Offer #2023-06409

Post-Doctoral Research Visit F/M Large-Scale Density Systems: Modeling and Control for Electromobility Applications

Contract type : Fixed-term contract

Level of qualifications required : PhD or equivalent

Fonction : Post-Doctoral Research Visit

About the research centre or Inria department

The Centre Inria de l'Université de Grenoble groups together almost 600 people in 22 research teams and 7 research support departments.

Staff is present on three campuses in Grenoble, in close collaboration with other research and higher education institutions (Université Grenoble Alpes, CNRS, CEA, INRAE, ...), but also with key economic players in the area.

The Centre Inria de l'Université Grenoble Alpe is active in the fields of high-performance computing, verification and embedded systems, modeling of the environment at multiple levels, and data science and artificial intelligence. The center is a top-level scientific institute with an extensive network of international collaborations in Europe and the rest of the world.

Context

Context. This research will be conducted by the DANCE research team (webpage): DANCE ("Dynamics and Control of Networks") is a joint team of GIPSA-lab and Inria Grenoble–Rhône-Alpes. Our team has a strong expertise in modeling, estimation and control problems for networks, and specifically for large networks. The research will be part of the ANR project Continuous Methods for the Control of Large Networks (COCOON).

Scientific Context and Previous Work Current research in control theory is focused on utilizing the dynamics of large networks, such as traffic and transportation infrastructure, multi-agent systems, epidemic spreading, and electrification of vehicles, among others. Dealing with a high number of state variables that describe the nodes or edges of these networks, as well as significant uncertainties, calls for new reduction methods that are suitable for networks and can effectively navigate through different scales. Traditionally, the control community has tackled the control of large-scale network systems by seeking distributed control algorithms, where each node applies a control loop locally based on its own information. However, this approach often requires access to local information that may not be available for all nodes in the network. As an alternative to this decentralized approach, the objective of this thesis is to explore "the continuation method" proposed in the ERC Scale-FreeBack project [2,3,4].The continuation method represents a novel approach for approximating large-scale networks described by sets of ordinary differential equations (ODEs) using partial differential equations (PDEs). It is particularly applicable to high-dimensional spatially distributed ODE systems. Examples of such systems include urban traffic networks, ring oscillators, electrical networks, multi-agent robots, gas dynamics, fluid density studies, and electro-mobility networks. In essence, the continuation process can be understood as the inverse of the typical space discretization of PDEs, where a large set of ODEs is used. It begins with a set of coupled or uncoupled high-dimensional ODEs distributed in space, which is then approximated by a PDE using finite differences. Once this approximation is established, boundary controllers can be designed for the PDE instead of controlling each individual control system, or the PDE can be used for analysis purposes [5]. The control designed at the PDE level is subsequently applied to the real system by discretizing it back to the original ODE system.

Main activities

Work program. The project objectives are: to address several open theoretical problems relative to the continuation method and, apply our results to the electro mobility domain. The program considers several theoretical problems to be addressed and a study case:

Theoretical Problems.

- ***Accuracy, Convergence & Reversibility***. The challenge lies in determining the extent to which the PDE approximation can encompass all the impacts of the original ODE and how the choice of continuation order (the highest spatial derivative) influences the accuracy and convergence towards the solutions of the original ODE

- ***Density-based models.*** Typically, PDEs involve time and space derivatives, but derivatives can be written with respect to other variables. "Index derivatives" in PDEs are valuable for mobile multi-agent setups with position-based agent states (density-based models, see [5]). We propose to study the dependence of the quality of the obtained model on the chosen position function and to provide some justified guidelines on how to make this choice.
- ***Density-based models with multi-modal attributes.*** Another problem of interest concerns a new class of systems that, in addition to the moving spatial agents' variables, have also additional *multi-modal attributes*. For example, electrical vehicles in electro mobility networks, are not only characterized by their positions and velocities, but also by additional variables modelling the carried/used energy in the vehicle batteries.
- **Local for Global behavior.** Another problem to be investigated is how the local interactions affect the global behaviors of the PDE approximation. By local interaction, we mean the characteristics of the local connections in terms of parameters and connectivity. In this project we wish to investigate, at a general theoretical level, how the generic properties of the ODE network (values, connection parameters, graph structure, etc.) affect the global properties of the PDE.
- **Multi-modality controlled proxies**. The continuation method offers the advantage of recovering a PDE that describes the same physical system as the original ODE network. By using the obtained PDE, it becomes possible to design a continuous control that, when discretized, provides a control law for the original ODE system. In this project, we aim to explore alternative control approaches adaptable to other systems, such as multi-commodity systems with additional attributes like energy carried by particles. This will involve targeting high-dimensional PDE proxies and investigating the existence of approximations and the methodology for constructing the control law.

Study-case: Electro-mobility.

With the increasing adoption of electric vehicles (EVs) by the population, the integration of EVs with city infrastructure and the electrical power supply network presents unresolved critical challenges. Currently, there is a lack of models that capture EV mobility and energy storage, which are crucial for optimizing the energy balance between EVs and the power grid. This project aims to develop models combining EV motion, energy consumption, and storage using continuation models with multi-modality. Additionally, the evaluation, placement, and design of charging stations to support EV power demand will be addressed. The findings will be integrated into the eMob-twin platform, which is being developed in connection with the PoC eMob-Twin project https://www.ins2i.cnrs.fr/fr/cnrsinfo/emob-twin-la-modelisation-au-service-des-mobilites-electriques). A sample of this platform can be accessed at http://emob-twin.inrialpes.fr

Skills

Request Background. Control Systems, Electrical Eng., Applied mathematics

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking (90 days / year) and flexible organization of working hours
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage under conditions

Remuneration

- 2746 euros gross salary

General Information

- **Theme/Domain :** Optimization and control of dynamic systems
- **Town/city :** Grenoble/Montbonnot
- **Inria Center :** Centre Inria de l'Université Grenoble Alpes
- **Starting date :** 2024-06-01
- **Duration of contract :** 2 years, 6 months
- **Deadline to apply :** 2024-05-31

Contacts

- **Inria Team :** DANCE
- **Recruiter :**
  Canudas-de-wit Carlos / carlos.canudas-de-wit@inria.fr

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.

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

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.