Offer #2025-08705

PhD Position F/M Rare-event detection with local pattern modeling for large scale physical simulations

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

About the research centre or Inria department

The Inria Saclay-Île-de-France Research Centre was established in 2008. It has developed as part of the Saclay site in partnership with **Paris-Saclay University** and with the **Institut Polytechnique de Paris** .

The centre has **40 project teams**, 27 of which operate jointly with Paris-Saclay University and the Institut Polytechnique de Paris; Its activities occupy over 600 people, scientists and research and innovation support staff, including 44 different nationalities.

Context

This PhD focuses on developing novel unsupervised machine learning techniques for rare-event detection in large-scale physics simulations on high-performance computing (HPC) clusters. By leveraging in situ processing, the goal is to efficiently characterize local data distributions, identifying rare but meaningful events and anomalies while minimizing computational and communication overhead. The project will explore convolutional dictionary learning and hybrid unrolled models to enhance interpretability and scalability, with a strong emphasis on benchmarking and integration into real-world scientific applications. The research aims to contribute to machine learning for science by improving event detection

methodologies and fostering interdisciplinary collaborations.
The results of this thesis will be published in ML conferences as well as integrated into dedicated benchmarking packages such as benchopt, to improve the impact of the work and the quality of ML benchmarks.

Assignment

This project aims to provide guidelines to develop tools needed for efficient discovery of rare events and
anomalies. For the first year, indicative planning can be split into trimesters:
• First trimester: Bibliography and synthesis of existing practices for rare-event discovery. Study of basic methods
based on CDL reconstruction error.
• Second trimester: Derivation of a first algorithm to detect surprising events based on CDL. Definition of an
experimental protocol to evaluate the different methods.
• Third trimester: Theoretical and experimental evaluation of the proposed method on multiple benchmarks.
Particular care will be taken with the statistical validity of the results and the ease of use.
• Fourth trimester: Synthesis of the obtained results and redaction of a first conference paper on evaluating
confidence interval during a random search with reduced repetitions.

The second year will be aimed toward building hybrid unrolled model to characterize normal patterns and detect
anomalous reconstruction in novel signals. During the first trimester, the candidate will explore classical unrolling
techniques in line with the CDL-based approach studied during the first year. This work will serve as a basis in
the next 6 months to allow deriving a transformer-based architecture which will expand on capacity of our model to
characterize unseen signals. This will be applied to various existing benchmarks and the validity of the conclusion will
be evaluated on HPC simulation results. By the end of the second year, we expect the candidate would have published
a conference and a journal paper.

Main activities

Main activity: Conduct research on event detection models for physical signals.

Additional activity: Participate in the development of the team's open source software.

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

Remuneration

Gross salary : 2.200 euros/month

General Information

- **Theme/Domain :** Optimization, machine learning and statistical methods Scientific computing (BAP E)
- **Town/city :** Palaiseau
- **Inria Center :** Centre Inria de Saclay
- **Starting date :** 2025-04-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2025-04-30

Contacts

- **Inria Team :** MIND
- **PhD Supervisor :**
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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.

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.