Offer #2025-08574

PhD Position F/M Computational Bayesian optimal sensor placement for ocean models: a majorize-then-optimize strategy

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

About the research centre or Inria department

The Centre Inria de l'Université de Grenoble groups together almost 600 people in 23 research teams and 9 research support departments.

Staff is present on three campuses in Grenoble, in close collaboration with other research and higher education institutions (Université Grenoble Alpes, CNRS, CEA, INRAE, …), but also with key economic players in the area.

The Centre Inria de l'Université Grenoble Alpes is active in the fields of high-performance computing, verification and embedded systems, modeling of the environment at multiple levels, and data science and artificial intelligence. The center is a top-level scientific institute with an extensive network of international collaborations in Europe and the rest of the world.

Context

The PhD thesis will take place at the in the AIRSEA team (https://team.inria.fr/airsea/en/) of the Inria Centre at the University Grenoble Alpes.

Assignment

Where should one observe a given system in order to maximize knowledge about it? This question lies at the core of **optimal sensor placement** and is critical in numerous applications, especially in **ocean modeling**, where data acquisition can be costly (e.g., satellite observations, ocean buoys, underground drilling, etc.). While computational Bayesian optimal experimental design (BOED) is relatively straightforward for linear models with Gaussian priors, the challenge grows significantly with realistic operational models. These models are often nonlinear, exhibit non-Gaussian behaviors, and are computationally expensive to evaluate, making the BOED problem much more demanding from a computational perspective.

Recently, a gradient-based approach has been proposed to alleviate this computational burden [1]. The strategy behind this approach is to minimize a bound of the so-called Expected Information Gain (EIG), which is relatively easy to work with, rather than minimizing the EIG itself. In principle, this bound serves as a surrogate for the EIG which providing a computationally favorable way to guide the sensor placement. This is because the error-bound can be evaluated and optimized much more efficiently than the actual error, which requires numerous expensive numerical simulations of the numerical model.

The objective of this project is to address various numerical aspects associated with the gradient-based solution for the BOED problem. The project has three main goals:

1. Firstly, we seek to enhance our understanding of the majorize-then-minimize approach used in the gradient-based solution. We will achieve this by comparing the solutions obtained from the bound-based approach with those obtained from the conventional EIG-based approach. Ultimately, we hope to use the bound-based approach as a preconditioning step for the EIG-based solution to improve its accuracy.
2. Secondly, we will employ randomized linear algebra methods to accelerate the computation of the bound which, for realistic models, can still be quite expensive to compute. This will help to improve the computational efficiency of the gradient-based approach, making it more practical for large-scale systems.
3. Finally, we will address the challenge of incorporating physical constraints into the sensor placement problem. Specifically, we will investigate how to take into account the constraints (physical/technical/financial) on the way the system can be observed, in order to obtain more realistic and practical sensor placement solutions.

[1] Chen, Arnaud, Baptista, Zahm 2024. “Coupled Input-Output Dimension Reduction: Application to Goal-oriented Bayesian Experimental Design and Global Sensitivity Analysis”. arXiv preprint arXiv:2406.13425.

Main activities

Skills

This PhD project sits at the intersection of **high-performance computing, statistics, and machine learning**. Candidates should possess strong expertise in at least one of these fields and a motivation to rapidly develop complementary skills. The project involves both **practical implementations and theoretical developments**. Candidates should demonstrate experiences and skills in scientific creativity, writing, autonomy, oral communication, and a strong enthusiasm for teamwork.

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 (90 days / year) and flexible organization of working hours
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage under conditions

Remuneration

2200 euros gross salary /month

General Information

- **Theme/Domain :** Earth, Environmental and Energy Sciences
  Scientific computing (BAP E)
- **Town/city :** Montbonnot
- **Inria Center :** Centre Inria de l'Université Grenoble Alpes
- **Starting date :** 2025-10-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2025-04-30

Contacts

- **Inria Team :** AIRSEA
- **PhD Supervisor :**
  Zahm Olivier / olivier.zahm@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

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.