
**Level of qualifications required:** Graduate degree or equivalent  
**Function:** PhD Position

### About the research centre or Inria department

The Inria Sophia Antipolis - Mériditerranée center counts 37 research teams and 9 support departments. The center's staff (about 600 people including 400 Inria employees) is composed of scientists of different nationalities (250 foreigners of 50 nationalities), engineers, technicians and administrators. 1/3 of the staff are civil servants, the others are contractual. The majority of the research teams at the center are located in Sophia Antipolis and Nice in the Alpes-Maritimes. Six teams are based in Montpellier and a team is hosted by the computer science department of the University of Bologna in Italy. The Center is a member of the University and Institution Community (ComUE) "Université Côte d'Azur (UCA)."

### Context

Acumes Project-Team (http://team.inria.fr/acumes) is a joined team from Inria Sophia Antipolis - Mériditerranée Research Center and mathematics laboratory Jean-Alexandre Dieudonné at University of Nice. The research conducted concerns the analysis and optimization of systems governed by partial differential equations, with applications ranging from fluid and structural mechanics to modeling of biological phenomena, road and pedestrian traffic. In this context, the development of efficient numerical schemes plays a major role in the team.

For some years, a new simulation paradigm has been emerging, the isogeometric analysis, which consists in solving partial differential equations by a variational approach, using NURBS (Non-Uniform Rational B-Spline) bases originating from CAD (Computer-Aided Design) domain. This approach has the advantage to allow a resolution without geometrical approximation, i.e. with a computational domain supported exactly by the CAD geometry, contrary to classical mesh-based methods that approximate the geometry by local linearization. Consequently, isogeometric analysis relies on a unique high-order representation for both the geometry and the fields to solve, yielding a significant gain in terms of accuracy and ease of interaction. This approach has been popularized by T. Hughes [CHB09], mainly for elliptic and parabolic problems.

Acumes Project-Team has recently proposed a formulation dedicated to hyperbolic problems, based on a Discontinuous Galerkin method [Duv18]. This approach has been applied to compressible aerodynamics in the context of Euler, and then Navier-Stokes, equations including strategies for local refinement and shock capturing.


### Assignment

The aim of this work is to study the extension of the proposed isogeometric Discontinuous Galerkin method to problems with moving interfaces, for which the computational domain is subject to displacements. Different problems are targeted, such as sensitivity analysis with shape parameters, for which the solution changes due to local geometrical perturbations are estimated, or problems involving deformable or moving (translated, rotated) bodies, for which the global displacement is explicitly imposed. One can also study problems with fluid-structure interactions, for which the displacement is ruled by a physical coupling. The accuracy of the proposed approach will by especially investigated, including comparison with classical mesh-based methods. The gain of using a high-order and geometrically exact computational domain will be quantified.
Main activities

The doctoral student will be part of the Acumes Project-Team at Inria Sophia Antipolis - Méditerranée Research Center. At first, he/she will have to formalize the targeted extensions in the context of the isogeometric Discontinuous Galerkin method. Regarding sensitivity analysis, the development will rely on the continuous sensitivity equation method, which consists in solving additional partial differential equations obtained by differentiating the state equations with respect to the geometry [DP06]. This approach is a priori well adapted to high-order NURBS representations. Regarding analysis with moving computational domains, the work will rely on the ALE (Arbitrary Lagrangian-Eulerian) [PPB09] formulation, which has to be extended to high-order NURBS descriptions.

On the basis of the existing code (C++ language) solving Euler/Navier-Stokes equations on NURBS domains, the doctoral student will implement the proposed approaches and will conduct a set of numerical tests based on academic and then industrial problems, in order to qualify the methods and quantify their accuracy. The targeted applications concern compressible flows around airfoils or turbine blades.


Benefits package

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

Remuneration

Duration: 36 months
Location: Sophia Antipolis, France
Gross Salary per month: 1982€ brut per month (year 1 & 2) and 2085€ brut/month (year 3)