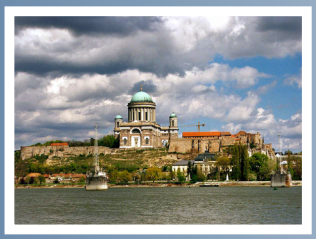

VOCAL 2018

PROGRAM and ABSTRACTS

VOCAL 2018
Program and Abstracts

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VOCAL 2018

The 8th VOCAL Optimization Conference: Advanced Algorithms will be held at the St. Adalbert Conference Center in Esztergom, Hungary, December 10-12, 2018.

Conference scope

The VOCAL conference focuses on recent advances on optimization algorithms: continuous and discrete; complexity and convergence properties, high performance optimization software and novel applications are reviewed as well. We aim to bring together researchers from both the theoretical and applied communities in the framework of a medium-scale event.

Plenary Invited Speakers

Darinka Dentcheva

Stevens Institute of Technology, Hoboken NJ, USA

Asymptotics of Optimization Problems with Composite Risk Functionals

Risk quantification and risk management in finance, insurance and other areas have attracted a lot of attention among scientists and practitioners due to the practical relevance and theoretical challenges they present. Mathematical models of risk lead to new structures in convex analysis, optimization, optimal control, and statistics. Risk models evaluate gains or losses depending on a decision

maker's choice z and random quantities, which may be summarized in a random vector X. We are interested in a functional $f(z, X)$, which may be optimized under practically relevant restrictions on the decisions z. Next to some moments of the random variable $Y = f(z, X)$, very frequently, models of risk use a nonlinear functionals of the distribution of Y. In practice, we can only use observations to estimate the model. Several measures of risk have an explicit formula, which can be used as a plug-in estimator, with the original measure P replaced by the empirical measure. The questions pertaining to statistical estimation of risk functionals and its effect on optimization problems using such functionals are crucial for practical application. The composite structure and limited differentiability properties of coherent measures of risk render the existing theory inapplicable.

In this talk, we discuss statistical estimation of composite risk mappings depending on random vectors and their moments. We present a central limit formula for such functionals and provide a characterization of the limiting distribution of the empirical estimators.

Several popular risk measures will be presented as illustrative examples. While we show that many known coherent measures of risk can be cast in the presented structures, we emphasize that the results are of more general nature with a potentially wider applicability.

Additionally, we consider sample based optimization problems in which composite risk functionals are used as objectives or constraints. We characterize the asymptotic behavior of the optimal value and the optimal solutions of the problems. Applications of the results to hypothesis testing of stochastic orders and portfolio efficiency will be outlined.

Laureano F. Escudero

Universidad Rey Juan Carlos, Móstoles (Madrid), Spain

New trends on Matheuristic Algorithms for Mathematical Optimization under Uncertainty. Some results

Given the huge dimensions (very frequently, up to hundreds of thousands of constraints and variables) of multiperiod stochastic mixed 0-1 models to deal with in practical applications, it seems unrealistic to seek for optimal solutions, although the scheme for guaranteeing the solution's quality is a must. A review of new matheuristic algorithms in the literature is presented for the risk neutral model as well as for considering some risk averse measures, especially stochastic dominance –based ones. A good tendency in this type of research lies on matheuristic versions of the Nested Stochastic Decomposition (NSD) methodology for while considering period wise dependent uncertainty for solving large-scale dynamic mixed 0-1 problems. One of the main reasons for its good performance is that the partition of the periods in stages (of consecutive stages) makes the NSD decomposition procedure easier, where each iteration has forward and backward steps. Notice that the constraint system of any stage submodel includes independent submodels in its risk neutral version. Each submodel is supported by a subtree that is rooted with a strategic node includes also the set of immediate successor nodes

of each leaf strategic node in the previous stage. So, those submodels can be solved in parallel, whose their good performance requires some type of communication between them. However, in spite of the advantages of using the NSD methodology for dynamic problem solving, it has still some drawbacks. In fact, it can be observed in computational experience with stochastic mixed 0-1 models that the NSD's efficiency is reduced for those problems with stepwise dependent non-Markovian processes where the state variables link several consecutive stages. Some modeling hints are given for reducing it down to two consecutive stages, if possible. Versions of the NSD for expected conditional stochastic dominance functional will also be presented. Computational experience is reported for some real-life problems.

Jiří Jaromír Klemeš

Brno University of Technology, Brno, Czech Republic
Pázmány Péter Catholic University, Budapest, Hungary

Mathematical Programming and Graph-Based Tools in Process Systems Engineering

Process Systems Engineering have traditionally used Mathematical Programming (MP) with creating a superstructure and using various optimisation methods to obtain an optimum. MP methods enable the search among many design alternatives and explicitly account for both investment and operating costs. MP problems may be generally formulated as Mixed Integer Nonlinear Programming (MINLP) problems. However, to avoid local optima, in many cases, the problem needs to be simplified to reformulate MINLP into Linear Programming (LP) problem, Nonlinear Programming (NLP) problem or Mixed Integer Linear Programming (MILP). Some efficient approaches have been presented in the past as MILP-NLP or MILP-MINLP.

This methodology has been well rehearsed over the years, with escalating available computing power meaning the main issue of the computing time being overcome. However, there are still key issues to be dealt with – such as local optima of MINLP (Mixed Integer Nonlinear Programming) problems and especially exploiting physical insights and industrial experience during the solution development. However, as can be seen from the example of Pinch

Analysis, applying physical insight helps reduce the search space and steer solutions towards the global optimum.

A big step forward has been brought about by P-graph, a methodology using graphs combined with powerful optimisation. This has been a lean, streamlined tool for Process Network Synthesis, and despite a strong MP lobby become more and more spreading out. However, as engineers, especially practising engineers in the industry, are traditionally by nature preferring the graphical insight for understanding processes as well as the interpretation of results, some other methodologies have been developed.

The traditional Process Integration based on Pinch Methodology tools to analyse and target process performance, starting firstly with Heat Exchanger Network (HEN), facilitated the development, which included Composite Curves, Grand Composite Curves, Time Slices and Time Average Composite Curves and classical Grid Diagram. These tools have been extended to Total Sites (integration of integrated processes) and further to Local Energy Integrated Sectors (covering beside industrial units also various civic, business, cities and even agriculture units). For visualisation, analysis and optimisation of those sites have been developed Site Source – Sink Profiles, Site Utilities Grand Composite Curves and Exergy Site Profiles. Extensions to resource optimisation and targeting has led to the introduction of Water and Waste Water Profiles, Power Composite Curves, Power Site Profiles, Emissions Composite Curves and a number of the others. However those tools have been also supported with developed numerical tools, including Total Site Problem Table Algorithm (TS-PTA), Segregated Problem Table Algorithm (SePTA), Total Site Sensitivity Table (TSST), Total Site Utility Distribution, Time Super Targeting and some others.

The very recent developments have resulted in (i) the Energy Transfer Diagram, (ii) Heat-Exchanger Load Diagram, (iii) Heat Surplus-Deficit Table, (iv) Shifted Retrofit Thermodynamic Diagram, (v) Retrofit Tracing Grid Diagram, (vi) Stream Temperature vs. Enthalpy Plot - STEP, and (vii) Retrofit Dashboard. Each of these visualisation tools provides a lens to increase the understanding of existing process.

Using this insight together with defined steps and rules, it becomes easier to design and implement effective grassroots design and especially retrofit strategies which are at the cornerstone of PSE.

This lecture has been an attempt to present an overview of

mainly graph-based approaches to raise awareness of usefulness of graphical representation-based method as well as an exploitation the hybrid approach.

Joint work with Petar Sabev Varbanov and Timothy Gordon Walmsley (Brno University of Technology, Brno, Czech Republic).

Acknowledgement
The EU supported project Sustainable Process Integration Laboratory - SPIL funded as project No. CZ.02.1.01/0.0/0.0/15_003/0000456, by Czech Republic Operational Programme Research and Development, Education, Priority 1: Strengthening capacity for quality research.

Ulrike Leopold-Wildburger

University of Graz, Graz, Austria

Optimization and behavior

While methods of OR represent the field of a science for delivering better decisions using optimal (or near-optimal) solutions to complex decision-making problems our actual behavior in practical applications quite often has to deal with non-fully rational decision makers. We try to make aware the tension between the two scopes and we will support this research by some examples. Coming from the field of OR we are aware that that techniques such as mathematical modeling, statistical analysis, and mathematical optimization are engaged in applications of advanced analytical methods with the aim to make better decisions. However, in everyday life OR is not executed in its pure version but often connected with other fields and disciplines, as psychology and behavioral sciences, microeconomics and even nowadays integrating neuroscience.

Some characteristic examples from the field of game theory will be prepared and checked with the actual behavior of decision makers in specific economic situations. We will deal with topics as cooperation, fairness and honesty and we will try to compare theoretical concepts with empirical data.

Andrzej Ruszczynski

Rutgers University, Piscataway NJ, USA

Risk-Averse Control of Markov System

We shall focus on modeling risk in dynamical systems and discuss fundamental properties of dynamic measures of risk. Special attention will be paid to the local property and the property of time consistency. Then we shall focus on risk-averse control of discrete-time Markov systems. We shall introduce the class of Markovian risk measures, and derive their structure. This will allow us to derive a risk-averse counterpart of dynamic programming equations. Then we shall extend these ideas to partially-observable systems and continuous-time Markov chains and derive the structure of risk measures and dynamic programming equations in these cases as well. In the last part of the talk, we shall discuss risk-averse control of diffusion processes and present a risk-averse counterpart of the Hamilton–Jacobi–Bellman equation.

Ana Viana

Centre for Industrial Engineering and Management of INESC TEC, Porto, Portugal

Optimization challenges in Kidney Exchange Programs: past, present and future

Kidney exchange programmes (KEPs) represent an alternative of transplant for patients with an incompatible living donor: in these programs patients with a willing incompatible donor join a pool of incompatible patient-donor pairs and, if compatibility between patient in one pair and donor in another is found, patient in one pair can receive an organ from the donor in another pair and vice-versa. Pair-matching should be done in such a way that maximum social welfare (that can be measured by e.g. the number of transplants that will be performed) is achieved.

Pioneering contributions in this area used integer programming as a natural framework to represent the problem and find an optimal solution. However, those models did not consider data uncertainty, associated to pair dropout or undetected incompatibilities, which in practice may have a considerable impact on the solution to implement. Given that, current research has been addressing data uncertainty in different manners: robust optimization, stochastic optimization, and simulation.

In this talk we will present different Integer Programming models proposed in the literature for KEP, when data is considered to be

certain. We will proceed with the description of some approaches that address data uncertainty. Finally, we provide some insights on future challenges in the area. In particular, we focus on the case where multiple agents collaborate in a joint pool.

Technical Program

December 9, 2018 (Sunday)

6:00 pm – 8:00 pm **Registration Office Open**

December 10, 2018 (Monday)

8:00 am – 6:00 pm **Registration Office Open**

9:00 am – 9:30 am **Opening ceremony**

9:30 am – 10:30 am **Plenary Session 1**

Optimization and behavior
Ulrike Leopold-Wildburger

10:30 am – 10:50 am **Coffee break**

10:50 am – 12:05 pm **Parallel Session 1A**

IP solutions for international kidney exchange programmes
Péter Biró, Márton Gyetvai, Radu-Stefan Mincu, Alexandru Popa, Utkarsh Verma

Integer programming formulations for college admissions with ties
Kolos Csaba Ágoston, Péter Biró, Zsuzsanna Jankó, Endre Kováts

Integer programming formulations for the stable exchange problem
Xenia Klimentova, Péter Biró, Virginia Costa, Ana Viana, João Pedro Pedroso

10:50 am – 12:05 pm **Parallel Session 1B**

Redundant coalitions for weighted least cores
Tamás Solymosi

Equilibria in large semi games
Miklós Pintér

On solving the symmetric non-negative matrix tri-factorization problem
Timotej Hrga, Janez Povh, Nataša Pržulj

10:50 am – 12:05 pm **Parallel Session 1C**

Feature selection and transformation based analysis and reduction of many-objective optimisation problems
János Abonyi, Gyula Dörgő, Tamás Torgyik

Efficiency test of priority vectors derived from pairwise comparison matrices
Ádám Antal, Sándor Bozóki, János Fülöp

Multi-criterial 2DOF PID controller design
Stanislav Lang ,Radomil Matousek, Tomas Marada, Jakub Kudela

12:05 pm – 1:00 pm **Lunch**

1:30 pm – 2:30 pm **Guided tour in Esztergom Cathedral**

2:30 pm – 3:00 pm **Organ concert in Esztergom Cathedral**

3:20 pm – 4:20 pm **Plenary Session 2**

Optimization challenges in Kidney Exchange Programs: past, present and future
Ana Viana

4:20 pm – 4:40 pm **Coffee break**

4:40 pm – 5:55 pm **Invited Parallel Session 2A**

Fleet composition and routing decisions in municipal solid waste collection problem
Dušan Hrabec, Jorge L. Oyola, Richard Hartl, Radovan Šomplák, Vlastimír Nevrlý

Circular economy implementation in waste management network design problem: A case study
Dušan Hrabec, Jakub Kudela, Vlastimír Nevrlý, Radovan Šomplák, Pavel Popela

Incomplete recourse programs for engineering problems
Pavel Popela, Jaromír Hošek, Jaroslav Sklenar, Karen Caruana

4:40 pm – 5:55 pm **Parallel Session 2B**

A myopic greedy algorithm for kidney exchange programs
Tiago Monteiro, Xenia Klimentova, João Pedro Pedroso, Ana Viana

A heuristic approach for kidney exchange program
Utkarsh Verma, Narayan Rangaraj

Sensitivity analysis of the County Health Rankings
Ádám Huszárik

4:40 pm – 5:55 pm **Parallel Session 2C**

A framework for defining scheduling problems
Attila Tóth, Miklós Krész

Review and comparison of MILP approaches for cyclic scheduling of robotic cells
Ádám Papp, Olivér Ősz, Máté Hegyháti

Interlacing in cyclic scheduling
Máté Hegyháti, Olivér Ősz

6:30 pm – 10:00 pm **Dinner & wine at Hilltop Winery**

(additional registration required)

December 11, 2018 (Tuesday)

8:00 am – 6:00 pm **Registration Office Open**

9:00 am – 10:00 am **Plenary Session 3**

Asymptotics of Optimization Problems with Composite Risk Functionals
Darinka Dentcheva

10:00 am – 10:20 am **Coffee break**

10:20 am – 12:00 am **Parallel Session 3A**

A new predictor-corrector interior-point algorithm for linear optimization problem
Zsolt Darvay, Tibor Illés, Behrouz Kheirfam, Petra Renáta Rigó

Generating sufficient matrices and test examples for interior point algorithms
Gábor Sunil Morapitiye, Tibor Illés

New trends in interior-point algorithms
Petra Renáta Rigó

A new adaptive predictor-corrector interior-point algorithm for sufficient linear complementarity problems
Zsolt Darvay

10:20 am – 12:00 am **Invited Parallel Session 3B**

3D reconstruction with depth prior using graph cut
Hichem Abdellali, Zoltan Kato

Segmentation of complex structures with parts based RJMCMC
Laszlo Czuni, Karim Ben Alaya

Registration of heterogeneous point clouds through Hough space based optimization
Balázs Nagy, Örkény H. Zováthi, Csaba Benedek

Camera pose optimization in applications
Levente Tamas

10:20 am – 12:00 am **Parallel Session 3C**

Task assignment to workers on the basis of their competencies
Bozena Staruch

The problem of using remnants of fabrics in upholstered furniture factories
Bozena Staruch, Bogdan Staruch

Scheduling of custom printed napkin manufacturing by P-graphs
Márton Frits, Botond Bertók

Optimal cutting and nesting problem in manufacturing process of rubbered steel rule dies
Dániel Zombori, Balázs Bánhelyi, István Nagy, Tibor Csendes

12:00 am – 1:30 pm **Lunch**

1:30 pm – 2:30 pm **Plenary Session 4**

Risk-Averse Control of Markov System
Andrzej Ruszczynski

2:30 pm – 4:10 pm **Parallel Session 4A**

Markov decision processes with total effective payoff
Endre Boros

A fairer penalty shootout design in soccer
László Csató

A new algorithm for fitting vine copulas in higher dimensions
Edith Kovács, Tamás Szántai

On the supermodularity of the information content and a new sufficient condition for the equivalence between the Markov properties
Edith Kovács, Tamás Szántai

2:30 pm – 4:10 pm **Parallel Session 4B**

On the implementation of the crossover algorithm
Csaba Mészáros

Some practical issues related to the implementation of type III sensitivity analysis of LP models
Imre Dimény, Tamás Koltai

A new interior point algorithm for a class of market equilibrium problems
Anita Varga, Tibor Illés

On a sufficient property for sufficient matrices
Janez Žerovnik

2:30 pm – 4:10 pm **Parallel Session 4C**

Quickly proving that a specific sparse graph has no triangle
Mihály Hujter

The Quadratic Assignment Problem: computational experiments/experience
Radomil Matousek, Jakub Kudela, Pavel Popela, Ladslav Dobrovsky

Fast Minimization of MRF Energies with Separable Convex Prior over Product Labelspaces
Csaba Domokos, Frank R. Schmidt, Daniel Cremers

Stackelberg location problem on networks with discrete quality variables and operational costs
Kristóf Kovács, Boglárka G. Tóth

4:10 pm – 4:30 pm **Coffee break**

4:30 pm – 5:45 pm **Parallel Session 5A**

P-graph algorithms for the synthesis of reliable processing systems
Ákos Orosz, Zoltán Kovács, Ferenc Friedler

P-graph based risk evaluation model for optimal design of complex systems
Zoltán Süle, János Baumgartner, János Abonyi

Multiobjective optimal sensor placement for data reconciliation
Gyula Dörgő, Tamás Ruppert, János Abonyi

4:30 pm – 5:45 pm **Parallel Session 5B**

Mathematical model for power plant scheduling and its properties
Péter Naszvadi

Optimal solution of nonlinear, constrained multi-period production problems
Zsolt Ercsey, Péter Novák, Zoltán Kovács

An efficient heuristic for a complex scheduling problem
György Dósa , Tibor Dulai, Ágnes Werner-Stark

4:30 pm – 5:45 pm **Parallel Session 5C**

Joint optimization of transition rules, number of classes and premiums in a Bonus-Malus system
Márton Gyetvai, Kolos Csaba Ágoston

The efficiency analysis of commercial banks
Attila Poesz

Measuring longevity risk in annuities
Kolos Csaba Ágoston, Dávid Burka, Erzsébet Kovács, Ágnes Vaskövi, Péter Vékás

7:00 pm – 10:00 pm **Conference banquet at Primate Cellar**

December 12, 2018 (Wednesday)

8:00 am – 12:00 am **Registration Office Open**

9:00 am – 10:00 am **Plenary Session 5**

Mathematical Programming and Graph-Based Tools in Process Systems Engineering
Jiří Jaromír Klemeš

10:00 am – 10:20 am **Coffee break**

10:20 am – 12:00 am **Invited Parallel Session 6A**

A randomized method for probabilistic problems
Csaba Fábián, Edit Csizmás, Rajmund Drenyovszki, Tibor Vajnai, Lóránt Kovács

Utilizing strengthened lift-and-project cuts in decomposition methods to solve two-stage stochastic programming problems with binary first-stage variables
Pavlo Glushko, Achim Koberstein, Csaba Fábián

An oracle for an inner approximation based probability maximization method
Rajmund Drenyovszki, Csaba Fábián, Lóránt Kovács

An application of Ant Colony Optimization to minimize the total changeover time on unrelated parallel machines with sequence-dependent changeover times
Zsolt Mihály, Adrienn Boldizsár, Boglárka G. Tóth, Zoltán Lelkes

10:20 am – 12:00 am **Parallel Session 6B**

Targeting the options for utility system retrofit using efficiency and footprint indicators
Petar S. Varbanov, Timothy G. Walmsley, Jiří Jaromír Klemeš, Sharifah Rafidah Wan Alwi

What are the fair steam cost and environmental footprint allocations for multi-company total sites?
Timothy G. Walmsley, Raymond G. Tan, Petar S. Varbanov, Jiří Jaromír Klemeš

Modeling technique in the P-graph framework for operating units with variable input and output ratios
András Éles, István Heckl, Heriberto Cabezas

Energia design synthesis
István Kistelegdi, Kristóf Horváth, Zsolt Ercsey

12:00 am – 1:30 pm **Lunch**

1:30 pm – 2:30 pm **Plenary Session 6**

New trends on Matheuristic Algorithms for Mathematical Optimization under Uncertainty. Some results
Laureano F. Escudero

2:30 pm – 3:45 pm **Invited Parallel Session 7A**

Stochastic optimization in Hilbert spaces with applications to PDE constrained shape optimization
Georg Pflug, Caroline Geiersbach

Modelling cascading effects for systemic risks: A copula approach
Sándor Guzmics, Georg Pflug

Optimization of reliable beam-column construction and its statistical verification
Lukáš Kokrda, Pavel Hrabec

2:30 pm – 3:45 pm **Parallel Session 7B**

Optimizing data collection: a data-driven approach for sea exploration
Davi Pereira dos Santos, João Pedro Pedroso

Optimal route and trajectory planning for automatic guided vehicles
Botond Bertók

Combination of simulated annealing with radial basis function networks model for global optimization problems
Hemmak Allaoua

3:45 pm – 4:00 pm **Closing the conference**

4:00 pm – 4:20 pm **Coffee break**

Abstracts

3D reconstruction with depth prior using graph cut

Hichem Abdellali
University of Szeged, Hungary
Zoltan Kato
University of Szeged, Hungary

Keywords: 3D reconstruction, Graph cut, MRF modelling.

Recent years has seen the revolution over the 3D reconstruction area since the acquired information, are important and useful for many field usages like robotics, 3D city, virtual environment, navigation, cultural heritage, and more. To achieve high accuracy 3D reconstruction, we focused in this work on stereo setup; the problem here is to find in each image the projection of the objects in the scene, which aim to find the depth information of the scene, generally called: disparity. Thus, this will raise two questions. First is how to calculate the disparity. Second, is how to use disparity knowledge to find the 3D information? Although, even if depth sensors are widely available, like Time-of-flight devices, or Lidar, these sensors may be sensitive to lighting conditions and require a special setup, while stereo camera systems are more flexible and cheaper. Furthermore, with rectified images, the disparity estimation is reduced to one dimension. We explored the possibility if partial depth data can be used as a prior information to achieve an efficient 3D scene reconstruction. However, it is not trivial to include meaningful prior information about the 3D scene. These questions have been answered through this work using MRF Modelling and graph-cut, which represent the disparity as an energy function. We propose a novel graph-cut based 3D reconstruction method which is able to take into account partially available depth data as a prior. We formulate the energy in two representations: 1) assignment-based, which yields a standard binary energy; as well as 2) a multi-label one, which yields a non-binary energy. Both representations have its advantages and disadvantages, which are analyzed in detail through various experiments on the Middlebury stereo data set and on real stereo images. Results show, that the use of depth prior information from different sources produces better 3D reconstructions.

Feature selection and transformation based analysis and reduction of many-objective optimisation problems

János Abonyi
MTA PE Lendület Complex Systems Monitoring R. G., Hungary

Gyula Dörgő
MTA PE Lendület Complex Systems Monitoring R. G., Hungary

Tamás Torgyik
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Keywords: Many-objective optimization, Feature selection, Problem reduction, Beer fermentation.

In practical optimisation problems frequently happens that many (more than three) objectives should be taken into account. Despite there are several approaches to deal with these many-objective optimization problems (MaOPs) all of these have drawbacks. Our motivation is to support the solving of these MaOPs by providing a method to analyse the hidden nature of the objective space and the Pareto fronts (PFs). The analysis of the conflicts and correlations between these objectives can support the related many-criteria optimisation problems. We identify conflicting sets of correlated objectives based on multivariate statistical and machine learning models to define a reduced optimisation problem. Novel performance and similarity measures were developed for the comparison of Pareto fronts to study the effect of the reduction of the objectives. The applicability of the methodology is presented by the visualization and reduction of multiobjective benchmark optimization problems and in a realistic case study related to the optimisation of a beer fermenter.

Integer programming formulations for college admissions with ties

Kolos Csaba Ágoston
Corvinus University of Budapest, Hungary

Péter Biró
Hungarian Academy of Sciences, Hungary

Zsuzsanna Jankó
Hamburg University, Germany

Endre Kováts
Budapest University of Technology and Economics, Hungary

Keywords: Integer programming, Matching, College admission.

When two students with the same score are competing for the last slot at a university programme in a central admission scheme then different policies may apply across countries. In Ireland only one of these students is admitted by a lottery. In Chile both students are admitted by slightly violating the quota of the programme. Finally, in Hungary none of them is admitted, leaving one slot empty. We describe the solution by the Hungarian policy with various integer programing formulations and test them on a real data from 2008 with around 100,000 students. The simulations show that the usage of binary cutoff-score variables is the most efficient way to solve this problem when using IP technique. We also compare the solutions obtained on this problem instance by different admission policies. Although these solutions are possible to compute efficiently with simpler methods based on the Gale-Shapley algorithm, our result becomes relevant when additional constraints are implied or more complex goals are aimed, as it happens in Hungary where at least three other special features are present: lower quotas for the programmes, common quotas and paired applications for teachers' studies.

Measuring longevity risk in annuities

Kolos Csaba Ágoston
Dávid Burka
Erzsébet Kovács
Ágnes Vaskövi
Péter Vékás
Corvinus University of Budapest, Hungary

Keywords: Actuarial science, Longevity risk, Mortality, Annuities, Generalized Age-Period-Cohort Model.

Hunt and Blake (2015) and Villegas et al. (2016) have recently created the Generalized Age-Period-Cohort (GAPC) family of mortality forecasting models, which is an attractive unifying framework of several popular mortality forecasting techniques. We apply the GAPC framework on long time series of 50 years of Hungarian age-specific mortality rates of people aged at least 65 years, perform model selection based on several popular criteria from the literature, and estimate the life expectancy at the retirement age of 65 years and the net single premium of an annuity starting at retirement. We compare our results to the values obtained by the assumption of static mortality rates as well as to earlier results from the literature. We select the best model based on the out-of-sample forecasting accuracy of five popular mortality forecasting techniques, and conclude that the Cairns-Blake-Dowd model provides the best predictive performance based on several widespread statistical criteria. For the sake of methodological correctness, we model parameter uncertainty using semi-parametric bootstrapping. Finally, we quantify the financial impact of ignoring longevity risk in life annuities, and based on a survey of earlier results, we argue that the role of longevity risk in Hungary has increased significantly in the past eight years. Beyond its global significance, we argue that this question is highly relevant in in Hungary due to a relatively new local law enabling voluntary pension fund members (about 1.5 million individuals) to convert their third-pillar retirement savings into annuities.

Combination of simulated annealing with radial basis function networks model for global optimization problems

Hemmak Allaoua
Mohamed Boudiaf University, Algeria

Keywords: Simulated annealing, Radial basis function networks model, Enhanced simulated annealing, optimization.

In most cases, many problems in several fields involve the determination of global optimum of multidimensional function with a great number of local optima. Despite their contribution in terms of efficiency, the existing methods still reveal a major handicap to escape the trap of the local optimum.This paper presents a new scenario of hybridizing the global and stochastic metaheuristics, Simulated Annealing (SA), with a Radial Basis Function Networks Model (RBFNM) to deal such problems. The proposed approach, called Enhanced Simulated Annealing (ESA), aims to take advantage of the power of neuron networks in terms of optimization. Supervised learning is applied to build a network model that can simulate the objective function. Our goal is to provide a new tool to both improve the solution quality and avoid premature convergence of SA. It is a low-level relay hybridization since the RBNFM is incorporated in the SA algorithm instead of the neighborhood process. A comparison between SA and BNFNM is performed to show the efficiency of the new approach applied on some standard test optimization functions known as multi-dimensional and with several local optima. Despite the cost in terms of computing time, the results are encouraging and promising in terms of convergence.

Efficiency test of priority vectors derived from pairwise comparison matrices

Ádám Antal
Eötvös Loránd University, Hungary

Sándor Bozóki
MTA SZTAKI, Hungary

János Fülöp
MTA SZTAKI, Hungary

Keywords: Multi-attribute decision making, Pairwise comparison matrix, Efficiency, Pareto optimality.

A weight vector is called efficient (Pareto optimal) if it cannot be improved such that all the pairwise ratios remain at least as close to the matrix elements and at least one of them gets strictly closer. Three weighting methods, the eigenvector, the arithmetic mean of all spanning trees' weight vectors (AMAST) and the cosine maximization have been investigated in case of 4x4 pairwise comparison matrices, with elements chosen from the usual ratio scale $1, 2, \ldots, 9, 1/2, 1/3, \ldots, 1/9$. Out of the 32157 permutation filtered matrices fulfilling the rule of acceptable inconsistency ($CR \leq 0.1$), 591 (1.84%); 197 (0.61%) and 602 (1.87%) have inefficient eigenvector, AMAST and cosine maximizing weight vector, respectively. All these examples are listed in an online appendix. If arbitrary values of inconsistency index CR are considered, the ratio of inefficient weight vectors is maximal (28%; 14% and 29%, respectively) at around $CR = 1.2$. All the three methods provide efficient priority vectors for matrices with extremely high inconsistency ($CR > 2.6$). The frequencies of inefficient weight vectors inferred from larger pairwise comparison matrices are also provided. Results might help the research of efficiency, especially solving the open problem of a necessary and sufficient condition of the eigenvector's efficiency.

Optimal route and trajectory planning for automatic guided vehicles

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Keywords: Route planning, P-graph, Combinatorial optimization.

Automatic guided vehicles (AGV) traditionally follows routes and trajectories planned during their setup, in contrast, developments in navigation techniques and the advanced computing, sensor, and communication capabilities of resent AGV makes their free movement safe and manageable. However, fleet management in a cooperative environment requires fast optimization algorithms to calculate and optimal movement. A two level method is to be presented providing complex solution for optimal route and trajectory planning of AGV's. Trajectory planing aims at minimizing the maximum of the accelerations of the vehicle in any direction while achieving its target in time starting from its initial location. The space is represented as union of convex cells and gateways between them. Due to response time critical computation the multidimensional acceleration is minimized a by direction independent linear approximation with proper accuracy. Route planning is computed on a graph representing interconnection and distance of cell, as well as traffic rules. Optimal and alternative routes are calculated by P-graph algorithms involving several logical implications accelerating the search. The overall optimization method is to be illustrated by case studies.

IP solutions for international kidney exchange programmes

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Keywords: Integer programming, Kidney exchange, Optimisation, matching.

In kidney exchange programmes patients with end-stage renal failure may exchange their willing, but incompatible living donors among each other. National kidney exchange programmes are in operation in ten European countries, and some of them have already conducted international exchanges through regulated collaborations. The exchanges are selected in regular matching runs (typically in every three months) according to well-defined constraints and optimisation criteria, which may differ across countries. In this work we give integer programming formulations for solving international kidney exchange problems, where the optimisation goals and constraints may be different in the participating countries and various feasibility criteria may apply for the international cycles and chains. We also conduct simulations showing the long-run effects of international collaborations for different kidney exchange pools (regarding their sizes and the proportions of hard-to-match pairs) and under various national restrictions and objectives.

Markov decision processes with total effective payoff

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Keywords: Markov processes, Stationary strategies.

We consider finite state Markov decision processes with undiscounted total effective payoff. We show that there exist uniformly optimal pure and stationary strategies that can be computed by solving a polynomial number of linear programs. This implies that in a two-player zero-sum stochastic game with perfect information and with total effective payoff there exists a stationary best response to any stationary strategy of the opponent. From this, we derive the existence of a uniformly optimal pure and stationary saddle point. Finally we show that the traditional mean payoff can be viewed as a special case of total payoff.

Joint work with Khaled Elbassioni (Masdar Institute, Abu Dhabi, UAE), Vladimir Gurvich (Rutgers University, NJ, USA), and Kazuhisa Makino (RIMS, Kyoto, Japan).

A fairer penalty shootout design in soccer

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Keywords: OR in sports, Sports rules, Fairness, Soccer, Markov processes.

Tournament organizers supposedly design fair rules. However, the standard soccer penalty shootout mechanism contains a well-known bias in favor of the first shooter, which can be a problem because an order of actions that provides an ex-post advantage to one team may harm efficiency by reducing the probability of the stronger team to win. It is demonstrated by a mathematical model that the recently suggested Catch-Up Rule – despite it makes penalty shootouts substantially fairer – is not worth implementing since it does not outperform the simpler Alternating (ABBA) Rule. A slightly modified version of this mechanism, the Alternating Catch-Up Rule, is introduced by prohibiting the first-mover team to kick the first penalty in the sudden death stage. We show that the Alternating Catch-Up Rule is fairer than both designs, while it remains straightforward to implement and is essentially strategy-proof. Hence it seems to be a promising candidate if penalty shootouts are to be made as fair as possible.

Segmentation of complex structures with parts based RJMCMC

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Keywords: Image segmentation, Parts based recognition, RJMCMC.

Segmentation of Complex Structures with parts based RJMCMC The segmentation of complex visually observable structures is a challenging task in computer vision. There are several applications where there is a strong need to detect, to recognize, and to classify parts of complex objects in scattered, occluded environments. Such problems arise in the remote sensing and detection of road structures, in blood vessel segmentation, or in the segmentation of trunks in forest images. Our presentation gives a brief historical overview of different approaches to solve parts based segmentation problems. Then we focus on a general model which should be able to handle the problem of occlusion, scattering, sensory noise, and information loss due to projection of 3D structures to 2D image planes. Our target application is the segmentation of trees from forest images. For observation data we use color images and depth maps generated from uncalibrated stereo. We propose to use a Reversible Jump Markov Chain Monte Carlo optimization approach where prior knowledge about the trunks and structural constraints are also involved to form energy functions. The optimal labeling of image parts should be found by optimizing complex energy functions. The proposed technique has clear advantages compared to pixel-based clustering or semantic labeling with convolutional networks (such as SegNet). These alternatives will also be highlighted in the presentation.

A new adaptive predictor-corrector interior-point algorithm for sufficient linear complementarity problems

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Keywords: Linear complementarity problem, Interior-point algorithm, Adaptive predictor-corrector method.

In this talk we deal with a special class of linear complementarity problems (LCPs). We suppose that the LCP has the property of sufficiency and we introduce a new interior-point method, which solves the problem. Our method is based on an algebraic equivalent transformation of the central path. This trajectory is defined by a system that consists of two parts. The first one guarantees that feasibility will be maintained and the second one is responsible for getting well centered iterates, therefore is called centering equation. We apply componentwise a univariate function to both sides of the centering equation and we use Newton's method to obtain the search directions. Each iteration of the algorithm starts with a full Newton corrector step and it is followed by a predictor one with damped step. The specificity of our algorithm is that the barrier update parameter and the length of the predictor steps are modified in an adaptive way. Preliminary numerical results show that the algorithm is also efficient in practice.

A new predictor-corrector interior-point algorithm for linear optimization problem

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Keywords: Linear programming problem, Interior-point algorithm, Predictor-corrector algorithm.

We introduce a predictor-corrector interior-point algorithm (PC IPA) for solving linear optimization (LO) problems which is based on a new search direction. We use the algebraic equivalent transformation (AET) introduced by Darvay (2003) of the system which defines the central path and we apply the difference of the identity map and the square root function to this system. After that we use Newton's method in order to obtain the new search directions. Moreover, we prove the polynomial complexity of the proposed predictor-corrector algorithm. This is the first predictor-corrector interior-point algorithm which is based on the above mentioned search direction. We discuss the effects of different AETs both on analysis and complexity of PC IPAs. Finally, we present some preliminary numerical results of the new PC IPA for LO problems. Furthermore, we compare our PC IPA with other PC IPAs using different AETs on standard Netlib LO problems. Conclusions and future research questions closes our talk.

Some practical issues related to the implementation of type III sensitivity analysis of LP models

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Keywords: Decision support, LP Sensitivity analysis.

Allocation of scarce resources is a typical problem often encountered by managers, and linear programming (LP) is a widely used tool for supporting decision making in this area. Since many of the parameters involved in the models are generally approximations, expectations or forecasts based on statistically available data, managers must deal with the uncertainty of the available data. LP sensitivity analysis provides information about the validity range of the primal and dual optimum. The theoretical problems of sensitivity analysis under degeneracy are well known in the literature. Many papers demonstrate erroneous management decisions based on the misinterpretation of sensitivity analysis results. Koltai and Terlaky classified three types of sensitivity information. Most of the commercial LP solvers provide only Type I sensitivity information but from a management standpoint Type III sensitivity information are far more important. Type III sensitivity provides information about the invariance of the rate of change of the objective value function and thus is independent of the optimal solution found and depends only on the problem data. This paper discusses some practical problems related to the implementation of Type III sensitivity information in practice.

Fast Minimization of MRF Energies with Separable Convex Prior over Product Labelspaces

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Keywords: MRF, Energy minimization, Graph-cut.

Solving a multi-labeling problem with a convex penalty can be achieved in polynomial time if the label set is totally ordered. In this work we propose a generalization to partially ordered sets. To this end, we assume that the label set is the Cartesian product of totally ordered sets and the convex prior is separable. For this setting we introduce a general combinatorial optimization framework that provides an approximate solution. More specifically, we first construct a graph whose minimal cut provides a lower bound to our energy. The result of this relaxation is then used to get a feasible solution via classical move-making cuts. To speed up the optimization, we propose an efficient coarse-to-fine approach over the label space. We demonstrate the proposed framework through extensive experiments for optical flow estimation.

An efficient heuristic for a complex scheduling problem

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Keywords: Scheduling, Heuristics, Problem splitting.

We deal with a complex scheduling problem. Several types of products should be produced with a heterogeneous resource set: some resources have the same operating capabilities, some of them are quite different, while others have similarities regarding their capabilities but they have different parameters (like operation time). Setup time is also considered in our model. The production of the products follows different workflows, allowing also assembly lines. Our goal is to produce all the products in minimum time. Because of the complexity of the problem exact solvers require too much time to solve the problem. We introduce a compound heuristic algorithm that finds very fast a near-optimal solution. The method follows the idea of "Divide et Impera": we divide the basic problem into smaller sub-problems that are easier to solve. During the solution process we apply simplifications, and first we solve a preemptive version of the simplified problem. Then a rounding procedure results in a non-preemptive solution. Finally, for improving the solution, we apply several kinds of local search. We demonstrate the efficiency of our heuristics on multiple problem classes. In our investigation a multitude of instances were solved and analyzed according to different aspects.

Multiobjective optimal sensor placement for data reconciliation

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Keywords: Data reconciliation, Sensor placement, Multiobjective optimisation, Fault detection .

Data reconciliation is a model-based technique that utilizes redundant measurements of sensor networks to improve the reliability of the multivariate measured data and estimate unmeasured process variables. As the redundancy of the sensors is reflected in the structure of the balance equations, the placement of the sensors should be designed based on the available model, the accuracy and the investment cost of the sensors, and the intended use of the reconciliated and estimated data. In our presentation, we formalise this data reconciliation based sensor placement problem and proposes a multiobjective metaheuristic algorithm for its optimisation. The balance equations are represented by local linear models and QR decomposition is used to evaluate the degree of redundancy and to evaluate the estimability of the variables. As the information matrix integrates the uncertainty of the measurements and the model equation, the cost function is based on the analysis of its eigenvalues and the performance of the utilized gross error detection algorithm. Multiobjective metaheuristic algorithms (NSGA, MOGA and simulated annealing) are utilized to solve the resulted NP-hard optimization problem. The proposed methodology is developed to design a sensor network for fault detection in activity time monitoring and heat exchanger networks.

An oracle for an inner approximation based probability maximization method

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Keywords: Stochastic optimization, Probabilistic programming, Computation of MVN.

A large number of engineering problems require optimization and in many cases the variables involved are random. The field of stochastic programming deals with such problems with presence of uncertainty. Subfields of SP are probability maximization and probabilistic constrained problems. In this paper we present the implementation details of the oracle algorithm of our earlier published inner approximation based probability maximization method. Our method bears a resemblance to the stochastic approximation family, but in contrast to stochastic approximation, the method builds a model problem. The solution involves a linear programming task, iteratively adding improving columns to it by unconstrained convex minimization. In case of the logconcavity of the multidimensional distribution function $F(z)$, we can construct convex function in the form of $\phi(z) = -logF(z)$. We used a randomized gradient method for the handling of the convex function whose gradient computation is demanding. We present the details of the line search algorithm and the estimation of the multivariate normal distribution function and gradient.

Modeling technique in the P-graph framework for operating units with variable input and output ratios

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Keywords: P-graph framework, Process Network Synthesis, Operating units, Variable input/output, Sustainability.

The P-graph framework is an effective tool for modeling and optimization of Process Network Synthesis problems. It is based on a bipartite graph where one partition of the nodes represents materials in the system, while the other partition represents operations on the materials. Arcs between materials and operating units correspond to consumption and production. Originally, an operating unit in a P-graph model uses a fixed proportion of each input material it consumed, as well as output materials produced. Hence, decisions regarding the unit in the optimization model are solely determined by the production volume. In some scenarios, however, the ratio of each input material may vary, often according to specific limits. Also, outputs may depend on the input materials used. Recent works sought the modeling of such kind of operations by the manipulation of the underlying Mixed-Integer Linear Programming model generated from the original P-graph. In this work, we present a method for modeling operations with variable input and output material ratios, solely based on the introduction of additional materials and operating units, resulting in a P-graph model that can be directly optimized with the original tools of the P-graph framework. This technique is demonstrated with motivational examples, including a pelletizer model with different biomass inputs to address an optimization problem for a sustainable energy supply.

Optimal solution of nonlinear, constrained multi-period production problems

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Keywords: Multi-period production, Constraints, Non-linear costs, Optimal solution.

Production processes have a significant impact on the economy. In a multi-period operation the load of production as well as the capacity of the inventory varies from period to period to satisfy the demand, assuming conditions remain steady in each period. A systematic approach with various subsequent generalizations are widely available when solving such cases where no constraints are considered for the production nor for the inventory, based on the so called Wagner Within optimality criteria. Other approaches solve cases where constraints are considered, however, considering only linear cost functions for the production and for the inventory. The current work focuses on the general case, with potential constraints on any quantity, and where nonnegative, monotone, concave cost models are assigned both to the production as well as for the inventory levels. Exploiting the property that the optimal value of such cost functions are at their extreme points, and constraints strictly affect the feasibility of the production problem, an effective algorithm is developed. A binary tree is constructed, starting from the last production period, i.e. the root of the tree. Backwards from there, the inventory and production cases are branching out towards the previous period with considering the minimum and maximum constraints. Repeating recursively this branching results in the generation of the set of leaves of the tree either representing a feasible solution structure of the production problem or representing an infeasible subproblem. Finalizing this tree generation results in the optimal solution and the order of the n-best solutions. An example demonstrates the efficacy of the presented method.

A randomized method for probabilistic problems

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Keywords: Convex optimization, Stochastic optimization, Probabilistic problems.

We propose a randomized gradient method for handling a convex function whose gradient computation is demanding. The method bears a resemblance to the stochastic approximation family. But in contrast to stochastic approximation, the present method builds a model problem. The approach is adapted to probability maximization and probabilistic constrained problems. We discuss simulation procedures for gradient estimation. We apply inner approximation of the epigraph of the probabilistic function. This approach endures noise in gradient computation without any special effort. Noisy gradient estimates may yield iterates that do not improve much on our current model. But we retain a true inner approximation of the function, provided function values are evaluated with appropriate accuracy. This inherent stability of the model enables the application of randomized methods of simple structure. For probability maximization, we propose a stochastic approximation procedure with relatively easy generation of new test points. A probabilistic constraint function is handled in a Newton-like scheme, approximately solving a short sequence of probability maximization problems, with increasing accuracy. As this scheme is built from randomized components, we provide a statistical analysis of its validity. The proposed stochastic approximation procedure can be implemented using standard components. The master problem is conveniently solved by an off-the-shelf solver. New approximation points are found through simple line search whose direction can be determined by standard implementations of classic Monte Carlo simulation procedures. – The Newton-like scheme can be implemented through minor variations on a standard Newton method. Computational results confirm the usability of the approach.

Scheduling of custom printed napkin manufacturing by P-graphs

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Keywords: Scheduling, Manufacturing system, PNS.

Scheduling of manufacturing systems is an active research area resulting in methods typically providing effective solutions to specific classes of problems. In practice, however, only few of them are flexible enough to handle the constraints and objectives of an already functioning manufacturing process. IT implementation is even more difficult in an environment where enterprise resource planning (ERP) system is not available, especially at small manufacturing plants. However, their survival depends more on their efficiency than their larger competitors. In the presentation an automated scheduling method will be introduced based on process network synthesis (PNS) extended with time constraints (TCPNS) and applying P-graphs for model prototyping. Scheduling by TCPNS is to be illustrated by real implementation case studies of the custom printed napkin production process. Manufacturing is done on only two types of printing devices, but the conditions set by the company require a flexible modeling and effective solution method capable to consider raw material transportation, work schedule, complex calculation of changeover times, deadlines, and order priorities in parallel. This manufacturing process was modeled by TCPNS, and a software module was implemented that can generate production schedule for the orders. For real-time solution, several acceleration techniques have been developed in the modeling step. The model was validated by applying it to historical data and comparing it to the original process schedule.

Utilizing strengthened lift-and-project cuts in decomposition methods to solve two-stage stochastic programming problems with binary first-stage variables

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Keywords: Stochastic optimisation, Integer programs, Decomposition.

Over the recent years we have developed a modelling and solution system for two and multi-stage stochastic programming problems. Embedded in the COIN-OR framework, it extends the FlopC ++ modelling language for stochastic programs and provides a parallelized implementation of the nested Benders' decomposition algorithm. Several computational techniques have been devised and combined to speed up the solution process, such as cut aggregation and consolidation, dynamic sequencing, level regularization and on-demand accuracy. In this talk we would like to discuss the ways to use Lift-and-project cuts in Benders' type decomposition algorithms for solving two-stage stochastic programming problems with binary first-stage variables. Lift-and-project cuts are well-known general 0-1 programming cuts which are typically deployed in branch-and-bound-type methods to solve MILP problems. In particular, we show how L&P cuts derived for the mixed-binary first-stage master problem can be strengthened by utilizing second-stage information. We present an adapted L-shaped algorithm and some computational results.

Modelling cascading effects for systemic risks: A copula approach

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Keywords: Systemic risk, Copula ordering, Lorenz order.

We consider a joint lifetime model for economic agents, which accommodates cascading effects of the default of one agent to the lifetime of the other agents. We study the properties of the pertaining copula with respect to different stochastic orderings, for instance lower and upper orthant order and convex order. In particular, we examine bivariate and three-variate cases. Even in these cases the copula does not have a closed form, and does not belong to the Archimedean class, neither. As an application we provide a numerical case study using CDS-spreads of European banks to estimate parameters of the copula. We will use similar considerations in gambling type settings to show the wide range of possible applications.

Joint optimization of transition rules, number of classes and premiums in a Bonus-Malus system

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Keywords: Integer programming, Insurance pricing, Adverse selection.

Bonus-Malus (BM) systems are widely used methods in actuarial sciences. These systems are applied by insurance companies, to distinguish the policy-holders by their risks. The most-known application of BM systems are the compulsory third party liability insurances. In Bonus-Malus systems there are several classes and the premium of a policy-holder depends on the class he/she is assigned to. The classification of policy-holders depends on the class and the number of claims reported in the previous period. Operating such a system one needs to set somehow the transition rules and premiums of each classes. In general, optimization of these systems usually means to calculate appropriate premium scales considering the number of classes and transition rules as outer parameter. We present a mixed integer programming formulation for determining jointly the premium scales with the transition rules and the number of classes for a given set of policy-holders. Furthermore, we present numerical examples to demonstrate that this IP technique is suitable to handle existing Bonus-Malus systems.

Interlacing in cyclic scheduling

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Keywords: Scheduling, Cyclic, Interlacing.

From the practical point of view, long-term scheduling, i.e. planning for a few months holds a great importance. However, the scheduling of most production systems is a mathematically complex problem, thus, approaches relying on exact methods can usually provide the optimal solution only up to a few days of planning period within a reasonable time. The approach of cyclic scheduling assumes the schedule of the whole planning horizon to have a repeating nature. While the optimal solution may be lost if the cycle time is limited, this approach brings the problem to a manageable level, and provides solutions that are easier to execute and manage in practice. Cyclic scheduling is a reasonable trade-off between the quality of the solution and the computational complexity, however, it also introduces new modeling challenges. This work focuses on interlacing, which is the overlapping of different cycles. Allowing such overlaps may provide significantly better schedules, however, modeling them appropriately is not self-evident. In this work, we emphasize the importance of interlacing via examples, and present novel models to address this issue.

Circular economy implementation in waste management network design problem: A case study

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Keywords: Robust optimization, Circular economy, Facility location, Waste treatment, Uncertain production.

The paper presents a new approach to support strategic decision-making in the area of municipal solid waste management applying modern principles of circular economy. A robust two-stage integer non-linear program is developed. The primary goal tends to reduction of waste produced. The generated waste should be preferably recycled as much as possible and the resultant residual waste might be used for energy recovery. Only some waste residues are appropriate for landfilling. The aim is to propose the optimal waste allocation for its suitable processing and find an optimal waste transportation plan at an operational level. In addition, the key strategical decisions on waste treatment facilities location must be made. Since waste production is very often hard to predict and control, the formulated optimization model considers the waste production as an uncertain decision-dependent quantity. To support the circular economy ideas, advertising and pricing principles are introduced and applied. Due to size of available real-world data and complexity of the designed program, the presented model is linearized and uncertainty is handled by a robust optimization methodology. The model, data, and algorithm are implemented in MATLAB and Julia, using state-of-the-art solvers, and the obtained computational results are presented and discussed.

Fleet composition and routing decisions in municipal solid waste collection problem

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Keywords: Heterogeneous VRP, Solid waste collection, Fleet composition, Routing, meta-heuristics.

Solid waste generation rates are rising faster and faster each year that makes solid waste management (WM) one of modern society's most relevant and challenging issues. As urban population is growing very fast, there is an urgent need for efficient WM in urban areas. The collection and treatment of waste is one of the most difficult and expensive operational problems faced by local authorities. In this work, a heterogeneous real fleet composition and routing problem is studied within the WM area. The primary objective is to minimize operational costs. A general mathematical model of the problem is developed and basic ideas for a solution algorithm are presented. The problem is modeled as a node-routing, multi-trip and heterogeneous VRP, where various waste types produced are considered. A case study is provided on real data from a solid waste collection problem in the Czech Republic. The developed model will serve as a tool for support of the so-called smart cities, where waste bins and containers features sensors and so fast and dynamic computational approaches will be necessary.

On solving the symmetric non-negative matrix tri-factorization problem

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Keywords: Non-negative matrix tri-factorization, ADMM, Projected gradient method.

Symmetric non-negative matrix-tri factorization problem is a model to approach dimension reduction idea in data science, like clustering analysis. It can be formulated as

$$\begin{aligned} &\min \ \sum_i \|D_i - GS_iG^T\|_F^2 \ + \ \sum_i \alpha_i \|S_i\|_F^2 \\ &\text{subject to} \quad G^TG = I, \quad G, S_i \geq 0, \quad S_i = S_i^T \end{aligned} \tag{1}$$

This is a hard optimization problem since the objective function and the feasible set are not convex, so we can not hope to solve it to optimality. However, usually in data science, like in bioinformatics, we are happy also with approximate solutions. In this talk we will present approximation ideas based on fixed point method, projected gradient method and Alternating Direction Method of Multipliers (ADMM). With numerical results we demonstrate that these methods yield reasonable good solutions and can be used also for solving large scale instances. Regarding relative error, ADMM gives best results. In the talk we also demonstrate application of this model in cancer research.

Quickly proving that a specific sparse graph has no triangle

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Keywords: Triangle counting, Effective graph algorithms, Clustering coefficient, Geometrical arrangements.

We consider the problem of proving that there is no triangle in a graph, or we want to find one if a triangle exists. The graph has n vertices and m edges where n will focus on those cases where $\log m / \log n$ is very close to one. We will show some new algorithms with improved time complexities.
Our results can easily be improved for counting and/or listing the triangles in graphs.
Our new results are useful for the following: The clustering coefficient of a vertex in a social network is a fundamental measure. Its computation can be reduced to counting the number of triangles incident on the particular vertex in the network.
We will also show that finding a triangle in a large sparse graph can also be used for the maximum independent set problem. This way even some geometrical arrangement questions can be studied by combinatorial numerical methods. An example is this: Can seven infinite tubes kiss a ball simultaneously? (The diameters are the same.)

Sensitivity analysis of the County Health Rankings

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Keywords: Inverse sensitivity analysis, County Health Rankings, Simultaneous change of the weights/evaluations.

There are many factors that influence the stability of rankings: number of weights and alternatives, weights of criteria, reliability of evaluations and the similarity of alternatives as well. All of them play a key role when we determine how sensitive a ranking is. It is difficult to measure their combined effects, but we can perform analyses by bringing to the fore some of them. In this paper, the sensitivity of the County Health Rankings is discussed by analysing the effects of change in weights and evaluations with inverse sensitivity analysis. With this method we can measure global sensitivity, which means that we might take into consideration every weight and/or evaluation simultaneously. The notion behind this concept is to define the maximal possible intervals for weights and/or evaluations within which rank reversal cannot happen regarding an arbitrarily selected subset of alternative pairs. In most cases the County Health Rankings proves to be sensitive to minor changes, which means that counties relatively far from each other might swap positions.

Energia design synthesis

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Keywords: Synthesis, P-graph, Architecture, Energy, Comfort.

Design of buildings and settlements plays a key role in solving our environmental problems and creating a sustainable future. Today's conventional building design method consists of solely one imagined plan, relying on an experience based architectural development procedure without any scientific engineering optimisation. Coupled with the fact that the actual international building regulations do not require to create optimized buildings in terms of energy, climate, comfort, lighting, aerodynamics, life cycle assessment and further building physics performance, the need grows for a new design method. The Energia Design Method is a planning technique to develop sustainable architectural design, by integrating the actual highest level of engineering calculations. Core content of the method includes heuristic building simulations that quantify and thus verify the chosen design concepts. In this way, until now unreached building energy and climate performance could be achieved. However, this method only includes a limited number of concept versions, without considering all possible solutions including the optimal concept. The current research further develops this Energia Design Method. The Energia Design Synthesis method proposed is the sole technique to ensure de facto optimal buildings with highest comfort and lowest energy consumption. This goal is achieved by introducing mathematical modelling and optimisation into the field of architectural design. The P-graph framework is applied. First the synthesis step is performed: specific algorithms generate all feasible and potentially optimal building concept combinations, then the optimal building solution is sought. Moreover, this novel method is capable of determining the n-best solutions according to different scenarios of predefined user specific preferences, including thermal and visual comfort, air hygiene as well as energy performance. A specific building problem (design task) was considered as illustration.

Integer programming formulations for the stable exchange problem

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Keywords: Integer programming, Stable exchange, Kidney exchanges, Optimisation.

In the stable exchange problem the agents are endowed with a single good, e.g. a house or a kidney donor, and they have preferences over the others' endowments. The problem is to find an exchange of goods such that no group of agents can block the solution in an exchange cycle. An exchange is called stable is there is no blocking cycle where all the agents involved strictly prefer the new solution. An exchange is strongly stable if no weakly blocking cycle exists, where at least one agent improves and neither of them gets a worse allocation. When the lengths of the exchange cycles is not limited then a stable solution always exists and can be found efficiently by Gale's Top Trading Cycle algorithm. However, when the length of the exchange cycles is limited then a (strongly) stable solution may not exist and the problem of deciding the existence is NP-hard. This setting is particularly relevant in kidney exchange programmes, where the length of exchange cycles is limited due to the simultaneity of the transplantations, e.g. the maximum length of the cycles is 3 in the UK and 4 in the Netherlands. In this work we develop several integer programming formulations to solve the (strongly) stable exchange problem, which is a novel approach for this solution concept. We compare the effectiveness of these models by conducting computational experiments on generated kidney exchange data.

Optimization of reliable beam-column construction and its statistical verification

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Keywords: Reliability constraint, Differential equations in constraints, Stochastic programming.

The aim of the paper is to present recent research advances in the area of optimum and reliable engineering design problems. In this paper, reliability-constrained optimal Bernoulli beam construction design problem is formulated.The problem combines different design elements and is further complicated by exogenous random parameters. The corresponding mathematical model involves ODE-type constraints that are next modelled by a finite element method (FEM) based discretization. The probabilistic constraints concerning reliability are reformulated by using a suitable penalty transformation. Hence, the stochastic programming scenario-based approach is chosen to obtain robust enough solutions. The developed solution algorithm involving preprocessing and postprocessing steps has been implemented in Matlab system. Various computational results based on different input data for considered test cases, which were consulted by experts in civil engineering, are presented and discussed. Selected results were verified by simulation-based procedures and empirical confidence regions for chosen beam's design reliability levels have been constructed.

A new algorithm for fitting vine copulas in higher dimensions

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Keywords: Vine copula, Truncated vine copula, Cherry tree copula, Conditional independency.

Vine copulas earn a lot of interest as a mean of modelling multivariate probability distributions. These probabilistic models are very popular because they are able to encode many types of pair dependencies into their structure. However their flexibility has the drawback of getting a high number of parameters, and this way the curse of dimensionality occurs even for dimensions greater than 10. Their structure can be graphically represented as a sequence of cherry trees. To each edge a pairwise copula or a conditional pairwise copula is assigned. In 2011 a new type of vine copula, called truncated vine copula was introduced. Its property is that independence copula is assigned to edges of the high level trees. This way the number of parameters is restricted to the lower levels. The cherry tree copulas are more general structures than the truncated vine copulas and can also tackle the problem of dimensionality. Brechmann (2012) has introduced a greedy algorithm for fitting truncated vine copulas which uses only the dependencies between the random variables. Now we introduce a new algorithm for fitting cherry tree copulas and truncated vines, which exploits also the conditional independences between the variables. The algorithm, will be illustrated on real data.

On the supermodularity of the information content and a new sufficient condition for the equivalence between the Markov properties

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Keywords: Markov properties, Information content, Supermodularity, Multiinformation.

The discovering of the conditional independences between random variables of a multidimensional random vector is very important task in many fields of machine learning. Markov networks can be represented by graph structure which encode conditional independences. It is well known that the global Markov property implies the local Markov property which implies the pairwise Markov property. If all vectors defined by the Cartesian product of the ranges of the random variables are taken on with positive probability then the Hammersley Clifford theorem states that the three properties are equivalent. However the positivity condition is very restrictive. For the equivalence of the three Markov properties a necessary and sufficient condition was also defined by using an axiomatic structure, called probabilistic graphoid. The probabilistic graphoid is a structure which is defined by axioms on conditional independences. Testing the random variables of a multivariate random vector for this axioms is computationally infeasible. In the present work we give a sufficient condition for the equivalence of the three properties, which can be easily tested. Moreover we give a short and elegant proof for the supermodularity of the information content (multiinformation).

Stackelberg location problem on networks with discrete quality variables and operational costs

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Keywords: MINLP, Location problem, Stackelberg problem, Network problem.

We introduce a Huff-like Stackelberg problem, where the leader has to decide its facility's location so that its profit is maximal after the competitor (the follower) also built its facility. It is assumed that the follower's aim is to maximize its own profit, while in the event of multiple optima minimize the leader's profit (pessimistic choice). The newly placed facility's location as well as its quality has to be determined. The inelastic demand is aggregated into the vertices of a graph, and facilities can be located continuously along the edges. The quality of the facilities can be chosen from a predetermined finite set of numbers. The firms have to deal with operational costs, depending on the quality and location of their new facility. In the considered instances the firms are either already established on the market or they are newcomers. The proposed method is two nested Branch and Bound algorithm where the bounding procedures include interval, DC and also gradient based calculations.

Multi-criterial 2DOF PID controller design

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Keywords: PID, 2DOF PID, Control design, Pareto optimization.

The feedback loop process is a powerful control scheme, where the control system (the controller) takes into account also the outputs of the controlled system. The design of said controller involves solving a nontrivial (in particular, nonconvex) optimization problem. Furthermore, based on the requirements on the control, the resulting optimization problem is a multi-criterial one. In this talk, we present methods for the optimal controller design, based on the chosen criteria - namely the controlled system response to control and its response to error. We show a practical application of the pareto optimization for the selected class of systems in relation to the optimal 2DOF PID controller design. The feedforward compensator is PD and the feedback compensator is PID. In the PID Controller (2DOF) and Discrete PID Controller (2DOF) blocks, the setpoint weights b and c determine the strength of the proportional and derivative action in the feedforward compensator. Furthermore, we will demonstrate the advantages of the 2DOF PID (2-degrees-of-freedom proportional–integral–derivative) controller over the classical PID controller and compare the performance of the two controllers using their respective pareto frontiers.

The Quadratic Assignment Problem: computational experiments/experience

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Keywords: QAP, Metaheuristics, HPC.

The Quadratic Assignment Problem is one of the central and most challenging combinatorial problems. As such, it has enjoyed a rather high attention from many different operations research and optimization research groups. A wide range of techniques, ranging from exact reformulations, special-tailored branching schemes and lower bounding methods to specialized heuristics and metaheuristics have been developed to tackle this NP-hard optimization problem. In this talk, we present our computational experience with the quadratic assignment problem. We describe an original metaheuristic. This metaheuristic will be compared to other suitable approaches on hard instances of the quadratic assignment problem from the well known QAPLIB library. The compared approaches will contain the state-of-the-art bounding techniques based on a semidefinite programming relaxation, exact reformulations solved with a high performance solver (arguably the best mixed-integer linear solver, GUROBI) and other high-performance metaheuristics, all in a unified framework.

On the implementation of the crossover algorithm

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Keywords: Crossover algorithm, Parallel computing.

In several applications of linear programming an optimal vertex solution is more advantageous than a solution from the interior of the optimal face, therefore at the end of a barrier optimization a crossover procedure may be needed to derive an optimal basic solution. Albeit the crossover procedure has lower complexity than the barrier algorithm, sometimes it requires excessive computational work, especially on primal and/or dual degenerate problems. For example, on Hans Mittelman's benchmark set for the barrier algorithm, the crossover dominates the execution time and the efficiency of the barrier algorithm has lower influence only on the final performance numbers. In the presentation we outline our crossover implementation which exploits multithreading in the primal and dual phases of the crossover algorithm by dividing the work into independent parts and concurrently executing them, similarly to the parallel implementation of the dual simplex method by Qi and Hall. We discuss the advantages and the drawbacks of our implementation and demonstrate its effectiveness by numerical experiments.

An application of Ant Colony Optimization to minimize the total changeover time on unrelated parallel machines with sequence-dependent changeover times

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Keywords: Parallel machine scheduling, Ant colony optimization.

Production scheduling is a key success factor in all manufacturing industries. The choice of the schedule has a powerful impact on lead time, cycle time, on-time delivery, the utilization of resources, and consequently on the costs. This paper addresses the non-preemptive unrelated parallel machine scheduling problem with machine-dependent and sequence-dependent changeover times. All jobs are available at time zero, all times are deterministic, and the objective is to minimize the total changeover time. In the literature, when unrelated parallel machine scheduling and Ant Colony Optimization are considered, two-level Ant Colony Optimization has been found. In the first level, the jobs are assigned to the machines. In the second level, the jobs on each machine are sequenced. An application of one-level Ant Colony Optimization is introduced. The performance and the possible use of one-level Ant Colony Optimization is investigated on different sized problems. The examination is done using AIMMS mathematical modelling language.

A myopic greedy algorithm for kidney exchange programs

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Keywords: Kidney exchange programs, Simulation, Myopic greedy algorithm, Waiting time.

Kidney Exchange Programs (KEP) allow an incompatible patient-donor pair, whose donor cannot provide a kidney to the respective patient, to have a transplant exchange with another pair in a similar situation. The problem can be represented on a graph, where vertices are incompatible pairs and arcs define the compatibility between a donor in one pair and patient in another. In this way, a feasible exchange is defined by a set of vertex disjoint cycles in the graph. The objective for optimization in KEP is generally to maximize the collective benefit, measured by the number of possible transplants. In many programs altruistic donors, i.e. donors that do not have associated patient, are also included in the program. The altruistic donor initiates a chain of exchanges, where the last donor either donate to the deceased donor waiting list, or act as a bridge donor for the next matching. Recent approaches consider a dynamic matching where, instead of performing periodic matching runs, exchanges are decided every time a pair or an altruistic donor joins the pool. Following this idea, we propose a myopic greedy algorithm, which determines all cycles or chains that can be created upon the new entity arrival, and selects the one that includes the pair that has been in the pool for more time. We implemented simulation, where pairs or altruist donors arrive over time and each time they arrive a myopic greedy algorithm is run. The results of simulation were compared with those obtained when periodic matching is performed, giving the preference to the pairs with higher waiting time.

Generating sufficient matrices and test examples for interior point algorithms

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Keywords: Sufficient matrices, Interior point algorithms, IPA.

The class of sufficient matrices (SU) has a strong connection with the linear complementarity problem (LCP) as it was proven that SU-LCPs can be solved in polynomial time. Many different interior point algorithms (IPA) have been published for SU-LCPs, but in most cases there is no numerical examination of the IPAs. Main reason for this lies in the fact that only few SU matrices are known that does not fall into the classes of PSD- and P-matrices. Our goal was to generate different SU matrices (that does not belong to the classes of PSD and P) and test problems on which the different IPAs can be tested, so the results can be compared. Now, we present the results of our work, namely some new constructions for SU matrices, and different test examples for IPAs. We made 10 test problems with coefficient matrices of order 10, 20, 50, 100, 200 and 500. These problems can be downloaded from the following webpage: https://det.math.bme.hu/sumatrices. We also show the way we built these matrices and examples.

Registration of heterogeneous point clouds through Hough space based optimization

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Keywords: Hough space, Optimization.

In this lecture we introduce an optimization based 3D point cloud alignment approach for self-driving vehicle (SDV) localization. Our method is able to accurately register sparse point cloud data recorded by rotating multi-beam laser scanners of the moving vehicle to a 3D high resolution and geo-referenced point cloud map recorded by a mobile mapping system (MMS). Using an initial GPS position, we transform the SDV point cloud into the coordinate system of the MMS, thereafter we perform the following key steps: abstract object detection both on the SDV and the MMS point clouds, key point extraction from the detected objects, and finally a robust transformation estimation through optimization in the Hough space based on the selected key points. Due to occlusion and scanning artifacts, we should expect that in the SDV's sparse point clouds several objects fall apart to many pieces. Therefore, we utilize a many to many assignment technique, by extending the standard Hungarian graph matching algorithm with a backtracking step. We evaluated our approach on a large dataset obtained by a Riegl VMX-450 MMS and a Velodyne HDL 64 rotating multi-beam Lidar in the streets of Budapest, Hungary. The dataset contains main roads with heavy traffic, narrow streets and road junctions usually with a large GPS error.

Mathematical model for power plant scheduling and its properties

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Keywords: Power plant scheduling, Integer programming, Network matrix, TU matrix.

The power plant scheduling is one of the main tasks of the energy traders and electric transmission system operators worldwide. It is a cardinal question to achieve a feasible and suboptimal integer solution in a heck of time usually in a daily period regularly, where the objective is the cost of the produced energy to be minimized. Due to the more or less precise short-term electric consumers' forecasts, in practice the schedule generation is handled as a mixed integer programming problem. In this paper, it will be shown that the constructed optimization model contains a discretized form of a differential equation system covering the most important technical constraints, including the gradients and the bounds of the performance of each unit. It will also be proven that the mixed integer programming model has a network matrix, thus it can be solved in strongly polynomial time. Most of the technical and/or financial constraints make the feasibility problem NP-complete as it will be shown here later. Some of them are very common - however, in practice, adding a strict subset of such constraints still keeps the necessary resources low for solving the schedule generation model. In 2004 the author proved in his MSc thesis that the polynomial part of the model, namely the LP relaxation, has a totally unimodular matrix. In 2006, he also proposed the results above including network property of the LP matrix. Contributed relevant AMPL/GMPL example model files to the open-source solver called GNU Linear Programming Kit (GLPK) in 2017, and merged since version 4.64. GLPK 4.64
Release Information: http://lists.gnu.org/archive/html/help-glpk/2017-12/msg00000.html

P-graph algorithms for the synthesis of reliable processing systems

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Keywords: P-graph, Processing system, Reliability engineering.

Recently, more and more indicators are to be considered in designing processing systems because of regulations, competition, and profit requirements. Such indicators include cost (profitability), reliability, sustainability, flexibility, maintainability, controllability, and robustness. In practice, the indicators are usually considered step by step. Because of that, the optimality of the result cannot be guaranteed, in most cases, the result is far from the optimal solution. To determine the optimal solution for a selected set of indicators, they must be taken into account simultaneously during the process synthesis. In the current work, the cost and the reliability are selected as indicators for the determination of the optimal solution, more exactly, the cost optimal process is to be determined that satisfies the constraint on reliability. A process or processing system is composed as a network of operating units, where an operating unit represents a specific transformation of the properties of its inputs to its outputs. An operating unit can be realized by physically available equipment units. During the synthesis of the process, the network of the best process is to be determined together with the assignments of the equipment units to the operating units of the process. A processing system is called as redundancy-free, if the failure of any of its operations makes the system non-operational. Because of the high level of requirements on reliability, in most cases, redundancy free systems are not acceptable, redundant systems are to be designed. In this work, reliability determination is integrated into process network synthesis to find the cost optimal process that satisfies the reliability constraint. Since both the synthesis algorithm for cost optimal solution and the reliability analysis are based on P-graph algorithms, the latter is embedded into the former with minor increase of the complexity of the procedure.

Review and comparison of MILP approaches for cyclic scheduling of robotic cells

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Keywords: Cyclic scheduling, Robotic cell, Mixed-integer linear programming.

Automatization is a popular trend in modern manufacturing processes. The so-called robotic cells are widely used in various industrial systems. A robotic cell consists of multiple production machines, one or more material handling robot arms, and input/output buffers. Product parts must go through some operations that can be carried out by the given subsets of machines. The paths of the products may be the same (flow-shop) or arbitrary (job-shop), and the processing times can differ for varying products and machines. Robotic cells are mainly used in mass production environments where demands are stable. In this scenario, it is common to use a cyclic scheduling approach for long-term production planning. This means that a short-term schedule is determined, which will be repeated periodically, hence it is called a cycle. In cyclic scheduling of robotic cells, the goal is to determine the sequence of robot movements and machine operations for the production cycle, which maximizes the profit divided by cycle time, while satisfying the practical feasibility constraints. With Integer Programming approaches, this ratio would introduce undesirable non-linearities, therefore, usually only the subproblem of minimizing the cycle time for a given quantity of parts is addressed, which can be solved for different product mixes. This work aims to review the recent advancements in cyclic scheduling of robotic cells. Different problem classes were identified and compared, with relation to the types of constraints, such as material flow, waiting policy and travel time metrics. Selected MILP models were implemented and compared based on their modeling capabilities and solution performances.

Stochastic optimization in Hilbert spaces with applications to PDE constrained shape optimization

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Keywords: Stochastic optimization, PDE-constrained optimization, Stochastic gradient methods.

We consider a stochastic gradient projection-type algorithm for optimization in Hilbert spaces. In the convex resp. strictly convex case, we can prove weak resp. strong convergence. In the nonconvex case convergence of the function values and convergence of the gradient projection to zero can be shown, but the sequence need not to converge. The application of this type of algorithms is in stochastic shape optimization (in our case a cantilever optimization), where the resistance to random forces should be optimized under constraints about the volume and some boundaries of the shape. This is an example of PDE-constrained stochastic optimization, since the deformation patterns of the shape are solutions of a partial differential equation given by the physical properties of the used material.

Equilibria in large semi games

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Keywords: Game theory.

Infinite strategic situations are considered. We focus on such situations which are not games in the classic sense, e.g. Wald game (Wald, 1945), hence the existence result (Nash equilibrium (Nash, 1950;Nash, 1951)) of Marinacci (1997) cannot be applied. In these non-classical strategic situations a (mixed) strategy profile does not necessarily define the payoffs of the players. This means a player is not sure about her payoff even if she knows exactly what all the players play. This gives a special extra uncertainty flavor to the situation. We consider such mixed strategies where the mixing by probability charges (as in the Wald game), that is, non-negative, additive, normed to one set functions. We give a new characterization of equilibria of large games, then generalize it to large semi games. This characterization says that a strategy profile is a Nash equilibrium in a (large) game if and only if it can be (weakly) approximated by finite games. This characterization provides a new equilibrium notion for large semi games.

The efficiency analysis of commercial banks

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Keywords: Performance, Efficiency analysis, DEA, MEA, LP.

The non-parametric techniques are widely used to analyse performance, or the relative performance of one decision making unit (DMU). One of the most used non-parametric technique for efficiency analysis of commercial banks is the Decision Envelopment Analysis (DEA) which is developed to measure efficiency in two different ways (input and output orientated model). The input orientated DEA model determines the maximal reduction in input levels conditional on fix output for all decision making units (DMU). In contrast, the output orientated point of view we can estimate the maximum potential outputs for given input levels. By using the different orientation DEA models for the same problem it could be determined different efficiency of DMUs. The Multi-directional efficiency analysis (MEA) methodology is also a non-parametric technique based on a different benchmark selection processes. The MEA has been developed to measure efficiency in input and also output orientated way. On the other hand, it is possible to rewrite the original MEA model for an input-output orientated form. In order to see the differences between the DEA and MEA techniques derived from benchmark selection process, we analyzed the efficiency of the Hungarian commercial banks.

Incomplete recourse programs for engineering problems

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Keywords: Stochastic programming, Scenario-based two-stage programs, Incomplete recourse.

In engineering problems solved by stochastic programming approach, a typical technique to model uncertainty is to identify a set of scenarios representing future possible behaviour of random elements included in the model. Then, the important task is to solve a large-scale mathematical program with a special structure. As the program size may grow very large mostly because of variety of random input parameters that must be taken into the account, the key challenge is to approximate it by a smaller program ideally with the optimal solution near to the original one. Various approximating techniques have been developed and improved, many of them are based on sampling based techniques. Frequently, the authors also successfully study the quality of obtained approximating results and evaluate it by using suitable statistical results. Most of the results in case of two-stage stochastic linear programs with fixed recourse is obtained for relatively complete recourse cases. However, quite often the considered engineering problems are two-stage problems with incomplete recourse. So, the studied cases will illustrate the related difficulties and authors will discuss several possibilities to avoid such situations for selected engineering problems. The ideas, theoretical assumptions, limitations, algorithmic realizations, and ways of their software implementation will be presented and analysed.

New trends in interior-point algorithms

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Keywords: Sufficient linear complementarity problem, Predictor-corrector interior-point algorithm.

Linear complementarity problems (LCPs) have a wide variety of applications in different fields, such as optimization theory, economics, engineering. The predictor-corrector (PC) interior-point algorithms (IPAs) turned out to be an efficient tool for solving LCPs. The determination of the search directions plays an important role in case of these IPAs. In this talk we present a widely used method for determining search directions, namely the algebraically equivalent transformation (AET) on the centering equation of the system which defines the central path. After that, we give a systematization of the Newton-systems and scaled systems in case of PC IPAs for solving sufficient LCPs. This structure leads to new trends in the theory of IPAs. Furthermore, we study the computational efficiency of the proposed PC IPA on a broad set of problems, including such problems, where the matrix does not belong to the class of sufficient matrices. In this case the theoretical properties of the PC IPAs are not known. However, we present promising numerical results.

Optimizing data collection: a data-driven approach for sea exploration

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Keywords: Combinatorial optimization, Machine learning, Evolutionary computation.

This work describes the sea exploration problem, also present in other contexts. The goal is to schedule the journey of a ship for collecting information about the composition of the seafloor. We consider a bounded surface, for which a limited number of points the resource level is known. Optimal expedition planning involves three subproblems: *assessment*, *planning* and *estimation*. *Assessment* consists of estimating the amount of information that would be conveyed by probing the surface. We assume that after committing to probing at a certain place, the information obtained can immediately be used to change the course of the following decisions. *Planning* consists of deciding on the position of points to probe until the end of the expedition. The objective is to maximize the overall informational reward obtained, taking into account that the total duration of the trip is limited. *Estimation* aims to quantify through regression the resource level available at any point on the surface, based on all the information available at the end of the trip. This is done through regression using both the initially available points and those collected during the expedition. In this work we detail an hybrid algorithm, including components of combinatorial optimization, machine learning and evolutionary computation, for tackling this problem. The objective is to carefully plan a data collection expedition that maximizes the information available at the end of the trip. The trip length is determined by means of an integer programming model for orienteering. In a Gaussian processes model, points with high variance are initial candidates for probing, but their position will evolve through random distortion towards a solution which minimizes a measure of the variance allover the relevant surface. Experiments with simulated data show that the proposed method improves the quality of the ship's schedule.

Redundant coalitions for weighted least cores

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Keywords: Cooperative game, Least core, Per-capita least core, Computation.

The main solution concepts of transferable utility cooperative games take, in principle, into account all available quantified information on the cooperative possibilities of the various groups of players. Although the definitions formally involve every coalitional value, many solutions related to the core may actually be determined by a smaller family of coalitions. Disregarding superfluous coalitions can make the analysis and/or the computation of these solutions significantly easier, especially for games related to situations with structured cooperation possibilities. In this paper we investigate the redundancy of coalitions with respect to certain linearly weighted least cores. Most importantly, we identify a family of coalitions that is sufficient to completely determine both the standard least core and the per-capita least core, provided the game has a full-dimensional core. We discuss a few special classes of balanced games where this characterization family consists of polynomially many coalitions, henceforth we can compute these weighted least cores in polynomial time. By means of examples we also explore the "sharpness" of our result.

Task assignment to workers on the basis of their competencies

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Keywords: Linear and integer programming, Lean manufacturing, Production management, Task assignment.

We will present the issue of assigning tasks to employees in medium-sized upholstered furniture plants managed using the Lean production method. This problem is motivated by real problems described by upholstered furniture plants managers in Poland. Lean manufacturing requires a high degree of flexibility in planning on-demand production and hence production plans are very diverse, often from one day to the next. Therefore, there is a great need to create an effective and flexible system supporting production management, in particular human resources management. As far as upholstered furniture factories are concerned, such a solution is most needed in two stages of production: sewing covers and upholstering. We propose an integer linear optimization model for solving the problem of task assignment to workers. The model is further enhanced by competence coefficients that describe the skills or capabilities of each employee to perform each specific task. The competence coefficients may be determined on the basis of a subjective appraisal by the superiors or on the basis of some automatic evaluation system. Alternatively, these two ways can be mixed. Regardless of the method of evaluation, the values of these factors are to be such that a lower value of the coefficient indicates greater predisposition of the employee to perform a given task. An additional element that ensures the existence of a solution to this NP-hard problem has also been introduced. Algorithmic method of solution to this problem will be also discussed.

The problem of using remnants of fabrics in upholstered furniture factories

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Keywords: Linear and integer programming, Cutting stock problem, Production planning, Remnants of fabrics.

We will present a real problem that arises in the management of upholstered furniture plants in Poland. As fabric costs are one of the main factors influencing production costs, there is a need to use remnants of fabrics. The practice is that residual fabrics are stored in warehouses and from time to time "ventilating the warehouse" is carried out, i.e. planning the optimal possible use of the existing leftovers. This problem is similar to the very known NP-hard problem: 1-dimensional cutting problem. However it is much more difficult, because the remnants of fabric are of different lengths and this causes a great variety of patterns, which weakens the effectiveness of algorithms. On the other hand, this problem can be treated as a kind of multi-knapsack problem, which is also known as an NP-hard problem. That is why we have to look for effective algorithms of searching the state space in order to find the optimal solution. Another difficulty is to define the objective function. We obtain a linear integer optimization model. We will discuss different types of objective function and algorithmic solution as well.

P-graph based risk evaluation model for optimal design of complex systems

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Keywords: Risk-based optimal design, P-graph, Redundancy allocation.

Operational excellence in asset-intensive chemical, oil, gas as well as energy sectors should also be ensured by risk-based optimal design and maintenance planning. Redundancy allocation is widely used to identify critical elements which redundancy can maximise the reliability of the system under minimum cost [1]. In a sophisticated model-based optimisation methodology the costs associated with maintenance and equipment failure consequences should be structured according to the hierarchy of the assets, and the time-dependence of the failure probabilities and maintenance activities should also be handled. We extend the P-graph process synthesis and optimisation methodology [2] with time-dependent risk evaluation models (fault trees, success trees, event trees) and utilise time-dependent risk-relevant constraints in the optimisation of the system topology. Weibull distributions are used to model the reliability of subsystems and system components. The importance of the components are evaluated based on the cut sets of the P-graphs. The resultant nonlinear mixed integer programming problem is solved by tailored meta-heuristic algorithms to determine the optimal maintenance cycle times and the degrees of the redundancies of the critical elements. We apply the proposed methodology for benchmark problems in the energy and process industry, like the analysis of reforming reaction systems in a petrochemical plant and heat exchangers in thermoelectric power plant [3].

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Camera pose optimization in applications

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Keywords: Registration, Pose estimation, Applications.

The main focus of this presentation is the external pose optimization of various cameras in different real life applications. The camera pose estimation has a long history, although this problem is far from being solved in a general context: each application, user specific environment has its own challenge. The camera pose estimation or in other words the external calibration has rather application specific solutions, and for most of them the solution can be boiled down to a parameter optimization problem. In this presentation starting from simple closed form parameter estimation, through singular value decomposition (SVD) based optimization, towards more complex Levenbeg-Marquardt based parameter optimization and active perception (POMDP) based variants are also covered. For each theoretical approach a practical example with real life experiments highlights the advantages and limitations of the algorithm. The range of applications spans from indoor camera mounted on mobile/fixed robots, augmented reality devices and outdoor large scale LiDAR devices.

A framework for defining scheduling problems

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Keywords: Scheduling, Framework.

Scheduling is one the most classical optimization problems, which is studied in general as follows: a set of resources and a set of jobs are given and the aim is to assign a resource to each job minimizing (or maximizing) a cost function observing a given set of rules. Numerous types of scheduling problems are defined according to the resources, the cost function and the defined constraints for the jobs. In practice, many optimization problems can be formalized as scheduling problems, such as machine scheduling, crew scheduling and time-table scheduling to mention a few. The main difficulty for applying the published methods in industry is the adaption of the general methods to the given field. Usually real life rules are much more complicated than the published constraints and these rules can be totally various in different application area. Furthermore, industrial applications must be flexible to adapt to the changing circumstances. In this study, we present a general definition structure for the rules. Hereby using this framework, the optimization methods can be flexible in managing the different constraint of the application areas. In this concept, a rule forms an independent block containing three definitions: the basic structure of the rule, the testing method of the rule, and the transforming operation of the basic structure during the optimization steps. In this system, the rule set can be easily modified without reconstructing the bases of the optimization method.

Targeting the options for utility system retrofit using efficiency and footprint indicators

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Keywords: Site Utility System, Retrofit, Energy Efficiency, Footprints.

Optimising the operation or the design of Industrial Utility Systems has been matured in the research and industrial practice. There are robust synthesis and operational optimisation tools for research, consulting, and everyday use – e.g. Aspen Utilities Planner. However, the retrofit task has received little attention. There have been works on the retrofit of a single industrial process interacting with separation (e.g. distillation) or direct operational optimisation for achieving minimal operating costs. Retrofit related to the Utility System has been considered in Top-Level Analysis which used successive operational optimisation and marginal price analysis to target HEN retrofit. Also the heat recovery aspect of Site Utility Systems and the implications of adding a steam turbine to a utility system with inter-process heat recovery only have been analysed. This work proposes a set of tools for evaluating the efficiency of existing Site Utility Systems. The properties to be evaluated include, in addition to the traditional heat recovery and cogeneration targets, also the comparison of current power generation, inter-process heat recovery, fuel utilisation efficiency to the thermodynamic targets. The efficiency of using the generated steam and the drawn primary energy sources is also estimated and allocated to the system parts – energy users, steam turbines, letdowns, vents.

A new interior point algorithm for a class of market equilibrium problems

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Keywords: Fisher type market exchange models, Interior point methods, Convex optimization.

The Fisher type market exchange model is a special case of the Arrow-Debreu type market exchange model. In this case, the players are divided into two groups, consumers and producers. Producers sell their products for money, and the consumers have an initial amount of money that they can use to buy a bundle of goods which maximizes their utility functions. In his article in 2006, Yinyu Ye presented and analyzed an interior point algorithm to solve the Fisher type linear and Leontief market exchange models. He generalized the Eisenberg-Gale convex optimization formulation of the Fisher exchange market exchange model to a weighted analytic center problem, and then presented an interior point algorithm to solve it. In this presentation, we introduce a new interior point algorithm to solve the weighted analytic center problem discussed by Yinyu Ye, therefore we show a new way to find the solution of the Fisher type linear and Leontief market exchange models. We also present our new numerical results.

A heuristic approach for kidney exchange program

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Keywords: Kidney exchange program, Heuristic method.

Kidney exchange program was developed to find compatible matches through exchange cycles within an incompatible donor-recipient registry. Execution of long exchange cycles are logistically challenging - thus a bound on cycle length is required. Solving kidney exchange program with a bound on cycle length more than 2 is NP-hard. So we propose a heuristic approach to solve large size kidney exchange program by identifying the crucial pairs for creating 3-way cycles. It uses the blood group distribution to find the crucial pairs and prioritize them in the solution. It was observed that these crucial pairs were having hard to match recipients as well. Thus prioritizing them will increase the success probability of execution of the proposed transplants. We compared our heuristic with exact approaches and it was observed that the difference between the heuristic and exact methods was minimal. The heuristic approach has a polynomial running time which allows us to run the algorithm multiple time if required.

What are the fair steam cost and environmental footprint allocations for multi-company total sites?

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Keywords: Process integration, P-graph, Cooperative Game Theory.

Negotiations of shared utility systems across multi-company Total Sites and Locally Integrated Energy Sectors presents a potential barrier to cooperation, maximising heat integration and utility system efficiency for the collective benefit of all parties. In addition, environmental impacts caused by the shared utility system must also be appropriately allocated to the companies involved. This paper aims to formulate a mathematical basis for determination of the "fair" steam costs and environmental footprint allocations. The method to determine the fair cost allocations involves the development of a robust model of the shared utility system using the P-graph framework followed by the application of a Cooperative Game Theory – CGT model. There is significant synergy between P-graph and CGT, in that P-graph's Solution Structure Generator – SSG algorithm determines all feasible structures followed by Linear Programming to optimise each, comprising the essential inputs to the CGT model. On the case study side, a further intriguing point has been the inclusion of indirect geothermal heat in addition to a natural gas boiler and steam turbine. For an example four-plant problem with different owners, the results show the different distributions of steam costs compared to greenhouse gas (GHG) emissions and Water Footprints. Further research will focus on how to implement the model in practice where steam and power demands regularly vary and the structure of the utility system are significantly more complex to operational optimise.

On a sufficient property for sufficient matrices

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Keywords: Sufficient matrix, Linear algebra, Interior point methods.

A matrix M is column sufficient if for all $\mathbf{x} \in \mathbb{R}^n$, $X(M\mathbf{x}) \leq 0$ implies $X(M\mathbf{x}) = 0$. A matrix M is row sufficient if and only if M^T is column sufficient and is sufficient if it is both row and column sufficient. In other words, $X(M\mathbf{x})$ is a column with entries $x_i(Mx)_i$ and the property reads: if $x_i(Mx)_i \leq 0$ for all $i \in [1, n]$ then $x_i(Mx)_i = 0$ for all $i \in [1, n]$. We prove a couple of theorems providing necessary and sufficient conditions for matrix sufficiency.[1]

[1]Work in progress with Janez Povh and Tibor Illes. Based on notes after the talk at 2-nd Hungarian-Slovenian OR workshop Budapest 16-17.7.2018

Optimal cutting and nesting problem in manufacturing process of rubbered steel rule dies

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Keywords: Cutting problem, Packing problem.

Our partner firm is capable to make steel rule dies with broaching, combined or perforating rules of special sizes. By these steel rule dies the hydraulic machines cut paper boxes from laminated paper. These tools are assembled on wood table, which contains rules, the very sharp blades. Steel rule dies contain a rubber among these blades. The rubber holds the paper not to move while the hydraulic machines cut the paper by pressing. The rubbed forms are made automatically by a rubber designer software. However the large size rubbers are cut in CAD by hand. Our fully automatic methods optimize the cutting of the CAD designed parts to help nesting and optimize layout to save costly materials. In case of optimal manual layout and optimal nesting the aims are different. The shape of the rubber is optimal for nesting if it is close to a rectangle. To determine the rubber position manually is difficult if there are many similar or identical rubber parts. At the same time these properties are good to make nesting. Our automatic technique involves cutting the rubber into small parts. This is good for nesting, but contains too many parts for manual lay down. After cutting we join the small parts repeatedly, if it is reasonable. In this step we considered mostly the shape of the parts. After this we elaborate nesting with different parameters. The applied nesting technique [1] is very fast, so we can determine the good parameters in every case. In our presentation we show the details of our automatic algorithm, and compare the original manual technique with our automatic technique. [1] https://svgnest.com/

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