Offer #2026-10556

Gray-Box Tunneling for Multi-Objective Combinatorial Optimization

Contract type : Internship

Level of qualifications required : Master's or equivalent

Fonction : Internship Research

About the research centre or Inria department

Created in 2008, the Inria center at the University of Lille employs 360 people, including 305 scientists in 16 research teams. Recognized for its strong involvement in the socio-economic development of the Hauts-De-France region, the Inria center at the University of Lille maintains a close relationship with large companies and SMEs. By fostering synergies between researchers and industry, Inria contributes to the transfer of skills and expertise in the field of digital technologies, and provides access to the best of European and international research for the benefit of innovation and businesses, particularly in the region.

For over 10 years, the Inria center at the University of Lille has been at the heart of Lille's university and scientific ecosystem, as well as at the heart of Frenchtech, with a technology showroom based on avenue de Bretagne in Lille, on the EuraTechnologies site of economic excellence dedicated to information and communication technologies (ICT).

Assignment

Multi-objective combinatorial optimization aims at simultaneously optimizing several, potentially conflicting, objective functions over a discrete decision space. In many combinatorial optimization problems, objective functions exhibit a **gray-box structure**, e.g., they can be decomposed into sub-functions involving only a restricted number of decision variables. Such structure can be exploited to design specialized and computationally efficient optimization algorithms.

For example, for many binary optimization problems, objective functions can be represented using a bounded-degree **Walsh/Fourrier transform**, providing a natural framework for analyzing and exploiting variable interactions. Other combinatorial problem representations may also be considered, provided that they expose a suitable structure that can be leveraged by specialized gray-box evolutionary and search operators.

While gray-box optimization has received increasing attention in the single-objective setting, the study of gray-box multi-objective optimization remains largely unexplored. This internship aims to contribute to this emerging research direction by **developing new algorithmic approaches for efficiently navigating the landscape of multi-objective combinatorial optimization problems**.

A particular focus will be placed on **Pareto Local Optima (PLOs)**. PLOs generalize the notion of local optima to the multi-objective setting by considering the dominance relation. **The general objective of the internship is to develop new tunneling mechanisms** that allow optimization algorithms to efficiently navigate between PLO solutions, potentially enabling the discovery of high-quality regions of the Pareto set that are difficult to reach through conventional local search.

Depending on the candidate's background and interests, the work may involve theoretical analysis, algorithm design, experimental evaluation, or a combination of these aspects.

Main activities

The internship may focus on one or more of the following research directions:

1. **Analyzing Pareto Local Optima under tunneling mechanisms such as partition crossover**. Study the structure and properties of Pareto Local Optima (PLOs) that can be exploited by partition crossover and related gray-box operators.
2. **Designing new multi-objective tunneling mechanisms**. Develop and investigate partition-crossover-based mechanisms to efficiently move between PLOs, with a particular focus on (i) decomposition-based multi-objective optimization and cooperation between neighboring subproblems and/or (ii) Dominance based techniques.
3. **Integrating tunneling into (HPC-)accelerated multi-objective search algorithms**. Incorporate partition crossover and related tunneling mechanisms into specialized evolutionary and local-search algorithms, especially by exploiting parallel and high-performance computing to accelerate the search.

Consequently, the internship may involve:

- reviewing the literature on gray-box optimization, multi-objective optimization, local search, and Pareto Local Optima
- analyzing existing gray-box optimization algorithms
- conducting theoretical or empirical analyses of fitness landscapes and PLO structures
- designing new tunneling operators and search mechanisms
- implementing and experimentally evaluating new optimization algorithms
- designing computational experiments and analyzing algorithmic performance
- exploiting parallel and HPC computing when relevant
- contributing to scientific publications and/or research software.

The internship is intended as a **research-oriented project**, and the research questions and methodology will be refined continously according to the results obtained during the internship.

Skills

A strong interest in conducting **fundamental research** and exploring open-ended applied algorithmic questions is particularly welcome. **Good programming skills** are expected.

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking (after 6 months of employment) and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

Remuneration

According to current regulations: €4.50 per hour

General Information

- **Theme/Domain :** Optimization, machine learning and statistical methods
- **Town/city :** Villeneuve d'Ascq
- **Inria Center :** Centre Inria de l'Université de Lille
- **Starting date :** 2027-03-01
- **Duration of contract :** 6 months
- **Deadline to apply :** 2026-12-31

Contacts

- **Inria Team :** BONUS
- **Recruiter :**
  Derbel Bilel / Bilel.Derbel@inria.fr

About Inria

Inria, the French national institute for research in digital science and technology, supports the French government in national research and innovation strategies in

the digital field, acting as Digital Programs Agency. Inria leads over 300 research and innovation projects with its 3,500 scientists, engineers, and support staff, in partnership with universities and the digital ecosystem (businesses, entrepreneurs, and public stakeholders). Together, we explore strategic fields such as artificial intelligence, cybersecurity, quantum computing, cloud technologies, digital transformation in healthcare, digital twins, and digital technologies for defence. We develop practical solutions such as software, tech startups, partnerships with national companies, and cutting-edge training programmes. Our goal is to drive scientific, technological, and industrial excellence to ensure France's digital sovereignty.

The keys to success

The internship will involve both **fundamental and applied research** in gray-box multi-objective optimization. The candidate will have the opportunity to work on open research problems, contribute to the development of new optimization algorithms, and potentially contribute to scientific publications resulting from the work.

Warning : you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

Instruction to apply

Please submit your CV and your cover letter

Defence Security :
This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST).Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :
As part of its diversity policy, all Inria positions are accessible to people with disabilities.