Handling uncertainty in extensive-form Games

1 Context

The overall objective of EAGPLAN project, headed by Orange labs, is to design and implement efficient algorithms for computing optimal solutions that will enable to derive recommendations on the best actions that a telecommunication operator can undertake for multiperiod network planning in competitive landscape, considering the actions of the other operators. The project builds on research carried out in [2, 3] that addressed this problem through the lens of extensive-form Games. The findings highlighted the effectiveness of combining tools and methodologies from Graph Theory, Mathematical Programming and Dynamic Programming to compute the outcomes of pure Nash equilibria in extensive-form games. Building upon these promising perspectives, we will propose algorithms to 1) tackle challenging problems arising from multiperiod deployment and decommissioning of network technologies in a competitive environment, while also accounting for uncertainties related to competitors, such as their payoffs values or order of actions and 2) provide solutions that will be used by an operator to derive strategic planning of the actions (for example deployment or decommissioning) necessary to develop its network. We aim at integrating the resulting algorithms in an open source demonstrator for solving game theory problems. This demonstrator will also provide a realistic and large size extensive-form game instances generator that can be used for benchmarking and validation purpose in the scientific community.
PhD: The internship can possibly be pursed by a PhD, depending on the outcome of the internship.

2 Objectives of the internship

Practical games suffer from uncertainty regarding the parameters in their definition. The first source of uncertainty is related to the payoff function that is used to compare the different players' outcomes, as it is often difficult or even impossible to have its exact value. The first purpose of this internship will be to address this uncertainty through the lens of robust optimization, assuming the possible utilities belong to a given set U. In this setting, we will apply the concept of the Aghassi and Bertsimas [1] to game under extensive-form by considering *worst-case best responses* over the uncertainty set U. We shall study how to extend the two algorithms proposed in [2, 3] to the robust setting.
Details: The work will be carried out in the Laboratoire d'Informatique, de Robotique et de Microélectronique de Montpellier (LIRMM), with Michaël Poss as principal advisor (poss@lirmm.fr).

3 Required skills

The recruited students must have knowledge in Integer Programming, Combinatorial Optimization. Knowledge of Game Theory and Robust Optimization would be a plus.

4 Application procedure

Please send to Michaël Poss your application, with the subject "Application for EAGPLAN Position", containing the following items: (i) a cover letter written specifically for the topic, outlining their research interests and relevant experience, (ii) a detailed CV, (iii) academic transcripts (including Bachelor & Master's/Engineering courses and rankings), and (iv) up to two reference letters from individuals who have supervised or worked closely with the applicant.

References

[1] Michele Aghassi and Dimitris Bertsimas. Robust game theory. *Mathematical programming*, 107(1):231–273, 2006.

[2] Paolo Zappalà, Amal Benhamiche, Matthieu Chardy, Francesco De Pellegrini, and Rosa Figueiredo. Analysis and computation of the outcomes of pure nash equilibria in two-player extensive-form games. *Dynamic Games and Applications*, pages 1–34, 2024.

[3] Paolo Zappalà, Amal Benhamiche, Matthieu Chardy, Francesco De Pellegrini, and Rosa Figueiredo. Extension of backward induction for the enumeration of pure nash equilibria outcomes. *Operations Research Letters*, page 107305, 2025.