Offre n°2024-07903

Post-Doctoral Research Visit F/M Event detection for Large-Scale Physical Simulations

Le descriptif de l’offre ci-dessous est en Anglais

Type de contrat : CDD
Niveau de diplôme exigé : Thèse ou équivalent
Fonction : Post-Doctorant

A propos du centre ou de la direction fonctionnelle

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 since 2021.

The centre has 39 project teams, 27 of which operate jointly with Paris-Saclay University and the Institut Polytechnique de Paris. Its activities occupy over 600 scientists and research and innovation support staff, including 54 different nationalities.

Contexte et atouts du poste

While artificial intelligence is growing at a fast pace, the bulk of the world's computing power remains targeted at modeling and predicting physical phenomena, such as climate models, weather forecasting, or nuclear physics. These simulations are run on highly parallel supercomputers on which both the hardware and the software are optimized for the task at hand. While the computing power of each processing unit is still increasing, the communication networks and the storage capabilities in these clusters do not follow such fast trends. As a result, computing nodes produce outputs faster than what can be stored or sent to process elsewhere: These simulations are IO-bound.

To reduce the communication burden, a promising venue is in situ computations, meaning that most of the data is processed locally by the nodes, and only meaningful aggregates are stored or sent over the network. However, this is a difficult problem in general since to detect meaningful information for the global simulation, one often needs to detect particular events, requiring non-local information that depends on the other nodes’ output. The goal of this postdoc is to leverage machine learning techniques to bypass IO bottlenecks in the context of physics simulation on high-performance computing (HPC) clusters and help steer them optimally. This work is thus placed in a broader "Machine Learning for Science" context, which aims at using ML to solve key problems arising in traditional sciences. More specifically, we will focus on distributed event detection techniques, which critically inform where the communication and storage budget needs to be spent to retain most of the information.

Environment. The postdoc will take place in Inria Saclay, in the MIND team. This is a large team working focused on mathematical methods for statistical modeling of brain function using neuroimaging data (fMRI, MEG, EEG). Particular topics of interest include machine learning techniques, numerical and parallel optimization, applications to human cognitive neuroscience, event detection, and scientific software development. A particular emphasis is put on interdisciplinary projects. The postdoc will include frequent interaction with Virginie Grandgirard and Julien Bigot, from the CEA, who are experts in the Gysela code, a fusion plasma simulation code used in the ITER project. The supervisors are dynamic researchers, with a strong track record in machine learning, HPC and physical simulation. This project also takes place in the PEPR NumPEX, an initiative to improve the use of supercomputers for physical simulations. The results from the postdoc will thus be integrated into the software stack for these applications. This position thus provides the unique opportunity to discuss with scientists from other fields and to improve their workflows through IA research. Interaction with scientists developing computational simulations in various fields will be encouraged.

Mission confiée

This postdoc intends to provide efficient statistical modeling tools for large distributed HPC outputs. The goal of these tools will be to help identify anomalies or errors in the data, which can indicate problems with the HPC system or the underlying algorithms. This information can then be used to adjust the
computations and ensure that the HPC system is running smoothly and efficiently. Moreover, statistical processing can also be used to analyze the outputs and detect events of interest to select the right snapshots of the simulation to allow post-processing of the results. By properly selecting the information to save, we can ensure that the HPC system is able to handle large volumes of output without running into storage or bandwidth limitations.

As specified above, the project will first focus on event and anomaly detection techniques for large scale simulation. The two main objectives are the following:

- **Benchmark existing methods**: This will require a thorough state-of-the-art review, as well as defining the relevant metrics for evaluating event detection in physics simulations (precision/recall, distance to the event, distribution of the events...). The benchmark will be realized with benchopt [5] and will benefit from the event detection expertise of the supervisors, and from their expert knowledge in the simulations.
- **Designing efficient implementation for existing methods**: To account for the structure of physics simulations, we propose to investigate how to efficiently leverage the distributed in-situ framework to efficiently leverage existing event detection methods [3, 4, 8, 1].
- **Looking for events with self-supervised learning**: Finally, the postdoc will consider developing novel unsupervised event detection algorithms, either based on recurring patterns for common events or based on anomaly detection for rare events. Methods based both on optimization—such as convolutional dictionary learning [2] and event modeling [9]—and on deep learning—such as self-supervised object detection [7]—will be considered.

These event detection methods will be evaluated on the previously defined benchmarks, to test their efficiency in highlighting known events. They will then be integrated into the in-situ framework to test their efficiency in a real-world setting. A strong emphasis will be put on the interpretability of the detected events, to ensure that the detected events are meaningful for the scientists. To fit the requirements imposed by the HPC setting, we will consider distributed methods, that work with streaming data split over many computing nodes. An important consideration in our context is that, unlike classical data stream, the data is not i.i.d. on the nodes, but stems from the domain partitioning imposed by the physic of the problem. These considerations will benefit from the supervisors expertise in distributed optimization, for instance from the DICODILE algorithm used to scale up dictionary learning [6].

### Principales activités

**Main activities :**

- Read papers and state of the art
- Benchmark existing algorithms
- Write problem formulation and proofs of convergence.
- Adapt the formulation to the target scenario.
- Propose a new dedicated algorithm.
- Program, run, and analyze simulation results.

**Complementary activities**

- Participate to the teams activities: scientific meetings, seminars, scientific presentations.

### Compétences

- Strong mathematical background. Knowledge in machine learning is a plus.
- Good programming skills in Python. Knowledge of a deep learning framework is a plus.
- The candidate should be proficient in English. Knowing French is not necessary, as daily communication in the team is mostly in English due to the strong international environment.

### Avantages

- 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

### Rémunération

2788 € gross/month

### Informations générales
Thème/Domaine : Calcul distribué et à haute performance
Statistiques (Big data) (BAP E)
Ville : Palaiseau
Centre Inria : Centre Inria de Saclay
Date de prise de fonction souhaitée : 2024-09-01
Durée de contrat : 2 ans
Date limite pour postuler : 2024-08-31

Contacts

- Équipe Inria : MIND
- Recruteur : Moreau Thomas / thomas.moreau@inria.fr

A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 215 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3900 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L’institut fait appel à de nombreux talents dans plus d’une quarantaine de métiers différents. 900 personnels d’appui à la recherche et à l’innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneuriaux qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 200 start-up. L’institut s’efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l’économie.

L’essentiel pour réussir

We seek candidates strongly motivated by challenging research topics in machine learning for science. Applicants should have a strong mathematical background with knowledge of numerical optimization and machine learning. With regards to software engineering, proficiency in Python is expected and experience in applying ML to large scale data is a plus.

Attention : Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.

Consignes pour postuler

- CV
- Cover letter
- Letter(s) of recommendation, where applicable

 Sécurité défense :
Ce poste est susceptible d’être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d'établissement, après avis ministériel favorable, tel que défini dans l'arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du recrutement.

Politique de recrutement :
Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.