# Offer #2024-07200

# Post-Doctoral Research Visit F/M Registration methods for shock-dominated flows

**Contract type :** Fixed-term contract

**Level of qualifications required :** PhD or equivalent

**Fonction :** Post-Doctoral Research Visit

**Level of experience :** Recently graduated

## About the research centre or Inria department

We aim at a step change in numerical modeling in order to answer actual industrial needs. Our goal is to implement these new models in performing codes on HPC infrastructures and to make them available to respond to societal needs. We do that by developing two fundamental enablers: reduced-order models and Cartesian grid methods. Thanks to these enablers it will be possible to transfer complexity handling from engineers to computers, providing fast, on-line numerical models for design and control.

## Context

In the framework of parametric model reduction, registration is the process of finding a bijection (or morphing) to align coherent structures of the solution in a reference configuration, over a range of parameters [2]. The problem is tightly linked to point-set registration in image processing, and shares relevant features with mesh morphing (r-adaptation) in scientific computing; nevertheless, registration for model reduction applications has several specificities that require innovative methodological solutions and motivate further research. First, in order to allow the correct enforcement of boundary conditions, the map□ping should exactly preserve the boundary of the domain for all parameter values; second, the quality of the deformed mesh should be controlled; third, registration should rely on a moderate number of possibly low□fidelity snapshots to reduce the offline costs.

The objective of the exploratory action AM2OR (www.inria.fr/en/am2or) is to combine mesh adap□tation, registration, and model order reduction to devise cost-efficient reduced-order models for parametric advection-dominated systems. In this respect, the importance of registration is twofold: first, to contribute to find a low-rank nonlinear representation of the solution field over a range of parameters; second, to facilitate the task of building a common mesh for all elements of the solution set. The recent publication [1] illustrates an integrated procedure to adaptively build the mesh, the parametric mapping, and the reduced-order model for two-dimensional conservation laws.

**Keywords:** model order reduction; registration methods; mesh morphing.

## Assignment

The aim of the postdoctoral project is to develop and analyze a registration technique for general three-dimensional geometries, and to integrate the method in the integrated framework of [1]. To meet this goal, we identify two research tracks :

· Definition of general approximation spaces for diffeomorphisms in bounded domains. We plan to extend the method in [3] to three-dimensional geometries: we wish to find an ansatz which enables the rigorous enforcement of the bijectivity constraint for a broad class of Lipschitz domains of interest in engineering and to investigate the approximation properties in the space of diffeomorphisms.

· Development of a computational framework for registration. We plan to develop a general simulation framework to solve registration problems. This task encompasses numerical optimization, mesh morph□ing and generation techniques, and nonlinear model reduction.

Time permitting, we also envision the integration of the registration procedure in the mesh adaptation/model reduction framework proposed in [1].

**References**

[1] NICOLAS BARRAL, TOMMASO TADDEI, AND ISHAK TIFOUTI, Registration-based model reduction of parameterized PDEs with spatio-parameter adaptivity, Journal of Computational Physics, vol. 499, 2024.

[2] TOMMASO TADDEI, A registration method for model order reduction: data compression and geometry reduction, SIAM Journal on Scientific Computing, vol. 42(2), 2020.

[3] TOMMASO TADDEI, Compositional maps for registration in complex geometries, submitted in 2023.

## Main activities

· Define a general approximation spaces for diffeomorphisms in bounded domains.

· Develop a computational framework for registration.

· Implement 3D test cases to demonstrate the method.

· (Integrate the procedure in the proposed mesh adaptation/model reduction framework.)

**Additional activities :**

· Publications (journal articles, conference presentations)

· Participation to meetings

· (Co-)supervision (masters students)

## Skills

The candidate should have a strong background in numerical methods for PDEs.

Background in

(i) finite element/finite volume programming in C/C++,

(ii) mathematical optimiza□tion, and

(iii) computational differential geometry will be highly valued.

## Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- 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
- Social security coverage

## General Information

- **Theme/Domain :** Numerical schemes and simulations
  Scientific computing (BAP E)
- **Town/city :** Talence
- **Inria Center :** Centre Inria de l'université de Bordeaux
- **Starting date :** 2024-05-01
- **Duration of contract :** 2 years
- **Deadline to apply :** 2024-05-31

## Contacts

- **Inria Team :** MEMPHIS
- **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.

## The keys to success

We are looking for a motivated and ambitious candidate, ready to work in a truly interna□tional environnement and in a team involving collaborators from different horizons (applied math, engineering, computer science).

**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

Thank you to send:
- CV
- Cover letter
- Support letters (mandatory)
- List of publication

**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.