2022-05151 - Post-Doctoral Research Visit F/M Advanced computational design of cascaded metadeflectors for an ultra-flat antenna system

Contract type : Fixed-term contract
Renewable contract : Oui
Level of qualifications required : PhD or equivalent
Fonction : Post-Doctoral Research Visit
Level of experience : From 3 to 5 years

About the research centre or Inria department

The Inria Université Côte d'Azur center counts 36 research teams as well as 7 support departments. The center's staff (about 500 people including 320 Inria employees) is made up of scientists of different nationalities (250 foreigners of 50 nationalities), engineers, technicians and administrative staff. 1/3 of the staff are civil servants, the others are contractual agents. The majority of the center's research teams are located in Sophia Antipolis and Nice in the Alpes-Maritimes. Four teams are based in Montpellier and two teams are hosted in Bologna in Italy and Athens. The Center is a founding member of Université Côte d'Azur and partner of the I-site MUSE supported by the University of Montpellier.

Context

The present postdoctoral project is part of a collaborative project between the Atlantis project-team from the Inria Research Center at Université Côte d'Azur, (2) Thales R&T in Palaiseau, France, which is the main multidisciplinary research center of Thales group, and one of the main world players in professional electronics (3) and Nanoe in Ballainvilliers, France, whcih is a SME (Small and Medium Entreprise) specialized in development and fabrication of innovative ceramic materials for the industries.

Atlantis is a joint project-team between Inria and the Jean-Alexandre Dieudonné Mathematics Laboratory at Université Côte d'Azur. The team gathers applied mathematicians and computational scientists who are collaboratively undertaking research activities aiming at the design, analysis, development and application of innovative numerical methods for systems of partial differential equations (PDEs) modelling nanoscale light-matter interaction problems. In this context, the team is developing the DIOGENeS [https://diogenes.inria.fr/] software suite, which implements several Discontinuous Galerkin (DG) type methods tailored to the systems of time- and frequency-domain Maxwell equations possibly coupled to differential equations modeling the behaviour of propagation media at optical frequencies. DIOGENeS is a unique numerical framework leveraging the capabilities of DG techniques for the simulation of multiscale problems relevant to nanophotonics and nanoplasmonics.

Assignment

Enabling the Internet accessibility in mobility, in particular on board of public land and air transport (trains, buses, airliners), as well as the access to secure communication servers (for combat aircraft or military vehicles, etc.)requires the development of agile, ultra-flat and low-cost Ka-band antennas. Nonetheless, meeting the targeted performance while ensuring a low-profile and cost-effective antenna is a major challenge. To address it, the antenna architecture proposed in this project consists of a planar radiating panel associated with two compact deflectors, whose rotation ensures the beam-steering capacity. Moreover, the compactness and the moderate cost of the deflectors can be obtained thanks to the subwavelength structuration of a dielectric matter by usingadditive manufacturing. Indeed, the sub-wavelength patterning technique has recently shown the possibility to realize antenna components much thinner than their homogeneous bulk counterparts, with equivalent or even better radiofrequency performance.

In this context, the general objective of the present postdoctoral project is to develop an advanced numerical methodology for the virtual design of subwavelength structured deflectors and their cascading to achieve an ultra-flat Ka-band antenna system composed of two such metadeflectors. For this purpose, we will rely on recent achievements in our Inria team for the design of optical metasurfaces. More precisely, in [3] we have proposed and demonstrated an inverse design methodology that combines a high order finite element solver for time-domain nanophotonics [1] with a statistical learning-based global optimization method [2], which has been further extended for the multiobjective optimization of an achromatic metalens [3] and robust optimization of metadeflectors [4]. Here, our specific objectives will be (1) to adapt this inverse design methodology to the microwave regime and, (2) to substantially increase its computational efficiency for coping with the large-scale nature of the underlying application. For what concern the second objective, we will investigate two complementary directions: on the one hand, the evaluation cost of the objective function at each optimization iteration could be drastically reduced by designing a reduced order model for the parametrized time-domain Maxwell equations taking into account both material and geometry parameters (our recent contributions in [6]-[7] will serve as a basis for this research); on the other hand, the availability of both high and low fidelity electromagnetic solvers motivates the possibility of leveraging multifidelity optimization [8].

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

[3] M.R. Elsawy, S. Lanteri, R. Duvigneau, G. Brière, M.S. Mohamed and P. Genevet, « Global optimization of metasurface designs using statistical learning methods », Scientific Reports, Vol. 9, No. 17918, 2019.

[4] M.R. Elsawy, A. Gourdin, M. Binois, R. Duvigneau, D. Felbacq, S. Khadir, P. Genevet and S. Lanteri, « Multiobjective statistical learning optimization of RGB metalens », ACS Photonics, Vol. 8, No. 8, pp. 2498–2508, 2021.

[5] M.R. Elsawy, M. Binois, R. Duvigneau, S. Lanteri and P. Genevet, « Optimization of metasurfaces under geometrical uncertainty using statistical learning », Optics Express, Vol. 29, pp. 29887-29898,

General Information

- **Theme/Domain :** Numerical schemes and simulations
- **Town/city :** Sophia Antipolis
- **Inria Center :** CRI Sophia Antipolis - Méditerranée
- **Starting date :** 2022-10-01
- **Duration of contract :** 12 months
- **Deadline to apply :** 2022-12-31

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.

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.

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.

2021.

[6] Li, T.-Z. Huang, L. Li and S. Lanteri, « POD-based model order reduction with an adaptive snapshot selection for a discontinuous Galerkin approximation of the time-domain Maxwell's equations », Journal of Computational Physics, Vol. 396, pp. 106-128, 2019.

[7] Li, T.-Z. Huang, L. Li and S. Lanteri, « Non-intrusive reduced-order modeling of parameterized electromagnetic scattering problems using cubic spline interpolation », Journal of Scientific Computing, Vol. 87, Art. no. 52, 2021.

[8] L. Gratiet and J. Garnier. Recursive co-kriging model for design of computer experiments with multiple levels of fidelity. International Journal Uncertainty Quantification, Vol. 4, No. 5, pp. 365–386, 2014.

Main activities

Main activities: (1) Theoretical investigation of the mathematical and numerical techniques for reduced order modeling and multifidelity optimization, (2) formulation and study of the novel methodologies for addressing the above-mentioned specific objectives, (3) software development and validation activities, (4) application of novel methodologies to the desiggn of cascaded metadeflectors for an ultra-flat antenna system and, (5) scientific publications, participation to conferences and technical meetings with the project partners.

Complementary activities: partiicpation to the development and valorization of the DIOGENeS software plaform with the other members of the Atlantis project-team.

The postdoctoral project will be carried out within a tight collaboration with Thales R&T (for the antenna system design) and with Nanoe (for the fabrication of the demonstrators). During the mission, occasional stays (1-2 weeks each time) will be organized at Thales R&T. The postdoctoral fellow will be able to benefit from Thales's expertise in the application fields of electronic and antenna components. He/she will work with a research engineer from Thales R&T on the design and optimization of the cascaded metadeflectors for an ultra-flat antenna system.

Skills

Academic background: Ph.D. in applied mathematics or scientific computing or electrical engineering.

Required knowledge and skills

- Theory and methodology: computational electromagnetics, finite element methods for PDEs, reduced order modeling, numerical optimization
- Programming: Fortran 2008, Python, MPI, OpenMP

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 (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

Remuneration

Gross Salary: 2653 € per month