2020-02374 - PhD Position F/M [AR] Ultra-scale Multidisciplinary Optimization of Aerospace Vehicles with a focus on Layout issues

Type de contrat : CDD
Niveau de diplôme exigé : Bac + 5 ou équivalent
Fonction : Doctorant

A propos du centre ou de la direction fonctionnelle

The Inria Lille - Nord Europe Research Centre was founded in 2008 and employs a staff of 360, including 300 scientists working in sixteen research teams. Recognised for its outstanding contribution to the socio-economic development of the Hauts-de-France region, the Inria Lille - Nord Europe Research Centre undertakes research in the field of computer science in collaboration with a range of academic, institutional and industrial partners.

The strategy of the Centre is to develop an internationally renowned centre of excellence with a significant impact on the City of Lille and its surrounding area. It works to achieve this by pursuing a range of ambitious research projects in such fields of computer science as the intelligence of data and adaptive software systems. Building on the synergies between research and industry, Inria is a major contributor to skills and technology transfer in the field of computer science.

Contexte et atouts du poste

Within the framework of a public partnership between Inria Lille - Nord Europe with the support of the Hauts-de-France region and ONERA, this PhD research proposal aims to define new methods adapted to the conceptual design phase in order to optimize the position of all on-board components inside or outside (e.g. engine nacelles) the outer mould line of a vehicle according to a number of objectives - e.g. mass distribution, compactness, inertia, etc. - while satisfying a number of constraints such as no overlapping between subsystems, functional compatibility and enforced proximity between components, etc.

Even though some work has been carried out on the optimal placement of internal components inside of an external shape [2], the handling of complex constraints such as functional and/or legal requirements is, however, currently not well treated in the open literature.

Over the course of this research study, the PhD candidate will first be encouraged to evaluate and combine various optimization methods that come from the field of multidisciplinary optimization, metamodelning and artificial intelligence and high-performance computing. Layout optimization is a challenging problem combining multi-objective optimization, numerous design variables and constraints and presence of discrete variables (e.g. number of components), that make even not well-suited the use traditional algorithms. After a first phase of evaluating the existing algorithms (e.g. particle swarm algorithms), the candidate will develop adapted algorithms in order to solve this problem and will connect it into the global design process of the aerospace concept.

On the other hand, given the targeted number of design variables, objectives and constraints (a few hundreds) the time complexity required to tackle effectively the problem is prohibitive making unavoidable massively parallel computing using ultra-scale supercomputers. On the road to the exascale era, these supercomputers are becoming more and more complex because they include up to millions of processing cores and heterogeneous devices including Graphics Processing Units (GPUs) and multi-core processors with various hardware designs. Such hardware complexity and scale make the parallel programming of these supercomputers tedious. Another major objective is to think the parallel design and implementation of the proposed optimization methods to deal with the challenging issues associated with these supercomputers mainly scalability, heterogeneity and complex programming targeting high-performance and productivity.

From the validation point of view, the simplified International Global Communication Satellite [3] will serve as a testbed and benchmark to aid in the development of new methods and their experimental validation. The internal subsystems of the telecommunication satellite will have to be correctly arranged in order to satisfy a number of design objectives (such as the location of its center of mass and its inertia tensor) while fulfilling a number of user-defined constraints (no overlapping, placement preferences, and so on). Extensive experiments will be conducted on the Grid5000 (funded via CPER Data and the future Comelia CPER) and the Jean-Zay national supercomputer (located at IDRIS (Paris)). As we usually do it, the outcome of the PhD thesis will be published in high-impact international journals and conferences.

Is regular travel foreseen for this post?

Travel expenses are covered within the limits of the scale in force by the two partners of the PhD thesis.

Mission confiée

Assignements :
With the help of the supervisors, the recruited person will be taken to go through the steps indicated below (main activities).

Bibliography:

ONERA, and particularly the Information Processing and Systems Department (DTIS), has a strong experience in the design of aerospace concepts. More specifically, the CEVA and MCCI teams have an expertise in the development of Multidisciplinary Design Optimization (MDO) techniques and application to a wide range of aerospace vehicles such as reusable launch vehicles, blended wing body, new generations of aircraft [6, 10, 11].

The BONUS team has an expertise in the modeling and mathematical formulation of the layout

Informations générales

• Thème/Domaine : Optimisation, apprentissage et méthodes statistiques
• Ville : Lille
• Centre Inria : LRI Lille - Nord Europe
• Date de prise de fonction souhaitée : 2020-10-01
• Durée de contrat : 3 ans
• Date limite pour postuler : 2020-04-23

Contacts

• Equipe Inria : BONUS
• Directeur de thèse : Melab Nouredine / Nouredine.Melab@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 200 équipes-agiles, en général communiquées avec des partenaires académiques, impliquent plus de 3500 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 entrepreneurs qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 180 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

The applicant should have the following skills:

• Cross-disciplinary knowledge and expertise in optimization, machine learning and parallel computing.
• Active about software development and innovation, especially in the area of aerospace design.
• Essential qualities in order to fullfil this assignment are feeling at ease in an environment of scientific dynamics and wanting to learn and listen.

Consignes pour postuler

CV, application letter, list of publications, one or more letters of recommendation and a short research statement.

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.
Avantages

Other valued appreciated: skills in parallel computing/programming and machine learning tools.

Relational skills:

Languages: Python, C++

Technical skills and level required: good (object-oriented) software development capabilities,

Compétences

Principal activities (5 maximum):

The PhD thesis will include four major steps summarized in the following:

- **TO à T0+6**: State-of-the-art on the major topics related to the thesis. The PhD student will investigate multi- and many-objective optimization with a particular interest to strongly constrained problems. A focus will also be put on the layout optimization problem of aerospace domains. Finally, the state-of-the-art will also include the different models for parallelization of multi-objective optimization considering different hardware architectures: multi-core processors, GPU accelerators, and hybrid clusters. Depending on his/her background the PhD student will have a training on multi-objective optimization considering different hardware architectures: multi-core processors, GPU accelerators, and hybrid clusters.

- **T0+6 à T0+12**: Multi-objective modeling of the strongly constrained layout optimization problem. Various mathematical formulations will be investigated.

- **T0+12 à T0+30**: Design and implementation of parallel multi-objective optimization approaches for the big layout optimization problem using large GPU-powered clusters. Different multi-objective and strongly constrained management methods will be explored. In addition, multi-level parallelization approaches will be considered.

- **T0+12 à T0+30**: Validation through extensive experimentation on the Grid'5000 testbed and Jean-Zay GPU-powered supercomputer considering as test cases at least the application of the optimization of convolutional neural networks to image classification.

- **T0+24 à T0+36**: PhD manuscript writing. Submission for review.

Additional activities (3 maximum):

- Write documentation for the code
- Write works' progress reports and present them to the partners to an audience of financiers
- Write publications and present them in international conferences

**Compétences**

Technical skills and level required: good (object-oriented) software development capabilities, modeling capabilities.

Languages: Python, C++

Relational skills: open minded, accept constructive criticism

Other valued appreciated: skills in parallel computing/programming and machine learning tools

**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 (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

Rémunération

1st and 2nd year : 1 982€ Gross monthly salary (before taxes)
3rd year : 2085€ gross monthly salary (before taxes)