Edited by: Panos Pardalos and Victor Korotkich

OPTIMIZATION AND INDUSTRY

2001 JULY 1 6

GREAT KEPPEL ISLAND
QUEENSLAND AUSTRALIA

International Conference Optimization and Industry

Great Keppel Island
Australia
1-6 July
2001

Organizers:
Panos Pardalos and Victor Korotkich

Organised by:
University of Florida
Central Queensland University
Centre for Applied Optimization,
University of Florida

Endorsed by;
Society for Industrial and Applied Mathematics(SIAM)
Activity Group on Optimization
Australian Mathematical Society
The Pacific Optimization Research Activity Group(POP)

Sponsors:
Faculty of Informatics and Communication, CQU
Deal-Fx
ILOG
Mackay Taxi Holdings Limited

Preface

Optimization and Industry: Challenges in the New Century

Optimization from Human Genes to Cutting Edge Technologies

Today's challenges faced by industry are so complex that they can only be solved through the help and participation of optimization experts. For example, many industries in e-commerce, finance, medicine, and engineering, face several computational challenges due to massive data sets that arise in their applications. Some of the challenges include, extended memory algorithms and data structures, new programming environments, software systems, cryptographic protocols, storage devices, data compression, mathematical and statistical methods for knowledge mining, and visualization. With advances in computer and information systems technologies, and many interdisciplinary efforts, many of the "data avalanche challenges" are beginning to be addressed. Optimization is the most crucial component in these efforts.

Optimization principles are evident in nature (the perfect optimizer) and appeared early in human history. Did you ever watch how a spider catches a fly or a mosquito? Usually a spider hides at the edge of its net. When a fly or a mosquito hits the net the spider will pick up each line in the net to choose the tense line? Some biologists explain that the line gives the shortest path from the spider to its prey.

Have you heard the following story about a wise general? He had a duty to capture a town behind a mountain. When he and his soldiers reached the top of the mountain, he found that his enemy had already approached the town very closely from another way. His dilemma was how to get in the town before the enemy arrive. It was a challenging problem for the general. The general solved the problem by asking each soldier to roll down the mountain in a blanket. Why is this faster? Physicists tell us that a free ball rolling down the mountain always chooses the most rapid one.

Optimality is a fundamental principle, establishing natural laws, ruling biological behaviors and conducting social activities. Concepts of optimization probably are in human genes as people always strive for perfection creating new technologies and systems. Optimization started from the earliest stages of human civilization. Of course, before mathematics was well established, optimization could be done only by simulation. One may find many wise men's stories in the human history about it. For example, to find the best way to get out of a mountain, someone followed a stream, and to find the best way to get out from a desert, someone set an old horse free and followed the horse's trace.

Nowadays, the main task of optimization is to investigate the cutting edge frontiers of these technologies and systems and find the best solutions for their realization. The decision making process in industry, business and government consists of several activities. Some of these activities may be improved upon using a scientific approach, but others are highly subjective in nature. Optimization, which is a scientific approach to problem solving, may not be of much help in the subjective activities, but it can be of considerable aid in the other activities and may be even help the decision maker to improve upon the subjective aspects. Optimization has become a very important tool for industrial and business management for improving the efficiency of their operations. The application of optimization to an industrial or business problem requires the mathematical formulation of the problem and an explicit statement of the desired objectives. In many instances such rigorous thinking about the problems clarifies aspects of management decision making which previously remained hidden in a haze of verbal arguments.

Roots of Optimization in Industry

Optimization, as a scientific discipline, may be viewed to have its roots in World War II, when the American military, for the first time in its history, had recruited legions of scientists and used them to help win the war. World War II was a war in which the talents of scientists were exploited to an unprecedented degree. First, there were all the new inventions of warfare - radar, infrared detection devices, long-range rockets as well as the atomic bomb. Second, the military had only the vaguest idea about how to use these inventions. Someone had to devise new techniques for these new weapons, new methods of assessing their effectiveness and the most efficient way to use them. It was a task that fell to the scientists, who eventually came up with optimization to deal with the problems.

Initially, the scientists worked on narrow technical problems - for example, how to build the bomb, how deep to set the charges, the choice of targets. But when it became clear that people didn't know the best way to use this incredibly expensive and destructive weaponry, they were increasingly drawn into discussions of strategy. Military matters had become so complex and so involved that the ordinary experience and training of the generals and admirals were no longer sufficient to master the problems. More often than not their attitude was, "here is a big problem. Can you help us?" And this was not restricted to making new bombs, better fuel, a new guidance system. It often comprised tactical and strategic use of things on hand and things only planned.

In the final years of the war, the Air Force generals began to worry about the brain drain of top scientists. How to keep the best and brightest thinking about military problems was far from obvious. The solution was a private organization outside the military, called RAND Corporation. RAND was a civilian think tank in Santa Monica, described by *Fortune* as the "the Air Force's big-brain-buying venture", where academics pondered the new theory of optimization. Operations research, linear programming, dynamic programming and systems analysis were all techniques of optimization that RAND brought to bear on the problem of "thinking the unthinkable".

Industrial production, the flow of resources in the economy, the exertion of military effort in a war theater - all are complexes of numerous interrelated activities. Differences may exist in the goals to be achieved, the particular process involved and the magnitude of effort. Nevertheless, it is possible to abstract the underlying essential similarities in the management of these seemingly disparate systems. To do this entails a look at the structure and state of the system and at the objective to be fulfilled in order to construct a statement of the actions to be performed, their timing and their quantity, which will permit the system to move from a given status toward the desired objective.

If the system exhibits a structure which can be represented by a mathematical model and if the objective can be also so quantified, then some computational method may be evolved for choosing the best schedule of actions among alternatives. The observation that a number of military, economic and industrial problems can be expressed or reasonably approximated by mathematical systems of linear inequalities and equations helped to give rise to the development of linear programming.

The discovery of linear programming started a new age of optimization. George B. Dantzig who first proposed the simplex method to solve linear programming in 1947 stated in his article *Linear Programming: The Story About How It Began:* "What seems to characterize the pre-1947 era was lack of interests in trying to optimize". Due to the lack of interests in optimization, many important works appeared before 1947 were ignored.

It is not quite correct; there were some late exceptions. Fourier (of Fourier series fame) in 1823 and the well-known Belgian mathematician de la Vallee Poussin in 1911 each wrote a paper about it. Their work had as much influence on post-1947 developments as would finding in an Egyptian tomb an electronic built in 3000 BC. Leonid Kantorovich's remarkable 1939 monograph on the subject was also neglected for ideological reasons in the USSR. It was resurrected two decades later after the major developments had already taken place in the West.

Dantzig also recalled how he made his discovery. "My own contribution grew out of my World War II experience in the Pentagon. During the war period (1941-1945), I had become an expert on programming-planning methods using desk calculators. In 1946 I was Mathematical Advisor to the US Air Force in the Pentagon. My Pentagon colleagues, D. Hitchcock and M. Wood, challenged me to see what I could do to mechanize the planning process. I was asked to find a way to more rapidly compute a time-staged development, training and logistical supply program. In those days "mechanizing" planning meant using analog devices or punch-card equipment. There were no electronic computers".

In the summer of 1949 at the University of Chicago, a conference on linear programming was held under the sponsorship of the Cowles Commission for Research in Economics. Mathematicians, economists and statisticians from academic institutions and various government agencies presented research using the linear programming tool. The problems considered ranged from planning crop rotation to planning large-scale military actions, from the routing of ships between harbours to the assessment of the flow of commodities between industries of the economy. The conference was a milestone in optimization.

During the last 50 years the role optimization plays for industry and society as a whole has been enhanced immensely. Today, optimization has become a very large and important interdisciplinary area between mathematics, computer science, industrial engineering, management science and economics. New branches of optimization appeared in almost every decade, *global optimization, nondifferential optimization, geometric programming, large-scale programming,* etc. No one in his/her whole life is able to study all branches in optimization. Each researcher can only be an expert in a few branches of optimization.

Of course, the rapid development of optimization is accomplished with recognition of its achievements. One important fact is that several researchers in optimization have received the Nobel Price in economics, including Leonid Kantorovich and Tjalling C. Koopmans. They received the Nobel Price in economics in 1975 for their contributions to the theory of optimum allocation of resources. Harry Markowitz received the Nobel Price on economics in 1990 for his contribution on the quadratic programming model of financial analysis.

Globalization of Industry: New Opportunities and Challenges for Optimization

There is no doubt that optimization will progress along its current conventional path. More efficient methods will be developed for solving specific problems in industry. Moreover, there is a possibility that in a distant future quantum and biological computers will appear providing a new medium for optimization.

But could optimization be on the threshold of a different new age that would enhance immensely the role it plays for industry and society as a whole? We would dare to contemplate that it is the case and optimization has potential to embrace this age coming with looming changes in industry. By recognizing the potential optimization could rapidly expand to provide all the ingredients for a surge of a much broader flowering of technological, business and financial innovations. This would impact industry and society to a much greater extent than fifty years ago with the appearance of optimization as it is understood now.

With the Globalization being underway the emergence of planet-wide computer system envisioned in many science-fiction stories is becoming clearer. This system connected by the Internet is integrating different industries and technologies into one whole revealing itself as the world e-economy. How to design "the brain and the nervous system" of the world e-economy, which would allow its different entities, similarly to organs in human body, co-exist in an optimal way? It seems that this huge task should challenge and fall to optimization scientists, much as the post-WWII problems did for their colleagues at the dawn of optimization.

The outlines of the world e-economy can be discerned even now. The Internet rapidly is becoming the cornerstone of global industrial and business networks. One such network is already with us - the international financial markets. They are a gigantic circulatory system sucking up capital into financial markets and institutions and then pumping it out either directly in the form of credits and portfolio investments or indirectly through multinational corporations. International capital flows are now worth 10 times the "real" world economy. The markets transact more than $US1.6 trillion a day, more than all the central bank reserves in the world.

It has led to entirely new forms of business trade in capital. Hedge funds, companies that essentially take gambles on foreign-exchange positions, have shown themselves powerful and adept enough to vanquish central banks by undertaking a new form of business transaction: business-to-business gamble on currency values.

Not all cross-border capital flows are business-to-business and are usually electronic information exchanges between companies engaged in commerce, not finance. But the metamorphosis of the international financial markets may be an indication of the extent to which business is about to change as a result of the combination of global communications and deregulation.

There are signs that the on-line revolution is about to begin in earnest as the world's largest companies start to adapt their organizational structures. Late last year, British Telecom announced that its 1000 suppliers would be going on-line. Even the car industry, thought of as the epitome of the industrial era, is being transformed by electronic commerce. Ford and General Motors announced jointly last year that they would be taking their entire supply chains on-line. Toyota management now thinks of the company as principally a finance company. Because the sale of cars is relatively predictable, what is more crucial is the financial exchanges with suppliers, distributors and the company's different national divisions: all part of the business-to-business matrix.

It is expected that business-to-business activity to constitute about 90 per cent of e-commerce activity. In this respect the Internet's potential as it applies to business is actually much more about strategy than it is about technology or direct sales to consumers. This naturally calls for optimization to step in to make this process viable.

Co-incident with the rise of the Internet is a world-wide reduction in the number of global providers of industrial-era products, and an increasing number of alliances between global companies. This is perhaps most pronounced in the car industry, where alliances between the big companies are common to the point where it is getting hard to tell them apart.

What appears to be occurring is the development of commercial networks, in which companies are nodes at the center of the business-to-business networks, rather than discrete entities. Just as there is now a global financial network creating entirely new forms of information usage around money, so there is likely to be a global commercial network that generates new forms of production and wealth creation.

To find efficient solutions for the world e-economy to sustain and function in an optimal way gives optimization a potential to undergo a major transformation in scope and dimension.

"Optimization and Industry" Conference

The Conference provides a unique opportunity for people from industry to be aware of latest accomplishments, new developments and future directions of optimization in: telecommunications, finance, primary production industries, chemical industries, auto-manufacturing, aerospace engineering and computing.

Finding efficient solutions for the world e-economy gives optimization a potential to undergo a major transformation in scope and dimension. We believe that the Conference will be a first attempt for researchers in optimization and captains of industry to understand the significance and meaning of this potential and how it could be realized for a never-ending growth of humanity in intelligence and spirit.

The Editors
Gainesville-Mackay, June 2001

Plenary Talks

Massive Multi-Digraphs

James Abello
Shannon Laboratory, AT&T Labs-Research
Florham Park, NJ 07932-0971, USA
email: abello@research.att.com

Abstract

A variety of massive data sets exhibit an underlying structure that can be modeled as dynamic weighted multi-digraphs. Their sizes range from tens of gigabytes to petabytes. The sheer volume of these graphs brings with it an interesting series of computational and visualization challenges.

We will discuss external memory algorithms for connectivity, minimum spanning trees and maximal matchings together with heuristics for quasiclique finding and diameter computations. From the visualization store we will describe an external memory hierarchy that allow us to use computer graphics techniques like dynamic visibility to provide navigation control. We will present experimental results with graphs having on the order of 200 million vertices and we will point out some mathematical problems that have surfaced along the way.

(some of this work has been done in cooperation with A. Buschbaum, J. Korn, S. Krishnan, P. Pardalos, M. Resende, A. Ucko, J. Westbrook and S. Sudarsky)

Addressing the Solution of Nonsmooth Optimization Problems Arising in Industry

Sharon Filipowski
Boeing Corporation
PO Box 3707, Seattle, USA
email: sharon.k.filipowski@boeing.com

Abstract

In a real-world setting, numerous optimization problems involving nonsmooth functions arise. These problems appear in circumstances that range from addressing the solution of difficult combinatorial optimization problems using Lagrangian relaxation to attempting to solve problems involving semidefinite constraints, such as model tuning problems arising in the area of aircraft structures.

In this talk we will discuss some nonsmooth optimization problems appearing in industry and some of our approaches to solving them.

Recent Advances in Deterministic Global Optimization

Christodoulos A. Floudas
Princeton University
Princeton, NJ 08544-5263, USA
email: floudas@titan.princeton.edu

Abstract

Global optimization addresses the computation and characterization of global optima (i.e., minima and maxima) of nonconvex functions constrained in a specified domain. Given an objective function f that is to be minimized and a set of equality and inequality constraints S, the area of *Deterministic Global Optimization* focuses on the following important issues:

(1) Determine a global minimum of the objective function f (i.e., f has the lowest possible value in S) subject to the set of constraints S;

(2) Determine *lower* and *upper* bounds on the global minimum of the objective function f on S that are valid for the whole feasible region S;

(3) Enclose all solutions of the set of equality and inequality constraints S.

In the last decade, we have experienced an explosive growth in the area of Global Optimization. This is complemented by the ubiquitous applications that include important problems such as the structure prediction in protein folding and peptide docking in computational chemistry and molecular biology, phase and chemical equilibrium in thermodynamics, pooling and blending in chemical refineries, robust stability analysis in control, parameter estimation and data reconcilliation, energy recovery systems in process synthesis, and multiple steady states in reactors.

In this plenary talk, we will discuss recent advances in the area of deterministic global optimization. We will focus on (i) constrained optimization problems that are twice-continuously differentiable, (ii) nonlinear and mixed integer optimization models, and (iii) systems with differential and algebraic constraints. The difference of convex functions method, denoted as α**BB**, which can address general continuous twice-differentiable problems that arise in a variety of engineering and applied science problems, will be presented. The α**BB** (i) offers theoretical guarantee of attaining an e-global optimum solution in a finite number of iterations, (ii) provides valid lower and upper bounds on the global solution, and (iii) identifies local optima close to the global minimum. Applications from a variety of disciplines will demonstrate the power of these recent advances.

Optimization in the Automotive Industry

Donald R. Jones
General Motors Corporation
Warren, MI 480901, USA
email: don.jones@gm.com

Abstract

How is optimization currently used in the automotive industry? What are the outstanding challenges? These are the questions that will be addressed in this talk. My goal is to provide the audience with a big-picture perspective and, hopefully, with some ideas they can take back to the office. Accordingly, the talk will not dwell on the details of any one application, though references will occasionally be given so that interested individuals can dig deeper.

Today, most successful applications of optimization in the automotive industry are at the detailed-design level. Examples include structural optimization of metal gauges and beam cross sections, topology optimization of cast parts, piston shape optimization, cutting stock problems, engine calibration, optimization of shock-absorber rates, assembly-line resequencing, and line balancing. Several of these examples will be reviewed. Persons unfamiliar with topology optimization will find this methodology especially fascinating, since it finds good topologies without explicitly defining parameters, objective functions, etc. Despite these successes, however, it is fair to say that optimization is used less often, and has had a smaller impact, than most researchers in the field of optimization might have expected. The reason is the presence of numerous barriers that need to be overcome.

What are the barriers? In engineering, a major barrier has been the poor interface between computer-aided design (CAD) and computer aided engineering (CAE). For example, much CAD work is still non-parametric and not geometrically clean, making it difficult to export data for CAE analysis and to iterate the process with new design parameters suggested by an optimization algorithm. Crashworthiness presents a challenge because crash is a notoriously non-repeatable phenomenon. To obtain a robust design, one must take into account the likely variation in angle of impact, driver position, material stiffness, etc. Yet data on the natural variation of these factors may be poor, and assessing how this variation will impact performance may require more computer runs than can easily be afforded. Managers may be reluctant to trust the results of optimization runs unless the math models are sufficiently accurate; hence, issues of model validation and calibration have come to the forefront. While the value of multidisciplinary optimization is well recognized, different disciplines (structures, durability, crashworthiness, etc.) often develop models at different points in the design process (because they require different levels of detail). As a result, care must be taken to insure that each discipline is working with the same version of the design. In operations research, applications of optimization have sometimes met resistance due to excessive data requirements.

While these barriers are substantial, much progress has been made. As I review this progress, I will point out implications for University curricula, for research, and for successfully implementing optimization within industry.

Optimization and Industry: New Frontiers

Panos Pardalos
Department of Industrial and Systems Engineering
University of Florida
Gainesville, FL 32611, USA
email: pardalos@ufl.edu

Abstract

TBD

Combinatorial Optimization in Telecommunications

Mauricio G. C. Resende
AT&T Labs-Research
Florham Park, NJ 07932-0971, USA
email: mgcr@research.att.com

Abstract

Combinatorial optimization problems are abundant in the telecommunications industry. In this paper, we present four real-world telecommunications applications where combinatorial optimization plays a major role. The first problem concerns the optimal location of modem pools for an internet service provider. The second problem deals with the optimal routing of permanent virtual circuits for a frame relay service. In the third problem, one seeks to optimally design a SONET ring network. The last problem comes up when planning a global telecommunications network.

Combinatorial optimization problems are abundant in the telecommunications industry. In this paper, we present four real-world telecommunications applications where combinatorial optimization plays a major role. In Section 2, we consider the PoP (point-of-presence) placement problem, an optimization problem confronted by internet access providers. The most common, and potentially least expensive, way for a customer to access the internet is with a modem by making a phone call to a PoP of the provider. It has been conjectured that potential customers are more likely to subscribe to internet access service if they can make a local (free unmetered) phone call to access at least one of the internet provider's PoPs. Given that the number of PoPs that can be deployed is limited by a number of constraints, such as budget and office capacity, one would like to place (or locate) the PoPs in a configuration that maximizes the number of customers than can make local calls to at least one PoP. We call this number of customers the coverage. A greedy randomized adaptive search procedure (GRASP) is used to find solutions to this location problem that, in real-world situations, are shown to be near-optimal.

A Frame Relay (FR) service offers virtual private networks to customers by provisioning a set of permanent (long-term) virtual circuits (PVCs) between customer endpoints on a large backbone network. During the provisioning of a PVC, routing decisions are made either automatically by the FR switch or by the network designer, through the use of preferred routing assignments, without any knowledge of future requests. Over time, these decisions usually cause inefficiencies in the network and occasional rerouting of the PVCs is needed. The new PVC routing scheme is then implemented on the network through preferred routing assignments. Given a preferred routing assignment, the FR switch will move the PVC from its current route to the new preferred route as soon as that move becomes feasible.

Section 3, deals with a GRASP for optimal routing of permanent virtual circuits for a frame relay service. Survivable telecommunications networks with fast service restauration capability are increasingly in demand by customers whose businesses depend heavily on continuous reliable communications. Businesses such as brokerage houses, banks, reservation systems, and credit card companies are willing to pay higher rates for guaranteed service availability. The introduction of the Synchronous Optical Network (SONET) standard has enabled the deployment of networks having a high level of service availability. In Section 4, we describe an approach for optimal design a SONET ring network.

With the worldwide market liberalization of telecommunications, the international telecommunications environment is changing from the traditional bilateral mode of operation, where each network between pairs of administrations (AT&T and British Telecom, AT&T and France Telecom, British Telecom and France Telecom, etc.) is planned separately, to a more global, alliance-based, environment, where the network needs of several administrations may be planned simultaneously. This allows network planning to be done more in the manner that a single national network is designed, as opposed to many individual networks. In Section 5, we describe a problem that comes up when planning a global telecommunications network.

Simulation, Scenarios, and Uncertainty in Optimization

R. Tyrrell Rockafellar
University of Washington
Seattle, WA 98195-2420, USA
email: rtr@amath.washington.edu

Abstract

In a great many applications of optimization, there are uncertainties over what the future may bring. Decisions have to be taken in the absence of full information, and this leads to important questions about how a problem should be formulated. A common approach is to develop, often through simulation, a collection of scenarios which describe how the future might unfold, and to solve for each scenario a deterministic problem based on foreknowledge of that particular future. The difficult follow-up task then, however, is that of coming up with a single compromise decision that balances the different results so obtained. Unfortunately, such an approach is not only lacking in theoretical support but flawed. It fails to capture properly the way that uncertainty should influence the present and can lead to poor decisions that are not well hedged.

In this talk, the issues that are crucial to successful modeling under uncertainty will be discussed along with some of the numerical techniques that have been devised to get sound answers. A key point is the need for early involvement of someone who is aware of the guidelines for this kind of optimization, not only in setting up the problem in the application environment, but even in the approach to simulation, if things are to be done right.

Advisory Committee Talks

Distributed Approaches to Multidisciplinary Optimization Management

Natalia M. Alexandrov
NASA Langley Research Center
Hampton, Virginia 23681-2199, USA
email: n.alexandrov@larc.nasa.gov

Abstract

This work is concerned with analytical and computational foundations of multidisciplinary optimization. We analyze several distributed, multilevel approaches to formulating MDO problems. We show how, in some cases, analytical features of the resulting optimization problems have deleterious consequences for computational optimization algorithms. These difficulties derive from the multilevel nature of the optimization problems. Multilevel approaches to MDO maintain a disciplinary autonomy through the formulation. We claim that the same practical degree of autonomy can be attained through the choice of optimization algorithm applied to more conventional formulations, without the inherent computational difficulties associated with distributed optimization formulations. Techniques that lead to complicated, structure-based formulations are contrasted with algorithm-based techniques applied to simpler problem formulations.

Softcomputing for Integrated Softgoods Supply Chain Management

Shu-Cherng Fang
North Carolina State University
Raleigh, NC 27695-7906, USA
email: fang@eos.ncsu.edu

Abstract

A softgoods supply chain involves the activity and interaction of many entities of the fiber-textile-apparel-retail industry. Usually each of these entities knows how to make locally optimal decisions when the situation is clear. Unfortunately many decisions must be made in settings involving vagueness and uncertainty. Furthermore successful supply chain operation requires coordination of decisions of the individual entities while the level of uncertainty is amplified as information is passing through the chain. Even in the emerging data rich environment with current information technology, lack of fundamental knowledge about supply chain operation in a fuzzy environment is still a key problem faced by the industry.

The goal of this talk is to explore and demonstrate the use of fuzzy mathematics, neural networks, and other softcomputing techniques in addressing some critical problems for softgoods supply chain management.

Tactical Air Traffic Management: Enhanced Optimization Model with Cancellations and Curfew Costs

Jerzy A. Filar, Prabhu Manyem and Kevin White
University of South Australia
Mason Lakes, SA 5095, Australia
email: j.filar@unisa.edu.au, p.manyem@unisa.edu.au,
k.white@unisa.edu.au

Simon Visser
University of Twente
The Netherlands

Abstract

In this paper we report on the progress of a project that aims to develop strategies for the reduction of departure and arrival delays at Sydney airport, thereby reducing the need to place incoming planes in holding patterns.

Our approach is based on a European static integer programming model of Navazio and Romanin-Jacur (the NRJ model [1]), which can be viewed as a descendant of an earlier Vranas, Bertsimas and Odoni model [2]. We report on some experimental results obtained by testing the model with generated schedules that resemble the traffic pattern at Sydney. We also report on an enhanced model that includes additional features of air traffic at Sydney. Firstly, we allow flights to be cancelled if their arrival would otherwise be delayed beyond a reasonable upper bound. Secondly, we allow flights to land in the airport's curfew hours by paying a penalty. Sydney airport has a curfew between 23:00 and 06:00 hours.

Using the AMPL and CPLEX packages, both models have been tested under various weather scenarios and with two different types of schedule. For one weather scenario the enhanced model performs better than the NRJ model, and for another it produces a feasible solution while the NRJ model does not.

However, uncertainties associated with airport capacities call for more frequent runs of dynamic optimization models, rather than for a single run of a static model at the beginning of each day. An airport can be said to be in one of a finite number of discrete states, depending on, for example, the weather conditions. We present a discussion of how such airport states can be modelled as states of Markov decision processes. We illustrate this with a simple pseudo-dynamic model of a situation that occurs frequently at busy airports.

References

1. P.B.M. Vranas and D. Bertsimas and A.R. Odoni, *The Multi-Airport Ground-Holding Problem in Air Traffic Control*, Operations Research, 42:2 (1994), pp. 249-261.

2. L. Navazio and G. Romanin-Jacur, *The Multiple Connections Multi Airport Ground Holding Problem: Models and Algorithms*, Transportation Science, 32:3, (1998), pp 268-276.

Mathematics-in-Industry: More than an Application

Phil Howlett
University of South Australia
Mawson Lakes, SA 5059, Australia
email: phil.howlett@unisa.edu.au

Abstract

The annual workshop of the Australian Mathematics-in-Industry Study Group (MISG) is an internationally recognised industrial problem solving forum. In seventeen years we have considered more than a hundred problems presented by companies from all over Australia; we have worked with large companies and small companies; we have solved problems for the mining industry, the food industry, the rail industry, the service industry and manufacturing industry; and we have published our findings in respected international journals. But in spite of our success MISG has no home. The workshop is staged on an ad hoc basis and the future is not guaranteed. To move forward we could propose a more radical view; that Mathematics-in-Industry is more than an application; that it is a subject in its own right; that it is not the margin of mathematics but rather the essence.

The Mathematics-in-Industry Network, MI*Net, is a proposed national network for Technology Diffusion, that will be funded by the Federal Department of Industry Science and Resources. MI*Net represents a new direction for MISG. For many years we have solved problems for industry but have not regarded the Mathematics-in-Industry connection as an essential part of our profession. MI*Net will cultivate the connection by creating a systematic communication network with a strong industry basis and a focus on industry-oriented outcomes. Our aim is to develop MISG and MI*Net as core components of a Special Research Centre for Mathematics-in-Industry.

Nonlinear Programming Methods for Optimisation Problems with Complementarity Constraints

Danny Ralph and Stefan Scholtes
University of Cambridge
Cambridge, CB2 1AG, United Kingdom
email: danny.ralph@jims.cam.ac.uk, stefan.scholtes@jims.cam.ac.uk
Roger Fletcher and Sven Leyffer
University of Dundee, United Kingdom

Abstract

Nonlinear programs with complementarity constraints are becoming important in economics and engineering for both designing systems - e.g. setting tolls in a traffic network, or beam thickness in mechanical structures - and finding system parameters via inverse optimisation - e.g. determining demand elasticities in American options pricing, or material properties in civil engineering.

While this class of problems can be tackled by classical nonlinear optimisation methods, it is also well known for apparently intrinsic theoretical and numerical difficulties. However, recent computational experiments initiated by Roger Fletcher and Sven Leyffer have shown surprisingly good behaviour of certain SQP-based methods, including superlinear convergence rates. We investigate this surprising phenomenon.

Optimising Design Configuration for Desired Relialibility and Availability Levels of Telecommunication Systems

Ebrahim Shayan
Industrial Research Institute Swinburne
Hawthorn, Victoria 3122, Australia
email: EShayan@groupwise.swin.edu.au

Abstract

Communication systems such as mobile phone systems are configured of hundreds of electronic components receiving the messages, processing them against some protocols, and distributing them over the network until connection is established. Items used are under heavy load, working in harsh environments and are very much dependable by other social systems.

This makes them very sensitive requiring high reliability redundant items to provide high availability for the system. To provide the required availability, communication provider companies use a high level of redundancy of expensive items. On failure they replace the items with new ones as quickly as possible. This in turn forces a high capital cost in terms of inventory or procurement.

This paper discusses an optimisation approach to configure a section of a complex structure in a mobile communication system at minimum cost while maintaining a desirable level of availability for the system. First availability of the system is formulated based on available data and expert opinion, then a nonlinear mathematical optimisation model is developed to identify the number of components of each type necessary to maintain the availability.

Invited Talks

Optimization of Telecommunication Networking and Planning

M. M. Ali, C. Oppermann and B. Thomas
Witwatersrand University
Private Bag-3, Wits-2050
Johannesburg, South Africa
email: mali@cs.wits.ac.za

L. Wolmarans
Altech Telecoms, Alcatel
238 Roancrascent, Sage Corporate Park North
Midrand, Johannesburg, South Africa

Abstract

In this paper we have proposed a methodology for optimized telecommunication network planning. A practical example is considered to demonstrate that the methodology can assist the network designer. An image processing technique is used to identify major land marks, rivers, mountains and potential users from an aerial photograph. These are then taken into account to optimally place the network. Given the demand for different services, demographic estimation, costs and the growth rate, the methodology can forecast the economic viability of the proposed network.

Keywords: telecommunication network, image processing, demographic and geographical estimation, growth rate, resource and financial optimization.

Nash Equilibria in Electricity Markets with a Pool Structure

Eddie Anderson
Australian Graduate School of Management
Sydney, Australia
email: eddiea@agsm.edu.au

Abstract

This paper considers wholesale electricity markets in which generators sell power to distributors (or very large users). Many markets of this sort exist in the world. In a pool market generators offer supply functions and then a central dispatching mechanism decides in real time which generators will be dispatched. We will look at models in which the demand is uncertain and the generators wish to maximise their expected profit. We consider the characteristics of a Nash equilibrium for the two player game in the case that only a small number of fixed price points are available to the generator. This model is appropriate for the behaviour of the Australian market in the short term (half-hour time intervals). We also argue that it is relevant to other pool markets in which generators may choose voluntarily to limit their price competition.

Intelligent Agent Applications within Distributed Networking Simulation System

Amir M. Anvar
Defence Science and Technology Organisation
PO Box 1500 Salisbury
South Australia 5108, Australia
email: amir.anvar@dsto.defence.gov.au

Abstract

The main requirements for the next generation of distributed architectures to support network decision-making strategy is to include sophisticated team interaction and problem solving capabilities between components by employing intelligent-agent technology. The agent-oriented system requires an architectural approach with a strong emphasis on software engineering processes and methods.

The fundamental objective of this work is to investigate the benefits of developing the multi-agent system within a distributed networking system. This aim is based on contemplation of fundamental design variables that can be directed in different ways to assist the creation of agents with reactive, cognitive, deliberative behaviors or hybrid attitude.

The agent model under consideration consists of a set of facts representing its local knowledge, a set of rules exhibiting its strategies and behaviour, and a set of services that define the agent's interface. The domain planned of this association can be optimized via a colored Petri nets simulation model. Moreover, the procedural behaviour of the Petri net-agent is considered to demonstrate the coordination mechanism as well as communication behaviour and reasoning about the agent's cooperation.

On Solving Constrained Nonlinear Mixed - Integer Optimization Problems Using Evolutionary Algorithms and the Augmented Lagrangian Penalty Function

Jason Bell
Faculty of Informatics and Communications
Central Queensland University
Rockhampton, Queensland, 4740, Australia
email: j.bell@cqu.edu.au

Abstract

This paper studies the use of various penalty functions including an Augmented Lagrangian Penalty function on Constrained Nonlinear Mixed - Integer Optimization problems using Evolutionary Algorithms.

Today, the complexities of problems that we wish to optimize are becoming quite large. Some of these problems require the use of both integer and real type variables. Most studies that have been done in the past have focused on the study of continuous problems, in which all of the variables are real numbers. Mixed - integer type problems, which include both integer and real variables, are becoming quite common.

Mixed - integer problems are more complex and tend to create their own problems. Integer type variables can only be changed by given discrete increments, any changes that occur can produce vast changes to the overall fitness value of the function. Real type variables are continuous, they are able to be changed by a very small amounts, this means that the change in the overall result of the function being evaluated can be small.

Given that a wide variety of problems include equality and/or inequality constraints, there has been a tremendous amount of research done on how evolutionary algorithm's handle infeasible individuals. One option that has been suggested is the use of a penalty. This method applies a penalty value to the overall fitness of the infeasible individual.

There are various types of penalties that can be applied. This research uses some of the standard penalty functions that are commonly used and compares the results with those obtained using the Augmented Lagrangian Penalty function.

This paper shows that the use of the Augmented Lagrangian Penalty function on Constrained Non-Linear Mixed-Integer Optimization problems is quite successful and a viable option to use, even in the presence of discontinuous jumps caused by the integer type variables.

Branch-and-Bound Approaches Standard Quadratic Optimization Problems

Immanuel M. Bomze
Universittaet Wien
Universittaetsstrasse 5, A-1010
Wien, Austria
email: immanuel.bomze@univie.ac.at

Abstract

Several possibilities are explored for applying branch-and-bound techniques to a central problem class in quadratic programming, the so-called Standard Quadratic Problems (StQPs), which consist of finding a (global) minimizer of a quadratic form over the standard simplex. Since LP-based bounds often turn out to perform poorly, main emphasis is laid upon quadratic difference-of-convex (d.c.) decomposition. Various strategies for obtaining d.c. decompositions are discussed, among them variants which are based on a (single) SDP used to select an efficient d.c. decomposition.

Upper Bound on Convergence Rate of Optimization Algorithms for Continuous Functions under the Wiener Measure

James M. Calvin
New Jersey Institute of Technology
Newark, NJ 07102, USA
email: calvin@cis.njit.edu

Abstract

Let f be a continuous function defined on the unit interval. One of the most basic optimization problems is to approximate the minimum of f by evaluating the function at sequentially selected points. This problem is well-understood for several special classes of objective function; for example, unimodal or Lipschitz functions. In both of these cases, a subset of the unit interval can be ignored after a certain number of function evaluations because the assumptions on f are strong enough to allow certain subsets to be ruled out. If f is unimodal then there exist optimization algorithms that bracket the minimizer inside a subinterval that after n observations is of width $O(e^{-cn})$ for some positive constant c (for example, the Fibonacci search method; see [2]).

In this talk we are concerned with the optimization problem where the objective function is not assumed unimodal. Specifically, we are interested in the case where no subinterval can ever be ruled out. In [1] the optimization problem was analyzed in a probabilistic setting with f a sample path of a Brownian motion process. An algorithm was constructed with the property that the error is $O_P(\exp(-nc_n))$, where $\{c_n\}$ (a parameter of the algorithm) is a deterministic sequence that can be chosen to approach zero at an arbitrarily slow rate; thus the convergence rate is almost exponential in the number of observations n.

These two results raise the general question of whether exponential convergence is a feature of unimodal optimization only, or if it can be attained in a more general optimization setting. In this paper we address the specific question of whether exponential convergence is possible in the average sense for optimization on the Wiener space; we show that it is not. More precisely, let $\Delta_n = M_n - M$ denote the error after n observations, where $M = \min_{0\leq t\leq 1} f(t)$ denotes the global minimum and M_n is the minimum of the first n function values observed. Then for any algorithm and $c > 0$,

$$P\left(\Delta_n \leq e^{-cn}\right) \to 0,$$

where P is the Wiener measure.

Key words: probabilistic complexity, continuous optimization.

References

1. Calvin, J. (2001), *A One-dimensional Optimization Algorithm and its Convergence Rate under the Wiener Measure*, *Journal of Complexity*, to appear.
2. Kiefer, J. (1953), *Sequential Minimax Search for a Maximum*, *Proc. Amer. Math. Soc.*, **4**, pp. 502–506.

On Copositive Programming and Standard Quadratic Optimization Problems

Mirjam Duer
Vienna University of Economics
Augasse 2-6, A-1090
Vienna, Austria
email: Mirjam.Duer@wu-wien.ac.at

Abstract

A standard quadratic problem (QP) consists of finding (global) maximizers of a quadratic form over the standard simplex. In this paper, the usual semidefinite programming relaxation is strengthened by replacing the cone of positive semidefinite matrices by the cone of completely positive matrices (the positive semidefinite matrices which allow a factorization FF^T where F is some non-negative matrix.)

The dual of this cone is the cone of copositive matrices (i.e., those matrices which yield a non-negative quadratic form on the positive orthant). This conic formulation allows us to employ primal-dual affine-scaling directions. Furthermore, these approaches are combined with an evolutionary dynamics algorithm which generates primal-feasible paths along which the objective is monotonically improved until a local solution is reached. In particular, the primal-dual affine scaling directions are used to escape from local maxima encountered during the evolutionary dynamics phase.

Variational Inequalities for Fuzzy Mappings over a Fuzzy Domain

Cheng-Feng Hu
I-Shou University, Kaohsiung
Taiwan, R.O.C.
email: chu1@isu.edu.tw

Abstract

This paper studies variational inequalities for fuzzy mappings over a fuzzy domain. It is shown that such problem can be reduced to a bilevel programming problem. A penalty function algorithm is introduced with a convergence proof, and a numerical example is included to illustrate the solution procedure.

Key words: fuzzy optimization, variational inequalities, mathematical programming.

On Nature of Correlations in Portfolio Optimization

Galina Korotkikh
Faculty of Informatics and Communications
Central Queensland University
Mackay, Queensland, 4740, Australia
email: g.korotkich@cqu.edu.au

Abstract

Recent results based on random matrix theory suggest that some commonly used financial methods find correlations that are not real. This raises serious doubts on the blind use of empirical correlation matrices for risk management.

Motivated by these results a different approach is considered in the talk. The approach combines random matrix theory and a nonclassical definition of correlation to develop solid methods for differentiating real trends from randomness in financial markets. In particular, this allows to define a metric on the space of stocks and a distance between pairs of them.

A General Framework to Study Interacting Agents and Related Optimization Problems

Victor Korotkich
Faculty of Informatics and Communications
Central Queensland University
Mackay, Queensland, 4740, Australia
email: v.korotkich@cqu.edu.au

Abstract

A collection of interacting agents that cooperatively solve an optimization problem is considered. The consideration aims to determine conditions for the agents to demonstrate their best performance for the problem. A general framework based on a concept of structural complexity is proposed to determine the conditions. The main merit of this framework is that it allows to set up computational experiments revealing a condition of best performance. The experiments give evidence to suggest that the condition is realized when the structural complexity of interacting agents equals the structural complexity of the optimization problem. This motivates to introduce a notion of complexity space to capture the condition.

The results of the paper give a new perspective in the developing of optimization methods based on interacting agents. The optimization methods according to the condition should be devised to have parameters controlling their structural complexity handy. The use of the methods for an optimization problem could be interpreted as a process in which the parameters must be tuned in an optimal way to get the condition. This emphasises the importance to control the position of points in the complexity space in order to obtain the best performance condition. In other words, it is necessery to find laws of motion and control in the complexity space. Two important optimization problems stand out to be considered initially:

1. two points x_0 and x_1 in the complexity space are given. Among all admissible controls that transfer a point from the position x_0 to the position x_1 find one that does it in an optimal way. The significance of the problem is clear. Suppose that agents satisfy the best performance condition for a situation at the position x_0. Since adaptation to a new situation at the position x_1 can be critical, there is the problem to transfer the agents from the position x_0 to the position x_1 as soon as possible to satisfy the condition;

2. the same problem but when the position of a situation in the complexity space is unknown, i.e., no information about the structural complexity of a situation is available in advance. The identification of the point x_1 is a part of the problem to transfer agents from the position x_0 to the position x_1 in an optimal way. For example, a formation flying team of air vehicles may not know the capacity of an adversarial team to fulfil a mission. The first team to demonstrate its best must identify the structural complexity of the adversarial team to meet the condition.

A Robot Soccer Virtual Laboratory for Optimising Intelligent Strategies

Victor Korotkich and Noel Patson
Faculty of Informatics and Communications
Central Queensland University
Mackay, Queensland, 4740, Australia
email: v.korotkich@cqu.edu.au, n.patson@cqu.edu.au

Abstract

Robot Soccer is a test bed for many applications of interest to industry. Cooperation and coordination of team members, intelligent decision making, developing winning strategies, interpretation of visual signals are a few examples that are pertinent to industry. The interplay between autonomous team members and their opponents can serve as analogies for many aspects of our dynamic and complex world such as manufacturing processing, organisational structure and communication.

A robot soccer virtual laboratory for optimising intelligent strategies is presented in the paper. The virtual simulation and computation laboratory has been developed "from scratch" as this approach has never been applied to understanding robot soccer team dynamics. In particular, we discuss how by using the laboratory the eigenvalue spectrum of matrices associated with the dynamics of a robot soccer team is found to be a solid invariant that may serve as a global characteristic.

The understanding gained through this research may have application in many diverse areas such as coordination of traffic, scheduling, resource optimisation, logistics, data mining, decision support systems and telecommunications.

An Automated Equality Constraint "Polisher" for Use in a (Hybrid Evolutionary) Optimisation Algorithm

Scott Ladley
Faculty of Informatics and Communications
Central Queensland University
Rockhampton, Queensland, 4740, Australia
email: s.ladley@cqu.edu.au

Abstract

In the current economic climate, any small improvement in an industrial process can reap huge rewards. To this end many processes need to be run right on the 'constraint' boundaries in order to achieve maximum efficiency. Thus when using computer models to determine the optimal set of operating parameters it is necessary to find optimal solutions that are very close to the constraint boundaries.

Evolutionary algorithms are good at producing near optimal solutions of highly non-linear optimisation problems. However, they do not necessarily produce solutions that tightly adhere to the constraint boundaries, especially when equality constraints are involved.

A fully automatic algorithm based on a simple iterated hill-climber with Gaussian perturbations is presented in the talk. This algorithm, which requires no parameters, can drive a solution which satisfies all the equality constraints to an accuracy of $\bigcirc(0.1)$ to a point where all the constraints are satisfied to machine accuracy. This is achieved by switching between absolute and quadratic penalty functions to reduce the overall error and 'evenly distribute' the error between the constraints. The key to the success of the algorithm is in the controlled increment of the penalty multiplier and the reduction in the standard deviation of the perturbations.

To demonstrate the algorithms efficiency, several discrete optimal control problems are solved, including the "harvest problem", from a Mathematical Programming perspective. Mathematical Programming problems, by their nature, involve a large number of variables and a large number of equality constraints.

Variational Type of Fractional Programming Problem

H. C. Lai
I-Shou University, Kaohsiung, 840
Taiwan
email: hclai@isu.edu.tw

Abstract

We consider a variational problem in a fractional programming as the following form :

$$(P) \qquad \text{Minimize} \quad \phi(x) = \frac{\displaystyle\int_a^b [f(t,x(t),\dot{x}(t)) + \|A(t)x(t)\|_L]\,dt}{\displaystyle\int_a^b [g(t,x(t),\dot{x}(t)) - \|B(t)x(t)\|_M]\,dt} \left(\equiv \frac{\Phi(x)}{\Psi(x)}\right)$$

$$\text{subject to}: \quad x \in PS(T,R^n), \quad x(a) = k^a, \ x(b) = k^b, \qquad (1)$$

$$h_i(t,x(t),\dot{x}(t)) + \|C_i(t)x(t)\|_{N_i} \leq 0, \qquad (2)$$

$$t \in T = [a,b], 1 \leq i \leq m.$$

where $T = [a,b]$ denotes the time interval and $PS(T,R^n)$ is the state space of all piecewise smooth n-dimensional vector states x defined on T, $\|\cdot\|_L$, $\|\cdot\|_M$ and $\|\cdot\|_{N_i}$, $1 \leq i \leq m$ are arbitrary norms. Throughout the paper, we assume that $f,g : T \times R^n \times R^n \longrightarrow R$ and $h : T \times R^n \times R^n \longrightarrow R^m$ are continuously differentiable functions; $A(t), B(t)$, and $C_i(t)$, $1 \leq i \leq m$, $t \in T$ are $p \times n, q \times n$ and $r_i \times n$ matrices respectively; and assume that $\Phi(x) \geq 0$, $\Psi(x) > 0$ for any feasible solution x.

We establish optimality conditions under some specific conditions, and study certain duality models in the framework of optimality conditions.

Global Minimization of Lennard-Jones Clusters by a Two-Phase Monotonic Method

Marco Locatelli
University of Turin, Corso Svizzera
185-10149 Torino, Italy
email: locatelli@di.unito.it

Abstract

Atoms in a molecule tend to place themselves in positions which minimize the overall energy. Therefore, a common approach to detect their positions is by minimization of a mathematical model of the energy. A widely used model for the energy is the Lennard-Jones (LJ) potential. The number of local minima grows exponentially with the number of atoms in this model, thus making minimization a very difficult task.

An approach is proposed which combines two methods. The first method exploits the special shape of the LJ functions landscape by generating nonincreasing sequences of local optima. The second method is based on a multistart approach where local searches are subdivided in two phases, the first one minimizing a modified LJ potential and the second one minimizing the original LJ potential.

The combination leads to the detection of all the putative global optima up to $N = 110$ and is extremely efficient for some magic numbers ($N = 75, 98, 102$) which, in the existing literature, are considered the most challenging ones.

An Exact Approach to the Strip Packing Problem

Silvano Martello, Michele Monaci and Daniele Vigo
Dipartimento di Elettronica, Informatica e Sistemistica
University of Bologna, Viale Risorgimento 2
40136 - Bologna, Italy
email: smartello@deis.unibo.it, mmonaci@deis.unibo.it,
dvigo@deis.unibo.it

Abstract

We consider the problem of orthogonally packing for a given set of rectangular items into a given strip, by minimizing the overall height of the packing. The problem is NP-hard in the strong sense, and finds several applications in cutting and packing. We propose a new relaxation which produces good lower bounds and gives information to obtain effective heuristic algorithms. These results are used in a branch-and-bound algorithm, which was able to solve test instances from the literature involving up to 200 items.

Intelligent Systems in Public Transport and Optimization

Maxwell McBride
Mackay Taxi Holdings Ltd
Po Box 13, Mackay, Queensland, 4740, Australia
email: Taxismackay@ezyweb.com.au

Abstract

As urban travel patterns become more complex and diverse the ability of conventional forms of public transport to satisfy the needs of the community is diminishing. Given that modern marketing is based on the premise that consumers will choose the product that best satisfies their needs, then in the urban transport market there is little debate concerning the market dominance of private transport.

In Australia private transport satisfies in excess of 89% of all urban travel movements. The failure of public transport systems to compete effectively with private transport has resulted in substantial private and public economic costs. The public transport system comprises supply side, mass transit services provided by the bus and rail industries, and demand responsive services provided by the taxi industry. The provision of mass transit services is heavily reliant on government funding and regulation to remain viable. Mass transit services are sustained with government inputs totalling in excess of $5 billion per year. Despite this, mass transit patronage is in decline.

Taxi services are provided on a commercial basis with no requirement for government funding. Despite the commercial viability of the taxi industry most companies successfully operate with productivity levels of 30%. In Queensland this means that on average there are 1800 vehicles available and 8900 unutilised public transport seats. Clearly transport planners are overlooking a substantial resource in the public transport system.

The market dominance of private transport is forcing industry to seriously question the type of public transport products being offered to the consumer. In Mackay, a regional Queensland city, the local taxi company has developed an innovative alternative to fixed route bus services. The service, which is marketed as Taxi Transit is a demand responsive, to/from the door, multi pick up transport service. It has been so successful that it has now replaced most conventional bus services. Taxi Transit utilises a fleet of taxis and maxi taxis that do not have established routes, but rather provide a to/from the door service based on customer needs. Customers phone a toll-free number to prebook a service, with the schedule for each route determined by the most efficient route to simultaneously collect and deliver a number of customers.

As Taxi Transit is demand driven, services are only provided when required. This results in dramatic reductions in operational costs, by firstly enabling the service provider to utilise appropriately sized vehicles and secondly by substantially reducing route travel. Since August, 1995 the service has grown by an average 16% per year.

The future growth and broader application of Taxi Transit will be dependent on the ability to quickly and efficiently develop schedules for each service

provided. Further to this if demand responsive products are to reach their potential, fleet management and scheduling systems are critical.

In the paper we discuss the development of a scheduling system that will make Taxi Transit maximally efficient. The scheduling system will be progressively developed for applications in regional centres and larger metropolitan areas. The development has the potential to give rise to a merger of decision making, information management and communication. The utilisation of new optimization methodologies and technologies in this merger would lead to a quantum leap in the field of intelligent transportation systems.

Outsourcing OR? Web-based and other Strategies

Michael Nealon
Applied Decision Analysis
PricewaterhouseCoopers, Australia
email: michael.j.nealon@au.pwcglobal.com

Abstract

The presenter will describe practical experience in delivering the benefits of optimisation systems for strategic and tactical business planning. In particular he will describe the new "web-based planning" paradigm, and the advantages it offers over traditional methods. He will draw upon direct experience of alternative strategies including:

- in-house OR teams
- delivery of model code (e.g. AMPL)
- database and spreadsheet-based systems
- stand-alone applications
- "off-the-shelf" software

The "web-based planning" paradigm draws upon both consulting and modelling to provide a service well suited to applications such as strategic and tactical value chain analysis and other resource planning studies.

Optimising Offers for Hydroelectric Generators in an Electricity Market

Phil Neame, Andy Philpott and Geoff Pritchard
University of Auckland
Private Bag 92019
Auckland, New Zealand
email: p.neame@auckland.ac.nz, a.philpott@aucland.ac.nz,
email: g.pritchard@auckland.ac.nz

Abstract

We consider the case of a generator offering electricity into a spot market. If the generator has no market power (that is, the generator cannot affect the market clearing price), then it would seem that the optimal strategy is to offer in at marginal cost of production. However, market rules stipulate that an offer consists of a finite number (5 in New Zealand, 10 in Australia) of "tranches" (price/quantity pairs). Furthermore, these amounts be increasing, which is a particular problem if the marginal cost curve is non-convex. We give an example where this arises in the case of a hydroelectric generator. We focus on techniques for constructing these offers, and look at how these methods can be extended to the multi-period case, and to the case where the generator has significant influence on the market clearing price.

Estimation and Optimisation in Electricity Pool Markets

Andy Philpott
University of Auckland
Private Bag 92019
Auckland, New Zealand
email: a.philpott@aucland.ac.nz

Eddie Anderson
Australian Graduate School of Management
Sydney, Australia
email: eddiea@agsm.edu.au

Abstract

Electricity generators offering power into pool markets seek to maximise their profits subject to uncertainty in the demand for power and the behaviour of other participants in the pool. In a recent paper, Anderson and Philpott show how this uncertainty can be modelled by an appropriate probability distribution. The information that can be used to estimate the parameters defining this distribution will vary with the structure of the market being studied. We describe a set of Bayesian update techniques that can be used to estimate these parameters. When all generators and demand are regarded as being at a single pool node this approach is straightforward. We consider this case as well as the situation where generators are located at different nodes of an electricity transmission network. The results of applying these techniques to data collected from the New Zealand electricity market will be presented.

Packing Models and Global Optimization

Janos D. Pinter
Pinter Consulting Services, Inc. and Dalhousie University
129 Glenforest Drive, Halifax, NS
Canada B3M 1J2
email: jdpinter@is.dal.ca

Abstract

The objective of global optimization (GO) is to find the absolutely best solution of nonlinear decision models that often have multiple - local and global - optima.

In packing models, the globally optimal arrangement of a set of points or (some other, two- or higher dimensional) 'packing objects' is sought, according to a certain geometrical 'container' structure and a given criterion function. Additional constraints may also be present.

Numerous examples of application can be found in applied mathematics, physics, computational chemistry, biology, medical research, and industrial engineering.

Packing models - as a rule - lead to very difficult, multiextremal problems. The issue of finding suitable solution strategies to produce globally optimized configurations (for non-trivial configurations, using a reasonable effort) has been open for decades, for a large number of model-instances.

In this talk, we review several uniform and non-uniform sphere packing models and a variety of potential energy model forms. This is followed by a discussion related to model formulations as a (corresponding) GO problem.

For illustration, LGO - an integrated model development and solver system for analyzing and visualizing GO problems - is applied to solve instances of several packing models. A summary of numerical results - reported in details elsewhere - will also be presented.

We conclude by discussing the broad applicability of GO to this area, including far-reaching possibilities for energy model generalizations and extensions.

References

1. Conway, J.H. and Sloane, N.J.A. (1988), *Sphere Packing, Lattices and Groups*, Springer-Verlag, Berlin Heidelberg New York.
2. Greengard, L. (1988), *The Rapid Evaluation of Potential Fields in Particle Systems*, The MIT Press, Cambridge, MA.
3. Horst R. and Pardalos, P.M. (eds.) (1995), *Handbook of Global Optimization*, Kluwer Academic Publishers, Dordrecht/Boston/London.
4. Pardalos, P.M., Shalloway, D. and Xue, G. (1996), *Global Minimization of Nonconvex Energy Functions: Molecular Conformation and Protein Folding*, DIMACS Series, Vol. 23, American Mathematical Society, Providence, RI.
5. Pinter, J.D. (1996), *Global Optimization in Action*, Kluwer Academic Publishers, Dordrecht/Boston/London.
6. Pinter, J.D., Stortelder, W.J.H. and de Swart, J.J.B. (1997), *Computation of elliptic Fekete point sets*, Research Report MAS-R9705, CWI, Amsterdam.

7. Pintr, J.D. (1998), *A Model Development System for Global Optimization*, pp. 301-314. In: De Leone, R., Murli, A., Pardalos, P.M. and Toraldo, G.(eds.), High Performance Software for Nonlinear Optimizaton: Status and Perspectives, Kluwer Academic Publishers, Dordrecht/Boston/London.
8. Pinter, J.D. (2000), *Extremal Energy Models and Global Optimization*, pp. 145-160. In: Laguna, M. and Gonzalez-Velarde, J.L. (eds.), Computing Tools for Modeling, Optimization and Simulation, Kluwer Academic Publishers, Dordrecht/Boston/London.
9. Pinter, J.D. (2001a), *Computational Global Optimization in Nonlinear Systems - An Interactive Tutorial*, Lionheart Publishing, Inc., Atlanta, GA.
10. Pinter, J.D. (2001b), *Computation of Globally Optimized Spherical Point Arrangements: Model Variants and Illustrative results*, Annals of Operations Research (to appear).
11. Saff, E.B. and Kuijlaars, A.B.J. (1997), *Distributing Many Points on the Sphere*, The Mathematical Intelligencer 19 (1), pp. 5-11.
12. Smale, S. (1998), *Mathematical Problems for the Next Century*, The Mathematical Intelligencer 20 (2), pp. 7-15.

Network Survivability Analysis

Wayne Pullan
Griffith University, Gold Coast
Queensland, Australia 4215
email: 'w.pullan@gu.edu.au

Abstract

With the increasing reliance on computer networks, network survivability (as distinct from network reliability) is becoming a more important issue. A commonly accepted heuristic is: networks with high survivability are those where all links and nodes have approximately equal relative importance in satisfying network traffic demands.

This paper describes a traffic flow based method of evaluating aspects of network survivability. A genetic algorithm is used to optimise the concurrent max-flow between a set of source-terminal pairs within the network and, by comparing how concurrent max-flow changes as nodes/links are removed, measures for relative node/link importance are determined.

Using these measures, a network survivability metric S_i is proposed and used to investigate the simultaneous maximisation of average network survivability $(\frac{1}{N}\sum_{i=1}^{N} S_i)$ and minimisation of the range over which S_i varies $(var(S_i))$ by enhancing link capacities within a given budget.

For some networks there appears to be an unique optimal set of link capacities however, for others, a number of possible optima exist. For these networks a Pareto-optimal set is generated so that a decision can be made on which link enhancements should be performed. The change in optima as a consequence of changes in the budget for link enhancements is also investigated.

Results are presented for two networks, both containing 25 nodes and 41 links.

Operating in Modern Electricity Markets: the Role of Optimisation

E. Grant Read
Energy Modelling Research Group
University of Canterbury, New Zealand
email: ERR@mang.canterbury.ac.nz

Abstract

Over the last decade a wave of reform has substantially re-shaped electricity markets all over the globe. Some experiences have been positive, some less so, and the jury is still out with respect to the overall economic impact of these reforms. For better, or worse, though, industry must now come to grips with new realities, and learn to identify and exploit the economic opportunities which such markets present. As a first step, industry needs to understand the critical role which optimisation models play in clearing such markets, and the implications this has for price formation. Given such understanding, optimisation tools can be built to maximise profits for industries involved in producing, or in generating electricity.

Asset-liability Management for Pension Funds Using CVaR Constraints

H. Edwin Romeijn, Erik Bogentoft and Stan Uryasev
Department of Industrial and Systems Engineering
University of Florida
Gainesville, Florida, USA
email: romejn@ise.ufl.edu

Abstract

A pension fund is an institute that has been set the task to make benefit payments to people that have ended their active career. We consider a fund, which has two sources to fund these liabilities: revenues from its asset portfolio (investment income and appreciation of the value of the portfolio) and contributions to the fund by its sponsor (the employer and/or active participants). Two types of decisions are considered: 1) investment decisions (allocation of funds in a portfolio); and 2) decisions on the level of contributions.

The goal is to find a desirable risk/reward structure with respect to the financial development of a pension plan. In particular, we minimize the cost of funding while safeguarding the pension fund's abilities to meet its liabilities. The fund should be able to make all benefit payments timely, without becoming underfunded. We use Conditional Value-at-Risk (CVaR) for constraining downside risk of an investment portfolio. The CVaR risk measure has several intuitively appealing and attractive mathematical properties. Also, risk management with CVaR can often be done using Linear Programming.

We will discuss theoretical and numerical results on a single-period variant of the model, as well as preliminary numerical results on a multi-period variant, using real-life data.

Optimization and Biomedical Science Diagnosis of Epilepsy

Rasa Ruseckaite
Centre for Visual Sciences, RSBS
Australian National University, Australia
email: @

Abstract

Optimization methods are very popular and going to be used in different life and science areas. Some of them are used in biomedical science as well. This paper describes the usage of global optimization methods for the human brain state evaluation.

Almost 1 percent of the whole population suffers from epilepsy. 30 percent of them have refractory epilepsy. Epilepsy is a very difficult brain disease, it is very important to diagnose it in time. Electroencephalogram (EEG) may help detect areas of increased nerve cell activity and diagnose epilepsy.

Digital EEG analysis and global optimization methods were used to solve the epilepsy diagnosis problem in my work. My task was to predict the appearance of the seizure for the epileptic persons from their EEG data.

40 EEG were recorded from the people suffering from temporal and occipital lobe epilepsy. The EEG recordings were analyzed and processed by means of special multivariate regression algorithms (ARMA - MULTI).

Results showed a possibility to determine the seizure exactly for 31 persons. We can say that the methods mentioned above are useful and will be used for further data analysis.

Tools for Rapid Development of Optimization-based Decision Support Systems

Sanjay Saigal and Irv Lustig
Ilog Inc.
email: ssaigal@ilog.com, ilustig@ilog.com

Abstract

Experience tells us that after data collection and validation, software implementation represents the primary bottleneck in the development of optimization-based decision support systems. New software precepts such as object-oriented modeling and new technologies such as Microsoft's Component Object Model (COM) promise relief. We present an overview of alternative software models for embedding Ilog's optimization engines, with a detailed discussion of pros and cons of each approach illustrated with code samples.

Using the Augmented Lagrangian Penalty Method to Force the Continuous Equivalent of a Mixed-Integer Problem to Satisfy the Integer Values to a High Degree

Stephen Smith
Faculty of Informatics and Communication
Central Queensland University
Rockhampton, Australia
email: s.smith@cqu.edu.au

Abstract

Non-linear Mixed-Integer problems are an important class of optimisation problems that are becoming more and more prolific in industry. However, from a research point of view, they are not very popular. Most people tend to concentrate on either fully discrete or fully continuous problems.

This paper investigates the possibility of using the Augmented Lagrangian Penalty method as a vehicle for transforming discrete variables into continuous variables with a hidden "discrete" constraint on them. This then allows the full arsenal of optimisation techniques for constrained continuous problems to be brought to bear on Mixed-Integer problems.

We describe a technique which uses the power of the Augmented Lagrangian Penalty method, "behind the scenes", to force the relevant real valued variables to take on a set of discrete values to a *high* degree of accuracy. This technique is then used within an Evolutionary Algorithm to solve some 'industrial' Mixed-Integer problems.

Gap Functions of VVI with Set-valued Mappings

X.Q. Yang
Department of Applied Mathematics
The Hong Kong Polytechnic University
Kowloon, Hong Kong
email: mayangxq@polyu.edu.hk

J.C. Yao
Department of Applied Mathematics
National Sun Yat-sen University
Kaohsiung 804, Taiwan, ROC
email: yaojc@math.nsysu.edu.tw

Abstract

In this paper we study vector variational inequalities with set-valued mappings. We introduce gap functions and establish necessary and sufficient conditions for a solution of vector variational inequalities. We also investigate the existence of a strong solution of generalized vector variational inequalities.

Keywords: vector variational inequality, set-valued mapping, gap function, existence.

Evolving Agents for Global Optimization

*Baolin Wu and Xinghuo Yu**
Faculty of Informatics and Communication
Central Queensland University
Rockhampton, Queensaland, 4702, Australia
*Corresponding Author. email: x.yu@cqu.edu.au

Abstract

A search agent can search a solution in a given search space where the states are discrete and large but finite. It is difficult, however, for an agent to find a global solution alone where the search space is large and continuous. Optimization problems are one of such problems that have been extensively studied using sophisticated algorithms such as evolutionary computation techniques. These techniques deploy population based approaches to find a global solution by exchanging information between individuals that may retain better solutions to the problem. In this study, we consider to use an evolutionary approach for coordination of a group of agents, and apply it to solving the global optimization problem.

The global optimization problem that we consider in this paper is to minimize $f(x), x \in D \subset R^*$, where D is the search space and n is the dimension of state variables. First a group of search agents is defined in the search space D. Each agent has its own states about its position in D and the performance of the agent is measured by $f(x)$. The common goal of agents is to adapt themselves toward a position x' such that $\forall x, f(x') \leq f(x)$ in a random manner, where $x' = x + \lambda N(0,1)$ with $N(0,1)$ being a standard random number and λ the distance between the state of the agent and the closest agent who has a better performance. We regard an agent as a higher performer if the agent achieves the best performance among the group. As each agent self-adapts toward the closest agent that has better performance, for a given sufficient iteration time, the group (population) of agents can converge to perform as good as the higher performer, which will be shown mathematically. Meanwhile, it is of interest to create offspring that explore new area where the global solution may exist. In order to do so, the mutation operation is used within each agent to create an offspring in the direction of its opposite search direction. The search process is updated in one generation to another to achieve the search of global solution.

Simulation will be presented on various types of function optimization problems to show the effectiveness of this approach. We conclude that the proposed approach of evolving agents can improve search capability for global optimization in comparison with the conventional evolutionary computation techniques.