems? Of course, this is difficult. I have been doing a lot of programming, and I studied a lot of algorithms, so I have coded many algorithms to see which algorithm works best for a given problem.

DDH: Best for your implementation then?

JL: Right... it's not mature yet, but my current results are very promising, especially for unconstrained optimization.

OPTIMA: ***Is there some particular event from your time as a Ph.D. student that you remember particularly well?***

DDH: I remember several occasions when the whole interior point method group at Delft was very excited about new results which we obtained. I also remember many phone calls with my supervisor, Kees Roos, late in the evenings, when one of us suddenly discovered something!

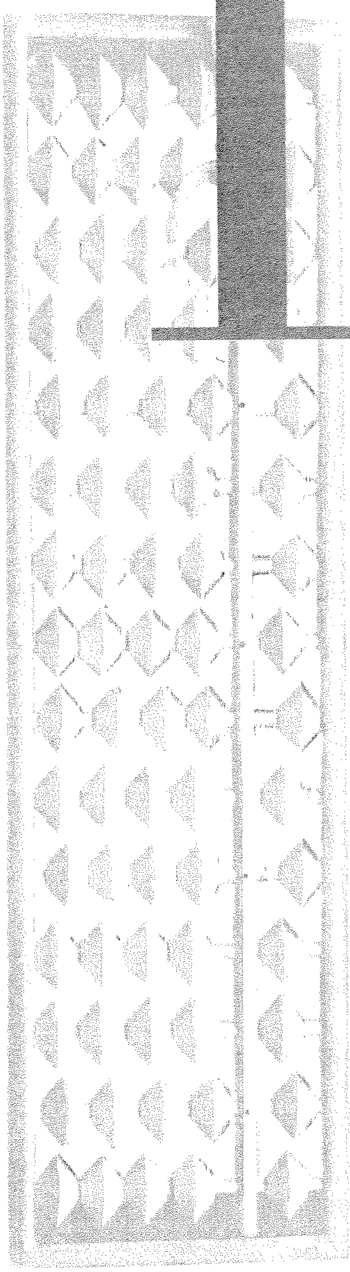
JL: It's a happy occasion to obtain a new result. I also remember once I wrote a paper, and I discovered later that the basic assumption was wrong! It was very embarrassing. But mostly I remember the happy moments.

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

DDH: I like it very much to work in the consultancy firm. It is very enjoyable to talk to people about their problems and to solve them by OR techniques. I am actually very astonished that these techniques can be so useful in practice, because I heard so many negative stories. I don't think they are true. But I still want to stay in touch with the academic world and to publish papers, mainly on practical work. I was also surprised that these two years at CQM gave me a lot of very good ideas on what I would like to work on in the future. What I would like to do is to work about four years at CQM, then two or three years at a university, four years CQM and so on. That would be ideal!

JL: I prefer to get an academic job, but the market now is very tough, and I don't think it will improve in the next two or three years. I just have to see what happens!

7397-CITY TRAVELING SALESMAN INSTANCE SOLVED



David Applegate, Bob Bixby, Vašek Chvátal and Bill Cook have solved the instance pla7397 in the TSPLIB. This 7,397-city instance is by far the largest one for which an optimal solution is known. The previous record–4,461 cities (instance fnl4461 from the TSPLIB)–was held by the same group.

Applegate and his colleagues started their first runs on a 3,038-city instance in January 1992, using about sixty workstations and a computer program based on known techniques. After monitoring the growth of the branch-and-cut tree, they realized that new tricks were needed. By April 1992, they had come up with sufficiently good tools to solve the 3,038-city instance. Since then they have improved their techniques further and solved several previously unsolved instances from the TSPLIB.

The 7,397-city instance was actually solved twice. The first time was on a network of Sun Sparcations at Bellcore, taking the idle cycles from machines at night and weekends. The second time, to write a certificate of the optimal solution, was with the array of Silicon Graphics machines at Silicon Graphics' Center in Houston. The array consisted of 10 Challenge XL machines, each having 20 processors and 2 gigabytes of memory.

In their paper [1], the group modestly describes the technique as follows: "In 1954 Dantzig, Fulkerson, and Johnson [2] showed a way to solve large instances of the TSP; all that came afterward is just icing on the cake. The purpose of the present paper is to describe some of the icing we have added on top of the previous layers. Our icing comes in five flavors:

(i) new ways of finding cuts,
(ii) new ways of handling the LP relaxations,
(iii) new ways of selecting an edge on which to branch,
(iv) new ways of finding an incumbent tour,
(v) solving the problem in parallel on a network of UNIX workstations."

Along with a comprehensive description of the "latest layer of icing," they present a nice historical account of the computational development since Dantzig, Fulkerson and Johnson. The paper is available by anonymous ftp from **netlib.att.com** in the directory **netlib/att/math/applegate/TSP**. The certificate of optimality of instance pla7397 can be found in the same directory.

ON THE INSTANCE PLA7397

The instance arose in an AT&T Bell Laboratories application involving programmable logic arrays (PLA's), and was contributed, together with a 33,810 and an 85,900-city instance, by David Johnson. Programmable logic arrays are VLSI chips that are initially fabricated as a regular array of interconnected components which can be converted to custom integrated circuits by using a laser to vaporize specified interconnections. Choosing the order in which the interconnections are to be vaporized is a more-or-less canonical traveling salesman problem.

ANOTHER LAYER OF ICING ON THE CAKE

The "LaserLogic" process was devised at the AT&T Bell Laboratories facility in Cedar Crest, New Jersey, in 1986. At the time, it seemed as if it might well be competitive with other methods for producing custom chips. For the technique to work, it was necessary to be able to get good solutions to the TSP in under 20 minutes on their workstations. Given the speed and memory capacity of the workstations at the time and the size of the largest instances, it was not possible to use very sophisticated TSP heuristics. However, Jon Bentley (of AT&T Bell Labs' Computing Science Research Center) and David Johnson did provide a fast implementation of the simple nearest neighbor heuristic, which easily met the time bounds and produced solutions that were two to four times shorter than the ones initially used, which were simply to cut the interconnections in the order in which they occurred in the listings produced by the CAD tools used to design the circuits. The LaserLogic process eventually proved

NEXT PAGE ▶

OPTIMA

uncompetitive but, as David Johnson puts it, "Nevertheless, it is nice to know, even after the fact, precisely how much room for improvement there was. For larger instances, we must settle for slightly weaker estimates, such as those determined by the Held-Karp lower bound on optimal tour length, which is typically between 0.5 and 1% below the optimal length. Had the LaserLogic application arisen today, we probably could have provided much better solutions within the specified 20 minute time bound, although still not optimal ones. On a modern workstation, nearest neighbor takes just 3 seconds to handle the 85,900-city instance. Thus we might try something like the Clarke-Wright savings heuristic, which gets within 10.1% of the Held-Karp lower bound for this instance in about 17 seconds, or a fast implementation of 3-opt, which gets within 3.7% in about 90 seconds, or even the famous Lin-Kernighan algorithm, which gets within 1.6% in about 7 minutes." For further details see [3].

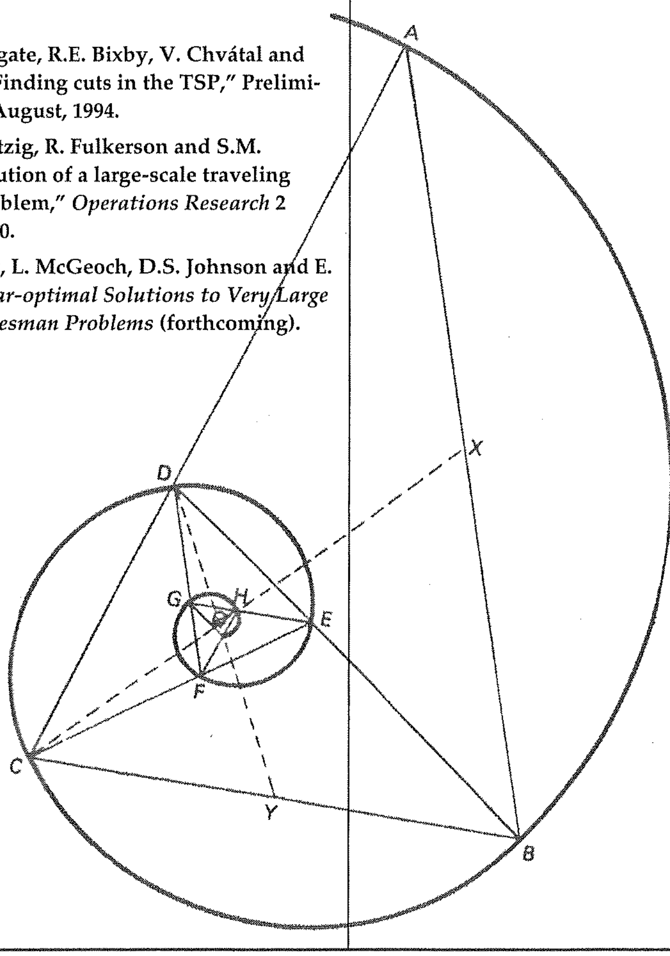
–COMPILED BY KAREN AARDAL, USING INFORMATION PROVIDED BY WILLIAM J. COOK, BELLCORE, AND DAVID S. JOHNSON, AT&T BELL LABORATORIES.

References

[1] D. Applegate, R.E. Bixby, V. Chvátal and W.J. Cook, "Finding cuts in the TSP," Preliminary report, August, 1994.

[2] G.B. Dantzig, R. Fulkerson and S.M. Johnson, Solution of a large-scale traveling salesman problem," *Operations Research* 2 (1954), 393-410.

[3] J. Bentley, L. McGeoch, D.S. Johnson and E. Rothberg *Near-optimal Solutions to Very Large Traveling Salesman Problems* (forthcoming).



The Committee on Stochastic Programming (COSP)

COSP is an official committee of MPS, currently with 12 members: Aharon Ben-Tal (Israel), John R. Birge (U.S.A.), Michael Dempster (England), Jitka Dupačová (Czech Republic), Yuri Ermoliev (Austria/Ukraine), Kurt Marti (Germany), John Mulvey (U.S.A.), András Prékopa (Hungary), Secretary Andrzej Ruszczyński (Austria/Poland), Tamas Szántai (Hungary), Chair: Stein W. Wallace (Norway), William Ziemba (Canada).

The major activity of COSP is to organize an International Conference in Stochastic Programming every three years. So far, there have been six such conferences: Oxford, England (Dempster, 1974), Koszeg, Hungary (Prékopa, 1981), Laxenburg, Austria (Wets, 1983), Prague, Czechoslovakia (Dupačová, 1986), Ann Arbor, U.S.A. (Birge, 1989), Udine, Italy (Andreatta and Salinetti, 1992). The next meeting will be in Israel in 1995. It is described separately in this issue of OPTIMA. During its history, COSP has had two previous chairs, namely András Prékopa and Roger J.-B. Wets. Until 1992, the secretary was Jitka Dupačová.

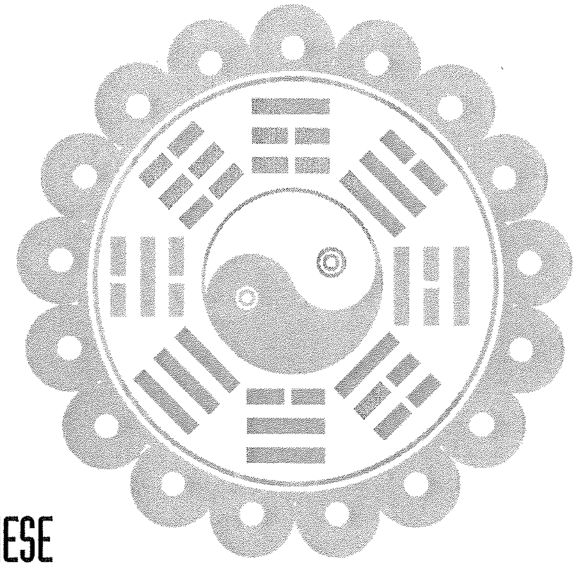
About one year before a conference takes place, the chair of COSP appoints two committees, one to suggest the site of the next meeting, the other to nominate a new chair and secretary of COSP. This committee may also nominate new ordinary members. During the conference a business meeting is held, and those present vote on the choice of the next site and on new members. The list of names is sent by the chair to the Council of MPS for approval. The current committees are chaired by Sen (committee members) and King (site).

COSP operates an e-mail list of scientists interested in stochastic programming. Anything sent to **cosp@iiasa.ac.at** will be forwarded to all addresses on the list. To be included in this list, please contact Ruszczy´nski at **rusz@iiasa.ac.at**. This rather extensive list has been used to communicate new results, report on computational experiments, and gives news about positions, conferences, workshops, etc.

Another concern of COSP is the establishment of a database for stochastic programming problems and the design (modification) of standard input formats.
Karl Frauendorfer (**frauendorfer@sgcl1.unisg.ch**) and David Gay (**dmg@research.att.com**) are working on these issues. Frauendorfer takes the main responsibility for the contents of the database, whereas Gay will run it; Gay already administers netlib's lp/data and lp/generators collections (linear programming test problems).
Together they also consider the possibility of adding features to the standard input format. Anyone with ideas on the input format or with problems they think fit for the problem base, should contact Frauendorfer or Gay. There will be a special session on these issues at the next International Conference on Stochastic Programming in Haifa, Israel.

Stein W. Wallace, Department of Managerial Economics and Operations Research, The Norwegian Institute of Technology, University of Trondheim, N-7034, Trondheim.

Eithan Schweitzer, Faculty of Industrial Engineering and Management Technion–Israel Institute of Technology, Haifa 32000, Israel.



CHINESE MATHEMATICAL PROGRAMMING SOCIETY FOUNDED

The Third National Conference on Optimization, with about 100 participants, was held in Xi'an October 5-10, 1994. At the conference it was unanimously decided that a permanent organization for mathematical programming should be created, which led to the establishment of the Chinese Mathematical Programming Society. The council was formed with Yue Minyi as president, Yu Wenci and Zhang Xiansun as vice presidents, and Han Jiye as secretary.

The purpose of the society is to promote the development of the theory and application of mathematical programming in China. To coordinate with the activities of MPS, it was decided to hold a triennial national symposium the same years as the international symposia. Hence, the next Chinese symposium will be held in 1997 in Wuhan, which is the capital of the Hubei province. In addition to the triennial symposia, conferences on special topics in mathematical programming will occasionally be organized. A biannual newsletter will be issued in Chinese.

SOFTWARE & computation

Now for a few words about COAL and the decision to dissolve it: The Committee on Algorithms (COAL) was formed in 1973 by a handful of members of the Mathematical Programming Society to develop guidelines for the reporting of computational results and for the comparison of optimization software. The guidelines were subsequently published and adopted by *Mathematical Programming* and *Operations Research,* as well as other journals.

In order to keep the growing community of researchers informed of new developments in computational mathematical programming and to promote the goals of COAL, a newsletter (later called the COAL Bulletin) was started with the first issue appearing in September 1978. Initially, the newsletter was only distributed to a small group of researchers engaged in software development but was eventually sent to all members when the Society agreed to cover the publication and mailing costs.

In addition to the newsletter, COAL actively promoted increased research on computational issues and worked to open more channels for the publication of such research. This was accomplished by sponsoring sessions at MPS, ORSA/TIMS, and SIAM meetings, organizing small focused meetings, and maintaining a library of test problems and problem generators.

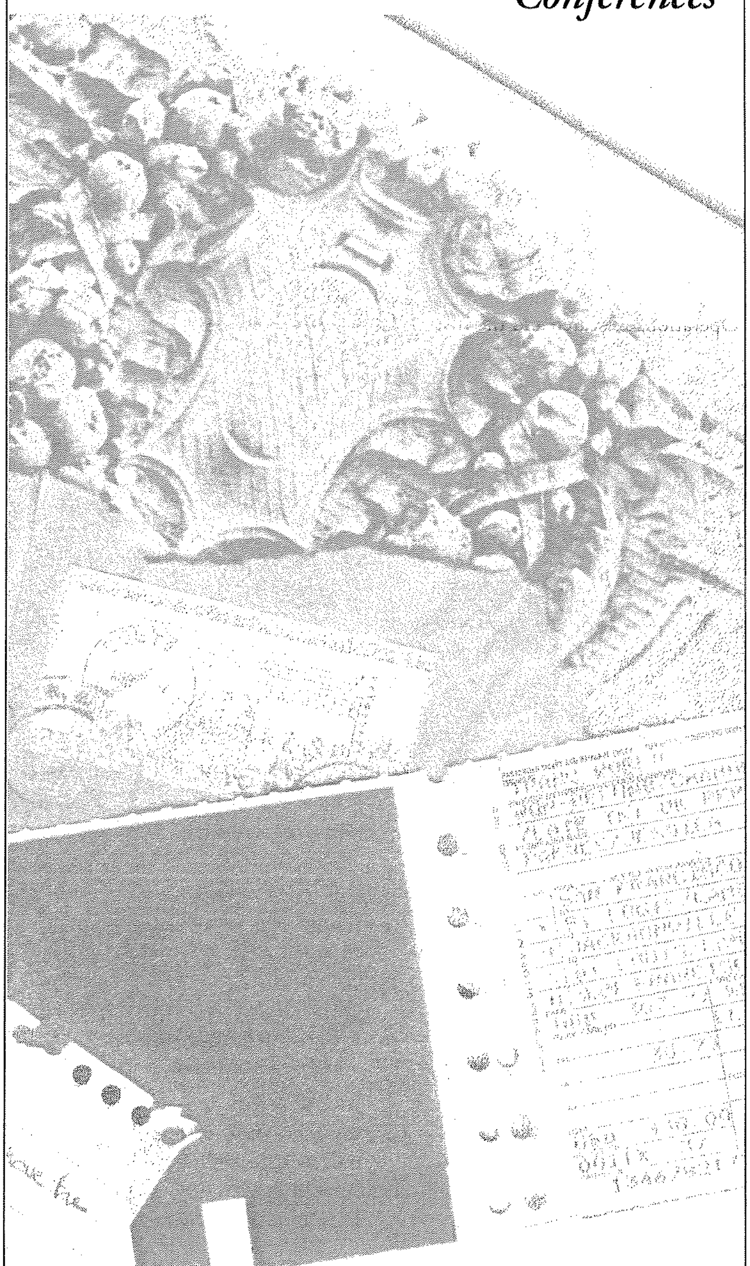
As the quality and significance of the contributions improved, the Beale/Orchard-Hayes Prize was created to recognize outstanding developments in computational optimization. As computational issues became more and more an integral part of the optimization community and the optimization literature, the members of COAL reduced their activities as a group. Then, at the MPS meeting in Ann Arbor last August, COAL voted unanimously to dissolve itself, having succeeded in accomplishing all of its goals. There will be a final farewell issue of the Bulletin to include contributions that were in-hand at the time, an article on the history of COAL and the newsletter, and a master index of all issues.

Simultaneously, the MPS Council suggested that an expanded OPTIMA can serve as the focal point for communicating with interested members. There are still many issues that need to be addressed and certainly the speed of progress in computing, both hardware and software, calls for a forum to keep abreast of developments. The Software and Computation Department will fill this void.

Faiz Al-Khayyal, Software and Computation Editor
School of Industrial and Systems Engineering
Georgia Institute of Technology
Atlanta, Georgia 30332-0205 USA
e-mail: faiz@isye.gatech.edu
phone: +1 404 8943037
fax: +1 404 8942301

CONFERENCE NOTES

Forthcoming Conferences



- **OPTIMIZATION DAYS 1995 Montréal, May 10-12**
- **Seventeenth Symposium on Mathematical Programming with Data Perturbations Washington, D.C., May 25-26, 1995**
- **Ettre Majorana Centre for Scientific Culture International School of Mathematics "G. Stampacchia", Erice, Sicily, Italy, June 13-21, 1995**
- **6th Stockholm Optimization Days, Stockholm, Sweden, June 26-27, 1995**
- **VII International Conference on Stochastic Programming, Nahariya, Israel, June 26-29, 1995**
- **Conference on Optimization '95, Braga, Portugal, July 17-19**
- **International Symposium on Operations Research with Applications in Engineering, Technology, and Management (ISORA), Beijing, Aug. 19-22, 1995**
- **International Workshop on Parallel Algorithms for Irregularly Structured Problems, Lyon, France, Sept. 4-6, 1995**
- **Symposium on Operations Research 1995, University of Passau, Germany, Sept. 13-15**
- **AIRO '95 Annual Conference, Operational Research Society of Italy, Ancona, Italy Sept. 20-22, 1995**
- **ICCP-95-International Conference on Complementarity Problems: Engineering & Economic Applications, and Computational Methods, Baltimore, Maryland, U.S.A. Nov. 1-4, 1995**
- **Conference on Network Optimization, Feb. 12-14, 1996, Center for Applied Optimization, Gainesville, Florida**
- **XVI International Symposium on Mathematical Programming, Lausanne, Switzerland, Aug. 1997**

OPTIMIZATION DAYS 1995
Montréal, May 10-12

GERAD (Groupe d'Études et de Recherche en Analyse des Décisions)
5255, avenue Decelles, Montréal, CANADA, H3T 1V6
Tel: (514) 340-6043; e-mail: jopt95@crt.umontreal.ca
FAX: (514) 340-5665

Seventeenth Symposium on Mathematical Programming with Data Perturbations

Washington, D.C.
May 25-26, 1995

This symposium is designed to bring together practitioners who use mathematical programming optimization models and deal with questions of sensitivity analysis with researchers who are developing techniques applicable to these problems.

Contributed papers in mathematical programming are solicited in the following areas:

(1) Sensitivity and stability analysis results and their applications. (2) Solution methods for problems involving implicitly defined problem functions. (3) Solution methods for problems involving deterministic or stochastic parameter changes. (4) Solution approximation techniques and error analysis.

Clinical presentations that describe problems in sensitivity or stability analysis encountered in applications are also invited.

Abstracts of papers for presentation should be sent in triplicate to Professor Anthony V. Fiacco. Abstracts should provide a good technical summary of key results, avoid the use of mathematical symbols and references, not exceed 500 words, and include a title and the name and full mailing address of each author. The deadline for submitting abstracts is 17 March 1995.

Approximately 30 minutes will be allocated for presenting each paper.

Anthony V. Fiacco, Organizer
Sponsored by the Department of Operations Research and the Institute for Management Science and Engineering, School of Engineering and Applied Science, The George Washington University, Washington, D.C. 20052. Tel. (202) 994-7511.

Ettre Majorana Centre for Scientific Culture
International School of Mathematics "G. Stampacchia"
Erice, Sicily, Italy
June 13-21, 1995

FIRST ANNOUNCEMENT

This workshop aims to review and discuss recent advances and promising research trends in the field of Nonlinear Optimization concerning theory, algorithms and innovative applications. Both the finite and the infinite dimensional cases will be of interest.

As usual, the course will be structured to include invited lectures and contributed lectures. Proceedings including the invited lectures and a selection of contributed lectures will be published.

Invited lecturers are:

J. Abadie, V. Demyanov, Y.G. Evtushenko, M. Fukushima, L. Grippo, J.J. Judice, O.L. Mangasarian, J.J. Moré, J. Nocedal, J.S. Pang, P.M. Pardalos, E. Polak, L. Qi, S.M. Robinson, R.T. Rockafellar, R. Schnabel, E. Spedicato, Ph. Toint

For details contact:

Prof. Gianni Di Pillo, Dipartimento di Informatica e Sistemistica, Università di Roma "La Sapienza", via Buonarroti 12, 00185 Roma, Italy.
e-mail: erice@peano.dis.uniroma1.it
FAX: +39-6-48299218

VII International Conference on Stochastic Programming

Nahariya, Israel, June 26-29, 1995

The VII Conference on Stochastic Programming will be hosted by the Technion–Israel Institute of Technology, and held in Nahariya, Israel (near Haifa) on June 26-29, 1995.

The conference is followed by the EURO XIV–14th European Conference on Operational Research, which will be held at the Hebrew University, Jerusalem, July 3-6, 1995.

The Conference will take place at the Carlton Hotel, Nahariya, Israel. Nahariya is a lovely small resort town on the Mediterrenean Sea, located 30 kilometers north of Haifa and about 140 kilometers from Ben-Gurion Airport. The weather in June-July in Nahariya is about 28-30C by day and about 20-22C by night. The hotel is located at the center of the town with shops and restaurants nearby. It provides full service, air-conditioned rooms with telephone, radio, T.V. and video service, outdoor swimming pool, sauna, night-club, bar, cafeteria and a restaurant. The beach is within walking distance.

NEXT PAGE ▶

6th Stockholm Optimization Days

Stockholm, Sweden,
June 26-27, 1995

Theoretical, computational and applied papers are welcome for the **6th Stockholm Optimization Days**, a two-day conference on optimization, to be held at KTH (Royal Institute of Technology) in Stockholm, Sweden, June 26-27, 1995.

Sessions are planned on various aspects of optimization, including nonsmooth optimization, linear and nonlinear programming.

CALL FOR PAPERS

Invited speakers include:

A. Ben-Tal, Technion, Haifa, Israel
R.E. Bixby, Rice University, Houston, TX, USA
J. Desrosiers, GERAD, Montreal, Canada
P.E. Gill, UC San Diego, CA, USA
C.C. Gonzaga, Federal Univ. of Rio de Janeiro, RJ, Brazil
A. Griewank, Technische Universität Dresden, Germany
D.W. Hearn, U. Florida, Gainesville, FL, USA
C. Lemaréchal, INRIA, Rocquencourt, France
R. Mifflin, Washington State University, Pullman, WA, USA
W. Murray, Stanford University, CA, USA
A. Nemirovskii, Technion, Haifa, Israel
Yu. Nesterov, CORE, Belgium
M.L. Overton, Courant Institute, NY, USA
C. Sagastizàbal, INRIA, Rocquencourt, France
A. Sartenaer, FUNDP, Namur, Belgium
T. Steihaug, University of Bergen, Norway
Ph. Toint, FUNDP, Namur, Belgium
R. Vanderbei, Princeton University, NJ, USA

Abstracts (maximum 200 words) should be sent by May 1, 1995, (preferably by e-mail) to:

e-mail: optdays@math.kth.se

address:
Optimization Days
Division of Optimization and Systems Theory
KTH
S-100 44 Stockholm Sweden

Fax: +46 8 - 22 53 20.

Further information may be obtained from the addresses listed above.

The conference is financially supported by the Göran Gustafsson Foundation and the Swedish National Board for Industrial and Technical Development (NUTEK). Organizers are Ulf Brännlund (head), Anders Forsgren, Per Olov Lindberg and Krister Svanberg from the Division of Optimization and Systems Theory, Department of Mathematics, Royal Institute of Technology (KTH).

The main topics of the conference are:

•Stochastic programming, theory and application
•Stability and sensitivity analysis
•Stochastic combinatorial optimization
•Statistical approach to stochastic programming
•Stochastic approximation techniques
•Optimization of discrete event (simulation) models
•Application of stochastic programming to artificial intelligence, finance, production, reliability, etc.

One hour, state-of-the-art tutorial and review lectures will be presented by invited speakers: J.R. Birge, A. Gaivoronsky, G. Pflug, B. Polyak, A. Shapiro and S. Zenios. The tutorial and review lectures will be held in special (non parallel) sessions.

Contributed sessions and presentations are welcome. The contributed presentations are expected to be 30 minutes (including about 5 minutes for questions and/or discussion). Presentations will be grouped into sessions of 90 minutes each, by topic. There will be two or three simultaneous parallel sessions.

The social part of the conference will consist of a reception, sponsored by the Mathematical Programming Society, a dinner at Rosh-Haniqra after visiting the famous caverns formed by the powerful waves of the Mediterrenean, and a banquet on the last evening of the conference. An excursion to Galilee on Friday, June 30, 1995, will be organized for participants who stay over the weekend.

The members of the international scientific committee are: Z. Artstein (Israel), M. Avriel (Israel), H. Ben-Haim (Israel), A. Ben-Tal (Israel), J.R. Birge (U.S.A.), M.A.H. Dempster (Canada), J. Dupačová (Czech Rep.), D. Elmakis (Israel), Y. Ermoliev (Russia), A. Gaivoronsky (Italy), G. Infanger (U.S.A.), A.J. King (U.S.A.), P. L'Ecuyer (Canada), T.M. Liebling (Switzerland), K. Marti (Germany), A.S. Nemirovskii (Israel), G. Pflug (Austria), A. Prékopa (U.S.A.), B. Polyak (Russia), S.M. Robinson (U.S.A.), R.T. Rockafellar (U.S.A.), U.G. Rothblum (Israel), A. Ruszczyński (Poland), S. Sen (U.S.A.), A. Shapiro (U.S.A.), M. Teboulle (Israel), S. Uryasev (U.S.A.), and S.W. Wallace (Norway).

The members of the organizing committee are: Arkadi Nemirovskii, Reuven Y. Rubinstein (Chair), Eithan Schweitzer of the Faculty of Industrial Engineering and Management at the Technion, and Marc Teboulle of the Department of Statistics and Operations Research at Tel-Aviv University.

The last date for submitting abstracts was March 1, 1995, but for more information and for registration please contact the conference secretariat:

Mrs. Nilly Schnapp, Faculty of Industrial Engineering and Management, Technion, Haifa 32000, Israel. Fax: 972-4-235-194 E-mail: ierns01@technion.technion.ac.il

The e-mail address of the organizing committee is: gosp@ie.technion.ac.il

---

Conference on Optimization '95
Braga, Portugal, July 17-19

The main aim of the meeting is to gather experienced researchers in Optimization and to invite them to describe their latest results, experiences or applications in a friendly atmosphere for an audience with an expected large number of students.

The conference is organized by the Optimization Group of APDIO - The Operations Research Society of Portugal. It will take place at the University of Minho, in Braga, a city 50 km north of Oporto. The program includes contributed communications and invited lectures in six different themes by the following experts:

(1) Linear Programming, D. Shanno, Rutgers University, USA (2) Nonlinear Programming, J. Dennis, Rice University, USA (3) Global Optimization, R. Horst, University of Trier, Germany (4) Integer Programming, L. Wolsey, CORE, Belgium (5) Network Problems, T. Magnanti, MIT, USA (6) Complementarity and Variational Inequalities, K. Murty, University of Michigan, USA.

There is a limit of 60 contributed talks. The conference language is English.

Prospective authors are requested to submit an extended abstract (1 page, 1.5 space), by March 30, 1995, with a cover page including the name of the author, affiliation and address, and key words. All the submitted abstracts will be refereed by the Program Committee. Authors will be notified of acceptance by May 1, 1995.

Submit abstracts to:

CONFERENCE SECRETARIAT
Departamento de Produçào e Sistemas
Escola de Engenharia Universidade do Minho
4700 Braga, Portugal
Tel.: +351-53-604455
FAX: +351-53-604456 e-mail: copt95@ci.uminho.pt

CALL FOR PAPERS

International Symposium on Operations Research with Applications in Engineering, Technology, and Management (ISORA)
Beijing, Aug. 19-22, 1995

The symposium is intended to provide a forum for researchers working in Operations Research who deal with theoretical, computational and applications aspects of optimization. Optimization is understood in the widest sense to include linear, nonlinear, stochastic, combinatorial, and multiobjective systems. Papers presenting original research in these areas are sought. Typical, but not exclusive, topics of interest include:

• Linear and nonlinear programming • Combinatorial and global optimization • Multiobjective optimization • Stochastic programming • Scheduling and network flow • Queuing systems • Quality technology and reliability • Simulation • Optimizations in VLSI • Neural network • Financial modeling and analysis • Manpower planning • Production/ Inventory control • Flexible manufacturing systems • Decision analysis • Decision support systems • Microcomputer software of OR methods.

Papers on real-world applications will be especially appreciated.

Authors are requested to submit 5 copies (in English) of an extended abstract of not more than 10 pages by April 1, 1995, to one of the following addresses:

Professor Kan Cheng, Institute of Applied Mathematics, Chinese Academy of Sciences, Beijing 100080, P.R. China; or Dr. Ding-Zhu Du, Computer Science Department, University of Minnesota, Minneapolis, MN 55455, U.S.A.

The extended abstract should include the e-mail address of the contact person. Authors will be notified of acceptance or rejection by April 25, 1995. A camera-ready copy of each accepted paper is required by May 30, 1995. The conference welcomes any special session on the above topics. The proposal for a special session should also be sent to one of the above addresses before April 1, 1995. A formal proceedings will be published and selected papers will be put in a special issue of *The Journal of Global Optimization.* One author of each accepted paper should attend the conference and present the paper.

The symposium will be held at the West Suburb Hotel, a three-star hotel in the university area, 15 kilometers from the center of Beijing. The room rate is about US$35 per day.

One day of sightseeing to the Great Wall is included in the Registration fee (US$300).

For information about the program, registration and local arrangements, please contact Kan Cheng at FAX 86-1-254-1689 or e-mail ISORA@amath3.amt.ac.cn or D.-Z. Du at FAX 1-612-625-0572 or e-mail dzd@cs.umn.edu.

Conference sponsor: The Asian-Pacific Operations Research Center within APORS and CAS.

Co-sponsors: The Institute of Applied Mathematics, Chinese Academy of Sciences; The Operations Research Society of China; The National Natural Science Foundation of China; The State Science and Technology Commission of China

Symposium on Operations Research 1995
University of Passau, Germany, Sept. 13-15

Sections at this conference include: Linear Programming; Nonlinear Programming; Combinatorial and Discrete Optimization; Stochastic Models and Optimization; Realtime Optimization; Scheduling; Control Theory; Statistics, Econometrics; Macroeconomics; Mathematical Economics and Game Theory; Neural Networks and Fuzzy Control; Simulation; Decision Support and Information Systems; Banking, Finance, Insurance; Production; Logistics; Transportation and Traffic; Inventory; Practical OR (Application Reports); Decision Theory and Experimental Economics; and Environmental Aspects.

Conference languages are English and German. The scientific program includes invited plenary and semiplenary lectures as well as contributed papers. Presentation of the latter is limited to 30 minutes including discussion. The deadline for submission of abstracts is April 1, 1995.

Software Presentation: Participants are encouraged to present software solutions for their contributions or software systems.

Mailing address for abstracts and further information:

Prof. Dr. P. Kleinschmidt, Universität Passau, Wirtschaftswissenschaftliche Fakultät D-94030, Passau
Tel. +49-951-509-339 e-mail: sor95@winf.uni-passau.de

PRELIMINARY ANNOUNCEMENT

Conference on Network Optimization
Feb. 12-14, 1996, Center for Applied Optimization University of Florida

Organized by Bill Hager, Don Hearn and Panos Pardalos
hager@math.ufl.edu
hearn@ise.ufl.edu
pardalos@ufl.edu

The conference will bring together researchers working on many different aspects of network optimization: algorithms, applications, and software. The conference topics include diverse applications in fields such as engineering, computer science, operations research, transportation, telecommunications, manufacturing, and airline scheduling.

Since researchers in network optimization come from many different areas, the conference will provide a unique opportunity for cross-disciplinary exchange of recent research advances as well as a foundation for joint research cooperation and a stimulation for future research.

Advances in data structures, computer technology, and development of new algorithms have made it possible to solve classes of network optimization problems that were recently intractable. For example, recent advances have been made in techniques for solving problems related to airline scheduling, satellite communication and transportation, and VLSI chip design. Computational algorithms for the solution of network optimization problems are of great practical significance.

The conference will be held at the Center for Applied Optimization, University of Florida, Gainesville, FL.

All presentations are invited. A collection of refereed papers will be published in book form by Kluwer Academic Publishers. For further details, please contact one of the conference organizers.

ICCP-95
International Conference on Complementarity Problems: Engineering & Economic Applications, and Computational Methods
The Johns Hopkins University (Homewood Campus) Baltimore, Maryland, U.S.A.
Nov. 1-4, 1995

The conference will bring together for the first time engineers, economists, industrialists, and academicians from the U.S. and abroad who are involved in pure, applied, and/or computational research of complementarity problems, to present and discuss the latest results in this subject and to offer suggestions for collaborative research and further development of the field.

The conference will last four days and will consist almost entirely of invited presentations. There will be a small number of selected contributed talks, and the conference is limited to 100 participants (including the speakers). A refereed volume of proceedings of the conference will be published.

There are three major themes of the conference: engineering applications, economic equilibria, and computational methods. Each theme will be represented by experts in the area. Topics to be covered in the conference are listed below.

Engineering applications: Contact mechanics problems, structural mechanics problems, nonlinear obstacle problems, elastohydrodynamic lubrication problems, traffic equilibrium problems.

Economic applications: Applied general economic equilibrium, game–theoretic models, NEMS.

Computational methods: Pivotal and path following methods, smoothing techniques, quadratic programming based methods, interior point methods, and projection/proximal based methods; software development, modeling language interfaces.

Contact one of the organizers for further details if you are interested in participating in the conference or in contributing a paper for possible presentation.

Organizers:

Michael C. Ferris, (on leave at) Department of Economics, University of Colorado Campus, Box 256, Boulder, CO 80309
Tel.: (303) 492-2651
E-mail: ferris@cs.wisc.edu

Jong-Shi Pang, Department of Mathematical Sciences, The Johns Hopkins University, Baltimore, MD 21218 Tel.: (410) 516-7216
E-mail: jsp@vicp1.mts.jhu.edu

CALL FOR PAPERS

AIRO '95 Annual Conference, Operational Research Society of Italy
Ancona, Italy, Sept. 20-22, 1995

AIRO '95 - Prof. Ferdinando Pezzella Istituto di Informatica - Facoltà di Ingegneria Università degli Studi di Ancona Via Brecce Bianche - 60131 Ancona, Italy
Tel: +39-71-2204826
FAX: +39-71-2204474
e-mail: airo@anvax1.unian.it

BOOK REVIEWS

The Linear Complementarity Problem

by R.W. Cottle, J.-S. Pang, and R.E. Stone
Academic Press, Boston, USA, 1992

ISBN 0-112-192350-9

The linear complementarity problem (LCP) originated in the works of Cottle and others as a unifying model for the study of linear and quadratic programming problems and bimatrix games. Given an $n \times n$ real matrix M and a real n-vector q, the problem seeks a nonnegative vector x such that $Mx+q$ is nonnegative and orthogonal to x. LCP and its various generalizations, namely, the nonlinear complementarity problem, the generalized complementarity problem (over closed convex cones), the variational inequality problem, generalized equations, and the recent vertical (horizontal, mixed) linear complementarity problem, have found many applications in optimization, economic and traffic equilibria, engineering, geometry, etc. The study of LCP has led to new ideas and techniques for analyzing complex systems. For example, Scarf's computational scheme for finding fixed points of continuous mappings, Robinson's inverse and implicit function theorems for nonsmooth functions, and (the somewhat recent) univalence results for piecewise affine functions have had their origins in the LCP theory. Although basic existence, uniqueness, and stability questions have been answered and various computational schemes have been proposed, there are still many interesting open problems.

"This extremely well-written book can be used either as a textbook (at the senior undergraduate or at the graduate level) or as reference book."

The book under review contains an exhaustive account of the LCP. Of the seven chapters in the book, the first two deal with introduction and background material. Chapter 3 deals with the existence and uniqueness aspects. In this chapter, various matrix classes associated with the LCP are introduced and studied. Chapter 4 deals with the pivotal algorithms for solving LCPs. Here, the algorithms due to Lemke, Cottle, Chandrasekaran, and Van der Hayden are fully discussed. In Chapter 5, splitting and Newton type iterative methods are discussed in great detail while a short section is devoted to the interior point methods. This chapter also deals with residues and error bounds. Intricate geometric and degree-theoretic analysis of LCP is covered in Chapter 6. The final chapter deals with the stability and sensitivity aspects of the LCP.

The notes and references given at the end of each chapter outline the historical development of the subject. The exercises vary from routine to challenging. There is an extensive bibliography. This extremely well-written book can be used either as a textbook (at the senior undergraduate or at the graduate level) or as reference book.

This book is highly recommended to anyone interested in the LCP, linear and quadratic programming, optimization, variational inequalities, and other related topics.

–M. SEETHARAMA GOWDA

Interior-Point Polynomial Algorithms in Convex Programming

by Y. Nesterov and A. Nemirovskii
SIAM, Philadelphia 1994
ISBN 0-89871-319-6

The appearance of Karmarkar's article [2] ten years ago opened a new chapter in the study of complexity in mathematical programming, which has since resulted in the production of over 1000 papers according to the bibliography [3]. Karmarkar's method had a slight theoretical advantage and a very significant computational advantage over the only other polynomial-time algorithm for linear programming at the time–Khachiyan's modification of the ellipsoid method of Yudin and Nemirovskii, originally devised for nonsmooth convex optimization. The computational developments since Karmarkar's paper, both for interior-point and simplex methods, have been significant and are well summarized in the lead article by Lustig, Marsten, and Shanno with commentaries on it appearing in [5]. These developments, however, are not the subject of the present book, which provides a truly comprehensive study of the foundations of interior-point methods for convex programming.

Karmarkar used projective transformations and an auxiliary potential function in his algorithm which was presented for linear programming problems in a rather restrictive form. A large amount of effort went into understanding and extending these ideas and removing the restrictive assumptions over the next few years. Also, connections with classical barrier methods and methods of centers were established, and the first path-following methods, with a superior theoretical complexity bound, were developed by Renegar and soon thereafter Gonzaga. These led to primal-dual algorithms and the explosion of research referred to above.

At the same time as these developments, mainly concerned with complexity issues and practical computation for linear programming, Nesterov and Nemirovskii began their path-breaking (as opposed to path-following?) research into what the key elements of interior-point methods were, what allowed polynomial complexity bounds to be established, and to what general classes of problems such analyses could be extended. This book is the result of five years of their investigations.

The key idea is that of a ***self-concordant barrier*** for the constraint set, a closed convex set or cone in a finite-dimensional space. The notion of self-concordance requires that the convex barrier function satisfy certain inequalities between its various derivatives; roughly, its third and first derivatives should be suitably bounded when measured in terms of its second derivative, which defines a semi-norm at every point of the interior of the convex set or cone. These conditions ensure, for instance, that Newton's method behaves

OPTIMA

nicely in a reasonably global sense. From such a barrier one can construct path-following methods, of either barrier or method-of-centers type; if the barrier satisfies an additional property natural for a convex cone, one obtains potential-reduction methods. In all cases, the number of iterations necessary to obtain an ε-optimal solution depends polynomially on $ln\ (1/\varepsilon)$ and θ, a parameter associated with the barrier.

Chapter 1 of the book provides a very useful overview of the ideas underlying the work and the contents of each chapter. Then Chapter 2 contains the basic definitions and properties of self-concordant functions and barriers, including the beautiful result that every convex set in R^n admits a self-concordant barrier with parameter θ of order n. Chapters 3 and 4 are concerned with path-following and potential-reduction algorithms respectively and demonstrate that the main requirement for efficiently solving a convex programming problem (without loss of generality, with a linear objective function) is the knowledge of a self-concordant barrier together with its first two derivatives for the constraint set, with a reasonably small value for its parameter. (The authors also show concern for the practical efficiency of variants of their methods.)

Chapter 5 provides tools for constructing such barriers and several examples. While the result quoted above assures the existence of a barrier with parameter of the order of the dimension, such a barrier may not be easily computable. For example, the usual barrier for a polyhedral set in R^n defined by m inequalities is the standard logarithmic barrier, with parameter m not n. On the other hand, the cone of positive semidefinite matrices of order n, a set of dimension $n(n+1)/2$, admits a barrier of parameter n. (This cone arises frequently in important optimization problems.) Chapter 6 discusses applications of the tools developed previously to a wide range of nonlinear problems and hence obtains efficient methods for their solution. Chapters 7 and 8 address extensions to variational inequalities and various acceleration techniques respectively.

This is a book that every mathematical programmer should look at, and every serious student of complexity issues in optimization should own. For a brief idea of the approach, the first chapter, the introductory material in subsequent chapters, and the bibliographical notes at the end of the book can be read. For a more detailed study, a serious commitment is necessary; this is a technically demanding tour-de-force. The authors provide motivation and examples, but many of the beautiful ideas require long technical analyses. The reader is advised to skim forwards and backwards to help understand some of the definitions and results. For example, the standard logarithmic barrier function $-\Sigma_j \ln x_j$ for the nonegative orthant is introduced on page 40 (with related barriers on pages 33 and 34), but it is helpful for motivation and illustration where self-concordant functions are first defined on page 12. Likewise, a hint of the barrier-generated family on page 66 would assist in understanding the definition of a self-concordant family on page 58. The authors' overview in Chapter 1 is also very helpful in showing the direction the argument will take.

"This is a book that every mathematical programmer should look at, and every serious student of complexity issues in optimization should own."

There seem to be very few misprints. One possibly confusing one appears in (2.2.16): ω^2 should be ω in the numerator. And the excellent bibliographical notes were prepared for an earlier version of the book; the chapter-by-chapter remarks need the chapter numbers incremented by one. The bibliography itself is somewhat limited and often refers to reports that have since appeared in print. For comprehensive references, see the bibliography [3]; unfortunately, this has not been systematically updated since the summer of 1993.

Before concluding, let me mention two subsequent reports. Güler [1] has found a lovely connection between self-concordant barriers for convex cones and their characteristic functions, which were introduced by Köcher and play an important role in characterizing homogeneous cones. And Nesterov and the reviewer [4], by further restricting the class

OPTIMA

of cones and their barriers (while allowing many important examples), have developed long-step and symmetric primal-dual interior-point methods for certain convex problems, extending those for linear programming.

In summary, this is an outstanding book, a landmark in the study of complexity in mathematical programming. It will be cited frequently for several years and is likely to become a classic in the field.

References

1. O. Güler, "Barrier functions in interior-point methods," Department of Mathematics and Statistics, University of Maryland, Baltimore County, Baltimore, MD, 1994.

2. N.K. Karmarkar, "A new polynomial–time algorithm for linear programming," Combinatorica 4 (1984), 373-395.

3. E. Kranich, "Interior point methods for mathematical programming: a bibliography," available from NETLIB: send e-mail to **netlib@research.att.com** containing the message "send intbib.tex from bib" and/or "send intbib.bbl from bib."

4. Yu.E. Nesterov and M.J. Todd, "Self-scaled cones and interior-point methods in nonlinear programming," School of Operations Research and Industrial Engineering, Cornell University, Ithaca, NY, 1994.

5. ORSA Journal on Computing, 6 (1994), 1 ff.

M.J. TODD

Constructive Approximation

by R. A. De Vore and G. G. Lorentz

Springer-Verlag, Berlin, 1993

ISBN 3-540-50627-6

As stated in the preface, the book under review is to be seen as a modern version of G. G. Lorentz: ***Approximation of Functions***, New York, 1966. It deals essentially with the same classical questions in approximation theory, a field also known as constructive theory of functions. Of course, the authors have added many new results obtained since the publication of that book, and the presentation is in a more general frame; nevertheless the choice of the topics considered has almost been unchanged, and some modern aspects of approximation theory are only sketched or missing. New are, for example, the theory of *K*-functionals and interpolation spaces, and the Ditzian-Totik approach to algebraic approximation. Furthermore, there are three chapters (5, 12, 13) on splines, approximation by splines and interpolation by splines, altogether more than 100 pages which is about a quarter of the book.

Another major part of about 100 pages is devoted to best approximation, in particular, best approximation by algebraic and trigonometric polynomials as well as by splines. Chapter 3 is concerned with the standard material, e.g., the general theory of existence and uniqueness of elements of best approximation, the Chebyshev theory, and the theory of Haar systems. The "Central Theorems of Approximation" as called by the authors, namely Jackson-Bernstein-type theorems for best approximation, are given in Chapters 7 and 8. The latter deals in detail with the influence of the endpoints in case of algebraic approximation. Here the reader can find the classical results of A.F. Timan and V.K. Dzjadik as well as the more recent ones of Z. Ditzian and V. Totik.

OPTIMA

"...we can recommend this book to everyone who is interested in the topics dealt with and who wishes to have a presentation in modern language of approximation theory."

Apart from this there are some minor chapters dealing with Lagrange, Hermite and Birkhoff interpolation (Chapter 4), with approximation by linear operators, in particular with the norms of projection operators and the Butzer-Scherer theory of commuting operators (Chapter 9), with Bernstein and Kantorovich polynomials (Chapter 10), and with saturation and Müntz approximation (Chapter 11).

Chapters 2 and 6 provide the necessary material on the function spaces used throughout and on the moduli of smoothness and *K*-functionals. In particular, the equivalence between moduli of smoothness and *K*-functionals in certain instances, Marchaud-type inequalities and the extension theorems of Whitney are given here. There is also a short exposition of the so-called θ,q-interpolation spaces.

Let us also mention Chapter 1 which may serve as an introduction presenting, among others, the celebrated theorems of K. Weierstrass (1885), L. Fejér (1900) and S. Bernstein (1912) on the approximation of continuous functions by polynomials.

All in all, the book is exactly what the authors state in the preface or, in other words, "a modern presentation of selected topics in classical approximation theory." Most of the material is covered by at least one of the textbooks on approximation theory which were published up to 38 years ago, e.g., those of N.I. Achieser (1956), P.J. Davis (1961), A.F. Timan (1963), I.P. Natanson (1964/65), E.W. Cheney (1966), G.G. Lorentz (1966), or the book on splines by L.L. Schumaker (1981).

Of course, one cannot give an absolute answer to the question whether the choice of topics is optimal or whether there was a need to write this book at all. This answer has to be left to the reader, but we can recommend this book to everyone who is interested in the topics dealt with and who wishes to have a presentation in modern language of approximation theory.

Let us finally mention that the book contains an extensive bibliography, even if some of the above-mentioned textbooks are missing. On the other hand, there is only a very poor index, e.g., no entries mentioning the theorems of Bernstein, Weierstrass, Fejér or Timan can be found, and the entries 'Fejér operator' or 'Fourier series' only give a hint to Page 3, although these topics are dealt with in detail in Chapter 11.

R. L. STENS

O P T I M A

Gallimaufry

Nº 45

MARCH 1995

The Faculty of Management, McGill University, announces a tenure track position in Operations Management beginning Sept. 1995. Apply in writing to: Professor Albert Teitlebaum, Faculty of Management, McGill University, 1001 Sherbrooke St. West, Montréal, Quebec, Canada H3A 1G5. Scholars interested in conducting research in Germany may contact the Alexander von Humboldt Foundation, Suite 903, 1350 Connecticut Ave. NW, Washington, DC 20036, Phone: 202-296-2990, Fax: 202-833-8514. Deadline for the next OPTIMA is June 1, 1995.

Donald W. Hearn, EDITOR
e-mail: hearn@ise.ufl.edu

Karen Aardal, FEATURES EDITOR
Department of Econometrics
Tilburg University
P.O. Box 90153
5000 LE Tilburg
The Netherlands
e-mail: aardal@kub.nl

Faiz Al-Khayyal, SOFTWARE & COMPUTATION EDITOR
Georgia Tech
Industrial and Systems Engineering
Atlanta, GA 30332-0205
e-mail: faiz@isye.gatech.edu

Dolf Talman, BOOK REVIEW EDITOR
Department of Econometrics
Tilburg University
P.O. Box 90153
5000 LE Tilburg
The Netherlands
e-mail: talman@kub.nl

Elsa Drake, DESIGNER

PUBLISHED BY THE MATHEMATICAL PROGRAMMING SOCIETY AND GATOR ENGINEERING PUBLICATION SERVICES, UNIVERSITY OF FLORIDA.

Journal contents are subject to change by the publisher.

APPLICATION FOR MEMBERSHIP

Mail to:

The Mathematical Programming Society, Inc.
c/o International Statistical Institute
428 Prinses Beatrixlaan
2270 AZ Voorburg
The Netherlands

Cheques or money orders should be made payable to **The Mathematical Programming Society, Inc.**, in one of the currencies listed below. Dues for 1995, including subscription to the journal *Mathematical Programming*, are HFL100.00 (or USD55.00 or DEM85.00 or GBP32.50 or FRF300.00 or CHF80.00).

Student applications: Dues are ½ the above rates. Have a faculty member verify your student status and send application with dues to above address.

I wish to enroll as a member of the Society. My subscription is for my personal use and not for the benefit of any library or institution.

I enclose payment as follows:

Dues for 1995 ____________________

NAME ____________________

MAILING ADDRESS (PLEASE PRINT) ____________________

____

SIGNATURE ____________________

FACULTY VERIFYING STATUS ____________________

INSTITUTION ____________________

O P T I M A
MATHEMATICAL PROGRAMMING SOCIETY

UNIVERSITY OF
FLORIDA

Center for Applied Optimization
378 Weil Hall
PO Box 116595
Gainesville FL 32611-6595 USA

FIRST CLASS MAIL