Offer #2024-07232

Post-Doctorant F/H Modélisation et schémas numériques des échanges radiatifs mesurés par un capteur infrarouge multispectral

Contract type : Fixed-term contract

Level of qualifications required : PhD or equivalent

Fonction : Post-Doctoral Research Visit

About the research centre or Inria department

The Inria Centre at Rennes University is one of Inria's eight centres and has more than thirty research teams. The Inria Centre is a major and recognized player in the field of digital sciences. It is at the heart of a rich R&D and innovation ecosystem: highly innovative PMEs, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute, etc.

Context

European Brighter Project

This research work is part of the European project HORIZON CHIPS JU BRIGHTER (https://project-brighter.eu/), which focuses on the design, implementation, and study of new uncooled infrared detectors with lower thermal time constants called "Fast Pixel" (FP) or spectral functionalization at the pixel level of the detector array "MultiSpectral Pixel" (MSP). The first prototypes of infrared thermal cameras were developed in 2023 and made available to Inria and Gustave Eiffel University to conduct various R&D works. These prototypes incorporate focal plane microbolometer arrays designed by CEA and LYNRED. The camera prototypes themselves were developed by Xenics (FP) and SENSIA (MSP).

Assignment

State of the Art

The latest technological advancements in uncooled infrared detectors and cameras offer new opportunities for estimating the temperature of observed objects, contactless and at various distance. In particular, multispectral infrared thermography can be used for thermal monitoring of civil engineering structures for which data is acquired over a long period. However, without any knowledge about the observed object, the temperature can only be exploited relatively. Indeed, calculating the temperature of an object via infrared thermography cannot be done without knowledge of emissivity, an intrinsic radiative property of the object. Writing the physical equations thus leads to an ill-posed problem.

Traditional approaches to temperature and emissivity separation (TES) rely on simplified assumptions and empirical models. These methods often assume uniform emissivity over a given spectral band or rely on databases to estimate emissivity. Although effective in some cases, these approaches lack precision and robustness, especially in complex and heterogeneous environments. Consequently, more advanced approaches have been studied and developed in the literature, particularly in the field of remote sensing.

These methods can be subjectively divided into different categories:

- **Domain-specific separation methods**: these methods assume either a known part or an unknown part of the emissivity spectrum. They mainly rely on assumptions about the measurement system used and the particular properties of emissivity in the application domain and thus are not easily transferable to other applications (Thermal log residuals, multi-channels algorithms, TISI indices, Temperature-Emissivity separation method (TES), etc.).
- **General separation methods**: initially, linearization of equations simplifies the problem and thus allows for simultaneous estimation of emissivity and temperature. However, the literature shows the limitations of numerical approximations of such an approach. Therefore, the latest methods resort to Bayesian approaches for simultaneous estimation. In particular, the MCMC method provides interesting results, at the cost of significant computational resources and time.
- **Machine learning methods:** neural networks have been widely used in remote sensing. However,

these methods still rely on the underlying database available. While remote sensing has many training data sets, this is not yet the case for the team's area of interest, long-term structure monitoring.

Despite significant progress, several challenges remain in estimating temperature via infrared thermography:

- **Spatial and temporal variability**: accounting for the spatial and temporal variability of surface properties poses a challenge, especially in dynamic environments.
- **Sensor calibration and noise:** precise sensor calibration and noise attenuation are essential for reliable temperature and emissivity estimation.
- **Data availability and annotation**: limited availability of annotated training data hinders the development of learning models.
- **Integration with other sensors**: integrating thermal data with other sensors is an avenue for improvement but with potentially higher maintenance and instrumentation costs.

The team has developed and studied its method for joint estimation of temperature and emissivity, in the case of structural health monitoring. This method is based on the assumption of long-term thermal monitoring with dynamic evolution. From a simplified radiometric model, a dynamic model estimates both emissivity and temperature when the latter evolves. The goal is therefore to delve deeper into the equations of the physical model to mitigate the required assumption and improve estimation.

Main activities

Objectives: The objective is to increase complexity in physical models, especially not limiting to the linear case and better accounting for the radiative transfer equation as a whole. To reflect this physical model in the temperature evolution equations and try to decouple the temperature and emissivity issues to improve temperature estimation performance.

Research Directions

The postdoctoral researcher will start from the radiative transfer equation and simplified models of thermal cameras to familiarize themselves with the measurement problem. In parallel, a literature review on joint estimation of temperature and emissivity will be conducted. In a second step, focus on formulating the surface temperature estimation problem of an object considering emissivity as a disturbance in the corresponding dynamic model of measurements will be addressed. In particular, a research direction for the postdoctoral researcher will be to consider and transpose recent methods for rejecting unmeasured disturbances as used in seismic disturbance rejection problems for mechanical systems. Furthermore, efforts will be made to leverage some of the team's R&D work in active infrared thermography applied to non-destructive testing (NDT) of materials or vision problems. This includes using knowledge of the shape of the active source control signal (Sum of sines, Temporal or spatial modulation, Impulse). The work will be conducted on simulated data and/or data acquired in controlled laboratory conditions (within the team or at its partners in the BRIGHTER's project).

Partners:

CEA Tech PIMS team, Lynred Applications Laboratory

Location:

Nantes Campus with travel to Rennes Beaulieu Campus or vice versa depending on the personal constraints of the recruited individual.

Skills

Prerequisites:

Less than 3 years post-PhD

PhD in the field of Physics or Mechanics

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs

- Possibility of teleworking (90 days per year) and flexible organization of working hours
- Partial payment of insurance costs

Remuneration

Monthly gross salary amounting to 2788 euros.

General Information

- **Theme/Domain :** Numerical schemes and simulations
- **Town/city :** Nantes
- **Inria Center :** Centre Inria de l'Université de Rennes
- **Starting date :** 2024-09-01
- **Duration of contract :** 12 months
- **Deadline to apply :** 2024-09-30

Contacts

- **Inria Team :** I4S
- **Recruiter :**
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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

Please submit online : your resume, cover letter and letters of recommendation eventually

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.