Ahmad Abdi

Talk 1: A polyhedral study of tractable set covering problems

Talk 2: Two case studies: postman sets in graphs, and joins in digraphs

Abstract. An important fact at the intersection of Mathematical Optimization and Complexity Theory is that Integer (Linear) Programming is NP-hard while Linear Programming can be solved in polynomial time. Three of Karp's 21 NP-complete problems, VERTEX COVER, SET COVERING, and HITTING SET, can in fact be cast as an integer programming problem of the form $min\{<w,x>: Ax \geq 1, x \geq 0, x\, a\, 0-1\, vector\}$, where A is a 0,1 matrix. These are known as set covering integer programs. For a special class of matrices, called ideal matrices, which root all the way back to Shannon's switching game, the Theory of Polyhedral allows one to reduce the set covering integer program to solving its linear relaxation, and therefore move into the complexity class P!

In the first lecture, we study ideal matrices from different perspectives, namely, polyhedral theory, network theory, and clutter theory, and present many open questions about them. In the second lecture, we focus on two special cases coming from undirected and directed graphs. In particular, we relate the Generalized Berge-Fulkerson Conjecture and Woodall's Conjecture to questions about ideal matrices.

Tiziano Bacci

Talk 1: Dynamic programming based formulations for power energy production

Abstract. In the context of the electrical power production, the Unit Commitment problem consists into deciding whether each power generation unit has to produce energy or not and in which amount for each time period over a short time horizon. The objective is to satisfy a given energy demand at minimum cost while satisfying several constraints: minimum and maximum power output, minimum up- and down-time, start-up and shut-down limits, ramp-up and ramp-down limits. We present the first formulation describing the convex hull of the Unit Commitment problem with single unit and convex power generation costs having a polynomial number of variables and constraints. It is based on the efficient Dynamic Programming algorithm proposed in [Frangioni A. and Gentile C., Solving Nonlinear Single-Unit Commitment Problems with Ramping Constraints. Operations Research 54(4):767-775] together with the Perspective Reformulation technique proposed in [Frangioni A. and Gentile C., Perspective cuts for a class of convex $0-1$ mixed integer programs. Math. Progr. 106(2):225-236.].

Since the new exact formulation is large and hard to solve, we propose other new formulations representing different trade-offs between the size and the quality of the bounds. Computational results show that navigating these trade-offs may lead to improved performances.

Based on a joint work with Antonio Frangioni and Claudio Gentile.

Talk 2: A new heuristic algorithm for the stochastic block relocation problem

Abstract. The traffic of containers has recorded a strong increase during the last few decades. For this reason the need to optimize the movements of containers and the vehicles inside the ports has actually been increased as well. One of the best known problems in the literature dealt with the logistics of containers is the Block Relocation Problem. It consists in emptying a storage area containing a group of containers piled into stacks with the minimum number of moves. In this problem, the retrieval order is known in advance. However, this hypothesis is usually unrealistic. In this sense, the stochastic container relocation problem defines a variant of the problem in which the retrieval order of the containers is not known at the beginning of the time horizon. Here we present a new heuristic approach for the stochastic case capable of providing solutions to large instances in a short time. Experiments conducted on instances taken from the literature demonstrate the effectiveness of the proposed method.

Based on a joint work with Sara Mattia and Paolo Ventura.

Claudio Gentile

Talk1: Power Energy Production and Optimization (I)

Talk 2: Power Energy Production and Optimization (II)

Abstract. In this lecture we revise two main approaches for the solution of the most studied operational planning problem in Power Energy Production: the Unit Commitment (UC) problem. UC is to schedule a number of power production units over a short time horizon (from one day to a week) with the aim to decide, for each unit, when and at what power level to produce satisfying system-wide constraints and technical constraints depending on the unit technology with the purpose to minimize the total production cost.

System-wide constraints include demand constraints, reserve constraints, and network constraints.

Technical constraints describe the working features of each production unit. Thermal, hydro, solar, wind (and other) units are described by completely different constraints. In this lecture we will extensively deal with thermal units that have a complex combinatorial structure.

The first solution approach for UC is based on Lagrangian Relaxation and on Dynamic Programming (DP). Lagrangian Relaxation applied to system-wide constraints enables us to decompose UC into single-unit Unit Commitment (1UC) subproblems that can be solved by combinatorial approaches. For thermal units, (1UC) is usually solved by Dynamic Programming. We will revise the main variants of DP algorithms.

The second solution approach for UC is based on Mixed-Integer Non Linear Programming (MINLP) formulations. Indeed, production costs on thermal units is usually expressed as a convex quadratic function. The resulting type of MINLPs may be reformulated by Second Order Conic Quadratic Programming, Semi-infinite Mixed-Integer Linear Programming, and Mixed-Integer Quadratic Programming. Other sources of nonlinearities can also appear with other types of production units.

Nezam Mahdavi Amiri

A combined trust region–line search projected structured algorithm for solving constrained nonlinear least squares problems

Abstract. Based on an adaptive projected structured exact penalty scheme due to Mahdavi-Amiri and Bartels, we present a combined trust region–line search projected structured algorithm for solving constrained nonlinear least squares problems; we make use of an adaptive penalty updating scheme, a combined trust region–line search strategy, and a special structured consideration for the approximate projected least squares Hessians. Several variants of the algorithm enjoy both the global and a local superlinear rate of convergence. A structured algorithms is implemented and the resulting program is tested on well-known small and large residual least squares test problems available in the literature along with a number of random test problems having various numerical properties due to Bartels and Mahdavi-Amiri. Numerical results confirm the robustness and efficiency of the algorithm. Outperformance of the algorithm is evidenced by the Dolan-More performance profiles of our numerical results in comparison with the ones obtained by a number of well-known general nonlinear programming methods.

Ahmadreza Marandi

Multi-stage adjustable robust location-transportation problems with integer-valued demand

Abstract. A Location-Transportation (LT) problem concerns designing a company's distribution network consisting of one central warehouse with ample stock and multiple local warehouses for a long but finite time horizon. The network is designed to satisfy the demands of geographically dispersed customers for multiple items within given delivery time targets. The company needs to first decide on the locations of local warehouses before the start of the time horizon. During the time horizon, the stocks at the local warehouses are repeatedly replenished and the company has to decide on how far the inventory levels are increased at those moments. Our problem is such that we can use time-independent basestock levels at all warehouses at those moments. Between any two replenishments, integer-valued demands are realized multiple times and the company needs to satisfy them by shipments from central or local warehouses to customers.

In this talk, we follow an Adjustable Robust Optimization approach for the design of the distribution network. We prove two main characteristics of our LT problems, namely convexity and nondecreasingness of the optimal shipment cost function. Using these characteristics, we show for two commonly used uncertainty sets (hyper-box and budget uncertainty sets) that the optimal decisions on the location and the basestock levels of local warehouses can be made by solving a polynomial number of deterministic problems. For a general uncertainty set, we propose a new method, called Simplex-type method, to find a locally robust solution. The numerical experiments show the superiority of our method over using the integer-valued affine decision rules, which is the only available method for this class of problems in the literature.

Hadi Mosadegh

A heuristic algorithm for solving real-world car sequencing problems in assembly lines

Abstract. With the emerge of novel production technologies and variant methods of car manufacturing and assembling, a variety of problems have been defined and studied in the area of mixed-model assembly systems. In this study, the problem of sequencing car bodies entering into the line aiming to balance workload of operators is studied. A mathematical programming model is proposed to minimize the amount of operators' work overload and idleness within the workstations. However, due to the complexity of the problem and since solving the model is very time consuming especially in cases with large number of workstations, a simulation-based heuristic algorithm is developed to deal with large scale problems. The problem is solved with different line configurations in terms of conveyor's speed scenarios. Numerical results show that with a proper sequence of car bodies entering into the assembly line, the company can benefit from significant improvements such as: reducing operators' idleness, reducing and balancing operators' work overload, increasing the production rate, and enhancing the overall performance of the assembly system.

Mohammad Mahdi Naghsh

Max-min optimizations in active sensing and communication systems

Abstract. Several applications demand for guaranteed worst-case performance of systems. In such circumstances, design in average sense does not make sense and the designer should resort to a robust design methodology. In this presentation, we exemplify robust design approaches in active sensing/communication systems. More precisely, exploiting max-min design methodology, we improve worst-case performance of radar systems in the presence of targets with unknown Doppler shifts as well as coexistence of strong and weak targets in the scene. As to communication systems, the worst-case rate of the users in MIMO interference systems is taken into account as the design metric to be optimized. The discussed optimization techniques in the talk include SDR, CD, and MM.

Diego Maria Pinto

OR and ML applications for Green Supply Chain Management

Abstract. Circular economy is fundamental to reach green supply chain targets. It considers products, but also infrastructure, equipment and services offered by waste facilities where materials are collected and then sorted to be converted into secondary raw materials. Because circular economy imposes a new view of operations with the aim of zero waste, in order to obtain this result it is critical to optimize every step of production and logistics processes. In this talk we review how these targets can be addressed by the development and integration of operations research models to optimize both strategical and operational tasks of waste management. The stochastic nature of waste streams should be considered when modeling these scenarios in order to promote solutions that are robust to data uncertainties, like those related to waste supplies. A framework of these models is fueled by data that generate the chance of extracting additional valuable information: data analysis techniques such as machine learning can indeed recognize data patterns revealing profitable insights.

Performing process cost analysis and estimation provides important outcomes to support and verify management decisions such service pricing, updating contracts of loss making customers or increasing service level in profitable locations.

Maryam Salami

Introductory to Combinatorial Optimization: Problems and Methods

Abstract. Optimization means finding the maximum or minimum of a certain function, called the objective function, defined on some domain. Classical theories of optimization i.e., differential calculus, variational calculus and optimal control theory deal with the cases when this domain is infinite. From this angle, the subject of combinatorial optimization. Combinatorial optimization searches for an optimum object in a finite collection of objects. Typically, the collection has a concise representation (like a graph), while the number of objects is huge more precisely, grows exponentially in the size of the representation (like all matchings or all Hamiltonian circuits). So scanning all objects one by one, even for instances of very moderate size, and selecting the best one is not an option. More efficient methods should be found. In the framework of complexity theory, we want to find the optimum in polynomial time. Almost every combinatorial optimization problem has since been either proved to be polynomial-time solvable or NP-complete. In this lecture, we study some of those combinatorial optimization problems that have been proved to be solvable in polynomial time, means, belong to P. Next to polynomial-time solvability, we focus on the related polyhedral and the fundamental combinatorial optimization algorithms by which these problems have been solved successfully.

Esteban Salgado

New heuristics for ground state optimization of spin glasses

Abstract. Max-cut is the problem of finding, in a graph, a partition of the node-set such that the sum of the weights of the edges with endpoints in both sets of the partition is maximal. This problem has a variety of applications in several domains (e.g. statistical physics, VLSI design, quantum computing) and is widely known to be NP-hard, therefore heuristics and metaheuristics have been conceived to provide fast and "good" solutions. In this context we present a general subgraph sampling based heuristic with results that are comparable to approaches ad-hoc for some particular classes of graphs.

Giuseppe Stecca

Talk 1: Green Supply Chain Management

Climate change is the most though challenge for humanity, requiring a paradigm shift in the planning and operation of almost all the human activities. In these settings Green Supply Chain Management consider the relations between supply-chain management and the green targets.

This talk will survey the main operations research models used to address green supply chain problems both at strategic, tactical and operational level. Problems related to reverse logistics, product recovery, closed loop supply chain and green supply chain management are addressed. The "green" word, introduces problems related to complexities such as the integration between strategical and tactical phase, but also the problem on how to account the CO2 emission and how to consider it in a mixed integer linear program.

Talk 2: Negotiation based approach for collecting and recycling operations in circular economy

Abstract: Circular economy and zero waste paradigms consider that production and logistics processes must meet new levels of efficiency. In this work we address the problem of optimal planning of the collection and the recycling operations for a company operating recycling plants which process waste materials and sells “secondary” raw materials. The recycling is performed in a multi-stage process and the collection is performed via trucks. The output of the collection process is the input of the recycling planning operations. Moreover some operations are outsourced to third party operators. The problem is modeled as an optimization problem and solved with an auction based mechanism.

Paolo Ventura

Talk 1: Exact and heuristic approaches to the logistics of containers (I)

Talk 2: Exact and heuristic approaches to the logistics of containers (II)

Abstract. Over the past 20 years, the number of containers handled around the world has more than doubled and approximately 170 million TEU were transported only in 2020. In order to manage the associated logistic operations, the ports contain special areas, called terminals, that act as storage and inter-modal exchange buffers for the containers that travel by ships, trains or trucks. For limited capacity reasons, in such terminals the containers are generally stacked one on top of the other and moved from one stack to the other by cranes (usually, gantry cranes on wheels). Each crane is able to move around the terminal and place / pick up a single container from / on top of a stack. Each of these operations has a non-negligible operating cost. When a certain container is retrieved from the terminal, all the containers that are placed above it must be moved to some other stacks of the terminal. Such moves are also called reshuffles. An efficient management of these relocation operations is essential for the overall operational efficiency of the terminal. The problem of defining container relocation strategies that minimize the total number of reshuffles is known in the literature as the Container (or Block) Relocation Problem (CRP). Given the importance of its practical applications, the CRP, in its different variants, has been the subject of numerous scientific publications, especially in the last decade. Dozens of mathematical models and algorithms have been proposed. In fact, this growing attention of the scientific community corresponds to an insistent request of the logistics operators for tools and methods that can support their decisions.

Here we will give an overview of different variants of the problem as well as on the solution approaches that have been proposed in the literature.