

INTERNATIONAL RELATIONS



INTERNSHIP SUBJECT

2882 - Matrix-Theoretic Approaches for Two-Stage Stochastic Optimization

Research Topic

Optimization plays a central role in decision-making in industrial contexts, where uncertainty poses significant challenges. Many problems in this domain are modeled as stochastic programs, which, when solved, produce decisions that mitigate the uncertainty involved in decision-making [1]. The research proposed in this internship focuses on so-called two-stage stochastic linear programs. Typically, these assume a finite representation of uncertainty represented as a discrete set of scenarios capturing historical or estimated realizations of uncertain parameters. However, the computational complexity of solving such programs increases with the number of scenarios, rendering large-scale problems intractable. This phenomenon is known as the curse of dimensionality [1]. To overcome this, scenario clustering methods have a lot of attention in the stochastic programming literature. These group similar scenarios to construct reduced models that preserve the original scenario set's essential information [3, 7].

Although these approaches reduce computational complexity, they often lack guarantees regarding the quality of the solution obtained relative to the original problem [4, 5]. To address these challenges, researchers have developed integrated approaches that combine clustering with optimization techniques [8, 6]. However, the literature reveals two major gaps: (1) there is no unified mathematical description of scenario clustering methods, and (2) existing integrated approaches often focus on specific stochastic optimization problems or require restrictive assumptions on the uncertain parameters that drive the decision making.

This internship aims to explore a new perspective on scenario clustering using matrix-theoretic tools. By leveraging these tools, we aim to unify existing clustering methods and study their impact on optimization models. Additionally, this perspective will enable the development of novel computational approaches that integrate clustering and optimization, with broad applicability to generic two-stage stochastic programs. The intern will investigate the mathematical structure of clustering matrices and their role in constructing inner and outer approximations of stochastic models. This work will address fundamental research questions, such as the design of efficient clustering methods, their impact on computational tractability, and their influence on solution quality.

References


1. John R Birge and Francois Louveaux. Introduction to stochastic programming. Springer Science & Business Media, 2011.
2. Steven L Brunton and J Nathan Kutz. Data-driven science and engineering: Machine learning, dynamical systems, and control. Cambridge University Press, 2022.
3. Holger Heitsch and Werner Römisch. "Scenario reduction algorithms in stochastic programming". In: Computational Optimization and Applications 24 (2003), pp. 187–206. doi: 10.1023/A:1021805924152.
4. Julien Keutchanian, Janosch Ortmann, and Walter Rei. "Problem-driven scenario clustering in stochastic optimization". In: Computational Management Science 20.1 (2023), p. 13. doi: 10.1007/s10287-023-00446-2.
5. Juan M Morales et al. "Scenario reduction for futures market trading in electricity markets". In: IEEE Transactions on Power Systems 24.2 (2009), pp. 878–888. doi: 10.1109/TPWRS.2009.2016072.
6. Cristian Ramirez-Pico and Eduardo Moreno. "Generalized adaptive partition-based method for two-stage stochastic linear programs with fixed recourse". In: Mathematical Programming 196.1-2 (2022), pp. 755–774. doi: 10.1007/s10107-020-01609-8.
7. Napat Rujeeapaiboon et al. "Scenario reduction revisited: Fundamental limits and guarantees". In: Mathematical Programming 191.1 (2022), pp. 207–242. doi: 10.1007/s10107-018-1269-1.
8. Yongjia Song and James Luedtke. "An adaptive partition-based approach for solving two-stage stochastic programs with fixed recourse". In: SIAM Journal on Optimization 25.3 (2015), pp. 1344–1367. doi: 10.1137/140967337.

Required Skills

The selected intern should have a solid background in mathematics, particularly in mixed-integer linear optimization. Strong programming skills are required. Experience with Mixed-Integer Programming solvers and Scikit-learn is also required. Familiarity with stochastic programming and matrix theory is a plus.

General Information

- **Research Theme :** Optimization, machine learning and statistical methods
- **Locality :** Villeneuve d'Ascq
- **Level :** PhD
- **Period :** 1st February 2026 -> 30th April 2026 (3 months)

 *These are approximative dates. Please contact the training supervisor to know the precise period.*

- **Deadline to apply :** 1st July 2025 (midnight)

Contacts

- **Training Supervisor :** Jacques-marius Roland / jacques-marius.roland@inria.fr
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More information

- **Inria Team :** INOCS
- **Inria Center :** Centre Inria de l'Université de Lille

