Offer #2024-07597

PhD Position F/M Campagne doctorant 2024 - Small-time controllability of bilinear partial differential equations via Lie bracket methods

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

Context

The PhD thesis witll be co-supervised by Mario Sigalotti (CAGE) and Eugenio Pozzoli (CNRS, IRMAR).

Assignment

The goal of this project consists in developing nonlinear geometric control methods for the analysis of bilinear partial differential equations. The main focus is in the study of the set of **small-time approximately reachable states**. Typical examples of dynamics we are interested in are the Schrödinger equation (modeling the evolution of closed quantum systems) and the Liouville transport equation along Hamiltonian fields (modeling the evolution of a density of classical particles).

The determination of the minimal time for controlling quantum systems is a fundamental challenge for engineers, physicists and mathematicians. Since the seminal works of Khaneja, Brockett, and Glaser [1] on the time-optimal control of finite-dimensional spin systems, special Lie algebraic properties of dynamical generators have proved to be effective for deriving time-optimal control strategies, such as pulse-drift-pulse, in order to generate unitary gates. In some of these cases, the minimal time can be pushed approximately to zero. This fact is well-understood for finite-dimensional bilinear control systems [2,3]. In this project, we are interested in studying such problems in infinite-dimensional frameworks: this setting includes several physically relevant examples of quantum dynamics such as harmonic oscillators and rotors. New Lie algebraic properties of the dynamical generators, also in the infinite-dimensional setting, can be used as tools for the controllability analysis, and furnish explicit time-zero control strategies [4]. The goal of this thesis is to expand and generalize these properties in order to characterise small-time cotrollability in general bilinear evolution equations in infinite-dimensional spaces.

[1] Navin Khaneja, Roger Brockett, and Steffen J. Glaser. Time optimal control in spin systems. Physical Review A, 63(3), 2001.

[2] Domenico D'Alessandro. Small time controllability of systems on compact Lie groups and spin angular momentum. J. Math. Phys., 42(9):4488–4496, 2001.

[3] Andrei Agrachev, Ugo Boscain, Jean-Paul Gauthier, and Mario Sigalotti. A note on time-zero controllability and density of orbits for quantum systems. In 2017 IEEE 56th Annual Conference on Decision and Control (CDC), pages 5535–5538, 2017.

[4] Thomas Chambrion and Eugenio Pozzoli. Small-time bilinear control of Schro dinger equations with application to rotating linear molecules. Automatica, 153:111028, 2023.

Main activities

The PhD student will contribute to the development of Lie algebraic methods for the analysis of small-time controllability of partial differential equations.

Skills

The candidate should have a strong mathematical background, incuding in particular nonlinear control theory. Previous knowledge of the basics of quantum physics will be highly appriciated.

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 and flexible organization of working hours (after 12 months of employment)
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

Remuneration

According to civil service salary scales

General Information

- **Theme/Domain :** Optimization and control of dynamic systems
- **Town/city :** Paris
- **Inria Center :** Centre Inria de Paris
- **Starting date :** 2024-09-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2024-05-19

Contacts

- **Inria Team :** CAGE
- **PhD Supervisor :**
  Sigalotti Mario / Mario.Sigalotti@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.

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Instruction to apply

In your application (which can be in English or in French), please include:

- CV
- Letter of motivation
- Letters of recommendation
- Master's grades

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.