Yalta Conference on Discrete and Global Optimization

International Conference in Honor of the 50th Anniversary of the Founding of Glushkov Institute of Cybernetics

July 31-August 2, 2008

Yalta, Ukraine

Conference Program

INDUSTRIAL AND SYSTEMS ENGINEERING | TEXAS A&M ENGINEERING

Welcome to Yalta!

Dear Colleague,

We are pleased to welcome you in Yalta, one of the world's most famous historical conference sites, as it makes new history for discrete and global optimization. We hope that this event will provide an excellent forum for exchange of ideas, sharing the latest advances and challenges in theoretical and applied optimization, and discussing opportunities for future international collaborations on research and education in these areas. Enjoy the conference and your stay in Yalta!

Conference Organizers

Acknowledgements

The conference has been organized with the financial and technical support from Glushkov Institute of Cybernetics of the National Academy of Sciences of Ukraine and the Department of Industrial and Systems Engineering in Texas A&M University's Dwight Look College of Engineering.

The Department of Industrial and Systems Engineering in Texas A&M University's Dwight Look College of Engineering was established in 1941. It has been consistently ranked in the top 10 departments in the United States over the past 10 years by the Gourman Report, the National Research Council and US News and World Report.

We provide education, research and professional service programs that contribute to the economic and technological advancement of the state, the nation and the world. Our outstanding faculty is nationally and internationally recognized for the quality of its research and teaching, and its leadership in the profession. We have especially strong teaching and research programs in optimization, manufacturing and production systems, operations research, applied probability and statistics, and system simulation.

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Conference Schedule

Thursday, July 31: Morning Sessions

8:00–8:30	Registration
8:30–9:00	Opening Remarks
Session T.1	Chairman: Sergiy Butenko
9:00-9:45	**Keynote lecture** Panos M. Pardalos **Optimization and Data Mining in Biomedicine**
9:45-10:15	I. V. Sergienko, V. Shylo, P. M. Pardalos, and O. Shylo **Solving the Problem of Finding Maximum Size Error Correction Codes**
10:15 –10:30	**Coffee Break**
Session T.2	Chairman: Panos Pardalos
10:30-11:00	Sergiy Butenko and Oleg Prokopyev **On Complexity of Some Gap Recognition Problems in Optimization**
11:00-11:30	Petro I. Stetsyuk **On Interesting Properties of Shor's Upper Bounds for Weighted Stability Number of a Graph**
11:30-12:00	Oleksiy P. Lykhovyd and Petro I. Stetsyuk **On Numerical Experiments with Two LP-oriented Upper Bounds for the Stability Number of a Graph**
12:00-1:30	**Lunch**

Thursday, July 31: Afternoon Sessions

Session T.3 Chairman: Volodymyr Shylo

1:30-2:15 **Keynote lecture**
Yury Evtushenko and Mikhail Posypkin
Covering Techniques for Global Optimization

2:15-2:45 Mikhail Posypkin
A Programming Environment for Solving Large Scale Optimization Problems on Multiprocessors and the Grid

2:45-3:15 **Coffee Break**

Session T.4 Chairman: Gerardo Toraldo

3:15-4:45 Joaquín Pacheco, Julian Molina, and Manuel Laguna
A Linked Tabu Search for a Bi-Objective Routing Problem; Application to School Bus Routes in Rural Areas

3:45-4:15 Daniela di Serafino, Susana Gomez, Leopoldo Milano, Gerardo Toraldo, and Filippo Riccio
On the Use of Genetic Algorithms for Gravitational Wave Detection

4:15-4:45 D. Matsypura, D. Oron, V. G. Timkovsky
Option Spreads: Centipedes That Cannot Have More Than 134 Legs

7:00 **Banquet Dinner**

Friday, August 1: Morning Sessions

Session F.1 Chairman: Volodymyr Melnykov

9:00-9:45 **Keynote lecture**
Vladimir Tsurkov
Multidimensional Knapsack Problems with Stair Structure of Constraints

9:45-10:15 Volodymyr Shylo and D.E. Korenkevich
A Global Equilibrium Search Algorithm for the Quadratic Assignment Problem

10:15 –10:30 **Coffee Break**

Session F.2 Chairman: Oleg Shylo

10:30-11:00 Michael A. Osborne, Roman Garnett and Stephen J. Roberts
Gaussian Processes for Global Optimisation

11:00-11:30 S. Scheuring and L. N. Trefethen
The Chebfun System - A New Alternative to Global Optimization?

11:30-12:00 Volodymyr Melnykov
On Finding Maximum Likelihood Estimates for Dependent Data in Finite Mixtures via EM Algorithm

12:00-1:30 **Lunch**

Friday, August 1: Afternoon Session

Session F.3 **Poster Presentations**

1:30-3:00

I.G. Kryvonos, I.V. Krak, O.V. Barmak, G.M. Efimov
Some Problems of Data Smooth Approximation for Realistic Models Analysis and Synthesis

I.V. Sergienko, E.O. Lebedev, and N.V. Semenova
Discrete Optimization of Retrial Queues in Set of Multithresholds and Hysteresis Strategies

I. V. Sergienko, V. P. Shylo, and V.P. Ogar
The Global and Discrete Optimization Problems Arising in Market Power Industry

Yuriy Shkvarko
Experiment Design Optimization Paradigm for Super-Resolution Imaging with Remote Sensing Data

V. Shylo, V.O. Roschyn, D.O. Boyarchuk
Effective Discrete Programming Algorithms for Intellectual Data Mining Analysis

Presentations by students participating in U.S. - Ukraine IRES Program:
Jean-Paul Baharet
David John Jeziorski
Erika Short
Iryna Zhukovska
Anna Lytvynenko

Saturday, August 2: Morning Sessions

Session S.1 Chairman:

9:00-9:45 **Keynote lecture**
Yaroslav D. Sergeyev
Numerical Computations with Infinite and Infinitesimal Numbers: Foundations and the Infinity Computer

9:45-10:15 Oleg Granichin and Dmitry Shalymov
Speaker-Independent Isolated Words Recognition Problem Solving Based on Simultaneous Perturbation Stochastic Approximation Algorithm

10:15 –10:30 **Coffee Break**

Session S.2 Chairman:

10:30-11:00 Oleg A. Shcherbina
Local Elimination Algorithms in Discrete Optimization

11:00-11:30 Maria Fonoberova
Optimal Flows in Dynamic Networks and Algorithms for their Finding

11:30-12:00 Vasyl Gorbachuk
Simple Descent Algorithm without Subproblems for a class of Nonsmooth Bilevel Programming

12:00-1:30 **Lunch**

Saturday, August 2: Afternoon Sessions

Session S.3 Chairman:

1:30-2:00 Anatoliy Kosolap
Quadratic Optimization with Nonconvex Quadratic Constraints

2:00-2:30 L. Hulianytskyi and S. Sirenko
A New Metaheuristic Approach Combining ACO and *H*-method

2:30-3:00 Steffen Rebennack
Markov Chain Monte Carlo Method for the Maximum Stable Set Problem

3:00-3:30 Vitaliy Yatsenko
Applications of Global Optimization in Space Weather Prediction

3:30 Conference Adjournment

Abstracts of the Talks

Sorted in alphabetical order of the first author's last name
Titles of poster presentations are marked with *

Attainability of Optimal Solutions of Lexicographical Maximization Problem with Convex Criterion Functions on their Weighed Sum*

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Abstract

The lexicographical maximization problem is considered

$$\max{}^{L} F(x) = (f_1(x), f_2(x), ..., f_q(x)), \; x \in X, \tag{1}$$

where $X = \{x \in R^n | Ax = b\}$ is a nonempty limited set, $f_i(x)$, $i = 1, 2, ..., q$ are convex on X functions. Let us introduce the following notations: X^V is a set of permissible solutions which are the vertices of set X, $\hat{X}(F)$ is a set of optimal solutions of problem (1).

Let $\hat{X}$ is a set of optimal solutions of the problem

$$\max f(x), \; x \in X, \tag{2}$$

where $f(x)$ is convex on X function. Then the following statements are valid.

Lemma 1. *If* $\hat{X} \neq \emptyset$, *then* $\hat{X} \cap X^V \neq \emptyset$.

Lemma 2. *If* x^*, $x^* \notin X^V$ *is an optimum solution of problem* (2) *and*

$$x^* = \sum_{i=1}^{m} \beta_i x^i, \; x^i \in X^V, \; \beta_i > 0, i = 1, 2, ..., m, \; \sum_{i=1}^{m} \beta_i = 1, \; m \leq N,$$

then points x^i, $i = 1, 2, ..., m$ *are optimum solutions of this problem.*

Theorem 1. *If* $\hat{X}(F) \neq \emptyset$, *then* $\hat{X}(F) \cap X^V \neq \emptyset$.

Let $\alpha_q > 0$, and all of other coefficients $\alpha_{q-1}, \alpha_{q-2}, ..., \alpha_1$ are gradually obtained in accordance with the condition

$$\alpha_r > \frac{1}{\mu_r} \sum_{l=r+1}^{q} \alpha_l M_l, \; r = q-1, q-2, ..., 1,$$

where $0 < \mu_r \leq \inf\limits_{\substack{x, y \in X^V \\ f_r(x) \neq f_r(y)}} |f_r(x) - f_r(y)|$; $M_l \geq \max\limits_{x \in X} f_l(x) - \min\limits_{x \in X} f_l(x)$.

Theorem 2. *Let* $\hat{X}^*$ *is a set of optimum solutions of the problem*

$$\max \; L(x) = \sum_{i=1}^{q} \alpha_i f_i(x), \; x \in X.$$

Then $\hat{X}^* \cap X^V \subset \hat{X}(F)$.

On Complexity of Some Gap Recognition Problems in Optimization

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Abstract

We study the complexity of several related gap-recognition problems arising in graph theory and nonlinear optimization. The obtained results allow to theoretically justify the usage of some simple greedy heuristics for solving hard optimization problems in graphs.

Covering Techniques for Global Optimization

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Abstract

Global optimization remains an important area of active research. The paper discusses new techniques for solving continuous global optimization problems in the cases where the objective function, its gradient and Hessian are Lipschitzian. Unconstrained problems and problems with box constraints are considered. For all cases we introduce new lower bounds and pruning rules for use in Branch-and-Bound method and theoretically estimate convergence rates. The theoretical results are confirmed by computational experiments. Obtained results show that using gradient information can notably improve the performance of Branch-and-Bound methods w.r.t. conventional Lipschitzian approach. It is interesting that for some problems with box constraints the proposed algorithm can converge to an exact solution in a finite (and relatively small) number of steps.

For acceleration of a computational process the various local methods are used (conjugate gradient, basing-hoping etc.) For many practical problems the complexity of search is beyond capabilities of a single-CPU machine. For such problems using multiprocessors is inevitable. Fortunately Branch-and-Bound algorithms are highly suitable for parallel implementation. We describe the parallel implementation of proposed algorithms and demonstrate its performance on a number of test problems. Experimental results are obtained on different multiprocessors for a different number of processors.

Optimal Flows in Dynamic Networks and Algorithms for Their Finding

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Abstract

The paper is dedicated to investigation and solving optimal flow problems on dynamic networks with different forms of restrictions by parameters of network and time. Optimal dynamic flow problems are used to model numerous real world phenomena arising in applications within almost all industries. These applications include, for example, production-distribution systems, fleet management, evacuation, scheduling, and communications. In such optimization problems the factor time is a key ingredient to the problem formulation. In classical network flow theory, however, this factor is not sufficiently reflected. For that reason, we consider network flows over time, which provide an adequate framework for modeling time-dependent and network-structured problems. We extend and generalize the classical optimal flow problems on networks for the cases of nonlinear cost functions on arcs, multicommodity flows and time- and flow-dependent transactions on arcs of the network. We assume that all parameters of the network depend on time. In many applications, the amount of time needed to traverse an arc of the underlying network increases as the arc becomes more congested and it also depends on the moment of time. So, we also investigate the dynamic models with transit time functions that depend on flow and time. Moreover, we consider the optimal dynamic generalized network flow problem which extends the traditional problem by introducing the gain-factor in the model. To develop algorithms for solving the considered flow problems we use the special techniques based on the time-expanded network method together with classical optimization methods. We also investigate multiobjective versions of the optimal multicommodity flow problems by using the concept of cooperative and noncooperative games. Each commodity corresponds to a player with his own vector utility function that has to be optimized in response to the actions of the other players. All players perform this optimization simultaneously and at the same time players are interested to preserve Nash optimality principle when they interact between them. We solve the considered problem on the basis of the concept of multiobjective games using the notion of the Pareto-Nash equilibrium.

Speaker-Independent Isolated Words Recognition Problem Solving Based on Simultaneous Perturbation Stochastic Approximation Algorithm

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Abstract

This paper represents the using of the new simultaneous perturbation stochastic approximation algorithm (SPSA) for the solving of the speaker-independent noise robust isolated words recognition problem. The noise robust speech recognition method which is based on mel-frequency cepstral coefficients (MFCC) is briefly described. Main features of SPSA algorithm are shown. The effectiveness of the proposed method is demonstrated.

Abstract Problems of the speech recognition are still important today. Many of modern methods which are used to solve this problem are computationally resource-intensive. The capacity of such resources is often bounded. For many algorithms it is impossible to use it in portable devices. This moves researches to find more effective methods. This paper represents the using of the new simultaneous perturbation stochastic approximation algorithm (SPSA) for the solving of the noise robust isolated words recognition problem. Due to SPSA's simplicity and small number of operations per each iteration, this algorithm can be considered as an alternative method for real time speech recognition approaches. It can be efficiently used in the complex models with a stochastic nature. For example, in the stochastic neural network models. The noise robust speech recognition method which is based on mel-frequency cepstral coefficients (MFCC) is briefly described. Each sound-wave that entered in the recognition system includes some noise. In case of noisy measurements of loss function SPSA algorithm keeps reliable estimations under almost arbitrary noise. It is very important to the speech recognition problem where the noise represents often the phase or spectrum shifts of signal, or external environment, or recording device settings, etc. SPSA algorithm is based on trial simultaneous perturbations which provide appropriate estimations under almost arbitrary noise. The main characteristic of SPSA algorithm is that only two measurements of function to approximate loss function gradient are needed for any dimension of an unknown feather vector. Based on this characteristic it is convenient to use SPSA algorithm in speech recognition problem where feature vectors of large dimensions are used. It is simple to use this kind of algorithm in optimization problems with large number of variables. In that way we have an opportunity to operate with many words at once. Moreover its realization is simple for understanding and embedding in electronic devices.

Simple Descent Algorithm without Subproblems for a class of Nonsmooth Bilevel Programming

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Abstract

Consider the class of nonsmooth bilevel programming problems [1]:

$$\begin{array}{l} \min F(x) \\ x \in S_2 = \arg\min\{f(x) : x \in X\} \end{array} \quad , \tag{3}$$

where $F : E^n \to E^1$, $f : E^n \to E^1$ are convex functions, X – closed convex bounded subset in E^n. Denote S_1 the set of problem (3) solutions.

Theorem 1 [2]. All the limit points of $\{x^s\}$, generated by the algorithm

$$x^{s+1} = \pi_X(x^s - \lambda_s z^{s+1}),$$

$$z^{s+1} = \sigma_s G^s + (1 - \sigma_s) g^s,$$

$$\sigma_s \in (0, 1],$$

$$||G^s||, ||g^s|| \le C \quad \forall s,$$

$$\sigma_s \to 0,$$

$$\sum_{s=0}^{\infty} \lambda_s \sigma_s = \infty,$$

$$\frac{\lambda_s}{\sigma_s} \to 0,$$

$$\frac{\varepsilon_s}{\sigma_s} \to 0,$$

$$\lambda_s > 0, \quad \varepsilon_s \ge 0,$$

$\pi_X(\cdot)$is orthogonal projector onto X, $g^s \in \partial_{\varepsilon_s} f(x^s)$, $G^s \in \partial_{\varepsilon_s} F(x^s)$ are arbitrary -subgradients, $s = 0, 1, 2, ...,$ belong to S_1.

The algorithm suggested is similar to the descent algrorithm [3], but doesn't need any search or subproblems on iterations.

1 References

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A New Metaheuristic Approach Combining ACO and H-method

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Abstract

Combinatorial optimization problems and approximate algorithms of their solving are considered in the paper. An approach to COP formalization is suggested, which allows not only to distinguish single COP classes, but also to classify optimization problems in general. A new metaheuristic method of solving NP-hard combinatorial optimization problems is proposed, which is based on two population algorithms – ant colony optimization (ACO) and H-method. ACO is bio-inspired example of swarm intelligence and has been successfully applied to a number of hard combinatorial optimization problems. H-method is a population-based metaheuristic, applying during the search process specially defined segments. The method shares remote similarities with a well-known nondifferential continuous optimization method – the Nelder-Mead method. The presented method was tested on benchmark instances of multidimensional assignment problem.

Quadratic Optimization with Nonconvex Quadratic Constraints

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Abstract

In this paper we consider optimization problems defined global minimum by a convex quadratic objective function and a finite number of nonconvex quadratic inequality constraints. Numerous problems in real world applications, including problems in planning and scheduling, economies, financial, engineering design, and control are naturally expressed as quadratic problems. We consider the NP-hard problem of finding a minimum norm vector in n-dimensional real Euclidean space, subject to m nonconvex quadratic constraints. In recent years, for search global minimum general quadratic functions use branch and bound (B&B) search strategies, convex underestimation of nonconvex functions and semidefinite relaxation and second order cone programming relaxation. This relaxation only in simple cases will be exact. In this talk we propose new deterministic method for global optimization for general quadratic problems. These problems can be formulated as follows:

$$\min\{\|x\|^2 | x^T A_i x + b_i^T x + c_i \leq q, i = 1, \ldots, m, x \in E^n\}, \tag{1}$$

where A_i is an $n \times n$ symmetric matrices, $b_i \in E^n, c_i, q \in E^1$. The problem (1) will be transformed to an equivalent problem

$$\min\{\|x\|^2 | x^T A_i^* x + b_i^T x + c_i \leq d, i = 1, \ldots, m, r\|x\|^2 + q = d, x \in E^n\}, \tag{2}$$

where $A_i^* (A_i^* = A_i + r\|x\|^2)$ are positive definite matrices. It is necessary to find the minimum value d at which solution of a problem (2) is feasible for a problem (1). The solution of a problem (2) continuously depends on parametre d, hence it is sufficiently to consider only discrete set of values on variable d. For the solution of a problem (2) we use outer approximation an intersection of ellipsoids. We search ellipsoid the minimum volume of as follows:

$$\min\{\sum \alpha_i^2 | \sum \alpha_i A_i^* (x_i^0 - x^c) = 0, \sum \alpha_i = 1, \alpha \geq 0\},$$

where x_i^0 are centers of ellipsoids and x^c - center of the intersection of ellipsoids. Covering ellipsoid we use for the solution of a problem (2). Our outcomes show that this approach is both conceptually and computationally attractive.

Some Problems of Data Smooth Approximation for Realistic Models Analysis and Synthesis*

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Abstract

The methods of realistic models analysis and synthesis are examined for research of human mimic and emotional states. For data approximation of non-uniform rational B-splines (NURBS) are used. The problems of models synthesis, fitting and morphing are solved base on NURBS approximation. For the tasks of analysis as features of splines control points are selected. New properties and algorithms of NURBS-splines construction are brought for the decision of the indicated over tasks. Numeral experiments confirm efficiency of the offered methods.

On Numerical Experiments with Two LP-oriented Upper Bounds for the Stability Number of a Graph[1]

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Abstract

We consider two LP-oriented upper bounds for the stability number of a graph based on approximation of the stable set polytope by linear inequalities for odd cycles and p-wheels. Algorithms for finding these upper bounds use solution of a linear programming problem with a finite number of edge and clique constraints, odd cycle and p-wheel constraints, and procedure for calculation of violated odd cycles, that can be done in polynomial time. For generating violated linear inequalities related to p-wheels a greedy method, in which vertices with maximal weights obtainted from solution of LP-problem are included consecutively, is used.

The first upper bound is related to CSTAB(G) polytope and is exact for t-perfect graphs. The second upper bound, obtained by adding valid inequalities for p-wheels in a graph to the constraints of CSTAB(G) polytope, is also exact for t-perfect graphs. For many other graphs it can be considerably tighter bound than the upper bound based on CSTAB(G) polytope. A large number of numerical experiments on Dimacs examples (`http://dimacs.rutgers.edu/Challenges/`), BHOSLIB examples (`http://www.nlsde.buaa.edu.cn/~kexu/benchmarks/`) and for graphs arising from coding theory taken from the library of N. Sloane (`http://www.research.att.com/~njas/doc`) were accomplished. The results showed that for many examples upper bounds, which are equal to the stability number, were found.

The algorithms may be applied also to finding upper bounds for clique number, k-clique number and k-stability number.

[1]Supported by CRDF (Cooperative Grants Program, Project UKM2-2812-KV-06).

Option Spreads: Centipedes That Cannot Have More Than 134 Legs

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Abstract

In December 2005, the U.S. Securities and Exchange Commission approved margin rules for complex option spreads with 6, 8, 10, 12 and 14 legs (option positions). Only basic option spreads with 2, 3 or 4 legs were recognized before. This paper presents a mathematical model for option spreads with any number of legs and proposes their full characterization as vectors of a linear space. Taking advantage of complex option spreads substantially reduces margin requirements and, at the same time, adequately estimates the risk for margin accounts with options. We show that risk free option combinations, i.e., invariant to underlying security market price changes, can be characterized in a similar way. We also give recommendations how to create more efficient hedging margin rules for options.

On Finding Maximum Likelihood Estimates for Dependent Data in Finite Mixtures via EM Algorithm

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Abstract

The expectation and maximization (EM) algorithm is a widely used tool for finding maximum likelihood estimates (MLEs) in problems with missing or unobserved data. One particular application where the EM algorithm is standard is finite mixture models. Here, the observed classification of observations is considered "missing". Although the case of independent identically distributed observations is usually the most appealing, there are many problems with data having dependent structure. In these cases, the application of the EM algorithm is not straightforward as E-step calculations cannot be done in a usual way. The all-permutation solution is often computationally prohibitive. To address this issue, we suggest the Markov Chain Monte Carlo (MCMC) approach. As an application, we consider a proteomics study in two-dimensional gel electrophoresis which is a biochemical technique that combines approaches of isoelectric focusing and SDS-polyacrylamide gel to achieve simultaneous separation of protein mixtures on the basis of charge and molecular weight. Upon staining, each protein on such gels can be characterized by intensity that reflects its abundance in the mixture. This can be used to determine differentially expressed proteins under different experimental conditions. Through a set of experiments and data-based simulations, we demonstrate that our approach based on stochastic calculations is more successful than a "naive" t-test that ignores the uncertainty in spot matching.

This research is joint with Ranjan Maitra and Dan Nettleton. Support was provided, in part, by the National Science Foundation awards NSF CAREER DMS-0437555, NSF DMS-0091953 and NSF IOS-0236060.

Gaussian Processes for Global Optimisation

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Abstract

We introduce a novel Bayesian approach to global optimisation using Gaussian processes. Other optimisation algorithms employing Gaussian processes (under the name "kriging") have been proposed by [1] and [4]. However, our approach rests upon more principled Bayesian foundations and hence is able to correct some flaws in the aforementioned algorithms, while leading to several powerful extensions. It provides a natural balancing of the dual demands of exploration and exploitation within the context of optimisation. The efficacy of our algorithm is demonstrated with its performance on a wide range of canonical test problems.

The key concept in our approach is to frame optimisation as an optimal sequential decision problem over potential function evaluations. Imagine that we have an unknown $y(x)$ that we seek to minimise. To evaluate $y(x)$ is expensive in either time or energy, and so we must restrict ourselves to a finite number of function evaluations $\boldsymbol{y}_D$. Ultimately, we must return a final point x_M in the domain, where the cost of this choice is $y(x_M)$: as we aim to minimise our costs, we aim to minimise $y(x_M)$.

Gaussian processes [3] have laid down diverse roots in the machine learning community over the last decade. They offer a convenient and flexible method for function estimation, a problem at the heart of optimisation. This is made explicit by techniques of optimisation that employ response surfaces or surrogates. Our goal is to build a statistical picture of the function's overall form given our observations of it, $\boldsymbol{y}_D$. On that basis, we can determine where best to evaluate the expensive function in future.

The "expected improvement" criterion used to do this by, for example, [1], is conceptually close to the Bayes optimal approach for our decision problem. However, we can improve further upon this criterion by considering multiple function evaluations into the future. Our sequential formulation of a Gaussian process [2] also offers a principled means to marginalise a model's hyperparameters, and indicates how we can trivially incorporate noisy observations or observations of the derivative. This final fact also leads to an innovative resolution of conditioning issues. We conclude by discussing logical extensions to our technique to address multiple fidelity and concept-drift problems. Throughout we contrast our Bayesian formalism with several *ad hoc* proposed alternatives.

References

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A Linked Tabu Search for a Bi-Objective Routing Problem; Application to School Bus Routes in Rural Areas

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Abstract

The minmax VRP is a variant of classic VRP in which the objective is to minimize the duration of longest route. Maybe, this model has been analyzed less than others VRP variants. However it appears in some real situations, specifically several of them in the context of school transport in rural areas. In this work we consider the VRP with two objectives: To minimize the duration of the longest route and to minimize the total duration of all routes. The trade-off in this problem is between service level, which is represented by the first objective (maximum time that a pupil pass in the bus), and operational cost, which is represented by the second objective. For obtain good approaches to efficiency curve a Tabu Search based algorithm is designed and some comparisons with classic strategies for Multi-objective problems are also reported.

Optimization and Data Mining in Biomedicine

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Abstract

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

A Programming Environment for Solving Large Scale Optimization Problems on Multiprocessors and the Grid

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Abstract

Global optimization (GO) problems frequently arise in practice. Application examples include potential energy minimization, financial and economical forecasting, robot design and manipulating, VLSI layout design and many others. Unfortunately a significant fraction of such problems can not be solved by existing methods on a single-CPU workstation. This makes the use of parallel and distributed computing inevitable. In the talk an environment for solving GO problems on multiprocessor systems and on the Grid are presented. It provides a generic infrastructure for branch-and-bound, heuristic methods and combined approaches. Currently several resolution methods for knapsack and continuous global optimization problems are supported. The environment is designed to be easily extended: its flexible modular structure and separation of problem-specific and problem-independent parts make implementing new optimization problems a relatively simple task. The system is resistible to hardware and network failures in the Grid environment and supports checkpoints mechanism, i.e. the computation can be interrupted at any moment and then continued later. To illustrate the performance of our tools experimental results for different optimization problems and computing platforms are presented.

Markov Chain Monte Carlo Method for the Maximum Stable Set Problem

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Abstract

The Chebfun System - A New Alternative to Global Optimization?

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Abstract

The Chebfun System is a new object-oriented Matlab module with the capacity to perform a wide range of numerical linear algebra operations on piecewise-smooth functions, including global optimization. It is currently under development by a group led by Prof. L.N. Trefethen in the Numerical Analysis Group at the University of Oxford. In Chebfun functions are split at breakpoints, which are determined by numerical root-finding, recursive subdivision or automatic edge detection. Each part of the function is then approximated through polynomials in Chebyshev points. Finally, global optima of the polynomials are quickly computed using recursive colleague matrix root-finding. If necessary, high accuracy of the optima may be achieved, by applying local search methods. This paper describes recent adjustments to Chebfun to increase its efficiency, the performance of which is then compared to other state of the art solvers. While Chebfun is still under development, it is clear that it already provides a "user-friendly", efficient and convenient alternative to solve unconstrained global optimization problems in low dimensions.

On the Use of Genetic Algorithms for Gravitational Wave Detection

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The detection of gravitational waves from coalescing binaries through the Matched Filtering [1] approach, leads to a box constrained global optimization problem, where the objective function is highly nonlin-ear, with many local minima, due to the dense amount of noise. The detection of a possible signal becomes then a difficult problem. In this work a real coded genetic algorithm [2] is considered in which the choice of the initial population is specifically tailored to the specific problem. We analyze different combinations of selection, crossover and muta-tion operators on three representative test problems, with the aim of capturing the specificity of the problem, thus reducing the number of function evaluations, while preserving the accuracy of the solution. A numerical comparison with a grid search algorithm, widely used in the astrophysics community [3], shows the effectiveness of the ge-netic algorithm.

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Numerical Computations with Infinite and Infinitesimal Numbers: Foundations and the Infinity Computer

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Abstract

A new computational methodology for executing calculations with infinite and infinitesimal quantities is described. It is based on the principle 'The part is less than the whole' introduced by Ancient Greeks and applied to all numbers (finite, infinite, and infinitesimal) and to all sets and processes (finite and infinite). It is shown that it becomes possible to write down finite, infinite, and infinitesimal numbers by a finite number of symbols as particular cases of a unique framework. The new methodology allows us to introduce the Infinity Computer working with all these numbers. Philosophical issues are discussed. A number of examples is given. The Infinity Calculator using the Infinity Computer technology is presented during the talk. Additional information can be downloaded from the page http://www.theinfinitycomputer.com

Discrete Optimization of Retrial Queues in Set of Multithresholds and Hysteresis Strategies[*2]

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Abstract

Retrial queues stimulate the functioning of nodes in modern informational-telecommunicational networks (ITN). The main purpose of simulation consists of an analysis and calculation of basic functioning characteristics for ITN tacking into account efficiency increase (decrease of information delay and aging, traffic expansion, increase of reliability). To reach the purpose it is necessary to develop models with controlled parameters. The control means adaptive (depending on a state of the system) variation of model parameters such as a rate of input flow, service rate, rate of repeats. We introduce the model control to maximize an economic criterion of quality connected with functioning of the system and, at last, to increase an efficiency of their work.

In the paper we consider the models of multi-channel retrial queues, queues with impatient calls and queues with a finite number of sources of primary calls. In this model system parameters were controlled by multithresholds or hysteresis strategies. A new approach was proposed to construct objective functions in optimization problems under consideration.

The results of construction and ground of mathematical models and de-composition methods of exact and approximate solution of complex discrete optimization problems which arise in an analysis and optimization of the Markov systems with retrial calls and controlled local characteristics are presented. They are based on approximation their problems by more simple structures.

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The Global and Discrete Optimization Problems Arising in Market Power Industry*

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Abstract

The economy of Ukraine basically works on market principles of pricing, a supply and demand that ensures the real mechanism of promoting of new, more effective "know-how" of production and step-by-step substitution of old, ineffective process engineering's with today. At the same time strongly monopolized sector of economy - electric power industry still works in conditions of state regulation. Due to specific features of the electric power as product, the deregulation of this sector of economy in all countries with market economy (Great Britain, USA, etc.) was carried out relatively late, starting in the nineties of the last century. The late deregulation was promoted by the development of electronic communication system, an increase of computational capabilities and a decrease of computer equipment costs. Additionally, the protocols and mechanisms of interaction of computer intelligence systems have been developed, the effective optimization methods and software were offered allowing effective tools ensuring operation of the market of the electric power and power systems in real time. Due to an inevitable deregulation of electric power industry, Ukraine should solve the following problems:

1. Learning of world experience, development of the concept of a deregulation of electric power industry.
2. Development (adaptation) of optimization algorithms for the real tasks arising in conditions of market electric power industry, their code implementation, an estimation of efficiency.
3. Development of the architecture of an information system for support of functioning of the electric power market.
4. Estimation of prospective outcomes of deregulation.
5. Developing plan of activities towards the deregulation of electric power industry.

First of all problems of item 2 are of interest for us. The real tasks arising in conditions of market electric power industry, are often formulated in terms of global and-or discrete optimization. Computing difficulties which take place at solving of such tasks, are frequently linked to their complicated nature, high dimensionality, presence of discrete variables. Practical usage of standard tools of mathematical programming at solution of real tasks of high dimensionality often does not lead to success. Therefore application of the approximate methods is expedient. The most effective among them are methods of local type in which the various ideas developed within the local optimization are combined. The method of global equilibrium search concerns to such methods (GES). Application of GES method for solution of various classes of discrete optimization problems has shown its high performance. In V. M. Glushkov's Institute of cybernetics NAS of Ukraine wide experience of development and research of solution techniques and software for various classes of global and discrete optimization problems is accumulated. This experience will form a basis of creation of optimization algorithms and software for solution of the real tasks arising in the market of electric power industry.

Solving the Problem of Finding Maximum Size Error Correction Codes

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Abstract

Local Elimination Algorithms in Discrete Optimization

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Abstract

The use of algorithms and models of discrete optimization (DO) [1] makes it possible to solve many real-life problems in scheduling theory, optimization on networks, routing in communication networks, facility location, optimization in enterprise resource planning, and logistics (in particular, in supply chain management). Recently, there has been growing interest in graph-based approaches to decomposition of DO problems; one of them is the tree decomposition (TD). The importance of these approaches is explained by the results that some NP-hard problems formulated in terms of the second-order monadic logic can be solved in polynomial time using dynamic programming on graphs with a bounded treewidth that describe the structure of the DO problem. A class of *local elimination algorithms* for solving DO sparse problems is proposed; these algorithms make it possible to obtain global information about the whole problem using local computations (usually, by solving subproblems). Note that the main factor in the problems considered below is the local nature of information and the introduction and examination of elements' neighborhoods (see [2, 3]). The algorithmic scheme of local elimination algorithms is represented by a directed acyclic graph (DAG) whose vertices correspond to local subproblems and the edges reflect informational dependence of subproblems on one another. It is shown that the DAG of local elimination algorithm is a tree. Specifying the structural graph of a discrete optimization problem, one can obtain various decomposition schemes such as nonserial dynamic programming, block decomposition, or tree-block decomposition.

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Experiment Design Optimization Paradigm for Super-Resolution Imaging with Remote Sensing Data*

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Abstract

Increasing capability of co-registered multi-sensor remote sensing (RS) imagery has spurred development of various system/method fusion techniques for enhancing the RS images as required for end-user-oriented environmental resource management. These techniques are aimed to produce the fused/reconstructed/enhanced images with improved performances of information content, resolution and accuracy. In engineering practice, it is very important, on one hand, to have some theoretical guarantees that the developed image formation and reconstruction/post-processing method can improve the image performances before its application to real systems, but on the other hand, some unified computational architecture of the image formation, reconstruction and post-processing algorithms are desired, in which case it allows coping with different RS system models. These tasks can be performed via extended computer simulations of different techniques with the use of specialized problem-oriented software. In this work, we intend to address a novel look at the enhanced and super-resolution RS imaging pursuing new descriptive experiment design regularization (DEDR) methodology that aggregates the concept of sensor array design with different methods for sensor system and reconstructive imaging method fusion, and report the simulation results of the computer simulations of different DEDR-related imaging techniques with the specialized elaborated software that we refer to as "Virtual Remote Sensing Laboratory" (VRSL). First, we undertake an extensive study of the DEDR-based optimization of the sensor array geometries that provide the desirable overall angular power ambiguity function (AF) and related point spread function (PSF) of a multi-sensor RS imaging system. The AF and PSF cross-sections in the x-y imaging scene provide explicit information on the spatial resolution cells achievable with different DEDR-configured sensor arrays that employ the matched spatial filtering method for RS image formation. This study provides the necessary background for the AF and PSF optimization in terms of DEDR resolution metrics that balance the minimization of the resolution cell and the grating sidelobes suppression. The developed VRSL provides a possibility to perform such DEDR optimization of the sensor system configuring experiment design (ED) stage of the problem for different number of sensors, inter-sensor distances, array geometries, etc. The achievable AFs and PSFs are computed for all ED specifications and visualized for the user at the VRSL interface. Second, the unified computational methodology and software that performs the RS image enhancement/post-processing employing a manifold of the recently developed celebrated non-parametric robust high-resolution and super-resolution techniques is developed. Such DEDR-optimized image reconstruction techniques encompass, in particular, the regularized constrained least squares method, the weighted constrained least squares technique, the robust Bayesian minimum risk method, and the robust maximum entropy method. Next, we perform the unification of these techniques with the ED descriptive regularization paradigm that we address to as the robust DEDR computational methodology for high-resolution and super-resolution RS image reconstruction and post-processing. The presented study establishes a new foundation to assist in understanding the basic algorithmic and computational aspects of the multi-level optimization of the RS image formation, enhancement and post-processing techniques as required for end-user-oriented environmental imaging and resource management. The perspective developments of this study relate to applications of the proposed intelligent experiment design paradigm and elaborated software to the alternative application areas such as intelligent sensor fusion, dynamic image discrimination for resource management, RS image perception and understanding, etc.

A Global Equilibrium Search Algorithm for the Quadratic Assignment Problem

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Abstract

The quadratic assignment problem (QAP) is considered. The problem can be formulated as follows: given two $n \times n$ matrices (a_{ij}) and (b_{kl}), find a permutation p of integers $1, \ldots, n$, minimizing:

$$c(p) = \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij} b_{p(i)p(j)}.$$

An approach based on the global equilibrium search method (GES) is proposed. The algorithm consists of a sequence of temperature cycles. In each cycle a number of iterations is performed. Each iteration consists of two phases: the utilization of the elite solutions based on GES method and improvement of obtained solutions using taboo search procedure. The concept of intensification and diversification is implemented in the algorithm. On high temperature levels the solutions being choosed almost in a random way. A decrease of the temperature parameter leads to sampling of high quality solutions properties. For a number of benchmark problems the number of iteration of the taboo search procedure is increased for low temperature stages, i.e. intensification has been carried out not only by the process convergence to the good solutions, but also by extending the search in the neighborhood of good solutions. The RESTART-methodology is used to accelerate the performance of the algorithm. Computational experiments on the well-known benchmark problems from QAPLIB library (http://www.opt.math.tu-graz.ac.at/qaplib/) are provided. An analys of experimental results shows a high effectiveness of the proposed algorithm, especially on the problems of high dimension.

Effective Discrete Programming Algorithms for Intellectual Data Mining Analysis*[3]

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Abstract

In recent years a growing interest to the intellectual data analysis (Data Mining) is observed in a variety of fields: pattern recognition, signal processing, molecular genetics, telecommunications, banking and etc. Researchers have realized that they could achieve great advantages by using Data Mining techniques. In Data Mining systems many different methods are implemented, some of these systems incorporate several approaches. Usually in every system there is some key component. In our data mining information technology such key component is represented by new efficient approximate discrete optimization methods. Discrete optimization problems have a broad field of applications. Most of such problems are universal (NP-hard). The analysis of known mathematical and software tools for solving discrete optimization problems showed that the most effective approaches are based on ideas of local optimization. A global equilibrium search (GES) is one of such methods, and at present it is one of the most effective methods of discrete programming. Its efficiency is especially revealed when solving large scale problems. Numerous experimental and practical calculations by means of GES and its modifications showed that it is much more stable in getting better solutions and require less time than other known methods. Application of GES would allow significantly reduce the cost and time of complex decision making, and thus to enhance the developed Data Mining information technology.

[3]This research is partly supported by Science and Technology Center in Ukraine (Project 4138).

On Interesting Properties of Shor's Upper Bounds for Weighted Stability Number of a Graph[4]

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Abstract

N.Z. Shor developed several upper bounds for weighted stability number of a graph $\alpha(G, w)$. Each Shor's bound corresponds to Lagrangean dual bound for corresponding nonconvex quadratic boolean problem and can be found in polynomial time by nondifferentiable optimization methods. Two Shor's upper bounds will be the subjects in our discussion: the bound $\psi(G, w)$ which corresponds to the simplest boolean quadratic problem and is equal to the known Lovász number $\vartheta(G, w)$; and the bound $\psi_1(G, w)$ which corresponds to the boolean quadratic problem received after adding to the simplest quadratic boolean problem the family of superfluous quadratic constraints.

In this talk we consider new interesting properties of the bounds $\psi(G, w)$ and $\psi_1(G, w)$, connecting with approximation of the stable set polytope $STAB(G)$ by polytopes defined by families of valid linear inequalities for $STAB(G)$. For the bound $\psi_1(G, w)$ the families of linear inequalities characterise a number of substructures in a graph generated by some combination of cliques Q_p and odd cycles C_{2k+1}. They include such known families of inequalities as clique constraints, odd-cycle and odd-antihole constraints, wheel and p-wheel constraints, web and antiweb constraints.

Properties of the bound $\psi_1(G, w)$ give the possibility to specify new families of graphs, for which the weighted stability number can be found in polynomial time. The simplest of these families – W_p-perfect graphs, which includes such known families of graphs as t-perfect, h-perfect and W-perfect as particular cases, will be considered.

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Multidimensional Knapsack Problems with Stair Structure of Constraints

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Abstract

When applying Benders method to optimization models in telecommunications networks, intermediate knapsack problems arise. The constraints have stair structure of different types. Depending on the linking of variables, we develop optimum finding algorithms with polynomial complexity with respect to the number of unknown variables.

Applications of Global Optimization in Space Weather Prediction

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Abstract

This report concentrates on applications global optimization in Space Weather Prediction using satellite experimental data related to solar flares, sun-spots, and coronal mass ejections. A new approaches towards purposeful prediction problems, derived from a recently developed quantum algorithms, is introduced in this report. The proposed algorithms inherently emphasizes learning to predict future peaks, and performs remarkably accurate predictions among the important regions, features, or objectives. Space weather forecasting is an excellent example of using this methodology, and in fact was the motivation to introduce purposeful prediction via multiobjective learning algorithm in this research. Discrete recursive (nonlinear autoregressive moving average model with exogenous inputs) models are also considered. This is a so-called 'black box' or 'input-output' model, which seeks only to reproduce the behaviour of the system's output in response to changes in its setpoint or inputs. One of the most important features of NARMAX models is that model terms are physically interpretable. For example, discrete and continuous time models of the evolution of Dst can be derived using NARMAX methodology. For their effective use it is proposed four new methods of structure and parameter identification: multi-objective optimization, genetic programming (GP), quantum optimization, and wavelets. NARMAX model representation is used for the basis of the hierarchical tree encoding in GP. Criteria related to the complexity, performance and chaotic invariants obtained by chaotic time series analysis of the models are considered in the fitness evaluation, which is achieved using the concept of the non-dominated solutions. The solution set provides a trade-off between the complexity and the performance of the models, and derived model were able to capture the dynamic characteristics of the system and reproduce the chaotic motion. The simulation results show that the proposed technique provides an efficient method to get the optimum NARMAX difference equation model of chaotic systems. Experimental data related to the coronal mass ejections, solar flares, and sun-spots is used for illustration of new identification procedures. An additional analysis and validation of the hybrid forecasting model of solar activity, which includes dynamical-information and Bayesian models, are also considered. A forecasting algorithm which based on Lyapunov exponents is analysed.