Veszprém Optimization Workshop

Abstracts

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Here, there or everywhere - modelling the evolution of spatial economic patterns

Zsuzsanna Bacsi
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Economic problems often lead to mathematical models of complex structure, even with necessary simplifications. These simpifying assumptions are needed to make the model tractable, but may turn out to be unrealistic from the economic viewpoint. The hardest part of building economic models close to the reality is to grasp the human component, i.e. to describe the process of human decision making. The present talk deals with the mathematical model known as the model of New Economic Geography, that earned a Nobel Prize to its author, Paul Krugman. The model describes how the output and the labour force are distributed between regions of an economy, leading to agglomeration or dispersion patterns of production. The structure of the full model is too complex to be solved analytically, but numerical simulations can reveal its behaviour. However, simplifying assumptions about the behaviour of economic agents allow the construction of a model structure that is possible to solve analytically, and is not less realistic than the original model structure. The talk introduces such a simplified model version with true-world examples. The evolution of various spatial patterns predicted by the model is compared to true historical data.

On the interplay between discrete geometry, analysis, and combinatorics

Károly Bezdek
University of Calgary, Canada and University of Pannonia, Hungary

I will survey some recent progress on the following three major topics in discrete geometry: (Part I) The Kneser-Poulsen conjecture; (Part II) Densest unit sphere packings and largest contact numbers for unit sphere packings; (Part III) Extremal properties of totally separable unit sphere packings.

Web technology for the automation of traceability assessment in safety-critical software development

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The establishment, maintenance and assessment of the completeness of traceability and the consistency of the requirements during the development of software in general and of safety-critical software in particular is demanding and costly. The special requirements are reflected in software process related general and industry specific standards and the popular agile approaches as well. For practical and logical reasons, there is an imminent need for automation as far as possible. The Augmented Lifecycle Space approach is introduced gracefully integrating Open Services for Lifecycle Collaboration (OSLC) technology and formal modeling which is fundamentally necessary for securing completeness and consistency, but customarily rejected due to the usually prohibiting up-front effort needed to formally process all artifacts of an already established traditional system.

The capabilities of Prezi are applied to give a systematic overview of the structure of the presentation while going into any desired detail of the phases of research from the business needs through the generalized formulation and solution approach to the publication of research results.

New interior-point algorithm for sufficient linear complementarity problem

Zsolt Darvay and Gizella Noémi Márk
Babeş-Bolyai University, Romania

Recently, Darvay and Takács introduced a new wide neighborhood of the central path and proposed a primal-dual algorithm for solving linear optimization problems. In spite of the fact that this new neighborhood is different from the one proposed by Ai and Zhang, the iteration complexity of the new large-update algorithm presented by Darvay and Takács is as good as the best-known small-update methods.

In this talk we prove that Darvay and Takács's neighborhood can be extended to the more general case of sufficient linear complementarity problems. We introduce a new algorithm based on the technique of the algebraically equivalent transformation of the central path, proposed by Darvay. We prove polynomial complexity of the new method and we present some numerical results as well.

A randomized method for probabilistic problems

Csaba Fábián, Edit Csizmás, Rajmund Drenyovszki, Tibor Vajnai, Lóránt Kovács
John von Neumann University, Hungary

Tamás Szántai
Budapest University of Technology and Economics, Hungary

We deal with probability maximization and probabilistic-constrained problems. Based on a simple approximation scheme, we propose a column generation method that results easy subproblems and tolerates noise in gradient computation. The randomized method bears a resemblance to the stochastic approximation family. Computational results confirm the usability of the approach.

Strongly polynomial complexity of some pivot algorithms on max flow problems

Tibor Illés, Richárd Molnár-Szipai
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We start with the summary of the most important types of network flow problems, and then discuss in more details the maximum flow problem.

One possible solution strategy to solve maximum flow problems is based on linear programming approach, already discussed by Dantzig in some of his early works in 1950s. However, first result on efficiency, i.e. strongly polynomial complexity of a variant of primal simplex method is due to Goldfarb and Hao (Mathematical Programming, 1990).

Up to our best knowledge no other polynomial complexity result for any pivot algorithm that could solve maximum flow problem as special linear programming problem was known before. We proved that a variant of the monotonic build-up simplex algorithm (MBU SA), developed by Anstreicher and Terlaky (Operations Research, 1994) is strongly polynomial on maximum flow problems (Optimization 2014, Discrete Applied Mathematics, 2016). Interestingly enough that the MBU SA is neither a purely primal, nor a purely dual algorithm, thus during the iterations visits primal feasible and dual infeasible; neither primal nor dual feasible bases (spanning trees) until reaches the optimal basis.

The Ekeland's Variational Principle in optimization and equilibria

Gábor Kassay
Babeş-Bolyai University, Romania

Ekeland variational principle (EVP in short) is one the most elegant and important results from nonlinear analysis related to optimization and it has many applications in different areas of science: engineering, social sciences, management, etc. Oettli and Théra (1993) first extended EVP for bifunctions and used it to establish the existence of solutions to the equilibrium problem in the setting of complete metric spaces. In the past decade, several authors have studied EVP for real-valued bifunctions as well as for vector-valued bifunctions and also in different settings.

The aim of this talk is to review some of the most important results concerning EVP's related to equilibria, underline their usefulness, and present recent results of the author in this area.

Review on Béla Vizvári's activity – on the occasion of his 70th birthday

Gergely Kovács
Edutus University, Hungary

The talk is a short summary of the research and educational activity of Béla Vizvári.

Béla Vizvári got his MSc from mathematics (operations research) from Eötvös Loránd University of Budapest (ELTE) in 1973. He is the holder of the further degrees as follows: PhD from mathematics 1979 ELTE, dr. sc. nat. TH Merseburg (Germany) 1987, CSc Hungarian Academy of Sciences 1988, dr. habil. ELTE 2003.

He was with the operations research department of the Computer and Automation Institute of the Hungarian Academy of Sciences from 1973 to 1989. He taught at the following universities: Bilkent University, Ankara, Turkey, 1989-1993; Eötvös Loránd University, Budapest, Hungary, 1993-2007; Rutgers University, New Jersey, USA, 1994-1995; Budapest University of Technology and Economics, Hungary, 2013; Eastern Mediterranean University, Famagusta, North Cyprus, 2007-.

He was supervisor of approx. 80 MSc and 8 PhD theses. He is the author of six books and approx. 100 papers in referred journals, with more than 1000 independent references.

But he thinks the impact of a teacher or a researcher is more than the above mentioned numbers. What are more important: How can he convince his colleagues that what he is researching is important? How does he view the world? What kind of remote relationships does he point to? How does he make the profession useful to society? Béla Vizvári is exemplary in these, too.

The benefit of exploiting conditional independences in network reliability calculations

Tamás Szántai and Edith Kovács
Budapest University of Technology and Economics, Hungary

Network reliability can be determined as the probability of the union of events representing the permeability of all paths from the source node to the sink node. In the case of real size networks we cannot determine all paths so the network reliability can be only approximated by using the first k most reliable paths from the source node to the sink node.

In this talk we will give a method for discovering conditional independences between the permeability of paths which can be used when approximating the network reliability.

We will present numerical results for small networks when the exact network reliability can also be determined. In the case of randomly generated large sized networks we will compare the approximation to simulation results.

On joint works

János Tóth
Budapest University of Technology and Economics
and Eötvös Loránd University, Hungary

The aim of the talk is to review past, present and–hopefully–future joint work with Béla Vizvári. The usual setting is that I formulate a problem originating in formal reaction kinetics in (vague) mathematical terms and Béla translates it into an OR model and constructs an algorithm to effectively solve it. I am mentioning three problems.

Mass conservation

The chemical reaction $\sum_{m=1}^{M} \alpha(m,r)X(m) \to \sum_{m=1}^{M} \beta(m,r)X(m)$ is **mass conserving**, if $\exists \rho > 0 \ : \ \sum_{m=1}^{M} \alpha(m,r)\rho(m) = \sum_{m=1}^{M} \beta(m,r)\rho(m)$ holds for all reaction steps. We provided an "explicit" result for a class of reactions that could also be translated into chemical terms. Note that checking a condition—necessary or sufficient—also needs an algorithm and a code, no matter how nice it is. However, the chemical form may be fulfilled based on chemical knowledge. The general case of arbitrary reactions could be treated via reformulating it in the form of a LP problem, thus it is—theoretically—solvable for any reaction. (As the problems arising here are not too large for usual LP solvers, they are also practically solvable.) Another difference is that the conditions in the first

two cases can be dealt with for symbolic parameters while LP only works with numbers. ([1])

Decomposition

Another problem also successfully treated — among others — by István Szalkai [4, 5] is the decomposition of overall reactions into elementary steps. As a first step, one has to enumerate all the possible elementary steps. As the second, one has to find the decompositions. Both leads to the search of nonnegative integer solutions of linear equations. In the mathematical and programming part Dávid Papp also participated [7, 3]. The real application was worked out together with the chemists Miklós Riedel and Krisztián Kovács [2].

Positivity

The third problem is to find the minimal sets of chemical species in a reaction that are enough to imply that all the species have positive concentration for all positive times. In the talk practical applications and theoretical consequences will be shown together with a brute force solution. Béla together with his student Mahdi Shavarani has found a more elegant and more effective solution and they applied it also to large combustion systems.

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Colorings of hypergraphs

Zsolt Tuza
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A hypergraph is a pair $\mathcal{H} = (V, \mathcal{E})$ where V is the vertex set and $\mathcal{E}$ is a collection of subsets of V, called edges. The classical version of hypergraph coloring, termed proper coloring, is an assignment of colors to the vertices, such that no edge is monochromatic. This condition implies a lower bound on the possible number of colors. On the other hand, C-coloring is a color assignment in which no 'rainbow edge' occurs, that is an edge whose vertices have mutually distinct colors. This implies an upper bound on the number of colors. The combination of the two conditions — where the 'D-edges' are not allowed to be monochromatic, and the 'C-edges' are not allowed to be rainbow — leads to the notion of mixed hypergraph. (Some mixed hypergraphs are uncolorable.) A more general further model is obtained if we put lower and upper bounds on the maximum sizes of the monochromatic and the rainbow subsets in each edge. We discuss problems and results concerning such colorings. Most of the presented results are joint works with Csilla Bujtás.

The Giants Who Gave Their Shoulder to Me

Béla Vizvári
Eastern Mediterranean University, Turkey

Age 70 is a good point to look back to a carrier. Most of the fights are over. Many events got different meaning because of the consequences experienced later. There are important older colleagues who had good effect on the carrier. I recall my memories on seven of them. They are in the order of getting to know them: János Surányi who was the professor of algebra and number theory, András Prékopa who founded the Hungarian school of operations research, László Béla Kovács who was my MSc thesis supervisor, Tibor Vámos is the founder and first director of MTA SZTAKI, Joachim Piehler who was my professor during the work on dr.sc.nat., Peter L. Hammer who had Boolean personality, and Ihsan Doğramaci who founded Bilkent University and many other institutions.

Assignment of Patients to Hospitals in a Case of a Large-Scale Earthquake

Béla Vizvári, Tareq Babaqi, Aysun Pinarbaşi,
Eastern Mediterranean University, Turkey

Disasters may cause many damages and troubles every year all around the world. There are many ways to significantly decrease the rate of fatalities after a disaster. Beside, to take precautions in pre-disaster period, to provide medical help to save people in post disaster period is possible with a proper management. In this study, slightly injured people, who needs to transport a medical center, they are dispatched to closest hospitals. In this case, we receive calls from victims to the management call center and after the determination of their location, the system starts to work. In theory, if we do not have any limitations, there will not be a problem to save all people who needs help after a disaster. But in real cases there are many limitations of capacity in an opposite way. For this study limitations are time, number of medical personnel, hospitals and ambulances. It is assumed that in a case of a large-scale earthquake and a case study provided in İstanbul. The city is divided into regions by Voronoi diagram. The strategy is that according to location of the victim to take him/her to the closest hospital. So, the algorithm developed by greedy algorithm, will decide which patient should be delivered to the hospital first? And for this case; a list-scheduling algorithm will be applied for minimizing makespan on identical machines.

Learning the parameters of a reinforcement learning algorithm for process optimization

Gyula Ábrahám, György Dósa, Ágnes Werner-Stark, Tibor Dulai
University of Pannonia, Hungary

In case of process scheduling any process consists of tasks, and there can be precedence constraints among them. We assign the tasks to unrelated machines so that the makespan is minimized. In our earlier work we proposed a metaheuristic algorithm called QLM (Q-Learning Motivated) based on a reinforcement learning technique. The QLM algorithm uses several parameters (discount rate, learning rate, temperature for simulated annealing and iteration number). Currently these parameters are set manually and the goal is to determine the appropriate parameter values automatically.

On online bin packing

György Dósa
University of Pannonia, Hungary

In case of pure bin packing there are items having positive sizes, and any size is at most one. The items should be packed into minimum number of unit capacity bins. In the online case the items come one by one; this is in fact a harder case as we do not now the input in advance. The packing algorithm is compared to the offline optimal algorithm and the measure is called (asymptotic) approximation ratio. We show what attempts happened regarding this, from the beginning until now.

Linear complementarity problem and matrix classes

Marianna E.-Nagy
Budapest University of Technology and Economics, Hungary

Several matrix classes have been already defined related to the linear complementarity problem (LCP). We cannot expect a polynomial algorithm to solve LCPs without assuming about its coefficient matrix some special properties, because LCP is an NP-complete problem.

The sufficient matrix class is the widest class for which the criss-cross and the interior point algorithms are able to solve LCPs efficiently in some sence. However, it is also an NP-complete problem to decide whether a matrix is sufficient, or not. Therefore, we investigate these matrices, discover new special properties and develope different techniques to generate such matrices. We build a library of sufficient matrices to provide a test set for algorithms solving such LCPs.

On parameter estimation in functional differential equations

Ferenc Hartung
University of Pannonia, Hungary

In this talk we consider several classes of functional differential equations. We formulate the quasilinearization method for the parameter estimation problem, and we present numerical studies to illustrate the convergence of the method. We also discuss the related problem of smooth dependence of the solutions on parameters.

On parameter fitting via Bayesian optimization

Edith Kovács and Tamás Szántai
Budapest University of Technology and Economics, Hungary

Determining the parameters of a mathematical model is a frequent problem in different fields as engineering, medical science, machine learning and management. When the model can be expressed explicitly as a function which depends on a set of parameters and in addition the cost function (the goodness of its fitting to the real data) has "good properties" i.e. is convex, differentiable, there exist many global optimization methods for finding the optimal set of parameters.

In the present talk we suppose having a mathematical model, defined by many equations, which depends implicitly on the parameters which have to be determined. To a given parameter set a time depending model is associated. The problem is to design the parameter vector such a way that the mathematical model emulates the real data as good as possible. This problem cannot be solved by the well known global optimization procedures. For the solution we adapt the Bayesian optimization procedure to this problem.

The idea is to define an acquisition function which we optimize sequentially using the past information. Based on this in each sequence we determine a new parameter set where the model should be evaluated in the next step. This way by solving sequential optimization problems on the feasible set of parameters, we get a near optimal solution for the parameter set. In each step we gain new information which reduces the uncertainty of the model and we get a new set of parameters wich is likely to improve the fitting of the model.

We close our talk by listing some problems and open questions for further work.

Graph rigidity based augmentation problems

András Mihálykó and Csaba Király
Eötvös Loránd University, Hungary

Consider the following augmentation problem: given a graph G that consists of k disjoint spanning trees. What is the minimum cardinality edgeset H, so that leaving out any (one) edge from $G + H$ the remaining graph still contains k edge-disjoint spanning trees? Or another problem: given a minimally rigid graph in two dimensions, what is the smallest edgeset that augments it to a redundantly rigid graph? Both of these graphs are members of a broader family: the so-called (m, ℓ)-*tight* graphs (also known as the bases of the (m, ℓ)-*count-matroid*). In this talk we consider the following general problem: given an (m, ℓ)-tight graph, augment it to (m, ℓ)-redundant with a minimum cardinality edgeset. With the help of the so-called *co-tight sets* we prove that the minimum number of edges that is to be added equals to the half of the maximum number of disjoint co-tight sets in the given graph. This gives a new min-max theorem to the smallest edgeset and also we give an efficient algorithm to find such. This leads to a polynomial algorithmic solution for both of the original problems.

On Square Packing

György Dósa and Tomas Attila Olaj
University of Pannonia, Hungary

The origin of our considered square packing problem comes from 1918. This is as follows: Given squares of sizes $1x1$, $2x2$, and so on, the last one has size NxN. For $N = 24$, is it possible to pack them (without overlapping) into a $70x70$ accommodating square? The answer from the literature is "not", but the proof is a computer assisted proof, a pure and complete theoretical proof is not known yet. We consider this topic.

There are concerning problems also, like the problem of Erdős and Graham from 1932 where given k small equal squares, and we look for the smallest square that can accommodate them. Or the reverse problem: For a given "big" square of size "a", what is the maximum number of small unit squares that can be packed into the big square.

We will present some (pure theoretical or computer aided) results regarding the first mentioned problem: Given the squares of sizes from $1x1$ up to NxN, what is the smallest accommodating square? For example, what is the case for N=18? Here the total area is 2109, where $45x45 = 2025$ and $46x46 = 2116$. So they definitely cannot fit into $45x45$. But they neither fit into $46x46$, the smallest appropriate square is of size $47x47$.

A generalization of Thurtone method for consideration of possible assets

Éva Orbán-Mihálykó, Csaba Mihálykó
University of Pannonia, Hungary

Methods based on paired comparisons are suitable to rank objects. One of the frequently applied methods is the Thurstone method. Its main idea is to consider the power of an object as a random variable and the comparison of the objects means the consideration of the differences of the latent random variables. If the values of the differences are in certain intervals, the decisions between the objects are better, equal or worse and so on, respectively. These intervals are exclusive in the publications.

If the evaluation concerns chess players, the beginner has considerable advantage. An interval corresponding to white winning should include the winning of dark as well. Therefore, the intervals are not exclusive in this model.

In this presentation we provide a model which is able to take into consideration the advantage. The problem is solved by optimization of the likelihood function, moreover the existence and uniqueness of the optimum is related to the connectedness of a graph. We apply the method to the results of the European Team Chess Championship (Open Section) in 2012.

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Industry 4.0 solutions for optimizing manufacturing processes

Zoltán Süle, János Baumgartner, János Abonyi
University of Pannonia, Hungary

In the present talk, we demonstrate some Industry 4.0 solutions for optimizing manufacturing processes. Our research covers two areas: testing and design. Testing is an indispensable process for ensuring product quality in production systems. Reducing the time and cost spent on testing whilst minimizing the risk of not detecting faults is an essential problem of process engineering. A mixed-integer non-linear programming (MINLP) model to formalize how the total cost of testing depends on the sequence and the parameters of the elementary test steps are proposed. On the other hand, the design, operation and maintenance processes of safety-critical systems require careful planning, modeling and optimization steps. A novel multi-objective optimization-based method will be presented to evaluate the criticality of the units and subsystems. The applicability of the proposed methods is demonstrated using real-life case studies.

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Matrix-based Maintenance Management Methods and Models

Zsolt Kosztyán and István Szalkai
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We are given a set of **components** with **reliability values** and **critical values** (for ultimate repairing) for each of them, a set of *mandatory* or *optional* **tasks** (for repairing the components) with **score values** for each of them (positive and negative). Further we are given a set of **precedences** about the order of the tasks to manage (parallel, sequential and to be decided). The tasks can be managed in different (given) **protocols** (ways), which possibilities include the required time, cost, resource and the reliability increasement values. We also have a set of **dependencies** on the **order** of handling the tasks: *parallel*, *sequential* and *uncertain* (i.e. the second task can or can not be started unless the first had been finished, or we can decide later). Each dependency has a signed **score value**. We also may have different ways to summarize the above score values and various **functions** to optimize with various side assumptions.

We provide a mathematical foundation of the problems, algorithmic solutions and dozens of example runs with analysis.

Gyula Ábrahám, 11
Zsuzsanna Bacsi, 2
Károly Bezdek, 2
Miklós Biró, 3
Zsolt Darvay, 3
György Dósa, 11
Marianna E.-Nagy, 12
Csaba Fábián, 4
Ferenc Hartung, 12
Tibor Illés, 4
Gábor Kassay, 5
Edit Kovács, 13
Gergely Kovács, 6
András Mihálykó, 14
Tomas Attila Olaj, 15
Éva Orbán-Mihálykó, 16
Zoltán Süle, 17
István Szalkai, 17
Tamás Szántai, 7
János Tóth, 7
Zsolt Tuza, 9
Béla Vizvári, 10