Offer #2024-08080

Inverse design of an optical power splitter using a global optimization method

Contract type : Internship agreement

Level of qualifications required : Graduate degree or equivalent

Other valued qualifications : Master in applied mathematics or scientific computing

Fonction : Internship Research

About the research centre or Inria department

The Inria center at Université Côte d'Azur includes 42 research teams and 9 support services. The center's staff (about 500 people) is made up of scientists of di?erent nationalities, engineers, technicians and administrative staff. The teams are mainly located on the university campuses of Sophia Antipolis and Nice as well as Montpellier, in close collaboration with research and higher education laboratories and establishments (Université Côte d'Azur, CNRS, INRAE, INSERM ...), but also with the regional economic players.

With a presence in the fields of computational neuroscience and biology, data science and modeling, software engineering and certification, as well as collaborative robotics, the Inria Centre at Université Côte d'Azur is a major player in terms of scientific excellence through its results and collaborations at both European and international levels.

Context

This internship project is part of a collaborative project between the Atlantis project-team from Inria Research Center at Université Côte d'Azur, Sophia Antipolis and Ansys Lumerical R&D, La Farlède.

Atlantis is a team from Inria Research Center at Université Côte d'Azur located in Sophia Antipolis. It gathers researchers in numerical mathematics and computational physics, with an interdisciplinariy focus. The team has developed a specific expertise in the efficient numerical modeling of propagation of electromagnetic wave in complex media with a strong emphasis on nanoscale light-matter interactions. Through the years, the Atlantis team has developed a strong expertise in the design, analysis and development of dedicated efficient numerical methods (based on high order accurate Discontinuous Galerkin finite elements methods). More recently, the team has also acquired a know-how of numerical optimization using various techniques, and a solid experience on high

performance computing practices (parallel numerical algorithms and parallelization strategies for large-scale problems). This materializes concretely through the DIOGENeS software suite [1] that has already proven its crucial efficiency in nanophotonics. DIOGENeS will be the corner stone to numerically address the various complex scenarios in this internship project.

Assignment

Photonic Integrated Circuits (PICs) are considered among the most promising approaches to ensure progress in computer technology. Their possible applications range from improving the performance and efficiency of modern AI accelerators to realizing solid state LIDAR detectors for autonomous driving. However, the design of large-scale PICs still lags the design process of electronic circuits and presents unique challenges.

The goal of our research is to improve photonic components by reducing their footprint, enhancing their performance, and improving their robustness against manufacturing variations. To do so, we develop and employ advanced simulation and optimization methods, such as inverse design and topology optimization.

Main activities

This internship project aims at realizing a preliminary (and preparatory) study prior to a more ambitious project that will be undertaken in the context of a Cifre PhD thesis between Ansys R&D and Inria. The internship will take place in the Atlantis project-team from Inria Center at Université Côte d'Azur in Sophia Antipolis. The overall objective will be to develop and assess an inverse design strategy leveraging a modern global optimization algorithm. Specifically, we want to implement the global optimization of a PIC device by combining the following approaches:

- A DGTD (Discontinuous Galerkin Time-Domain) Maxwell solver [1] to simulate a device and compute a specified figure-of-merit (FoM) for a given design;
- The EGO (Efficient Global Optimization) method, which is a statistical learning-based global optimization algorithm [2] belonging to the family of Bayesian optimization methods [3];
- A shape parameterization technique, which is compliant with the fact that the DGTD method makes use of an unstructured tetrahedral mesh for the simulations.

As an initial use case, we will optimize a symmetric Y-branch (50:50 optical splitter). This basic and well-studied device [4] requires a relatively low number of parameters (< 20) and is therefore well-suited for global optimization.

The individual software components mentioned above are already available in the DIOGENeS software suite developed by the Atlantis project-team. The internship focusses on the geometrical modeling and parametrization of the PIC device as well as the integration of the individual components. The results of the internship will be integrated in DIOGENeS.

[1] S. Lanteri, C. Scheid and J. Viquerat. *Analysis of a generalized dispersive model coupled to a DGTD method with application to nanophotonics*. SIAM Journal on Scientific Computing, Vol. 39, No. 3, pp. A831–A859 (2017)

[2] D. Jones. *Efficient global optimization of expensive black-box functions*. Journal of Global Optimization, Vol. 13, No. 4, pp. 455-492 (1998)

[3] R. Garnett. *Bayesian Optimization*. Cambridge University Press (2023)

[4] https://optics.ansys.com/hc/en-us/articles/360042305274-Inverse-design-of-y-branch

Skills

Technical skills and level required :

- Master or engineering degree in numerical mathematics or scientific computing
- Sound knowledge of numerical analysis for PDEs
- Basic knowledge of physiscs of electromagnetic wave propagation

Software development skills : Python and Fortran 2003

Relational skills : team worker (verbal communication, active listening, motivation and commitment)

Other valued appreciated : good level of spoken and written english

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
- Contribution to mutual insurance (subject to conditions)

Remuneration

Traineeship grant depending on attendance hours

General Information

- **Theme/Domain :** Numerical schemes and simulations
  Scientific computing (BAP E)
- **Town/city :** Sophia Antipolis
- **Inria Center :** Centre Inria d'Université Côte d'Azur
- **Starting date :** 2025-02-01
- **Duration of contract :** 6 months
- **Deadline to apply :** 2026-06-30

Contacts

- **Inria Team :** ATLANTIS
- **Recruiter :**
  Lanteri Stéphane / Stephane.Lanteri@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.

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.