Offer #2024-07703

M1 Summer Internship: Optimal Control of an Algae-Bacteria Consortium via Application of Hybrid PMP

Contract type: Internship agreement

Level of qualifications required: Master’s or equivalent

Fonction: Internship Research

About the research centre or Inria department

The Inria centre at Université Côte d’Azur includes 37 research teams and 8 support services. The centre’s staff (about 500 people) is made up of scientists of different nationalities, engineers, technicians and administrative staff. The teams are mainly located on the university campuses of Sophia Antipolis and Nice as well as Montpellier, in close collaboration with research and higher education laboratories and establishments (Université Côte d’Azur, CNRS, INRAE, INSERM ...), but also with the region’s economic players.

With a presence in the fields of computational neuroscience and biology, data science and modeling, software engineering and certification, as well as collaborative robotics, the Inria Centre at Université Côte d’Azur is a major player in terms of scientific excellence through its results and collaborations at both European and international levels.

Context

This summer internship, lasting three months (between June and September 2024), will be held at the Inria Center of the University of Côte d’Azur. It is paid at the prevailing hourly rate at Inria, which corresponds to a stipend of about 600 EUR per month. Interns will also benefit from additional perks such as access to the cafeteria, partial reimbursement of transport costs, and potentially assistance in securing a room in a university residence at a reduced rate. This internship is designed as preparation for a longer, five to six-month internship at the M2 level, to be offered in 2024/2025.

This three-month internship proposal aims to develop a modeling and control framework for microalgae-bacteria consortia. The goal is to explore beyond current methods by using advanced mathematical models to investigate the biotechnological potential of algae-bacteria interactions. Unlike pre-existing studies that focus on stable or predictably variable cultivation environments, this project will propose exploring extreme and abrupt conditions. For instance, we plan to examine the effect of radical variations in light and temperature, as well as the impact of intermittent environmental stresses on the growth of these microorganisms. These stresses include sudden changes in temperature, unconventional light cycles, and controlled interruptions of nutrient supply. Modeling of these scenarios will be done using nonlinear ordinary differential equations (ODEs) with discontinuities and dynamic switching (e.g. including event-triggered phenomena), which simulate transitions between different states or environments through hybrid dynamic models. This approach could also incorporate discontinuous optimization goals, such as maximizing growth before focusing on water purification, among others. The ambition is to surpass the traditional approach of Pontryagin’s Maximum Principle for optimal control, in favor of a Hybrid Maximum Principle (PMP-hybrid, [1,2]) better suited to these switching systems.


Assignment

This preliminary internship will lay the groundwork for more in-depth research. It involves conducting a literature review on the posed research question, analyzing the bibliography, and analyzing/simulating a simple model of a microbial culture on a rotating biofilm, passing through different culture media, including a control loss zone. Following this work, an extension to a paid Master 2 internship, lasting five to six months on the same topic, is conceivable in 2024/2025.

Benefits package
Subsidized meals
Partial reimbursement of public transport costs
Possibility of teleworking (after 6 months of employment) 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

General Information

- **Theme/Domain:** Modeling and Control for Life Sciences
- **Scientific computing (BAP E)**
- **Town/city:** Sophia Antipolis
- **Inria Center:** Centre Inria d'Université Côte d'Azur
- **Starting date:** 2024-06-15
- **Duration of contract:** 4 months
- **Deadline to apply:** 2024-06-30

Contacts

- **Inria Team:** BIOCORE
- **Recruiter:** Djema Walid / walid.djema@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

**Candidate profile:** We are seeking an intern at the Master 1 level in mathematics or applied mathematics, or with an equivalent level of education, with a strong interest in biological models. The candidate must have knowledge of dynamic systems described by ordinary differential equations (ODEs). It is strongly desired that the intern selected for this summer be initially interested in the possibility of continuing with a Master 2 internship thereafter.

**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.