A propos du centre ou de la direction fonctionnelle

At the frontier between integrative and computational neuroscience, we propose to model the brain as a system of active memories in synergy and in interaction with the internal and external world and to simulate it as a whole and in situation. Major cognitive and behavioral functions (eg attention, recognition, decision, planning, execution) emerge from adaptive sensorimotor loops involving the external world, the body and the brain. We study, model and implement such loops and their interactions toward a fully autonomous behavior. With such a “systemic” approach, we mean that such complex systems can only be truly apprehended as a whole and in natural behavioral situation. To design the functioning and learning characteristics of such models at the level of the neuronal circuitry and to implement them in systems interacting in loops with the world, we combine principles, methods and tools from different fields of science.

- We model the main cerebral structures and flows of information in the brain (as in integrative and cognitive neuroscience), stressing the links between brain, body and environment (embodied cognition)
- We use distributed computing formalisms allowing us to implement such models at different levels of description (as in computational neuroscience)
- We deploy our models at large scale (high performance computing), incarnate them in bodies interacting with the environment (autonomous robotics) and simulate them interactively with respect to events encountered by a (virtual/real) robot.

Not only do we expect to share back such an integrative approach among these different fields of science, but beyond, we also aim at contributing to other related areas of both life sciences (neuroscience, medicine) and digital science (computer science, machine learning).

Contexte et atouts du poste

The ANR SOMA project gathers neuroscientists, computer science researchers, hardware architects and micro-electronics designers to explore the concept of a Self-Organizing Machine Architecture : SOMA.

This Self-Organizing property already studied in various fields of computer science (artificial neural networks, multi-agents and learning systems, cellular automata ...), is studied for the very first time in a new context with a transverse look from the computational neuroscience discipline to the design of reconfigurable microelectronic circuits. The project focuses on the blocks that will pave the way in the long term for smart computing substrates, exceeding the limits of current technology.

Neurobiological systems have been a source of inspiration for computer science and engineering. The rapid technological improvements of computing devices have recently strengthened this trend through two complementary though with apparent contradictory consequences: by offering a huge computational power, it has made the simulation of very large neural structures possible, and by reaching its end programming and intellectual limitations, it has motivated the emergence of alternative computing devices based on bio-inspired concepts. Thus, by evolving from a personal computing usage to a ubiquitous computing paradigm, present both in daily objects (connected objects), embedded systems and beyond daily digital services (social networks, emails ...), computing devices and computers deserve now to be rethought: how to represent complex information, how to handle this information, why dissociating data and computation? In front of such issues, the brain still remains our best source of inspiration. It offers us a different perspective on the organization of computing systems to meet the challenges of the increasing complexity of current and future problems to be solved by these systems. Several current issues such as analysis and classification of major data sources (sensor fusion, big data, Internet of things) and the need for adaptivity in many application areas (autonomous drones, driving delegation in automotive systems, space exploration...) lead us to study a desirable property from the brain that encompasses all others: the cortical plasticity.

Mission confiée

The model will be designed under the supervision of Nicolas Rougier who has an extensive experience in computational modelling. Predictions of the model will then be tested experimentally by measuring the neuronal activity in the BG loop and the downstream neural population (in RA) under the supervision of Arthur Leblois. Chronic electrophysiological recordings in singing birds are routinely performed in the lab of Arthur Leblois, and will be implemented in a protocol allowing the induction of song plasticity in young adult birds over short periods of time.

Principales activités

The proposed research lies at the interface of neurophysiology, cognitive science, applied mathematics, and theoretical physics. The concepts and methods that will be used will draw on single neuron physiology, electrophysiological studies in behaving animals, statistical mechanics, dynamical system theory, and stochastic differential equations. The aim is to reveal the microscopic (cellular, neuronal) factors which underlie the reorganization of neural circuits during the adaptation of behaviour. More specifically, the ultimate goal is to propose a framework in which the control of vocal output is transferred from the BG networks to cortical premotor networks during song learning.
this end, we will combine a theoretical approach (development of a mathematical model of the song system) and an experimental one (chronic neural recording in awake birds, behavioural manipulations). Therefore, a collaboration with a team of physiologists at the IMN, and in particular with Arthur Leblois who has a long-established expertise in the neural mechanisms underlying vocal learning in songbirds.

**Compétences**
The candidate must:
- have a solid formation in neurosciences at both the theoretical and experimental levels
- have a prior experience in research (master level)
- be fluent in English

**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.