



Offer #2022-04593

Engineer: Development of a Software Architecture for Automated discovery of self-organising patterns in complex systems

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : Temporary scientific engineer

Level of experience : Recently graduated

About the research centre or Inria department

The Inria Bordeaux Sud-Ouest centre is one of Inria's eight centres and has around twenty research teams. The Inria centre is a major and recognized player in the field of digital sciences. It is at the heart of a rich R&D and innovation ecosystem: highly innovative SMEs, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute...

Context

In many complex dynamical systems, artificial or natural, one can observe self-organization of patterns emerging from local rules. For example, cellular automata abstract models like Conway's Game of Life (GoL), despite their apparent simplicity, generate a wide range of complex patterns and behaviors reminiscent of various life-like phenomena. Similarly many chemical and biological systems in nature display fascinating self-organizing dynamics: molecular and cellular self-assembly are observed in snowflake crystallization, protocell formation and morphogenesis of living organisms among many others. However, findings of self-organized patterns in such systems have so far relied on manual tuning of parameters and initial states, and on the human eye to identify interesting patterns. For this aim, we are designing a fully open-source interactive software for assisting human users to search for interesting patterns in such complex systems (see below for technical details on the software architecture).

In this project, we formulate the problem of automated scientific discovery of diverse self-organized patterns in high-dimensional complex dynamical systems. We study how intrinsically-motivated machine learning algorithms, initially developed for learning of inverse models in robotics, can be transposed and used in this novel application area. First steps were made in (Reinke, Etcheverry and Oudeyer, 2020), where we studied the behaviour of these algorithms in a continuous game of life (e.g. Lenia (Chan, 2019)). Further steps will involve experimenting with dynamical patterns in similar numerical models, but also exploring novel patterns in real bio-chemistry systems, through collaborations with scientists from diverse backgrounds interested in exploring different types of self-organizing behaviors (ranging from the the formation of protocells from inorganic matter to the design of functional products in bio-engineering applications).

In general, we believe that modern tools from machine learning (including the one developed in the team) hold great promises to assist scientists in mapping and navigating the space of possible outcomes toward novel or hard-to-reach morphological/functional targets in a variety of complex systems. For instance in a recent work (Hamon, Etcheverry, Chan, Moulin-Frier and Oudeyer 2022) we showed how ML tools can efficiently assist us when studying challenging questions such as the origins of sensorimotor agency in self-organising systems or the design of novel forms of collective intelligence.

However, in spite of the exciting future for automated scientific discovery opened up by these recent works, their deployment remains largely limited considering how difficult to grasp they are for scientists lacking prior expertise in machine learning and programming. Additionally, (Etcheverry, Moulin-Frier and Oudeyer 2020) also showed that adding human in the exploration loop can be a key to obtain interesting mappings, enabling scientists to interactively drive curiosity-driven exploration of novel patterns.

To encourage and facilitate the re-use of these tools by a broader audience of chemists, biologists, artists and others, we are designing a fully open-source interactive software that aims to provide tools to easily use exploration algorithms (e.g. the developed curiosity-driven ones) for assisting discovery in various complex systems. In this context, we are seeking a research engineer that will be in charge of developing the proposed software, in collaboration with researchers from the FLOWERS team.

Reinke, C., Etcheverry, M., & Oudeyer, P. Y. (2020). Intrinsically Motivated Discovery of Diverse Patterns in Self-Organizing Systems. ICLR 2020. Blogpost: https://developmentalsystems.org/intrinsically_motivated_discovery_of_diverse_patterns

Chan, Bert Wang-Chak (2019). Lenia: Biology of Artificial Life. Complex Systems, 28(3). Web page: <https://chakazul.github.io/lenia.html>

Etcheverry, M., Moulin-Frier, C., & Oudeyer, P. Y. (2020, December) [Hierarchically Organized Latent Modules for Exploratory Search in Morphogenetic Systems](#). In *NeurIPS 2020-34th Conference on Neural Information Processing Systems*.

Gautier Hamon, Mayalen Etcheverry, Bert Wang-Chak Chan, Clément Moulin-Frier, Pierre-Yves Oudeyer. Learning Sensorimotor Agency in Cellular Automata. 2022. Blogpost: <https://developmentalsystems.org/sensorimotor-lenia/>

Assignment

This research engineer position will imply implementing and designing a software framework enabling to study both the behaviour of interactive automated discovery algorithms, and to contribute to new discoveries of self-organizing patterns in various target complex systems.

In particular, it will include:

- Working on a modular Python library allowing to define and study various combinations of exploration and visualization algorithms with several target systems. This will involve implementing advanced machine learning algorithms, collaborating with other members of the team to develop novel versions of these algorithms and testing them in various scientific studies about target dynamical systems with end-users (collaborations with other labs).
- Participating in building a user-friendly web application to control the Python library enabling scientists to perform, guide and visualize experiments. This will involve working on a microservice-based architecture made of multiple databases, REST APIs and an Angular application.
- Leading the packaging, open-source release and maintenance of the overall framework. This will involve disseminating and interacting with scientist end-users (internal or external of the lab).

How to apply: send an email to clement.moulin-frier@inria.fr AND pierre-yves.oudeyer@inria.fr with a CV and letter of motivation (with [APPLICATION] included in subject of email), in addition to applying on the Inria web site. **We recommend that interested candidates contact us as soon as possible.**

Main activities

- Implementation of a modular Python library for connecting exploration algorithms, visualization algorithms and the dynamical systems
- Implementation of a microservice-based software connecting the Python library to an interface for users
- Implementation of exploration and representation learning algorithms
- Participation in the design and study of novel interactive algorithms and their scientific study in experimentations
- Participation in experiments studying novel patterns through the use of the framework in various target systems
- Dissemination of the work through documentation, blog post and article writing

Skills

Technical competences:

- Software engineering:
 - Python (Flask)
 - SQL and NoSQL databases (PostgreSQL, MongoDB)
 - Front-End development (Angular, Bootstrap)
 - Docker
- Scientific programming:
 - Python
 - Machine learning algorithms and frameworks (PyTorch)

Other competencies appreciated:

- Machine Learning and Deep Learning
- Computer visualization of data
- User-centered design, design of interfaces
- Interest in the study of self-organizing complex systems

Language: English

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- Possibility of teleworking 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

Remuneration

From 2632€ to 3240€ gross monthly depending on experience

General Information

- **Theme/Domain** : Robotics and Smart environments
Statistics (Big data) (BAP E)
- **Town/city** : Talence
- **Inria Center** : [Centre Inria de l'université de Bordeaux](#)
- **Starting date** : 2022-06-01
- **Duration of contract** : 1 year, 9 months
- **Deadline to apply** : 2022-09-30

Contacts

- **Inria Team** : [FLOWERS](#)
- **Recruiter** :
Oudeyer Pierre-yves / Pierre-Yves.Oudeyer@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

Thank you to send:

- CV
- Cover letter
- Master Degree

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.