2018-00651 - Post-doctoral position: Structural analysis of nonsmooth DAE systems. FUI Modeliscale

**Contract type**: Public service fixed-term contract  
**Level of qualifications required**: PhD or equivalent  
**Function**: Post-Doctoral Research Visit  
**Level of experience**: Recently graduated

**About the research centre or Inria department**

Grenoble Rhône-Alpes Research Center groups together a few less than 800 people in 35 research teams and 9 research support departments.

Staff is localized on 5 campuses in Grenoble and Lyon, in close collaboration with labs, research and higher education institutions in Grenoble and Lyon, but also with the economic players in these areas.

Present in the fields of software, high-performance computing, Internet of things, image and data, but also simulation in oceanography and biology, it participates at the best level of international scientific achievements and collaborations in both Europe and the rest of the world.

**Context**

TRIPOP is a joint research team of Inria Grenoble Rhône-Alpes and of the Laboratoire Jean Kuntzmann and started in January 2018 as a follow up of the BIPOP team. The team is mainly concerned by the modeling, the simulation and the control of nonsmooth dynamical systems. Nonsmooth dynamics concerns the study of the time evolution of systems that are not smooth in the mathematical sense, i.e., systems that are characterized by a lack of differentiability, either of the mappings in theirs formulations, or of theirs solutions with respect to time. In mechanics, the main instances of nonsmooth dynamical systems are multibody systems with Signorini’s unilateral contact, set-valued (Coulomb-like) friction and impacts. In Electronics, the main instances are switched electrical circuits with ideal components (diodes, switches, transistors, ...)

**Within the framework of a partnership**

This position is available in the context of a FUI project, Modeliscale [https://team.inria.fr/modeliscale/](https://team.inria.fr/modeliscale/) coordinated by Dassault Systems and in collaboration with two others INRIA teams, HYCOMES, INRIA Rennes and PARKAS, INRIA Paris.

**Assignment**

Modeling languages such as Modelica [https://www.modelica.org](https://www.modelica.org) and SimScape [https://fr.mathworks.com/products/simscape.html](https://fr.mathworks.com/products/simscape.html) are based on systems of algebraic differential equations (DAE). Although modeling is made scalable with the use of DAE, simulating large CPS is a challenge because of their exponential number of modes. Although the structural analysis of pure DAE systems is now well established and benefits from fast algorithms (based on graph theory or linear programming), the state-of-the-art structural analysis methods for multi-mode DAE systems either relies on overly restrictive assumptions on the structure of the model, or faces the combinatorial explosion of mode enumeration.

Modeling CPS with hybrid state machines is not always the best option at hand: there are alternative modeling paradigms, avoiding the inherent drawbacks of hybrid state machines. A fine example are
NonSmooth Dynamical Systems (NSDS), a formalism best suited to capture the dynamics of multibody mechanical systems (with contacts and friction), switched electronic circuits, or gene regulatory networks in cell biology. NSDSs can be formulated in several ways, using Filippov differential inclusions (with piece-wise continuous functions appearing on the right-hand side of the differential inclusions), or using complementarity conditions.

The correct formulation of a NSDS has to follow a very strict structure, and modeling a CPS in this way often proves to be a challenging task. CPS models expressed in an equation-based language such as Modelica should not be expected to follow a predetermined structure. On the contrary, the model should rather be structured according to the physical structure of the system, in a component-based fashion. The mathematical structure of the model has to be discovered by the compiler, and this is the purpose of the structural analysis, implemented in most Modelica tools. Extending Modelica to NSDS requires new structural analysis algorithms, adapted to the new language constructs (piece-wise continuous operators or complementarity conditions).

Main activities
The main activities of the post-doctoral fellows will be:

- Enrich the Modelica language capabilities including new components based in the nonsmooth dynamical systems paradigm (complementarity, relay, multi-valued law)
- Perform the structural analysis of the hybrid systems mixing DAE and nonsmooth dynamics
- Implement a prototype that allows to generate simulation code for siconos from a Modelica description.

Skills
Applied Mathematics, Dynamical Systems, Hybrid Systems, Programming languages

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

Remuneration
Gross income: 2653€

General Information
- **Theme/Domain**: Optimization and control of dynamic systems
  Scientific computing (BAP E)
- **Town/city**: Montbonnot
- **Inria Center**: CRI Grenoble - Rhône-Alpes
- **Starting date**: 2018-05-02
- **Duration of contract**: 2 years
- **Deadline to apply**: 2018-06-01

Contacts
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Recruiter :
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The keys to success
A PhD Thesis in Applied Mathematics with a strong taste for Computer Sciences or conversely.

About Inria
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. With its 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. Inria is the source of many innovations that add value and create jobs.

Conditions for application
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.