Offer #2025-08547

PhD Position F/M Stochastic modelling of dynamical resource allocation and analysis of single-cell data

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

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

The Ph.D. project will be carried out in the project-team MICROCOSME at Inria Grenoble - Rhône-Alpes under the joint supervision of Aline Marguet (https://team.inria.fr/microcosme/aline-marguet/) and Hidde de Jong (https://team.inria.fr/microcosme/hidde-de-jong/) within the framework of the ARBOREAL ANR project (https://project.inria.fr/arboreal/). MICROCOSME is an interdisciplinary team that includes applied mathematicians, engineers, computer

scientists, biologists as well as experimentalists from the microbiology/biophysics team BIOP of the Université Grenoble-Alpes (https://liphy.univ-grenoble-alpes.fr/fr/recherche/equipes/biop-fluctuations-regulations-et-evolution-systemes-vivants).

Assignment

Gaining an understanding of the cellular processes underlying bacterial growth is crucial for fundamental research in biology as well as for applications in biotechnology, health, and environmental technology. New experimental technologies have been developed to monitor growth and gene expression at the single-cell level, opening the path to the exploration of the origins of variability in growth phenotypes within a population of bacterial cells. So far, the data obtained from these technological breakthroughs have been exploited only in part. In particular, appropriate mathematical models and methods to relate single-cell gene expression data with the emergence of growth variability in a population are rare [1].
The ARBOREAL ANR project aims at developing a new mathematical framework for the analysis of growth variability from single-cell data, by combining structured branching processes [2, 3] with models of bacterial growth [4] at the single-cell level. We will obtain a new class of stochastic individual-based models, called Branching Resource allocation Processes (BRP), that will enable investigation of the variability of growth phenotypes in a proliferating microbial population in terms of the variability of physiological and cell division processes. The development of the BRP framework will entail modelling, analysis, and inference, and will exploit microfluidics experiments comprising single-cell measurements of growth and expression levels of ribosomes and enzymes in the model organism Escherichia coli [5].

The proposed Ph.D. project involves the development, numerical simulation, and analysis of branching resource allocation processes and the application of this new framework to existing single-cell datasets in the team to study the onset of growth variability in bacterial populations.

Main activities

Using a variety of mathematical tools and algorithmic approaches (Continuous-Time Markov chains, Mixed-Effects modelling, Branching processes, stochastic simulation) as well as single-cell gene expression datasets, we will address several of the following points:

- Explore different combination of models of single-cell resource allocation and cellular replication (varying lifetime distribution for the individuals, possible asymmetry in the sharing of the cell content at division, switching mechanisms etc.)

- Analyse the new BRP models (asymptotic behavior, comparison of population and lineage dynamics, compute the large population limit and compare with existing population-average resource allocation models).

- Develop numerical simulation tools for the BRP models.

- Use the BRP framework to analyse single-cell *E. coli* datasets from our laboratory [5] and other datasets to relate growth phenotypes on the population level to resource allocation strategies on the single-cell level.

[1] Thomas, P., G. Terradot, V. Danos, and A. Y. Wei?e, Sources, propagation and consequences of stochasticity in cellular growth. *Nat Commun* 9:4528, 2018.

[2] A. Marguet, Uniform sampling in a structured branching population, *Bernoulli*, 25, pp. 2649–2695, 2019.

[3] S. Méléard and V. Bansaye, Stochastic Models for Structured Populations: Scaling Limits and Long Time Behavior, Springer Cham, 2015.

[4] N. Giordano, F. Mairet, J.-L. Gouzé, J. Geiselmann, and H. de Jong, Dynamical allocation of cellular resources as an optimal control problem: Novel insights into microbial growth strategies, *PLoS Comput Biol*, 12, p. e1004802, 2016.

[5] A. Pavlou, E. Cinquemani, C. Pinel, N. Giordano, M. Van Melle-Gateau, I. Mihalcescu, J. Geiselmann and H. de Jong. Single-cell data reveal heterogeneity of investment in ribosomes across a bacterial population. *Nat Commun* **16**, 285 (2025).

Skills

Interested candidates are expected to have a solid preparation in dynamical system / stochastic process modelling and analysis and some familiarity with scientific programming, and to be interested in biological applications and data processing.

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 daus per yerar) and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training

- Social security coverage

General Information

- **Theme/Domain :** Modeling and Control for Life Sciences
  Biologie et santé, Sciences de la vie et de la terre (BAP A)
- **Town/city :** Montbonnot
- **Inria Center :** Centre Inria de l'Université Grenoble Alpes
- **Starting date :** 2025-10-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2025-09-30

Contacts

- **Inria Team :** MICROCOSME
- **PhD Supervisor :**
  Marguet Aline / aline.marguet@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.

The keys to success

The successful candidate shall be able to work in collaboration with other people. He/she will be working in a stimulating international context. English reading and writing skills are necessary, English speaking skills are highly desirable.

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.