Centre de Mathématiques Appliquées

MINES ParisTech

Call for one Ph.D. Student Position at CMA

Nonconvex nonsmooth optimization methods for decision making under uncertainty

The importance of mathematical optimization in engineering and economics has been recognized for a long time. With the increasing demand for sustainable actions, the need to model real-life optimization problems as faithful as possible has become paramount for better use of natural resources, carbon footprint reduction, environmental impacts, market competitiveness, and higher reliability and profitability. Unfortunately, modelers often end up with a mathematical model fitting their preferences rather than a model representing the true nature of the underlying problem. It is thus not surprising that crucial strategic optimization problems are tackled via simplistic models, often based on unrealistic assumptions and sacrificing model fidelity for computational ease.

Modeling a given problem as truthfully as possible may imply characterizing nonconvexities of the objective and constraint functions and modeling possible random parameters impacting the decision-making process. In pursuing this endeavor of model fidelity, the advantage is that the original foundations of the model and the link to the original problem are clearly exposed. On the other hand, the underlying optimization model might be too complex to be solved by out-of-the-shelf solvers due to nonconvexities and a possible lack of smoothness. When nonconvexity and nonsmoothess appear together in problems of the form

$$\min_{x \in X} f(x) \quad \text{s.t.} \quad c(x) \le 0, \qquad (1)$$

with $\emptyset \neq X \subset \mathrm{R}^n$ a convex closed set, $f\colon \mathrm{R}^n \to \mathrm{R}$ and $c\colon \mathrm{R}^n \to \mathrm{R}^m$, finding a global solution with an optimality certificate is out of reach even for problems of moderate size. Computing stationary points becomes then the only achievable goal. However, for nonsmooth nonconvex optimization problems such as (1), several kinds of stationarity can be specified, depending on the structure of the objective f and constraints c, and subdifferential definitions (e.g., Bouligand, Clarke, Toland, regular, limiting, and others). Targeting points satisfying sharp stationary conditions increases the chance of finding a local solution. To this end, particular structures of the underlying optimization model must be exploited to design effective algorithms.

The proposed Thesis aims to develop new (and extend known) optimization methods with guaranteed convergence (to stationary points) for tackling certain optimization models fitting the general formulation (1). In particular, a great deal of effort will be dedicated to optimization problems modeling real-life decision-making under uncertainty. For instance, the objective in (1) might be the expectation/risk function of random nonconvex costs (i.e., stochastic programming with recourse), or the constraints can be (approximations of) challenging probabilistic functions (i.e., chance-constrained programming).

Duration of the Thesis: 3 years, ideally starting in November 2022 or as soon as possible thereafter.

PhD adviser: Welington de Oliveira, HdR. Web-page: www.oliveira.mat.br

Institution: [**École Nationale Supérieure des Mines de Paris - Mines Paris PSL**]

MINES Paris - PSL is a *Grande Ecole* centered on its research activities. With over 230 years of history for the Graduate School, 1281 students, 18 research centers, 286 talented research professors, Mines Paris PSL ranks top among the *Grandes Ecoles* for the volume of contractual research.

Laboratory: [**Centre de Mathématiques Appliquées - CMA**]

The CMA develops an original scientific approach through its fundamental competencies in modeling, mathematics of control and decision-making, and real-time computing in order to tackle increasingly complex systems. Over the last decade, the CMA has focused most of its activities on energy and climate. In this context, the CMA's control and decision-making mathematics offer a range of innovative approaches that are effective in analyzing complex systems specifically connected to climate issues (e.g., technologies, carbon, energy, water, rarefaction of materials). The CMA also applies this approach to investigate the maturity of electricity and carbon markets and deal with the issues of deploying electrical systems integrating renewable energy and smart grid technologies.

The CMA is located at Sophia Antipolis, in the French Riviera, and is 10 Km away from Antibes, 12 Km from Cannes, and 20 Km from Nice.

Candidate profile: The candidate must hold an MSc. degree in mathematics, statistics, engineering, or computer science and demonstrate a strong interest in mathematical programming. She or he must have

1. a background in convex analysis and nonlinear optimization;
2. good programming skills in one of the following programming languages: Matlab, Python, Julia, or C++;
3. excellent communication skills (written and spoken) in English

Application process: Interested candidates are invited to send

- detailed CV
- motivation Letter
- two names of referees

by e-mail to Welington de Oliveira (welington.oliveira@minesparis.psl.eu).
Applications received by the end of May 2022 will receive full consideration.

References

1. A.M. Bagirov, M. Gaudioso, N. Karmitsa, M.M. Makela, S. Taheri, **Numerical Nonsmooth Optimization: State of the Art Algorithms**, Operations Research Mathematical Programming, Springer 2020
2. Y. Cui and J-S.Pang, **Modern Nonconvex Nondifferentiable Optimization**, MOS-SIAM Series on Optimization, 2021
3. M. Cordova, W. de Oliveira, C. Sagastizábal, **Revisiting Augmented Lagrangian Duals.** Mathematical Programming, 2021.
4. W. Hare, C. Sagastizábal, M. Solodov, **A proximal bundle method for nonsmooth nonconvex functions with inexact information**. *Computational Optimization and Applications,* 2016
5. W. de Oliveira, **Risk-averse stochastic programming and distributionally robust optimization via operator splitting.** Set-Valued and Variational Analysis, 2021.
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