Post Doc02109 - Research post-doc in Applied Mathematics

Function: Post-Doctoral Research Visit

About the research centre or Inria department

Inria, the French National Institute for computer science and applied mathematics, promotes “scientific excellence for technology transfer and society”. Graduates from the world’s top universities, Inria’s 2,700 employees rise to the challenges of digital sciences. Research at Inria is organised in “project teams” which bring together researchers with complementary skills to focus on specific scientific projects. With this open, agile model, Inria is able to explore original approaches with its partners in industry and academia and provide an efficient response to the multidisciplinary and application challenges of the digital transformation. The source of many innovations that add value and create jobs, Inria transfers expertise and research results to companies (startups, SMEs and major groups) in fields as diverse as healthcare, transport, energy, communications, security and privacy protection, smart cities and the factory of the future.

The Inria Nancy - Grand-Est centre conducts sustained activity in the sector of information science and technologies, including computer science, applied mathematics, control engineering and multidisciplined themes situated at the crossroads between information science and technologies and other scientific areas, including life sciences, physics and human and social sciences. We also have strong commitments linked to technology transfer. Our establishment at the heart of a major cross-border region, together with our industrial and university partnerships, constitute a major advantage in achieving these commitments.

SPHINX (Heterogeneous Systems: Inverse problems, Control and Stabilization, Simulation) is an Inria team-project located in Institut Elie Cartan de Lorraine (IECL). We work on Partial Differential Equations, Control theory, Inverse Problems, and Numerical Analysis. One of our main research topics is the study of fluid-structure interaction systems. Such systems are classical in Fluid Mechanics and appear in many applications: medicine (motion of the blood in veins and arteries), biology (animal locomotion in a fluid, such as swimming fishes or flapping birds but also locomotion of microorganisms, such as amoebas), civil engineering (design of bridges or any structure exposed to the wind or the flow of a river), naval architecture (design of boats and submarines, seeking of new propulsion systems for underwater vehicles by imitating the locomotion of aquatic animals). The fluid-structure interaction systems can be studied by modeling their motions through Partial Differential Equations and/or Ordinary Differential Equations. This leads to the study of difficult nonlinear free boundary problems which constitute a rich and active domain of research over the last decades.

Place of work: INRIA Nancy Grand Est Research Center, 615 rue du Jardin Botanique, 54600 VILLERS LES NANCY

Laboratory: Institut Elie Cartan de Lorraine, Site de Nancy

Context

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Assignment

Job offer description:

In many applications, it is crucial to work with deformable structures moving in a fluid: vascular systems, vesicles, aquatic animals, etc. However, in the case of deformable structures, the problem turns out to be very tricky. Among many others, a serious difficulty is that the equations driving the motion of the fluid (namely, the Navier-Stokes equations or the Euler equations) are written with Eulerian variables whereas the equations for the dynamics of the structures (such as the equations of elasticity) are usually written with Lagrangian variables. Moreover, the regularity of the fluid domain depends on the deformation of the structure that is unknown could be low (for weak solutions). For strong solutions, this problem might be avoided, but the fact that one deals with different types of PDE systems plays an important role and could lead to several technical difficulties. Before even dealing with control and stabilization in this context, one has to obtain suitable well-posedness results.

- Missions:

  The system that will be considered consists in the coupling between beam or plate equations with the Navier-Stokes system. A first work would be to obtain a suitable framework for the global in time existence of solutions for the corresponding system. Several results have been obtained in that direction in the case of damped beam or plate. Without this approximation, there are very few results due the coupling between systems of different natures. One could consider the simplified case of very viscous or inviscid fluids in order to obtain a suitable model for the control part.

  In a second part, we aim at controlling/stabilizing this system and a standard method for this needs to find good properties in the linearized system. With a damping, the linear system is parabolic which allows us to use standard method for the stabilization of the linear part and for the fixed point. Without this damping, one need to introduce a new theory to handle both the stabilization part but also the fixed-point procedure. In the point of view of controllability, one could try first to control the linear system in a particular geometry or even in the case of very high or very low Reynolds numbers.

  For the both parts, we would like to develop a numerical scheme to simulate the corresponding systems. In this numerical part, one of the most complicated point will consists in handling the free boundary issue.

Main activities

* **Skills and profile:** Knowledge in partial differential equations and in control theory

* **Life skills:** Ability to work in a team, capacity to listen and to share.
* **Education:** PhD in applied mathematics

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