Solution algorithms for decision-dependent adjustable robust optimization

- **Topic:** Optimization under uncertainty, Mathematical Programming, Network flows
- **Location:** Institut de Mathematiques de Bordeaux (IMB), Talence (Bordeaux)
- **Supervision:**

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  Co-supervisor Boris Detienne[2], boris.detienne@math.u-bordeaux.fr

- **Profile:** Second-year master's or third-year engineering student in Operations Research or related fields

  Required skills:

  Mixed-integer linear programming

  C++, Python, Julia or similar programming language

  Knowledge in decomposition methods in MILP and optimization under uncertainty approaches is appreciated

About these offers

Team EDGE of Inria-Bordeaux proposes two six-month research internships at the Mathematics Institute of Bordeaux (IMB). The positions are proposed as part of the ANR (French National Research Agency) project DDROP and ANR PEPR TASE project PowDev, which concern the study of certain types of robust optimization problems and their applications and **can lead to PhD positions within the same projects**.

Team EDGE is a very active team with five permanent members working around operations research and optimization with a special focus on decomposition approaches in mixed-integer programming as well as optimization under uncertainty approaches. Further information about our research activities and industrial collaborations can be found on our webpage[3].

Scientific context

Robust optimization is now a very popular paradigm for considering uncertain parameters in the optimization context. The classical robust optimization paradigm assumes that the uncertain parameters lie within a known uncertainty set and seeks a solution that performs best with respect to the worst-case parameter realizations within this set. This paradigm is particularly appropriate in applications where risks related to uncertain parameters need to be minimized, such as in resilient network design and disaster management. Robust

[1] https://edge.gitlabpages.inria.fr/team-members/arslan/
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[3] https://edge.gitlabpages.inria.fr/

optimization problems in which all decisions should be made here-and-now before observing the uncertain parameters, known as static robust optimization, are now ubiquitous and well-studied in the literature.

The robust optimization paradigm can also be extended to delay certain decisions until the realization of uncertain parameters can be observed. In that case, we talk about adjustable robust optimization. For instance, in disaster management, it is desirable to decide the location of supply warehouses and stock these warehouses with necessary materials in anticipation of possible disasters while distribution of such materials should be made only when a disaster strikes and information about affected areas is available. Adjustable robust optimization models are theoretically more challenging to solve compared to their static counterparts, but significant progress has been made in their exact and approximate solution in recent years.

Project DDROP[4] aims to take interactions between the decision-maker and uncertain parameters into account within static and adjustable robust optimization models. These interactions may take the form of controlling uncertain parameters or querying them through investments, known as information discovery. Taking such interactions into account is essential in many applications: for instance, in kidney exchange programs, medical tests can be performed before constructing a solution, allowing for the reduction of the effects of uncertainty, whereas in network design, future exploitation of the network by the users may directly depend on constructed links and their respective capacities. Decision-dependent uncertainty can also be a promising modeling tool to address approximate solution of adjustable robust optimization problems. The numerical solution of the resulting mathematical models is challenging and not well-studied in the literature. As such, one of the principal objectives of this project will be to study such models and develop appropriate solution algorithms.

Project PowDev[5] aims to evaluate and optimize the resilience of electrical systems in response to extreme climate events and the large-scale integration of renewable energy, considering socio-economic factors. The goal is to minimize the impacts of cascading failures and enhance resilience through effective operational and design strategies. The project will approach such problems through the robust optimization paradigm with decision-dependent uncertainty. Exploiting the special structure of network flow problems will be key to the difficult task of designing numerically efficient algorithms to solve the resulting models.

Objectives

The goal of these internships and the associated PhD projects is to study the associated robust optimization problems from methodological and practical perspectives. This will involve mathematical formulations, algorithmic development, and numerical testing. Our tools will often fall under the mathematical programming paradigm, in particular, linear programming and decomposition methods in mixed-integer linear programming and convex optimization (Dantzig-Wolfe decomposition, Benders decomposition, Lagrangian relaxation, cutting plane algorithms. . .).

[4] https://edge.gitlabpages.inria.fr/projects/ddrop/
[5] https://www.pepr-tase.fr/projet/powdev/

Robust optimization problems with decision-dependent uncertainty have many diverse applications. Our developments will be tested with realistic optimization problems such as resilient network design and the kidney exchange problem. Developed methods will be compared to those existing in the literature both in terms of their numerical performance and the quality of the solutions they produce.