Programme Doctoral en Recherche Opérationnelle

Zinal Spring Seminar 2014, January 12–16

	Sunday 12	Monday 13	Tuesday 14	Wednesday 15	Thursday 16
07:30 - 08:30		Breakfast	Breakfast	Breakfast	Breakfast
08:30 - 10:00		Singh	Orlin	Singh	Orlin
10:00 - 10:30		Coffee	Coffee	Coffee	Coffee
10:30 - 12:00		Orlin	Singh	Orlin	Singh
12:00 - 17:00		Sport and discussions			
17:00 - 17:20		Kuhn	Zemmer	Bock	
17:20 - 17:40			Rujeerapaiboon	Cevallos	
17:40 - 18:00			Kalaitzis	Ambrus	
18:00 - 18:20	Welcome cocktail		Cavat	Ruiz Vargas	
18:20 - 18:40			Chestnut	Thevenin	
18:40 - 19:00			Lücker	Zimmermann	
19:30	Dinner	Dinner	Dinner	Dinner	

Venue:
Hotel Europe
3961 Zinal
Tel.: 027 475 44 04

Public transport:
Station *Zinal Poste*

Keynote presentations

James B. Orlin (MIT)

Title: **Max Flows 1: basic algorithms**

Abstract: We will review the Ford Fulkerson algorithm for the max flow problem. The FF algorithm runs in polynomial time if one augments along the shortest augmenting path or the maximum capacity augmenting path. We then show that the straightforward implementation of the first technique can be sped up by a factor of m/n by using simple data structures. And a straightforward implementation of the second algorithm can be sped up by a factor of m/n by using simple data structures plus a technique called scaling.

Title: **Max Flows 2: excess scaling algorithms**

Abstract: We present the preflow push algorithm. We show that the wave algorithm runs in $O(n^3)$ time. The excess scaling technique runs in $O(nm + n^2 \log U)$ time. And a hybrid algorithm called the wave excess scaling algorithm is even faster. A critical technique to establish the running times of the latter two algorithms is potential function analysis.

Title: **Max Flows 3: an O(nm) algorithm for max flows**

Abstract: In this paper, we present improved polynomial time algorithms for the max flow problem defined on sparse networks with n nodes and m arcs. We show how to solve the max flow problem in $O(nm + m^{31/16} \log^2 n)$ time. In the case that $m = O(n^{1.06})$, this improves upon the best previous algorithm due to King, Rao, and Tarjan, who solved the max flow problem in $O(nm + n^{2+\epsilon})$ time. This establishes that the max flow problem is solvable in $O(nm)$ time for all values of n and m. In the case that $m = O(n)$, we improve the running time to $O(n^2/\log n)$.

Title: **Why is elementary probability theory so hard to understand?**

Abstract: Charles Pierce wrote, "This branch of mathematics [probability] is the only one, I believe, in which good writers frequently get results which are entirely erroneous." In this talk, we highlight some of the reasons that elementary probability theory is so challenging as well as some ideas that might make it a little simpler as well as a little more interesting.

Keywords: Overview of robust optimization; applications in statistical learning; sparse statistical learning; applications in text summarization

Mohit Singh (Microsoft)

Title: **Iterative Methods in Combinatorial Optimization**

Abstract: I will describe a simple iterative method for proving a variety of results in combinatorial optimization. The talk will first describe the classical application of the technique on survivable network design problem by Jain. We will then show its recent application to degree constrained network design problems where the task is to minimize the cost of the network and also satisfy given degree bounds on nodes. The most studied problem in this class is the Minimum Bounded Degree Spanning Tree problem. We will present a polynomial time algorithm for the problem that returns a spanning tree of optimal cost while exceeding the degree bound of any vertex by at most an additive one.
We will also discuss the method's applications to other problems and show that it achieves additive approximation algorithms in many settings adding to a rather small list of combinatorial optimization problems which have an additive approximation algorithm.

Title: **Maximum Entropy Distributions and Applications in Approximation Algorithms**

Abstract: Given a polytope P and a point x in the P, there can be many ways to write x as a convex combination of vertices of P. Interpreting any convex combination as a probability distribution over vertices of P, the distribution that maximizes entropy has received considerable interest. Interest in such distributions arises due to their applicability in areas such as statistical physics, economics, biology, information theory, machine learning, combinatorics and, more recently, approximation algorithms. In this talk, I will discuss the computability of maximum entropy distributions as well its applications in approximation algorithms.
A key difficulty in computing max-entropy distributions has been to show that they have polynomially-sized descriptions. We show that such descriptions exist under general conditions. Subsequently, we show how algorithms for (approximately) counting the vertices of P can be translated into efficient algorithms to (approximately) compute max-entropy distributions. In the reverse direction, we show how access to algorithms that compute max-entropy distributions can be used to count, which establishes an equivalence between counting and computing max-entropy distributions.
In applications of the method, we will mainly focus on the traveling salesman problem. We will show that the method leads to improved approximation algorithm for the asymmetric as well the symmetric traveling salesman problem improving on some classical algorithms.

Daniel Kuhn (EPFL)

Title: **Worst-Case Value at Risk of Nonlinear Portfolios**

Abstract: Portfolio optimization problems involving value at risk (VaR) are often computationally intractable and require complete information about the return distribution of the portfolio constituents, which is rarely available in practice. These difficulties are compounded when the portfolio contains derivatives. We develop two tractable conservative approximations for the VaR of a derivative portfolio by evaluating the worst-case VaR over all return distributions of the derivative underliers with given first- and second-order moments. The derivative returns are modelled as convex piecewise linear or—by using a delta–gamma approximation—as (possibly nonconvex) quadratic functions of the returns of the derivative underliers. These models lead to new worst-case polyhedral VaR (WPVaR) and worst-case quadratic VaR (WQVaR) approximations, respectively. WPVaR serves as a VaR approximation for portfolios containing long positions in European options expiring at the end of the investment horizon, whereas WQVaR is suitable for portfolios containing long and/or short positions in European and/or exotic options expiring beyond the investment horizon. We prove that—unlike VaR that may discourage diversification—WPVaR and WQVaR are in fact coherent risk measures. We also reveal connections to robust portfolio optimization.

PhD presentations

Gergely Ambrus (EPFL)

Title: **Tight frames and energy**

Abstract: Tight frames are finite systems of unit vectors that provide a decomposition of the identity operator. They are important both for the theory and the applications in information theory. A beautiful result of Benedetto and Fickus from 2003 gives a characterisation result for tight frames. I will show a short proof of this result, which exploits duality between the vector systems and operators.

Discussants: Farah Charab, Slobodan Mitrovic

Adrian Bock (EPFL)

Title: **Odd cycles and stable sets**

Abstract: The *stable set* problem is fundamental in Combinatorial Optimization. It asks for maximum cardinality set of nodes in a graph that are pairwise non-adjacent. We study the approximability of the stable set problem characterized by the *odd cycle packing number* ocp. This is the maximum number of vertex-disjoint cycles of odd cardinality in the graph.
We observe that $ocp = \log_2 \Delta$ where Δ is the maximum absolute value of a subdeterminant of the edge-node incidence matrix A of the graph. Note that for $\Delta \leq 1$, the matrix A is totally unimodular and the graph is bipartite ($ocp = 0$).
Our results are a polynomial time approximation scheme for $ocp = o(n/\log n)$ and an α-approximation algorithm with α smoothly increasing from a constant to n as ocp grows from $\Theta(n/\log n)$ to $n/3$. We also obtain similar results for the weighted stable set problem.

Discussants: Abbas Bazzi, Sumedha Gupta

Joël Cavat (HES-SO)

Title: **Multi-threaded algorithms used for solving the airline crew pairing problem**

Abstract: In airline scheduling, the crew pairing problem consists in covering flight legs by crew duties at minimal cost. For a given set of flights, a set of crew routes is to be generated in a preliminary phase in order to solve this problem. This set is then fed to an integer linear programming solver. A crew route is a legal succession of flights which starts from a base airport and returns to this same airport. We present a multi-threaded algorithm that enumerates all crew routes for a given set of flights.

Discussants: Fabrizio Albertetti, Adrian-Claudiu Valculescu

Alfonso Cevallos (EPFL)

Title: **Orienteering with Delay Factor**

Abstract: We introduce the problem Orienteering with Delay Factor, as well as some first approximation results. Given a graph G with edge distances, vertex profits, a root s, and a delay factor R, the objective is to find a path that starts in s and maximizes the sum of profits of the vertices that are visited within their deadlines (assuming that the path is traversed at unit speed), where the deadline of a vertex v is defined as R times the distance between v and s. This is a special case of the Deadline Orienteering problem, for which the best approximation algorithm is logarithmic. We present a new logarithmic result for our special case.

Discussants: Andrea Baggio, Samuli Leppänen

Steve Chestnut (Johns Hopkins University)

Title: **Sampling Binary Contingency Tables**

Abstract: Given two sequences of integers $r = r_1, r_2, \ldots, r_m$ and $c = c_1, c_2, \ldots, c_n$ how many $m \times n$ binary matrices have row sums r and column sums c? How can we sample from the set of all such matrices efficiently? In this talk I will review two existing exact sampling algorithms, discovered 30 years apart, and describe a new algorithm that uses elements of both. The algorithm is targeted at instances describing sparse tables with highly irregular row and column sums.

References:

- Wormald N (1984): Generating random regular graphs. Journal of Algorithms 5(2), 247–280
- Miller J, Harrison M (2013): Exact sampling and counting for fixed-margin matrices. The Annals of Statistics 41(3), 1569–1592

Discussants: Reinhard Bürgy, Tomas Robenek

Christos Kalaitzis (EPFL)

Title: **On the Configuration LP for Maximum Budgeted Allocation**

Abstract: We study the Maximum Budgeted Allocation problem , i.e., the problem of selling a set of m indivisible goods to n players, each with a separate budget, such that we maximize the collected revenue. This problem falls into the broad category of indivisible goods allocation problems, and shares structural similarities with other well-known problems(e.g. Generalized Assignment Problem). We will present an approach which utilizes linear programming relaxations; the natural Assignment-LP has an integrality gap of 3/4, and there are known algorithms which achieve it. On the contrary, we will present an algorithm which improves upon this guarantee in the restricted version of the problem where every item has one unique price for all the players, using a stronger LP relaxation known as the Configuration-LP.

References:

- Chakrabarty D, Goel G (2010): On the approximability of budgeted allocations and improved lower bounds for submodular welfare maximization and gap. SIAM J. Comput. 39(6):2189–2211

- Srinivasan A (2008): Budgeted allocations in the full-information setting. APPROX-RANDOM, 247–253

Discussants: Stefan Binder, Marija Nikolic

Florian Lücker (EPFL)

Title: **Managing disruption risks: on the application of risk mitigation strategies**

Abstract: Production disruptions can have a severe business impact and require an appropriate management. For a manufacturing firm key operational mitigation measures are safety inventory, dual sourcing and agility capacities. In this talk we investigate the relationship between these three mitigation strategies by modeling a manufacturing firm that can deposit safety inventory of finished goods, maintain free production capacities and avail on emergency sourcing. It turns out that in certain cases agility capacity or dual sourcing are important risk mitigation strategies. Within our modeling framework we introduce an operational metric that enables us to quantify the resilience of the manufacturing process.

Discussants: Evanthia Kazagli, Iliya Markov

Andres Ruiz Vargas (EPFL)

Title: **Many disjoint edges in topological graphs**

Abstract: A cylindrical graph is a topological graph drawn on a cylinder with a vertical axis satisfying the condition that every vertical line intersects every edge at most once. It is called simple if any pair of its edges have at most one point in common: an endpoint or a point at which they properly cross. We show that every simple complete cylindrical graph on n vertices contains $\Omega(n^{1-\epsilon})$ pairwise disjoint edges for any $\epsilon > 0$. As a consequence, we show that every simple complete topological graph (drawn in the plane) with n vertices contains $\Omega(n^{\frac{1}{2}-\epsilon})$ pairwise disjoint edges for any $\epsilon > 0$. This improves the previous lower bound of $\Omega(n^{\frac{1}{3}})$ by Suk and by Fulek and Ruiz-Vargas. We remark that our proof implies a polynomial time algorithm for finding this set of pairwise disjoint edges.

Discussants: Adam Kurpisz, Ashkan Norouzi Fard

Napat Rujeerapaiboon (EPFL)

Title: **Robust Growth-Optimal Portfolios**

Abstract: The log-optimal portfolio is known to outperform any other portfolio in the long run if stock returns are i.i.d. and follow a known distribution. In this talk, we establish similar guarantees for finite investment horizons where the distribution of stock returns is ambiguous. By focusing on fixed-mix portfolios, we exploit temporal symmetries to formulate the emerging distributionally robust optimization problems as tractable conic programs whose sizes are independent of the investment horizon.

Discussants: Antonin Danalet, Oliver Strub

Simon Thevenin (University of Geneva), Nicolas Zufferey, Jean-Yves Potvin

Title: **Mutual exclusion scheduling with preemption**

Abstract: We consider the problem of scheduling n jobs of different durations on parallel machines with preemptions and incompatibilities (i.e., some pairs of jobs cannot be performed simultaneously). Three objectives have to be minimized in a lexicographical approach: (1) the makespan, (2) the number of job interruptions, (3) the sum of job throughput times. The problem is modeled as a graph multi-coloring problem with an additional constraint, which states that the size of each color class should be lower than the number of available machines. To solve the problem, a greedy algorithm and a tabu search method are proposed.

References:

- Blöchliger I, Zufferey N (2013): Multi-coloring and job-scheduling with assignment and incompatibility costs. Annals of Operations Research 211:83—101
- Thevenin S, Zufferey N, Potvin J (2013): A multi-coloring approach for an order acceptance and scheduling problem with preemption and job incompatibilities. CIRRELT-2013-45
- Chiarandini M, Stützle T (2007): Stochastic Local Search Algorithms for Graph Set T-Colouring and Frequency Assignment. Constraints 12:371–403

Discussants: Anna Fernández Antolín, Tom Rihm

Kevin Zemmer (ETHZ), A. Del Pia, R. Hildebrand and R. Weismantel

Title: **Homogeneous Polynomial Integer Optimization in the Plane**

Abstract: Consider the problem of minimizing a homogeneous polynomial with integer coefficients over the integral points of a polyhedron. We show that if the dimension of the space is equal to two, the degree of the polynomial is fixed and the polyhedron is bounded, then this problem is solvable in polynomial time.

Discussants: Salvatore Ingala, Mervegul Kirci

Adrian Zimmermann (University of Bern)

Title: **Operational planning of assessment centers**

Abstract: To assess the potential and the skills of candidates for a position to be filled, human resources managers often conduct assessment centers. During an assessment center, the candidates perform a series of exercises while they are observed by so-called assessors. We present an MILP formulation for the scheduling of such assessment centers, and we report on computational results for four real-life examples. Our MILP formulation is based on the resource-flow concept presented in Koné et al. (2011).

References:

- Koné O., Artigues C., Lopez P. and Mongeau M., 2011. Event-based MILP models for resource-constrained project scheduling problems, *Computers & Operations Research*, Vol. 38, pp. 3-13.

Discussants: Flurin Hänseler, Sofia Kalakou