Multi-Objective Covering Location Problems with advanced connectivity features and zonal requirements: Exact and Matheuristic approaches

Time: 11:30

Serena Fugaro (Institute for Applications of Calculus “Mauro Picone” – National Research Council of Italy), Sgalambro Antonino

Real-world facility location problems often demand to tackle simultaneously zonal requirements and facility interconnection issues; these may arise from administrative, managerial and operational needs, aiming to ensure an equal distribution of services, while concurrently securing an efficient flow of
goods, people or information among the located facilities. As the literature appears rather limited at addressing this challenge, in this work we bridge such a gap by exploring the integration of the Maximal Covering Location Problem with spatial-related requirements and advanced connectivity features. We adopt a broad modeling perspective, accounting for structural and economic aspects of connectivity attributes in facility location, while allowing for the choice of one or more depots to serve and feed the networks of located facilities, and containing the maximal distance between any located facility and such depots. The resulting mathematical models find straightforward applications, among other fields, in Healthcare Management, allowing for instance to optimally design large scale vaccination campaigns or to efficiently set-up mass screening procedures, e.g. during the response to a pandemic. Under the above mentioned modeling assumptions, the objectives to be fulfilled result multiple and inherently conflicting in nature, thus reflecting the increased managerial complexity of the related problems. In order to enhance decision-making in this scenario, we introduce a novel class of Multi-objective Covering Location problems, prove their NP-hard computational complexity, and devise original Mixed Integer Linear Programming models for their mathematical formulations. As a first contribution to the solution process we adapt the robust version of the AUGMEnted epsilon-CONstraint generation method (AUGMECON-R) [1] as an efficient framework to explore the corresponding Pareto Sets. As a second contribution we exploit the mathematical properties of the introduced problems to design a Matheuristic algorithm which is integrated within the AUGMECON-R scheme to allow scalability of the solution method, with particular reference to the case of multiple depots. We conduct a comprehensive computational study on benchmark instances adapted from the extant literature on Location Problems with interconnected facilities and Clustered Shortest Path Problems. The numerical experiments provide a proof of concept of the proposed models and highlight the challenging nature of the advanced
connectivity features, particularly in presence of multiple depots. Both the Exact and the Matheuristic approaches provide a rich and articulate approximation of the relevant Pareto Sets for medium sized problems, while the Matheuristic shows a highly scalable performance when tackling large sized instances and multiple depot configurations.


Multi-objective design-for-control of water networks with global bounds

Time: 11:50

Aly-Joy Ulusoy (Imperial College London), Pecci Filippo, Stoianov Ivan

The optimal design and operation of water distribution networks (WDN) requires the consideration of conflicting operational objectives. In particular, this study investigates the problem of simultaneously optimizing the placement of new links (pipes or pressure control valves) and valve control settings, for the joint maximization of WDN resilience and the minimization of pressure-induced leakage. We investigate global methods for the solution of the resulting design-for-control problem, which belongs to the challenging class of bi-objective mixed-integer non-linear programs (MINLP) with non-convex constraints. Recently, multi-objective branch-and-bound methods have been proposed to compute outer approximations of the efficient and/or non-dominated sets of a wide range of multi-objective optimization problems, including convex MINLPs (De Santis et al., 2019), continuous NLPs with non-convex
objective functions (Niebling & Eichfelder, 2019) and non-convex multi-objective MINLPs (Eichfelder et al., 2022). Following the general framework presented by (Eichfelder et al., 2022), we develop a bi-objective branch-and-bound algorithm based on tailored branching rules, discarding tests and upper and lower bounding procedures to approximate the non-dominated set of the WDN design-for-control problem with guarantees of global non-dominance. We evaluate the proposed bi-objective branch-and-bound algorithm on case study networks with different sizes and levels of connectivity and show that it outperforms previously investigated scalarization-based methods (Ulusoy et al., 2021).


An interior point method for nonlinear constrained derivative-
In this paper we consider constrained optimization problems where both the objective and constraint functions are of the black-box type. Furthermore, we assume that the nonlinear inequality constraints are non-relaxable, i.e. their values and that of the objective function cannot be computed outside of the feasible region. This situation happens frequently in practice especially in the black-box setting where function values are typically computed by means of complex simulation programs which may fail to execute if the considered point is outside of the feasible region. For such problems, we propose a new derivative-free optimization method which is based on the use of a merit function that handles inequality constraints by means of a log-barrier approach and equality constraints by means of a quadratic penalty approach. We prove convergence of the proposed method to KKT stationary points of the problem under quite mild assumptions. Furthermore, we also carry out a preliminary numerical experience on standard test problems and comparison with a state-of-the-art solver which shows efficiency of the proposed method.