OPTIMA 102

Mathematical Optimization Society Newsletter

MOS Chair's Column

April 5, 2017. When I write this column we are in a period that involves a lot of important decisions for MOS, related to the preparation of the next ISMP. As you all know, our Society awards several prizes for important contributions in the past couple of years. Some of these prizes are awarded jointly with other societies and we need to put together juries that complement and balance the jury members from the other societies. This is an important puzzle to put together and I hope that those of you who get a "call for help" are willing to serve.

Even though it seems to be a long time until the next ISMP we also need to think about where ISMP 2021 will take place! Again, there is a committee that will make sure that site nominations are in place, but it is good to start thinking about whether you are willing to be one the next organizers!!! In the meantime I wish the Bordeaux-team the very best in the final preparations for ISMP 2018.

Mathematical Reviews together with *Zentralblatt MATH* are maintaining the Mathematics Subject Classification (MSC) and there is ongoing work on updating the 2010 MSC. It is important to have good classifications of our research and you can contribute to the update via msc2020.org. I will also discuss with the Publications Committee how we best can influence the categories most relevant to optimization.

INFORMS is in the process of starting up a new journal: *INFORMS Journal on Optimization*. This new journal will of course be a "competitor" to *Mathematical Programming*. Does the new journal call for changes in the profile of MP? Another interesting topic for the Publications Committee and the membership to discuss! Do not hesitate to provide us with comments and suggestions on the topics discussed here or any other topic that you feel is relevant for MOS.

When you read this column, we are already well into a new calendar year. I nevertheless wish you all a happy, healthy and productive 2017 with lots of exciting endeavors!

Karen Aardal
Delft Institute of Applied Mathematics
k.i.aardal@tudelft.nl

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Note from the Editors

Dear MOS members,

This issue of Optima provides you with fascinating accounts of the lives and work of six researchers who have shaped different parts of Mathematical Optimization for decades and who each passed away in 2016: Jonathan M. Borwein (1951–2016), Jitka Dupačová (1939–2016), Roger Fletcher (1939–2016), Chris Floudas (1959–2016), Andrăs Prékopa (1929–2016), and Philip Starr Wolfe (1927–1916). It seems hard to imagine what our field would look like without the numerous fundamental contributions made by these individuals. One might see this reflected in their total of 890 publications listed by MathSciNet. But it certainly is much more impressive to read about the individual contributions made by each of them in the articles that you will find below by Henry Wolkowicz, Marida Bertocchi, David P. Morton, Jorge Nocedal, Ignacio Grossmann, Andrzej Ruszscynski, and Alan J. Hoffman. (We are grateful to Springer Science for granting us permission to reprint his chapter *Philip Starr Wolfe* from the volumne *Profiles in Operations Research*, A. A. Assad, S. I. Gass (eds.), International Series in Operations Research & Management Science 147, 2011).

With Philip Wolfe, the Mathematical Optimizaton Society and in particular its newsletter *Optima* lost a founding father. Not only did he start together with Michel Balinski our flagship journal *Mathematical Programming*. He was also the chairman of our society from 1978 to 1980, when the decision to introduce a newsletter for the society was shaped. In fact, in addition to pushing forward the idea of "having an informal means of communication available and that this could best be attained by establishing a Newsletter" he also suggested the name *Optima* "since it translates so well into many languages", as you can read in a column by Michael Held (then the chairman of the Publications Committee of the society) in the first issue of our newsletter.

In the likely case you don't have a printed copy of *Optima* 1 at hands, don't worry: Electronic access to all issues of *Optima* is available at http://www.mathopt.org/?nav=optima_details. If you take the chance to have a look into Volume 1 of our newsletter, you will see that in fact the very first article that ever appeared in *Optima* was written by Philip Wolfe on "The Ellipsoid Algorithm". The article starts out "Who would have thought that what must be the only front-page article about mathematics ever to appear in the New York Times ('A Soviet discovery rocks world of mathematics', November 7, 1979) would be about mathematical programming?." It then continues to explain how Khachian had talked about the ellipsoid algorithm for Linear Programming at an Oberwolfach meeting in May 1979 and how researchers like Lawler, Gacs, and Lovász subsequently had put efforts in reconstructing what they got from the talk and in presenting details at a special session of the International Symposium on Mathematical Programming (ISMP X), held in Montreal in August 1980. If that raises your interest, take the chance to browse through this and maybe more of the early issues of our newsletter.

Sam Burer, Co-Editor, Volker Kaibel, Editor,
Jeff Linderoth, Co-Editor

Henry Wolkowicz

Jonathan M. Borwein (1951–2016)

Basic History

Jonathan (Jon) Borwein was born in Scotland. The family moved to Ontario, Canada in September 1963. Jon received his B.A. (Honours Math) from the University of Western Ontario in 1971. He then went on to receive his Ph.D. from Oxford University in 1974 as an Ontario Rhodes Scholar; he worked with Michael Dempster. He then worked at Dalhousie University (1974–1991) with a short stint at Carnegie Mellon University (1980–1982) before moving to the University of Waterloo (1991–1993). In 1993, Dr. Borwein became the Shrum Professor of Science (1993–2003) and founded the Center for Experimental and Constructive Mathematics (CECM) at Simon Fraser University (SFU). He later served as a Canada Research Chair in Information Technology (2001–2008) at SFU before returning to Dalhousie University in the Faculty of Computer Science as a Canada Research Chair in Distributed and Collaborative Research, with a cross-appointment in Mathematics (2004–2009). In 2009, Jonathan moved to Australia, as the Laureate Professor of the School of Mathematical and Physical Sciences at the University of Newcastle. He became the founding director of CARMA (Computer Assisted Research Mathematics and its Applications). From April to July 2016, Jonathan Borwein served as the Distinguished Scholar in Residence at Western University.

Jon's many publications, quotations, and awards can be found in many places including the blog that he jointly ran (Math Drudge,[1]) his Wikipedia webpage,[2] and his personal webpage.[3] His many awards[4] include the Chauvenet Prize of the MAA in 1993 as well as being a Fellow of: the *Royal Society of Canada*, the *Australian Academy of Science*, the *American Association for the Advancement of Science*, the *American Mathematical Society*, and the *Royal Society of NSW*. Jon's interests were extensive – quite amazingly broad. He worked in many diverse areas of mathematics while starting projects such as CECM and chairing and working on various advisory and editorial boards. One need only look at his bio summary[5] to realize the extraordinary person he was. He has upwards of 500 publications, and as many of us involved with his work know, many publications are still to appear. It is extraordinary that one person can contribute to so many diverse areas of mathematics and that the contributions can be so *deep/serious*.

In Jon's personal life he also had many diverse interests starting with caring about his family deeply and, as those that he confided with know, sacrificing a lot for his family. In addition, he was a champion bridge player and fantastic at crosswords. Jon loved to talk/engage with people on many topics including mathematics and politics. So it is no surprise that he played bridge rather than, e.g., chess. He also was, not surprisingly, a gifted and amazingly fast writer. His articles were excellent both in the mathematics and in the grammar and choice of words. He also wrote articles for newspapers, e.g., *The Huffington Post*. Both in Canada and later in Australia he was heavily and seriously involved in both the political scene in mathematics and the politics of the country; a child of the *60's* he had strong socialist beliefs. If he had any faults (tongue in cheek) it was that he *never learned to drive a car* and in that he was, in this modern fast paced world, quite unique. And for those of us who studied and learned his mathematics, another fault (tongue in cheek) was that he loved to extend things to the greatest abstractions with elegant mathematics. Finite dimensions was hardly ever good enough for him as he seemed to always be working in the *infinite*.

I was lucky enough to have the opportunity of working with Jon for a year 1978–9 at Dalhousie University. This was early in Jon's career and the start of mine. He and Judy (and two-year-old Rachel) took my wife and me into their family/home. We had an amazing year both academically and socially. I am still applying results from theorems we derived back then. One of Jon's quotes (not verbatim) is "Excellent theorems will show their strength eventually."

Contributions in Optimization

I deal here with contributions related to optimization. This was just one of the many areas Jon contributed in, but it was definitely where he started. I concentrate on the parts that I am aware of and quickly mention others. We see that Jon early on concentrated on theoretical contributions but the theorems had lasting implications for both theory and computations.

Jon's Ph.D. thesis is titled *Optimization with Respect to Partial Orderings*. This is an excellent contribution to multi-objective (vector) optimization and influences several of Jon's later papers. One highly cited paper is [1]. It provides a characterization of proper efficiency for vector maximization over a partially ordered convex Hausdorff space using tangent cones; this is still the standard reference used in currently published books on multicriteria optimization. Beautiful relationships between existence of Pareto efficient points and the axiom of choice are presented in [2]. Though highly abstract, these results relate to important applications in Pareto optimization and portfolio financial problems, an area Jon worked on in later years. This work is followed up in the highly cited *Transactions* article [3] where the notion of *super efficiency* is introduced.

Jon's early contributions are to abstract optimization as well as to both convex analysis and geometric functional analysis. This includes solving open problems involving tangent and pseudo-tangent cones. The open questions Jon dealt with at this time were highly theoretical and often dealt with relaxations of differentiability and optimality conditions in Banach spaces.

1978–79 was the year that I worked with Jon. We concentrated on finding optimality conditions where constraint qualifications do not hold. The first paper [4] involved the general abstract convex problem in Banach spaces and provided a complete characterization of optimality that held without any constraint qualification. The next papers dealt with the special case where the constraint was given by a partial order in a finite dimensional space and was based on *facial reduction, (FR)*, [5, 6]. In particular, [7, 8] presented the FR process that regularizes cone convex optimization problems. FR has proven to be an important step in solving and regularizing many cone optimization problems in particular those arising from semidefinite programming relaxations of computationally hard problems, currently a highly researched area. (A forthcoming survey is [9].)

The work on facial reduction was followed up in [10] where the image of the linear transformation was still finite dimensional but the variables were in an infinite dimensional cone. This was then generalized by Jon with Adrian Lewis in the highly cited work on lattice orders [11, 12]. Jon and Adrian published many papers together including their beautiful book [13] which is both an excellent research tool as well as serving as a textbook for graduate courses in Convex Analysis and Optimization. Working on the problems in this book is a pleasure and a great learning experience and illustrates Jon's love of presenting examples.

During these early years Jon did not work on computational issues.[6] However, that did not mean that his work was not relevant to numerical optimization. In 1988 [14] the *two Jonathans* looked at trying to speed up the steepest descent method without the expense of approximating the Hessian as is done in quasi-Newton methods. The paper presents the new algorithm along with an elegant convergence proof. This led to the now well-known Barzilai-Borwein stepsize for steepest descent and has become Jon's most highly cited paper. This algorithm for minimization does the *unexpected* in that it allows non-descent steps. This has resulted in an amazing amount of related both theoretical and empirical work for inexpensive first-order type algorithms that converge faster than steepest descent.

Jon's work continued to provide beautiful theorems that had lasting importance. The results were in optimization and convex analysis. This involved Legendre functions and projection mappings. A major theme was monotone mappings. A long time colleague and close friend was Michel Théra with whom Jon published beautiful results in convex analysis, e.g., results on *sandwich theorems* [15]. A wonderful book to look at is (again by two Jons) [16]. This theme of providing examples and counterexamples is something Jon has followed many times including the last paper he wrote [17] where there is an excellent blend of examples with philosophy mixed in. He continued to provide important basic contributions to calculus of variations and convex analysis.

There is one additional major area related to optimization that I want to include. That is projection and splitting methods, an area that Jon worked on heavily beginning in the early 90's and where there are still papers waiting to be published. The paper [18] with Heinz Bauschke in SIAM Review provides an excellent exposition of some of these methods. Jon has became closely involved in these and in particular the Douglas-Rachford method for feasibility and optimization problems both for convex and nonconvex problems. He and his co-authors were arguably the main workers in this area with successful implementations for many diverse problems, e.g., [19–21]. Jon's final talks that I attended were on this topic. Jon gave the Tutte Colloquium at the University of Waterloo, Friday, May 6, 2016 on: *Douglas-Rachford feasibility methods for matrix completion problems*.

I have not included details on his work in financial mathematics where he looked at proper ways of data fitting, e.g., [22]. And as hinted at above, Jon became heavily involved in computations and as his wont, he went into this deeply. This was both for numerical as well as symbolic computations. This involved a long time collaboration with David Bailey and included their Math Drudge[7] blog. This followed Jon's work with his brother Peter that included many papers and books including their beautiful book on *Pi and the AGM*, [23].

In conclusion, Jon was a nonstop dynamo. Visiting from April to July 2016 at Western University Jon brought two Ph.D. students with him who worked on numerical computations for projection methods and symbolic computational problems. During this time he also organized three workshops of which two were in optimization and the third was on symbolic computations. He traveled to conferences and gave many talks locally. In addition, his constant companion Judy was him as well as his daughter Naomi and grandchildren. And, Jon was busy with one of his main aims in coming to visit Canada, organizing help for his retired father and mother who live in London.

The Optimization community has lost one of its leaders; his leadership and ideas will be greatly missed.

Henry Wolkowicz, Department of Combinatorics and Optimization, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1. hwolkowicz@uwaterloo.ca

Other obituaries
Experimental Math obituary for Jon: https://tinyurl.com/m4scaw3.
CMS obituary for Jon: https://tinyurl.com/l2mswbr
Anthony Bonato, obituary for Jon: https://tinyurl.com/n7uyzkc

Notes

1. http://experimentalmath.info/blog
2. http://en.wikipedia.org/wiki/Jonathan_Borwein
3. http://www.carma.newcastle.edu.au/jon/index-bio.shtml
4. https://www.carma.newcastle.edu.au/jon/CV/node2.html
5. https://www.carma.newcastle.edu.au/jon/index-bio.shtml
6. On a comical note, when I bought a PC in 1978 with a 5 Mbyte hard disk Jon chided me for wasting money as I would never in my life use 5 Mbytes. More on Jon and his contributions to large scale computing below.
7. http://experimentalmath.info/blog/

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Marida Bertocchi and David P. Morton

Jitka Dupačová (1939–2016)

Jitka Dupačová was an intellectual leader in stochastic programming since the 1960s. Her early influential work in *minimax* solutions of stochastic programs [1] was a deep, fundamental contribution, was indicative of her work to come, and predated a recent surge of follow-on work – in robust, and distributionally robust, optimization – by nearly half a century. Dupačová's minimax approach recognizes that distributional information is usually incomplete, and it proposes a practical method to analyze the potential consequences.

With similar motivation, Dupačová discovered the *contamination* technique [7] that allows for stability and postoptimality analysis of a stochastic program under a separate contaminating distribution. Like her minimax approach, the contamination technique is elegant, simple to employ, applicable in very general settings, and has strong theoretical roots and implications. And, unlike many tools, the contamination technique extends gracefully from two-stage to multi-stage problems.

Together with Gröwe-Kuska and Römish, Dupačová developed a theoretically principled and practically useful way to reduce the number of scenarios in a stochastic program. As described in the paper [32], the scenario-reduction problem is formulated via optimization:

> Determine a scenario subset of prescribed cardinality and a probability measure based on this set that is the closest to the initial distribution in terms of a natural (canonical) probability metric.

Precursor ideas to the seminal advancement of [32] are contained in [16, 22], and a software implementation in the GAMS modeling language, called SCENRED 2.0, is due to H. Heitsch. Like the contamination technique, her scenario-reduction scheme applies cleanly to two- and multi-stage stochastic programs.

Returning to the contamination technique, a brief sketch of the mathematics follows. In its simplest form, the idea applies to a stochastic program:

$$\min_{\mathbf{x}\in\mathcal{X}} f(\mathbf{x}, P). \tag{1}$$

Here, f is convex in $\mathbf{x}$ and linear in P, which is the probability distribution of the problem's random parameter, ω; $\mathcal{X}$ is a closed, nonempty, convex set that does not depend on P; and, $\mathbf{x}$ is the first stage decision vector. A typical form of f is $f(\mathbf{x}, P) = \mathbb{E}_P\, q(\mathbf{x}, \omega)$, where $q(\mathbf{x}, \omega)$ is measurable with finite expectation, although other forms are also possible and important.

Let $\phi(P)$ be the minimal value of the objective function in (1), and let $\mathcal{X}(P)$ be the set of optimal solutions. One can view model (1) as a specific case of a family of optimization problems depending on a scalar parameter, λ. This family arises via contamination of the original probability distribution, P, by another fixed probability distribution, Q, through the following convex combination:

$$P_\lambda = (1-\lambda)P + \lambda Q, \quad \lambda \in (0,1).$$

For the fixed distributions P and Q, P_λ depends only on λ. Hence, the modified objective function in (1) takes the following form:

$$f_Q(\mathbf{x}, \lambda) := f(\mathbf{x}, P_\lambda) = (1-\lambda)f(\mathbf{x}, P) + \lambda f(\mathbf{x}, Q),$$

which is linear in λ because expectation is a linear operator. That said, the contamination idea extends to handle the case in which $f(\mathbf{x}, P)$ is convex-concave, which allows it to handle mean-variance optimization models, certain types of robust optimization models, and models with modern risk measures.

In the linear setting, let

$$\phi_Q(\lambda) = \min_{\mathbf{x}\in\mathcal{X}} f_Q(\mathbf{x}, \lambda).$$

The derivative of ϕ_Q satisfies

$$\phi'_Q(0^+) = \min_{\mathbf{x}\in\mathcal{X}(P)} f(\mathbf{x}, Q) - \phi(P). \tag{2}$$

Using (2) and the concavity of ϕ_Q on [0,1], it is possible to derive bounds on the perturbed optimal value function. In particular, when problem (1) has a unique optimal solution, $\mathbf{x}(P)$, the derivative in (2) specializes to $\phi'_Q(0^+) = f(\mathbf{x}(P), Q) - \phi(P)$. Using the definition of concavity, and the gradient inequality, the bounds take the following form:

$$(1-\lambda)\phi(P) + \lambda\phi(Q) \le \phi(P_\lambda) \le (1-\lambda)\phi(P) + \lambda f(\mathbf{x}(P), Q). \tag{3}$$

The inequalities of (3) indicate the possible range of movements of the optimal value when one contaminates the initial distribution P with another distribution Q. The numerical effort to compute these bounds requires only the solution of the original problem under the contaminating distribution Q, and the evaluation of the function, $f(\cdot, Q)$, at the already known point $\mathbf{x}(P)$.

Dupačová was very active in applying stochastic programming to real-world problems: she contributed in solving a water management problem [14], a melt control problem [34], and mostly portfolio management problems. A couple of years after the XVIth AMASES, Association of Mathematics Applied to Economics and Finance, meeting in Treviso in 1992, where she was invited as plenary speaker to introduce stochastic programming, Dupačová became extremely interested in finance. A series of papers then appeared on bond portfolio management, on evaluation of the yield curve, on credit risk, and on management of pension funds [21, 25, 26, 28, 33, 35, 36]. Most recently, she also devoted attention to stress testing and robustness of risk-averse multistage stochastic programs, in part through application of the contamination technique; see [38–40]. The book [30] was explicitly shaped in order to introduce Master and PhD students to finance. The preface of this book with Hurt and Štěpán was written by her colleague and husband, Václav Dupač, and includes:

> The book consists of three Parts. Though they may seem disparate at first glance, they are purposively tied together. Many topics are discussed in all three Parts, always from a different point of view or on a different level.

Dupačová was born in České Budějovice in southern Bohemia and, at the age of six, she moved to Karlovy Vary in Czechoslovakia where she grew up. She took the MSc. studies at Charles University where she graduated cum laude at the Faculty of Mathematics and Physics. She attended the PhD studies, again at Charles University in the Department of Probability and Mathematical Statistics in Prague, where she graduated in 1967. It was during this period that she produced her first paper [1]. She was assistant professor from 1973 to 1979 and took her habilitation in 1979. She became in 1979 the first woman vice dean at the Faculty of Mathematics and Physics and the first female full professor in 1986. In the same year she organized the fourth International Conference on Stochastic Programming in Prague. She established a new PhD program in Econometrics and Operations Research, and supervised 15 PhD students, among them Petr Lachout, Pavel Popela, Milós Kopa, and Martin Branda, all active in the stochastic programming community, and Petr Dobiáš, Jan Polívka, and Václav Kozmík, all active in financial institutions. A significative honor, a memorial plaque for her pioneering contributions in the development of stochastic programming, was awarded to Dupačová during the Xth International Conference on Stochastic Programming in Tucson.

Throughout her career Dupačová made connections, continually reflected on the larger questions on which we should focus in stochastic programming, and emphasized the importance of techniques that extend to multi-stage models. She periodically wrote surveys and reviews – and embraced colorful and insightful examples like that of the flowergirl [15, 29], whose life was a bit more challenging than that of the newsboy – all to accomplish this goal. Some relevant citations include [2, 4, 6, 8–12, 17, 18, 23, 24, 27, 29].

During the most recent International Conference on Stochastic Programming, held in Buzios, Brazil, in June 2006, a session was organized in Dupačová's memory. Many people recalled her career in research and teaching, and particularly touching was a letter sent by her daughter, Gabriela, to the scientific community of stochastic programmers, which shows some specific aspects of Jitka's personality.

> Dear Stochastic Family,
>
> First of all I would like to thank you very much for organizing this special session in memory of my dear mum, Jitka Dupačová. I've always admired Jitka's talent to bring people together. Even when my brother and I were children, our mum used to invite foreign guests home for dinner. For us these were unique opportunities to try to speak English with real foreigners (in the grey communist times) and watch our mum in the role of an attentive host. Later on, at the beginning of 1990s, when finally we could travel as well, I could meet her friends abroad, enjoy fantastic holidays and get to know great people.
>
> In summer of 1991, I hitchhiked around Europe with a friend and we visited Wim Klein Haneveld, whose summer home in the Netherlands was our safe haven during this adventure. We also stopped over in Aachen for a couple of days as my mum was attending a conference there at that time. We joined her for an official conference dinner. And that was an eye-opening experience for me. Even before that I had known that my mum was a smart scholar, a successful lady, and a great organizer ... But I was a 20-year old student then, obsessed with literature and art, and I looked down my nose at mathematics. ("How can anyone spend their life dealing with numbers and x^s and y^s ...?" I asked myself.) During that dinner I had a chance to see my mum bloom in the company of her international family of mathematicians. She seemed to me like the queen of a ball, like Scarlett O'Hara surrounded by her admirers at the Twelve Oaks. Many men attended to her, so that her glass was never empty and I could see how happy, witty, and shining she was in that company. I started to be more tolerant of mathematics – when it brought my mum such good friends and fun.
>
> I've always been surprised at the scope of her interests, different tasks she could handle at the same time, her managerial skills, so different from the usual stereotype idea of an absent-minded professor. As a mum and as a teacher she was very demanding, but also very helpful. I believe that many of her students profited from her relentless attitude to deadlines. Many procrastinators managed to overcome their bad habits under her supervision and deliver results. (I'm certainly one of them.)
>
> In the last five years, after my dad had passed away, we became very close with my mum. She even entrusted me with the task of proofreading her reviews or official letters in English. This used to be my father's job, he was her thorough editor and a fine-tuner of her sentences. It was much more difficult for me, because I could rarely understand what the texts were about. I could just correct the spelling and suggest where to insert articles or commas, but she seemed to be pleased with my small contribution. I also accompanied her to conferences in Rome (EWGCFM) in 2012 and Bergamo in 2013 – and I'm thankful I could join the big family of stochastic programmers there. And no one spoke about variable x or y with me!
>
> When my family and I received a lot of kind letters and e-mails from many of you, in reaction to the sad news of her demise I realized how popular and famous my mother had been. And that the international stochastic community of mathematicians was in fact another, wider family of hers. It is relieving to know that Jitka still lives in your hearts and memory.
>
> Enjoy the conference – I am sure she is there with you, somehow.
>
> Best regards from Prague,
> Gabriela Zemanová

Marida Bertocchi† 2017, Dept. of Management, Economics and Quantitative Methods, University of Bergamo, Via dei Caniana 2, 24127 Bergamo, Italy

David P. Morton, Robert R. McCormick School of Engineering and Applied Science, Technological Institute, 2145 Sheridan Road, Evanston, IL 60208, USA
david.morton@northwestern.edu

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Jorge Nocedal

Roger Fletcher (1939–2016)

"… so I got this undeserved reputation for being intelligent", said Roger Fletcher on more than one occasion [1], referring to his early fame, brought on by the publication of three papers that marked the beginning of the modern era of nonlinear optimization (the DFP, BFGS and Fletcher-Reeves papers). This charming humility, which mysteriously coexisted with a most original, penetrating and fiercely independent mind, formed the essence of Roger's scientific personality.

His brilliance was evident to all. Over more than three decades, Roger produced a highly original body of work and left his imprint on most areas of nonlinear optimization. He was the originator of ideas, the practical problem-solver, and the programmer who knew how to get the numerics right. His writing style was unique. His papers felt very personal, as if they were addressing the reader directly, and contained very few references (to the consternation of some). He tried to derive things himself rather than relying on the literature, and this gave his famous textbook a unique flavor.

His contributions to unconstrained and constrained optimization are well known and celebrated, but the amazing range of his work is not fully recognized. For example, he made some of the early contributions to semi-definite programming, as a side project, and was the first researcher to understand how to use polyhedral structure in non-smooth optimization to derive efficient, practical algorithms. His ability to tackle so many novel subjects showed a great intellectual confidence, which might not have been foreseen from his un-auspicious beginnings.

Roger grew up in the harsh times of the Second World War and its aftermath. His father was killed in the war and his family was not affluent; he recalled the difficulty of getting food as a child. But his family believed that he was marked for success and he received an excellent primary school education. He enrolled in Cambridge University in 1960, majoring in theoretical physics. But the Cambridge atmosphere was not to his liking, so after graduation he enrolled in PhD studies at Leeds University where he spent three happy years. It was fertile ground for a curious young mind, as the university had one of the early computers at that time, and Roger dove into programming and algorithms with passion. He worked four years at Harwell, one of the leading hubs of scientific computing software, before moving to Dundee, where he lived a content and strikingly productive life for the remainder of his career. His name is often associated with that of Mike Powell, not only because of their famous DFP paper, but because they led the field of nonlinear optimization for several decades, each in his own unique way.

"You wouldn't say I invented it or anything …" [1] Roger once said referring to his work on structured non-smooth optimization. Yes, Roger, you did. We all know it and were amazed by all you accomplished. It is for all these inventions that he was awarded the Dantzig prize and was made a Fellow of the Royal Society. His imagination, originality and humility will be an example for future generations.

Jorge Nocedal, Robert R. McCormick School of Engineering and Applied Science, Technological Institute, 2145 Sheridan Road, Evanston, IL 60208, USA
j-nocedal@northwestern.edu

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Ignacio Grossmann

Chris Floudas (1959–2016)

Christodoulos Achilleus Floudas, widely known as Chris Floudas, unexpectedly died of a heart attack while vacationing in Greece on August 14, 2017. The mathematical optimization and process systems engineering communities were deeply shocked at his loss since he was only 56 years old, and at the pinnacle of his brilliant professional career.

I consider myself to have been extremely fortunate to have had Chris Floudas as a Ph.D. student at Carnegie Mellon. He graduated in 1986 after completing his Diploma of Chemical Engineering at the Aristotle University of Thessaloniki in 1982. As his former Ph.D. advisor, I could not have been prouder of him. He was a truly outstanding student who showed great passion and devotion for his research work. The main paper of his Ph.D. work on automatic synthesis of heat exchanger networks was based on a novel nonlinear programming model [4], and made a big impact in the area. The major reason is that for the first time network designs could be obtained by optimizing superstructures that contained all the alternative topologies (series, parallel and combinations thereof) for the minimum number of stream matches and minimum energy cost. The corresponding paper [4] has been highly cited (250 Web of Science; 370 Google Scholar). This work Chris also extended to synthesize flexible heat exchanger networks with uncertain flows and inlet temperatures.

After Chris graduated from Carnegie Mellon, he had an exceptional career, first at Princeton (1986–2015) where he became the Stephen C. Macaleer '63 Professor in Engineering and Applied Science, and then at Texas A&M (2015–2017) where he became the director of the Energy Institute and holder of the Erle Nye '59 Chair Professor for Engineering Excellence. Chris made outstanding contributions to the fields of Mathematical Optimization and Process Systems Engineering that had a large impact. He was a highly respected world leader who set very high standards, goals and challenges in research. Below I will try to summarize his major contributions in his professional career.

One of the major contributions of Chris was the development of global optimization algorithms. Initially, the most notable was the α-BB algorithm, which can be used to rigorously find global optima in nonlinear and mixed-integer nonlinear programs [1–3]. This research with his students Adjiman, Androulakis and Maranas has been regarded as pioneering work in global optimization due to the wide class of functions and constraints it can handle (e.g. bilinear, trilinear, concave, linear fractional, and general twice-differentiable). The key idea in the α-BB algorithm was the construction of a converging sequence of upper and lower bounds on the global minimum through the convex relaxation of the original problem. This relaxation is obtained by replacing all nonconvex terms of special structure (i.e., bilinear, trilinear, fractional, fractional trilinear, univariate concave) with customized tight convex lower bounding functions and by selecting some suitable value of α to generate valid convex underestimators for nonconvex terms of generic structure. A crucial step was in the use of interval arithmetic on the Hessian matrix or the characteristic polynomial of the function being investigated. These theoretical ideas were implemented using a number of rules for branching variable selection and variable bound updates. The algorithm was successfully tested on a set of challenging test problems, mostly from chemical engineering. The corresponding papers [1–3] were also highly cited (260–200 Web Science, 530–390 Google Scholar citations).

His more recent accomplishments in global optimization were with his Ph.D. student Ruth Misener, which resulted in the development of the global optimization codes GLOMIQO and ANTIGONE [8-10]. The former is for solving mixed-integer quadratic programming problems, which for instance has been applied successfully to the classic pooling problems that arise in the petroleum industry. The latter can handle the general algebraic nonconvex mixed-integer nonlinear programming models. The key ideas were the development of the facets of low-dimensional ($n \leq 3$) edge-concave aggregations dominating the termwise relaxation of MIQCQP at every node of a branch-and-bound tree. Concave multivariable terms and sparsely distributed bilinear terms that do not participate in connected edge-concave aggregations were handled through piecewise-linear relaxations [8]. The major algorithmic components of GLOMIQO [9] involved reformulating user input, detecting special structure including convexity and edge-concavity, generating tight convex relaxations, partitioning the search space, bounding the variables, and finding good feasible solutions. GLOMIQO was extensively tested on a set of 400 test problems of varying size and structure, including general nonconvex terms. The structure of ANTIGONE [10] was based on the previously mixed-integer quadratically-constrained quadratic program and mixed-integer signomial optimization computational frameworks. ANTIGONE was tested on a set of 2,500 test problems from standard libraries, and performed competitively with codes such as BARON, Couenne and SCIP.

Aside from the above contributions, his co-editorship of the "Encyclopedia of Optimization" [6] with Panos Pardalos (490 citations Google Scholar) attests to his stature in the optimization community.

Chris Floudas also made outstanding contributions in the area of batch scheduling where his work with Marianthi Ierapetritou introduced a novel mathematical formulation for scheduling problems for batch processes with general network structure [7]. The major novelty of that work is that it introduced a novel mixed-integer linear programming model based on a continuous time representation, whereas earlier work was based on the less rigorous discrete time representation. This work led to his most cited paper with 320 Web of Science and 500 Google Scholar citations. Chris also did very fine work in areas of synthesis of reactor networks and separation systems. His work has had industrial impact as it has been applied by companies such as Shell, AspenTechnology, BASF and Atofina Chemicals.

In computational biology Chris Floudas introduced a first-principles structure prediction method, ASTRO-FOLD, for helical and beta-sheet topology; invented new methods for NMR structure refinement based on atomistic modeling; and pioneered de novo design strategies for peptides and proteins. His first-principles approach to de-novo protein design led to the design of an inhibitor with 45-fold improvement over compstatin, the best known complement inhibitor, with Phase I clinical trials successfully completed by Potentia Pharmaceuticals for age-related macular degeneration.

More recently, Chris developed very large-scale supply chain models for hybrid feedstock for energy for converting coal, biomass, and natural gas to gasoline, diesel, and kerosene. This work, which is based on multi-scale modeling as it incorporates materials considerations for the various energy technologies, has received a great deal of attention as it addresses the supply chain for the entire United States. This work has been summarized in the recent AIChE J. perspectives article [5]. This work was also to a large extent the basis for his appointment as Director of the Energy Institute at Texas A&M.

Chris Floudas had great impact in the areas of mathematical optimization and process systems engineering where he is highly respected. He gave many keynote talks at major international meetings. He was very prolific in writing papers (over 400 publications), he was the author of two graduate textbooks, Nonlinear Mixed-Integer Optimization (Oxford University Press, 1995), and Deterministic Global Optimization (Kluwer Academic Publishers, 2000). He co-edited ten monographs/books. He had 13,000 citations and an h-index of 64 as per the Web of Science, while he had 29,000 citations and an h-index of 87 as per Google Scholar.

Chris Floudas was the recipient of numerous awards and honors for teaching and research that included the NSF Presidential Young Investigator Award, 1988; the Engineering Council Teaching Award, Princeton University, 1995; the Bodossaki Foundation Award in Applied Sciences, 1997; the Best Paper Award in Computers and Chemical Engineering, 1998; the Aspen Tech Excellence in Teaching Award, 1999; the 2001 AIChE Professional Progress Award for Outstanding Progress in Chemical Engineering; the 2006 AIChE Computing in Chemical Engineering Award; the 2007 Graduate Mentoring Award, Princeton University; he was elected Member of National Academy of Engineering in 2011; One thousand Global Experts, China 2012–2015; SIAM Fellow, 2013; TIAS Fellow and Eminent Scholar, 2013–14; AIChE Fellow, 2013; National Award and HELORS Gold Medal, 2013; Honorary Doctorate, Abo Akademi University, Finland, 2014; Member of TAMEST (The Academy of Medicine, Engineering, and Sciences of Texas), 2015; Corresponding Member of the Academy of Athens, 2015. He was named a Thomson-Reuters highly cited researcher (for 2003–2013 period), and was elected in 2015 as Fellow of the National Academy of Inventors.

Chris Floudas also mentored and directed outstanding Ph.D. students and postdocs who have taken academic positions. They include Claire Adjiman (Imperial College), Peter DiMaggio (Imperial College), Chrysanthos Gounaris (Carnegie Mellon), Faruque Hasan (Texas A&M), Marianthi Ierapetritou (Rutgers), Nina Lin (Michigan), Costas Maranas (Penn State), and Ruth Meisner (Imperial College). His students have also been very well received by industry.

Chris Floudas' death is a huge loss to the Mathematical Optimization and Process Systems Engineering communities. We have lost a major intellectual leader and a very good friend. His absence will be felt for many years to come. The only consolation is to know that Chris' legacy will continue through his students. Furthermore, through his work he will continue to inspire the new generation of researchers in Optimization and Process Systems.

Finally, we would like to offer our deepest sympathy to his wife Fotini and daughter Ismini. They both can be proud for having had as a loving husband and father such a prominent and respected intellectual leader. Chris will be sorely missed. May he rest in peace.

Ignacio E. Grossmann, Chemical Engineering, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, USA. grossmann@cmu.edu

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Andrzej Ruszczynski

András Prékopa (1929–2016)

András Prékopa, mathematician and operations researcher of extraordinary talent and energy, passed away on September 18, 2016, at the age of 87. We lost in him a brilliant researcher, a devoted mentor, and a great friend.

András Prékopa was born on September 11, 1929, in Nyiregyháza, Hungary. He obtained the Master of Sciences degree in mathematics, physics, and descriptive geometry in 1952 from the University of Debrecen. In 1956, at the Institute for Applied Mathematics of the Hungarian Academy of Sciences, he defended his Ph. D. dissertation, under the supervision of Alfréd Rényi. In 1971, he obtained his higher doctorate degree. From 1956 to 1968, he was a professor of Eötvös Loránd University and subsequently became a professor of the Budapest Technical University. In addition to the university responsibilities, from 1970 to 1985, he was the head of the Computer Science Center of the Hungarian Academy of Sciences, and subsequently the founder and head of the Applied Mathematics Division of the Computer Science and Automation Research Institute of the Academy. In 1983, he founded the Operations Research Department at the Eötvös Loránd University and became its first chairman. From 1985 to 2015, he was a Distinguished Professor of operations research and statistics at the Rutgers Center for Operations Research, Rutgers University in New Brunswick, New Jersey. Until his retirement in 2015, he was also affiliated with the Department of Management Science and Information Systems.

András Prékopa was member of the Hungarian Academy of Sciences, a foreign member of the National Academy of Engineering of Mexico, a fellow of the Econometric Society, a member of the International Statistical Institute, and the honorary president of the János Bolyai Mathematical Society and the Hungarian Operations Research Society. He was the founder of the sequence of international conferences on stochastic programming (held every three years since the 1981 meeting in Koszeg, Hungary). He was also a co-founder and chair (1981–1989) of the Committee of Stochastic Programming within the Mathematical Optimization Society.

András has published more than 350 papers and 15 books. His results, starting with his first paper, published while he was an undergraduate student in 1950, have ranged over several areas of mathematics and operations research. Below is a brief summary of his most influential contributions.

As a graduate student, András worked on Poisson processes, their generalizations, random set functions, and stochastic integrals. In his Ph.D. dissertation, as one of the first researchers he developed the theory of random measures and random set functions. He defined the notion of a random set function of independent increments in a general, abstract space. He obtained stochastic counterparts of the measure extension theorems, introduced the notion of a characteristic functional, proved Radon–Nikodym type theorems, and defined stochastic Lebesgue integrals with random measures and deterministic, measurable integrands. He proved several deep results on random point distributions of Poisson type in abstract spaces. He also initiated the theory of marked Poisson processes. At that time, Hungarian scientists were not allowed to publish abroad and his papers appeared in local journals.

In the 1960s András became one of the initiators of *stochastic programming* and one of its main contributors. When Charnes and Cooper first formulated chance constraints, they imposed them individually on each stochastic constraint, neglecting stochastic dependence among the random variables. Prékopa's general formulation of *joint chance constraints* took the dependence into account. One of his main results concerns convexity theory of stochastic programming problems with joint chance constraints. He introduced the concept of *logarithmic concave measures* and proved that if a probability measure is generated by a log-concave probability density function, then the measure is log-concave (an inequality that is key for this result is known as the *Prékopa-Leindler inequality*). These breakthrough results let to the proof of convexity of a wide class of stochastic programming problems with probabilistic constraints. For problems with chance constraints involving discrete distributions, he introduced the concept of a *p-efficient point* and successfully used it to develop effective methods for solving such problems. Nowadays, almost every work on problems with chance constraints uses, in one way or another, the ideas of András Prékopa.

In the mid-1980s András invented new ways to obtain sharp *bounds on the probability of the union and other Boolean functions of random events*. He discovered that bounds using few terms from the inclusion–exclusion formula are optimal values of linear programming problems, which are *moment problems* of a certain type. Then he extended the analysis of moment problems by using linear programming theory, both in the univariate and multivariate cases. In the univariate case he fully described the structure of the dual feasible bases for three cases: the probability of the union, and the probability that at least r or exactly r out of n events occur. The results allowed for closed-form solution of small scale problems, as well as the development of efficient dual type algorithms for large problems. Linear programming turned out to be the right tool to obtain best bounds. The bounds can be used for approximate solution of stochastic programming problems with probabilistic constraints.

András successfully combined his theoretical work with various applications. He often expressed his strong conviction that theory and applications have to come together motivating and reinforcing each other. At the beginning of the 1960s he worked out an original inventory control model using order statistics. The model became widely used, with major economic impact in Hungary. He created novel water reservoir system design models based on stochastic programming. He applied stochastic network theory to power systems. He also worked out a daily scheduling model for electricity production in an interconnected system with thermal power plants. He used moment bounds for analyzing the reliability of telecommunication and transportation networks.

András was very much interested in the history of science and used all opportunities to share his knowledge with others. He wrote about the life and works of Gyula Farkas, the eminent Hungarian mathematician and physicist of the 19th and 20th centuries, who developed the theory of linear inequalities and published fundamental papers on the mechanical equilibrium. In connection with that, András wrote a paper on the origins of nonlinear optimization. In a volume devoted to the memory of a János Bolyai, Prékopa gave an account of the discovery of non-Euclidean geometry in the first half of the 19th century, which changed the course of the development of mathematics and had an impact on the history of human culture. In further papers, he discusses the relationship between mathematics and the history of culture.

András supervised a record number of doctoral students: 52. His advisees are university professors and researchers in many countries on three continents. Among his books, most influential are those based on his undergraduate and graduate courses. His introductory book on linear programming was published in 1968, ten years after András gave his first course on the subject at the University of Budapest. It presents linear programming in a mathematically exact, elegant, and didactic way and is still in use in Hungary. His 1995 monograph *Stochastic Programming* is a high-level, very informative book with comprehensive coverage of the area that has become a standard reference and a text for doctoral courses.

The talents and achievements of András Prékopa were recognized early on by the scientific community. He received the Grünwald Géza prize of the János Bolyai Mathematical Society for his Ph.D. dissertation. He was the recipient of the INFORMS President's Award (2014), the Khachiyan Prize (2012), the EURO Gold Medal (2003), as well as many state and society distinctions and prizes. But the highest prize, one that never fades away, is the wide influence of his research ideas.

Andrzej Ruszscynski, Department of Management Science and Information Systems, 100 Rockafeller Road, Livingston Campus, Rutgers University, Piscataway, NJ 08854, USA. rusz@business.rutgers.edu

Alan J. Hoffman

Philip Starr Wolfe [1927–1916]

In the early 1950s, even though there were few university departments of operations research(OR), some students found the subject attractive due to the influence of a faculty advisor, specific work experience, or the intellectual challenges OR presented. In Phil Wolfe's case, all played a role.

Returning to college after military service, Phil became a leader in optimization theory. He is known principally for his research in mathematical programming (MP), particularly on extensions of linear and nonlinear programming. But his contributions extend beyond pure research. He worked hard to ensure that the MP community of scholars developed the professional bonds through a professional society, journals, regular symposia, informal meetings, and newsletters. His commitment to this cause earned him the respect and affection of the MP community.

Phil's research accomplishments and influence within the MP community were recognized with the John von Neumann Theory Prize of the Operations Research Society of America (ORSA) and The Institute of Management Sciences (TIMS), and the Distinguished Service Award given by the Mathematical Programming Society (MPS).

His research was conducted at the U.S. Air Force (Pentagon), Princeton University's mathematics department, the RAND Corporation, and IBM's Thomas J. Watson Research Center.

Shaped by Science Fiction

Phil Wolfe, the second son of Sidney and Dorothy Anderson Wolfe, was born in San Francisco, California, on August 11, 1927. At that time, his mother wrote human-interest stories for the San Francisco Chronicle, and his father ran a trade publication for the gift and art business on the West Coast. Phil's only sibling was his older brother David, born in 1921. Sidney's parents came to San Francisco from Poland in the 1870s. Dorothy's maternal grandfather, Henry Nikolas Bolander, was California's first state botanist. Dorothy's mother was one of twin sisters born to his wife in Guatemala, where Henry had been sent on a mission for the German government.

Phil's family moved frequently around California in his early years – he remembers living in Bakersfield, Los Angeles, San Jose, Mill Valley, Sausalito, Oakland, and Alameda. His interest in science began with the gift of a microscope for his seventh birthday, followed by studying his brother's high-school physics textbook. Phil's early school years went well; he was selected valedictorian for his sixth grade graduation. But his first year at Alameda High School was a disaster, except for his German and general science classes. He received the lowest passing grades in his algebra courses and understood neither the manipulations nor their motivations.

The next year he studied plane geometry, also a troubling course. One day, however, he experienced the epiphany of many mathematicians; "I recall deciding that it must make sense somehow, and spent the whole day reading Euclid's axioms and early theorems and putting it all together. It was a profound experience. By the end of it, I knew what Euclid was doing … we became colleagues" (Wolfe 2009). Phil was the star of that class, and the teacher, who was retiring, gave him her collection of mathematics books. He used them to learn differential and integral calculus on his own—he was a top student in science during the rest of his high-school years.

But these were unhappy years for Phil's family. His parents divorced and his brother David, who had joined the Army in 1939, was killed in the Japanese invasion of the Philippines. Phil lived with his mother in Alameda and later in Berkeley, where he entered the University of California in 1943. He did reasonably well as a student until he fell in love and more or less gave up on science and academic life. Eventually, he withdrew from the university and was drafted into the Army shortly after his 18th birthday and just as World War II was ending.

Love affair over, Phil liked the Army. He had various assignments, all in the U.S., the last one teaching German to intelligence agents for work in Germany. When he was discharged in 1947, he returned to Berkeley and received his A.B. in physics and mathematics in 1948 – and a mathematics department prize for the best undergraduate record. Phil wanted to go on for a Ph.D. in physics, but (like many other mathematicians) was not fond of the way physicists reasoned about mathematical concepts. He concluded physics was not for him and continued on in mathematics and received his M.A. in 1950.

He was interested in fundamental mathematical topics, especially set theory and logic. He wanted to study under the famous Berkeley logician Alfred Tarski. But, in 1949, he was diverted by a story, "The Finan-seer," that had appeared in the October issue of Astounding Science Fiction (Locke 1949). In this story, professors, using something called the theory of games, have amazing success in the stock market. Phil quickly bought the book, Theory of Games and Economic Behavior (von Neumann and Morgenstern 1944). He was intrigued by the idea that the theory might be a branch of mathematics that could be used in the real world of competitive activities; he aimed at writing a doctoral dissertation on the subject.

Since dissertations required an interested faculty advisor, Phil became the pupil of the statistician Edward Barankin. Barankin, who taught courses in optimization, had Phil read reports from the University of California at Los Angeles OR project and from the RAND Corporation, a center of game theory research. For the summer of 1951, Barankin arranged for an internship for Phil with Barankin's friend, the mathematician George Dantzig, at the Air Force's Project SCOOP in the Pentagon. (SCOOP is an acronym for Scientific Computation of Optimal Programs, an Air Force project for the analysis and computation of Air Force plans and programs. Dantzig had devised and formulated the basic and general linear-programming (LP) mathematical model and invented the simplex algorithm for solving it. Dantzig had received his Ph.D. from Berkeley in 1946.) George challenged Phil to find a way to resolve the problem of cycling (circling) that could cause the simplex algorithm not to converge to an optimal solution.

The simplex method finds the lowest point on a polyhedron in n-dimensional space, as measured by a minimizing linear objective function, by moving from a vertex to an adjacent lower valued vertex, and so on, until a lowest vertex (minimum) is reached. The mathematician Fourier proposed this method in the first decade of the 19th century – it is intuitively obvious that it should succeed (Fourier 1826, 1827; Grattan-Guinness 1970). But, the algebra needed to carry out these moves may have difficulties if the current vertex lies on more than n hyperplanes, a situation termed degenerate. It is conceivable that the required algebraic transformation could not cause a move to another vertex and not prove that a best vertex had been found, but only generate successive algebraic descriptions of the same vertex, and this cycle of transformations would continue. I believe the first person to recognize (but not resolve) the problem was Frank Hitchcock (1941).

J. Harvey Edmondson, who was taking Dantzig's 1951 LP class (the first of its kind) at the U.S. Department of Agriculture Graduate School, in response to a class exercise, wrote an unpublished paper that resolved the situation for the general LP problem with m equations and n variables. His approach was to slightly perturb the polyhedron so that each vertex was on exactly n hyperplanes (Dantzig 1963). At the time I was a mathematician at the National Bureau of Standards (NBS) in Washington, D.C., conducting research sponsored by Project SCOOP. Shortly before Phil came to Washington, I had constructed (in 1951) the first example of an LP problem for which cycling was shown to occur (Dantzig 1963; Hoffman 1953; Micchelli 2003). Phil found what Dantzig was looking for—an algebraic way of executing the Edmondson perturbation scheme. Phil's idea was to replace the real numbers used as coordinates in n-dimensional space by m-dimensional vectors, which are lexicographically ordered, that is, $x > y$ if, in the first coordinate where x and y differ, say the jth coordinate, $x_j < y_j$. This lexicographic ordering of vectors in m-space was something Phil learned from courses in logic, verifying the adage that nothing learned is ever wasted. Phil described his idea in an Air Force memorandum, but its first appearance in a mathematical journal was a paper by Dantzig et al. (1954). Dantzig, who seems to be the actual writer of the three-author paper, calls the resulting calculations a generalized simplex method. Phil's idea had legs. It was an essential part of the proof of Gomory's epochal papers establishing the scaffolding for integer linear programming (Gomory 1958, 1963). It inspired many generalizations of the simplex method, as well as the duality theorem in a variety of circumstances (Wolfe 1963a). Phil and I become lifelong friends.

Phil's summer at Project SCOOP was abbreviated by an impatient letter from his new girl friend in Berkeley. He returned early, and they married in 1952.

Berkeley and Princeton: 1952–1957

In 1952, Phil was a graduate student in mathematics, working toward a Ph.D. at the University of California, Berkeley. By 1965, he would become a leading authority in the field of optimization, the central theoretical and applied mathematical framework that was in the forefront of OR's major advances in industry, business, and government.

His dissertation, presented in 1954, consisted of two papers. The first was a version of his Air Force memorandum on a generalization of the simplex method. The second paper grew from Phil's desire to do something original in game theory; he proved a conjecture of Gale and Stewart (1953) about circumstances which would imply that an infinite win–lose game had a winning strategy (Lustig 2001). Phil was pleased with this result for a couple of reasons: it used material he had learned in a topology course from John Kelley, a professor he admired very much, not only for his pedagogy, but also for his vigorous protests of the loyalty oath that the California regents imposed on academics. Further, Phil had proved the conjecture before the Gale–Stewart paper appeared, showing he could raise research questions as well as solve them. This impressed Phil's adviser Barankin, although he was not warmly inclined to game theory. Barankin, however, defended Phil's work vigorously when the departmental chairman, Griffith Evans, also not warmly inclined to game theory, expressed some misgivings ["Where is the mathematics, Mr. Wolfe?" (Wolfe 2009)]. The title of Phil's dissertation reflected the two contributions: "I. Games of infinite length. II. A nondegenerate formulation and simplex solution of linear programming problems."

Ph.D. advisors sometimes help their students to find their first job, usually an academic one. In Phil's case, Barankin's efforts set the course of Phil's career. Barankin wrote to Princeton professor Albert Tucker about Phil's status, and Tucker offered Phil an instructorship.

Although the RAND Corporation had offered a job at twice the Princeton salary, Phil chose Princeton. He and his wife drove across the country in an old car whose maximum speed was below the legal minima of some toll roads, arriving in dense fog on the night of September 10, 1954. When he visited Fine Hall (the home of the mathematics department) the next morning, he was thrilled to see that Tucker had already posted P. Wolfe on the faculty directory.

The most important work Phil accomplished during his stay at Princeton was his research on quadratic programming, but many themes of his later career can be seen taking shape during this period. He took an interest in computing, and visited the Institute for Advanced Study where Julian Bigelow, its chief engineer, helped Phil write programs for the machine John von Neumann had designed. He helped Tucker administer the Office of Naval Research's sponsored Princeton Logistics Research Project, the pioneering research center in game theory and LP. Besides his own work, Phil wrote and distributed occasional reports on meetings and conferences to the Princeton mathematics community. He enjoyed the stream of visitors—George Dantzig, David Gale, Harold Kuhn, Theodore Motzkin, John von Neumann, and many others.

Marguerite Frank, who had written her Ph.D. thesis on Lie algebras with Adrian Albert at Harvard, was visiting Princeton and working in the ONR project. She and Phil joined forces and began studying nonlinear optimization under linear constraints. Using an observation of Barankin and Robert Dorfman, they developed a procedure for quadratic programming. Phil wrote their joint paper during a summer vacation at Big Sur, California, with his typewriter at the edge of the Pacific Ocean.

Their completed manuscript was submitted to Naval Research Logistics Quarterly during the time I was the journal's managing editor. I found that the paper had a conceptual and intellectual depth which caused me to worry about finding an appropriate referee. Fortunately, about the same time, Harry Markowitz submitted a paper with a similar theme, portfolio selection by parametric quadratic minimization. I sent each the other's paper for refereeing. Since neither found anything objectionable to warrant rejection, they were both accepted and published in the same issue (Frank and Wolfe 1956; Markowitz 1956).

Phil also taught undergraduate courses in calculus and a graduate course in game theory, and wrote papers in game theory (Sion and Wolfe 1957; Wolfe 1956). In 1957, inspired by Markowitz's paper, Phil developed a procedure based on the simplex method for solving quadratic- programming problems that only required making minor modifications in a simplex algorithm computer code. He sent a copy to Dantzig who replied, "This is a terrific result, if it's true" (Lustig 2001).

Princeton now offered Phil an assistant professorship, a 3-year, non-tenure track appointment. Instead, he accepted an offer from RAND at a salary twice as large as what was offered earlier. So, back to California; it was 1957.

At Rand: 1957–1966

The RAND corporation, located in Santa Monica, had been created in 1946 by the U.S. Air Force and, in 1948, was incorporated as a non-profit organization to improve policy and decision making through research and analysis. It has had many distinguished scholars in a wide array of fields and was a leader in OR research methods. Oddly, Phil was not assigned to the mathematics department, but to the computing group. Initially, Phil thought he was hired to replace William Orchard-Hays, the premier developer of LP computer codes, who had recently left RAND to join the Corporation for Economic and Industrial Research, a Washington, D.C. consulting firm (Mapstone 1972). George Dantzig had joined RAND in 1952, and Orchard-Hays, working with Dantzig, had developed simplex algorithm- based codes for the IBM card-programmed calculator and the IBM 701 and 704 digital computers. But Phil was not a master computer programmer – most of his time was spent on algorithmic research, finding ways to improve the simplex algorithm. He did, however, influence RAND computing in other ways. He persuaded members of the RAND computer programming staff to try FORTRAN, the new high-level computer language/compiler to see if it assembled computer code more deftly than the programmers could accomplish using machine/assembly code and their personal skills, which it did. (This was in contrast to Orchard-Hays writing elaborate LP codes in machine language.) He undertook with Leola Cutler a series of computational tests of various LP ideas, which was the beginning of the collection of test problems that have been useful to the MP community (Wolfe and Cutler 1963). And he continued the practice begun at Princeton of writing reports and giving lectures on the state of the art of computation in various optimization venues. His principal RAND associates were George Dantzig, Ray Fulkerson, and Lloyd Shapley. Phil also took advantage of the pleasant yearlong weather to run on Santa Monica beach and swim and bodysurf in the warm Pacific Ocean.

What is probably Phil's best known work, the Dantzig–Wolfe decomposition method, came from this environment (Dantzig and Wolfe 1960). Building on an idea of Ford and Fulkerson for multicommodity network flow problems (Ford and Fulkerson 1958), Dantzig and Wolfe observed that the methods of the simplex method could apply even when the columns of the LP matrix were not explicitly available. What was needed was a way of generating them when they had to be tested for insertion into the basis. In particular, if you had a LP model where several smaller linear-programming problems were subjected to only a few equations that linked variables of the separate smaller problems, you could, in principle, solve the whole problem by shifting the focus alternately between the smaller problems and the interconnected problem over vectors that were convex combinations of the vectors of the smaller problems. The idea had broad implications in both mathematical and economic contexts, and it inspired such applications as Gilmore and Gomory's analysis of the cutting-stock problem (Dantzig 1963; Gilmore and Gomory 1961, 1963). Phil continued his interest in nonlinear programming and published reviews of the field (Wolfe 1961, 1963b, 1967).

In early 1964, Phil and his wife divorced, at her request, which he eventually came to see was justified by his concentration on work and neglect of all else. His personal life was at a low point. His friend Ralph Gomory, who was Director of the Mathematical Sciences Department at IBM's T. J. Watson Research Center, Yorktown Heights, N.Y., arranged to have Phil spend a 6-month sabbatical at the IBM's Zurich research laboratory. He enjoyed the experience and wondered why he had absorbed from his RAND colleagues an anti-IBM prejudice. When Ralph later offered him a regular position at the Yorktown Heights research center, Phil agreed. There were also other reasons for leaving RAND: Dantzig had left to join the faculty at the University of California, Berkeley; Ray Fulkerson was contemplating leaving for academia (which he did by going to Cornell University); and RAND was beginning to urge researchers to find their own funding rather than rely on Project RAND. In April, 1966, Phil, with the Porsche he bought in Zurich, arrived in Southampton, England where he boarded the P&O cruise ship Chusan which stopped at various resorts, passed through the Panama Canal, and went on to San Francisco where Phil visited his mother. Later that year, he drove to New York to join the research staff of the Mathematical Sciences Department (MSD) at IBM Yorktown. He bought a tiny house not far from work and turned its basement into a compact carpentry shop.

IBM and beyond

I had been a member of the MSD since 1961, and I was thrilled to learn that Phil was joining our group. He was, in the opinion of many of us, the second leading figure in the mathematical optimization community (after George Dantzig, of course). Apart from integer programming, Phil was an authority on every aspect of optimization. He also had the distinction of being the only person to have received paychecks from each of the three shrines of MP: Project SCOOP at the Air Force, the Logistics Research Project at Princeton, and the RAND Corporation. Phil spent the rest of his career in the Mathematical Sciences Department of IBM's Thomas J. Watson Research Center, Westchester County, just 45 miles north of Times Square.

It did not take long for Phil to learn that it was not easy for a single man living in northern Westchester County to meet women. So he joined the Chappaqua Drama Group soon after his arrival, and was chosen for a part in their next production, Look Homeward, Angel, based on the book by Thomas Wolfe (which Phil had read years earlier while in the Army, attracted first by the author's name, but more profoundly by identifying with the hero, Eugene Gant). Phil played Ben, Eugene's brother, and I thought he did rather well; his voice resonated, his posture was graceful, and he had reason to be pleased with his work. He played in several other productions, but then decided to try his hand at stagecraft. In February, 1968, Phil contacted the Beechwood Players, a local theatre company that was in need of set builders. The young woman manager, Hallie Flanagan, explained to Phil that she had not been able to find a place suitable for building sets. Phil offered the use of his shop. Hallie agreed – they soon established a professional and social relationship, and were married in June. (Hallie was named after her father's mother, who was a prominent theatrical producer, director, playwright, and author. From 1935 to 1939, she was the director of the Federal Theater Project, part of Roosevelt's New Deal Works Project Administration.)

In 1970, Phil and Hallie moved to their present home some 20 minute's walk to work. Phil has made the round trip on foot every day the weather allowed it. Their daughter Sarah was born in 1974. Sarah showed early talent for mental arithmetic and independent thinking. She moved to Alaska in 1996 and attended the University at Fairbanks, earning a B.S. in mathematics, minor in geology, and an M.A.T. (Master of Arts in Teaching) in secondary education. She teaches high-school mathematics in Fairbanks and is a volunteer firefighter, an emergency medical technician, and a curling enthusiast.

By the time Phil joined IBM, Ralph Gomory had succeeded Herman Goldstine as head of MSD. Although IBM was deeply involved in the development of LP and related software in many parts of its organization, IBM Research had no group specifically identified with optimization (Spielberg 2007). For many reasons, especially anticipated growth, it became clear that MSD needed such a group, and a group leader had to be chosen. There were several MSD members who had made notable contributions to optimization (and to OR) – Paul Gilmore, T. C. Hu, Dick Karp, Alan Hoffman—but no one was as qualified as Phil, by interests or temperament or achievement to lead MSD's optimization research. Within a few years, he was given that responsibility and he organized a small, outstanding group that included Ellis Johnson, Earl Barnes, and Harlan Crowder.

Besides administration, Phil's work continued to deal with aspects of nonlinear programming: globally convergent methods for unconstrained optimization (Wolfe 1969, 1971); nondifferentiable optimization (Wolfe 1970, 1974); and constrained optimization (Wolfe 1966). A major achievement, in the spirit of other work in the department on limits of computation, is given in Brent et al. (1973) in which the authors prove the fundamental result: if d is the order of the highest derivative used in an algorithm to find a simple root of an analytic function of one variable, then the order of convergence cannot exceed $d + 2$.

Phil also applied his leadership abilities to the establishment of a professional community for furthering the developments of the rather new analytical and computational field of MP. There was probably no one more active in furthering research and applications of MP within the Association for Computing Machinery and its Special Interest Group in Mathematical Programming. In 1970, Phil and Michel Balinski started the journal Mathematical Programming. When the MPS was started in 1971 – to formalize the selection of sites for the triennial mathematical programming symposia, to supervise the journal and other publications, and to generally promote the subject – Phil was one of the principal founders. He was the MPS chairman in 1978–1980. Friends of Optimization (FoOp) was an informal organization started by Phil as a way of getting the MP community in the New York metropolitan area together. It held meetings at various venues, with speakers who were in the forefront of developments. FoOp disbanded in the late 1980 when its functions were served by other forums.

On the occasion of his 65th birthday, Phil was honored by his friends and colleagues for his fundamental contributions to the mathematical programming field with a two-issue Festschrift of Mathematical Programming (Cottle et al. 1993). A text and video interview of Phil is among those conducted by Irv Lustig in his interview series with optimization trailblazers (Lustig 2001).

Because of his wide knowledge of optimization—theoretical, computational, and algorithmic – Phil was often invited to speak at prestigious scientific groups. In 1974, he addressed the International Congress of Mathematicians, a most distinct professional honor. When the Russian mathematician L.G. Khachiyan's polynomial time ellipsoid method algorithm for LP (Khachiyan 1979) was first announced in the U.S., it was hilariously misunderstood by a New York Times reporter – "Soviet mathematician is obscure no more" and "the mystery author of a new mathematical theorem that has rocked the world of computer analysis" (New York Times 1979) – Phil was invited all over the world to explain the mistakes and put in perspective the theoretical value of Khachiyan's work, as well as its weak computational aspects. Phil also served as an adjunct professor, principally for Columbia University's Industrial Engineering and Operations Research Department, and also for the mathematics departments of the City University of New York and the New York (Brooklyn) Polytechnic Institute.

Phil retired from IBM in 1996, and continued teaching for several years at Polytechnic and Columbia. Now he enjoys full retirement, helping Hallie run her landscaping business, and volunteering as a tutor at a local college.

Honors and Awards

Phil is a fellow of the American Association for the Advancement of Science (1972), the Econometric Society (1983), and the Institute for Operations Research and the Management Sciences (2002). He was awarded the ORSA and TIMS John von Neumann theory prize in 1992. He received a Distinguished Service Award and a Founders Award from the MPS in 2000.

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May 26–27, 2017. The aim of the conference is to bring together researchers at all levels, from established to junior, and from cross disciplines that include computational and applied mathematics, optimization, statistics, computer science, and engineering to report on the state of the art of the conference subject, to exchange ideas for its further development, and to foster collaborations among the participants with the goal of advancing the science of the field of statistical learning and promoting the interfaces of the involved disciplines. Nonconvex statistical learning topics will be the main focus of this conference.

The conference organizers highly encourage interested researchers to participate at the conference. Contingent upon the availability of funds, partial travel support to junior participants are possible through a proposal pending at the National Science Foundation.

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- Hongbo Dong (Department of Mathematics and Statistics, Washington State University)
- Jianqing Fan (Department of Operations Research and Financial Engineering, Princeton University)
- Yingying Fan (Marshall School of Business, University of Southern California)
- Ethan Xingyuan Fang (Department of Statistics, Penn State University)
- Xiaodong He (Deep Learning Technology Center, Microsoft Research)
- Mingyi Hong (Department of Industrial and Manufacturing Systems Engineering, Iowa State University)
- Jason Lee (Marshall School of Business, University of Southern California)
- Poling Loh (Department of Electrical and Computer Engineering, University of Wisconsin-Madison)
- Yifei Lou (Department of Mathematical Sciences, University of Texas at Dallas)
- Shu Lu (Department of Statistics and Operations Research, University of North Carolina at Chapel Hill)
- Zhi-Quan(Tom) Luo (Department of Electrical and Computer Engineering, University of Minnesota)
- Jinchi Lv (Marshall School of Business, University of Southern California)
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Daniel J. Epstein Department of Industrial and Systems Engineering,
University of Southern California, 3715 McClintock Ave, GER 240,
Los Angeles, CA 90089-0193, USA
isedept@vsoe.usc.edu

Second announcement Mixed Integer Programming Workshop Quebec, Canada

June 19–22, 2017. We are pleased to announce that the 2017 workshop in Mixed Integer Programming (MIP 2017) will be held at HEC Montréal (Quebec, Canada). The 2017 Mixed Integer Programming workshop will be the fourteenth in a series of annual workshops held in North America designed to bring the integer programming community together to discuss very recent developments in the field. The workshop consists of a single track of invited talks and features a poster session that provides an additional opportunity to share and discuss recent research in MIP.

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- Yoshua Bengio, University of Montréal
- David Bergman, University of Connecticut
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- Austin Buchanan, Oklahoma State University
- Christoph Buchheim, TU Dortmund
- Phillipp Christophel, SAS
- Bill Cook, University of Waterloo
- Daniel Dadush, CWI Amsterdam
- Santanu Dey, Georgia Institute of Technology
- Dinakar Gade, Sabre
- Angelos Georghiou, McGill University
- Hassan Hijazi, Australian National University
- Dorit Hochbaum, UC Berkeley
- Volker Kaibel, Otto-von-Guericke-Universitat Magdeburg
- Thorsten Koch, TU Berlin
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For more information and updates, please see the workshop website at https://sites.google.com/site/mipworkshop2017/.

IPCO XVIV, Waterloo, Ontario, Canada

June 26–28, 2017. The 19th Conference on Integer Programming and Combinatorial Optimization (IPCO XVIV) will take place at the University of Waterloo, in Waterloo, Ontario, Canada. It will be organized by the Department of Combinatorics & Optimization.

The IPCO conference is under the auspices of the Mathematical Optimization Society. It is held every year, except for those in which the International Symposium on Mathematical Programming takes place. The conference is a forum for researchers and practitioners working on various aspects of integer programming and combinatorial optimization. The aim is to present recent developments in theory, computation, and applications in these areas.

Earlybird deadlines for conference registration, and hotel deadlines are May 1st and 28th, 2017, respectively.

A Summer School event will take place during the two days preceding the IPCO conference (that is, on June 24 and 25, 2017). The speakers are Aleksander Mądry, Anupam Gupta, and Sanjeeb Dash.

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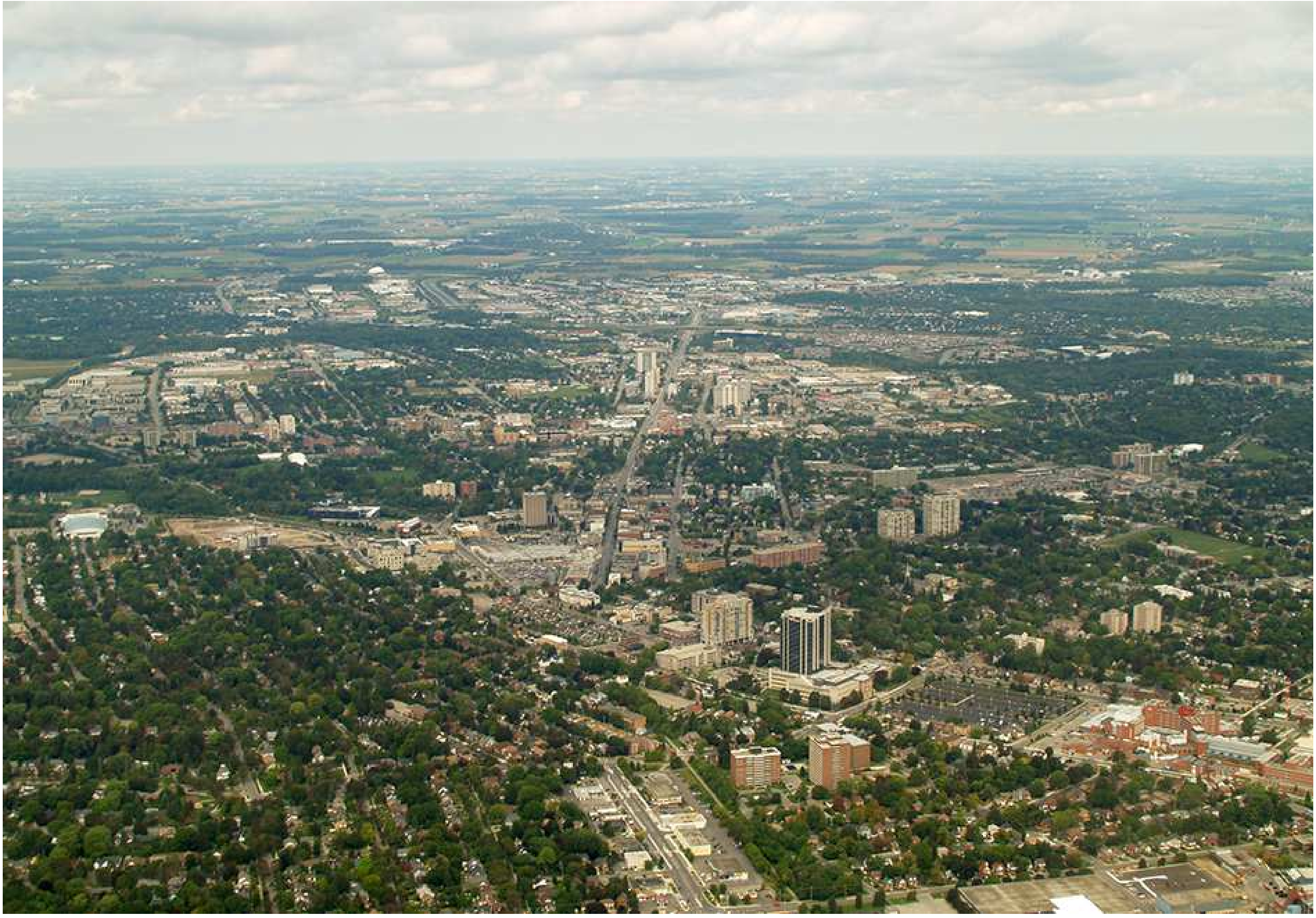

Downtown Waterloo from over Kitchener, Ontario (CC BY-SA 3.0)

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Editor: Volker Kaibel, Institut für Mathematische Optimierung, Otto-von-Guericke Universität Magdeburg, Universitätsplatz 2, 39108 Magdeburg, Germany. kaibel@ovgu.de ■ **Co-Editors:** Samuel Burer, Department of Management Sciences, The University of Iowa, Iowa City, IA 52242-1994, USA. samuel-burer@uiowa.edu ■ Jeff Linderoth, Department of Industrial and Systems Engineering, University of Wisconsin-Madison, Madison, WI 53706-1572, USA. linderoth@wisc.edu ■ **Founding Editor:** Donald W. Hearn ■ Published by the Mathematical Optimization Society ■ Design and typesetting by Christoph Eyrich, Berlin, Germany. optima@0x45.de ■ Printed by Oktoberdruck AG, Berlin, Germany.