2018-00577 - Structural analysis of nonsmooth DAE systems [PhD campaign-IPL]

Contract type : Public service fixed-term contract
Level of qualifications required : Graduate degree or equivalent
Fonction : PhD Position

About the research centre or Inria department

Inria is the French national institute for research in computer science and control, dedicated to fundamental and applied research in information and communication science and technology (ICST). Inria has a workforce of 3,800 people working throughout its eight research centers established in seven regions of France.

Grenoble is the capital city of the French Alps. Combining the urban life-style of southern France with a unique mountain setting, it is ideally situated for outdoor activities. The Grenoble area is today an important centre of industry and science (second largest in France). Dedicated to an ambitious policy in the arts, the city is host to numerous cultural institutions. With 60,000 students (including 6,000 foreign students), Grenoble is the third largest student area in France.

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 their formulations, or of their 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, ...).

Assignment

Modeling languages such as \url{https://www.modelica.org} (Modelica) and \url{https://fr.mathworks.com products/simscape.html} (SimScape) 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 \url{http://dx.doi.org/10.1007/s10543-016-0642-9} (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 \url{https://hal.inria.fr/hal-01521918} (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 \url{https://hal.inria.fr/inria-00423530} (NonSmooth Dynamical Systems) (NSDS), a formalism best suited to capture the dynamics of multibody mechanical systems (with contacts and friction), \url{https://hal.inria.fr/inria-00522358} (switched electronic circuits), or \url{https://hal.inria.fr/hal-00924044} (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 \url{https://www.modelica.org} (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

General Information

- **Theme/Domain**: Optimization and control of dynamic systems
- **Town/city**: Montbonnot
- **Inria Center**: CRI Grenoble - Rhône-Alpes
- **Starting date**: 2018-10-01
- **Duration of contract**: 3 years
- **Deadline to apply**: 2018-05-01

Contacts

- **Inria Team**: TRIPOP
- **Recruiter**: Acary Vincent / vincent.acary@inria.fr

The keys to success

Applied mathematics and/or Computer Science.

Conditions for application

The campaign is not open to local students who have not done any significant mobility.

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.
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**

This research topic encompasses both theoretical developments on the structural analysis of nonsmooth DAE systems (combining algebraic differential equations, complementarity conditions and/or piece-wise continuous operators), the design and implementation of efficient graph-theoretic structural analysis algorithms for these systems, and the generation of simulation code for NSDS numerical solvers (for instance, the Siconos library).

**Bibliography**


**Supervisors**

Vincent Acary, INRIA tripop.

Benoit Caillaud, INRIA Hycomes

**Complementary information**

In the realm of the IPL ModeliScale initiative (https://team.inria.fr/modeliscale/)

- **Keywords**

  Cyber-physical systems, Hybrid dynamical systems, Nonsmooth dynamical systems, structural analysis of DAE systems, Modelica

**Benefits package**

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

**Remuneration**


Monthly salary after taxes: around 1596,05€ for 1st and 2nd year. 1678,99€ for 3rd year. (medical insurance included).