Offer #2025-08891

PhD Position F/M Large-scale graybox tunneling for multi-objective optimization

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

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 15 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).

Context

This PhD project will take place within the framework of the ANR PRCI TunnelOPT in collaboration with Colorado State University, USA.

Assignment

This PhD project aims at investigate new graybox tunneling techniques for multi-objective optimization (MO) problems. More specifically, we will consider combinatorial optimization problems where multiple objective functions are to be optimized simultaneously. Importantly, we consider graybox objective functions. This typically includes objective functions that can be linearly decomposed into sub-functions depending on a restricted number of variables. Other combinatorial problems could also be considered as far as they allow us to investigate and to apply specialized graybox evolutionary and search operators to design efficient solving mechanisms. The literature on graybox MO is in fact very limited and new state-of-the-art approaches are needed. Our general goal is then to develop new algorithmic tools to efficiently tunnel between Pareto Local Optima (PLO) solutions. By tunneling, we mean the design of new search techniques allowing us to efficiently navigate the space of PLO solutions. PLO solutions generalize the concept of LO using the dominance relation. Besides, we will consider the well-established MO decomposition concept as a natural approach to leverage existing single-objective techniques, and also those borrowed from the existing theory. Consistently with the three general tasks described below, **this PhD project will conduct fundamental research on graybox multi-objective optimization. Three key achievements are expected: (i) to understand the structure of PLOs under graybox tunneling, (ii) to design new tunneling mechanisms based on decomposition, and (iii) to smartly integrate tunneling into specialized MO search processes**.

Main activities

The PhD project is organized into three task as described in the following.

Task 1. (M01?M06) Understanding the structure of Pareto Local Optima under tunneling. This task aims at conducting theoretical and empirical investigations, to discover and to inform about the structure of PLO solutions under graybox tunneling. At the theoretical level, we conjecture that in the MO setting too, PLOs organize into particular lattices. Firstly, we will consider applying graybox recombination to some input PLOs. This relatively simple setting undergoes a number of fundamental and challenging research questions. Secondly, connectivity of PLOs under tunneling can be modeled using a (hyper-)graph object by leveraging existing models and enabling in-depth empirical investigations on the PLOs connectivity structure.

Task 2. (M07?M18). **Designing new decomposition-based MO tunneling mechanisms.** This task takes inspiration from the well-established class of decomposition-based MO in order to design new tunneling mechanisms. In fact, a MO problem can be solved by decomposing it into a number of N single-objective problems. We will then study the idea of cooperative tunnellings, by mixing and recombining the local optima obtained for different neighboring subproblems. In other words, we aim at tunneling between (single-objective) subproblems and transferring the knowledge among them. The fundamental question is to elicit the structure under which different (single-objective) local optima with respect to

different (scalarized) subproblems obtained by decomposition, can organize in the objective space.

Task 3. (M19?M30) Integrating tunneling in a specialized MO search process. This task complements the two previous tasks, by integrating our findings into more sophisticated MO search processes. The tunneling mechanisms studied in Tasks 1 and 2 constitute the necessary building blocks for designing empowered MO algorithms. In the class of dominance-based MO algorithms, we will consider the generic framework of the well-established Pareto Local Search (PLS) algorithm as a natural candidate for integrating the tunneling mechanisms studied in Task 1. In the class of decomposition-based MO algorithms, we will consider the framework of well-established MOEA/D (Multi-objective Evolutionary Algorithm based on Decomposition) for integrating the tunneling mechanisms studied in Task 2. It is worth noting that these two generic algorithmic frameworks have several modern variants with a number of configurable components and parameters. Hence, the main challenge consists in the smart and efficient integration of tunneling within their respective algorithmic flow, including parallel or HPC accelerated algorithms.

Skills

Languages : English

Other valued appreciated : keen to learn new concept and to work in a competitive international research environment

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 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

General Information

- **Theme/Domain :** Optimization, machine learning and statistical methods Scientific computing (BAP E)
- **Town/city :** Villeneuve d'Ascq

- **Inria Center :** Centre Inria de l'Université de Lille
- **Starting date :** 2025-09-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2025-06-06

Contacts

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

About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

The keys to success

We look for a highly motivated student with excellent background in applied math and/or computer science.

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

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.