INTERNATIONAL WORKSHOP ON STOCHASTIC AND APPLIED GLOBAL OPTIMIZATION (SAGO 2008)

July 19th -22th, 2008

Skukuza, Kruger National Park, South Africa

Book of Abstracts

Edited by

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Preface

Dear Colleague:

It is our great pride and pleasure to offer our warmest greetings to you, the participants of the ***"International workshop on Stochastic and Applied Global Optimization (SAGO 2008)"*** at the Skukuza, Kruger National Park, South Africa. This workshop is financially supported by the National Research Foundation (NRF), Pretoria and Faculty of Science as well as the School of Computational and Applied Mathematics of the University of the Witwatersrand, Johannesburg, South Africa. The individual contribution of Professor Tshilidzi Marwala of the same university is also acknowledged.

Global Optimization, the field including theory, methods and applications of optimization techniques aimed at detecting a global optimum for difficult mathematical programming problems in which many local optima might exist, is a rich area of research.

The subject generates many papers published in qualified scientific journals and books; a journal and a series of monographs explicitly dedicated to the field exist now for more than a decade.

The purpose of the conference is to bring together both experts and novices in the dealing with this topic. The workshop is organised mostly in single stream sessions, in order to give all participants the opportunity to enjoy each of the presentations. The main theme of the meeting will be stochastic and applied global optimization.

In addition to attending the conference's exciting sessions, we encourage each of the participants to take advantage of our historic city and tourist centre of the Kruger National Park, Skukuza, South Africa, which is a center of attraction for many International Visitors. We hope you will share in the beauty of natural creations and creatures as well as scientific knowledge. Last but not least we want to extend our best wishes to all of the conference participants and to its Organizing Committee members.

Sincerely,

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Organising Committee

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1. Professor Tshilidzi Marwala, Witwatersrand University, Johannesburg, South Africa

2. National Research Foundation (NRF), Pretoria, South Africa

3. Faculty of Science, University of the Witwatersrand, South Africa

4. School of Computational and Applied Mathematics, University of the Witwatersrand

List of Presentations

Schedule of Talks

Day 1 - Saturday, July 19, 2008

Time	Schedule of Events
09.00 – 17.00	Travel from Johannesburg to the Kruger National Park (450 Km from Johannesburg) with panorama tour and lunch
17.00 – 18.30	Get Together Party and Dinner

Day 2 - Sunday, July 20, 2008

Time	Schedule of Events	Topics	Presenter
07.00 – 08.00	**Breakfast**		
08.00 – 09.00	**Plenary Talk – Professor Panos Pardalos**		
09.00 – 09.35	Talk 1	Global Optimization of Binary Lennard-Jones Clusters using the TRUST non-Lipschitzian Dynamics Code	Jacob Barhen
09.35 – 10.10	Talk 2	The use of a Stochastic Approach for Life Cycle Assessment (LCA) for Mittal Steel Poland S.A. - A Case study on Krakow Plant Energy Generation	Bogusla Bieda
10.10 – 10.40	**Tea/Coffee Break**		
10.40 – 11.15	Talk 3	Parallel Strategies for solving a Continuous Multiple Competitive Facilities Location and Design Problem	José Fernandez,
11.15 – 11.50	Talk 4	A Model Reference Adaptive Search Method for Stochastic Optimization with Applications to Markov Decision Processes	Michael Fu
11.50 – 12.25	Talk 5	Robust Solutions of Bi-blend Recipe Optimisation with Quadratic Constraints	Inmaculada Garcia Fernandez
12.25 – 13.40	**Lunch Break**		

13.40 – 14.15	Talk 6	Applications of the Electromagnetism-Like Mechanism in Discrete Optimization Problems	Mohsen Gol-Alikhani
14.15 – 14.50	Talk 7	Optimization in R	Gerrit Gort
14.50 – 15.25	Talk 8	Reformulation Techniques based on such RLT and RRLT Constraints	Leo Liberti
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15.45 – 16.20	Talk 9	Optimal control of an Introduced Herbivore species: Economic Analysis of a Two Compartment Ecosystem Model	Lia Hemerik
16.20 – 16.55	Talk 10	A tutorial for Global Optimisation Branch-and-Bound	Eligius Hendrix
16.55 – 17.30	Talk 11	Parametric Optimization for Dynamic Control of a Machine Tool with Stochastic Tool Life	Bernard Lamond
17.30 – 18.05	Talk 12	High-Dimensional Phenomena and Global Optimization	Iskander Aliev
18.05 – 18.30	**Discussion Session**		
18.30	**Dinner**		

Day 3 - Monday, July 21, 2008

Time	Schedule of Events	Topics	Presenter
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12.00 – 13.00	**Lunch Break**		
13.00 – 13.35	Talk 13	Estimating the Minimal Value of a Function in Global Random Search: Comparison of Estimation Procedures	Vippal Savani
13.35 – 14.10	Talk 14	Limited-Memory Interval Branch and Bound Algorithms	Jordan Ninin
14.10 – 15.45	Talk 15	Optimisation of Parameters of Statistical Procedures	Valentina Moskvina
15.45 – 16.15	**Tea/Coffee Break**		
16.15 – 16.50	Talk 16	Development of a Higher-Order Conjugate Gradient Method for Optimizing Non-Linear Problems	Olabode Bamigbola
16.50 – 17.25	Talk 17	The Particle Collision Algorithm	Wagner Sacco
17.25 – 18.25	**Plenary Talk – Professor Anatoly Zhigljavsky**		
18.25 – 18.45	**Discussion Session**		
18.45	**Dinner**		

Poster Presentation

Title: Steam System Network Optimization Using Process Integration: Embracing Boiler Efficiency
Presenter: Tim Price

Day 4 - Tuesday, July 22, 2008

Time	Schedule of Events	Topics	Presenter
07.00 – 08.00	**Breakfast**		
08.00 – 08.35	Talk 18	On a Micromodel of Optimal Economic Development: An Application of Control Theory	Timothy Adewale
08.35 – 09.10	Talk 19	Stochastic Optimization Approaches for solving SUDOKU	Meir Perez
09.10 – 09.45	Talk 20	Stochastic Global Optimization Using Discrete and Mixed Hit-and-Run	Zelda Zabinsky
09.45 – 10.15	**Tea/Coffee Break**		
10.15 – 10.50	Talk 21	Solving the (1,1)-Centroid Problem in the Plane	Boglárka G.-Tóth
10.50 – 11.25	Talk 22	A Modified Genetic Algorithm Metaheuristics for Space Allocation Problem based on Integrated Crossover Rule	Aderemi Adewumi
12.15 – 11.55	Talk 23	Adaptive Threshold Selection Method for Evolutionary Algorithms	Aderemi Adewumi
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12.30 – 17.15	**Game Drive and Safari Walk**		
17.15 – 18.15	**Plenary Talk – Professor Pierre Hansen**		
18.15 – 18.45	**Discussion Session**		
18.45	**Dinner/Boma Braai @ Skukuza Restaurant**		

Abstracts of Talks

A Modified Genetic Algorithm Metaheuristics for Space Allocation Problem based on Integrated Crossover Rule

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Integrated crossover rule (ICR) was recently proposed and applied to continuous global optimization problems with good results. The rule seeks to produce a better offspring from selected set of three parents (rather than two) base on a new recombination rule. Due to the continuous nature of the model used in ICR, the resulting modified Genetic algorithm (GA) has not been applied to discrete optimization problems.

In this paper, we modify the original ICR strategy in order to make it applicable to discrete optimization problems. We present our initial work where the rule is applied to a newly defined real-life case of Space Allocation Problem (SAP), namely, the Hostel Space Allocation in a tertiary institution setting. Results obtained from the modified GA based on ICR are compared with the traditional GA. It is thus shown that the ICR can also be successfully applied to discrete optimization problem.

Keywords: Combinational Optimization, Space Allocation Problem, Metaheuristics, Genetic Algorithm, Integrated Crossover Rule

Study of Convergence of Genetic-type Algorithms for Stochastic Global Optimization

Anatoly Zhigljavsky
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United Kingdom

A broad class of random search algorithms for global optimization is introduced. This class of algorithms contains several well-known families of algorithms including the genetic algorithms. The main topic of the talk will be an approach for studying the convergence and the rate of convergence of many of these algorithms. This approach is based on studying stationary distributions associated with certain Markovian operators. In the case of the genetic algorithms, these operators describe the probabilistic rules used to obtain the population of children from the parent population. The results follow the lines of research described in Section 3.5 of the monograph Zhigljavsky A, Zilinskas A.G. *Stochastic Global Optimization*, Springer-Verlag, 2008.

Adaptive Threshold Selection Method for Genetic Algorithms

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Evolutionary Algorithms (EAs) are a class of stochastic search methods that mimic the workings of natural organic evolution. They are widely used in solving difficult optimization problems especially in areas where traditional optimization techniques fail. The selection of survivors for the next generation of potential solutions is an important step in EAs that influences the efficiency of the algorithm and drives the evolutionary search of the algorithm. A high selection pressure can leads to premature convergence of EAs while a weak selection pressure can make the search not to converge to optimality as expected.

In this paper, we present an adaptive selection scheme that addresses the problem of premature convergence. The scheme is based on an adaptive form of the truncation class of selection methods. A comparative simulation study of this scheme with traditional selection schemes is done using some benchmark functions. Results obtained show remarkable performance of the proposed selection method.

Parametric Optimization for Dynamic Control of a Machine Tool with Stochastic Tool Life

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We discuss two parametric optimization problems encountered in the dynamic operation of a machine tool under stochastic tool wear. The goal is to find decision rules for adjusting the cutting speed as a function of remaining distance, each time a tool change occurs, in order to minimize the expected processing time (sum of cutting time and tool setup time). In the first problem, a static model is solved where the cutting time is deterministic and the expected setup time is the renewal function of the tool life distribution. The objective function is relatively easy to compute in some cases (e.g., Erlang) but it is multimodal so a global optimization strategy must be used. In the second problem, we have a dynamic model whose optimal decision rule is computed by a dynamic programming approach. The objective function of the DP model, also multimodal, is more expensive to compute than for the static model. We discuss some properties of these parametric optimization problems and report on our computational experience in solving them. We also investigate the quality of the decision rules obtained with the static model as an approximation for the optimal decision rules of the dynamic model.

Solving the (1,1)-Centroid Problem in the Plane

Boglárka G.-Tóth[1] and J. Fernández[2]
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Hungary

[2]University of Murcia
Spain

A chain (the leader) wants to set up a single new facility in a competitive environment, where similar facilities of competitors, and possibly of its own chain, are already present. A future competitor (the follower) is expected to enter the market and locate also one single new facility at its best site. The best location and quality for the leader's facility are to be found such that the profit following the competitor's entry is maximized. Fixed demand points are assumed to split their demand probabilistically over all facilities in the market proportionally with their attraction to each facility, determined by the different perceived qualities of the facilities and the distances to them, through a gravitational type model. An exact interval branch-and-bound method is proposed to solve this hard-to-solve global optimization bi-level problem.

The Use of a Stochastic Approach for Life Cycle Assessment (LCA) for Mittal Steel Poland S.A. - a Case study on Krakow Plant Energy Generation

Bogusla Bieda
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Krakow, POLAND

This paper provides an overview of Life Cycle Assessment (LCA) and Life Cycle Inventory (LCI) techniques for energy production applied to a Power Plant of Mittal Steel Poland in Krakow, Poland. We present an energy medium generating scenario, using a stochastic approach for Life Cycle Assessment (LCA) conception for input/output data in the energy generating case study (including the electric energy, technology practice steam, blast to iron blast furnace, etc.). In this paper, LCA is limited to inventory analysis. LCI models for energy generation management decision support systems are based on a stochastic approach, because this technique accounts for uncertainties in the assumptions. Moreover, we perform a sensitivity analysis in LCI data collection to aid in the optimization of design aspects in the energy generation management systems. Monte Carlo simulation with the Excel spreadsheet and Crystal Balls software was used to develop scenarios for uncertainty inputs.

A tutorial for Global Optimisation Branch-and-Bound

Eligius Hendrix[1] and L. Casado[2]
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Universidad de Malaga
Europe

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Spain

Branch-and-Bound (B&B) algorithms for Global Optimization lead to a kind of guarantee that we obtain the global optimum. The aim of our contribution is to come to a didactical introduction for non-mathematic students of about 20 pages into the concepts of mathematical structures and resulting algorithms. How can structures be recognised and be used to derive bounds? How can bounds be used in an algorithmic context to construct algorithms leading to a guaranteed optimum? The idea is to elaborate small examples a student can elaborate by hand, such that the concepts are grasped.

In one page text with an example the structures of concavity, DC, Lipschitz continuity, Quadratic, Bilinear, Fractional Programming and Interval arithmetic are explained. We stress that in fact, use of DC and Lipschitz continuity requires value information to come to bounds, whereas concavity does not. It is sketched how value information is revealed by the other structures. A generic B&B algorithm is outlined. This is elaborated for two numerical examples from quadratic programming with the aim to illustrate generic features of B&B.

Optimization in R

Gerrit Gort and E.M.T. Hendrix
Wageningen University
The Netherlands

R is a general purpose statistical analysis program that is used nowadays on a global (i.e. worldwide) scale. The website of R (the letter "R" on Google guides you easily to it) mentions: "R is a language and environment for statistical computing and graphics". Its popularity stems from the fact that it is open source software, making it available for everyone for free. It can easily be extended using packages and contains the newest statistical developments by numerous contributions of statistical experts.

In the presentation, some of the capabilities of R in the field of (global) optimization are discussed, as it is used in general statistical practice. For illustration, an example is used, based on one of the most important statistical techniques: maximum likelihood estimation. In maximum likelihood, we try to find optimal parameter values, that is, parameter values for which the data have the highest likelihood to occur. The complexity of the resulting optimization problem can be very different depending on the case to be solved.

Robust Solutions of Bi-blend Recipe Optimisation with Quadratic Constraints

Inmaculada Garcia[1], L.G. Casado[1] and E.M.T. Hendrix[2]
[1]University of Almeria
Spain

[2]Wageningen University
The Netherlands

To find a cheap robust recipe for a blending problem that has quadratic requirements is a hard problem. In practice, companies are also dealing with so-called multi-blend problems where the same raw materials are used to produce several products. This complicates the search process for feasible and optimal robust solutions if we intend to guarantee the optimality and robustness of the final solution. We focus on possible solution approaches to solve bi-blending problems, where two end products are produced with partly the same raw materials. The problem is described and several search strategies based on Branch-and-Bound are analysed. We illustrate the whole process numerically.

High-Dimensional Phenomena and Global Optimization

Iskander Aliev and A. Zhigljavsky
School of Mathematics
University of Cardiff
United Kingdom

In recent years there has been a significant progress in understanding phenomena that occur in high-dimensional systems, those whose characteristic behaviour appears as the number of variables grows to infinity. Roughly speaking, the characteristic features of high-dimensional phenomena can be described as "unexpected uniformity" and "sharp discontinuity". In the present talk we will give an overview of recent results in this area and their relation to global optimization.

Global Optimization of Binary Lennard-Jones Clusters using the TRUST non-Lipschitzian Dynamics Code

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United States of America

The technological potential of alloy clusters and emerging paradigms of materials by design are driving a growing interest in the study of binary Lennard-Jones (BLJ) atomic clusters. The corresponding global optimization problem is extremely difficult because of the presence of homotopes. There are many more minima on the BLJ potential energy surface than for LJ clusters, while atomic composition further complicates structural complexity. Customarily, nano-cluster simulations start from some physically realizable lattice configuration, thus adding some form of "hard wiring" to the algorithm. Proposed schemes then operate discrete moves on the underlying lattice structure (e.g. the well-known Northby algorithm). Electronic databases document the resulting sets of putative global minima for BLJ clusters up to 100 atoms. A decade ago, a very promising approach to global optimization acronymed TRUST (Terminal Repeller Unconstrained Subenergy Tunneling) was introduced. This unconventional approach is applied here to BLJ clusters. We demonstrate that TRUST can find the putative global minima with the following advantages: (1) minima are found starting from unbiased random initial starting coordinates in the domain of interest, and (2) the computational cost is vastly reduced when compared to other available optimization algorithms.

Limited-Memory Interval Branch and Bound Algorithms

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France

Interval Branch and Bound algorithms have already been used to solve some industrial problems in a deterministic way. However, the exponential complexity of time and memory of these algorithms involve their intrinsic limits. We propose an extension of these kind of algorithms by introducing an upper bound to the available memory. Therefore, solutions will not be exact but heuristic. Moreover, the algorithms provide a lower bound on the exact solution to estimate the quality of the heuristic solution. Besides, limiting the memory reduces the exponential complexity of time to a polynomial complexity.

This new algorithm is being used at the GREM3 -LAPLACE laboratory in Toulouse (France) for the design of electromechanical actuators. The main idea of the method is to propose a reverse process of optimization via heuristics rather than improving local solutions by using meta-heuristics such as Taboo or VNS. We begin with an exact method and modify it into a heuristic. In this way, the quality of the solution can be evaluated.

Parallel Strategies for solving a Continuous Multiple Competitive Facilities Location and Design Problem

José Fernandez[1], J.L.Redondo[2], P.M.Ortigosa[2] and I. García[2]
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Spain

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Spain

We consider a continuous location problem in which a firm wants to set up two or more new facilities in a competitive environment. Both the locations and the qualities of the new facilities are to be found so as to maximize the profit obtained by the firm. This optimization problem has been solved in [1] using several approaches. Through a comprehensive computational study it was shown that the evolutionary algorithm UEGO is the heuristic which provides the best and more reliable solutions.

In this work, we parallelize UEGO in order to reduce the computational time of the sequential version while preserving its capability to find the optimal solutions. The parallelization follows a 'coarse grain' model where each processor executes the UEGO algorithm that evolves independently of the other processors during most of the time, although, occasionally, some genetic information can migrate from a processor to another according to a migratory policy. In order to determine the effects of the migration process, different migration mechanisms are implemented and executed using a large set of experiments.

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[1] J.L. Redondo, J. Fernández, I. García, and P.M. Ortigosa. Solving the multiple competitive facilities location and design problem on the plane. Evolutionary Computation, 2008. To appear.

Reformulation Techniques based on such RLT and RRLT Constraints

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The RLT is a useful technique for tightening the convex relaxation of non-convex QCQPs, among other problems. Reduced RLT (RRLT) representations utilize a subclass of relevant RLT constraints, and are especially useful when solving QCQPs subject to linear equality constraints. In this approach, the RRLT constraints pose a linear system of equations, involving original and RLT linearization variables, which provides an exact reformulation of the QCQP that has additional linear equality constraints but fewer quadratic terms than the original problem. The choice of the quadratic terms to replace depends on a given basis of the RRLT system. We provide a review of reformulation techniques based on such RLT and RRLT constraints. We present new results on how to choose a basis of the RRLT system that minimizes the "convexity gap" (the sum of the volumes defined by all the McCormick envelopes of the bilinear terms in the QCQP). Finally, we explain how to exploit RRLT systems to improve the performance of a spatial branch-and-bound algorithm applied to the QCQP.

Optimal Control of an introduced Herbivore Species: Economic Analysis of a Two Compartment Ecosystem Model

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This contribution reports on a multi-disciplinary control problem, where mathematical biologists, ecologists and economists co-operate to find effective control strategies against invasive plant species, while trying to conserve desired biodiversity of plant species. Invasive plant species pose a great problem to native plants, animals and ecosystems, and can have negative impacts on for instance agricultural practice. Biological control by means of a specialist herbivore might control such invasions. On the long run this is regarded a safer and more cost effective option than application of herbicides. Although the aim of an herbivore species is to perform as a biological control agent, favourable plants might also be consumed. In that case, the introduced herbivore might be controlled itself in that part of the ecosystem where favourable plant species naturally occurs.

We first explain a two compartment model with a managed (agricultural) compartment, where an invasive plant species is controlled by an introduced herbivore. In the other,

natural compartment, the favourable plant species competes with another plant species and is under attack of the herbivore that freely can disperse from the managed compartment. The dynamics and its dependence on parameter values are explained. For the economic optimisation analysis we sketch the procedure. The general results are discussed in an applied setting.

A Model Reference Adaptive Search Method for Stochastic Optimization with Applications to Markov Decision Processes

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We propose a randomized search method called Stochastic Model Reference Adaptive Search (SMRAS) for solving stochastic optimization problems. The method is a generalization of the recently proposed Model Reference Adaptive Search (MRAS) method for deterministic global optimization. It is based on sampling from an underlying probability distribution "model" on the solution space which is updated iteratively after evaluating the performance of the samples at each iteration. We present global convergence results of SMRAS in a general stochastic setting and explore its potential applications for solving Markov Decision Processes (MDPs). Numerical studies illustrate the performance of the method.

Stochastic Optimization Approaches for solving SUDOKU

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In this paper the Sudoku problem is solved using stochastic search techniques. The techniques are Cultural Genetic Algorithm (CGA), Repulsive Particle Swarm Optimization (RPSO), Quantum Simulated Annealing (QSA) and the Hybrid method that combines Genetic Algorithm with Simulated Annealing (HGASA). The results obtained show that the CGA, QSA and HGASA are able to solve the Sudoku puzzle with CGA finding a solution in 28 seconds, while QSA finding a solution in 65 seconds and HGASA in 1.447 seconds. This is mainly because HGASA combines the parallel searching of GA with the flexibility of SA. The RPSO was unable to solve the puzzle.

Applications of the Electromagnetism-Like Mechanism in Discrete Optimization Problems

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The electromagnetism-like mechanism (EM) is a meta-heuristic algorithm utilizing an attraction-repulsion mechanism to move sample points (i.e. our solutions) towards the optimality. In general, the EM method has been initially used to solve continuous optimization problems and it cannot be applied on discrete optimization ones. In this paper, we modify and extend the original EM method in order to make it applicable for discrete optimization problems. To show the efficiency of our proposed EM, we solve two famous combinatorial optimization problems, namely the traveling salesman problem (TSP) and the single machine scheduling problem. Furthermore, we compare our computational results obtained by the proposed EM with those results taken from the literature. Finally, we conclude that this method is capable of solving such well-known foregoing problems.

Development of a Higher-Order Conjugate Gradient Method for Optimizing Non-Linear Problems

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Kwara State, Nigeria

The conventional conjugate gradient method, CGM, was designed, mainly, for optimizing unconstrained quadratic functionals approximately. The CGM solves the problem:

$$\text{Optimize } F(x) = F(x) = F_0 + \langle a, x \rangle_H + \tfrac{1}{2}\langle x, Ax \rangle_H$$

where $a, x \in H$ (H being a Hilbert space), F0 is a constant and A is an n x n constant, symmetric and positive definite matrix. In practice, however, one often encounters functionals that are not necessarily smooth and for which the CGM yields grossly inaccurate results. This inadequacy is addressed with the development of a higher-order gradient method, HOGM. Among the interesting properties possessed by the HOGM are intrinsic conjugacy and rapid convergence. We are exploring further properties which guarantee the existence of a global optimum.

Global Optimization Applications in Biomedicine

Panos M. Pardalos
University of Florida
United States of America

In recent years, optimization has been widely used in many problems in biomedicine. These problems are inherently complex and very difficult to solve. In this presentation, we focus on global optimization techniques (multi-quadratic 0-1 integer programming) in computational neurosciences and bi-clustering (nonlinear fractional 0-1 integer programming) based data mining approaches in cancer research. We also discuss briefly several other applications.

New Heuristics and Exact Algorithms for the p-median Problem

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The p-median problem consists, given an mxn matrix with nonnegative entries, in choosing p lines such that the sum of minima of entities in those lines for all columns is smallest possible. It has many applications in location theory and clustering. Consequently, it has been much studied. In this presentation, we focus on heuristic methods of VNS-type as well as on their use within exact methods. This led to exact solution of instances with up to 20000 x 20000 matrices. Moreover, we briefly discuss the recent "message-passing" heuristic of Frey and Dueck which appears to be very promising.

On a Micromodel of Optimal Economic Development: An Application of Control Theory

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In micro- and macro-economic theory of consumer behaviour, utility preferencing and indifference are concomitants. In this Study, a mathematical strategy is wielded characterized by a positive monotonic transformation and global improvement of controls in the maximization of utility. Specifically, a study is undertaken of a macromodel of optimal-economic development. Tables of values are provided to aid decision-making.

Optimisation of Parameters of Statistical Procedures

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University of Cardiff
United Kingdom

Many statistical procedures have parameters which have to be optimized. Assume we want to estimate unknown parameters of a distribution. Then the natural optimization criterion (for choosing the parameters of the estimation procedure) is the average mean squared error of the estimators, where the averaging is made, for example, with respect to the prior distribution of unknown parameters of the model. In testing statistical hypotheses, the natural optimization criterion is the power of the statistical procedure. Arising optimization problems are always stochastic (where the objective function is computed with random errors); very often they are also multi-extremal. As illustrative examples, we consider several procedures of statistical analysis of time series including the singular-spectrum analysis for change-point detection.

Estimating the Minimal Value of a Function in Global Random Search: Comparison of Estimation Procedures

Vippal Savani, A. Zhigljavsky and E. Hamilton
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United Kingdom

For the estimation of the lower bound of a function over a continuous set, a variety of linear estimators are used, as well as the maximum likelihood estimator. The asymptotic mean square errors (MSE) of several linear estimators asymptotically coincide with the asymptotic MSE of the maximum likelihood estimator. We consider the non-asymptotic behaviour of different estimators and show that the MSE of the best linear estimators is superior to the MSE of the maximum likelihood estimator.

The Particle Collision Algorithm

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The Particle Collision Algorithm (PCA) is a recently introduced optimization concept similar to Simulated Annealing, without, though, the necessity of estimating the free corresponding parameters. It is loosely inspired by the physics of nuclear particle collision reactions, particularly scattering and absorption. A "particle" that reaches a promising area of the search space is "absorbed", while one that hits a low-fitness region is "scattered". PCA is also a Metropolis algorithm, as a solution worse than the currently best may be accepted with a certain probability. In this article, we introduce a hybridization of PCA and the well-known Hooke-Jeeves local search algorithm, where the latter algorithm exploits the most promising areas of the search space. Our new algorithm, HJ-PCA, is applied to test functions from the literature and to a practical problem and shows to perform well when compared to other methods.

Stochastic Global Optimization Using Discrete and Mixed Hit-and-Run

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Stochastic global optimization algorithms can be viewed as sampling points from distributions that have an increasing probability of sampling close to the optimum. Successful optimization algorithms over continuous domains have made use of Hit-and-Run, a Markov chain Monte Carlo sampler known to be the most efficient method for sampling from log-concave distributions over convex bodies in Euclidean space. Recently, we have developed Discrete Hit-and-Run (DHR) that preserves many of the desirable theoretical properties as continuous Hit-and-Run. We prove that DHR asymptotically approaches an arbitrary distribution in a manner similar to Hit-and-Run.

In addition to this asymptotic analysis, we investigate finite-time behaviour of DHR. We also develop Mixed Hit-and-Run (MHR), that combines aspects of continuous and discrete Hit-and-Run, and demonstrate its use in a global optimization algorithm for mixed continuous/discrete problems. Theoretical and computational results will be presented.

Steam System Network Optimization Using Process Integration: Embracing Boiler Efficiency

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The traditional steam system comprises of a steam boiler and the associated heat exchanger network (HEN). Most research published in literature tends to address both the elements of the steam system as separate entities instead of analyzing, synthesizing and optimizing the overall system in a holistic manner. True optimality of the steam system can only be achieved if the analysis is conducted within an integrated framework. Process integration has proven to be a powerful tool in similar situations. This project involves the development of a process integration framework using conceptual and mathematical analysis without compromising boiler efficiency.

Kruger National Park

Kruger National Park is the largest game reserve in South Africa. It covers 18,989 square km (7,332 sq mi) and extends 350 km (217 mi) from north to south and 60 km (37 mi) from east to west.

To the west and south of the Kruger National Park are the two South African provinces of Mpumalanga and Limpopo. In the north is Zimbabwe, and to the east is Mozambique. It is now part of the Great Limpopo Transfrontier Park, a peace park that links Kruger National Park with the Gonarezhou National Park in Zimbabwe, and with the Limpopo National Park in Mozambique.

The park is part of the Kruger to Canyons Biosphere, an area designated by the United Nations Education and Scientific Organisation (UNESCO) as an International Man and Biosphere Reserve (the "Biosphere").

Attractions

Kruger National Park has nearly 2 million hectares of unrivalled diversity of life forms fuses with historical and archaeological sights - this is real Africa. The world-renowned Kruger National Park offers a wildlife experience that ranks with the best in Africa.

Established in 1898 to protect the wildlife of the South African Lowveld, this national park of nearly 2 million hectares, is unrivalled in the diversity of its life forms and a world leader in advanced environmental management techniques and policies. Truly the flagship of the South African National Parks, Kruger is home to an impressive number of species: 336 trees, 49 fish, 34 amphibians, 114 reptiles, 507 birds and 147 mammals. Man's interaction with the Lowveld environment over many centuries - from bushman rock paintings to majestic archaeological sites like Masorini and Thulamela - is very evident in the Kruger National Park. These treasures represent the cultures, persons and events that played a role in the history of the Kruger National Park and are conserved along with the park's natural assets.

Plants

The Kruger National Park is divided into six eco-systems: Baobab sandveld, Mopane scrub, Lebombo knobthorn-marula bushveld, mixed acacia thicket, Combretum-silver clusterleaf woodland on granite and riverine forest. Altogether it has 1,982 species of plants.

Birds

Out of the 517 species of birds found at Kruger, 253 are residents, 117 non-breeding migrants, and 147 nomads. Also, eagles can be found there.

Mammals

All the Big Five game animals are found at Kruger National Park, which has more species of mammals than any other African Game Reserve (at 147 species). There are webcams set up to observe the wild life.

As of 2004, the park has counted approximately 25150 African Buffalo, 200 African Hunting Dogs, 350 Black Rhinoceros, 32000 Burchell's Zebras, 500 Bushbucks, 200 Cheetahs, 300 Common Eland, 9000 Giraffes, 5000 Greater Kudus and 3000 Hippopotamus

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