



IN PARTNERSHIP WITH:
CNRS

Université de Lorraine

Activity Report 2013

Team CORTEX

Neuromimetic intelligence

IN COLLABORATION WITH: Laboratoire lorrain de recherche en informatique et ses applications (LORIA)

RESEARCH CENTER
Nancy - Grand Est

THEME
**Computational Medicine and Neuro-
sciences**

Table of contents

1. Members	1
2. Overall Objectives	1
3. Research Program	2
3.1. Computational neuroscience	2
3.2. Computational neuroscience at the microscopic level: spiking neurons and networks	3
3.3. Computational neuroscience at the mesoscopic level: dynamic neural fields	3
3.4. Connectionist parallelism	3
3.5. The embodiment of cognition	4
4. Application Domains	4
5. Software and Platforms	4
5.1. Spiking neural networks simulation	4
5.2. CLONES: Closed-Loop Neural Simulations	5
6. New Results	5
6.1. Understanding embodied neural systems	5
6.1.1. Bio-physical modeling and embodied olfaction	5
6.1.2. Somato-sensory cortex	6
6.1.3. K-cells in visuomotor tasks	6
6.2. Neuro-inspired computational models	7
6.2.1. Motion detection	7
6.2.2. Multimodal learning through joint dynamic neural fields	7
6.2.3. Adaptive sensori-motor loop	7
6.2.4. Randomly spiking dynamic neural fields	7
7. Partnerships and Cooperations	7
7.1. National Initiatives	7
7.1.1. ANR project PHEROTAXIS	7
7.1.2. ANR project KEOPS	8
7.2. International Initiatives	8
7.3. International Research Visitors	8
7.3.1.1. Visiting professors/researchers	8
7.3.1.2. Internships	8
8. Dissemination	9
8.1. Scientific Animation	9
8.1.1. Responsibilities	9
8.1.2. Review activities	9
8.2. Teaching - Supervision - Juries	9
8.2.1. Teaching	9
8.2.2. Supervision	9
8.2.3. Juries	9
9. Bibliography	10

Team CORTEX

Keywords: Computational Neurosciences, Signal Processing, Neural Network, Machine Learning, Brain Computer Interface

Creation of the Project-Team: 1997 January 01, *updated into Team:* 2013 January 01, end of the Team: 2013 June 30.

1. Members

Research Scientists

Dominique Martinez [CNRS, Researcher]
Thomas Voegtlin [Inria, Researcher]
Nicole Voges [CNRS, short term contract researcher]

Faculty Members

Bernard Girau [Univ. Lorraine, Professor, Faculté des Sciences et Technologies de Nancy, Team leader, HDR]
Yann Boniface [Univ. Lorraine, Associate Professor, IUT Charlemagne]
Patrick Hénaff [Univ. Lorraine, Professor, from Sep 2013, École des Mines de Nancy, HDR]

Engineer

Nicolas Carrara [Inria, granted by ANR KEOPS project, from Jun 2013 until Sep 2013]

PhD Students

Carlos Carvajal-Gallardo [Inria, granted by ANR KEOPS project and Région Lorraine]
Benoît Chappet de Vangel [Univ. Lorraine, granted by Univ. Lorraine doctoral contract]
Georgios Detorakis [Inria, CORDI-S, until Nov 2013]

Visiting Scientists

Fatiha Hendel [Univ. Oran, Apr 2013]
César Torres-Huitzil [Cinvestav Tamaulipas, Mexico, Jul 2013]
Siqi Zhang [Macquarie Univ., Sydney, from Sep 2013]

Administrative Assistants

Laurence Benini [Inria]
Laurence Félicité [Univ. Lorraine]

Others

Chahinez Bentaouza [Univ. of Mostaganem, Algeria, Dec 2013]
Pedro Alberto Cerna Garcia [from Oct 2013]
Benjamin Gras [Univ. Lorraine, student, from Jun 2013 until Jul 2013]
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2. Overall Objectives

2.1. Overall Objectives

The goal of our research is to study the properties and computational capacities of distributed, numerical and adaptative networks, as observed in neuronal systems. In this context, we aim to understand how complex high level properties may emerge from such complex systems including their dynamical aspects. Three main scales of description of neural mechanisms are usually studied in Neuroscience, namely neurons, populations and behaviors.

1. **Neurons:** At the microscopic level, precise and realistic models of neurons and of the related dynamics are defined, analyzing the neural code in small networks of spiking neurons (*cf.* § 3.2).

2. **Population of neurons:** At the mesoscopic level, the characteristics of a local circuit are integrated in a high level unit of computation, i.e. a dynamic neural field (*cf.* § 3.3). This level of description allows to study larger neuronal systems, such as cerebral maps, as observed in sensori-motor loops.
3. **Higher level functions:** At the macroscopic level, the analysis of physiological signals and psychometric data is to be linked to more cognitive and behavioral hints.

Previously involved in the study of neural computations at these different levels of description around four major research lines (spiking neurons, dynamic neural fields, higher level functions, embodied and embedded neural systems), the Cortex team has recently drastically evolved by splitting in three parts. The Mnemosyne team has been created at Inria Bordeaux with three former members of Cortex, now focusing on modeling the brain as a set of situated active memories. Two other former members of Cortex have initiated the Neurosys team in LORIA, that targets multi-level modeling of neural mechanisms. Following these team creations, the Cortex team now gathers five researchers, one of them having joined the team at the end of the year (and another one having been involved in a project to build a small company). The scientific activity of the team now focuses on the previous transversal axis “Embodied and embedded neural systems”, while being still involved in the study of microscopic and mesoscopic aspects of neural computations that we use in our systems.

Our research is linked to several scientific domains described in the next section. In the domain of computer science, we generate neuromimetic paradigms of distributed spatial computation and we aim at explaining their properties, intrinsic (e.g. robustness) as well as functional (e.g. self-organization). From a cognitive science point of view, our models are used to emulate various functions (e.g. attention, olfaction, sensori-motor coordination) which are consequently fully explained by purely distributed asynchronous computations.

In order to really explore such bio-inspired computations, the key point is to remain consistent with biological and ecological constraints. Among computational constraints, computations have to be really distributed, without central clock or common memory. The emerging cognition has to be situated (*cf.* § 3.5), i.e. resulting from a real interaction in the long term with the environment. As a consequence, our models are particularly well validated with parallel architectures of computations (e.g. FPGA, clusters, *cf.* § 3.4) and embodied in systems (robots) that interact with their environment (*cf.* § 3.5).

Accordingly, two topics of research have been carried out this year.

- Understanding embodied neural systems: bio-physical modeling and embodied olfaction; somato-sensory cortex; K-cells in visuomotor tasks,
- Neuro-inspired computational models: motion detection; multimodal learning through joint dynamic neural fields; randomly spiking dynamic neural fields.

3. Research Program

3.1. Computational neuroscience

Computational neuroscience combines experiments with data analysis and functional models with computer simulation on the basis of strong theoretical concepts and aims at understanding mechanisms that underlie neural processes such as perception, action, learning, memory or cognition.

Today, computational models are able to offer new approaches for the understanding of the complex relations between the structural and the functional level of the brain, thanks to models built at several levels of description. In very precise models, a neuron can be divided in several compartments and its dynamics can be described by a system of differential equations. The spiking neuron approach (*cf.* § 3.2) proposes to define simpler models concentrated on the prediction of the most important events for neurons, the emission of spikes. This allows to compute networks of neurons and to study the neural code with event-driven computations.

Larger neuronal systems are considered when the unit of computation is defined at the level of the population of neurons and when rate coding and/or correlations are supposed to bring enough information. Studying Dynamic Neural Fields (*cf.* § 3.3) consequently lays emphasis on information flows between populations of neurons (feed-forward, feed-back, lateral connectivity) and is well adapted to defining high-level capabilities related for example to visuomotor coordination.

3.2. Computational neuroscience at the microscopic level: spiking neurons and networks

Computational neuroscience is also interested in having more precise and realistic models of the neuron and especially of its dynamics. We consider that the latter aspect cannot be treated at the single unit level only; it is also necessary to consider interactions between neurons at the microscopic scale.

On one hand, compartmental models describe the neuron at the inner scale, through various compartments (axon, synapse, cellular body) and coupled differential equations, allowing to numerically predict the neural activity at a high degree of accuracy. This, however, is intractable if analytic properties are to be derived, or if neural assemblies are considered. We thus focus on phenomenological punctual models of spiking neurons, in order to capture the dynamic behavior of the neuron isolated or inside a network. Generalized conductance based leaky integrate and fire neurons (emitting action potential, i.e. spike, from input integration) or simplified instantiations are also considered in our group.

On the other hand, one central issue is to better understand the precise nature of the neural code. From rate coding (the classical assumption that information is mainly conveyed by the firing frequency of neurons) to less explored assumptions such as high-order statistics, time coding (the idea that information is encoded in the firing time of neurons) or synchronization aspects. At the biological level, a fundamental example is the synchronization of neural activities, which seems to play a role in, e.g., olfactory perception: it has been observed that abolishing synchronization suppresses the odor discrimination capability.

3.3. Computational neuroscience at the mesoscopic level: dynamic neural fields

Our research activities are also interested in the understanding of higher brain functions using both computational models and robotics. These models are grounded on a computational paradigm that is directly inspired by several brain studies converging on a distributed, asynchronous, numerical and adaptive processing of information and the continuum neural field theory (CNFT) provides the theoretical framework to design models of population of neurons.

This mesoscopic approach underlines the fact that the number of neurons is very high, even in a small part of tissue, and proposes to study neuronal models in a continuum limit where space is continuous and main variables correspond to synaptic activity or firing rates in population of neurons. This formalism is particularly interesting because the dynamic behavior of a large piece of neuronal tissue can be studied with differential equations that can integrate spatial (lateral connectivity) and temporal (speed of propagation) characteristics and display such interesting behavior as pattern formation, travelling waves, bumps, etc.

The main cognitive tasks we are currently interested in are related to sensorimotor systems in interaction with the environment (perception, coordination, planning). We build models inspired by the neuronal structures involved in these tasks, trying to emulate the corresponding information processing (filtering in perceptive maps, multimodal association in associative maps, temporal organization of behavior in frontal maps, selection of action in basal ganglia). Our aim is to iteratively refine these models, implement them on autonomous robots and make them cooperate and exchange information, toward a completely adaptive, integrated and autonomous behavior.

3.4. Connectionist parallelism

Connectionist models, such as neural networks, are among the first models of parallel computing. Artificial neural networks now stand as a possible alternative with respect to the standard computing model of current computers. The computing power of these connectionist models is based on their distributed properties: a very fine-grain massive parallelism with densely interconnected computation units.

The connectionist paradigm is the foundation of the robust, adaptive, embeddable and autonomous processings that we aim at developing in our team. Therefore their specific massive parallelism has to be fully exploited. Furthermore, we use this intrinsic parallelism as a guideline to develop new models and algorithms for which parallel implementations are naturally made easier.

Our approach is related to a very fine parallelism grain that fits parallel hardware devices, as well as to the emergence of very large reconfigurable systems that become able to handle both adaptability and massive parallelism of neural networks. More particularly, digital reconfigurable circuits (e.g. FPGA, Field Programmable Gate Arrays) stand as the most suitable and flexible device for low cost fully parallel implementations of neural models, according to numerous recent studies in the connectionist community.

3.5. The embodiment of cognition

Recent theories from cognitive science stress that human cognition emerges from the interactions of the body with the surrounding world. Through motor actions, the body can orient toward objects to better perceive and analyze them. The analysis is performed on the basis of physical measurements and more or less elaborated emotional reactions of the body, generated by the stimuli. This elicits other orientation activities of the body (approach and grasping or avoidance). This elementary behavior is made possible by the capacity, at the cerebral level, to coordinate the perceptive representation of the outer world (including the perception of the body itself) with the behavioral repertoire that it generates either on the physical body (external actions) or on a more internal aspect (emotions, motivations, decisions). In both cases, this capacity of coordination is acquired from experience and interaction with the environment.

The theory of the situatedness of cognition proposes to minimize representational contents (opposite to complex and hierarchical representations) and privileges simple strategies, more directly coupling perception and action and more efficient to react quickly in the changing environment. For example, the organism can keep track of relevant visual targets in the environment by only storing the movement of the eye necessary to foveate them. We do not memorize details of the objects but we know which eye movement to perform to get them: the world itself is considered as an external memory.

In this view, learning emerges from sensorimotor loops and a real body interacting with a real environment are important characteristics for a learning protocol.

4. Application Domains

4.1. Overview

Our application domain is twofold:

We design embedded systems such as in-silico implementations of bio-inspired processes, focusing on spatial and distributed computing.

We develop embodied systems such as robotic implementation of sensori-motor loops, the bio-inspiration yielding such interesting properties as adaptivity and robustness.

5. Software and Platforms

5.1. Spiking neural networks simulation

Participants: Dominique Martinez, Yann Boniface.

A spiking neuron is usually modeled as a differential equation describing the evolution over time of its membrane potential. Each time the voltage reaches a given threshold, a spike is sent to other neurons depending on the connectivity. A spiking neural network is then described as a system of coupled differential equations. For the simulation of such a network we have written two simulation engines: (i) Mvaspike based on an event-driven approach and (ii) sirene based on a time-driven approach.

- Mvaspike: The event-driven simulation engine was developed in C++ and is available on <http://mvaspike.gforge.inria.fr>. Mvaspike is a general event-driven purpose tool aimed at modeling and simulating large, complex networks of biological neural networks. It allows to achieve good performance in the simulation phase while maintaining a high level of flexibility and programmability in the modeling phase. A large class of spiking neurons can be used ranging from standard leaky integrate-and-fire neurons to more abstract neurons, e.g. defined as complex finite state machines.
- Sirene: The time-driven simulator engine was written in C and is available on <http://sirene.gforge.inria.fr>. It has been developed for the simulation of biologically detailed models of neurons —such as conductance-based neurons— and synapses. Its high flexibility allows the user to implement easily any type of neuronal or synaptic model and use the appropriate numerical integration routine (e.g. Runge-Kutta at given order).

5.2. CLONES: Closed-Loop Neural Simulations

Participant: Thomas Voegtlin.

The goal of this work is to provide an easy-to-use framework for closed-loop simulations, where interactions between the brain and body of an agent are simulated.

We developed an interface between the Sofa physics engine, (<http://www.sofa-framework.org>) and the Brian neural simulator (<http://www.briansimulator.org>). The interface consists in a Sofa plugin and a Python module for Brian. Sofa and Brian use different system processes, and communicate via shared memory. Synchronization between processes is achieved through semaphores.

As a demonstration of this interface, a physical model of undulatory locomotion in the nematode *c. elegans* was implemented, based on the PhD work of Jordan H. Boyle.

6. New Results

6.1. Understanding embodied neural systems

Participants: Dominique Martinez, Carlos Carvajal-Gallardo, Georgios Detorakis.

6.1.1. Bio-physical modeling and embodied olfaction

Our understanding of the computations that take place in the human brain is limited by the extreme complexity of the cortex, and by the difficulty of experimentally recording neural activities, for practical and ethical reasons. The Human Genome Project was preceded by the sequencing of smaller but complete genomes. Similarly, it is likely that future breakthroughs in neuroscience will result from the study of smaller but complete nervous systems, such as the insect brain or the rat olfactory bulb. These relatively small nervous systems exhibit general properties that are also present in humans, such as neural synchronization and network oscillations. Our goal has been therefore to understand the role of these phenomena by combining biophysical modelling and experimental recordings, before applying this knowledge to humans. In the last year, we have extended our neuronal model of the insect olfactory system. This model is capable of reproducing and explaining the stereotyped multiphasic firing pattern observed in pheromone sensitive antennal lobe neurons [10].

Using this model in robotic experiments and insect antennae as olfactory sensors, we related these multiphasic responses to action selection. The efficiency of the model for olfactory searches was demonstrated in driving the robot toward a source of pheromones. Two different classes of strategies are possible for olfactory searches, those based on a spatial map, e.g. Infotaxis, and those where the casting-and-zigzagging behaviour observed in insects is purely reactive, without any need for an internal memory, representation of the environment, or inference [15]. Our goal was to investigate this question by implementing infotactic and reactive search strategies in a robot and test them in real environmental conditions. We previously showed that robot Infotaxis produces trajectories that feature zigzagging and casting behaviours similar to those of moths, is robust and allows for rapid and reliable search processes. We have implemented infotactic and reactive search strategies in a cyborg using the antennae of a tethered moth as sensors, since no artificial sensor for pheromone molecules is presently known [10].

6.1.2. Somato-sensory cortex

In a joint work with the Mnemosyne team, we have investigated the formation and maintenance of ordered topographic maps in the primary somatosensory cortex as well as the reorganization of representations after sensory deprivation or cortical lesion. We consider both the critical period (postnatal) where representations are shaped and the post-critical period where representations are maintained and possibly reorganized. We hypothesize that feed-forward thalamocortical connections are an adequate site of plasticity while cortico-cortical connections are believed to drive a competitive mechanism that is critical for learning. We model a small skin patch located on the distal phalangeal surface of a digit as a set of 256 Merkel ending complexes (MEC) that feed a computational model of the primary somatosensory cortex (area 3b). This model is a two-dimensional neural field where spatially localized solutions (a.k.a. bumps) drive cortical plasticity through a Hebbian-like learning rule. Simulations explain the initial formation of ordered representations following repetitive and random stimulations of the skin patch. Skin lesions as well as cortical lesions are also studied and results confirm the possibility to reorganize representations using the same learning rule and depending on the type of the lesion. For severe lesions, the model suggests that cortico-cortical connections may play an important role in complete recovery [11], [19], [7].

6.1.3. K-cells in visuomotor tasks

In another joint work with the Mnemosyne team, we have explored the role of the thalamus in visuomotor tasks implicating non-standard ganglion cells. Such cells in the retina have specific loci of projection in the visuomotor systems and particularly in the thalamus and the superior colliculus. In the thalamus, they feed the konio pathway of the LGN. Exploring the specificities of that pathway, we discovered it could be associated to the matrix system of thalamo-cortical projections, known to allow for diffuse patterns of connectivity and to play a major role in the synchronization of cortical regions by the thalamus. An early model led to the design of the corresponding information flows in the thalamo-cortical system, that we expanded, in the framework of the Keops project, to be applied to real visuomotor tasks [13].

We proposed to implement the computational principles raised by the study on the K-cells of the retina using a variational specification of the visual front-end, with an important consequence. In such a framework, the GC are not to be considered individually, but as a network, yielding a mesoscopic view of the retinal process. Given natural image sequences, fast event-detection properties appear to be exhibited by the mesoscopic collective non-standard behavior of a subclass of the so-called dorsal and ventral konio-cells (K-cells) that correspond to specific retinal output. We considered this visual event detection mechanism to be based on image segmentation and specific natural statistical recognition, including temporal pattern recognition, yielding fast region categorization. We discussed how such sophisticated functionalities could be implemented in the biological tissues as a unique generic two-layered non-linear filtering mechanism with feedback. We used computer vision methods to propose an effective link between the observed functions and their possible implementation in the retinal network. The available computational architecture is a two-layers network with non-separable local spatio-temporal convolution as input, and recurrent connections performing non-linear diffusion before prototype based visual event detection [17].

6.2. Neuro-inspired computational models

Participants: Yann Boniface, Benoît Chappet de Vangel, Bernard Girau, Patrick Hénaff.

6.2.1. Motion detection

We develop bio-inspired neural architectures to extract and segment the direction and speed components of the optical flow from sequences of images. Following this line, we have built additional models to code and distinguish different visual sequences. The structure of these models takes inspiration from the course of visual movement processing in the human brain, such as in area MT (middle temporal) that detects patterns of movement, or area FST where neurons have been found to be sensitive to single spatio-temporal patterns. This work has been extended to complex movements: to fight, to wave, to clap, using real-world video databases [9].

6.2.2. Multimodal learning through joint dynamic neural fields

We have developed a coherent multimodal learning for a system with multiple sensory inputs. To this aim, we modified the BCM synaptic rule, a local learning rule, to obtain the self organization of our neuronal inputs maps and we used a CNFT based competition to drive the BCM rule. In practice, we introduced a feedback modulation of the learning rule, representing multimodal constraints of the environment. We also introduced an unlearning term in the BCM equation to solve the problem of the different temporalities between the raise of the activity within modal maps and the multimodal learning of the organization of the maps [12].

6.2.3. Adaptive sensori-motor loop

We develop bio-inspired neural controllers to control humanoids robot when they interact physically (or socially) with the human. We focus on the role of rythmicity in the interaction: how the phenomena of coupling, synchrony or others are involved in the interaction between humans? what models of neural structures can incorporate rythmicity intrinsically, and can include learning or adaptive mechanisms of the rythmicity.

6.2.4. Randomly spiking dynamic neural fields

We have defined a new kind of spiking neural field that is able to use only local links while transmitting spikes through the map by successive random propagations. Such a model is able to be mapped onto FPGAs, while maintaining most properties of neural fields. This model has been validated from a behavioral point of view, and a fully scalable hardware implementation has been designed with several thousands of neurons on-chip. These first results are the object of an article that is currently reviewed after requested revisions.

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR project PHEROTAXIS

Participants: Dominique Martinez, Thomas Voegtlin.

How can animals so successfully locate odor sources? This apparently innocuous question reveals on analysis unexpectedly deep issues concerning our understanding of the physical and biological world and offers interesting prospects for future applications. Pherotaxis focuses on communication by sex pheromones in moths. The main aim of the project is to integrate the abundant experimental data on the pheromone plumes, neural networks and search behaviour available in the literature, as well as that collected or being collected by us at the molecular, cellular, systemic and behavioural levels into a comprehensive global model of the pheromonal olfactory processes. To reach this objective, the consortium combines several groups of specialists with different and complementary fields, in physics (Institut Pasteur IP), neurobiology (INRA) and bio-robotics (Inria).

7.1.2. ANR project KEOPS

Participant: Carlos Carvajal-Gallardo.

This «ANR Internal White Project» involving NEUROMATHCOMP and CORTEX (and now MNEMOSYNE since most Cortex members involved in this project are now in this team) Inria EPI in France with the U. of Valparaiso, U. Tecnica Frederico Santa-Maria, and U. De Chili is a 3 years, 248 person-months, sensory biology, mathematical modeling, computational neuroscience and computer vision, project addressing the integration of non-standard behaviors from retinal neural sensors, dynamically rich, sparse and robust observed in natural conditions, into neural coding models and their translation into real, highly non-linear, bio-engineering artificial solutions. An interdisciplinary platform for translation from neuroscience into bioengineering will seek convergence from experimental and analytical models, with a fine articulation between biologically inspired computation and nervous systems neural signal processing (coding / decoding).

7.2. International Initiatives

7.2.1. Participation In other International Programs

Conacyt project with Mexico (2010-2013):

We work with the Cinvestav Tamaulipas research center (Mexico), on the analysis, methods and techniques for the embedded implementation of massively distributed bio-inspired connectionist processing for perception tasks on reconfigurable devices under a hardware/model codesign approach, through a project funded by the Mexican ministry Conacyt. Our works were mostly oriented towards the study of the properties of massively distributed elementary computations in bio-inspired models for vision in order to provide efficient implementation into reconfigurable logic devices. Other activities extended our works to sensori-motor systems, including embedded control of low-level locomotion by means of CPG models (central pattern generators).

7.3. International Research Visitors

7.3.1. Visits of International Scientists

7.3.1.1. Visiting professors/researchers

Chahinez Meriem BENTAOUZA (December 2013)

Funding: University of Mostaganem

Subject: Etude bibliographique de méthodes d'apprentissage statistique pour l'analyse de signaux médicaux

Institution: University of Mostaganem, Algeria

Fatiha HENDEL (April 2013)

Funding: University of Oran

Subject: Apprentissage et classification automatique

Institution: University of Oran, Algeria

Cesar TORRES-HUITZIL (July 2013)

Funding: Conacyt project

Subject: Hardware implementations of neural networks

Institution: Cinvestav Tamaulipas, Mexico

7.3.1.2. Internships

Hariharan NATANASIHAMANI (from May 2013 until Sep 2013)

Subject: Developmental reinforcement learning

Institution: McGill University, Canada

8. Dissemination

8.1. Scientific Animation

8.1.1. Responsibilities

- Head of the Complex systems and AI department of the LORIA laboratory (B. Girau)
- Organization of a talk series on Image, Perception, Action & Cognition on a monthly basis at the Inria-Nancy Grand Est laboratory (<http://ipac.loria.fr/>), Y. Boniface with researchers of other teams).

8.1.2. Review activities

- Reviewing for journals and conferences: Artificial Intelligence in Medicine journal (P. Hénaff), International Journal of Advanced Robotic Systems (P. Hénaff), Progress in Artificial Intelligence (B. Girau)
- Member of program committees: Reconfig (B. Girau), IEEE 34th International Conference on Electronics and Nanotechnology ELNANO-2014 (P. Hénaff)
- Evaluation of ANR Blanc SIMI 3 projects (B. Girau)

8.2. Teaching - Supervision - Juries

8.2.1. Teaching

Many courses are given in universities and schools of engineers at different levels (LMD) by most team members, in computer science, in applied mathematics and in cognitive science. Moreover, several members of the team are implied in various kinds of academic responsibilities: Laurent Bougrain is head of the IPAC speciality of the Master In Computer Science, Bernard Girau is member of the Conseil de Collegium Science et Technologie of the University of Lorraine, as well as of the Conseil de Secteur Scientifique MIAE.

8.2.2. Supervision

PhD: Maxime Rio, Modèles bayésiens pour la détection de synchronisations au sein de signaux électro-corticaux, Université de Lorraine, 16/07/2013, B. Girau and A. Hutt (work in relation with the Neurosys team)

PhD: Georgios Detorakis, Plasticité corticale, champs neuronaux dynamiques et auto-organisation, Université de Lorraine, 23/10/2013, N. Rougier

PhD: Carolina Saavedra, Méthodes d'analyse et de débruitage multicanaux à partir d'ondelettes pour améliorer la détection de potentiels évoqués sans moyennage, Université de Lorraine, 14/11/2013, B. Girau and L. Bougrain (work in relation with the Neurosys team)

PhD in progress: Carlos Carvajal-Gallardo, Faisabilité d'une Rétine Artificielle pour la Vision Humaine : Étude Critique des Solutions Électroniques et Contre-Solutions, from 23/02/12, F. Alexandre

PhD in progress: Benoît Chappet, Champs neuronaux dynamiques impulsionnels aléatoires, from october 2012, B. Girau

PhD in progress: Artem Melnyk, Perfectionnement des algorithmes de contrôle-commande des robots manipulateur électriques en interaction physique avec leur environnement par une approche bio-inspirée, from january 2010, co-supervision between Donetsk Technical University (Ukraine) and University of Cergy Pontoise, P. Hénaff

8.2.3. Juries

PhD: Maxime Rio, Modèles bayésiens pour la détection de synchronisations au sein de signaux électro-corticaux, Université de Lorraine, 16/07/2013 (B. Girau, as advisor)

PhD: Carolina Saavedra, Méthodes d'analyse et de débruitage multicanaux à partir d'ondelettes pour améliorer la détection de potentiels évoqués sans moyennage, Université de Lorraine, 14/11/2013 (B. Girau, as advisor)

HDR: Slim Ouni, Parole multimodale : de la parole articulatoire à la parole audiovisuelle, Université de Lorraine, 29/11/2013 (B. Girau, president)

PhD: Nicolas Estibals, Algorithmes et arithmétique pour l'implémentation de couplages cryptographiques, Université de Lorraine, 30/10/2013 (B. Girau, president)

PhD: Julie Busset, Inversion acoustique articulatoire à partir de coefficients cepstraux, Université de Lorraine, 25/03/2013 (B. Girau, president)

PhD: Srikishna Bhat, Mots visuels pour le calcul de pose, Université de Lorraine, 22/01/2013 (B. Girau, president)

PhD: Hoda Sbaiti, Optimisation sur un modèle de comportement pour la thérapie en oncologie, Université de Versailles St Quentin en Yvelynes, 30/09/2013 (P. Hénaff as referee)

PhD: Gatean André, Modélisation oscillatoire de l'écriture manuscrite, Université de Toulouse, 11/12/2013 (P. Hénaff as referee)

9. Bibliography

Major publications by the team in recent years

- [1] H. BELMABROUK, T. NOWOTNY, J.-P. ROSPARS, D. MARTINEZ. *Interaction of cellular and network mechanisms for efficient pheromone coding in moths*, in "Proceedings of the National Academy of Sciences", 2011, vol. 108, n^o 49, pp. 19790-19795
- [2] M. CERDA, B. GIRAU. *Asymmetry in neural fields: a spatiotemporal encoding mechanism*, in "Biological Cybernetics", 2013, vol. 107, n^o 2, pp. 161-178 [DOI : 10.1007/s00422-012-0544-0], <http://hal.inria.fr/hal-00764861>
- [3] G. DETORAKIS, P. ROUGIER. *A Neural Field Model of the Somatosensory Cortex: Formation, Maintenance and Reorganization of Ordered Topographic Maps*, in "PLoS ONE", 2012, vol. 7, n^o 7
- [4] N. FOURCAUD, E. COURTIOL, N. BUONVISO, T. VOEGTLIN. *Stability of fast oscillations in the mammalian olfactory bulb: Experiments and modeling*, in "Journal of Physiology - Paris", 2011, vol. 105, n^o 1-3, pp. 59-70
- [5] D. MARTINEZ, A. CHAFFIOL, N. VOGES, Y. GU, S. ANTON, J.-P. ROSPARS, P. LUCAS. *Multiphasic On/Off pheromone signaling in moths as neural correlates of a search strategy*, in "PLoS ONE", 2013, vol. 8, n^o 4, <http://hal.inria.fr/hal-00858730>
- [6] N. P. ROUGIER, Y. BONIFACE. *Dynamic Self-Organising Map*, in "Neurocomputing", 2011, vol. 74, n^o 11, pp. 1840-1847

Publications of the year

Doctoral Dissertations and Habilitation Theses

- [7] G. DETORAKIS. , *Plasticité corticale, champs neuronaux dynamiques et auto-organisation*, Université de Lorraine, October 2013, <http://hal.inria.fr/tel-00879910>

- [8] M. RIO. , *Modèles bayésiens pour la détection de synchronisations au sein de signaux électro-corticaux*, Université de Lorraine, July 2013, <http://hal.inria.fr/teI-00859307>

Articles in International Peer-Reviewed Journals

- [9] M. CERDA, B. GIRAU. *Asymmetry in neural fields: a spatiotemporal encoding mechanism*, in "Biological Cybernetics", 2013, vol. 107, n^o 2, pp. 161-178 [DOI : 10.1007/s00422-012-0544-0], <http://hal.inria.fr/hal-00764861>
- [10] D. MARTINEZ, A. CHAFFIOL, N. VOGES, Y. GU, S. ANTON, J.-P. ROSPARS, P. LUCAS. *Multiphasic On/Off pheromone signaling in moths as neural correlates of a search strategy*, in "PLoS ONE", 2013, vol. 8, n^o 4, <http://hal.inria.fr/hal-00858730>

International Conferences with Proceedings

- [11] G. DETORAKIS, N. ROUGIER. *A computational view of area 3b of primary somatosensory cortex*, in "Annual Computational Neuroscience Meeting", Paris, France, BMC Neuroscience, July 2013, <http://hal.inria.fr/hal-00908566>
- [12] M. LEFORT, Y. BONIFACE, B. GIRAU. *SOMMA: Cortically Inspired Paradigms for Multimodal Processing*, in "International Joint Conference on Neural Networks", Dallas, United States, August 2013, <http://hal.inria.fr/hal-00859986>

Conferences without Proceedings

- [13] E. TEFTEF, C. CARVAJAL, T. VIÉVILLE, F. ALEXANDRE. *When early vision in the retina attempts to take decisions about visual motion events : the role of konio cells*, in "Third International Symposium on Biology of Decision Making", Paris, France, Université Pierre et Marie Curie (Paris 6), May 2013, <http://hal.inria.fr/hal-00826099>

Scientific Books (or Scientific Book chapters)

- [14] A. HUTT, N. P. ROUGIER. *Numerical simulation scheme of one-and two-dimensional neural fields involving space-dependent delays*, in "Neural Field Theory", P. B. GRABEN, S. COOMBES, R. POTTHAST, J. WRIGHT (editors), Springer, 2014, <http://hal.inria.fr/hal-00872132>
- [15] D. MARTINEZ, E. MARTIN-MORAUD. *Reactive and cognitive search strategies for olfactory robots*, in "Neuromorphic Olfaction", K. PERSAUD, S. MARCO, A. GUTIERREZ-GALVEZ (editors), Frontiers in Neuroengineering Series, CRC Press, 2013, pp. 153-172 [DOI : 10.1201/B14670-6], <http://hal.inria.fr/hal-00858731>

Research Reports

- [16] L. BUHRY, A. HUTT. , *Propofol-induced GABAergic Tonic Inhibition Diminishes α -rhythms and Induces δ -rhythms in neuronal populations*, Inria, February 2013, n^o RR-8230, <http://hal.inria.fr/hal-00787317>
- [17] E. TEFTEF, M.-J. ESCOBAR, A. ASTUDILLO, C. CARVAJAL, B. CESSAC, A. PALACIOS, T. VIÉVILLE, F. ALEXANDRE. , *Modeling non-standard retinal in/out function using computer vision variational methods*, Inria, January 2013, n^o RR-8217, 28 p. , <http://hal.inria.fr/hal-00783091>

Scientific Popularization

- [18] E. TEFTEF, T. VIÉVILLE. *La grenouille gobe t'elle aussi les cailloux ? Une introduction aux neurosciences computationnelles*, in "EpiNet", February 2013, vol. 152, <http://hal.inria.fr/hal-00789149>

Other Publications

- [19] G. DETORAKIS, N. ROUGIER. *A computational view of area 3b of primary somatosensory cortex*, in "Twenty Second Annual Computational Neuroscience Meeting : CNS 2013", Paris, France, July 2013, P333 p. , Twenty Second Annual Computational Neuroscience Meeting : CNS 2013, <http://hal.inria.fr/hal-00842311>