2018-00388 - PhD - Computational models of curiosity-driven exploration in humans and monkeys

Niveau de diplôme exigé : Bac + 5 ou équivalent
Fonction : Doctorant

A propos du centre ou de la direction fonctionnelle

The Flowers team studies computational mechanisms allowing robots and humans to acquire open-ended repertoires of skills through life-long learning. This includes the processes for progressively discovering their bodies and interaction with objects, tools and others. In particular, we study mechanisms of intrinsically motivated learning (also called curiosity-driven active learning), autonomous unsupervised exploration, imitation and social learning, multimodal statistical inference, embodiment and maturation and self-organization.

The team considers cognitive development as a complex dynamical system which needs to be understood through systemic thinking, leveraging tools and concepts from computational sciences (artificial intelligence, machine learning and robotics), neuroscience and psychology. In this perspective, algorithms and robotics models are powerful scientific languages to express theories of cognitive development in the living.

Of particular interest to the Flowers team is the formation of repertoires of sensorimotor and interaction skills as well as their relation with the acquisition and evolution of languages.

The team is also working on applications of this research in three fields: adaptive human-computer interfaces, educational technologies and open-source robotics for art and education.

Web site of Flowers Lab : https://flowers.inria.fr

Contexte et atouts du poste

Scientific priorities at Inria and strategic role for the Flowers team :

This topic is centrally relevant to several elements of the Inria strategic plan because it aims at understanding and modelling better human learning and development, dealing with the axis “Sciences that serve individuals, society and knowledge: The human as such ... the digital modelling of cognitive and psychological mechanisms constitutes a groundbreaking multi-disciplinary research field. ... inria will significantly develop its scientific partnerships on this subject with the human and social sciences. » This topic is also centrally related to the Inria associated team Neurocuriosity, where collaborations with Univ. Columbia, US and Univ. Rochester, US, are being developed.

Scientific research context :

Curiosity and creativity are among the last unexplored frontiers of higher cognition, and we know very little about their neural and behavioural mechanisms in humans and animals. In the last ten years, the Flowers team has been developing computational/mathematical models of spontaneous exploration and active information seeking, and recently teamed up with Jacqueline Gottlieb’s Cognitive Neuroscience Lab (Univ. Columbia, NY, US) and Celeste Kidd’s developmental psychology lab (Univ. Rochester, US), to develop theories as well as new experimental paradigms allowing to uncover mechanisms of curiosity (Gottlieb et al., 2013; Kidd and Hayden, 2015). In this context, curiosity can be understood as a family of mechanisms that evolved to allow agents to maximize their knowledge and control of the useful properties of the world - i.e., the regularities that exist in the world - using active, targeted investigations. In other words, we view curiosity as a decision process that maximizes learning (rather than minimizing uncertainty) and assigns value (“interest”) to competing tasks based on their epistemic qualities - i.e., their estimated potential allow discovery and learning about the structure of the world.
Mission confiée

The goal of this PhD will consist in elaborating and analysing new models of information-seeking and active exploration in the context of original experimental paradigms developed in the Inria Neurocuriosity 2 Associated Team project (associating Inria Flowers, Univ. Columbia, Univ. Rochester, starting in 2016). These models will be based on the technical framework of Bayesian reinforcement learning and extend models developed recently in the team (Daddoua et al., 2016; Gottlieb et al., 2013; Oudeyer and Kaplan, 2007), and be compared to the related theoretical framework by Friston (2010) and called the free-energy principle. The goal of these model will be to account for behavioural and neural data observed in three series of experiments that will happen in the project : experiments studying

1) information-seeking behaviour in humans during free exploration (and how it is modulated by individual cognitive and personality factors)
2) information-seeking behaviour in human children during free play (and how it is modulated by individual factors)
3) information-seeking behaviour and neural correlates in monkeys

Principales activités

A first phase of the work will consist in familiarization with the existing models, and to characterize the limitations of these models to account for existing data, and/or the limitations of current experimental data to confirm or invalidate these models. This analysis will lead to a second phase where on the one hand these models will be extended to account for a wider range of data, and on the other hand to collaborate with partners from Columbia Univ. and Rochester Univ. to define the details of new experimental protocols to test the predictions of these models. In particular, these model extensions will address individual and cross-species differences in curiosity-driven exploration, studying causal factors for these differences. Also, the design of new experimental paradigms will be designed so as to allow to test the Learning Progress hypothesis (Oudeyer et al., 2007; Gottlieb et al., 2013), which assumes a meta-cognitive mechanism that assigns value to competing tasks based on the learning progress (LP) related to each task.

During the PhD work, the collaboration with Jacqueline Gottlieb and Celeste Kidd will involve travels to their universities in the US (funded by associated team Neurocuriosity and project HFSP), and joint writing of scientific articles.

Web site of these collaborating labs :

- Kidd Lab, Univ. Rochester, US: [http://www.bcs.rochester.edu/people/ckidd/](http://www.bcs.rochester.edu/people/ckidd/)

Keywords : curiosity, exploration, learning, computational model, computational neuroscience, active learning, reinforcement learning, decision making

References :


Compétences

Required knowledge and background :

Strong skills in cognitive modelling, neural network models, machine learning. Advanced programming skills in script languages like python/Matlab. Motivation to work in an interdisciplinary project at the frontiers of computer science, neuroscience
and psychology.

**Avantages sociaux**
- Subsidised catering service
- Partially-reimbursed public transport

**Rémunération**
1982€ / month (before taxes) during the first 2 years, 2085€ / month (before taxes) during the third year.