Seminars in Optimization

2018

5 april 2018
Günther Raidl, Institute of Logic and Computation, TU Wien, Österrike

Hybrid Optimization Approaches for Challenges in Public Bike Sharing Systems

After a brief introduction of the Algorithms and Complexity Group of TU Wien, this talk will give some insight on algorithms we developed for two optimization problems arising in the setup and maintenance of public bicycle sharing systems (BSS).

Operators of traditional station-based BSSs have to regularly redistribute bikes across the rental stations in order to prevent them getting overly full or empty. This is usually achieved with a fleet of vehicles with trailers. We will consider hybrid PILOT, GRASP and Variable Neighborhood Search metaheuristics that utilize certain flow models for an effective transportation tour planning.

When establishing a new BSS or extending an existing one, one of the core questions is at which locations rental stations of which size should be built. We model this station planning problem on the basis of a given expected customer traveling demand over the considered geographical area and locations where stations can potentially be built.

Our objective is to maximize the actually satisfied demand under budget constraints. In order to deal with the huge amount of input data for a larger city, we apply a hierarchical clustering based modelling approach. The optimization problem is then solved by a multilevel refinement metaheuristic making use of mixed integer linear programming and local search techniques.

17 maj 2018
Seminariet är ett samarrangemang med Tvärvetenskapliga seminarier på Matematiska institutionen (MAI).

Daniel Petersson, Veoneer

Eyes for self-driving cars

The development of technical systems has in many ways been dramatically changed during the last years through the breakthrough of deep learning. Traditional machine learning techniques using hand-crafted features have been successful for many applications, such as object detection in vision systems. However, the deep learning framework often enables higher performance, shared computations between different applications, and the ability to solve more advanced problems such as autonomous driving.

In the seminar, I will share experiences from the Veoneer development of vision systems for cars, such as data driven development and how the new advancements in the field of deep learning affect our products/services, as well as our ways of working.

22 maj 2018
A joint seminar for Optimization (MAI) and Production Economics (IEI), Linköping University.

Mikael Rönnqvist, Université Laval, Québec, Kanada

Improving the Safety, Environmental Consciousness, and Cost Effectiveness of Truck Routing

Calibrated Route Finder (CRF), an online route generation system, successfully finds the best route when many conflicting objectives are involved by using analytics in a collaborative environment. CRF, which has been in use since 2009, uses many diverse big data sources, which must be revised continuously. One of its key features is its use of an innovative inverse optimization process that establishes more than 100 weights to balance distance, speed, social values, environmental impacts, traffic safety, driver stress, fuel consumption, CO2 emissions, and costs. The system enables the measurement of hilliness and curvature and incorporates rules that consider legal and practical issues related to routing in and around cities, turning in intersections, time delays, fuel consumption, and CO2 emissions that result from waiting, acceleration, and braking. The system is used by all major forest companies in Sweden and in 60 percent of the two million annual transports in this sector. It has resulted in a paradigm shift from manual, imprecise, and unilaterally determined routes to automatically determined routes, which the stakeholders determine jointly. It has also enabled standardization, promoted collaboration, and reduced costs, thus strengthening the competitiveness of the Swedish forest industry in the international market.

13 september 2018
Michael Saunders, Stanford University, USA

Algorithm NCL for constrained optimization

Standard optimization solvers have difficulty if the active-constraint gradients are not independent at a solution (if the problem doesn't satisfy LICQ). For example, problems of the form min f(x) st c(x) >= 0 (m constraints and n variables) may have more than n constraints active at a solution. Such problems arise in the modeling of tax policy (with perhaps millions of constraints and thousands of variables).

Algorithm NCL solves a sequence of about 10 augmented Lagrangian subproblems with constraints c(x) + r >= 0. The extra variables make the constraints linearly independent, and the subproblem solutions converge to the required solution as r is driven to zero. IPOPT and KNITRO are able to warm-start each subproblem. Assuming second derivatives are available, NCL expands the use of interior methods for large-scale optimization.

Joint work with Ding Ma, Kenneth Judd, and Dominique Orban.

20 september 2018
Hani Ahmadzadeh, Sharif University of Technology, Tehran, Iran

Recently, Mixed Integer Nonlinear Programming (MINLP) problems have attracted the attention of many researchers. Despite the flexibility of MINLP in modeling the real-life problems in various fields of science, engineering, and economics, solving this type of problems encountered different difficulties. Resolving these issues requires the combination and adaption of several techniques from Nonlinear Programming (NLP) and Integer Programming (IP).

In this presentation, we survey some of the well-known algorithms for solving MINLP problems. In each step of these algorithms, at least one NLP problem must be solved. Hence, we review three popular families of algorithms for solving NLP problems, namely Sequential Quadratic Programming (SQP), Interior Point Method (IPM) and Augmented Lagrangian (AL). We compare the advantages and disadvantages of these algorithms to clarify which one would be the best choice for solving NLP subproblems in MINLP algorithms. Finally, we introduce some of the best solvers for solving MINLP problems.

6 december 2018
Oleg Burdakov, Matematiska institutionen, Linköpings universitet

Semi-conjugate direction algorithms for saddle problems and monotone equations

Problem of finding saddle points for strictly convex-concave functions is considered. We present semi-conjugate direction algorithms for solving this problem. They are extensions of some conjugate direction algorithms known in unconstrained optimization. For quadratic functions, they converge to saddle points in a finite number of steps. In the non-quadratic case, the asymptotic rate of their convergence is quadratic. Extensions to monotone equations are discussed. We present results of numerical experiments for quadratic saddle problems and linear monotone equations.

Joint work with: Yu-Hong Dai and Na Huang

2017

26 januari 2017
Oleg Burdakov, Matematiska institutionen, Linköpings universitet

A dual active-set algorithm for regularized monotonic regression

Oleg Burdakov and Oleg Sysoev

Linköping University, Linköping, Sweden
Email: *oleg.burdakov@liu.se, oleg.sysoev@liu.se*

Monotonic (isotonic) Regression (MR) is a powerful tool used for solving a wide range of important applied problems. One of its features, which poses a limitation on its use in some areas, is that it produces a piecewise constant fitted response. For smoothing the fitted response, we introduce a regularization term in the MR formulated as a least distance problem with monotonicity constraints. The resulting Smoothed Monotonic Regrassion (SMR) is a convex quadratic optimization problem. We focus on the SMR, where the set of observations is completely (linearly) ordered. Our Smoothed Pool-Adjacent-Violators (SPAV) algorithm is designed for solving the SMR. It belongs to the class of dual active-set algorithms. We proved its finite convergence to the optimal solution in, at most, n iterations, where n is the problem size. One of its advantages is that the active set is progressively enlarging by including one or, typically, more constraints per iteration. This resulted in solving large-scale SMR test problems in a few iterations, whereas the size of that problems was prohibitively too large for the conventional quadratic optimization solvers. Although the complexity of the SPAV algorithm is $O(n^2)$, its running time was growing in our computational experiments almost linearly with n.

9 februari 2017
Andongwisye John Mwakisisile, Matematiska institutionen, Linköpings universitet

Asset Liability Management of Tanzania Pension Funds by Stochastic Programming

We present an asset liability management for Tanzania pension funds by stochastic program-ming. The pension system is a mandatory defined benefit pension fund which gives a final averagesalary benefit. We analyse two kinds of pension benefits, a commuted (at retirement) and monthly(old age) pensions considering increased life expectancy of pension fund members. We project thefuture members, retirees, contributions, asset values, benefits payouts, and liabilities. We test somealternative reformation of the system. The analysis shows that Tanzania pension funds will notbe sustainable in a long future. We develop a long term stochastic programming model based onKouwenberg(2001) model with some features from Tanzania pension system. Different with mostALM models for pension funds by stochastic programming, we model liability with a number ofyears of life expectancy for expected old age benefit. We generate scenario trees by Monte Carlosimulation. We build two models according to different initial states of the fund to analyse theaverage contribution rates, asset values and optimal asset allocation. The results show that ourmodel comply with Tanzania pension system regulations.

16 februari 2017
Alexander Trygg och Oscar Äng, Linköpings universitet (Bachelor's Thesis)

Solving the Cast Batching Problem using a heuristical approach

This study aims to investigate if it is possible to use a heuristic method to create feasible solution in a Cast Batching Problem at SSAB. The problem occurs when different kinds of steel should be cast during the same day. Depending on which order the groups of different steel is placed different amounts of waste is produced, the goal is to minimize this waste. Earlier work has been done on this problem and resulted in a mathematical model to create feasible solutions to this problem. In practice the time it takes to create good solutions are long and the question is if it is possible to use a heuristic method to generate good solutions in a shorter amount of time.

Drawing upon inspiration from metaheuristics such as Variable Neighbourhood Search, Simualted Annealing and Tabu Search multiple heuristics have been created, implemented and evaluated against the mathematical model. One of the heuristics perform better than the mathematical model does in 10 minutes. The result from the mathematical model after 60 minutes is slightly better than the heuristic, but the results are similar. With regards to running time the heuristic takes considerably less time than 10 minutes.

21 mars 2017
Johan Hagenbjörk, Produktionsekonomi, IEI, Linköpings universitet

Optimal Hedging of the Interest Rate Swap Book

Most large banks trade interest rate swaps (IRS) with customers who wish to exchange a fixed interest rate payment stream to a floating rate payment stream or vice versa. All these positions make up the IRS book, which may contain tens of thousands different swap contracts with different maturities. Banks make their earnings from the spread between bid and ask yields and do not wish to be exposed to the interest rate risk this book carries. Due to the Basel banking regulations, banks are required to hold additional capital to account for this market risk, making potential unhedged risk in their trading portfolios costly.

Traditional and naive hedging methods aim to eliminate all risk in the IRS book. Whilst these methods are very costly, it is impossible to eliminate all risk in an environment with bid ask spreads. By accurate measurements of the historical term structure of interest rates we identify risk factors through a principal component analysis. This enables us to generate scenarios for the interest rate market. In order to manage the risk of the IRS book in an optimal way we propose a stochastic programming model which takes both risk and hedging cost into account. Using performance attribution based on the previously identified risk factors, we are able to analyze the outcome of our method and other traditional hedging methods in great detail.

6 april 2017
Jonas Olsson, Linköpings universitet

The container loading problem considered in this thesis is to determine placements of a set of packages within one or multiple shipping containers. Smaller packages are consolidated on pallets prior to being loaded in the shipping container together with larger packages. There are multiple objectives which may be summarized as fitting all the packages while achieving good stability of the cargo as well as the shipping container itself.

According to recent literature reviews, previous research in the field have to large extent been neglecting issues relevant in practice. Our solution was developed for the industrial company Atlas Copco to be used for sea container shipments at their Distribution Center in Texas, USA.

Hence all applicable real-world constraints faced by the DC operators had to be treated properly. A high variety in sizes, weights and other attributes such as stackability among packages added complexity to an already challenging combinatorial problem.

Inspired by how the DC operators plan and perform loading manually, the "batch concept" was developed, which refers to grouping of boxes based on their characteristics and solving sub problems in terms of partial load plans. In each batch, an extensive placement heuristic and a load plan evaluation run iteratively, guided by a Genetic Algorithm (GA). In the placement heuristic, potential placements are evaluated using a scoring function considering aspects of the current situation, such as space utilization and horizontal support. The scoring function is weighted by coefficients corresponding to the chromosomes of an individual in the GA population. Consequently, the fitness value of an individual in the GA population is the rating of a load plan.

The loading optimization software has been tested and successfully implemented at the DC in Texas. The software has been proven capable of generating satisfactory load plans within acceptable computation times, which has resulted in reduced uncertainty and labor usage in the loading process. Analysis using real sea container shipments shows that the GA is able to tune the scoring coefficients to suit the particular problem instance being solved.

27 april 2017
Fred Mayambala, Matematiska institutionen, Linköpings universitet

Mean-Variance Portfolio Optimization: Eigendecomposition-Based Methods

Modern portfolio theory is about determining how to distribute capital among available securities such that, for a given level of risk, the expected return is maximized, or for a given level of return, the associated risk is minimized. In the pioneering work of Markowitz in 1952, variance was used as a measure of risk, which gave rise to the well-known mean-variance portfolio optimization model. Although other mean-risk models have been proposed in the literature, the mean-variance model continues to be the backbone of modern portfolio theory and it is still commonly applied. The talk will be about a solution technique for the mean-variance model in which eigendecomposition of the covariance matrix is performed. The talk will be given on two areas in mean-variance optimization.

In the first of these, a solution technique for solving the mean-variance problem will be discussed. This technique involves making an eigendecomposition of the covariance matrix and solving an approximate problem that includes only relatively few eigenvalues and corresponding eigenvectors.

The second part involves studying the mean-variance model with cardinality constraints, that is, with a restricted number of securities included in the portfolio. The solution technique from the first part is extended to solve such problems. With this technique, near-optimal solutions to large-scale cardinality constrained mean-variance portfolio optimization problems are obtained within a reasonable amount of computing time, compared to the time required by a commercial general-purpose solver.

17 augusti 2017
Pierre Flener, Uppsala universitet

Auto-tabling for subproblem presolving in MiniZinc

A well-known and powerful constraint model reformulation is to compute the solutions to a model part, say a custom constraint predicate, and tabulate them within an extensional constraint that replaces that model part. Despite the possibility of achieving higher solving performance, this tabling reformulation is often not tried, because it is tedious to perform; further, if successful, it obfuscates the original model. In order to encourage modellers to try tabling, we extend the MiniZinc toolchain to perform the automatic tabling of suitably annotated predicate definitions, without requiring any changes to solvers, thereby eliminating both the tedium and the obfuscation. Our experiments show that automated tabling yields the same tables as manual tabling, and that tabling is beneficial for solvers of several solving technologies.

24 augusti 2017
Serge Gratton, ENSEEIHT-IRIT, Toulouse, Frankrike

Truncated primal-dual iterative methods for large-scale nonlinear least squares

Data assimilation covers techniques where prediction of the state of a dy-namical systems is performed using data from various origins. We consider here the optimization problem that lies in the centre of this technique, when so-called variational formulations are considered. Our main interest will be focused on case where the dynamical systems under consideration is described by *stochastic* differential equations. Such a problem is called "Weak-constrained variational Data Assimilation".

We will compare the merits of the three main approaches that are considered by the community: state, forcing, saddle-point formulations. They lead to large-scale optimization problems which must be solved iteratively. As it is usually the case in this setting, efficiency will dramatically rely on the ability to design effective parallel implementations of suitably preconditioned, convergent and variationally coherent minimization algorithms. Using these principles we derive a new variant of the saddle point algorithm in which the monotonicity of the likelihood along the iterates is enhanced.

A parametric study of the algorithms will be presented both in a sequential and idealized parallel environment on the Burgers equation and on aquasi-Geostrophic model that are considered as representative of real models occurring in Meteorology of Oceanography. We show the merits of our new saddle-point formulation and of more classical ones based on the full orthogonalization method.

24 augusti 2017
Björn Morén, Matematiska institutionen, Linköpings universitet

Preventing Hot Spots in High Dose-Rate Brachytherapy

High dose-rate brachytherapy is a method of radiation therapy, used in cancer treatment, where the radiation source is placed inside or close to a tumour. In addition to give a high enough dose to the tumour it is also important to spare nearby organs. Mathematical optimization is increasingly used at clinics for dose planning of the treatment, in which the source irradiation pattern is decided. The recommended way to clinically evaluate dose plans is based on dosimetric indices. Such an index quantifies the discretised portion of the tumour that gets at least (or for organs, at most) the prescribed dose.

There are optimization models for dose planning that take homogeneity of the dose into account, but there are none, to our knowledge, that also includes the spatial distribution of the received dose. Insufficient spatial distribution of the dose may result in hot spots, which are contiguous volumes in the tumour that receive a dose that is too high (e.g. more than 200% of the prescribed dose). This aspect is a reason of concern because of risk for complications. With a given dose plan that satisfies the targets in terms of dosimetric indices, a common clinical practice is to inspect the spatial dose distribution before approving the dose plan and if the hot spots are too large, adjust the dose plan.

We study this adjustment process by means of mathematical optimization and introduce criteria that take spatial distribution of dose into account with the aim to spread out or reduce the size of hot spots. This results in large-scale mixed-binary models that are solved using nonlinear approximations. We show that it is possible to improve a dose plan in this respect while at the same time maintaining good values with respect to dosimetric indices.

31 augusti 2017
Emil Karlsson, Matematiska institutionen, Linköpings universitet

Explicit modelling of multiple intervals in a constraint generation procedure for multiprocessor scheduling

Multiprocessor scheduling is a well studied NP-hard optimisation problem that occurs in variety of forms. The focus of this presentation is explicit modelling of multiple task intervals. This work extends a constraint generation procedure previously developed for an avionics scheduling context. We here address a relaxation of the original problem and this relaxation can be considered as multiprocessor scheduling with precedence relations and multiple intervals.

The explicit modelling of multiple intervals strengthens the formulation used in the constraint generation procedure and we illustrate the computational effects on an industrial relevant avionics scheduling problem.

28 september 2017
Martin Singull, Matematiska institutionen, Linköpings universitet

Nonlinear Optimization in Statistics

In statistics, we want to perform statistical inference, i.e., we would like to draw conclusions from observed data $x = (x_1, ..., x_n)$, and do prediction for new observation x_0. Given a parametric statistical model $\mathcal{P} = \{f(\cdot; \boldsymbol{\theta} : \boldsymbol{\theta} \in \Theta\}$, we would like to get information about the parameters $\boldsymbol{\theta}$. The most famous way to estimate the parameters of a statistical model given observations, is the maximum likelihood estimator (MLE), where the likelihood function

$$L(\boldsymbol{\theta}; \boldsymbol{x}) = \prod_{i=1}^{n} f_i(x_i; \boldsymbol{\theta}),$$

is maximized. The MLEs can be seen as a special case of the maximum a posteriori estimation (MAP) with a suitable prior. These problems are in most cases nonlinear optimization problems.

In this talk we will discuss different approaches to find estimators for some parametric statistical models, with main focus on the MLEs.

5 oktober 2017
Thomas Kalinowski, University of Newcastle, Australien

Extended formulations for convex hulls of graphs of bilinear functions

Many methods in global optimization require the approximation of convex and concave envelopes of functions. For bilinear functions, a classic approach is the McCormick relaxation: introduce additional variables representing products of pairs of original variables and write down linear constraints approximating the bilinear terms. The McCormick relaxation can be strengthened by adding more inequalities. In this direction, the Boolean Quadric Polytope (BQP) is best possible in the sense that it provides an extended formulation for the graph.

Unfortunately, in general the BQP has exponentially many facets and no complete list is known. In the talk I will discuss a method which in certain cases allows the identification of a small subset of facets of the BQP describing an extended formulation for the graph of the function.

30 november 2017
Jessika Boberg, Linköpings universitet (examensarbete i matematik på kandidatnivå)

A comparison of sequencing formulations in a constraint generation procedure for avionics scheduling

This thesis compares different mixed integer programming (MIP) formulations for sequencing of tasks in the context of avionics scheduling. Sequencing is a key concern in many discrete optimisation problems, and there are numerous ways of accomplishing sequencing with different MIP formulations.

A scheduling tool for avionic systems has previously been developed in a collaboration between Saab and Linköping University. This tool includes a MIP formulation of the scheduling

problem where one of the model components has the purpose to sequence tasks. In this thesis, this sequencing component is replaced with other MIP formulations in order to study whether the computational performance of the scheduling tool can be improved.

Different scheduling instances and objective functions have been used when performing the tests aiming to evaluate the performances, with the computational times of the entire avionic scheduling model determining the success of the different MIP formulations for sequencing. The results show that the choice of MIP formulation makes a considerable impact on the computational performance and that a significant improvement can be achieved by choosing the most suitable one.

14 december 2017
Andreas Westerlund, Jeppesen Systems AB, Göteborg

Column generation for airline crew rostering: practical considerations in a production system

Jeppesen's crew rostering optimizer is today used by around 40 airlines to produce monthly schedules for their flying crew. The optimizer produces monthly schedules for problem instances with above 20k crew-members and 100k activities. A key ingredient within the optimizer is our column generation framework. In this presentation, some of the main challenges within that framework will be described.

2016

2 juni 2016
Panos M. Pardalos, University of Florida, and National Research University

A new Information theory perspective on network robustness

A crucial challenge in network theory is the study of the robustness of a network when facing a sequence of failures.

We propose a novel methodology to measure the robustness of a network to component failures or targeted attacks based on Information Theory, that considers measurements of the structural changes caused by failures of the network's components providing a dynamical information about the topological damage. The methodology is comprehensive enough to be used with different probability distributions and provides a dynamic profile that shows the response of the network's topology to each event, quantifying the vulnerability of these intermediate topologies.

7 juni 2016
Lei Lei, ITN, Linköpings universitet

Energy-efficient Resource Allocation in Load-Coupled Wireless Networks

We consider the problem of minimization of sum transmission energy in cellular networks where coupling occurs between cells due to mutual interference. The coupling relation is characterized by the signal-to-interference-and-noise-ratio (SINR) coupling model. Both cell load and transmission power, where cell load measures the average level of resource usage in the cell, interact via the coupling model. The coupling is implicitly characterized with load and power as the variables of interest using two equivalent equations, namely, non-linear load coupling equation (NLCE) and non-linear power coupling equation (NPCE), respectively. By analyzing the NLCE and NPCE, we prove that operating at full load is optimal in minimizing sum energy, and provide an iterative power adjustment algorithm to obtain the corresponding optimal power solution with guaranteed convergence, where in each iteration a standard bisection search is employed. To obtain the algorithmic result, we use the properties of the so-called standard interference function; the proof is nonstandard because the NPCE cannot even be expressed as a closed-form expression with power as the implicit variable of interest. We present numerical results illustrating the theoretical findings for a real-life and large-scale cellular network, showing the advantage of our solution compared to the conventional solution of deploying uniform power for base stations.

8 juli 2016
Ya-xiang Yuan, Chinese Academy of Sciences, Beijing

A new framework for a class of orthogonal constrained optimization

The orthogonal constrained optimization is widely used in many areas.

In this talk, we propose a new alogrithm frame for solving a class of orthogonal constrained optimization problems, where at each iteration there are two stages. In the first stage a step is obtained to reduce the projected gradient of the objective function.

In the second stage, a symmetrization step is employed to symmetrize the Lagrangian multiplier of the orthogonal constraint. Global convergence for this approach is established. Preliminary experiments illustrate that the new algorithm performs well and is of great potential.

8 juli 2016
Cong Sun, Beijing University of Posts and Telecommunications, Kina

On a special structured matrix problem

A special matrix problem is considered from the application in wireless communications. The dimensions of the variables are optimized along with the variables. First, we prove that the problem is NP-hard. Then, we approximate the objective function by a fraction function. By applying the alternating minimization method, we conclude the subproblem as a 0-1 quadratic programming. Efficient algorithms are proposed to solve the problem. Simulations show the good performances of our proposed algorithms.

23 augusti 2016
Jens Van Engeland, KU Leuven, Bryssel, Belgien

A column generation approach for building tactical waste collection schemes

Environmental considerations and corresponding legislation cause a shift from waste management to materials management. To achieve efficient collection and transportation of these materials, appropriate collection schemes should be in place. This paper develops a model for building tactical waste collection schemes. The tactical level is situated between the strategic (higher) and operational (lower level). Therefore, we propose a modified periodic vehicle routing problem in which a set of capacitated vehicles visit a set of customers during a time period.

Moreover, it is imposed that the vehicle should visit the collection point to discharge the waste after each customer visit. This is motivated (1) by the practical setting that served as the motivation for this research in which the waste of each customer has to be weighed at the collection point, (2) the fact that the focus is on the tactical level. Hence, the development of operational collection schemes is outside the scope of this paper. However, these lower level decisions could be taken once the tactical schemes are obtained.

The goal of the model in this paper is to find a set of routes for each vehicle that satisfy both the demand and the frequency constraints and minimize the sum of the costs of all routes. Since a state-of-the-art solver could not solve the standard MIP formulation to optimality within a reasonable time limit, nor find a solution with an acceptable gap within an acceptable time limit, a heuristic column generation approach is proposed. This solution strategy proved effective in all three test instances. Good results for the tactical collection schemes are obtained, in reasonable computation time. The impact of important model parameters is explored in sensitivity analyses.

15 september 2016
Oleg Burdakov, Matematiska institutionen, Linköpings universitet

Limited memory algorithms with cubic regularization

For generating trial points in our algorithms, we consider a model of the objective function composed of the standard quadratic model augmented by a cubic regularization. The cubic term is determined by the eigendecomposition of a limited memory Hessian approximation. Although the model function may potentially have an exponential number of distinct local minima, its global minimizer can be obtained in closed form. The required eigenvalue decomposition is produced using an efficient approach introduced recently for limited memory Hessian approximations. Convergence results are presented for a standard cubic regularization framework. The efficiency of our algorithms is demonstrated by results of numerical experiments.

8 december 2016
John C. Dunn, University of Adelaide, Australien

Testing models of psychology using state-trace analysis

Research in experimental psychology is divided into many fields which people are asked to make judgments in response to particular questions. These include, was this item studied previously (recognition memory), is this item an example of category A or B (category learning), does this conclusion follow from a set of premises (reasoning), or deciding which of two probabilistic outcomes is preferable (risky choice). Yet, despite their differences, one finds similar debates concerning whether these judgments are based on one or more than one process, system, or source of information. I argue that these theoretical debates are most appropriately addressed using the methods of state-trace analysis. I outline this methodology, describe recent conceptual and statistical advances, and review its application to the abovementioned fields.

Key words: state-trace analysis, decision making, single-process, dual-process, memory, categorization, reasoning, risky decision making.

2015

26 februari 2015
Masao Fukushima, Nanzan University, Nagoya, Japan

Multi-Leader-Follower Games

In a (single-)leader-follower game, also called a Stackelberg game, there is a distinctive player called the leader, who optimizes the upper-level problem, and a number of remaining players called the followers, who optimize the lower-level problems jointly. In particular, the leader anticipates the responses of the followers, and then uses this ability to chooses his/her optimal strategy. At the same time, the followers choose their own responses by solving their optimization problems parameterized by the leader's decision. In a more complicated case, several players take the position as leaders and the rest of players take the position as followers. Such a bilevel game is called a multi-leader-follower game. In this game, the leaders compete with each other in a non-cooperative way in the upper-level, while making their decisions by anticipating the responses of followers. Upon receipt of the leaders' decisions, all followers compete witheach other in a non-cooperative way in the lower-level with the strategies of leaders as exogenous parameters. Multi-leader-follower games play an important role in modeling complex 'conflict situations' that arise, for example, in economics and engineering. This talk will discuss some issues in studying such games, and then particularly mention arecent result on a class of multi-leader-follower games under uncertainty with some special and simplified structure. By means of the robust optimization technique, the game is first formulated as a robust Nash equilibrium problem, and then a generalized variational inequality problem. A numerical method is presented to compute a solution of the game.

28 maj 2015
Sina Khoshfetrat Pakazad, ISY, Linköpings universitet

Distributed Optimization: Divide and Conquer

In this talk, we propose a distributed algorithm for solving loosely coupled problems with chordal sparsity, which relies on primal-dual interior-point methods. We achieve this by distributing the computations at each iteration, using message-passing. In comparison to already existing distributed algorithms for solving such problems, this algorithm requires far less number of iterations to converge to a solution with high accuracy. Furthermore, it is possible to compute an upper-bound for the number of required iterations which, unlike already existing methods, only depends on the coupling structure in the problem.

2 juli 2015
John C. Dunn, University of Adelaide, Australia

Progress in solving the compound monotonic regression (CMR) problem II

John C. Dunn[1], Oleg P. Burdakov[2], Michael L. Kalish[3], Oleg Sysoev[2], Laura Anderson[4]

Affiliations:

1. University of Adelaide; 2. Linköping University; 3. Syracuse University; 4. Binghamton University.

Abstract:

A problem arises in experimental psychology in which a set of k observations on n variables may be considered as (potentially different) monotonic functions of linear (or nearly linear) functions of $m < n$ parameters. That is, $y = f(Ax) + \varepsilon$, where y is a vector of observed variables, f is a vector of *unknown* monotonic functions, A is a specified $n \times m$ matrix, x is a vector of *unknown* parameter values, and ε is an vector of random error terms. The problem of interest is to determine the extent to which a given set of data is consistent with such a model.

In the first part of the seminar, we review the procedure developed by the authors, called compound monotonic regression (CMR), that fits the specified model in the special case of $m = 1$ for both normally distributed and binomially distributed error terms. We also say a few words on how it is possible to construct a statistical test of the model fit.

In the second part of the seminar, we discuss how the CMR algorithm could be extended to the general case of $m > 1$. In so doing, we draw on the theory of *oriented matroids* to identify infeasible pairs of points that must be resolved by the algorithm. Comments are invited.

18 augusti 2015
Xiaohu Ge, Huazhong University of Science and Technology, Kina

Spatial Spectrum and Energy Efficiency of Random Cellular Networks

It is a great challenge to evaluate the network performance of cellular mobile communication systems. In this paper, we propose new spatial spectrum and energy efficiency models for Poisson-Voronoi tessellation (PVT) random cellular networks. To evaluate the user access to the network, a Markov chain based wireless channel access model is first proposed for PVT random cellular networks.

On that basis, the outage probability and blocking probability of PVT random cellular networks are derived, which can be computed numerically. Furthermore, taking into account the call arrival rate, the path loss exponent and the base station (BS) density in random cellular networks, spatial spectrum and energy efficiency models are proposed and analyzed for PVT random cellular networks. Numerical simulations are conducted to evaluate the network spectrum and energy efficiency in PVT random cellular networks.

18 augusti 2015
Ya-xiang Yuan, Chinese Academy of Sciences, Kina

On general p-regularized subproblems for p > 2

The p-regularized subproblem (p-RS) is a regularization technique in computing a Newton-like step for unconstrained optimization. The idea is to globally minimizes a local quadratic approximation of the objective function while incorporating with a weighted regularization term $\frac{\sigma}{p}\|x\|^p$. The global solution of the p-regularized subproblem for $p = 3$, also known as the cubic regularization, has been characterized in literature. In this paper, we resolve both the global and the local non-global minimizers of (p-RS) for $p > 2$ with necessary and sufficient optimality conditions. Moreover, we prove a parallel result of Martínez that the (p-RS) for $p > 2$, analogous to the trust region subproblem, can have at most one local non-global minimizer. When (p-RS) with $p = 4$ is subject to additional linear inequality constraints, we show that the problem is in general NP-hard. However, if the number of linear constraints is fixed as a constant, it can be solved in polynomial time.

Joint work with: Y. Xia and R.L. Sheu

2014

6 februari 2014
Gunnar Cedersund, Integrative Systems Biology, IKE/IMT, Linköpings universitet

Optimization challenges in systems biology

Systems biology, i.e. mathematical modelling of biological systems is a rapidly growing research field, which attracts scientists from both biology and biochemistry, as well as from mathematics, engineering, and optimization sciences. The key optimization problem is to find suitable parameters for the various interactions in the models, based on model fitting to available experimental data. Some of the key challenges is that these optimization problems are large (20-200 parameters), typically non-convex, and that the parameters are unidentifiable: i.e. that there is no unique optimum. In the last few years, rapid methodological developments have occured surrounding these questions. However, many open challenges and interesting problems still remain, and optimization lie at the heart of many of these. In this talk I will give an overview of this fascinating research field, and of some of its most important open optimization challenges.

27 februari 2014
Joaquim João Júdice, University of Coimbra, Portugal

Mathematical Programming with Linear Complementarity Constraints: Algorithms and Applications

A Mathematical Program with Linear Complementarity Constraints (MPLCC) is an optimization problem where a linear or nonlinear function is minimized on a set defined by linear constraints and complementarity conditions on pairs of complementary variables. This problem finds many applications in several areas of science, engineering and economics and is also an important tool for the solution of some NP-hard structured and nonconvex optimization problems. In particular, bilevel, bilinear and nonconvex quadratic programs and the linear complementarity problem can be reduced to MPLCCs and solved by exploiting these formulations. In this talk, the most important applications and formulations of the MPLCC are first reviewed.

The problems of finding a feasible solution, a stationary point and a global minimum for the MPLCC are addressed next. Local methods and special pur-pose techniques can be used for computing a feasible solution in some special cases, in particular for those MPLCCs associated with the reformulations men-tioned before. In general, an enumerative method is required for such a task.

Active-set algorithms have been designed for finding stationary points of the MPLCC and can be employed in a sequential complementarity algorithm for computing a global minimum to the MPLCC. Branch-and-bound algorithms can also be useful for finding a global minimum for the MPLCC and exploit the dichotomy of the complementary variables. RLT and SDP techniques can be incorporated in these algorithms in order to speed up the search for a global minimum. Finally the MPLCC can be shown to be equivalent to a zero-one program and solved by using a special purpose integer programming technique.

Some comments about the computational performance of the algorithms and a few topics for future research are presented in the last part of the talk.

21 mars 2014
Athanasios Migdalas, Luleå tekniska universitet

A hybrid clonal selection algorithm for the evhicle routing problem with stochastic demands

The Clonal Selection Algorithm is the most known algorithm inspired from the Artificial Immune Systems and used effectively in optimization problems. In this paper, this nature inspired algorithm is used in a hybrid scheme with other metaheuristic algorithms for successfully solving the Vehicle Rou\-ting Problem with Stochastic Demands (VRPSD). More precisely, for the solution of this problem, the Hybrid Clonal Selection Algorithm (HCSA) is proposed which combines a Clonal Selection Algorithm (CSA), a Variable Neighborhood Search (VNS), and an Iterated Local Search (ILS) algorithm. The effectiveness of the original Clonal Selection Algorithm for this NP-hard problem is improved by using ILS as a hypermutation operator and VNS as a receptor editing operator. The algorithm is tested on a set of 40 benchmark instances from the literature and ten new best solutions are found. Comparisons of the proposed algorithm with several algorithms from the literature (two versions of the Particle Swarm Optimization algorithm, a Differential Evolution algorithm and a Genetic Algorithm) are also reported.

24 april 2014
Gunnar Aronsson, MAI, Linköpings universitet

On production planning and activity periods

Consider a company which produces and sells a certain product on a market with highly variable demand. Since the demand is very high during some periods the company will produce and create a stock in advance before these periods. On the other hand it costs money to hold a big stock, so that some balance is needed for optimum. We use techniques from optimal control theory for the analysis, which leads to so-called activity periods. During such a period the production is maximal. Over a period of one or two years, there will be a few activity periods.

Outside these periods the policy is "lean", which roughly means: choose production = min(demand, U), where U is maximal production. We will sketch this theory, including some, but not all, proofs.

15 maj 2014
John Dunn, University of Adelaide, Australien

Progress in solving the compound monotonic regression (CMR) problem

Title:
Progress in solving the compound monotonic regression (CMR) problem

Authors:
John Dunn (University of Adelaide), Oleg Burdakov (Linköping University), Mike Kalish (Syracuse University), Oleg Sysoev (Linköping University).

Abstract:
The compound monotonic regression (CMR) problem arises in the context of testing psychological theories where the relationship between manifest variables (e.g., percent correct performance) and underlying latent variables (e.g., amount of learning) is assumed monotonic. If two manifest variables are products of the same latent variable, they will be co-monotonic (i.e., monotonic functions of each other).

The CMR problem is to find the best-fitting values of a set of observations under co-monotonicity (or isosign) constraints. That is, given vectors, $a, b, v, w \in R^n$, and a set E of pairs (i, j) corresponding to edges of a directed acyclic graph, find x and y that minimize:

$$\sum_i v_i (x_i - a_i)^2 + \sum_i w_i (y_i - b_i)^2$$

Subject to:
$$x_i \le x_j, \forall (i,j) \in E$$
$$y_i \le y_j, \forall (i,j) \in E \quad \text{(MR constraints)}$$

And:
$$x_i < x_j \Rightarrow y_i \le y_j, \ \forall i,j, 1 \le i,j \le n$$
$$y_i < y_j \Rightarrow x_i \le x_j, \ \forall i,j, 1 \le i,j \le n \quad \text{(CMR constraints)}$$

We present a branch-and-bound algorithm for solving this problem and examine its properties as a function of n.

5 juni 2014
Oleg Burdakov, MAI, Linköpings universitet

On a Reduction of Cardinality to Comlementarity in Sparse Optimization

Co-authors: Christian Kanzow and Alexandra Schwartz (University of Wuerzburg, Germany)

A reduction of cardinality-constrained problems (CardCP) to complementarity constrained problems is presented. We prove their equivalence in the sense that they have the same global minimizers. A relation between their local minimizers is also discussed. Local optimality conditions for CardCPs are derived on the base of presenting cardinality constraints in a disjunctive form. A continuous reformulation of portfolio optimization problem with semi-continuous variables and cardinality constraint is given.

12 juni 2014
Jorne Van den Bergh, KU Leuven, Belgien

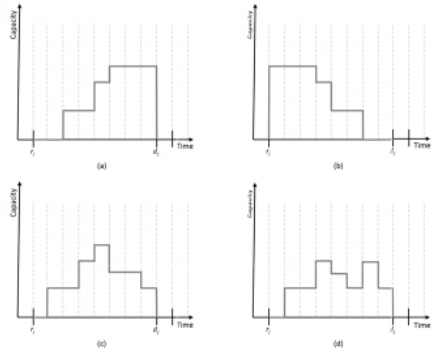
Solving the resource loading problem by column generation

Solving the resource loading problem by column generation

Jorne Van den Bergh[1,2] – Jeroen Beliën[1,2] – Roel Leus[3] – Erik Demeulemeester[4]

[1] KU Leuven, campus Brussels – Center for Information Management, Modeling and Simulation
[2] KU Leuven, campus Leuven – Research Center for Operations Management
[3] KU Leuven, campus Leuven – ORStat

We study a resource loading problem involving timing decisions. Each job must be executed within a given time window. The durations of the jobs are not fixed beforehand but depend on the intensity (number of resources per period) with which the jobs are executed. These intensities are not required to be fixed during the job execution but can change over time. The allowed intensity patterns are presented in Figure 1 (a)-(c).



Graph (a) gives an example a non-decreasing pattern. In this pattern, the intensity will never decrease during the execution of the job until it is finished. Similarly, graph (b) shows a non-increasing pattern in which the intensity will only remain the same or decrease over consecutive execution periods. Graphs (c) and (d) present combinations of the two former execution patterns. However, only patterns similar to the example in graph (c) are allowed. Once the intensity of a job has decreased during the execution, it cannot increase anymore. Therefore, the pattern in graph (d) is not allowed. These execution patterns are derived from practice.
The available capacity is considered to be fixed (but time varying) in our problem and is obtained by solving a workforce scheduling problem, previously studied by Beliën et al. However, in this workforce scheduling problem, the job characteristics are not taken into account. Hence, we want to evaluate whether a feasible schedule still exists, considering non-preemption, integer intensities and the execution patterns. Therefore, we apply a Dantzig-Wolfe decomposition and try a column generation method to solve the problem efficiently.

16 oktober 2014
This is a joint seminar with IDA Machine Learning Seminar.

Panos M. Pardalos, University of Florida and LATNA, Moscow

Knowledge Discovery and Optimization Heuristics for Massive Networks

In recent years, data mining and optimization heuristics have been used to analyze many large (and massive) data-sets that can be represented as a network. In these networks, certain attributes are associated with vertices and edges. This analysis often provides useful information about the internal structure of the datasets they represent. We are going to discuss our work on several networks from telecommunications (call graph), financial networks (market graph), social networks, and neuroscience.

In addition, we are going to present recent results on critical element selection. In network analysis, the problem of detecting subsets of elements important to the connectivity of a network (i.e., critical elements) has become a fundamental task over the last few years. Identifying the nodes, arcs, paths, clusters, cliques, etc., that are responsible for network cohesion can be crucial for studying many fundamental properties of a network.

30 oktober 2014
Markus Bohlin, SICS and Mälardalen University

Optimization Methods for Multistage Freight Train Formation

In this talk, we will discuss mathematical optimization for the multi-stage train formation problem, which at the core is the allocation of classification yard formation tracks to outbound freight trains, subject to realistic constraints on train scheduling, arrival and departure timeliness, and track capacity. The problem formulation allows the temporary storage of freight cars on a dedicated mixed-usage track. This real-world practice increases the capacity of the yard, measured in the number of simultaneous trains that can be successfully handled. In the talk we will discuss several optimization models and how they perform, using a 5-month historical data set from the largest freight yard in Scandinavia for evaluation. We also use the results to investigate the relationship between the number of simultaneous trains increase and the number of required extra train movements on the yard.

27 november 2014
Sina Khoshfetrat Pakazad, ISY, Linköpings universitet

Distributed Optimization: Divide and Conquer

In this talk we present efficient distributed algorithms for solving loosely coupled convex optimization problems. The algorithms are based on a primal-dual interior-point method in which we use proximal splitting and message-passing to compute the primal-dual directions at each iteration of the method. This enables us to join the exceptional convergence properties of primal-dual interior-point methods with the remarkable parallelizability of these approaches, and hence we expect the resulting algorithm to have superior convergence properties with respect to other existing distributed optimization algorithms.

Furthermore, the amount of computations that needs to be conducted by each computing agent is far less than other existing distributed algorithms for solving constrained optimization problems. In particular, the updates for all variables can be expressed in closed form, irrespective of the type of optimization problem.

27 november 2014
Ahmad Kamandi, Razi University, Kermanshah, Iran

A double-projection-based algorithm for large-scale nonlinear systems of monotone equations

In this seminar we propose a derivative free algorithm for solving large-scale nonlinear systems of monotone equations which combines a new idea of projection methodology with a line search strategy, while an improvement in the projection step is exerted. At each iteration, the algorithm constructs two appropriate hyper-planes which strictly separate the current approximation from the solution set of the problem. Then the new approximation is determined by projecting the current point onto the intersection of two halfspaces that are constructed by these hyperplanes and contain the solution set of the problem. Under some mild conditions, the global convergence of the algorithm is established. Preliminary numerical results indicate that the proposed algorithm is promising.

2013

10 January 2013
Niklas Dahlin (Linköping University, Master Thesis Presentation)

A Frank-Wolfe method with scaled search directions: derivation and evaluation

We examine the Frank-Wolfe method implemented for the stochastic transportation problem, STP, which is a well-known application for this method. We introduce a new solution scheme for the STP, which is similiar to the Frank-Wolfe method but uses scaled search directions.

The new method is implemented in Matlab and tested on randomly generated problems to evaluate how it performs compared to related methods for the STP. Several different strategies

to determine search-direction are tested, based on the Frank-Wolfe solution method. The conclusion from the test is that the method using scaled search directions has potential for a significantly better practical convergence rate.

14 January 2013 M.J.D. Powell (University of Cambridge)
The symmetric Broyden updating formula (seminar 1)

15 January 2013 M.J.D. Powell (University of Cambridge)
Trust region calculations (seminar 2)

16 January 2013 M.J.D. Powell (University of Cambridge)
Software for minimization without derivatives (seminar 3)

During the last ten years, the speaker has developed software for minimizing general objective functions when first derivatives are not available. He has released two packages, namely NEWUOA and UOBYQA, for the unconstrained case and for simple upper and lower bounds on the variables, respectively. His current research addresses general linear constraints on the variables, which is intended to provide the new LINCOA package. These algorithms require only of magnitude n squared operations on a typical iteration, where n is the number of variables, which has allowed them to be applied when n is in the hundreds. No attention is given to sparsity.

Some excellent numerical results have been achieved, which certainly depend on the use of the symmetric Broyden updating formula. That formula when derivatives are not available is the subject of Seminar 1. It supplies the solution to the following variational problem. Some values of the objective function and a quadratic approximation to the objective function are given, where usually the approximation does not interpolate all the given function values. A new quadratic approximation is required that does interpolate the given function values. The freedom that remains in the new approximation is taken up by making as small as possible the Frobenius norm of the change to the second derivative matrix of the approximation.

A trust region in the space of the variables is the set of all points that are within a prescribed distance of the best point so far. A typical change to the vector of variables is a move from the best point so far to a new point within the trust region, the new point being chosen to provide a relatively small value of the current quadratic approximation to the objective function. The calculation of the new point is the subject of Seminar 2. A version of truncated conjugate gradients is employed, in order that the amount of work is only of magnitude n squared. Several decisions had to be taken to specify an algorithm. They are particularly interesting for the LINCOA software, due to the linear constraints on the variables.

Seminars 1 and 2 describe vital ingredients of the software that has been mentioned. A few more details are addressed in Seminar 3, to complete an outline of how the algorithms work. The numerical results from several test problems are considered too. The accuracy and efficiency are much better than expected if one takes the view that the second derivative matrix of the current quadratic approximation should become close to the second derivative matrix of the objective function. We find clearly that this view is wrong. Also the numerical results show that nearly always good accuracy is achieved eventually. The number of iterations, however, is sometimes very sensitive to effects from computer rounding errors. A major challenge is to try to avoid automatically the cases when the number of iterations is relatively large.

21 February 2013
Amir Aminifar (Dept. of Computer and Information Science, Linköping University)

Optimization of sampling frequencies for embedded control systems

Many embedded systems comprise several controllers sharing available resources. It is well known that such resource sharing leads to complex timing behavior that can jeopardize stability of control applications, if not properly taken into account in the design process, e.g., mapping and scheduling. The stability of control applications is related to the amount of delay and jitter a control application can tolerate. Therefore, it is important to analyze the impact of variations in scheduling parameters, e.g., sampling frequency, on the delay and jitter, and ultimately, on stability. Based on such an analysis, we try to find the most robust, i.e., farthest from instability, sampling frequency assignment in the search space. While it seems that the original problem is not convex, under some simplifying assumptions, it can be converted to a convex programming problem.

1 March 2013
Di Yuan (Department of Science and Technology, Linköping University)

Optimal link activation and scheduling in wireless networks

This talk consists in two parts. In the first part, we revisit the maximum link admission problem with a generic model of wireless network that consists in a set of radio links being coupled by a channel gain matrix. Given the signal-to-interference-and-noise ratio (SINR) requirement, the problem amounts to determining how many of the links can be activated simultaneously at maximum. Link activation is a key element in scheduling and cross-layer resource allocation. We present mathematical formulations of the problem in the context of optimal scheduling, highlighting the impact of formulation on computational efficiency. In the second part of the talk, new results and perspectives are discussed. We present a reformulation of the link activation problem, enabling the global optimum to be reached in orders of magnitude faster. We then extend the problem definition and formulation along two directions: 1) interference cancellation with receivers having multi-user detection capability, and 2) cooperative transmission and relaying.

26 March 2013
Philip Gill (University of California, San Diego, USA)

Stabilized SQP Methods for Nonlinear Optimization

Sequential quadratic programming (SQP) methods are a popular class of methods for the solution of nonlinear optimization problems. They are particularly effective for solving a sequence of related problems, such as those arising in mixed-integer nonlinear programming and the optimization of functions subject to differential equation constraints.

Recently, there has been considerable interest in the formulation of stabilized SQP methods, which are specifically designed to give rapid convergence on degenerate problems. Existing stabilized SQP methods are essentially local, in the sense that both the formulation and analysis focus on a neighborhood of an optimal solution. In this talk we discuss an SQP method that has favorable global convergence properties yet is equivalent to a conventional stabilized SQP method in the neighborhood of a solution.

4 April 2013
Michael Hintermueller (Humboldt University of Berlin, Germany)

Semismooth Newton methods in PDE constrained optimization

Based on the notion of Newton differentiability for mappings between Banach spaces, semismooth Newton methods for non-smooth operator equations are introduced and analysed. A particular focus will be put on non-smooth systems resulting from reformulations of complementarity systems in Lebesgue and Sobolev space settings (arising, e.g., in PDE constrained optimization) by means of nonlinear complementarity problem functions. Among others, it is shown that the abstract, infinite dimensional convergence theory for the semismooth Newton method results in a mesh independent solver upon suitable discretization. Extensions to optimization problems with low multiplier regularity are discussed and various applications ranging from continuum mechanics to mathematical image restoration are highlighted.

26 April 2013
Martin Joborn (Swedish Insitute of Computer Technology and Linköping University)

Optimized operational control of freight cars at Green Cargo - 10 years experience

Green Cargo has during more than 10 years used an automated, optimization based system to plan the utilization of their freight cars. System is based on research from OPT/MAI/LiU. When the system was build it was really state-of-the-art of the area, and it is still quite unique. However, during time the usage of the system has changed, and the system has been questioned. There are many interesting conclusions to make for us who deliver advanced decision support systems that automate parts of the processes.

3 May 2013
Andreas Griewank (Humboldt University, Berlin, Germany)

From linear to piecewise linear modeling and back

Linear mappings are very well understood and form the backbone of computational mathematics. Successive linearization, as for example in Newton's method, yields rapid convergence on problems defined by Lipschitz continuously differentiable functions. The situation changes dramatically if one considers nonsmooth problems, which arise in many modern fields, e.g. the calculus of variations. Here piecewise linear functions must be used for local modeling. We review some well known and some surprising properties of such approximations, in particular how they can be generated, stored and manipulated in a natural and efficient way.

6 May 2013
Juma Kasozi (Makerere University, Uganda)

Ultimate ruin probabilities for a risk process compounded

This work deals with numerically computing ruin probabilities of an insurer whose portfolio is exposed to insurance risk. The risk process in this work has its origin in the classical risk process (a constant income stream from which is subtracted a claim process that is assumed to be a compound Poisson process). This classical risk process is then compounded by an

independent investments process. We derive a linear Volterra integral equation of the second kind and apply an order four Block-by-block method in conjuction with the Simpson rule to solve the Volterra integral equation for ultimate ruin. The several numerical examples show that the results are excellent and reliable.

6 May 2013
Fred Mayambala (Department of Mathematics, Linköping University)

Portfolio optimization over the past 61 years: challenges with large scale data

31 May 2013
Ingemar Fredriksson (Department of Biomedical Engineering at Linköping University, and Perimed AB)

Nonlinear optimization in model-based biomedical optics for improved microcircular assessment

Diffuse reflectance spectroscopy (DRS) and laser Doppler flowmetry (LDF) are two biooptical measurement techniques that can be used to reveal the oxygenation, blood tissue fraction (both DRS) and blood flow (LDF) in the smallest vessels in the body, the so called microcirculation. Conventionally, some indexes that reflects these three quantities are calculated direct from the measured spectra. Those indexes have several limitations, such as arbitrary units, non-linearities etc, since they have a limited relevance from a biooptical point of view. By using a model-based approach where both techniques are connected to the same model, these limitations can be overcome and the clinical value of the techniques may drastically improve.

I will give a talk about how the multiparameter (19 parameters) model is fitted to the measured spectra using non-linear search strategies in multiple steps.

22 August 2013
Spartak Zikrin (Department of Mathematics, Linköping University)

Limited-memory methods with shape changing trust region

Limited-memory quasi-Newton methods and trust-region methods represent two efficient approaches used for solving unconstrained optimization problems. A straightforward combination of them deteriorates the efficiency of the former approach, especially in the case of large-scale problems. For this reason, the limited memory methods are usually combined with a line-search. The trust region is usually determined by a fixed vector norm, typically, scaled L_2 or L_infinity norms. We present a trust-region approach where the model function is based on a limited-memory quasi-Newton approximation of theHessian, and the trust region is defined by a specially designed norm. Since this normdepends on certain properties of the Hessian approximation, the shape of the trust region changes with every iteration. This allows for efficiently solving the subproblem. We prove global convergence of our limited-memory methods with shape changing trust region. We also present results of numerical experiments that demonstrate the efficiency of our approach in the case of large-scale test problems.

10 September 2013
Hongmei Zhao (Department of Mathematics, Linköping University)

Power Efficient Uplink Scheduling in SC-FDMA: Bounding Global Optimality by Column Generation

We study resource allocation in cellular systems and consider the problem of finding a power efficient scheduling in an uplink single carrier frequency division multiple access (SC-FDMA) system with localized allocation of subcarriers, that is, the subcarriers allocated to a user have to be consecutive in the frequency domain in each time slot. This problem is discrete and nonconvex, thus the use of suboptimal algorithms has been a common practice. We leverage the power of mathematical programming in order to approach global optimality or a tight bounding interval confining global optimum, to arrive at an effective scheme for gauging the performance of suboptimal algorithms. Toward this end, we first provide a straightforward integer linear programming formulation, and then an alternative and less trivial, so-called column-oriented, formulation. The latter is solved by column generation, which is a solution technique for large-scale optimization problems with certain characteristics. The computational evaluation demonstrates that the column generation method produces very high-quality subcarrier allocations that either coincide with the global optimum or enable an extremely sharp bounding interval. Hence the approach serves well for the purpose of benchmarking results for large-scale instances of power efficient SC-FDMA scheduling.

12 September 2013
Kurt Jörnsten (Norvegian School of Economics, Bergen, Norway, and Aarhus University, Danmark)

Probabilistic cost efficiency and bounded rationality in the newsvendor model

In this paper we establish a link between probabilistic cost efficiency and bounded rationality in the newsvendor model. This sets up a framework where bounded rationality can be examined rigorously by statistical methods. The paper offers a relatively deep theoretical analysis of underorders/overorders in the newsvendor model. The theory is supported by empirical findings, where we analyze empirical data from laboratory experiments. In particular we observe that underorders are systematically larger than overorders, an issue we are able to explain from our theoretical model. Via statistical testing we conclude that all variation in our data can be explained by probabilistic cost efficiency when critical fractiles are small or big, while this is false in the mid-range.

25 September 2013
Michael Patriksson (Chalmers University of Technology, Gothenburg)

Algorithms for the continuous non-linear resource allocation problem: new implementations and numerical studies

The continuous, convex, separable and differentiable resource allocation problem with a single resource is an important model problem in many applications, in the engineering and economic sciences, manufacturing, statistics, military operations research and production and financial economics. It also often arises as a sub-problem in more complex resource allocation models., whence it is vital importance that the problem can be efficiently solved. The survey by Patriksson (European Journal of Operational Research, 2006) lists well over a hundred articles published since the late 1800s on the subject.

In this work we study the numerical performance of the most promising algorithms for solving this problem. We take advantage of earlier studies to improve the relaxation algorithm such that it theoretically performs better than the earlier ones. That is, we introduce a more sophisticated pegging process to the relaxation algorithm, earlier only used for the breakpoint algorithm, and we implement an efficient method for evaluating sub-solutions.

In the numerical study for large-scale problems, we compare six relaxation algorithms whereof our modified algorithms perform the best. Also three pegging methods for the breakpoint algorithm are evaluated. Finally, we compare the best relaxation algorithm, breakpoint algorithm and a quasi-Newton method. We conclude that our modification of the relaxation algorithm performs the best. At least for problem sizes up to 30 million variables, the result also implies that the practical time complexity for the breakpoint algorithm and the relaxation algorithm is linear.

3 October 2013
Åsa Holm (Linköping University, Department of Mathematics, Division of Optimization)

A multidimensional search technique

Quadratic problems with only a few number of constraints arise as subproblems in many contexts. In this talk I will describe one of the methods for solving continuous quadratic knapsack problems in linear time by solving the dual problem. Then I will generalize this idea to quadratic problems with more constraints, using a method by Megiddo called multidimensional search. Lastly I will describe how multidimensional search can be applied also to some other types of problems.

21 November 2013
Japhet Niyobuhungiro (Deapartment of Mathematics, Linköping University)

A conjugate duality approach for optimal decomposition in real interpolation and ROF model on the graph

In this talk, we will present a result on the dual characterization of optimal decomposition for an infimal convolution and the use of it to establish mathematical properties of exact minimizers (optimal decomposition) for the K-, L- and E- functionals of the theory of real interpolation. We will also discuss connection between our results and duality theorems for convex and linear programming. Finally we will present a proposed algorithm for the construction of such minimizers in the case of the well known ROF (Rudin-Osher-Fatemi) model on the graph and illustrate some experimental results from image processing.

27 November 2013
Jeroen Beliën (Katholieke Universiteit Leuven, Belgium)

A hybrid simulated annealing linear programming approach for treatment planning in HDR brachytherapy with dose volume constraints

We present a hybrid approach for developing radiation plans for high dose rate brachytherapy in cancer treatment. In order to take care of the computationally hard dose volume constraints, linear programming (LP) is alternated with heuristic neighborhood search which allows for a quick generation of multiple feasible treatment plans. The simulated annealing neighborhood search is guided by both the primal and dual information available after each LP optimization. The approach is very promising compared to a traditional mixed integer programming approach for dealing with the dose volume constraints.

2012

27 January 2012
Bogdan Tanasa (Linköping University, Dept. of Computer and Information Science)

Schedulability Analysis for the Dynamic Segment of FlexRay: A Generalization to Slot Multiplexing

Abstract: FlexRay, developed by a consortium of over hundred automotive companies, is a real-time communication protocol for automotive networks. The scope of the work is timing analysis of FlexRay Dynamic Segment using approximation algorithms. The paper is build around a column generation process which uses inside a logical transformation of the bin covering problem into the resource sharing problem. The method shows improvements compared with other known methods to compute the worst case delays of FlexRay messages.

16 March 2012
Adrian Lifa (Linköping University, Dept. of Computer and Information Science)

Tabu-Search Heuristic for the Hardware/Software Optimization of Error Detection in Real-Time Embedded Systems

Abstract: This work presents an approach to system-level optimization of error detection implementation in the context of fault-tolerant real-time distributed embedded systems. The addressed problem is a combined mapping and scheduling problem, which is NP-complete. We have developed a Tabu-Search heuristic to optimize the hardware/software implementation of error detection, in order to minimize the global worst-case schedule length, while meeting the imposed hardware cost constraints and tolerating multiple transient faults.

20 April 2012
Håkan Johansson (Linköping University, Dept. of Electrical Engineering)

Linear and nonlinear optimization problems in signal processing system design

Abstract: This talk gives an overview of different types of optimization problems that arise when designing signal processing systems. The focus is on research topics at the Division of Electronics Systems. Typical system applications included are filters, filter banks and transmultiplexers, error correction in analog circuits, and reconstruction of nonuniformly sampled (possibly sparse) signals. In the design of such systems, optimization is frequently used nowadays. Depending on the application, different types of optimization problems that need to be solved appear. These include linear and nonlinear problems, constrained and unconstrained problems, as well as optimization of appropriate norms. In addition, some problems have only a few unknowns and constraints whereas other problems can have a huge amount. Especially for these latter cases, any suggestions from the audience as to the best way to solve them are welcome.

11 May 2012
Kurt Jörnsten (Norvegian School of Economics, Bergen, Norway)

Electricity Market Design: Lessons from the Nordic Electricity Market

Abstract: The objectives of market design is according to Shmuel Oren: "Develop a set of trading rules and procedures so that when all market participants act selfishly so as to maximize profit while following the rules, the market outcome will replicate the results of a benevolent central planner with perfect information, or a perfectly regulated monopoly."

Why do we have to bother with market design? There are several reasons:

- Externalities require coordination
- Good markets are made, they don't just happen
- Design determines your business opportunities

We discuss the design of the Nordic Electricity Market, NORDPOOL, and present results from several studies of the NORPOOL market.

Pricing in Markets with Non-Convexities

Abstract: The issue of finding market clearing prices in markets with non-convexities has had a renewed interest due to the deregulation of the electricity sector. In the day-ahead electricity market, equilibrium prices are calculated based on bids from generators and consumers. In most of the existing markets, several generation technologies are present, some of which have considerable non-convexities, such as capacity limitations and large start up costs. In this paper we present equilibrium prices composed of a commodity price and an uplift charge. The prices are based on the generation of a separating valid inequality that supports the optimal resource allocation. In the case when the sub-problem generated as the integer variables are held fixed to their optimal values possess the integrality property, the generated prices are also supported by non-linear price-functions that are the basis for integer programming duality.

25 May 2012
Adrian Lifa (Linköping University, Dept. of Computer and Information Science)

Minimization of Average Execution Time Based on Speculative FPGA Configuration Prefetch

Abstract: One of the main drawbacks that significantly impacts the performance of dynamically reconfigurable systems (like FPGAs), is their high reconfiguration overhead. Configuration prefetching is one method to reduce this penalty by overlapping FPGA reconfigurations with useful computations. In this work we propose a speculative greedy heuristic that schedules prefetches at design time and performs HW/SW partitioning, in order to minimize the expected execution time of an application. Our algorithm takes into consideration profiling information (such as branch probabilities and execution time distributions), correlated with the application characteristics, in order to prefetch the configurations with the highest potential to provide a performance improvement.

5 June 2012
Kevin Wood (Naval Postgraduate School, Monterey, California, USA)

Game-theoretic search and detection

Abstract: This talk describes joint work with Professors Alan Washburn and Lee Ewing at the Naval Postgraduate School.

An *evader* wishes to travel between vertices s and t in a network $G = (V,E)$. To detect the evader, an *interdictor* controls m_r *searchers* of each type $r \in R$. The evader is detected with probability p_{er} if he traverses edge $e \in R$ when a searcher of type r is present, and the interdictor wants to position his searchers so as to maximize probability of detection (P_D). An application to border defense is described.

We model this situation as a two-person zero-sum Cournot game between evader and interdictor: the evader wishes to minimize P_D by choosing an s-t path according to a probabilistic strategy, and the interdictor wishes to maximize P_D with a strategy that assigns searchers to network edges; at most one searcher per edge is a assumed. Given a Poisson detection model, a linear program optimizes P_D in an apparently relaxed formulation: variables assign a fraction of search effort for each searcher type to each edge, while constraints require that at most one searcher be assigned to each edge, on average. We show that this "aggregated solution" is implementable as an exact solution in polynomial time. Thus, the full problem is solvable in polynomial time.

When different assumptions prevail, the model described above incorrectly accumulates multiple detections. We solve this case using a finite row-and-column generation algorithm with integer-programming subproblems. Polynomial solvability arises for interesting special cases, but not in general.

Bio: Dr. Kevin Wood is Distinguished Professor of Operations Research at the Naval Postgraduate School. At NPS since 1982, he has taught courses in networks and optimization and has studied problems of network reliability, optimization (integer and stochastic programming), interdiction and infrastructure protection. His 1993 paper "Deterministic Network Interdiction" renewed interest in applying analytical techniques to network and system interdiction, and has led to a series of papers on these topics, by him and by others. He is working on defensive models for electric power networks, on a variety of interdiction problems, and on stochastic programming models with joint chance constraints. He has long-term research support from the Office of Naval Research and the Air Force of Scientific Research. He has also been a visiting scholar or visiting faculty member at Stanford University, the National Security Agency, the University of Auckland, the University of Texas at Austin, and the Federal Armed Forces University, Munich, Germany. For further information see http://faculty.nps.edu/kwood/

8 June 2012

Oscar Gustafsson (Linköping University, Dept. of Electrical Engineering)

Combinatorial optimization problems arising at the Division of Electronics Systems

Abstract: In this talk, several different combinatorial optimization problems originating from the Division of Electronics Systems are presented along with their ILP formulations. Many of them result in finding a Steiner hypertree in a directed hypergraph, where each hyperarc has two tail nodes and one head node, although sometimes both tail nodes originate from the same arc. The problems considered here are the constant multiplication problem for binary numbers and for finite fields and the minimum addition chain/sequence problem. ILP models using modified Miller-Tucker-Zemlin constraints are proposed. Other problems considered include partitioning of distributed arithmetic computational units and memory scheduling in LDPC encoders. Finally, we show how problems related to finding suitable weights for digital-to-analog converters can be solved using ILP formulations. In addition, we briefly outline the tools we use for modeling and solving the problems.

For all the proposed models, it would be very useful to obtain comments on the suitability of the used models. Some of them are quite good, with the linear relaxation being integer optimal or requiring only a few iterations, while others are inherently hard and possibly badly formulated. For the latter ones, any ideas/directions for e.g. column generation would be especially welcome.

14 June 2012

Daniel Karch (TU Berlin, Germany), Joint work with: Andreas Bley and Fabio D'Andreagiovanni

Wavelength Division Multiplexing Replacement Scheduling

Abstract: During the last years, Wavelength Division Multiplexing (WDM) has become the reference technology adopted in optical networks to increase system capacity. In particular, the increase in capacity derives from the possibility of establishing multiple connections on the same optical fiber, by assigning each wavelength to a distinct connection. In this work we analyze the problem of migrating a network to a new technology: a new hardware technology is available and we want to update all the relevant elements of the network. While the installation takes place, the affected network element must be switched-off and connections that use it are temporarily disrupted. The installation cannot be performed on the whole network at the same time, since the number of technicians is limited. A key issue is thus to schedule the migration of the network components in such a way that the connection disruption is minimized. In this talk, I will present several ways to model the WDM Replacement Scheduling Problem as an ILP, and discuss their respective benefits and disadvantages.

13 August 2012

Panos Pardalos (University of Florida, USA)

From Local to Global in Numerical Optimization

Abstract: Many optimization problems in different fields require the computation of solutions that are globally optimal. During the past decades, several new theoretical, algorithmic, and computational contributions have been proposed to provide global solutions for these problems.The purpose of this lecture is to provide a brief introduction to a spectrum of these topics.

14 August 2012

Panos Pardalos (University of Florida, USA)

Detecting Critical Subsets (nodes, edges, shortest paths, or cliques) in Large Networks

Abstract: In network analysis, the problem of detecting subsets of elements important to the connectivity of a network (i.e., critical elements) has become a fundamental task over the last few years. Identifying the nodes, arcs, paths, clusters, cliques, etc., that are responsible for network cohesion can be crucial for studying many fundamental properties of a network. Depending on the context, finding these elements can help to analyze structural characteristics such as, attack tolerance, robustness, and vulnerability. Furthermore we can classify critical elements based on their centrality, prestige, reputation and can determine dominant clusters and partitions.

From the point of view of robustness and vulnerability analysis, evaluating how well a network will perform under certain disruptive events plays a vital role in the design and operation of such a network. To detect vulnerability issues, it is of particular importance to analyze how well connected a network will remain after a disruptive event takes place, destroying or impairing a set of its elements. The main goal is to identify the set of critical elements that must be protected or reinforced in order to mitigate the negative impact that the absence of such elements may produce in the network. Applications are typically found in homeland security, energy grid, evacuation planning, immunization strategies, financial networks, biological networks, and transportation.

From the member-classification perspective, identifying members with a high reputation and influential power within a social network could be of great importance when designing a marketing strategy. Positioning a product, spreading a rumor, or developing a campaign against drugs and alcohol abuse may have a great impact over society if the strategy is properly targeted among the most influential and recognized members of a community. The recent emergence of social networks such as Facebook, Twitter, LinkedIn, etc. provide countless applications for problems of critical-element detection.

In addition, determining dominant cliques or clusters over different industries and markets via critical clique detection may be crucial in the analysis of market share concentrations and debt concentrations, spotting possible collusive actions or even helping to prevent future economic crises.

This presentation surveys some of the recent advances for solving these kinds of problems including heuristics, mathematical programing, dynamic programing, approximation algorithms, and simulation approaches. We also summarize some applications that can be found in the literature and present further motivation for the use of these methodologies for network analysis in a broader context.

This is joint work with Steffen Rebennack, Ashwin Arulselvan, Clayton Commander, Vladimir Boginski, Chrysafis Vogiatzis, Jose L. Walteros, Neng Fan, Donatella Granata (CAO), and Olga Khvostova (LATNA).

15 August 2012
Panos Pardalos (University of Florida, USA)

Optimization-Based Data Mining Approaches in Neuroscience Research

30 August 2012
Michael Saunders (Stanford University)

GMINRES or GLSQR?

Abstract: Given a general matrix A, we can construct orthogonal matrices U, V that reduce A to tridiagonal form: U'AV = T. We can also arrange that the first columns of U and V are proportional to given vectors b and c. An iterative form of this bi-tridiagonalization was given by Saunders, Simon, and Yip (1988) and used to solve systems Ax = b and A'y = c simultaneously. (The proposed new solvers become MINRES and SYMMLQ when A is symmetric and b=c.)

The approach was rediscovered by Reichel and Ye (2008). With emphasis on rectangular A, it was regarded as a generalization of LSQR (though it doesn't become LSQR in any special case). Careful choice of c was shown to give improved convergence.

In his last year of life, Gene Golub became interested in "GLSQR" for estimating c'x and b'y without computing x or y (see Golub, Stoll, and Wathen (2008)). We review the development of the bi-tridiagonalization process and Gene's final insight into its true identity.

21 September 2012
Oleg Burdakov (Linköping University, Department of Mathematics, Division of Optimization)

An approach to solving decomposable optimization problems with coupling constraints

Abstract: We consider a problem of minimizing $f_1(x) + f_2(y)$ over $x \in X \subseteq R^n$ and $y \in Y \subseteq R^m$ subject to a number of extra coupling constraints of the form $g_1(x)g_2(y) \geq 0$. Due to these constraints, the problem may have a large number of local minima. For any feasible combination of signs of $g_1(x)$ and $g_2(y)$, the coupled problem is decomposable, and the resulting two problems are assumed to be easily solved. An approach to solving the coupled problem is presented. We apply it to solving coupled monotonic regression problems arising in experimental psychology.

27 September 2012
Anna Lindholm (Lund University, Department of Automatic Control)

Optimization problems in the process industry

Abstract: The integration of scheduling and control in the process industry is a topic that has been frequently discussed during the recent years, but many challenges remain in order to achieve integrated solutions that can be implemented for real large-scale industrial sites.

In this presentation, production control at disturbances in the supply of utilities at integrated sites are considered, together with the integration towards production scheduling. Utilities, such as steam and cooling water, are often shared between production areas at a site, which enables formulation of an optimization problem for determining the optimal supply of utilities to each area at the occurrence of a disturbance. Optimization at two timescales is suggested to handle the scheduling and disturbance management problems in an hierarchical fashion.

The first part of the presentation will discuss the topic of utility disturbance management in the process industry, and formulate this as an optimization problem. The second part will discuss initial ideas on how the disturbance management optimization can be integrated with production scheduling. This research is part of the the newly started PIC-opic project, which is a collaboration between the process industrial centers in Linköping and Lund, PIC-LI and PIC-LU.

20 November 2012
Athanasios Migdalas (Aristotle University of Thessalonica, Greece)

Game theory, cooperative and non-cooperative (part 1)

28 November 2012
David Pisinger (DTU Management, Technical University of Denmark)

A branch and cut algorithm for the container shipping network design problem
(Joint work with Line Blander Reinhardt.)

Abstract: The network design problem in liner shipping is of increasing importance in a strongly competitive market where potential cost reductions can influence market share and profits significantly. In this talk the network design and fleet assignment problems are combined into a mixed integer linear programming model minimizing the overall cost. To better reflect the real-life situation we take into account the cost of transhipment, a heterogeneous fleet, route dependent capacities, and butterfly routes. To the best of our knowledge it is the first time an exact solution method to the problem considers transhipment cost. The problem is solved with branch-and-cut using clover and transhipment inequalities. Computational results are reported for instances with up to 15 ports.

30 November 2012
Bernard Fortz (Université Catholique de Louvain, Belgium)

Benders decomposition for the hop-constrained survivable network design problem
(Joint work with Quentin Botton, Luis Gouveia and Michael Poss.)

Abstract: Given a graph with nonnegative edge weights and a set of pairs of nodes Q, we study the problem of constructing a minimum weight set of edges so that the induced subgraph contains at least K edge-disjoint paths containing at most L edges between each pair in Q. Using the layered representation introduced by Gouveia, we present the first formulation for the problem valid for any $K, L \geq 1$. We use a Benders decomposition method to efficiently handle the big number of variables and constraints. We show that our Benders cuts contain the constraints used by Huygens \emph{et al.} to formulate the problem for $L = 2, 3, 4$, as well as new inequalities when $L \geq 5$. While some recent works on Benders decomposition study the impact of the normalization constraint in the dual subproblem, we focus here on when to generate the Benders cuts. We present a thorough computational study of various branch-and-cut algorithms on a large set of instances including the real based instances from SNDlib. Our best branch-and-cut algorithm combined with an efficient heuristic is able to solve the instances significantly faster than CPLEX 12.

19 December 2012
John Dunn (University of Adelaide, Australia)

The problem of nomic measurement in psychological science

Abstract: Psychological science employs theoretical constructs that can be measured only indirectly. For example, memory is a theoretical construct that can be defined as the capacity to remember. But, while the accuracy of remembering can be measured using a variety of different methods, the magnitude of memory can only be inferred. This is an instance of "the problem of nomic measurement" (Chang, 2004) that can be stated as follows:

1. Let X be a quantity that is not directly observable.
2. Let Y = f(X) be a quantity that is directly observable.
3. To use Y as a measure of X, f(.) must be known. But f(.) is unknown and cannot be discovered empirically because that would involve knowing the values of both Y and X, and X is the unknown variable that we are trying to measure.

This problem is of particular relevance in psychological science when it is assumed that the same theoretical construct can be measured using several different methods. That is:

1. Let X be a quantity that is not directly observable.
2. Let Y1 and Y2 be quantities that are directly observable.
3. To use Y1 and Y2 as measures of X, then Y1 = f(X) and Y2 = g(X), for some unknown functions, f(.) and g(.).

A reasonable restriction on f(.) and g(.) is that they are *monotonically increasing*. In this case, (3) defines a compound monotonic regression problem (Dunn, Burdakov & Kalish, 2012) that can be solved using a branch-and-bound algorithm (Burdakov, 2012). I outline this work and discuss the role of monotonic regression in addressing the problem of nomic measurement in psychological science.

Burdakov, O. P. (2012). *An approach to solving decomposable optimization problems with coupling constraints*. 21st International Symposium on Mathematical Programming, Berlin.

Chang, H. (2004). *Inventing temperature: Measurement and scientific progress*. New York: Oxford: University Press.

Dunn, J. C., Burdakov, O. P., & Kalish, M. L. (2012). *A compound monotonic regression problem*. 3rd Conference on Optimization Methods and Software, Chania, Greece.

2011

10 February 2011
Gunnar Aronsson (Department of Mathematics, Linköping University)

On Ekeland's epsilon-variational principle

Abstract: This is a fundamental principle in nonlinear analysis, apparently not widely known. It deals with the search for the minimum of a function F on a complete metric space. The function need only be lower semi-continuous and bounded from below. Given a point x such that F(x) is within epsilon from the lower bound, the principle produces a "nearby" point y having a smaller , or equal, value for F, and such that y gives a unique minimum for a "slightly" perturbed function. This is good enough, but the striking fact is that one can now perform a "trade-off" between "nearby" and "slightly". The surplus quantity epsilon is of course basic for the trade-off; the smaller epsilon, the better everything! The principle does not alone lead to an algorithm, but hopefully it leads to better insight.

The principle was published in 1972 by Ivar Ekeland; a Norwegian-French mathematician.

17 February 2011
Edvard Reuterswärd

MS Thesis presentation: *A no-crossover genetic algorithm for the set partitioning problem*

Abstract: A no-crossover genetic algorithm is designed to solve the set partitioning problem by applying mutations to obtain new solutions. The algorithm keeps two populations for which sorting is used for the evaluation and selection process. To increase the number of feasible solutions found, a repair function is used. This function divides the problem matrix into blocks that are used to enable better guesses when repairing the chromosomes. When tested on real-world problems the algorithm has produced good solutions and been very stable.

3 March 2011
Mikael Call (Linköping University, Department of Mathematics, Division of Optimization)

Callbacks in CPLEX to solve a MIP where the number of constraints is exponential

28 March 2011
Valeri Marenitch

The Closed Orbit Controllability Criterion

Abstract: We consider a control dynamical system and prove that its closed "general" trajectory has an open neighborhood on which the system is controllable if

1) this orbit contains some point where the Lie algebra rank condition (LARC) is satisfied, and
2) the set of control vectors has non-empty interior in its linear hull (is "involved").

In particular, for the control systems on the compact connected manifold with a control set with non-empty interior this gives the following "Closed Orbit Controllability Criterion": The dynamical system of the considered type is controllable if and only if for an arbitrary point there exists a closed trajectory of the control system going through this point.

7 April 2011
Michal Ulbricht (University of Zilina, Slovakia)

Multi-criteria scheduling jobs in grid systems

Abstract: There will be an overview of my work as a PhD. student presented. Name of my thesis is: Multi-criteria scheduling jobs in grid systems. First part will be about work I have completed. This includes multi-criteria mathematical model as a tool to determine efficiency of algorithms and SPEA2 (improved strong pareto evolutionary algorithm) implementation. In a part "what I am dealing with now" is implementation of AMOSA (archived multi-objective simulated annealing). Both of those algorithms belong to family of posterior optimization algorithms. My future plans involve implementation of single-objective versions of those two algorithms. Single objective algorithms belong to family of priori optimization algorithms. Then they will be compared (single and multi objective algorithms) and confronted with optimal solutions obtained via mathematical model. Better approach for scheduling jobs in grid systems will be chosen (priori or posterior) and new algorithm or improvements in existing algorithms will be done.

14 April 2011
Per-Magnus Olsson (Linköping University, Department of Mathematics, Division of Optimization)

Positioning Algorithms for Surveillance Using Unmanned Aerial Vehicles

Abstract: Surveillance is an important application for unmanned aerial vehicles (UAVs). The sensed information often has high priority and it must be made available to human operators as quickly as possible. Due to obstacles and limited communication range, it is not always possible to transmit the information directly to the base station. In this case, other UAVs can form a relay chain between the surveillance UAV and the base station. Determining suitable positions for such UAVs is a complex optimization problem in and of itself, and is made even more difficult by communication and surveillance constraints.

In this talk I will present some of the research about developing algorithms for finding positions where UAVs can be placed to form such relay chains, to guarantee that surveillance of one or more targets can be performed. The presentation contains a discussion of how the problem is modeled, what algorithms have been developed as well as some discussion of the empirical results.

21 April 2011
Elina Rönnberg (Linköping University, Department of Mathematics, Division of Optimization)

A project on solving an open pit mining problem

Abstract: At this seminar I will present the results from a project I have been working on for the PhD-course Primal and Dual Decomposition methods. The problem to be solved was an open pit mining problem which can be stated as a minimum cut problem (the dual of a maximum flow problem) with capacity constraints. The instance under consideration has 800 000 nodes, 8 000 000 arcs and 26 capacity constraints. Compared to a regular maximum flow problem, the presence of capacity constraints on its dual makes the problem much more difficult to solve.

My task was to implement a dual search method that has been suggested for this problem. The method is tailored for the special structure of the problem, and is based on Lagrangian relaxation of the capacity constraints.

During the seminar I will share my experiences from this project. Firstly, the suggested method did not behave as expected and I will illustrate why. Secondly, the task included that I should use AMPL/CPLEX, and because of the size of the problem, this offered some challenges.

5 May 2011
Berkant Savas (Linköping University, Department of Mathematics, Division of Scientific Computing)

Kronecker product and orthogonal Kronecker product approximation of matrices

Abstract: In this talk I will consider two problems: (1) The approximation of a given matrix by a Kronecker product of matrices; and (2) the approximation of a given orthonormal matrix by a Kronecker product of orthonormal matrices. We will discuss the structure and relations of the two problems to tensor approximation problems in the context of multilinear algebra. We will see that the second problem (with orthonormal matrices) may be considered as a problem defined on a product of Stiefel manifolds. We will present numerical algorithms that explicitly take into account the manifold structure of the problem. A few experimental results will also be presented.

12 May 2011
Sara Modarres Razavi (Linköping University, Department of Science and Technology)

Tracking area planning in cellular networks

Abstract: The enormous competition in the telecommunications market results in the necessity of optimized and cost-efficient networks for the operators and service providers. Tracing users cost-efficiently is one of the major challenges in the study of location management of wireless cellular networks. In comparison to earlier generations of cellular networks, LTE systems allow for a more flexible configuration of TA design by means of Tracking Area List (TAL). How to utilize this flexibility in applying TAL to large scale networks remains almost unexplored. In this talk three approaches for allocating and assigning TA lists are presented, and their performance is compared with each other, as well as with the standard location management scheme.

9 June 2011
Spartak Zikrin (Linköping University, Department of Mathematics, Division of Optimization)

Sparse solution of linear least-squares problems

Abstract: Sparse approximation is one of the hot topics in optimization nowadays, where the decision variables are required to have not more than a given number of nonzero components.

In the fist part of this talk (45 minutes), we give an overview of approaches used for solving sparse linear least-squares problem. It is known to be an NP-hard combinatorial problem. We will present greedy heuristics, convex relaxations and methods to solve them, including mixed integer quadratic optimization techniques applied to a cardinality-constrained quadratic reformulation of the sparse linear least-squares problem.

In the second part (20 minutes), we will present our results in finding sub-filter sparsity for optimal design of filter networks.

30 September 2011
Elina Rönnberg (Linköping University, Department of Mathematics, Division of Optimization)

The transformation that saved the day

Abstract: The purpose of this very informal talk is to present an example of some practical issues that has occurred during the implementation of an algorithm. The problems that I experienced are by far the worst I have encountered, and what is even more interesting is that a simple transformation of the problem turned out to be the remedy.

14 October 2011
Per-Magnus Olsson (Linköping University, Department of Mathematics, Division of Optimization)

Algorithms for Derivate-free Optimization of Non-linear Functions

Abstract: In this presentation I will present algorithms for derivate-free optimization of non-linear functions. Algorithms for optimization without the use of derivatives are of interest e.g. when the time required for function evaluation is prohibitively long. In such cases the objective function is treated as a black box and one has to make do without derivatives.

The algorithms that I will present range from the Nelder-Mead simplex algorithm from the mid sixties to the state-of-the-art algorithms developed during the last few years. I will also briefly discuss the theory behind the newer model-building algorithms and how such models are built and updated during the execution.

17 October 2011
Alexandra Newman (Colorado School of Mines)

Optimization of Underground Production Scheduling

Abstract: We discuss optimization models for underground production scheduling, specifically, determining when to extract areas in an underground mine to achieve a goal while adhering to precedence relationships between the areas in the mine, and to minimum and maximum operational restrictions. In the first case, we address a sublevel caving mine in Kiruna, Sweden. The goal is to minimize deviations from long-term iron ore contracts. In the second case, we discuss a multi-method lead-zinc mine near Dublin, Ireland. In both cases, the corresponding mixed integer programming models are complex enough to require special solution techniques. We discuss these, and the implications of our solutions on long-term planning at both mines.

31 October 2011
Nils-Hassan Quttineh (Linköping University, Department of Mathematics, Division of Optimization)

Military Resource Planning

Abstract: We present a resource planning and scheduling problem, where a number of aircraft need to be assigned to and routed between a given set of targets. There are many practical issues and limitations, that will be discussed, but in all we are able to present a mathematical model with similarities to the standard "Vehicle Routing Problem" model.

4 November 2011
Fredrik Heintz (Linköping University, Dept. of Computer and Information Science)

Complex Task Allocation for Collaborative Unmanned Aircraft Systems

Abstract: Task Allocation is a well known problem studied in both mathematics and computer science. In its basic formulation each task is atomic and should be assigned to a single machine or agent. In our work with collaborative unmanned aircraft systems we have recognized the need for allocating complex tasks in the form of recursively defined, interdependent tasks. In this talk I will present an overview of the complex task allocation problem mainly from a multi-agent systems perspective. Most approaches are either based on distributed constraint satisfaction and optimization techniques or on defining a market for trading tasks. The purpose of the talk is to start a discussion about the potential for cross fertilization between optimization and multi-agent systems approaches to the interesting and challenging problem of complex task allocation.

18 November 2011
Åsa Holm (Linköping University, Department of Mathematics, Division of Optimization)

Optimizing brachytherapy using variable neighbourhood search and conditional value at risk

25 November 2011
Elina Rönnberg (Linköping University, Department of Mathematics, Division of Optimization)

Introduction to integer programming column generation. Part I.

Abstract: As a part of the PhD course Research seminars II, I will give two seminars introducing integer programming column generation. The seminars will cover the essential general concepts, including model formulation and strategies for handling integrality, as well as some computational issues. Each seminar will be around 60 minutes depending on the amount of questions.

2 December 2011
Mikael Call (Linköping University, Department of Mathematics, Division of Optimization)

Complexity of Inverse Shortest Path Routing

Abstract: The inverse shortest path routing problem is to decide if a set of tentative routing patterns is simultaneously realizable. A routing pattern is defined by its destination and two arc subsets of required shortest path arcs and prohibited non-shortest path arcs. A set of tentative routing patterns is simultaneously realizable if there is a cost vector such that for all routing patterns it holds that all shortest path arcs are in some shortest path and no non-shortest path arc is in any shortest path to the destination of the routing pattern. Our main result is that this problem is NP-complete, contrary to what has been claimed earlier in the literature.

Inverse shortest path routing problems naturally arise as a subproblem in bilevel programs where the lower level consists of shortest path problems. Prominent applications that fit into this framework include traffic engineering in IP networks using OSPF or IS-IS and in Stackelberg network pricing games.

In this paper we focus on the common subproblem that arises if the bilevel program is linearized and solved by branch-and-cut. Then, it must repeatedly be decided if a set of tentative routing patterns is realizable. In particular, an NP-completeness proof for this problem is given.

9 December 2011
Elina Rönnberg (Linköping University, Department of Mathematics, Division of Optimization)

Introduction to integer programming column generation. Part II.

Abstract: As a part of the PhD course Research seminars II, I will give two seminars introducing integer programming column generation. The seminars will cover the essential general concepts, including model formulation and strategies for handling integrality, as well as some computational issues. Each seminar will be around 60 minutes depending on the amount of questions.

16 December 2011
Alexander Kleiner (Linköping University, Dept. of Computer and Information Science)

Guaranteed search in large-scale outdoor terrain

Abstract: In this talk I present a novel approach for guaranteed search in real-world outdoor terrain. Guaranteed search requires a team of searchers to clear an environment of targets moving at unknown speeds. This implies to generate a search strategy that guarantees to locate any moving target in the area which is generally known to be a NP-hard problem. The problem is relevant, for example, when securing terrain and building structures, such as a museum, but also for large-scale victim search during Search And Rescue (SAR) missions. The

method presented in this talk is based on an elevation map representation of the three-dimensional environment. Elevation maps are particularly suitable for large-scale outdoor scenarios since they can capture 3d visibility of specific sensor types and target heights. From elevation maps a graph representation is extracted, which is used to compute guaranteed strategies for coordinating a team of searchers (humans or robots) and to generate trajectories based on an appropriate classification of the terrain. I will finally present results from experiments conducted with real-world data sets demonstrating the performance of the proposed approach. Furthermore, I present results from a large-scale outdoor experiment conducted at Gascola, one of Carnegie Mellon's robot training site nearby Pittsburgh, US.

2010

9 April 2010
Nils-Hassan Quttineh (Linköping University, Department of Mathematics, Division of Optimization)

The Multi-Aircraft Coordination Problem

Abstract: The Multi-Aircraft Coordination Problem is a control parameter optimization problem, i.e. an optimal control problem, where the problem is to coordinate a number given number of aircrafts P so that they rendez-vouz at a common position in space at a final state time T.

Both primal and dual decomposition techniques are applied on the problem, and some results are presented.

15 April 2010
Panos Pardalos (University of Florida, USA)

Optimization and Data Mining in Biomedical Informatics

Abstract: Biomedical Informatics is the interdisciplinary science of acquiring, structuring,analyzing and providing access to biomedical data, information and knowledge. Some of the basic tools of Biomedical Informatics include optimization, control, data mining, and knowledge discovery techniques.

In this talk we are going to cover a spectrum of biomedical problems where these techniques have been used successfully. These problems arise in brain dynamics, drug toxicity, and cancer data analysis.

16 April 2010
Oleg Sysoev (Linköping University, Department of Computer and Information Science)

PhD Thesis defense: *Monotonic regression for large multivariate datasets*

Abstract:

Linköping Studies in Statistics No. 11
Linköping Studies in Arts and Science No. 514

Monotonic regression for large multivariate datasets

Oleg Sysoev

Academic dissertation

Academic dissertation for the Degree of Doctor of Philosophy in Statistics at Linköping University to be publicly defended on Friday 16 April 2010 at 13.15 in Glashuset, Building B.

Abstract

Monotonic regression is a non-parametric statistical method that is designed especially for applications in which the expected value of a response variable increases or decreases in one or more explanatory variables. Such applications can be found in business, physics, biology, medicine, signal processing, and other areas. Inasmuch as many of the collected datasets can contain a very large number of multivariate observations, there is a strong need for efficient numerical algorithms. Here, we present new methods that make it feasible to fit monotonic functions to more than one hundred thousand data points. By simulation, we show that our algorithms have high accuracy and represent considerable improvements with respect to computational time and memory requirements. In particular, we demonstrate how segmentation of a large-scale problem can greatly improve the performance of existing algorithms. Moreover, we show how the uncertainty of a monotonic regression model can be estimated. One of the procedures we developed can be employed to estimate the variance of the random error present in the observed response. Other procedures are based on resampling techniques and can provide confidence intervals for the expected response at given levels of a set of predictors.

Department of Computer and Information Science
Linköping University
SE-58183 Linköping, Sweden

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23 April 2010
Marcel Ndengo Rugengamanzi (Linköping University, Department of Mathematics, Division of Optimization)

An Optimization framework for estimating the forward rates

Abstract: The topic of this paper is the development of an optimization framework that can be used for estimating the forward rates. While we review some of the traditional techniques such as interpolation methods and some suitable smooth functions employed for that purpose, the current work suggests a constrained optimization model that proved to be rather general for estimating the forward rates and handle any interest rate instruments. The paper intends to show that all existing methods and smooth functions used to date are particular cases for the suggested ones. For computation purposes, we use an interior point based solver developed by Jörgen Blomvall. Preliminary results show that the proposed model guarantees smooth forward rate curves and prices interest rate instruments traded in the market realistically.

21 May 2010
Thomas Kaijser (Linköping University, Department of Mathematics)

On the primal-dual algorithm for the transportation problem in R^n

Abstract: Since the 1980ies the solution to a transportation problem has been used as a distance measure between digital images. Today this distance measure is usually called the "earth mover's distance". Other names are the Kantorovich distance and the Wasserstein distance.

A drawback with the earth mover's distance as a measure between images is that the transportation problem one has to solve is often quite large.

In the 1990ies I wrote a computer programme based on the primal-dual algorithm for solving the Kantorovich distance for digital images in R^2. Computer experiments showed that the computation time was of order $O(N^2)$, where N denotes the number of pixels in the images. I managed to obtain this order of computation time by proving that if the cost-function for the transportation problem is either the l^1-metric or the square of the Euclidean metric, then one can at some places in the primal-dual algorithm eliminate a lot of comparison tests.

The purpose of this talk is to show how one can eliminate a lot of comparison tests when using the primal-dual algorithm for solving the transportation problem in R^n - and not only R2, when the cost-function is determined by a metric - for example the Euclidean metric - or by a function of a metric.

4 June 2010
Shuying Shi (Linköping University, Department of Electrical Engineering)

Monotonic Optimization and D.C. Programming: Theory and Applications

Abstract :In this talk, two classes of non-convex optimization problems will be considered: 1) maximizing/minimizing a monotonic increasing/decreasing function under monotonic constraints; 2) minimizing the difference of two convex functions (D.C.) over a convex set. Generally, it is a great challenge to compute and characterize the global optimum of a non-convex problem. Fortunately, these two classes of problems have special structures that can be exploited to find global optima. We will give an overview of the recent theoretical and algorithmic developments of monotonic optimization and D.C. programming. Resorting to these results, we are able to solve many non-convex problems encountered in communication systems. We will pay special attention to two typical applications: signal processing in multiple-input-multiple-output (MISO) interference channel (IFC) and dynamic resource allocation in wireless networks.

11 June 2010
Rana Yazdan (Linköping University)

MS Thesis presentation: *Multi-criteria-based optimal positioning unmanned aerial vehicles as communication relays for surveillance tasks*

Abstract: We consider the problem of placing a relay chain of unmanned aerial vehicles (UAVs) used for surveying a target and conveying the gathered information back to a base station. The placing should take into account the presence of obstacles, limited communication range and the free line of sight requirement for the communicating UAVs.

At Linköping University, it was earlier developed an efficient approach allowing for finding Pareto optimal UAV chain positioning which solves a bi-criteria problem. The criteria in this problem are the communication quality to be maximized and the number of UAVs to be minimized.

In this thesis, we present an approach aimed at solving the multi-criteria problem with one extra criterion, namely, the surveillance quality which is required to be maximized. The developed algorithm produces, for each number of available UAVs, Pareto optimal relay chain placements which maximize both the communication and the surveillance quality.

8 September 2010
Andreas Bley (Technische Universität Berlin, Germany)

Hierarchy planning for large communication networks

Abstract: Large communication networks are typically partitioned into a hierarchy of several backbone and aggregation networks. The problem of finding such a network hierarchy is one of the central strategic planning problems of a network operator. It involves the choice of the locations for aggregation and core nodes and the dimensioning of access, aggregation, and backbone links such that all traffic demands can be routed.

We present solution approaches based on mixed-integer programming and heuristics to optimize all these decisions in an integrated fashion and with provenly small optimality gaps. The presented approaches and algorithms also account for different technological network layers and different traffic types in the network and permit the consideration of alternative network architectures.

Our first, integrated mixed-integer programming approach uses a combination of an explicit flow model for the traffic routing in the aggregation networks and metric inequalities in the core, which permits the use of very compact models to ensure a feasible aggregation network. The metric inequalities, which are generated dynamically during the solution process, on the other hand guarantee sufficient capacity in the core network. Using specialized branching strategies and customized heuristics and parameter settings, it is possible to find provenly good solutions with this integrated approach for networks of up to 60 nodes quickly.

Our second approach decomposes the overall problem into the task of optimizing the aggregation and core node locations together with the aggregation network topology and capacities and the task of optimizing the core network. These two subproblems can be solved efficiently using well-established mixed integer programming techniques and they can be combined easily to obtain heuristic solutions. Preliminary computational results for nation-wide reference networks with more than 900 locations show the effectiveness of the decomposition approach.

9 September 2010
Mikael Call (Linköping University, Department of Mathematics, Division of Optimization)

Licentiate Thesis defense: *Inverse Shortest Path Routing Problems in the Design of IP Networks*

Abstract: This thesis is concerned with problems related to shortest path routing (SPR) in Internet protocol (IP) networks. In IP routing, all data traffic is routed in accordance with an SPR protocol, e.g. OSPF. That is, the routing paths are shortest paths w.r.t. some artificial metric. This implies that the majority of the Internet traffic is directed by SPR. Since the Internet is steadily growing, efficient utilization of its resources is of major importance. In the operational planning phase the objective is to utilize the available resources as efficiently as possible without changing the actual design. That is, only by re-configuration of the routing. This is referred to as traffic engineering (TE). In this thesis, TE in IP networks and related problems are approached by integer linear programming.

Most TE problems are closely related to multicommodity routing problems and they are regularly solved by integer programming techniques. However, TE in IP networks has not been studied as much, and is in fact a lot harder than ordinary TE problems without IP routing since the complicating shortest path aspect has to be taken into account. In a TE problem in an IP network the routing is performed in accordance with an SPR protocol that depends on a metric, the so called set of administrative weights. The major difference between ordinary TE problems and TE in IP networks is that all routing paths must be simultaneously realizable as shortest paths w.r.t. this metric. This restriction implies that the set of feasible routing patterns is significantly reduced and that the only means available to adjust and control the routing is indirectly, via the administrative weights.

A constraint generation method for solving TE problems in IP networks is outlined in this thesis. Given an "original" TE problem, the idea is to iteratively generate and augment valid inequalities that handle the SPR aspect of IP networks. These valid inequalities are derived by analyzing the inverse SPR problem. The inverse SPR problem is to decide if a set of tentative routing patterns is simultaneously realizable as shortest paths w.r.t. some metric. When this is not the case, an SPR conflict exists which must be prohibited by a valid inequality that is then augmented to the original TE problem. To derive strong valid inequalities that prohibit SPR conflicts, a thorough analysis of the inverse SPR problem is first performed. In the end, this allows us to draw conclusions for the design problem, which was the initial primary concern.

14 October 2010
Kaj Holmberg (Linköping University, Department of Mathematics, Division of Optimization)

Urban Snow Removal

Abstract: The question of how to do snow removal in cities contains several intresting optimization problems. In this talk we first address the general assignment and routing problem for a certain area, containing several different tasks and several different vehicles. We discuss a preliminary model and mention several possible objectives, for example minimizing the time when all tasks are done.

Then the talk will focus on a "subproblem", namely the routing of a single specialized machine. This machine is designed for doing specific tasks, such as clearing bicycle paths, sidewalks, paths in pedestrian areas, bus stops etc. It cannot be used for a general street, but may use any street for moving itself. For a given set of tasks to be performed by this machine, the routing problem boils down to the rural postman problem. Here we essentially wish to minimize the traveltime needed between the tasks.

Since the rural postman problem is NP-hard and the tool we are considering should be used in an iterative manner, where the solution time should be a matter of seconds, not minutes, we consider heuristics.

The heuristics are of the same type as the classical Frederickson heuristic. The ideas concern the order of the main steps in such a method, namely constructing a connected graph with all vertices having even degree, containing all the required edges. We also propose two postprocessing heuristics for improving the tours and removing obviously unnecessary detours.

Computational tests on a large number of instances show that the ideas are interesting alternatives to the classical approach, and that running times are acceptable.

28 October 2010
Åsa Holm (Linköping University, Department of Mathematics, Division of Optimization)

Linearity effects in brachytherapy treatment planning and catheter positioning

Abstract: Modern optimization techniques for inverse planning of HDR brachytherapy makes it possible to efficiently calculate dose plans. One of the tenets of such techniques is the use of linear penalty functions. Plans generated with these techniques tend to have a few dwell positions that dominate the solution, however physicians prefer homogeneous plans. In this talk we show that one reason for the long dwell times is the linear penalties and introduce a solution that reduces the effects of linearity. One additional decision that in treatment planning is the placement of catheter, in this talk we will also introduce a model to include this decision in the dose planning and present some preliminary results.

4 November 2010

Nils-Hassan Quttineh (Linköping University, Department of Mathematics, Division of Optimization)

Tactical mission planning

Abstract: We present a model for tactical mission planning, where the objective is to define an attack plan for aircrafts toward a convoy of ships, maximizing the probability of mission success under the constraint of a joint resource. Each ship in the convoy should be assigned an attack plan, defined by an angle of attack and the number of missiles to be launched. The objective function is nonlinear, which makes the problem difficult to solve, and possible ways around this obstacle are discussed. By a simple assumption, the optimization problem boils down to a knapsack like problem, providing both an upper and lower bound to our problem. We also present a possible way to linearly approximate the objective function, making the whole problem linear.

11 November 2010

Oleg Burdakov (Linköping University, Department of Mathematics, Division of Optimization)

Local search for hop-constrained directed Steiner tree problem with application to UAV-based multi-target surveillance

Abstract: Given a weighted directed graph with a selected root node and a set of terminal nodes, the directed Steiner tree problem (DSTP) is to find a directed tree of the minimal weight which is rooted in the root node and spanning all terminal nodes. We consider the DSTP with a constraint on the total number of arcs (hops) in the tree. This problem is known to be NP-hard, and therefore, only heuristics can be applied in the case of its large-scale instances.

For the hop-constrained DSTP, we propose local search strategies aimed at improving any heuristically produced initial Steiner tree. They are based on solving a sequence of hop-constrained shortest path problems for which we have recently developed efficient label correcting algorithms.

The approach presented in this talk is applied to solving the problem of placing unmanned aerial vehicles (UAVs) used for multi-target surveillance. The efficiency of our algorithms is illustrated by results of numerical experiments related to this applied problem.

9 December 2010

Oleg Burdakov (Linköping University, Department of Mathematics, Division of Optimization)

Optimal basis algorithm and its application to matrix scaling

Abstract:

We present the optimal basis (OB) problem and the OB algorithm introduced in:

O. Burdakov. A greedy algorithm for the optimal basis problem.
BIT Numerical Mathematics (1997) **37** No. 3, pp. 591–599.

The OB problem is formulated as follows. Given $m+1$ points $\{x_i\}_0^m$ in R^n which generate an m-dimensional linear manifold, construct for this manifold a maximally linearly independent basis that consists of vectors of the form $x_i - x_j$. This problem is present in, e.g., stable variants of the secant and interpolation methods, where it is required to approximate the Jacobian matrix f' of a nonlinear mapping f by using values of f computed at $m+1$ points. In this case, it is also desirable to have a combination of finite differences with maximal linear independence. As a natural measure of linear independence, we consider the Hadamard condition number which is minimized to find an optimal combination of m pairs $\{x_i, x_j\}$ that defines the optimal basis. It will be shown that this combinatorial-like-looking problem can be reduced to a problem which is solved by a greedy algorithm in $O(m^2)$ time. The complexity of this reduction is equivalent to one $m \times n$ matrix–matrix multiplication, and according to the Coppersmith–Winograd estimate, is below $O(n^{2.376})$ for $m = n$. We discuss possible applications of the OB algorithm for constructing simple non-diagonal prescaling procedures for iterative linear algebra solvers.