Lorraine Laboratory of **Research** in **Computer Science** and its **Applications**

ACTIVITY REPORT 2011 - 2016
PROSPECTIVES FOR 2017 - 2022

A research unit from the **research department AM2I** of **Lorraine University: Automatics, Mathematics, Computer Science and** their **Interactions**

Loria
Laboratoire lorrain de recherche en informatique et ses applications



Volume 6

Loria
cnrs
Inria
INVENTEURS DU MONDE NUMÉRIQUE
UNIVERSITÉ DE LORRAINE

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Activity Report

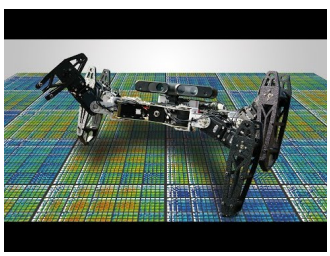
Department 5

Complex Systems, Artificial Intelligence and Robotics

Department Head: Patrick Henaff

Department 5 groups five teams that share scientific interests in *Complex Systems*, *Artificial Intelligence and Robotics*. The overall aim of Department 5 is to understand and model complex systems and their interactions. For us, a complex system is composed of a large number of coupled or interacting sub-systems for which studying its evolution is out of reach of purely mathematical approaches. Several scales of modelling can be considered in a global system or in an aggregate of sub-systems (from microscopic to macroscopic scale via mesoscopic scale). Some examples of the systems that we study are:

- Biological systems (e.g. neural systems) in the CORTEX and NEUROSYS teams.
- Biological and bio-chemical systems (e.g. protein interactions) in the CAPSID team.
- Social systems (e.g. user interaction, social networks) in the KIWI team.
- Robotic systems (e.g. robot swarms, robots, humanoid robots) in the MAIA (LARSEN), CORTEX and NEUROSYS teams.
- Purely computational systems (e.g. cellular automata) in the CORTEX team.
- Ambient assisted living in the MAIA (LARSEN since 2015) and NEUROSYS teams.



Overview of Department 5

1 Department Composition

Department leader

Bernard Girau (until September 2016)
Patrick Hénaff (since September 2016)

List of teams (June 2016)

Teams that existed throughout the evaluation period:

- **KIWI**: artificial intelligence, machine learning, data mining, recommender systems, collaborative filtering, user behavior modeling.

Teams that closed during the evaluation period:

- **CORTEX**, (EPC, until September 2016): computational neurosciences, neuro-robotics, sensori-motor models, human-robot interaction, neural networks, neuro-cellular computing, self-organization, spiking neurons, neural fields, brain-inspired hardware.
- **MAIA** (EPC, until December 2014): sequential decision making, Markovian models, multi-agent systems, complex systems.

Teams that were created during the evaluation period:

- **NEUROSYS** (EPC, created from CORTEX in January 2013): Computational system neuroscience, multiscale modeling, stochastic modeling, signal analysis, machine learning, general anesthesia, memory, brain-Computer interfaces.
- **CAPSID** (EPC, created from ORPAILLEUR (D4) in January 2015): computational biology, structural bioinformatics, biological data mining.
- **LARSEN** (EPC, created from MAIA in January 2015): robotics, machine learning, human-robot interaction, sensing environment, collaborative robotics.
- **BISCUIT** (EPC, created from CORTEX in September 2016, will be presented in the project part of the report): bio-inspired, situated, cellular, unconventional information technologies.

Number of department members:

	PR	MCF	DR	CR	Total
2011	2	14	4	9	29
2016	4	15	3	8	30

PhDs Defended	30	PhDs On-going	28
Postdocs	19	Engineers	23

Around 57% of our 58 PhD students (on-going and defended) are/were supported by institutional grants almost equally from Université de Lorraine (28%) and from INRIA (29%). For the rest, 29% are/were supported equally by European projects, the Lorraine Region, CIFRE grants and contracts (ANR or industrial partnership) and 8% are/were funded by foreign sources (French embassy, foreign grants).

Departement evolution

While the fundamental scientific aims of the department have not changed during the last five years, the department's teams have undergone some profound changes:

- NEUROSYS was created in January 2013 by two former members of the CORTEX team which was built around the ERC project MATHANA (A. Hutt). A. Hutt left the LORIA in November 2015.
- CAPSID was created in January 2015 by two former member of ORPAILLEUR (Department 4).
- MAIA was closed in december 2014. Its head, F. Charpillet, created the LARSEN team in January 2015 with other former members of MAIA and new researchers recruited in 2014. LARSEN continues to work on the same topics as MAIA, as well as new topics related to autonomous robotics and humanoid robotics.
- CORTEX: six of its nine members left the team (two members created NEUROSYS, two moved to INRIA Bordeaux). CORTEX will be reconfigured in September 2017 as a new team, BISCUIT (Bio-Inspired, Situated, Cellular and Unconventional Information Technologies), and will include members from Supelec-Metz. BISCUIT is presented in the project part of the report.

Since 2013 our research activities in robotics, especially in interactive robotics and autonomous robotics have been greatly enhanced by the recruitment of P. Hénaff (PR, CORTEX, September 2013), S. Ivaldi and F. Colas (Inria CRs, LARSEN, September 2014), the secondment of J.B. Mouret (from UPMC to Inria on the Resibot ERC project, May 2015), and the creation of LARSEN team. Thus, it was decided to change the title of the department from *"Complex systems and artificial intelligence"* to *"Complex systems, artificial intelligence and robotics"*.

The research activities of the department are involved in two of the LORIA's transversal axes, namely ***Cyberbiosanté*** and ***Cyber Physical Systems***. Several teams of the department (LARSEN, CORTEX, NEUROSYS) are deeply involved in a transversal LORIA project called ***CreativLab@Loria***. The aim of this project is to create in the laboratory a large and visible common working space dedicated to the *Cyber-Physical Systems* (CPS) transversal research axis. CreativLab@Loria will host different experimental platforms and set-ups from the teams and it will be equipped with two workshops: one for electronic design and instrumentation and one for prototyping and mechanical design.

A particular feature of Department 5 compared to other LORIA departments is its different technical platforms which are necessary to validate experimentally the models and approaches developed in the teams and which are shared with the teams from other departments: smart "sensorized apartment", robots, instrumentation systems, and electronic developments. These platforms (see Figure 1.1) are expensive to maintain sinc they require large and secure working spaces and the support of technicians and engineers.

2 Life of the department

In terms of administration of the department, we created a council that consists of the head of the department and the heads of the teams. The role of this council is to handle at the level of the department the evaluation and ranking of PhD candidates for UL contracts, the department bugdet, and to define new professor or associate-professor positions (in French, "les profils de postes").

At the level of the department, we organize each year a day of seminars called "la journée des doctorants" in which each PhD student presents his work in front of all the members of the department (professors, associate professors, researchers, and engineers). The goal of this seminar day is to get to know the PhD students, understand their topics, and thus know the scientific issues of each team.

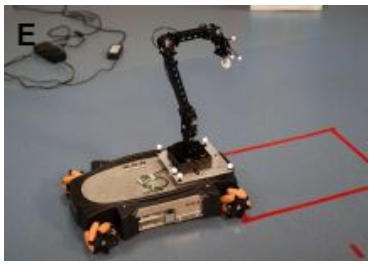




Figure 1.1: Overview of experimental platforms of Department 5: smart apartment, kuka mobile robot, experimental arena with motion capture.

The departmental council includes two elected PhD student representatives. They have the role of ”interface” between the students and the head of the department for all problems or questions other than science. They are also invited to participate in meetings with the heads of the teams.
The department manages the ”IPAC” (”Image, Perception, Action et Cognition”) transversal seminar series which involves LORIA Departments 1, 4, and 5 (http://ipac.loria.fr/). The aim of these seminars is to invite national and international specialists in these topics who have an original or non-conventional point of view. The frequency is around six seminars per year.
The teams of Department 5 collaborate in different ways, for example through co-supervised PhDs (MAIA and CORTEX), common projects through the CPER ”Contrat-plan état région” (MAIA and NEUROSYS), and joint ANR projects (NEUROSYS and CORTEX). Department 5 also collaborates with the teams from other departments through the CPER:

- LARSEN (MAIA) and MADYNES (Dept. 3) on the smart apartment project (Ambient Intelligence).
- LARSEN (MAIA) and MULTISPEECH through a co-supervised PhD.
- CORTEX and MULTISPEECH (Dept. 4) on a project for creating a corpus of data extracted from measurements acquired during multimodal interpersonal social interactions.
- CORTEX and ORPAILLEUR (Dept. 4).
- NEUROSYS and LARSEN (MAIA) on assistive robotics for disabled people through the Brain Computer Interface project.
- NEUROSYS and CORTEX through the common ANR project Keops.
- KIWI and ORPAILLEUR through a European project, and also with MULTISPEECH and SYNALP (Dep. 4) through a PIA e-Fran Project.

3 Research topics

Keywords: Structural Bioinformatics, Biological Data Mining, Bomputational Neurosciences, Brain-inspired Hardware, Self-organization, Behavioral Models, Robotics, Collaborative Robotics, Sensorimotor Models, Human-robot Interaction, Machine Learning, Sensing Environment, Sequential Decision Making, Markovian Models, Multi-Agent Systems, Artificial Intelligence, Data Mining, Recommender Systems, Collaborative Filtering, User Modeling, Multiscale Models, Stochastic Modeling, Signal Analysis, General Anesthesia, Memory, Brain-Computer Interfaces.

Our activities address different kinds of complex systems, from an ”artificial intelligence” point of view that characterizes our specific approaches. We mostly aim to design complex systems that perform tasks or to extract information from the evolution of these systems. We also study their evolution and properties, when this knowledge helps to better understand their global behavior. Moreover, when dealing with interacting systems that consist of ”intelligent” entities, studying systems of such entities involves the study of the active interactions of a single entity (or agent) with its environment. Therefore, part of our research extends to various aspects of decision-making, which is another active field of modern artificial intelligence.

More concretely, the systems we study are usually composed partially or totally of sub-systems (entities) coming or inspired from nature, as opposed to artificial (technical) systems, as in the following examples:

Artificial intelligence and cognitive science

- The study and modelling of the behavior of a person (or a group of persons) interacting with a software interface on the internet (navigator, social network...) through the analysis of usage traces: the human being can be considered as a ”natural” sub-system in the sense that one can define or use a behavior model that is more or less complex (KIWI).
- The multi-agent approach used in multi-modeling and simulation of complex systems or in the adaptive control of “free-riding” phenomenon in peer-to-peer file exchange networks (MAIA).
- The study of diverse models and human factors (that can be oriented to e-health, music, job offers, etc.) to the early detection of neurodegenerative diseases such as Alzheimer’s disease or autism (KIWI).

Biological inspired models

- The study and modelling of biochemical interactions between large macromolecules and proteins (CAPSID): here, all the subsystems are biological.
- The development of specific algorithms to control a robot that interacts physically and/or socially with a human (CORTEX, LARSEN): here, controllers can be inspired from biology or from developmental learning approach; a human can be considered as a ”natural entity”.
- The adaptation to unforeseen damage conditions in robots (LARSEN): here, trial-and-error algorithms may shed light on the principles that animals use to adapt to injury when they interact with their environment.
- The biophysical modeling of the insect olfactory system (CORTEX): here, a neuronal model is proposed and used to control a robot towards a source of pheromone.

Computational neuroscience

- The study and modelling of the effects of an anesthetic substance such as propofol on the brain (thalamus, cortex, hippocampus) or the study of the control of a robotic arm through a Brain Computer Interface (NEUROSYS): here, the natural part is the model of corctico-thalamic and hippocampal neural networks, or EEG signals used to command robots.

- The dynamic neural fields (bio-inspired neural architectures) used to code and distinguish different visual sequences or to model cortical areas involved in visual attention (CORTEX).

❹ Main results

Many important results are detailed in the individual team reports. We briefly present here the most significant results from a departmental point of view.

Web intelligence and human factors

In understanding the role and impact of some human factors on the decision-making process, the **KIWI** team conducted a large study on the users' need for diversity, and proved that diversity is perceived by users and improves users' satisfaction [173]. Aiming at conceiving new machine learning algorithms that improve the interaction and user satisfaction, the **KIWI** team built a model that allows to measure the diversity brought by each consulted item over time, within any sequence of consultation [144]. Another model has been used to understand automatically the user context in a privacy-preserving way [128]. The **KIWI** team proposed a model of user trust and reputation that improves and reinforces the quality of recommendations according to the context [112, 135].
In predictive modeling and user characterizing, the **KIWI** team are leaders in identifing representative users through matrix factorization (MF) and to investigate the detection of atypical users upstream the recommendation process [172, 110, 111].
In the identification of representative users, **KIWI** was the first team to show that NF can be modified from its original purpose to reach such a goal [125, 127]. In cold-start problems, **KIWI** proposed an original MF approach that has the advantage of not requiring any content information [177]. The **KIWI** team has been a leader in investigating Kalman Filters to predict the "trajectory" of users in the space of items [176, 115].

Artificial intelligence and complex systems

In understanding and mastering complex systems like smart-grids, the **MAIA** team (in collaboration with MADYNES Team, Dept. 4) has proposed a multi-agent meta-model for multi-modeling and multi-simulation of complex systems [287, 280] formalized using DEVS and is implemented in the MECSYCO software. This has been successfully applied in different real use cases in smart-grids domain with EDF R&D [335, 296] [408, 409].
In the field of sequential decision making for decentralized control under uncertainty, members of the **MAIA** team have made a breakthrough by proposing a method to solve any Decentralized Partially Observable Markov Decision Process (Dec-POMDP) as a continuous-state and deterministic MDP called Occupancy MDP. This method solves most benchmark problems orders of magnitude faster than other state-of-the-art approaches [340, 341].

Robotics

In the field of robotic adaptation and learning for lifelong autonomy of robotic systems, a novel trial-and-error algorithm that enables more robust and autonomous robots was proposed. This new approach in robot autonomy is the core of the "ResiBots" ERC project of J.B. Mouret (team **LARSEN**), and was highlighted on the cover of Nature in May 2015 [255]. This work was covered by all the major media outlets and the associated videos, and had more than 400,000 views on YouTube.
For perception in robotics and lifelong autonomy of robots, the **LARSEN** team proposed a dense visual

odometry method that performed better than state-of-the-art methods in previous and new datasets [269]. In Human-Robot interactions the **LARSEN** team has conducted experiments on iCub's humanoid robot that showed that human participants trusted more the answers about functional issues than social issues (arXiv:1510.03678[cs.RO]). Personal character traits (extraversion, introversion) influence the duration of a talk with a robot, and the manner in which people look at the robot's face or the areas of physical interaction (http://arxiv.org/pdf/1508.04603v1,[272]).

Neuroscience applied to Robotics

CORTEX has developed a neuronal model of the insect olfactory system able to drive a real mobile robot toward a source of pheromone [36, 25, 11, 36]. A multimodal learning algorithm for a system with multiple sensory inputs and a micro-electronic nose were also developed [99, 73, 72, 16][29] [53].
In the domain of sensori-motor loops, the **CORTEX** team has proposed a new adaptive controller model based on flexible Central Pattern Generators (CPG) able to generate adaptive rhythmic gait patterns for the locomotion of an hexapod robot [24, 23]. The same team has also developed a global control circuitry (lower and upper limbs) based on plastic CPGs able to control and to adapt the walk of humanoid robots [39].
To develop future models of sensory-motor loops for humanoid robots that interact with humans, the **CORTEX** team deeply studies the physical and cognitive phenomena underlying human "handshaking" acts in different social contexts [76, 75, 77].

Computational Neuroscience

In the field of better understanding of anaesthesia, the **NEUROSYS** team proposed a new model of hippocampal pyramidal neurons using the Hodgkin-Huxley model capable of exhibiting long-lasting persistent firing activity when subject to a strong transient stimulus. Among others, a model of cortico-thalamic interactions based on neural field and spiking neuron models [556][555]. This important work, that is the center of the ERC project MATHANA of A. Hutt in **NEUROSYS**, demonstrated a possible mechanism for the emergence of paradoxical excitation under general anaesthesia [521] [522].
Aiming at a better understanding limb of movement execution or their imagination-induced sensorimotor rhythms, the **NEUROSYS** team investigated electroencephalographic (EEG) activity during real movements, discrete and continuous motor imageries [576][532]. The team proposed a multi-label approach to detect simple and compound imagined movements to enlarge a BCI control [529] and to detect the increasing of oscillatory power synchronization at the end of motor imageries [531, 570][531]. The **CORTEX** team has developed several models inspired from cortical maps and sensori-motor loops at the microscopic and macroscopic level. Simplified spiking neural network were proposed to model the rat olfactory bulb [66, 32] and to design an artificial vision system implemented on FPGAs [44][43].
In the domain of Neural Fields, the team showed that dynamic neural fields offer a wide variety of potential applications at the computational level [46][10, 22][45][30, 64, 14] [83] and cognitive level[13, 27] [31][79][80][87]. The **CORTEX** has embodied and embedded its different neural models of dynamic neural fields and adapted it to hardware constraints through the use of spiking neurons [58][89] [28, 63][62] and stochastic arithmetic [49, 68, 50].

Computational Biology

In the field of computational biology, especially modeling of biochemical interactions between large macromolecules (DNA, RNA, and proteins) the **CAPSID** team explored new ways to describe and classify the 3D shapes of protein binding sites, to link 3D interactions and to predict new interactions within protein interaction networks [9]. The **CAPSID** team also developed in collaboration with Inria Grenoble

a novel protein docking algorithm which can build models of symmetrical protein complexes having any of the naturally occurring point group symmetries [7].

Scientific production and quality

5 Synthesis of publications

	2011	2012	2013	2014	2015	2016	Total
PhD Theses	6	4	6	5	4		25
H.D.R	2				1		3
Journals	21	19	10	17	10	3	80
Conference proceedings	66	47	57	53	49	1	273
Book chapters	7	5	4	3	3	1	22
Books (written)				1			1
Books or special issues (edited)	4	4	3	1	2	1	15
Patents							
General audience papers	2	2	1	4	6	1	16
TOTAL	108	81	81	84	75	6	435

The publications Department 5 cover a large spectrum of journals and conferences. The following lists are extracted from the lists detailed in each team report. The journals and conferences are grouped into large scientific domains: **Web Intelligence, artificial Intelligence and robotics, neuroscience and Computational Biology**.

6 List of top journals in which we have published

Web Intelligence

- Social Network Analysis and Mining (1) [111]
- Journal of Language Modelling (1)[114]

Artificial Intelligence, Robotics

- Nature (1) [255]
- IJRR- International Journal of Robotics Research (1) [257]
- Journal of Artificial Intelligence Research (JAIR) (3) [308, 307][256]
- Journal of Machine Learning Research (JMLR) (3) [311, 306, 310]

Neuroscience, Computational Biology

- PLoS One (5) [40, 54, 36, 30] [8]
- Frontiers in... [1] (9): Microbiology [1], Robotics and AI [55], Neurosciences [516], Neuroengineering [53], Syst. Neurosciences [522, 519, 503], Computational Neuroscience [504], Behavioral Neuroscience [37],
- Biology (1) [5]
- FASEB Journal (1) [4]
- Journal of Applied Crystallography (1) [7]
- Biological Cybernetics (2) [39, 27]

[1] in 2016, "Frontiers in" journal series tops open-access journal ranking in several JCR categories.

7 List of top conferences in which we have published

Web Intelligence

- EC-Web, Electronic Commerce and Web Technologies (1)[123]
- EC-TEL, european conference on technology enhanced learning (3) [148, 122, 131]
- SIGIR (special interest group on information retrieval) (1) [135]

Artificial Intelligence, Robotics

- International Conference on Robots and Automation (ICRA) (4) [411][273, 266, 263]
- IEEE/RSJ International Conference on Intelligent Robots and Systems - IROS (4) [412, 319][264, 268]
- International Joint Conference on Artificial Intelligence - IJCAI (6) [270] [390, 340, 389, 345, 270]
- Autonomous Agents and Multiagent Systems (AAMAS) (4) [343, 341, 356, 388]
- AAAI Conference on Artificial Intelligence (AAAI) (4) [333, 380, 392, 389]

Neuroscience, Computational Biology

- Neural Information Processing Systems (NIPS) (3) [396, 369, 397]
- CNS[2] [92, 65, 61, 59, 71, 80, 66].
- IEEE/IJCNN (6) [62, 79, 89, 84, 85, 73],
- Computational Neuroscience Meeting (12) [71, 528, 562, 547, 571, 558, 567, 554, 550, 570, 556, 561],
- IEEE EMBS Engineering in Medicine and Biology Conference (2) [525, 532]
- IEEE EMBS Neural engineering conference (1) [531],
- JOBIM-2015 (1) [9].

8 Software

We highlight here some of our principal software (please refer to the individual team sections for details).

Web Intelligence

The Event Prediction Tool (KIWI) aims at predicting events in a sequence of events, while controlling the distance of prediction (ARMURES project). Developed in Java, it exploits the sequence of verbatims published on the web. Its use is restricted to Credit Agricole S.A.
Dr Sport (KIWI) is the first full service dedicated to the diagnosis of sport pathologies (from the analysis of the pathology to the orientation towards the nearest competent professionals). Developed in collaboration with Dr Sport for national diffusion, it relies on artificial intelligence techniques and is available on iOS, Android, and on a website.

Artificial Intelligence, Robotics

MECSYCO (Multi-agent Environment for Complex SYstem COsimulation): Developed in collaboration between **MAIA** and **MADYNES** (Dep.4), MECSYCO aims to couple existing heterogeneous models and simulators in order to model and simulate complex systems. It is used for Smart-Grids modeling and simulation by EDF R&D.
FiatLux (**MAIA**) is a discrete dynamical systems simulator that allows the user to experiment with various models and to perturb them. It features classical cellular automata, moving agents, interacting particle systems, etc. It is registered by the APP.

[2] CNS is the major scientific conference in the Computational Neuroscience domain. Communications here are not to be considered as "publications" but as a proof of our embodiment in this scientific community

Neuroscience,Computational Biology

OpenViBE (NEUROSYS). Participating in the design and development. OpenViBE is the major software in BCI (with BCI2000) devoted to the design, test and use of real-time neuroscience and Brain-Computer Interfaces(LGPL-V2 license).
KBDOCK (CAPSID). A database of all known 3D protein-protein interactions. Querying the database can help model protein interactions that have not been solved experimentally.
MVASPIKE (CORTEX) is for modeling and simulating large, complex networks of biological neural networks. It is based on an event-based modeling and simulation strategy, targeting mainly pulse-coupled spiking neural networks.

The academic reputation and appeal

9 Prizes and Distinctions

Best papers

- MAIA : ICAPS 2012 [381];[333], AAMAS 2014 [341].

Distinctions

- 2011: MAIA was co-winner of the optimal track at the 7th International Planning Competition (IPC'11).
- 2011: A. Hutt (NEUROSYS) ERC Starting Grant MATHANA (Mathematical Modeling of Anaesthesia) (2011-2015).
- 2012: MAIA was winner of the final French robotics contest Defi CAROTTE organized by DGA and ANR.
- 2013: A. Boyer (KIWI) received the prize of the laboratory awarded by Société Industrielle de l'Est.
- 2015: the KIWI team and Sailendra company have been ranked first of Prime Minister Rakuten competition among all challengers.
- 2015: J. B Mouret (LARSEN) ERC project Resibots (GA 637972 - May 2015 to April 2020).

10 Editorial and organizational activities

Department members participated in the programme committees and steering committees of many national and international conferences (non-exhaustive list).

Editorial responsibilities: Journal Autonomous Robots; PLOS Computation Biology;Frontiers in AI and Robotics; springer Journal of Intelligent Service Robotics;Frontiers in AI and Robotics; Journal of Artificial Intelligence Research; RIA journal; Journal of Proteomics and Computational Biology; Frontiers in Neurorobotics; Computational Intelligence and Neuroscience (special issue 2016).

Steering and Program Committees: WWW 2012; IJCAI 2015; SOTICS 2013; RecSys2013; CORIA 2013; ICMI 2014; ISMIS'12;ISKO-Maghreb Int. Symp. 2012; 2015;Int. Conf. SIIE'2012, 2014, 2015; ePIC Forum conf. 2013;IEEE/ICRA 2015; GECCO 2015; IEEE/IROS 2015 workshop; ECAL'2013'2015; CEC'2015; EA'2015; MSDM 2015; DEMUR'15; ICAART'2015; SENSORNETS'2015; RSS 2015; ACM/HRI 2015; IEEE/RAS HUMANOIDS 2015; AIRO 2015; ACII

2015; ENHANCE 2015; EVOstar'2015; AAAI'12; NeuroComp 2011; IJCAI 2015; CAp 2012; ECCB; CAP'12; RECONFIG'11'12; International Workshop on Dynamical Olfaction, TAIMA'11, IEEE-ELNANO'13'14'15'16; IEEE International Conference on Intelligent Energy and Power Systems'14'15'16; IEEE IJCNN'13,14,15,16; NeuroComp/KEOpS'12 workshop; AUTOMATA'11; JFPDA 2012; AFIA; GdR BioComp.

Reviewing journals and conferences All the members of the department are regular reviewers for major international journals and conferences.

11 Services as expert or evaluator

Thesis and habilitation committees, Hiring committees.
We participated in over 130 PhD juries and over 15 Habilitation juries as external examiners and reviewers. We also served in several hiring committees both in Nancy and externally.

Non-local scientific responsibilities.
Department members have reviewed grant proposals for: H2020 ICT; ANR; PIA; FP7 Program; Swiss research projects COST; BBSRC (UK); NSERC (CANADA); NWO (Netherlands); INRA; several French regional and territorial agencies.
Department members are/were member of CNU, "Chargé de mission" at French ministry of higher education and research (HER), president of foundation in e-education, expert at EC.

Local scientific or pedagogic responsibilities.
We serve in many local committees. The main responsibilities we have undertaken are: member of the Conseil de Collegium Science et Technologie of the Université de Lorraine, as well as of the Conseil de Secteur Scientifique MIAE.

12 International Collaborations

Members of Department 5 have several strong and fruitful collaborations with regional teams from Université de Lorraine (CRAN, InterPsy, CHU...), national partners in laboratories and private companies (see teams reports for more details).
We list here only international partners with whom we developed particularly strong and productive collaborations (joint publications, joint software development): **Germany** (university of Chemnitz, Saarland University, TU Darmstadt,Humboldt University Berlin, Ruhr University Bochum), **USA** (university of Princeton, University of Wyoming, University of North Carolina, University of Houston,New York University, **Brasil** (University of Mato Grosso State, University of Maringá, Embrapa, and University of Brasilia), **Mexico** (Cinvestav Tamaulipas),**Ukraine** (Kiev Polytechnic Institute), **Tunisia** (Université des Sciences de Tunis), **Vietnam** (Hanoi University of Science), **Denmark** (Copenhagen Business School), **Morocco** (Laboratoire International Associé,LIA Linos), **Italy** (Italian Institute of Technology, Polytechnico Milan), **New Zealand** (University of Auckland), **Switzerland** (University of Lausanne),textbfSpain (Open University of Catalonia).

13 External support and funding

The main external funding of the department comes from **(number of projets as leader must be refine)**: 2 ERC grants, 8 ANR projects (6 as leader), 10 CNRS-PEPS (9 as leader), 1 InterReg (Grande Région) as leader, 6 European (2 as leader), 6 PIA (5 as leader).
.
The department is deeply involved in the "Contrat de Plan État Région" (CPER):

- 2015-2020 : Technological innovations, modeling and Personalized Medicine, we are contributing on platform SCIARAT (cognitive stimulation, Ambient Intelligence, Robotic assistance and Telemedicine).

- 2009-2014 : Action Modeling, Simulation and Interaction.

Moreover, the department is leader in two erasmus+ programs:

- 2014-2017 with Italy, Spain, Hungary and United Kingdom: (KA2) D-TRANSFORM, project on e-learning.

- 2015-2017 with Kiev Polytechnic Institute, Ukraine: research mobilities in the LORIA for Masters (8x6 months), PhD (4x12 months) and teachers (8x1 months).

Involvement with social, economic and cultural environment

Members of the department have been highly involved in scientific dissemination activities. The more important and regular of these are listed here:

14 Recurrent activities

- café des sciences.
- journée ISN-EPI (audience is computer science teachers of secondary school).
- organization of a talk serie on Image, Perception, Action and Cognition on a monthly basis at the INRIA-Nancy Grand Est laboratory.
- participation in the ”Cordée de la réussite”.
- forum for Cognitive Sciences, Université de Lorraine.
- demonstrations in ”fete de la sciences”, ”Village de la Science”, ”Nuits de la Science”, ”Sciences and You”.
- several ”Brain week” at central hospital, Nancy.

15 Non-recurrent activities

- festival du film du chercheur.
- articles for scientific large public dissemination.
- interviews and scientific spots in regional or national media : TV (France 3), radios (Europe 1), newspapers (Le Monde,Est-Républicain, Internet (Youtube, commentcamarche.net,...).
- participation in international colloque ”Robot Guido, fabrique des sciences, fabrique des arts” at MUDAM Luxembourg.
- Renaissance Nancy 2013 exhibit.
- Development of public smartphone applications (DrSport, KIWI).
- articles in transfer journals.

The involvement in training through research

Department 5 is involved in training and teaching at different levels in Université de Lorraine (from L1 to M2): ”Faculté des sciences” in specialities in computer sciences, UFR Mathématiques et Informatique (information and communication dept.), IUT Charlemagne, and more precisely in the following curriculums:

- Master IPAC.
- Master ”Pedagogical engineering – pedagogy and personal learning environments, Social networks and social media”.
- Master in ”Cognitive Science and Applications”.
- Master ”Métiers de l’enseignement, de l’éducation et de la formation”.
- Engineering Schools in Nancy.

We present here the main responsibilities in teaching (please see the individual team reports for more details):

- KIWI : A. Brun is the head of the Bachelor degree in Mathematics and Computer Science Applied to Human and Social Sciences (Licence MIASHS) and responsible for the Cognitive Science speciality
- CORTEX :
  - B. Girau has been head of the IPAC speciality of the Master of Computer Science, and is in charge of the relations between the LORIA and the various teaching programs related to computer science at Master level.
  - P. Hénaff is head of the ”Ambiant Systems and Robotics” theme of the Information and Systems department of Mines Nancy, and is also the head (for LORIA and Mines Nancy) of the cooperation with Ukraine (Kiev Polytechnic Institute).
  - Y. Boniface is head of the LP CISIIE at IUT Charlemagne.
- MAIA: C. Bourjot manages the Cognitive Science and Digital Media speciality of Cognitive Science and Application (SCA).
- NEUROSYS: L. Bougrain is responsible for the speciality IPAC (Interaction, Perception, Learning and Knowledge).

Computational Algorithms for Protein Structures and Interactions

Synopsis

1 Team Composition

Permanents

David Ritchie (DR Inria), Marie-Dominique Devignes (CR CNRS), Bernard Maigret (DR CNRS, Emeritus).

	PR	MCF	DR	CR	Total
2015			2	1	3
2016			2	1	3

Post-docs, and engineers

Antoine Chemardin (engineer, arrived 01/01/2015).

Doctoral students

Gabin Personeni (UL, 2013-2016) and Seyed Ziaeddin Alborzi (Région-ANR, 2014-2017).

Phd's defended	0	On-going PhD's	2

Team evolution

The CAPSID team was created on 01/01/2015. Before that date, all members of the team belonged to the ORPAILLEUR team.

2 Life of the team

As this is currently a small team, all management and administrative decisions are made through direct discussion amongst the permanent members.

3 Research topics

Keywords

Computational biology, structural bioinformatics, biological data mining.

Research area and main goals

Many of the processes within living organisms can be studied and understood in terms of biochemical interactions between large macromolecules such as DNA, RNA, and proteins. To a first approximation, DNA and RNA may be considered to encode the blueprint for life, whereas proteins make up the three-dimensional (3D) molecular machinery. This machinery works cooperatively to regulate the chemical composition within a cell or to carry out a wide range of biochemical processes such as photosynthesis, metabolism, and cell signalling, for example. Consequently, understanding how biological systems work at the level of 3D molecular structures presents fascinating challenges for biologists and computer scientists alike.

The overall aim of the Capsid team is to develop algorithms and software to help study biological systems and phenomena from a structural point of view. In particular, the team aims to develop algorithms which can help to model the structures of large multi-component biomolecular machines and to develop tools and techniques to represent and mine knowledge of the 3D shapes of proteins and protein-protein interactions. Thus, a unifying theme of the team is to tackle the recurring problem of representing and reasoning about large 3D macromolecular shapes. At a practical level, the main objectives of the team are to:

- classify and mine protein structures and protein-protein interactions,
- develop multi-component assembly techniques for integrative structural biology.

4 Main achievements

- The Hex protein docking program has had over 40,000 downloads. Google Scholar shows 490 citations for the first article on Hex.
- The KBDOCK protein interaction database has recorded over 17,500 visitors since 2011.

5 Research activities

Large-scale exploration of 3D protein domain family binding sites

Description The main aim of the PhD thesis project of Seyed Alborzi is to explore new ways to describe and classify the 3D shapes of protein binding sites, to link 3D domain interactions to the latest protein functional annotation schemes, and to investigate ways to mine these representations in order to predict new interactions within protein interaction networks.

Main results So far, this work has been published in JOBIM-2015 [9], A journal article on the large-scale association of enzyme classification numbers with Pfam domains is in preparation.

Exploration of linked open data in view of knowledge discovery

Description The PhD thesis project of Gabin Personeni concerns the exploitation of linked open data in the Life Sciences for integration and knowledge discovery purposes in the field of disease and disease genes. Disease networks are produced on the basis of various similarity measures. Inductive logic programming method is used on disease subgroups in order to better characterize the genes that are responsible for various types of intellectual disability.

Main results A conference paper on the construction of disease networks is in preparation for ECCB-2016.

Modelling symmetrical protein complexes

Description In collaboration with Inria Grenoble, we developed a novel protein docking algorithm called Sam, which can build models of symmetrical protein complexes.

Main results Sam is the first protein docking algorithm able to build protein complexes having any of the naturally occurring point group symmetries (cyclic, dihedral, tetrahedral, octahedral, and icosahedral). An article has been published in the Journal of Applied Crystallography [7].

Protein structure alignment

Description We have developed an algorithm for flexibly aligning two or more protein structures and and we have developed a novel scoring function for assessing the quality of multiple structural alignments.

Main results According to our new quality measure, our algorithm gives higher quality multiple structural alignments than all other published algorithms. A journal article describing these new developments is currently in review.

Scientific production and quality

6 Synthesis of publications

	2011	2012	2013	2014	2015	2016
PhD Thesis						
H.D.R						
Journal					5	2
Conference proceedings					1	
Conference proceedings (non selective)						
Book chapter						
Book (written)						
Book or special issue (edited)						
Patent						
General audience papers						1

7 List of top journals in which we have published

Biology (1) [5]. FASEB Journal (1) [4]. Frontiers in Microbiology (1) [1]. Journal of Applied Crystallography (1) [7]. Journal of Chemical Information & Modeling (1) [6]. PLoS One (1) [8]. Scientific Reports (1) [2].

8 List of top conferences in which we have published

JOBIM-2015 (1) [9].

9 Software

Kpax

Kpax is program for flexibly aligning two or more protein structures.

KBDOCK

KBDOCK is a database of all known 3D protein-protein interactions. Querying the database can help model new interactions that have not been solved experimentally.

Hex

Hex is a FFT-accelerated program for protein-protein docking and molecular superposition.

Sam

Sam is program for building models of protein complexes having arbitrary point group symmetry.

EC-DomainMiner

EC-DomainMiner is a content-based filtering tool for associating EC (Enzyme Commission) numbers with Pfam domains.

MD-Kmean

MD-Kmean is a program for the analysis of large numbers of molecular dynamics frames.

Protein-Marshmallow

Protein-Marshmallow is a program for the coarse-grained simulation large protein molecules.

The academic reputation and appeal

- The team has funding from three ANR projects (“IFB-Renabi”, “PEPSI”, and ‘FIGHT-HF”).
- The project “LBS” (Le Bois Santé) is a consortium funded by the European Regional Development Fund (FEDER) and the French “Fonds Unique Interministériel” (FUI).

- The MBI platform (Modeling Biomolecular Interactions; `http://bioinfo.loria.fr`) is a research node of the Institut Français de Bioinformatique (IFB).

- The Hex protein docking program has had over 40,000 downloads. Google Scholar shows 490 citations for the first article on Hex.

- The KBDOCK protein interaction database has recorded over 17,500 visitors since 2011.

10 Prizes and distinctions

11 Editorial and organizational activities

Marie-Dominique Devignes is a member of the Steering Committee for the European Conference on Computational Biology (ECCB). David Ritchie is a member of the Bureau of the GGMM (Groupe de Graphisme et Modélisation Moléculaire).

12 Services as expert or evaluator

Marie-Dominique Devignes is Chargée de Mission for the CyberBioSanté axis at the LORIA. The team members have participated in 4 PhD thesis juries and 2 HdR juries. The team members have reviewed grant proposals for ANR and BBSRC.

13 Collaborations

Predicting drug side effects

Together with Harmonic Pharma SAS (a LORIA / Inria spin-out company), we developed the "GESSE" method for proposing new uses for existing therapeutic drug molecules by associating the Gaussian shapes of known drug molecules with their clinically observed side-effects [6].

Identifying new anti-fungal agents

In collaboration with several Brasilian laboratories (at University of Mato Grosso State, University of Maringá, Embrapa, and University of Brasilia), we identified several novel small-molecule drug leads against the pathogenic fungus *Paracoccidioides lutzii* [8].

Large-scale exploration of integrative conjugative elements in *Streptococci*

As part of an on-going collaboration with the DynAMic lab (UMR 1128, INRA / Univ. Lorraine), we delimited and classified 105 integrative conjugative elements (ICEs) in several species of *Streptococci*, and we identified 8 new ICE insertion sites on the bacterial genome [1].

Modeling a GPCR receptor complex

Together with the BIOS team (INRA Tours) and the AMIB team (INRIA Saclay) we used our Hex protein docking software to model a large G-protein coupled receptor (GPCR) complex [2].

Modeling the Apelin receptor

In collaboration with the Centre for Interdisciplinary Research (CIRB) at Collége de France, we modeled the interaction between the Apelin peptide and the Apelin receptor [4]. This study could help the development of new therapeutic agents for the treatment of heart failure.

14 External support and funding

FEDER (co-funding with “Fonds Unique Interministériel” for project “Le Bois Santé”). Ministère de l’Éducation (funding for a PhD thesis). Région Lorraine (co-funding for phD thesis). ANR (projects “IFB-Renabi”, “PEPSI” and “FIGHT-HF”).

Involvement with social, economic and cultural environment

- An article on our KBDOCK resource was published in ERCIM News (edition 104) [3].

The involvement in training through research

- Doctorat: Bernard Maigret, *Virtual Screening*, 10-17 June, EMBRAPA, Brasil.

Computational Neuroscience

Synopsis

1 Team Composition

Permanents

Frédéric Alexandre (DR INRIA, left[1] 1/4/12), Yann Boniface (MdC UL), Laurent Bougrain (MdC UL, left[2] 1/1/13), Bernard Girau (Pr UL), Patrick Hénaff (Pr UL, arrived 1/9/13), Axel Hutt (DR INRIA, left[2] 1/1/13), Dominique Martinez (CR CNRS), Nicolas Rougier (CR INRIA, left[1] 1/4/12), Thierry Viéville (DR INRIA, left[1] 1/4/12), Thomas Voegtlin (CR INRIA, left 1/1/14).

	PR	MCF	DR	CR	Total
2011	1	2	2	4	9
2016	2	1		1	4

Post-docs, and engineers

Jean-Charles Quinton (postdoc, 11/2009-03/2011), Lucian Alecu (ATER, 09/2011-08/2012), Nicole Voges (postdoc CNRS, 04/2012-03/2014), Maxime Clement (engineer, 10/2014-12/2015), Gilles Tagne (postdoc UL-région, 09/2015-09/2016).

Doctoral students

Lucian Alecu (UL, 2008-06/2011), Mauricio Cerda (INRIA, 10/2007-10/2011), Wahiba Touali (UL, 09/2009-04/2012), Hana Belmabrouk (ANR, 03/2008-06/2012), Mathieu Lefort (UL, 10/2007-08/2012), Maxime Rio[3] (INRIA, 10/2008-07/2013), Carolina Saavedra[4] (Chilean government, 03/2009-09/2013),

[1] Frédéric Alexandre, Thierry Viéville and Nicolas Rougier have created the MNEMOSYNE team in Bordeaux: their activity in CORTEX is only described in this report until their departure on 1/4/2012.

[2] Axel Hutt and Laurent Bougrain have created the NEUROSYS team in LORIA: for sake of clarity, their activity (even before the creation of NEUROSYS) is not described in the CORTEX report, but only in the NEUROSYS report; similarly the activity of the post-docs, engineers and doctoral students from CORTEX who joined NEUROSYS are not described in this report.

[3] cosupervision between B. Girau and A. Hutt, see NEUROSYS report

[4] cosupervision between B. Girau and L. Bougrain, see NEUROSYS report

Georgios Detorakis (INRIA, 09/2010-11/2013), Carlos Carvajal-Gallardo (INRIA/Région, 01/2012-12/2014), Artem Melnyk (AUF-Ukraine, 01/2010-12/2014), Benoît Chappet de Vangel (UL, 10/2012-...), Matthieu Zimmer (UL, 10/2014-...).

Phd's defended	10	On-going PhD's	2

Team evolution

The currently evaluated period has seen many strong evolutions for the CORTEX team.

- 1/4/2012: three INRIA researchers (F. Alexandre, N. Rougier, T. Viéville) move to INRIA Bordeaux to create the MNEMOSYNE team on mnemonic synergy (situated active memories) - B. Girau becomes head of the CORTEX team (headed by F. Alexandre before)
- 1/1/2013: A. Hutt and L. Bougrain create the NEUROSYS team in LORIA on multi-level modeling of neural mechanisms
- 1/9/2013: recruitment of Patrick Hénaff
- 1/1/2014: Thomas Voegtlin leaves for a startup project
- 1/1/2016: end of the CORTEX team, three UL researchers (Y. Boniface, B. Girau and P. Hénaff) create the BISCUIT team in LORIA, together with A. Dutech (MAIA), H. Frezza-Buet and J. Fix (CentraleSupélec)

2 Life of the team

Team meetings and seminars are organized at four levels, depending of the focus (team-level, shared with NEUROSYS, department level, IPAC seminars). The team management has been highly related to the discussions about the above mentioned evolutions, resulting in three new teams (MNEMOSYNE, NEUROSYS and BISCUIT) that roughly correspond to the three main research axes of the team in 2011.

3 Research topics

Keywords

computational neuroscience, neural networks, neuro-cellular computing, self-organization, spiking neurons, neural fields, neural code, behavioral models, brain-inspired hardware

Research area and main goals

The research of the Cortex team takes part in the study of the properties and computational capacities of distributed, numerical and adaptative networks, as observed in neuronal systems considered at two main scales of description.

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, and implementing neural plasticity mechanisms in Central Pattern Generators aiming to have adaptive rhythmic movements for robots.

At the mesoscopic level of populations of neurons, the characteristics of a local circuit are integrated in a high level unit of computation, i.e. a dynamic neural field. This level of description allows to study larger neuronal systems, such as cortical maps, as observed in sensori-motor loops, with the main goal of designing embodied and embedded neural systems.

4 Main Achievements

Our most important results are mostly twofold:

- we have defined new neural models at the mesoscopic scale that partially or totally respond to well-known limits of this kind of models: DSOM [45] introduces dynamic properties in self-organizing maps, RSDNF [28] and CASAS [62] define purely local and decentralized neural fields based on distributed CA-based random number generators [50], and [22, 30] are significant steps in the definition of self-organizing neural fields

- we have modeled biophysical aspects of neural systems with interesting feedbacks to biology, through modeling of the olfactory bulb at the microscopic scale [53, 33, 66, 25] and related modeling of insect navigation strategies [52, 36, 38, 37], or through modeling the reorganization of the somatosensory cortex [30]

5 Research activities

Spiking Neurons and Networks

Description How do neurons encode information? This question is central in the field of neuroscience. Information can be conveyed locally in the brain by chemical mechanisms or direct electrical couplings. Over long distances, information is encoded in the spatiotemporal pattern of action potentials generated by a large population of neurons. The exact features of these spike trains that carry information between neurons is unknown. In order to deal with the complexity of living systems, a general trend in computational neuroscience is (i) to develop models in close relation with biologists and (ii) to study small but complete nervous structures, such as the brain of an insect. Along this line, our approach has been to model small and well-described neural systems, such as the insect antennal lobe or mammal olfactory bulb, for which experimental data are available. These small nervous systems exhibit general properties that are also present in higher mammals, such as neural synchrony and network oscillations.

Main results To understand how sensory information is encoded and processed by biological systems, we have contributed to research in three directions:

- Computational modelling and mathematical analysis: As biologically detailed conductance-based models may be difficult to analyse mathematically because of their intrinsic complexity, we have developed simplified spiking neural network models that lead to analytical calculations. These simplified models use generalized non-linear integrate-and-fire (I&F) neurons or neurons described by their phase resetting curve (PRC). Such models have allowed us:

  - to study the possible role of subthreshold membrane potential oscillations in stabilizing oscillations, in a computationnal model of the rat olfactory bulb [66, 32]
  - to design an artificial vision system based on spiking neurons, for which neural connections and synaptic weights are directly derived from recordings of spiking activities in the human visual system through a back-engineering approach [44] for which we designed an efficient implementation on FPGAs with tunable precision [43]

- Biophysical modeling: we have developed a neuronal model of the insect olfactory system capable of reproducing and explaining the stereotyped multiphasic firing pattern observed in pheromone sensitive antennal lobe neurons [36, 25, 11]. Using this model in robotic experiments and insect antennae as olfactory sensors, the efficiency of the model for olfactory searches was demonstrated

in driving the robot toward a source of pheromone [36]. In collaboration with Netta Cohen (University of Leeds, UK), we also developed a biophysical model of locomotion and olfaction in the nematode c elegans. [91]. Our simulation results suggest that motor feedback during sinusoidal oscillations of the body of the worm is involved in the search for odor sources (klinotaxis).

- Numerical simulation of spiking network models: 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 to model and simulate large networks of spiking neural networks and (ii) Sirene based on a time-driven approach to model biologically detailed models of neurons.

Neural Fields

Description Inspired by physics where a set of discrete events can be accurately approximated by a continuous variable, the idea that a continuous variable could serve as a model of a large set of discrete neurons led to a very large number of studies[WC72,Ama77,Tay99] where a dynamic neural field represents a neural mass. This initial assumption led to the resolution of many problems in the field of computational neuroscience. From a more experimental point of view, those dynamic neural fields also possess a number of computational properties that make them good and natural candidates as elementary building blocks of complex architectures. They represent indeed a good compromise between microscopic and macroscopic modeling levels.

Main results We found that dynamic neural fields provide a very consistent modeling framework that offers the advantage of being completely distributed and numerical and offers a wide variety of potential applications.

- Computational level:
  - In order to clarify the notion of distributed computing, we have proposed an unequivocal definition of asynchronous computations and an innovative way to perform them [46].
  - We studied the possibility to obtain properties of self-organization with dynamic neural fields and we proposed a new learning rule for self-organization [10, 22].
  - We designed a variation of the self-organising map algorithm [45] where the original time-dependent (learning rate and neighbourhood) learning function has been replaced by a time-invariant one.
  - Following [83], we have studied a computational model of the primary somato-sensory cortex based on the neural field theory that exhibits properties of synaptic plasticity in case of cortical lesion or sensory deprivation.

[WC72] Hugh R. Wilson and Jack D. Cowan. Excitatory and inhibitory interactions in localized populations of model neurons. *Biophysical Journal*, 12(1):1 – 24, 1972.

[Ama77] Shun-ichi Amari. Dynamics of pattern formation in lateral-inhibition type neural fields. *Biological Cybernetics*, 27:77–87, 1977. 10.1007/BF00337259.

[Tay99] J. G. Taylor. Neural 'bubble' dynamics in two dimensions: foundations. *Biological Cybernetics*, 80:393–409, 1999. 10.1007/s004220050534.

- We 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 [30, 64, 14].

- Cognitive level:

  - We have developed bio-inspired neural architectures to code and distinguish different visual sequences [13, 27].
  - In the context of the ANR MAPS project, we initially modeled the superior colliculus using a dynamic neural field that may explain the stereotyped nature of colliculus activity. Later, we extended this approach to wider contexts, by using an arrangement of several neural fields to model several cortical areas involved in visual attention [31].
  - We have defined models of neural fields that include anticipatory mechanisms [79] through the integration of spatiotemporal representations into the lateral interactions of a dynamic neural field, allowing multiple anticipated trajectories [80].
  - We investigated the transformation of spatial sensory representations into temporal motor actions within the visual-motor system. We focused on the visual flow from the retina to the superior colliculus to propose a minimalist model of automatic encoding of saccades to visual targets [21, 103].
  - In visuomotor tasks, the standard motion analysis is alternated with rapid reactions, like fleeing or approaching to specific motions, which are hard-wired. In addition, studying a fixation task in a real situation, e.g., when a predator slowly approaches its prey, not only involves a motion mechanism, but also requires the analysis of, at least, the image contrast. We have studied in a bio-inspired computational neural model how these different pathways can be modeled with a minimal set of parameters [87].

Embodied and Embedded Systems

Description This objective has gathered our activities that aimed at implementing our bio-inspired models on *dedicated architectures* and *autonomous systems*. Spiking models have been considered here through the design of fast embedded processing for olfactory perception. Nevertheless, most neural models we developed and implemented in this objective were based on associations of neural fields. Robotic platforms are able to provide an experimental playground for the underlying connectionist algorithms we have been promoting. But above all, autonomous systems have been central in our research, since embodiment guided our approach of cognition: if cognition is a higher level process, it is primarily anchored and situated in the action-perception loop. To understand cognition, we first had to tackle the problem of perception and action as emergent behaviors. The main properties of our embodied models (autonomy, adaptability, robustness) strongly depend on the fully distributed and decentralized nature of the underlying computations. Therefore we have been standing for bio-inspired connectionism as an alternative practice of massively distributed computing, in terms of models as well as computational resources for embedded systems.

Main results

- Embodied olfactory systems: 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 [100]. 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 have implemented infotactic and reactive search strategies in a cyborg using the antennae of a tethered moth as sensors -no artificial sensor for pheromone molecules is presently known- [36, 37, 42, 35, 52].

- Embedded olfactory systems: thanks to a collaboration initiated by the associate team Biosens, we constructed a micro-electronic nose model which incorporates spiking neurons [29]. Taking more inspiration from biology, we designed a simple yet robust glomerular latency coding scheme for processing gas sensor data [53].

- Multimodal learning: 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 [99, 73, 72, 16].

- Models of Central Pattern Generators:

  – At a lower-level, we have studied the elemental reflex processes. We have designed a flexible implementation of CPGs (Central Pattern Generators), as well as an embedded adaptation of the parameters that tune the rythmic patterns to enable different gaits for the locomotion of a robot [24, 23].

  – We have also develop bio-inspired neural controllers to control rythmic movements of humanoid robots (lower and upper limbs) [39]. The proposed CPG architecture is separated into three layers: rhythm-generation neurons, pattern-formation neurons and motoneurons. Sensory neurons (feedback) shape the activity of the CPG neurons.

- Adaptive sensori-motor loops: We develop bio-inspired neural controllers to control humanoid robots when they interact physically (or socially) with humans. We focus on the role of rhythmicity in the interaction: how the phenomena of coupling, synchrony or others are involved in the interaction between humans ? what models of plastic neural structures can incorporate rhythmicity intrinsically ?

  – To better understand the physical and cognitive phenomena underlying the ”handshaking” phenomenon in different social contexts, we used a special self-made data glove and a wearable sensor network to measure tightening forces and accelerations of hands and arms [77]. We have shown that the human handshake can be decomposed in four phases including pre-synchrony and mutual synchrony during physical contact [76, 75].

  – To model sensory-motor loops for rythmic movements, we used our previous model of neural controller based on central pattern generators (CPGs). The CPG implemented a neural plasticity property that allows the synchronization of its own rhythm to external signals: joint torque, hand acceleration, or visual perception of a movement.

  – Preliminary experiments with robots controlled by these plastic CPGs show that a robot arm (Kinova MICO) can learn the ”handshake” and that a Nao robot can learn the ”hello” sign looking at a human being doing the same sign.

- We have shown that dynamic neural fields can be adapted to hardware constraints by means of a purely cellular computing approach, through the use of spiking neurons [89], reduced neighborhoods and randomly propagating spikes [28, 63], and stochastic arithmetic [62] for which we use massively distributed pseudo-random number generators based on cellular automata [49, 68, 50].

6 Synthesis of publications

	2011	2012	2013	2014	2015	2016
PhD Thesis	2	3	3	2		
H.D.R	2					
Journal	12	6	4	8	4	
Conference proceedings	8	1	3	3	4	
Conference proceedings (non selective)	11	3	3	2		
Book chapter	2	2	1			
Book or special issue (edited)	1					

7 List of top journals in which we have published

Neurocomputing [24, 45], PNAS [25]. Neural Computation [34], Biological Cybernetics [39, 27], but also Frontiers in Robotics and AI [55], PLoS Computational Biology [52, 42], Frontiers in Behavioral Neuroscience [37], Frontiers in Neuroengineering [53], IEEE Transactions on Biomedical Circuits and Systems [29], PLoS One [40, 54, 36, 30], Cognitive Computation [31], Brain research [33], Journal of Physiology [43, 46, 32, 41], Journal of Cellular Automata [49, 50].

8 List of top conferences in which we have published

IJCNN [62, 79, 89, 84, 85, 73], ICANN [72], IEEE/ASME-AIM [76], CNS[3] [92, 65, 61, 59, 71, 80, 66].

9 Software

The **MVASPIKE** software is a general purpose tool aimed at modeling and simulating large, complex networks of biological neural networks. It is based on an event-based modeling and simulation strategy, targeting mainly pulse-coupled, spiking neural networks.

SIRENE is a time-driven simulator engine, written in C and developed for the simulation of a model of the antennal lobe, the first structure of the insect olfactory system.

D.A.N.A is a library that supports distributed, asynchronous, numerical and adaptive computation which is closely related to both the notion of artificial neural networks and cellular automaton.

EnaS is a middleware allowing to simulate and analyze so called ”event neural assemblies”.

CLONES provides an easy-to-use framework for closed-loop simulations, where interactions between the brain and body of an agent are simulated [51].

[3] CNS is the major scientific conference in the Computational Neuroscience domain. Communications here are not to be considered as “publications” but as a proof of our embodiment in this scientific community

The academic reputation and appeal

10 Prizes and Distinctions

Invited conference talks (11), international lectures (1) and invited seminar talks (5) are listed in appendix.

11 Editorial and organizational activities

- Review editor in Frontiers in robotics and AI, section computational intelligence (D. Martinez)
- Review editor in Frontiers in Neurorobotics (P. Hénaff)
- Reviewing for more than 10 journals: list in appendix.
- Member of more than 15 conference or workshop program committees: list in appendix.
- Organization and co-organization of 5 workshops (details in appendix).

12 Services as expert or evaluator

Members of the team are involved in various committees at the national (AFIA, NeuroComp, BioComp) and local levels (LORIA and University). See details in appendix. Moreover, B. Girau and then P. Hénaff have been head of the “Complex systems and artificial intelligence” department. Most members of the team have taken part in more than 30 PhD and HDR jurys. Details are given in appendix.

13 Collaborations

- on modeling visual attention with university of Chemnitz (Germany)
- on spike sorting with university of Princeton (USA)
- on embedded neural systems with Cinvestav Tamaulipas (Mexico)
- on analysis of biological signals in handshaking with Anton Popov (Ukraine, KPI)

14 External support and funding

Project title (project leader if **bold**)	begin	end	amount allocated to the team
National initiatives			
ANR KEOPS	2011	2014	214511
Investissement d'Avenir projet Pherotaxis	2010	2014	180000
International projects			
STIC AmSud MCC	2015	2016	8000
Conacyt project	2010	2014	4000
Conicyt-INRIA AMVIS project	2010	2011	
Associate team Cortina	2011	2013	30000
Scholarships			
PhD (région Lorraine)	2011	2014	53062
Postdoc (région Lorraine)	2015	2016	33500
Erasmus+ (with Ukraine, KPI for All LORIA)	2016	2018	250000 (for Loria)
Other funding			
PEPS-Mirabelle ShakeHands	2015	2015	13000
PEPS-Mirabelle + MSH Lorraine Psyphine project	2015	2015	10150
CNRS NeuroInformatics	2010	2011	15000
CNRS PEPII	2011	2012	4600
CNRS PEPII IMAVO	2011	2012	2500
CPER bio-robotics project	2014	2015	145000
INRIA-INRA project	2010	2011	7000

Involvement with social, economic and cultural environment

Members of the team have been highly involved in scientific dissemination activities (Interstices, adapted scientific teaching for secondary schools, Café des sciences, Festival du film du chercheur, etc.). Details are given in appendix.

The involvement in training through research

Members of the team are highly involved in training through research and in the animation of Master programs. P. Hénaff is head of the "Ambiant Systems and Robotics" way of the Information and Systems department of Mines Nancy and also involved in the International office of Mines Nancy for the cooperation with Ukraine. B. Girau has been head of the IPAC speciality of the Master of Computer Science, and is in charge of the relations between the laboratory and the various teaching programs related to computer science at Master level. Y. Boniface is head of the LP CISIIE at IUT Charlemagne. Other aspects are detailed in appendix.

Knowledge Information and Web Intelligence

Synopsis

1 Team Composition

Permanent Members

CNU 27: Anne Boyer [Team leader, Professor], Dominique Benmouffek [Ass. Prof.], Geoffray Bonnin [Associate Professor] from Sept. 2014, Armelle Brun [Ass. Prof.], Sylvain Castagnos [Ass. Prof.] from Sept. 2011, Azim Roussanaly [Ass. Prof.].
CNU 71: Audrey Knauf [Ass. Prof.] maternity leave in 2015/2016, Sahbi Sidhom [Ass. Prof.].
CNU 61: Samuel Nowakowski [Ass. Prof., HDR].

	PR	MCF	DR	CR	Total
2011	1	6	0	0	7
2016	1	8	0	0	9

Post-docs, and engineers

Past: Charif Alchiekh Haydar [ATER] Sept. 2014 - Aug. 2015, Brahim Batouche [PERICLES PIA Project] Jan. - Dec. 2014, Thomas Larguillier [ATER] Sept. 2011 - Aug. 2012
Current: Laura Infante Blanco [Dr Sport, PERICLES PIA] from Jan. 2014, Florian Marchal [KIWI funding] from Nov. 2015, Chan N. Nguyen [PERICLES PIA], Jan. 2014 - Feb. 2016.

Doctoral students

All the PhD Theses conducted in the KIWI team are funded by the projects the team is involved in. The team never got any state grant.

Past: Charif Haydar - def. 2014 - CIFRE, Sonia Benticha - def. 2015 Tunisian funding.
Current: Yacine Abboud from Nov. 2015 - Industrial partnership, Marharyta Aleksandrova from Dec. 2013 - co-mentorship with Nat. Tech. Univ. of Ukraine KPI - Campus France, Lina Fahed from Nov. 2012 - industrial partnership, Benjamin Gras from Jan. 2015 - Grand Nancy, Amaury L'huillier from Oct. 2014 - Region and Grand Nancy.

Associate members

Alain Lelu, [Professor, Université de Franche Comté], till Sept. 2014, CNU 71.

PhDs defended	2	On-going PhDs	5

Team evolution

Two new assistant professors, Sylvain Castagnos and Geoffray Bonnin, have joined the team in 2011 and in 2014 respectively. One associate professor, Alain Lelu, retired in 2014.

2 Life of the team

Anne Boyer is the scientific leader of the team since its creation in 2008. The team is collaboratively organized, with some permanent members in charge of the various scientific axes: Human Factors in Information Retrieval (S. Castagnos), Predictive Modeling and User Characterizing (A. Brun), Hybrid Modeling (A. Roussanaly), Education and Digital (A. Boyer). In 2013, a two-days internal workshop was organized to discuss ongoing research, future works and team evolution in terms of scientific goals and collaborative work that could be launched (local, national and international). During this meeting, it has been decided that Education and Digital should become a hot topic for the team, as well as the investigation of gaze tracking and mining.

3 Research topics

Keywords

Artificial Intelligence, Machine Learning, Data Mining, Recommender Systems, Collaborative Filtering, User Modeling.

Research area and main goals

Recommender systems are the common focus of the works conducted in the team, since its creation in 2008. KIWI has been the first team in the lab. to work on recommender systems.

The scientific focus is the automatic exploration of digital traces: logs, clickstreams, ratings, annotations, writing in blogs, etc. This exploration is based on models issued from machine learning, data mining, subjective logic, collaborative and content-based filtering; considering only traces or including human factors for their processing. The objective is to model the users behaviour (descriptive modeling), explain it (diagnostic analysis), predict its evolution (predictive modeling) or determine what actions to do to achieve a goal (prescriptive modeling).

Over the 5 past years, the research topics of have evolved from individual (user) to collective modeling (community), from modeling the instant to modeling the dynamic, from modeling a specific domain (cultural goods, educational ressources) to cross-domain, from personalisation (user adaptation) to flexibility (adaptation to the context).

Application domains were mainly e-(m-)commerce and intranets. Since the integration of S. Castagnos, a new focus has been put on diversity models and human factors, with a special orientation to e-health (autism, alzheimer and elderly people). When G. Bonnin joined the team, one additional scientific topic has been included: how to design a significant collection of items, given a user's characteristics. The main related application domain is music playlists.

Specificities of the team

One main specificity of the team lies in its pluridisciplinarity. It can be found in the approaches studied and in its members (several CNU sections). This pluridisciplinarity is the way KIWI has chosen to take from the beginning of its constitution in 2008, in order to tackle the various scientific challenges KIWI faces. It allows to propose innovative and multidisciplinariy approaches, especially in fields such as e-education or including human factors into recommender systems.

4 Main Achievements

The CROSSCULT H2020 project has been ranked 1st out of 137 proposals in 2015.
The METAL project, leaded by the KIWI team, is one of the 9 projects accepted at the e-FRAN national call in 2016.
The KIWI team with the Sailendra firm, have took part in the PriceMinister Rakuten Challenge, that aimed at providing recommendations and have been ranked 1st in this challenge.
Anne Boyer has been elected as the president of the UNIT foundation (Université Numérique Thématique en Sciences de l'Ingénieur et Technologie, dedicated to OER and LLL).
C. Nguyen submitted a project at the Paris French Tech Ticket in 2015, ranked 25/700 and retained as a winner of the program. It will be supported during 1 year to create a start-up.
Strong collaborations are conducted with Tiziana Zalla, from ENS ULM on autism.

5 Research activities

Human Factors in Information Retrieval

Description Recommender systems have been proven to be efficient and useful by reducing the cognitive load and time required during data search and access. Over the past two decades, this improvement of human-computer interactions is mainly relying on increasing systems' accuracy.

A crucial aspect is missing within the literature evaluation metrics. They do not take into account human factors playing a role within the decision process (context, confidence, trust, explanations and need for diversity). Within this context, our goal is to design holistic intelligent systems that provide the right information at the right time, in the correct manner, in agreement with users' policy and with valuable arguments. New challenges consist in: (1) identifying human factors that play a role within decision making an/or maximize users' acceptance, adoption and satisfaction, (2) integrating these factors in machine learning algorithms.

Main results We focus on understanding into details the role and impact of human factors on the decision-making process. We built a user study involving 250 users [173] and focused on the users' need for diversity. We proved that diversity is perceived by users and improve their satisfaction, but can require additional explanations to users.

At the same time, we took an interest on how to provide modes of interaction that facilite users' feedback. We proved that comparisons, instead of ratings, makes the interactions easier while reducing the imprecision of expressed preferences over time [142].

More recently, we studied the link between memory and gaze [218]. To infer what has been memorized by users, we aimed at identifying gaze features that best explain and efficiently predict visual memory. We found strong correlations between the memorized items and the number of fixation points and the relative angles saccade sum. In the medium term, these results will allow us to early detect neurodegenerative diseases, such as Alzheimer or Autism [219].

We aimed at conceiving new machine learning algorithms that improve the interaction and user satisfaction. As an example, we built a model that allows to measure the diversity brought by each consulted item over time, within any sequence of consultation [144]. This model is then used to automatically understand the user context in a privacy-preserving way [128].

At last, Haydar *et al.* investigated ways to model user trust and reputation, and to use it to improve and to reinforce the quality of recommendations according to the context [112, 135].

Predictive Modeling and User Characterizing

Description This axis, which only relies on users traces, is dedicated to user characterization through clustering, representative users (leaders), atypical users, etc. to provide a simplified representation of the set of users, and to provide them with accurate recommendations. It is also dedicated to predicting users future behavior. We mainly focus on machine learning approaches to reach these goals.

Main results We have been the precursors in investigating the representation of the set of users with an unweighted graph to identify communities [172, 110] and in coping with data sparsity [111]. More recently, we have identified representative users and have been the first to show that matrix factorization can be deviated from its original purpose to reach such a goal [125, 127] (PhD Thesis of M. Aleksandrova). In parallel, we have tackled the cold-start problem through MF and proposed original approach that has the advantage to not require any content information [177]. Recently, we focused on atypical users, who are so different of the others that they cannot receive any accurate recommendations. We have proposed new approaches to identify these users upstream the recommendations process [133] (PhD Thesis of B. Gras, in collab. with Sailendra).

To predict user preferences we have investigated K^{th}-order Markov Models [171]. In the frame of L. Fahed's Phd Thesis, we focus on distant events prediction. No work has focused yet on predicting distant events, due to complexity issues. We have tackled this problem and shown it could be solved with low-complexity algorithms [129]. We have been the precursors in investigating Kalman Filters, to predict the "trajectory" of users in the space of items [176, 115].

Hybrid Modeling

Description Hybridization aims to combine knowledge sources to design users model to produce personalized recommendations. The key idea is to globally improve the quality of recommendations taking advantage of the specificities of each method. The issues addressed are: cold start problem, robustness to attacks, data sparsity, their fluctuation and massification.
Knowledge sources allow to infer relevant information (indicators and features). They can be linked to items including their uses (this last information is the one used in the Predictive Modeling and User Characterizing axis), their contents but also to users social connections in a service. This informations can be explicit: ratings, votes, metadata and declared social links. They may also be implicit: we estimate them from the use of any kind (access, frequency, duration, sharing, downloading, printing ...), the content of items or the interactions among users.

Main results

S. Ben Ticha's thesis works highlighted several results on the performance of hybrid recommender systems combining collaborative filtering algorithm and content based approach. She has proposed a typology of features, based on dependent and non-dependent attribute classes with, for each of the observed subclass, a performance analysis using several techniques [203].

Charif Haydar's thesis work incorporates a study on hybridization between collaborative filtering and trust based approach that relies on explicit or implicit social links between users [112]. For implicit links, a modelling based on subjective logic has been proposed and tested [156].

Furthermore, hybridization has also been exploited in the PERICLES project for the recommendation of open educational resources. Both information about specific attributes of each resource and links between resources are exploited through a pageRank adapted algorithm [148].

Education and Digital

Description This axis is dedicated to e-education and more precisely to the way to develop personnalized education for any learner, based on the collect and exploration of digital traces. It includes questions such as how to recommend pertinent open educational resources (OERs) to a specific learner given his academic background, educational preferences and learning objectives, or how to adapt digital tools to his profile. The KIWI team maily focuses on designing an OERs recommender and on Learning Analytics (KIWI is involved in this topic since 2013, mainly via the PIA 2 Pericles project) to provide teachers and learners with explicative, predictive and prescriptive analysis.

Main results The KIWI team is involved in several projects in the field of Education and Digital such as the PIA 2 e-education Périclès project (end in April 2016), the INTERREG IV Interlingua project (end in July 2015), the Erasmus+ D-Transfrom project (scientific coordination by Anne Boyer, end in September 2017). The challenges related to e-education are numerous, sucha as tthe determination of factors explaining the current situation in a datastream, the real-time recommendation based on hybrid modeling (refer to previous section), the atypical learners modeling (refer to section Armelle). The main contributions of the KIWI team are: 1) two recommendation algorithms, one for open repository of resources to provide to non identified users with OERs suggentions (on-going test on 2 national open repositories), and one to include into the virtual desk of a given student (first release of the software for open distribution in April 2016); 2) a tool to cartography an open resources and determine what is called “isolated” resources [151]; 3) various studies on impact of culture on e-education [154], on OERs as a lever for digital transformation of Higher Education (D-Transform O1 deliverables); 4) a SOTA of Learning Analytics and their challenges (report for MENESR to be realeased in 2016).

Scientific production and quality

6 Synthesis of publications

	2011	2012	2013	2014	2015	2016
PhD Thesis	0	0	0	1	1	0
Journal	3	3	1	4	2	0
Conference proceedings	17	14	20	21	13	1
Book chapter	2	1	3	3	2	0
Book (written)	0	0	0	1	0	0
Book or special issue (edited)	3	2	1	1	2	0
General audience papers	2	2	1	4	6	0

7 List of top journals in which we have published

Journal of Intelligent Information Systems [109], Social Network Analysis and Mining [111], Advances in Multimedia [110], International Journal On Advances in Life Sciences [112], Journal of Language Mod-

elling [114], Revue d'Intelligence Artificielle (RIA) [171], Sciences et Technologies de l'Information et de la Communication pour l'Education et la Formation (STICEF) [174].

8 List of top conferences in which we have published

Web related conferences: UMAP [132], EC-Web [123], Web Intelligence [136, 127].
E-education related conferences: EC-TEL [148, 122, 131], EDEN [151, 167].
Data Mining related conferences: KDIR [129].
AI related conferences: ECAI [121], ACM GECCO [125], SIGIR [135], ICTAI [128, 118], CORIA [176, 177, 179].

9 Software

The Event Prediction Tool aims at predicting events in a sequence of events, while controlling the distance of prediction. It has been developed in the frame of the ARMURES project, and is implemented at Credit Agricole S.A., it exploits the sequence of verbatims published on the web. It has been developed in Java and its use is restricted to Credit Agricole S.A.
Dr Sport is the first full service dedicated to diagnosis of sport pathologies (from the analysis of the pathology to the orientation towards the nearest competent professionals). It relies on Artificial Intelligence techniques and is available on iOS, Android, and on a website. It has been developed in the frame of the collaboration with Dr Sport.
PERICLES-Reco is an open source software that has been developed in the frame of the PIA PERICLES project. It aims at providing recommendations of Open Educational Resources (EOR) to users of the portal of OER and to university students through their private LMS.

The academic reputation and appeal

10 Prizes and Distinctions

In 2015, the KIWI team was involved in the Price Minister Rakuten recommendation competition, associated with the Sailendra company. The algorithms proposed by KIWI and Sailendra have been ranked first among all challengers.
C. Haydar received a Best Paper Award at SOTICS 2013.
A. Boyer received the price of the laboratory awarded by Société Industrielle de l'Est in 2013.
C. Nguyen submitted a project at the Paris French Tech Ticket in 2015, ranked 25/700 and retained as a winner of the program. It will be supported for development during 1 year.

11 Editorial and organizational activities

Steering Committees and Program Committees

All the permanent members of the team have been program committee members of many national and international conferences or steering committee members.

Conference Organisation

A. Boyer and S. Castagnos organized a special session at ISMIS'12. S. Sidhom is general chair of the ISKO-Maghreb Int. Symp. 2012, 2015, he is also general chair of the Int. Conf. SIIE'2012, 2014 and 2015. S. Nowakowski is organiser of a special session in ePIC Forum conf. 2013.
All members of the team were organisation committee member for several conferences.

12 Services as expert or evaluator

Expertises A. Boyer was expert at the French ministry of higher education and research (Mission MINES), Oct. 2013- Dec. 2015. She is an expert for the French Ministry (DGRI/MEI) for bilateral calls since 2012 and an expert for PIA (Plan d'Investissement d'Avenir).
A. Brun was an expert of Swiss research projects COST 2013. S. Nowakowski was an expert for the national White paper on ePortfolio 2012, 2013.
A. Boyer, A. Brun and A. Roussanaly are experts for the French ministry HER for CIR. A. Boyer and A. Brun are experts of ANR projects.
PhD Committees A. Boyer, A. Brun, A. Lelu, S. Nowakowski, A. Roussanaly were reviewer or examinators of serveral PhD Theses and HDR in France and abroad.
CNU A. Boyer and A. Brun are members of the CNU 27.
Charges de Mission A. Boyer was chargée de mission at the French Ministry of HER. She is chargée de mission E-education of the LORIA lab. since Jan. 2016. She has been elected as the president of the UNIT foundation (Université Numérique Thématique).
Local Responsabilities A. Brun is the head of the Bachelor degree in Mathematics and Computer Science Applied to Human and Social Sciences (Licence MIASHS). A. Roussanaly is chargé de mission TICE at Université de Lorraine, since 2011.
Miscellaneous S. Nowakowski is co-supervisor of 1 PhD Thesis in University of La Rochelle, started Sept. 2012. S. Sidhom is co-supervisor of 3 PhD Theses: in Univ. Paris 8, and in Tunisia.

13 Invited Talks and others

A. Boyer, A. Brun gave an invited talk in CRESTIC lab (Reims) 2013 on recommender systems.
S. Nowakowski was invited speaker 5 times in France and abroad, in universities, conferences and forums. He was an invited professor at Carl von Ossietzky Universitat Oldenburg, 2014.
A. Boyer gave many invited talks abroad, for example at the "colloque e-éducation" organised by the university of Settat, Maroc 2014 at the ACE conference San Antonio, USA 2015, at the seminar CODAES abour OER in Mexico, in November 2014, at the séminaire IGAENR, etc.
A. Roussanaly gave a talk at Plate-forme I.A., atelier EIAH and Printemps du Numérique 2015.

14 Collaborations

A. Lelu has collaborated with the ISCC in 2011/2012 on Digital humanities, historical and prospective studies, in the framework of a part-time deal.
The team has strong collaborations and several joint publications with 'Kyiv Polytechnic Institute' Ukraine, Université des Sciences de Tunis, L3i Lab. from Université La Rochelle, concretized by the co-supervision of PhD Theses and joint publications.
A. Roussanaly has strong collaborations with Phuong Le Hong from Hanoi University of Science, through joint publications. Phuong was invited researcher of the KIWI team in 2013.
A Brun has strong collaborations with Liana Razmerita, from the Copenhagen Business School, on user modeling and e-learning: joint publications and visiting periods.

The KIWI team is involved in the Laboratoire International Associé (LIA Linos) with Morocco, the kick-off meeting held in September, 2015.
KIWI is part of the ORPHEE e-education network (ANR funding).
S. Castagnos collaborates with C. Luxembourger from InterPsy lab. (Univ. Lorraine) A tool is being developed to help researchers in psychology to lead their user studies. He collaborates with T. Zalla, CNRS researcher in cognitive science and psychopathology (ENS ULM).

15 External support and funding

European / international projects

STIC Asia project 2012-2013, in collaboration with Hong Kong Baptist University (Li Chen-Assistant Professor) and Asian Institute of Technology in Thailand (Raphael Duboz). KIWI was the scientific leader.
EHR project 2012- 2013, European project In RUS ERA NET program. Partner countries: France, Germany, Russia, Estonia. Leader Heinrich Heine University, Düsseldorf, Germany.
CROSSCULT project 2016-2020, H2020 project. Partner countries: France, Greece, Italy, Luxembourg, Malta Spain, UK.
Interlingua Project 2014-2015 - INTERREG IV. KIWI is the leader of Task 1. Partner countries: Belgium, France, Luxemburg, Germany).
The (KA2) D-TRANSFORM 2014-2017- KIWI is the scientific leader and leader of the sub-task O1-A3. Partner countries: France, Hungary, Italy, Spain, UK.

National projects

METAL project 2016-2019. PIA e-Fran project. This project deals with the proposition of new models and tools for school students and teachers. The KIWI team is the scientific leader.
BASAR project 2013-2016 - Scientific Cooperation Inter-Universitaire (PCSI project) Partner countries: Algeria, Bulgaria, Egypt and Lebanon. Leader: Egypt (AUF).
The PERICLES project 2012-2016. PIA project The KIWI team is the leader of the research activities of the project and is leader of task SP3.

Projects with French Ministry (MENSR) (2015-2016) KIWI has two main goals. 1) investigate if the use of the digital tools increases students (“bac pro”) success. 2) providing a state of the art of Learning Analytics in France. KIWI is the scientific leader of the project.

Contracts on institutional funding

Project with Sailendra A collaboration with Sailendra (local firm) 2014-2017 on the identification of atypical and anticipator users. This collaboration has been financed by Grand Nancy, and 1 PhD Thesis has started in Jan. 2015. KIWI is the scientific leader of the project.
Project with Yupeek A collaboration with Yupeek (local firm) 2014-2017, financed by Grand Nancy and by Region Lorraine, and 1 PhD Thesis has started in Oct. 2014. KIWI is the scientific leader of the project.
Dr Sport project 2014-2015 : between KIWI and a new Startup, selected by the Lorraine Region. Result: a full service dedicated to diagnosis of sport pathologies. Leader: Dr Sport.

Contracts on private funding

CIFRE Womup 2009-2012 -The collaboration between WOMUP Company and the KIWI team is concretized by a CIFRE grant, for a Phd Student.
ARMURES Project The ARMURES project 2012-2015 in collaboration with Crédit Agricole S.A, aims to improve the quality and reliability of customer and prospect models, modelling e-reputation of the firm, by analysing blogs, detecting new discriminative criterion.

Involvement with social, economic and cultural environment

The KIWI team has been the subject of two France 3 TV shows: “c’est à savoir”, 2011, “enquêtes de régions : tous surveillés ?”, 2013. The team has been involved in the Renaissance Nancy 2013 exhibit, with the Precog software (more than 10,000 persons). Each year the team participates to the exhibit “Village de la Science” and has participated to the “Nuits de la Science” in 2012.

The involvement in training through research

The KIWI members teach several courses related to the topics of the team: “Collective Intelligence / Intelligent Assistants”, “Ergonomics and Human-Computer Interaction” and “Cognitive technologies” in Master in Cognitive Science and Applications, “User Modeling and Recommender Systems” in Master Informatique,“ Pedagogical engineering – pedagogy and personal learning environments, Social networks and social media”, in M2 MEEF.

Lifelong Autonomy and interaction skills for Robots in a Sensing ENvironment

Synopsis

1 Team Composition

Permanents

François Charpillet (DR Inria), Amine Boumaza (MCF UL), Francis Colas (CR Inria), Serena Ivaldi (CR Inria), Jean-Baptiste Mouret (CR Inria on secondment from UPMC, Paris; arrived May 2015), Vincent Thomas (MCF UL).

	PR	MCF	DR	CR	Total
2014	0	0	0	0	0
2016	0	2	1	3	6

Post-docs, and engineers

Xuan Son Nguyen (postdoc ATER UL), Nicolas Beaufort (engineer Inria, until Aug 2015), Théo Biasutto-Lervat (engineer Inria, until Oct 2015), Dorian Goepp (engineer Inria, from Jul 2015), Mélanie Lelaure (engineer Inria), Thomas Moinel (engineer Inria), Maxime Rio (engineer Inria, until Oct 2015),

Doctoral students

Mihai Andries (Inria, 2012–2015), Adrian Bourgaud (Inria, 2015–), Konstantinos Chatzilygeroudis (Inria, 2015–), Oriane Dermy (Inria, 2015–), Abdallah Dib (Inria, 2013–), Arsène Fansi-Tchango (CIFRE Thalès, 2011–2015), Iñaki Fernández Pérez (UL, 2013–), Nassim Kaldé (UL, 2012–), Van Quan Nguyen (Inria, 2014–).

Phd's defended	2	On-going PhD's	7

Team evolution

The Larsen team has been recently created in January 2015 when the Maia team stopped on 31 December 2014. The permanent members of the team are of 1 DR Inria, 3 CR Inria, and 2 Assistant professors. Half of them are former members of MAIA Team (Amine Boumaza, Vincent Thomas, and François Charpillet). The other members are two new research fellows (Serena Ivaldi, CR2 and Francis Colas, CR1) who were recruited respectively in October and November 2014. In May 2015, Jean-Baptiste Mouret[4] joined the team.

This evolution of Maia team is the result of a process started after the previous evaluation of Aeres. It is linked to the development of the new platform HIS [5] started in 2010.

2 Life of the team

The team is directed by F. Charpillet (DR1) with F. Colas (CR1) as vice-director. The team has regular meetings:

- one full team meeting every two weeks, with a *tour de table* followed by general announcements;
- one meeting for the permanent researchers, every two weeks, to discuss the team strategies and research directions;
- a technical meeting every week, to report on the software and hardware developments;
- a lab seminar, every two weeks, with short and long presentations by team members.

3 Research topics

Keywords

Robotics, machine learning, human-robot interaction, sensing environment, collaborative robotics.

Research area and main goals

The goal of the Larsen team is to move robots outside of the research laboratories and manufacturing industries: current robots are far from being the fully autonomous, reliable, and interactive robots that could co-exist with us in our society and run for days, weeks, or months.

While there is undoubtedly progress to be made on the hardware side, robotics platforms are quickly maturing and we believe the main challenges to achieve our goal are now on the software side. We want our software to be able to run on low-cost mobile robots, and to be evaluated in real settings, such as in service and assistive robotic applications.

The robots we consider include mobile robots but also intelligent spaces that are equipped with sensors and actuators. In both cases, we are interested in making them sensitive to human needs, habits, gestures, etc. and adaptive and responsive to environment changes. We envision that all these systems (mobile robots and intelligent spaces) will be able to cooperate with each other: intelligent spaces can give robots improved skills, with less expensive sensors and actuators while mobile robots can help intelligent spaces to retrieve more information.

Among the particular issues we want to address, we aim at designing robots or intelligent spaces having the ability to:

[4] Jean-Baptiste Mouret changed the host institution of the Resibots ERC project (GA 637972 - May 2015 to April 2020) from Université Pierre et Marie Curie (UPMC), in Paris, France, to Inria Nancy - Grand Est

[5] `http://infositu.loria.fr`

- handle dynamic environment and unforeseen situations;
- cope with physical damages;
- interact physically and socially with humans;
- collaborate with each other;
- exploit the multitude of sensors measurements from their surrounding;
- enhance their acceptability and usability by end-users without robotics background.

All these abilities can be summarized by the following two objectives:

- *life-long autonomy*: continuously perform tasks while adapting to sudden or gradual changes in both the environment and the morphology of the robot;
- *natural interaction with robotics systems*: interact with both other robots and humans for long periods of time, taking into account that people and robots learn from each other when they live together.

4 Main Achievements

- The ERC project ResiBots (PI: Jean-Baptiste Mouret) started on the 1st of May, 2015;
- The preliminary work on which the ERC project ResiBots is based made it to the cover of Nature (28th of May, 2015). This work was covered by all the major media outlets and the associated videos total more than 400,000 views on YouTube.

5 Research activities

Adaptation / Learning for Lifelong Autonomy

Adaptation to Unforeseen Damage Conditions A promising approach to reducing robot fragility is to having robots learn appropriate behaviours in response to physical damage. We introduced an intelligent trial- and-error algorithm that allows robots to adapt to damage in less than two minutes without requiring self-diagnosis or pre-specified contingency plans [255]. The key idea is to exploit the robot's prior knowledge about the behaviours it can perform to guide a trial-and-error learning algorithm (based on Bayesian optimization) that conducts intelligent experiments to rapidly discover a behaviour that compensates for the damage.

Main results This work was highlighted in the cover of **Nature** on the 28th of May, 2015: [255]. The novel trial-and-error algorithm will enable more robust and autonomous robots, and may shed light on the principles that animals use to adapt to injury.

Robotics Perception for lifelong autonomy

Audio Source Localization We consider the audio source localization using a microphone array on a mobile robot. We propose an approach to control the robot movements so as to locate the source as quickly as possible [262]. We represent the belief about the source position by a discrete grid and we introduce a dynamic programming algorithm to find the optimal robot motion minimizing the entropy of the grid.

Geometric Registration Registration algorithms associate sets of data into a common coordinate system. They are extensively used in several robotics fields, particularly for localization of mobile robots in which point clouds are to be registered. We proposed a review of geometric registration to provide guidelines for robotics applications [261].

Robust Dense Visual Odometry for RGB-D Cameras in a Dynamic Environment Visual odometry is a fundamental challenge in robotics and computer vision. The aim of our work is to estimate RGB-D camera motion (onboard a mobile robot) from RGB-D images in a dynamic scene with people moving in the scene. We proposed a new dense visual odometry method [269] that uses random sampling consensus (RANSAC) to cope with dynamic scenes.

Main results Our dense visual odometry method performed better than state-of-the-art methods in previous and novel datasets in [269].

Distributed Sensing and Acting

Localisation of Humans, Objects and Robots Interacting on Load-Sensing Floors We proposed a novel algorithm for tracking and recognition of humans, objects and robots on load-sensing floors [253], which relies on the segmentation of the floor pressure images. The algorithm was successfully validated in the *intelligent apartment* in Inria Nancy.

Online Distributed Learning for a Swarm of Robots We propose a novel innovation marking method for neuro-evolution of augmenting topologies in embodied evolutionary robotics in [271]. The method does not rely on a centralized clock, which makes it well suited for the decentralized nature of embodied evolution where no central process governs the adaptation of a team of robots exchanging messages locally. In [271] we analyze the influence of selection pressure in distributed multi-robot tasks such as navigation and obstacle avoidance. We show that the performance increases with selection pressure in distributed agents, as opposed to low pressures in centralized approaches.

Online Distributed Exploration of an Unknown Environment by a Swarm of Robots We proposed a new taboo-list approach [264] for multi-robot exploration of unknown structured environments, in which robots with local view are implicitly guided in their navigation on a globally shared map until they gather at a designed rendez-vous. The novelty consists in using a distributed exploration algorithm which is not guided by frontiers to perform this task. In [259] we propose another exploration strategy for mobile robots in populated environments that explicitly accounts for human-robot interactions. Robots can locally choose a human guide to follow and define a parametric heuristic to balance interaction and frontier assignments.

Multi-Camera Tracking in Partially Observable Environment In collaboration with Thales There-SIS - SE&SIM Team (Synthetic Environment & Simulation), we focused on the problem of people tracking using multiple actuated cameras. We proposed algorithms to infer the people behavior even in presence of blind areas and occlusions [FTTB+14].

[FTTB+14] Arsène Fansi Tchango, Vincent Thomas, Olivier Buffet, Fabien Flacher, and Alain Dutech. Simultaneous Tracking and Activity Recognition (STAR) using Advanced Agent-Based Behavioral Simulations. In *ECAI - Proceedings of the Twenty-first European Conference on Artificial Intelligence*, Prague, Czech Republic, August 2014.

Main result This work has been published in A. Fansi Tchango's PhD thesis, defended in Dec. 2015 [251]. We provide a parallel implementation for human pose estimation in presence of occlusions, that runs on CPU and GPU at 4 frames/second. Our own dataset for human tracking with occlusions is available online (`http://www0.cs.ucl.ac.uk/staff/M.Firman/RGBDdatasets/`).

Cognitive Robotics and Human-Robot Interaction

PsyPhINe: *Cogito Ergo Es* In the interdisciplinary project PsyPhINe, funded by PEPS Mirabelle, we explore the human tendency to anthropomorphize devices and attribute intentions. We design a "non-verbal" Turing Test using a robotic prototype. We also organized an interdisciplinary workshop gathering top researchers from philosophy, anthropology, psychology and computer science to discuss and exchange on our methodology (see Events).

Multimodal Object Learning During Human-Robot Interaction To improve object recognition during human-robot interaction, in [260] we proposed a technique where visual input from cameras was combined with the robot proprioceptive information, in order to classify objects, robot, and human body parts. With a developmental learning approach, the robot learnt iteratively the appearances of objects through observation first, then through active object manipulation and human-robot interaction in a second phase. We validated with experiments with the iCub and the Meka robots.

Individual factors, social signals and acceptance in Human-Robot Interaction We carried out an experimental study with 56 adult participants and the iCub robot. To investigate robot acceptance, we used trust in the robot's answers as a main indicator of acceptance in decision-making tasks characterized by perceptual and socio-cognitive uncertainty. From the same study, we were able to assess the influence of two factors, namely extroversion and negative attitude toward robots, on speech and gaze during a cooperative assembly task with physical interaction with the iCub. This work follows up on the research on engagement with social robots [254].

Main results We found that participants trusted more the iCub's answers about functional issues than social issues (`arXiv:1510.03678[cs.RO]`). We found that the more people are extrovert, the more and longer they tend to talk with the robot; and the more people have a negative attitude towards robots, the less they will look at the robot face and the more they will look at the areas of physical interaction (`http://arxiv.org/pdf/1508.04603v1`). We also found that extroversion and negative attitude towards robots can be estimated from the human behavior in front of the robot during a first thin slice of interaction [272].

Scientific production and quality

6 Synthesis of publications

	2015	2016
PhD Thesis	2	
H.D.R	1	
Journal	7	1
Conference proceedings	11	
Conference proceedings (non selective)	2	
Book chapter	1	
Book (written)		
Book or special issue (edited)		1
Patent		
General audience papers		

7 List of top journals in which we have published

- Nature (1) [255]
- International Journal of Robotics Research - IJRR (1) [257]
- Autonomous Robots (1) [260]
- Journal of Artificial Intelligence Research - JAIR (1) [256]

8 List of top conferences in which we have published

- IEEE International Conference on Robotics and Automation - ICRA (3) [273, 266, 263]
- IEEE/RSJ International Conference on Intelligent Robots and Systems - IROS (2) [264, 268]
- IEEE-RAS International Conference on Humanoid Robots - HUMANOIDS (1) [265]
- Annual Conference on Genetic and Evolutionary Computation - GECCO (1) [271]
- International Joint Conference on Artificial Intelligence - IJCAI (1) [270]

9 Software and platforms

Smart Appartment

We have a “smart” sensorized apartment (bedroom, bathroom, living room and kitchen) equipped with a sensorized tactile floor, several RGB-D cameras, a motion capture system (Qualisys), and domotics sensors.

The apartment is used for our researches in ambient assisted living, human-robot interaction and human movement and activity analysis, particularly fall detection.

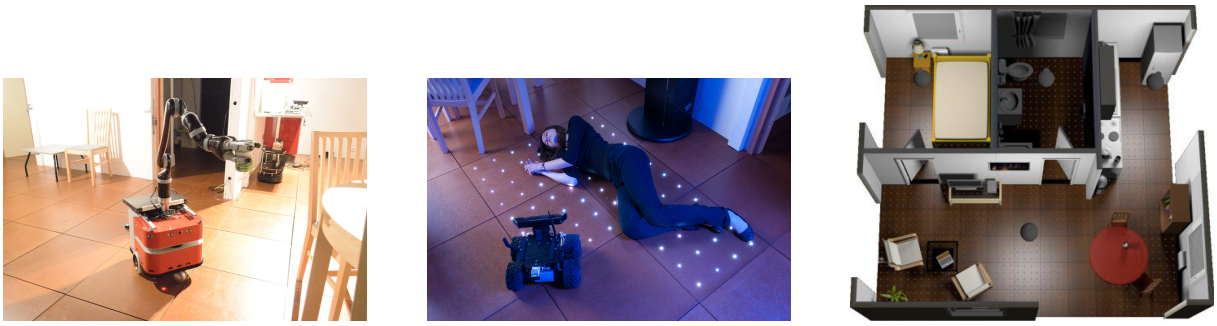


Figure 1.2: Overview of the smart apartment

Figure 1.3: Overview of the new experimental room.

Arena for mobile robots

A new room has been installed for the experiments of the ResiBots ERC project and of the Codyco FP7 project (Figure 1.3). This 100 m^2 room contains a 5.5 $\times$ 6 m experimental “arena” made with aluminium trusses.

It is equipped with:

- a 6D motion capture system (Optitrack), with 8 gibagit cameras (Prime 13);
- 4 high-power, studio lights;
- 3 mobile 19” racks (on wheels), which host the power supplies and the computers to control the robots;
- a 6-legged robot, used by the ResiBots project;
- an omnidirectional wheeled robot (Kuka Youbot), used by the ResiBots project;

- a hybrid, wheel-legged robot, used by the ResiBots project (loan by the Pierre and Marie Curie University);
- a Kinova robotic arm, used by the Codyco project.

The trusses support the motion capture system and the lights, and hold all the cables (network, power, etc.).

This room will also host the iCub humanoid robot that should be received in March 2016.

The academic reputation and appeal

10 Prizes and Distinctions

11 Editorial and organizational activities

- guest Editor for the Springer Journal Autonomous Robots, for PLOS Computation Biology,
- 3 members of the team are Review Editor for Frontiers in AI and Robotics,
- associate editor of IROS 2015, of ICRA 2015, of HRI 2015, associate editor of HUMANOIDS 2015.
- organization of ICRA 2015 Workshop on Force & Tactile sensing, co-organization of IROS 2015 workshop DEMUR on “On-line decision-making in multi-robot coordination”,
- co-chair of the track “Learning and Adaptive Systems III” at the IEEE International Conference on Robotics and Automation (ICRA) 2015, chair of the “Generative and Developmental Systems” track at international Genetics and Evolutionary Computation Conference (GECCO) 2015.
- reviewer for Signal Processing: Image Communication, reviewer for Autonomous Robots, for the Journal of Intelligent and Robotics Systems, for the Journal of Field Robotics, for IEEE Transaction on Robotics, for Frontiers in AI and Robotics, IEEE Transactions on Evolutionary Computation, PLOS One, Evolutionary Computation.
- PC member of GECCO’2015, ECAL’2015, EVOstar’2015, DEMUR’15, ICAART’2015, SENSORNETS’2015, CEC’2015, EA’2015.
- PC member in several workshops at international conferences (ICRA 2015, AIRO 2015, ACII 2015, ENHANCE 2015, AAMAS)

12 Services as expert or evaluator

- panel member and reviewer for the call H2020 ICT in Innovation Actions 2015 (7 projects reviewed)
- member of the CIS task force -web presence- for the IEEE Technical Committee on “Cognitive and Developmental Systems”,
- chair of the “Evo-Devo-Robot” task force of the IEEE Technical Committee on “Cognitive and Developmental Systems”.

- 2 HDR and 6 PhD committees
- member of GDR Robotic scientific committee

13 Collaborations

The team has developed a strong collaboration with Jeff Clune (University of Wyoming) about the evolution of artificial neural network and about novel approaches to evolutionary computation. So far, it resulted in 3 journal article (including the cover of Nature in 2015) and 1 conference paper.

The team cooperates with Elizabetta Zibetti (psychology, CHART-Lutin/ Universitée Paris 8-CNRS) and Mohamed Chetouani (ISIR/UPMC-CNRS) about social signals and human-robot interaction. In 2015, this collaboration resulted in one journal article and one conference paper.

Thanks to the CodyCo project, the team also has strong connections with TU Darmstadt (Jan Peters, 3 conference papers, 2 journal papers), with the Pierre and Marie Curie University (Vincent Padois, 1 journal paper), and with the Italian Institute of Technology (Francesco Nori, 1 conference paper, 1 journal paper).

14 External support and funding

- Resibots (ERC Starting Grant), coordinator. *Robots with animal-like resilience*
- CoDyCo (FP7). *Whole-body Compliant Dynamical Contacts in Cognitive Humanoids*
- PIA LAR. *Living Assistant Robots*
- AME Satelor
- PsyPhINe: Cogito Ergo Es (PEPS Mirabelle). Coordinator.
- MUROTEX (PHC). *Distributed planning framework for efficient task-allocation planning in exploration and reconnaissance missions by a group of mobile robots*

Involvement with social, economic and cultural environment

15 Dissemination

- participation in the R2T2 (Remote Rescue using Thymio2) Robot challenge organized by EPFL.
- Serena Ivaldi was portraited in the book “Le cerveau fait-il deux choses à la fois ?” by Fiamma Luzzatti.
- talk on “Robots that can adapt to damage in minutes” at Café Neu Romance, Prague (28th of November, 2015)
- talk and tutorial : “journées ISN-EPI”, Lycée Bichat-Lunéville, participation in “journées Village Master”, “Computer Science Exporoute”, creation of the exposition “jeux ateliers de la pensée”.

The involvement in training through research

MAchine Intelligente et Autonome/ Autonomous intelligent machine

Synopsis

1 Team Composition

Permanents

François Charpillet (DR INRIA, left 31/12/2014 for Larsen), Christine Bourjot (MCF UL), Vincent Chevrier (MCF UL, -2015)(PR UL, 2015-), Alexis Scheuer (MCF UL), Alain Dutech (CR INRIA), Bruno Scherrer (CR INRIA, left 31/12/2014 for BIGS team IECL), Vincent Thomas (MCF UL, left 31/12/2014 for Larsen), Nazim Fatès (CR INRIA), Olivier Simonin (MCF UL, left 31/08/2013), Olivier Buffet (CR INRIA), Joerg Hoffmann (DR INRIA, left 31/03/2012), Amine Boumaza (MCF UL, arrived 31/08/2012, left 31/12/2014 for Larsen).

	PR	MCF	DR	CR	Total
2011	0	5	2	4	
2014	0	5	1	4	
2016	1	2	0	3	

Post-docs, and engineers

Jilles Dibangoye (postdoc 2012-2014, engineer 2014), Arnaud Glad (postdoc Inria 2011-2012), Emil Keyder (postdoc Inria 2011-2011), Michael Katz (postdoc Inria 2011-2011), Boris Lesner (postdoc Inria 2012-2013), Xuan Son Nguyen (postdoc Inria 2013-2014), Nicolas Beaufort (engineer Inria 2010-2014, left 31/12/2014 for Larsen), Theo Biasutto-Lervat (engineer Inria 2014-2014, left 31/12/2014 for Larsen), Abdallah Dib (engineer Inria 2011-2011), Victorien Elvinger (engineer Inria 2014-2015), Lionel Havet (engineer Inria 2011-2012), Mélanie Lelaure (engineer Inria 2014, left 31/12/2014 for Larsen), Thomas Moinel (engineer Inria 2014, left 31/12/2014 for Larsen), Maxime Rio (engineer Inria 2013, left 31/12/2014 for Larsen), Marie Tonnelier (engineer Inria 2009-2012),

Doctoral students

Mihai Andries (Inria, 2012-2015), Mauricio Araya-López (Chilian gov., 2009-2013), Antoine Bautin (ANR, 2009-2013), Olivier Bouré (UL, 2009-2013), Benjamin Camus (UL, 2012-2015), Gabriel Corona (Inria, 2007-2011), Lucie Daubigney (Supélec, 2011-2013), Amandine Dubois (UL, 2011-2014), Arsène Fansi Tchango (CIFRE Thales, 2011-2015), Iñaki Fernandèz (UL, 2013-), Arnaud Glad (Inria,2007-2011) Nassim Kalde (UL, 2012-), Tomas Navarrete (Mexican gov., -2013), Thomas Paris (UL, 2015-) Cédric Rose (CIFRE Diatelic SA, -2011), Julien Siebert (UL, -2011), Manel Tagorti (Inria-ANR, 2011-2015), Mohamed Tlig (Inria-Europe, 2011-2015), Julien Vaubourg (Inria, 2013-), Jano Yazbeck (Inria-Europe, 2010-2014), Matthieu Zimmer (UL, 2014-).

Phd's defended	16	On-going PhD's	3

Team evolution

- Joerg Hoffmann (DR2 Inria) left the Maia team on March 1st, 2012 for a professor position at Saarland University.
- Amine Boumaza joined the team on September 1st, 2012, after a mutation from Littoral university, Calais.
- Olivier Simonin (MCF UL) left the Maia Team on August 31, 2013 for a professor position at INSA Lyon.
- Francis Colas (CR1) and Serena Ivaldi (CR2) joined the team at the end of 2014.

The departures of O. Simonin and J. Hoffmann have deeply disturbed the reorganization of the team, as it was scheduled end of 2011 for anticipating MAIA team stop (from Inria Side Maia stop was scheduled end of 2014). Although a proposition was ready end of 2011, for splitting MAIA team into two groups, we should drop it, when Joerg Hoffmann left the team. The recruitment in 2014 of Serena Ivaldi and Francis Colas (as CR1) moved the situation, making possible to create a new group called Larsen at the beginning of 2015.

The MAIA team ended on 31/12/2014. Part of its members founded the LARSEN team, whilst others were affiliated directly to the department 5 during restructuration and new teams founding.

This report corresponds to the MAIA activities from 2011 to 2014 with the activities reporting of people not affiliated to the Larsen team from 2015 to 2016.

2 Life of the team

The head of the team was François Charpillet. The team had regular meetings: (a) one full team meeting every weeks with a lab seminar, and (b) one meeting for the permanent researchers, every weeks, to discuss the team strategies and research directions, with a *tour de table* and general announcements.

3 Research topics

Keywords

Sequential Decision Making, Markovian Models, Multi-Agent Systems, Complex Systems.

Research area and main goals

The objective of the MAIA team is to address foundation and engineering aspects of artificial intelligence. In this general framework, the team investigates the design and understanding of intelligent agents, i.e., an entity which autonomously perceives and acts upon an environment achieving one or several goals. The MAIA team equally addresses the design of a single agent, a team of agents, or a huge number of agents. This common objective is considered from two perspectives organized around two main lines of research: (a) sequential decision making, and (b) understanding and mastering complex systems.

During the evaluation period a new research activity has emerged around Robotics and Ambient Intelligence. This has been backed up by the INRIA Large-scale initiative project termed PAL (Personal Assistant Living) and the regional council of Lorraine which supported this new research line through the CPER, (project ”situated computing” or ”INFOSITU” http://infositu.loria.fr).

4 Main Achievements

Understanding and mastering complex systems
We proposed a multi-agent approach for multi-modeling and specify its implementation in the mecsyco simulation software, we applied it successfully in different real use cases in smart-grids domain with EDF R& D.

Sequential decision making
In the field of decentralized control under uncertainty, members of the team have made a breakthrough by proposing a method to solve any Decentralized Partially Observable Markov Decision Process (Dec-POMDP) as a continuous-state and deterministic MDP called *Occupancy MDP*. This is analogous to solving POMDPs as Belief MDPs, so that similar algorithms have been proposed, which —also exploiting lossless compression techniques and mathematical optimization— solve most benchmark problems orders of magnitude faster than the state-of-the-art [340, 341].

Robotics and Ambient Intelligence
During the evaluation period the team members made some achievements both at the technical level, building a new plateform(a smart apartment) for robotics and ambient Intelligence and at the scientific level in the domain of multi-robotics [324, 355, 312] and assistance for elderly [290].

Multi-disciplinary work
Either with biologists to model learning mecanisms in rats [299], within the PsyPhINE group with psychologists and philosophers in order to better understand the notion of cognition, or within the PEPS MoMIS in order to study collective decision mechanism, the MaIA team has been involved in several very interesting multi-disciplinary works.

Research Organization
During the last 5 years, a considerable amount of time has been spend to the team reorganization. This has deeply affected the work environment of the team members during the evaluation period.

5 Research activities

Understanding and mastering complex systems

Description This activity is about representing and studying systems composed of simple interacting agents capable of collectively producing complex behaviors.

It is structured around the three following challenges:

- **Providing formal frameworks** is intended to i) remove the potential ambiguities that can appear if one describes a system without explicitly formulating each aspect of the simulation framework and; ii) provide quantitative characteristics of the system such as local or global stability, robustness, complexity, etc.

- **Controlling complex dynamical system** investigates under which conditions it is possible to guarantee a given property when the system is subject to perturbations.

- **Designing systems** seeks to conceive individual behaviors and interactions in order to produce a desired collective output. It also tackles "inverse problems" (decentralized gathering problem, density classification problem, etc.) which consist in finding individual behaviors in order to solve a given problem.

Main results We propose an adaptive control of a complex system based on its multi-agent model in an "equation-free" approach [387, 388, 285] and apply it on the "free-riding" phenomenon in peer to peer file exchange networks.

In the context of multi-modeling and multi-simulation of complex systems, we proposed a multi-agent meta-model[287, 280]. It is formalized using DEVS and is implemented in the Mecsyco software. We applied our proposals on proofs of concepts [335, 296] and industrial use cases [408, 409] in the MS4SG project with EDF R&D on smart-grid simulation.

As a means to examine connections between Cellular Automata and Reactive Multi-Agent Systems, we studied lattice-gas cellular automata (LGCA). We examined in detail the **robustness** of a bio-inspired model of swarm formation. We exhibited several new phenomena and proposed a finer view of the dynamics of the emergent patterns [294, 279].

We tackled the study of consensus problems in cellular automata. A simple solution to the decentralised aggregation problem was proposed and applied on teams of *Alice* and *Khepera* robots [300, 410]. The density classification problem was examined for finite and infinite systems in 1D and 2D [302, 295, 362]. We examined asynchronous cellular automata in order to understand their robsutness: a survey [303] was realised and various results on these models were exhibited such as the definition an asynchronous information transmission [328], a characterisation of the reversibility of some simple rules [399], an analysis of the second-order phase transitions that appear when the updating is varied [305], and an advance on classification problems [364, 365].

Sequential Decision Making

Description Sequential Decision Making consists in controlling the actions of an agent facing a problem whose solution requires not one but a whole sequence of decisions. This kind of problem occurs in a multitude of forms. For example, important applications addressed in our work include: Robotics, Medicine, Computer Security, and Business Process Management. Our work on such problems is characterized by four research trends: (A) *Exploring connections across problem variants and research areas*, (B) *Developing and understanding solution algorithms*, (C) *Supporting partial models and learning techniques*, (D) *Transfering our results in applications.*

The problems differ in several dimensions, in particular the extent of the model assumed as input (full vs. partial vs. none), the form of the model (factored vs. enumerative), the world dynamics (deterministic vs. stochastic), and the extent of observability (full vs. partial). The complexity of solving the problem – both in theory and in practice – depends crucially on where the problem resides in this categorization. One aspect of growing importance in our work is to address the interaction between methods addressing the different facets, and the exchange of ideas between the different areas involved, which so far have mostly developed separately in the literature.

Main results

- We have made some results on the analysis of dynamic programming (DP) algorithms for solving γ-discounted infinite-horizon MDPs. We have improved and derived the tightest bounds on the complexity of Policy Iteration [439, 397, 436]. We have studied several linear approximation schemes for estimating the value of some fixed policy in a large problem [372, 393, 430, 306, 371, 441, 403]. We have shown that under certain assumptions, most approximate DP that compute a *stationary policy* enjoy a performance guarantee of $\frac{C\epsilon}{(1-\gamma)^2}$ [483, 395, 435, 394, 437, 369, 370, 310]. We have proposed new algorithms that compute *non-stationary policies*, which improves the performance guarantee to $\frac{C\epsilon}{1-\gamma}$, and shown that all the above guarantees cannot be improved in general [438, 396, 484, 311, 383] [6]. Finally, we have studied the constant C in the above bounds, which suggests that some of our new non-stationary algorithms are preferable to more standard approaches [398].

- In the field of classical planning, three main lines of research have been pursued. (1) We have developed the Torchlight tool, which conducts an automatic analysis of search space surface properties based purely on input model syntax, i.e., without running any search [377, 308]. (2) We have investigated abstraction strategies within the framework of merge-and-shrink abstraction for computing lower bounds on goal distance [379]. (3) we have investigated partial delete relaxation heuristics, which go well beyond the delete relaxation in allowing to interpolate smoothly between delete-relaxation estimates and the actual goal distance [381]. In addition, we collaborated with researchers from the Univ. of Alberta (Canada) on resource-constrained planning [386].

- In the field of planning under partial observability (POMDPs), we have proposed both (i) a formalism to describe information gathering problems, and (ii) solution algorithms for them [420, 277]. Connections have been made with model-based reinforcement learning (learning to act while learning a model of controllable dynamics) [321, 320]. Other research work has considered more practical aspects, as for tracking multiple pedestrian in a real-world setting [283].

  Separately, we have also investigated POMDP models of simulated penetration testing, which allow to reflect such penetration test very accurately [392].

- In the field of decentralized control under uncertainty, we have made a breakthrough by proposing a method to solve any Decentralized POMDP as a continuous-state and deterministic MDP called *Occupancy MDP*. This is analogous to solving POMDPs as Belief MDPs, so that similar algorithms have been proposed, which solve most benchmark problems orders of magnitude faster than the state-of-the-art [340, 341].

- In the field of Reinforcement Learning, we explore the concept of a developmental learning [354, 353]. The idea is to incrementally learn complex tasks by progressively increasing the sensorimotor possibilities of the agent. Several subquestions are actively researched like, for example, reinforcement learning in continuous action spaces, transfer learning, automated task selection, etc.

Robotics and Ambient Intelligence

Description Robotics and Ambient Intelligence is a transversal research domain in Maia Team which has been increased during the evaluation period due to our involvement in PAL Inria action, LAR and

[6] [396] was one of the 20 papers selected for full oral presentation at NIPS (out of 370 accepted papers, out of 1497 submissions)

Satelor projects, CPER from Region lorraine and Intrade europeen project. Two domains have been addressed : multi-robotics and ambient intelligence for assistance of elderly people.

Main results

- Since 2010 we have been involved in the design and the construction of an innovative platform for favoring research in assistance for elderly people at home. It consists of a standard 2-room apartment, with a certain number of smart and connected devices such as sensor networks.

- Participation to the Carotte Defi organized by ANR. The Cartomatic project, which was part of the French robotic contest Defi CAROTTE organized by the General Delegation for Armaments (DGA) and French National Research Agency (ANR), has won the third and final edition of the contest. The Maia team has proposed a new frontier assignment algorithm for multi-robot exploration. We defined a new heuristic, based on counting the robots towards a frontier rather than considering only the distance between robots and frontiers. For this purpose we developed algorithms based on wavefront computations (artificial potential fields). We measured on benchmarks that our algorithm outperforms the two classical approaches *closest frontier* and *Greedy assignment*.

- Among the several goals that we were trying to achieve in InTraDE, we were interested in platooning. In her PhD thesis, Jano Yazbeck considers Platooning as a technique that aims at steering , safely and precisely, a train of vehicles along a path generated by a leader which can be driven by a human. Several near-to-near decentralized approach which has been proposed during the PhD of Jano Yazbeck.

- The use of floor-sensors in ambient intelligence contexts began in the late 1990's, with projects like ORL active floor, the Magic carpet by Paradiso et al., and the smart floor by Orr et al. These floors were, later on, integrated in smart environments, aimed at delivering assistance services like continuous diagnosis of users' health. We have ourselves developed a sensing floor. This load-sensing floor is composed of square tiles, each equipped with two ARM processors (Cortex m3 and a8), 4 load cells, and a wired connection to the four neighboring cells. Each tile has 16 light-emitting diodes which provide visual feedback. Several functionalities have been implemented on this prototype floor, including weight measurement, fall detection, footstep tracking and activity recognition. We also implemented heuristic real-time multi-user and multi-robot localization in an indoor setting using this prototype floor.

6 Synthesis of publications

	2011	2012	2013	2014	2015	2016
PhD Thesis	4	1	3	2	3	0
H.D.R.	0	0	0	0	0	0
Journal	6	10	5	5	3	0
Conference proceedings	17	21	16	22	7	0
Conference proceedings (non selective)	13	8	12	3	1	0
Book chapter	3	2	0	2	0	0
Book (written)	0	0	0	0	0	0
Book or special issue (edited)	1	2	2	0	1	0
Patent	0	0	0	0	0	0
General audience papers	0	0	0	0	0	0

7 List of top journals in which we have published

- Journal of Artificial Intelligence Research (JAIR) (2) [308, 307]
- Journal of Machine Learning Research (JMLR) (3) [311, 306, 310]
- Journal of Intelligent and Robotic Systems (JIRS) (2) [297, 313]
- Swarm Intelligence (1) [312]
- Natural Computing (3) [293, 294, 305]

8 List of top conferences in which we have published

- International Joint Conference on Artificial Intelligence (IJCAI) (5) [390, 340, 389, 345, 342]
- Autonomous Agents and Multiagent Systems (AAMAS) (4) [343, 341, 356, 388]
- AAAI Conference on Artificial Intelligence (AAAI) (4) [333, 380, 392, 389]
- International Conference on Automated Planning and Scheduling (ICAPS) (4) [377, 379, 381, 386]
- European Conference on Artificial Intelligence (ECAI) (3) [357, 382, 407]
- International Conference on Machine Learning (ICML) (7) [370, 321, 371, 395, 398, 383, 403]
- Neural Information Processing Systems (NIPS) (3) [396, 369, 397]
- International Conference on Intelligent Robots and Systems (IROS) (2) [412, 319]
- International Conference on Robots and Automation (ICRA) (1) [411]

Members of the MAIA team have also published in conferences such as UAI, ECML/PKDD, Automata, ACRI, UC, SAB, PAAMS, ICASSP, STACS, EMBC, or ICTAI.

9 Software

- Mecsyco (Multi-agent Environment for Complex SYstem COsimulation) is a framework that implements the AA4MM (agents and artefacts for multi-modeling and simulation) meta-model. The aim of Mecsyco is the coupling existing and heterogeneous models and simulators in order to model and simulate complex systems.

  Mecsyco is registered by the APP[7] and available on http://www.mecsyco.fr under AGPL. It is used for Smart-Grids modeling and simulation with EDF R& D.

- FiatLux is a discrete dynamical systems simulator that allows the user to experiment with various models and to perturb them. It features classical cellular automata, moving agents, interacting particle systems, etc.

  It is registered by the APP and available at http://fiatlux.loria.fr under the CeCILL licence.

- Cart-o-matic is a software platform for (multi-)robot exploration and mapping tasks. It has been developed by Maia members and LISA (Univ. Angers) members during the robotics ANR/DGA Carotte challenge (2009-2012).

  It is registered by the APP.

The academic reputation and appeal

10 Prizes and Distinctions

- Co-winner of the optimal track at the 7th International Planning Competition (IPC'11),
- Winner of the 3rd (and final) French robotics contest Defi CAROTTE organized by DGA and ANR ; see an Inria press report.
- Best paper awards: ICAPS 2012 [381], AAAI 2012[8] [333], AAMAS 2014 [341].

11 Editorial and organizational activities

Members of the MAIA team have acted as reviewers in about 30 international journals, and as PC members in about 30 international conferences.

Christine Bourjot was a board member of AFIA (Association pour l'Intelligence Artificielle).

François Charpillet is member of the scientific committee of the Robotics GDR.

Amine Boumaza was a review editor of the International Journal Frontiers in Robotics and AI: Evolutionary Robotics.

Joerg Hoffmann was Program Co-Chair of the 26th National Conference of the American Association for Artificial Intelligence (AAAI'12). He was an Associate Editor of JAIR and Area Chair for Planning of AI Communications.

Olivier Buffet was a member of the editorial board of JAIR.

Olivier Buffet and François Charpillet are or have been member of the editorial board of RIA journal.

[7] Agence pour la protection des programmes

[8] (Special Track on Computational Sustainability and AI)

Nazim Fatès has been a member of the editorial board of the *Journal of Cellular automata*. He was the co-chair of AUTOMATA'11, the 17th International Workshop on Cellular Automata and Discrete Complex Systems and the co-chair of ACA@ACRI'12, a satellite workshop on asynchronous cellular automata.

12 Services as expert or evaluator

Members of the MAIA team have acted as members in 3 HDR committees and 32 PhD committees, and referees in 1 HDR committee and 36 PhD committees.

Members of the MAIA team have participated to specialist/selection committees for Université de Lorraine (including its predecessors), Université de Grenoble, Université de Lyon, Université Technologique de Compiègne, Université Paris 13, Université Lille 1, Université de Caen Basse-Normandie, and Université Paris Dauphine.

Members of the MAIA team have served as reviewers in the assessment of research projects for NWO (Netherlands Organisation for Scientific Research) and INRA (Institut National de la Recherche Agronomique).

13 Collaborations

Collaboration with L. Ciarletta (Madynes team): MS4SG project, PhD co-advising (3), co-publications (8), co-authoring of Mecsyco software.

Collaboration with J. Dibangoye and O. Simonin (now at INSA-Lyon), and C. Amato (U. of New Hampshire) on solving Dec-POMDPs: co-publications (9), Dec-POMDP solver.

Collaboration with J. Hoffmann (now at Saarland University) on probabilistic planning and its application to penetration testing: publications (4).

14 External support and funding

Bilateral contracts

- The MS4SG (multi-simulation for smart grids) project is granted as a strategic action between INRIA and EDF R & D.
- Thèse CIFRE (2011-2014) of Arsène Fansi Tchango "Simulation-Based Behavior Tracking of Pedestrians in Partially Observed Indoor Environments partially" with Thales Theresis.

National projects

- ANR Cartomatic projet (2010-2012).
- BARQ (2010-2013) was a "Chaires d'Excellences" ANR project led by Joerg Hoffmann.
- PEA SUSIE (2009-2012) research project for DGA/D4S/MRIS "Supervising Swarm Intelligence".
- LAR(Living Assistant Robot) a Project funded by "Investissement d'avenir" or "Investments for the Future" program, a government initiative to reinforce long-term French competitiveness.
- PAL(Personally Assisted Living, 2010-2014), an Inria Project Lab.

Regional contacts

- SATELOR Project funded by Economic mobilisation agency in Lorraine (2013-2017).
- COMAC (2009-2012 - *contrôle optimisé multi-techniques des aérostructures composites*[9]) was a project of the regional competitive cluster Materalia.
- PsyPhINe : MSH Lorraine project, Exploratory Project LORIA, PEPS CNRS Mirabelle.
- Cooperation with Archives Poincaré (Univ. Lorraine) in the inderdisciplinary PEPS MoMIS (Mathematical models and social interaction).

European projects

- MUROTEX (Multi-agent coordination in robotics exploration and reconnaissance missions, 2014-2015) is a Hubert Curien Partnerships (PHC) with Olivier Simonin from Insa Lyon, Citi lab and Jan Faigl from Czech Technical University in Prague.
- InTraDE (2010-2014 - Intelligent Transportation for Dynamic Environment - http://www.intrade-nwe.eu) was an InterReg IV-B European project.

Involvement with social, economic and cultural environment

- Nazim Fatès was the president of the Jury for the Festival du film de chercheur 2014. He recorded a short video on Turing's legacy and participated to several events related to the celebration of the "Turing year". He was invited to give a conference in the "journée régionale APMEP" destined to high-school teachers.
- Vincent Thomas organized an exhibit about game design and cognitive sciences (*"Jeux, atelier de la pensée"*). The exhibit material was presented in several BU (*Bibliothèques universitaires*) including IUT Charlemagne BU, Campus Médecine BU and Campus Brabois BU. This exhibit is planned to be presented in other libraries in 2015 (Epinal, St Dié).
- Vincent Thomas participated in several dissemination activities like *"la nuit des chercheurs"*, *"ARTEM fête la science"* and several *"Fête de la Science"* between 2011 and 2015.
- Vincent Thomas organized several workshops about artificial intelligence during "Journée ISN-EPI" (2013, 2014, 2015) whose audience is computer science teachers of secondary school.

Involvement in training through research

- Master degree (research) in computer science: "Introduction to Mobile Robotics" (M1) and "Additional Mobile Robotics" (M2, IPAC option); "Metaheuristiques et Optimisation" (M1); contribution to "Complex Adaptive Systems" (M2, IPAC option); "Apprentissage numérique" (M2, IPAC)

[9] optimized multi-technique control of composite aeronautic parts

- C. Bourjot manages the Cognitive Science and Digital Media speciality of Cognitive Science and Application (SCA) Master's degree; 3 other team members participate to the SCA Master's degree
- Master level, contribution to "Artificial Life" (last year, equiv. M2), at École Supérieure d'Électricité.

Computational System Neuroscience

Synopsis

The team has been created in January 2013 by two former members of the Cortex team. The team aims at understanding the dynamics of neural systems on multiple scales and develops methods to invent monitoring devices. The approach is inspired by systems neuroscience, which relates microscopic modifications in neural systems to macroscopic changes in behavior. The team employs this systems neuroscience approach and develop models and data analysis tools in order to bridge the gap between microscopic and mesoscopic, and mesoscopic and macroscopic/behavior activity. These bridges are necessary to better understand neural systems and, in turn, control the neural systems. They also may allow to develop data monitors utilising the derived principles. As a long-term goal, the team shall develop such devices in medicine with application in general anaesthesia.

1 Team Composition

Permanents

Axel Hutt (DR INRIA, left 31/10/15), Laurent Bougrain (MCF univ. de Lorraine), Laure Buhry (MCF univ. de Lorraine, since 01/9/13).

	PR	MCF	DR	CR	Total
2013		1		1	2
2016		2			2

Post-docs, and engineers

Pedro Garcia Rodriguez (post-doc 2012-2013, engineer 2013-2015), Tamara Tosic (post-doc 2013-2015, ATER 2015-...), Laure Buhry (post-doc 2012-2013) Eric Nichols (engineer 2012-2015), Guillaume Serrière (engineer 2012-2015)

Doctoral students

Maxime Rio [INRIA, 2008-2013), Carolina Saavedra (CONICIY(Chile), 2009-2013), Meysam Hashemi [Europe, 2012-2016), Mariia Fedotenkova [INRIA, 2013-...), Cecilia Lindig-León [INRIA, 2013-...),

Francesco Giovannini (INRIA, 2014-...), Sébastien Rimbert (Region-CUGN-UL-INRIA-LORIA, 2016-...)

Phd's defended	3	On-going PhD's	4

Team evolution

The team has been created in January 2013 by two former members of the Cortex team. Thus, activities from former members for the Cortex team (A. Hutt & L. Bougrain) from 2011 are reported here and not in the Cortex report. Axel Hutt left the team on October 31st, 2015 for a 4-years secondment at Deutscher Wetterdienst (Germany). Laurent Bougrain is the team leader since November 1st, 2015. Laure Buhry has joined the team in September 2013.

2 Life of the team

A team meeting to present scientific work and discuss strategy and team organization is usually organized every two weeks alternating with a journal club. 15mn stand-up meetings are organized every week to report the news of the week if they do not require discussion. A weekly meeting is made between each Ph.D. student and his supervisor with a report.

3 Research topics

Keywords

Computational System Neuroscience, Multiscale Modeling, Stochastic Modeling, Signal Analysis, Machine Learning, General Anesthesia, Memory, Brain-Computer Interfaces.

Research area and main goals

The main challenge in computational neuroscience is the high complexity of neural systems. The brain is a complex system and exhibits a hierarchy of interacting subunits. On a specific hierarchical level, such subunits evolve on a certain temporal and spatial scale. The interactions of small units on a low hierarchical level build up larger units on a higher hierarchical level evolving on a slower time scale and larger spatial scale. By virtue of the different dynamics on each hierarchical level, until today the corresponding mathematical models and data analysis techniques on each level are still distinct. Only few analysis and modeling frameworks are known, which link successfully at least two hierarchical levels.

- From the microscopic to the mesoscopic scale:
  One research direction focuses on the *relation of single neuron activity* on the microscopic scale *to the activity of neuronal populations*. To this end, the team investigates the stochastic dynamics of single neurons subject to external random inputs and involving random microscopic properties, such as random synaptic strengths and probability distributions of spatial locations of membrane ion channels. Such an approach yields a stochastic model of single neurons and allows the derivation of a stochastic neural population model.
  This bridge between the microscopic and mesoscopic scale may be performed via two pathways. The analytical and numerical treatment of the microscopic model may be called a *bottom-up approach*, since it leads to a population activity model based on microscopic activity. This approach

allows to compare theoretical neural population activity to experimentally obtained population activity. The *top-down approach* aims at extracting signal features from experimental data gained from neural populations which give insight into the dynamics of neural populations and the underlying microscopic activity. The work on both approaches represents a well-balanced investigation of the neural system based on the systems properties.

- From the mesoscopic to the macroscopic scale:
  The other research direction aims to link neural population dynamics to macroscopic activity and behaviour or, more generally, to phenomenological features. This link is more indirect but a very powerful approach to understand the brain, e.g., in the context of medical applications. Since real neural systems, such as in mammals, exhibit an interconnected network of neural populations, the team studies analytically and numerically the network dynamics of neural populations to gain deeper insight into possible phenomena, such as traveling waves or enhancement and diminution of certain neural rhythms. Electroencephalography (EEG) is a wonderful brain imaging technique to study the overall brain activity in real time noninvasively. Hoewever, it is necessary to develop robust techniques based on stable features by investigating the time and frequency domains of brain signals. Two types of information are typically used in EEG signals: (i) transient events such as evoked potentials, spindles and K-complexes and (ii) the power in specific frequency bands.

4 Main Achievements

A. Hutt report results about neural oscillations by traversing scales in the brain [495].

In the context of general anaesthesia, it is not understood how single neuron properties, such as ion-channel conductivities or anesthestic action on neuron receptors, translate to population dynamics and consequently to behavior. We proposed a modeling approach how to bridge the microscopic and the mesoscopic scale extending standard neural field theory on the mesoscopic scale instead of introducing a new model [505].

Experimental data of general anesthesia are very important for our research and rare in the case of intracranian and surface data acquired simultaneously in Humans. We stepped up our collaboration with the *department of anesthesia of the university hospital in Nancy* (Dr. Denis Schmartz and Pr. Claude Meistelmann) leading to a cofunded PhD thesis by the school of medicine of the university of Lorraine, Inria, the Lorraine laboratory for research in computer science (LORIA), the Lorraine Region and the urban community of Nancy. The PhD will started in January 2016 on study dynamics of cerebral motor patterns during general anesthesia with Sébastien Rimbert under the supervision of Axel Hutt and Laurent Bougrain. We started a collaboration with the department of neurology of the University Hospital in Nancy (CHRU) and the Research Center for Automatic Control of Nancy (CRAN). This will give us access to intracranial data. We also participated in the design and the analysis of experimental animal data measured under anaesthesia by the University of North Carolina-Chapel Hill [505].

Laurent Bougrain co-organized an international Brain-Computer Interfaces competition on Error Potential Detection with Cross-subject Generalization. 311 participants of 260 different teams in the world participated to the competition. Gao Shangkai and Bin He were in the advisory board. IEEE EMBS, Inria, and Institute for Engineering in Medicine at University of Minnesota were sponsors of this event. The prizes have been presented to winners during the IEEE EMBS Neural Engineering conference, April 22-24, 2015. The winner has been invited to publish a manuscript at IEEE Transactions on Biomedical Engineering.
`https://www.kaggle.com/c/inria-bci-challenge`

5 Research activities

From the microscopic to the mesoscopic scale

Description One research direction focuses on the *relation of single neuron activity* on the microscopic scale *to the activity of neuronal populations*. To this end, the team investigates the stochastic dynamics of single neurons subject to external random inputs and involving random microscopic properties, such as random synaptic strengths and probability distributions of spatial locations of membrane ion channels. Such an approach yields a stochastic model of single neurons and allows the derivation of a stochastic neural population model.
This bridge between the microscopic and mesoscopic scale may be performed via two pathways. The analytical and numerical treatment of the microscopic model may be called a *bottom-up approach*, since it leads to a population activity model based on microscopic activity. This approach allows to compare theoretical neural population activity to experimentally obtained population activity. The *top-down approach* aims at extracting signal features from experimental data gained from neural populations which give insight into the dynamics of neural populations and the underlying microscopic activity. The work on both approaches represents a well-balanced investigation of the neural system based on the systems properties.

Main results

Memory and Anaesthesia We modelled a hippocampal pyramidal neuron using the Hodgkin-Huxley model capable of exhibiting long-lasting persistent firing activity when subject to a strong transient stimulus [556]. We shown that increasing doses of propofol reduce the overall network activity and slow down its oscillations until a critical value at which the synchronisation increases abruptly at values of twice the synchronisation displayed in the absence of tonic inhibition, and the mean firing rate increases [555]. This emergence of synchronous activity mediated by anaesthetic perfusion point towards a possible mechanism for the emergence of paradoxical excitation under general anaesthesia. Additive noise modulates the frequency of self-sustained neural rhythms [513].

Level of consciousness Neural fields serve as a model for experimental macroscopic activity. We have developed a numerical simulator NeuralFieldSimulator [575]. In addition, we have worked out a neural neural field model that exhibits a sequence of metastable activity states as observed in experimental data [519]. We presented analytical and numerical results on thalamo-cortical neural population models during general anesthesia [494].

From the mesoscopic to the macroscopic scale

Description The other research direction aims to link neural population dynamics to macroscopic activity and behaviour or, more generally, to phenomenological features. This link is more indirect but a very powerful approach to understand the brain, e.g., in the context of medical applications. Since real neural systems, such as in mammals, exhibit an interconnected network of neural populations, the team studies analytically and numerically the network dynamics of neural populations to gain deeper insight into possible phenomena, such as traveling waves or enhancement and diminution of certain neural rhythms. Electroencephalography (EEG) is a wonderful brain imaging technique to study the overall brain activity in real time non invasively. However it is necessary to develop robust techniques based on stable features by investigating the time and frequency domains of brain signals. Two types of information are typically used in EEG signals: (i) transient events such as evoked potentials, spindles and K-complexes and (ii) the power in specific frequency bands.

Main results

Level of consciousness Neural fields serve as a model for experimental macroscopic activity. We have developed a numerical simulator NeuralFieldSimulator [575]. In addition, we have worked out a neural neural field model that exhibits a sequence of metastable activity states as observed in experimental data [519] We have applied advanced data analysis techniques based on wavelet analysis to detect instantaneous partial synchronisation in experimental data [521]. We proposed a methodology to extract recurrent metastable states in univariate time series by transforming datasets into their time-frequency representations and computing recurrence plots based on instantaneous spectral power values in various frequency bands [522]

Motor system Limb movement execution or imagination induce sensorimotor rhythms that can be detected in electroencephalographic (EEG) recordings. Discrete motor imagery, corresponding to a single short motor imagery, would allow a better detection of event-related desynchronization (ERD) and event-related desinchronization (ERS) patterns than a continuous motor imagery. Indeed, a continuous motor imagery generates a later ERS as well as a more variable and less detectable ERD than discrete motor imagery [577]. This finding suggests an improved experimental paradigm. We deeper investigated the amplitude and latency of EEG Beta activity during real movements, discrete and continuous motor imageries [576].. The imagination of both hands movement generates in each brain hemisphere similar activity as the one produced by each simple hand MI in the contralateral side [532]. We proposed a multilabel approach to detect simple and compound imagined movements to enlarge a BCI control. [529]. We presented the interest of considering not only the beta frequency band but also the alpha band to detect the elicited EEG rebound, i.e. the increasing of oscillatory power synchronization, at the end of motor imageries [531, 570]. This phenomenon can be stronger over the alpha than the beta band and it is experimentally demonstrated [531] that the analysis on the alpha band improves the detection of the end of motor imageries. Moreover a variant method to compute the oscillatory power without referring to a baseline period is proposed; such capacity is useful for self-paced BCI control.

Pain under general anaesthesia Recurrence analysis allows to describe and visualise dynamics of a system and discover structural patterns contained in the data. Structure of each recurrence plot is characterised by Lempel–Ziv complexity measure, which shows a difference between pre- and post-incision [549].

We also proposed wavelet-based semblance methods to enhance single-trial Event-Related Potential detection [497].

Scientific production and quality

6 Synthesis of publications

	2011	2012	2013	2014	2015	2016
PhD Thesis	2		1			
H.D.R	1					
Journal	3	5	7	6	5	1
Conference proceedings		5	2		3	2
Conference proceedings (non selective)	1	1	5	6	10	
Book chapter	1		2	1	1	4
Book (written)						
Book or special issue (edited)	1					1
Patent						
General audience papers		1				

7 List of top journals in which we have published

Front. in Syst. Neurosci (3) [522, 519, 503], J. Comput. Neuroscience (2) [504, 505], J. Neurophysiology (2) [521, 520], Frontiers in Computational Neuroscience (1) [512], Frontiers in Neuroscience (1) [516].

8 List of top conferences in which we have published

Computational Neuroscience Meeting (12) [566, 528, 562, 547, 571, 558, 567, 554, 550, 570, 556, 561], Society for Neuroscience (1) [527], IEEE EMBS Engineering in Medicine and Biology Conference (2) [525, 532], IEEE EMBS Neural engineering conference (1) [531], IEEE International Conference on Systems, Man, and Cybernetics (1) [529], IEEE EMBS Bio-Inspired Systems and Signal Processing (1) [535], International Brain-computer interface meeting (3) [534, 578, 530], International Brain-computer interface conference (1) [568], Neurocomp (1) [533].

9 Software

See the Appendix for a complete description.

OpenViBE We are participating in the design and development of OpenViBE `http://openvibe.inria.fr`. OpenViBE is a C++ open-source software devoted to the design, test and use of real-time neuroscience and Brain-Computer Interfaces. The OpenViBE platform consists of a set of software modules that can be integrated easily and efficiently to design BCI applications. Key features of the platform are its modularity, high-performance, portability, its multiple-users facilities and its connection with high-end/Virtual Reality displays. The designer tool of the platform enables to build complete scenarios based on existing software modules using a dedicated graphical language and a simple Graphical User Interface (GUI). This software works on Windows and Linux operating systems, and is available under the terms of the LGPL-V2 license. OpenViBE is the major software in BCI with BCI2000.

AnaesthesiaSimulator AnaesthesiaSimulator (`https://gforge.inria.fr/projects/anasim/`) simulates the activity of networks of spiking neurons subject to specific receptor dynamics. The tool is a platform to test effects of anaesthetics on neural activity.

NeuralFieldSimulator The NeuralFieldSimulator (`https://gforge.inria.fr/projects/nfsimulator/`) computes numerically activity in two-dimensional neural fields by solving integral-differential equations involving transmission delays and visualizes the spatio-temporal activity.

The academic reputation and appeal

10 Prizes and Distinctions

Grants

- ERC Starting Grant MATHANA (Mathematical Modeling of Anaesthesia) (2011-2015) A. Hutt

Invited talks (see the Appendix for a full list)
Computational neuroscience, Inria Scientific Days, June 2014 (Laure Buhry)
OpenViBE, Inria Scientific Day, June 2014, Lille (L. Bougrain)
Is it really statistically significant? « dynamics of neural circuits » NETT workshop, March 2014, Florence (L. Bougrain)
Tutorial "Fundamentals in Neural Field and Neural Mass models", Computational Neuroscience Conference, July 2015, Prague (A. Hutt)
Seminar talk "Noise-induced neural oscillations", Max Planck Institute for Brain Research, May 2015, Frankfurt am Main (A. Hutt)
Seminar talk "Brain Signals Analysis for Brain-Machine Interfaces", UCL-France Workshop *Virtual reality in rehabilitation, accessibility and mobility*, Univ. College London, May 2015, London (L. Bougrain)
Seminar talk "EEG-based control of a Jaco robotic arm", ETN-NETT workshop *Neural Engineering in Medicine and Related Fields*, July 2-3, Nancy (L. Bougrain), National Brain week: Comment lire dans les pensées d'autrui ? 12 March 2014, central hospital, Nancy (L. Bougrain), National Brain week: Brain, Consciousness and Anesthesia, March 24th 2015, central hospital, Nancy (D. Schwartz, A. Hutt, L. Bougrain)

11 Editorial and organizational activities

Editorial activities

- Journal of Proteomics & Computational Biology (A. Hutt, Editor)

Organizational activities

- NeuroComp 2011 (first French BCI school) (L. Bougrain)
- CAp 2012 (French conference on Machine Learning) (L. Bougrain)
- g.tec workshop at LORIA, 2013 (L. Bougrain)
- Workshop at the Computational Neuroscience Conference in Paris, 2013 (A. Hutt)
- Tutorial at the Computational Neuroscience Conference in Paris, 2013 (A. Hutt)
- Member of the organization committee of Forum des Sciences Cognitives at Nancy, 2013 (L. Buhry)

- OpenVibe Workshop as a satellite event of the international conference on Brain-Computer Interfaces on September 15th, 2014 in Graz (with BrainProduct, TMSi, g.tec) (L. Bougrain & G. Serrière)
- BCI competition, IEEE Neural Engineering Conference , Montpellier, 2015 (L. Bougrain)
- NETT workshop about *Neural Engineering in Medicine and related fields* in Nancy, 2-3 July 2015 (A. Hutt & L. Bougrain)
- OpenVibe Workshop as a satellite event of the international meeting on Brain-Computer Interfaces on May 30 in Pacific Grove (CA, USA), 2016 (L. Bougrain)

PC member
NeuroComp 2011-first French BCI school (L. Bougrain), CAp 2012 (French conference on Machine Learning) (L. Bougrain), IJCAI 2015 (L. Bougrain)

12 Services as expert or evaluator

European experts: Programme FP7 (L. Buhry & A. Hutt)
PhD committees (see the Appendix for details): L. Bougrain (2 including [497]), L. Burhy (1), A. Hutt (6 including [496, 494])

13 Collaborations

- Jamie Sleigh (University of Auckland, New Zealand), who provides us with experimental EEG-data obtained in humans during anaesthesia (A. Hutt).
- Flavio Frohlich (University of North Carolina - Chapel Hill), we receive experimental data measured intracranially in ferrets and analyse them on spectral properties (A. Hutt).
- Jérémy Lefebvre (University of Lausanne), we have been working out together a stochastic delayed neural field analysis leading to new insights into the effects of additive noise (A. Hutt).
- Peter beim Graben (Humboldt University Berlin) on recurrence data analysis has led to analysis techniques to detect meta-stable states in EEG-signals (A. Hutt).
- Pr. Motoharu Yoshida at the Ruhr University Bochum, Germany, aiming to study the role of persistent firing neurons in memory and more specifically in neural network synchronization. M. Yoshida provides us with biological data that we combine with simulations to test hypotheses on memory formation (L. Buhry).
- Pr. LieJune Shiau (University of Houston, Texas, USA) on more theoretical approaches concerning the role of intrinsic neuronal dynamics in network synchronization and brain oscillations (L. Buhry).
- Pr. John Rinzel (New York University, USA) on more theoretical approaches regarding the generation of gamma-oscillations (L. Buhry).
- Maureen Clerc (Inria Sophia), Fabien Lotte (Inria Bordeaux) and Anatole Lécuyer (Inria Rennes) on Brain-Computer Interfaces (Initiative Project Lab BCI-LIFT, international competition) and the software OpenViBE (ADT project OpenViBE-NT, steering committee, development, workshop)

14 External support and funding

European Projects

- ERC Starting Grant MATHANA (Mathematical Modeling of Anaesthesia) (2011-2015) A. Hutt
- The ETN-project Neural Engineering Transformative Technologies (NETT) (2012-2016) A. Hutt & L. Bougrain

National Initiatives

- CNRS NeuroInformatique project 2010-2011: ”cortical signals to control a two-finger robotic hand driven by artificial muscles” (L. Bougrain)
- ANR project Keops: Algorithms for modeling the visual system: From natural vision to numerical applications (2011-2014). A. Hutt & L. Bougrain
- Inria Technological development action (ADT): OpenViBE-NT (2012–2015) to develop OpenViBE further on several fronts such as usability, new algorithms and scope of applicability. L. Bougrain.
- Multidisciplinary Exploratory Project PEPS 2014 Bio-Maths-Info (BMI): Characterizing the laminar profile of motor cortical oscillatory synchronization during visuomotor behavior with new analysis tools.
- PEPS JCJC INS2I 2016 Modeling and simulation of the oscillatory activity of the memory system during sleep and under general anesthesia (L. Buhry)

Regional Initiatives

- Contrat de Plan État Région (CPER) IT2MP 2015-2020 on Technological innovations, modeling and Personalized Medicine, we are contributing on platform SCIARAT (cognitive stimulation, Ambient Intelligence, Robotic assistance and Telemedicine) L. Bougrain
- Contrat de Plan État Région (CPER) Action Modeling, Simulation and Interaction (2009-2014), we are contributing to the axis Situed Informatic through the project CoBras for controlling a jaco robotic arm using EEG. L. Bougrain

Involvement with social, economic and cultural environment

Dissemination (see the Appendix for a full list)

- L. Bougrain & B. le Golvan, Neuroprosthetics, Evolution Psychiatrique, Elsevier [501] published on line on March 8, 2016.
- Nancy Renaissance 2013 Moments d’Invention with stand and talk on conference (L. Bougrain).
- Science Slam Talk on Sleep and Anaesthesia at University of Frankfurt / Main, February 2013 (A. Hutt).
- TV interview for France 3 Lorraine, April 7 2014 (L. Buhry)

- National Brain week: Comment lire dans les pensées d'autrui ? 12 March 2014, central hospital, Nancy (L. Bougrain)
- National Brain week: Brain, Consciousness and Anesthesia, March 24th 2015, central hospital, Nancy (D. Schwartz, A. Hutt, L. Bougrain)

Industrial contracts

- Lifestyle Research Association (LIRA): Philips (Netherlands), Fraunhofer (Germany), Inria (topic: sleep analysis)
- L. Bougrain is a member of the steering committee of OpenViBE and CertiViBE. CertiViBE, a medically certifiable core for OpenViBE, the software for Brain Computer Interfaces and Neuroscience research. It is a iLAB project between the Inria project-ream Hybrid and Mensia Technologies SA (`http://www.mensiatech.com/`)

The involvement in training through research

L. Bougrain is the responsible for the speciality IPAC (Interaction, Perception, Learning and Knowledge) and the education program devoted to research of the master of computer science of university of Lorraine since 2013. L. Bougrain teaches for the master of computer science of the university of Lorraine (*Machine learning*, *Human factors*). L. Buhry teaches for the master of cognitive science of the university of Lorraine (*Algorithms for artificial Intelligence*, *Artificial Intelligence and data mining*, *Formalisms and Reasoning*, *Memory and Machine Learning (in English)*, *Computationnal Neuroscience*).
A. Hutt and L. Bougrain are involved in the ETN-project Neural Engineering Transformative Technologies (NETT)[10] (2012-2016)

[10] `http://www.neural-engineering.eu/`

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Articles in International Peer-Reviewed Journal

[1] C. Ambroset, C. Coluzzi, G. Guédon, M.-D. Devignes, V. Loux, T. Lacroix, S. Payot, N. Leblond-Bourget, "New Insights into the Classification and Integration Specificity of Streptococcus Integrative Conjugative Elements through Extensive Genome Exploration", *Frontiers in microbiology 6*, January 2016, p. 1483, https://hal.archives-ouvertes.fr/hal-01262284.

[2] T. Bourquard, F. Landomiel, E. Reiter, P. Crépieux, D. W. Ritchie, J. Azé, A. Poupon, "Unraveling the molecular architecture of a G protein-coupled receptor/β-arrestin/Erk module complex", *Scientific Reports*, June 2015, p. 5:10760, http://hal-lirmm.ccsd.cnrs.fr/lirmm-01162594.

[3] M.-D. Devignes, M. Smaïl-Tabbone, D. Ritchie, "Kbdock - Searching and organising the structural space of protein-protein interactions", *ERCIM News*, 104, January 2016, p. 24–25, https://hal.inria.fr/hal-01258117.

[4] R. Gerbier, V. Leroux, P. Couvineau, R. Alvear-Perez, B. Maigret, C. Llorens-Cortes, X. Iturrioz, "New structural insights into the apelin receptor: identification of key residues for apelin binding", *FASEB Journal 29*, 1, January 2015, p. 314–322, https://hal.inria.fr/hal-01251633.

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[6] V. Pérez-Nueno, A. S. Karaboga, M. Souchet, D. Ritchie, "GESSE: Predicting Drug Side Effects from Drug–Target Relationships", *Journal of Chemical Information and Modeling 55*, 9, August 2015, p. 1804–1823, https://hal.inria.fr/hal-01216493.

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[8] A. K. Rodrigues Adabio, E. S. Kioshima, V. Leroux, N. F. Martins, B. Maigret, M. S. Soares Felipe, "Identification of New Antifungal Compounds Targeting Thioredoxin Reductase of Paracoccidioides Genus", *PloS One 10*, 11, November 2015, p. e0142926, https://hal.inria.fr/hal-01251619.

Major International Conferences

[9] S. Z. Alborzi, M.-D. Devignes, D. Ritchie, "EC-PSI: Associating Enzyme Commission Numbers with Pfam Domains", *in: JOBIM 2015*, Clermont-Ferrand, France, July 2015, https://hal.inria.fr/hal-01216743.

2 References for Cortex

Doctoral Dissertations

[10] L. Alecu, *A neuro-dynamic approach for designing self-organizing processes*, Theses, Université Henri Poincaré - Nancy I, June 2011, https://tel.archives-ouvertes.fr/tel-00606926.

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02

Project

Loria

Department 5

Complex Systems, Artificial Intelligence and Robotics

Department Head: Patrick Henaff

Department project

From January 2017, Department 5 will consist of five teams: BISCUIT (created in September 2016 from the CORTEX team), CAPSID, KIWI, LARSEN, and NEUROSYS.

1 Scientific project

The scientific project of the department is to continue its study of complex systems, artificial intelligence, and robotics, but with a stronger focus on homogeneous and heterogeneous interactions in multi-scale complex systems in the areas of:

- **computational biology** : CAPSID,
- **cognitive sciences** : KIWI,
- **neurosciences** : BISCUIT, NEUROSYS,
- **robotics** : BISCUIT, LARSEN, NEUROSYS.

Meeting these scientific challenges will involve the design of new algorithms and computational models in the following areas:

Computational biology. Aiming to facilitate and improve the 3D modeling of large multi-component biomolecular machines, we will develop algorithms and software to help study biological systems and phenomena from a structural point of view. The team's activities focus on two main themes: (1) computational modeling of protein-protein interactions (protein docking and molecular dynamics simulations), and (2) classifying and mining protein structures and protein interactions (knowledge discovery in biological databases). While the team's principal activity is algorithm and software development, it will also tackle "real-world" biological problems through collaborations with experimentalists.

Cognitive sciences. We will work on user modelling and recommender systems for web applications with a strong interest in data modelling. Our two main goals are mining information and inferring/predicting information. More specifically, we will focus on: (1) collecting interaction traces in order to infer a reliable and relevant user model from the observations; (2) using statistical modelling in order to predict future events, and to build recommender systems that can maximise a user satisfaction function. The approach will be applied to various application fields related to health

and education (e-health, recommendations in web applications,learning analysis, digital humanities...).

Neuroscience. We will focus on understanding better the central nervous system (or parts thereof) by modeling various brain areas, the thalamus, and the motor and sensory nervous systems at microscopic, mesoscopic, and macroscopic scales. More specifically, we will focus on: (1) mechanisms of sleep and anesthesia to better anticipate and control the waking phases of patients during surgical operations (the thalamus); (2) the sensorimotor loop to design bio-inspired adaptive controllers for humanoid robots (Central Pattern Generators), in order to control robots by thought (Brain-Computer Interfaces) and to find new exploration strategies for mobile robots (sensory-olfaction); (3) the bio-inspired processing of information and signals (neural fields) and its implementation in hardware architectures.

Robotics. We aim to design new algorithms to give robots the capacity for *life-long autonomy* and *natural interaction*. These two objectives have a common requirement for fast on-line computation, learning, and decision-making. For life-long autonomy, the aim is that a robot will continuously perform its tasks while being able to adapt to sudden or gradual changes in both its environment and its morphology. For natural interaction, the aim is that a robot may interact physically and/or socially both with other robots and human beings, taking into account the fact that people and robots learn from each other when they interact. The solutions that we will propose will mainly come from the fields of robotics, stochastic optimization, Bayesian modeling, and neuroscience.

2 Evolution of the department

The composition and organisation of Department 5 is evolving to better meet these scientific challenges. While some members of former MAIA team have joined other departments at the LORIA and laboratories at the University of Lorraine, several new researchers and assistant professors have been recruited and have been integrated within our teams during 2016. Our activities in multi-agents systems and Cyber-Physical Systems (from the former MAIA team) have joined Department 3. The CORTEX team has been reconfigured through the new team BISCUIT (Bio-Inspired, Situated, Cellular and Unconventional Information Technologies), incorporating two assistant professors from Centrale-Supélec Metz and one CR INRIA from the ex MAIA team. Our activities in neuroscience and in neuro-robotics are now primarily grouped in the NEUROSYS team incorporating members from CORTEX and an additional CR-HDR from INRIA Metz. KIWI team remains stable while increasing its research activities in cognitive neurosciences, especially in E-education.

To achieve these objectives, additional resources and collaborations will be sought. These endeavours will include:

- The participation in large national and EU scientific projects. In particular, we can mention ANR Investissement d'Avenir projects : FIGHT-HF (Fight Heart Failure) with CHRU Nancy (CAPSID) which started at the end of 2015 and the METAL E-FRAN project in cognitive science (KIWI), which started in 2016;
- The recruitment and integration of additional researchers, assistant professors, and professors. This has already started in 2016 with the recruitment of two assistant professors for CAPSID and LARSEN;
- An increase in experimental research activities in robotics, intelligent environments and human behavior analysis systems, through the acquisition of new equipment (e.g. the SCIARAT platform funded by CPER/ FEDER 2015-2020, see below);
- Pooling experimental resources and enhancing the visibility of our activities through the creation

of the Creativ'Lab CPS-Robotics platform;
- Re-structuring our neuroscience activities by integrating NEUROSYS, BISCUIT and KIWI (recent research activities of KIWI are related to cognitive neurosciences) into the University of Lorraine's "IT-Neuro" structure (Lorraine network Interdisciplinary Research and Translational Neuroscience) that already started in 2016.

The department will strengthen its collaborations at multiple levels, including :
- locally at the LORIA, with other teams from other departments (e.g. D3 on drones and "smart apartment", D4 on language processing);
- around the University of Lorraine, e.g. in neurosciences and cognitive sciences (CRAN, CHRU, INTERPSY, PERSEUS, Faculty of sport sciences);
- regionally, through collaborations in the Alsace-Champagne-Ardenne-Lorraine grand region and in the large area of European "Grande Region" (Sarre-Luxembourg-Lorraine);
- nationally, through becoming more visible in the research networks (e.g. GdR, GdT, Robotex) and through collaborations with other French laboratories in common areas (see Department 5 Team Project sections);
- pan-europe, e.g. by submitting collaborative Marie Curie training projects;
- internationally, e.g. with Japan through the agreement with JAIST at Kanasawa university, and with the USA and other countries through targeted ANR calls.

Department 5 will also forge new relationships with regional industries, in particular on the theme of the future factory through new contracts and CIFRE PhD projects. These collaborations will be supported by new technology platforms and computing resources that are starting to be acquired in 2016, mainly with the funding from the CPER/FEDER 2015-2020 programme. In particular, we can mention the SCIARAT platform (Cognitive Stimulation, Ambient Intelligence, Robotic Assistance and Tele-medicine) that will give the LORIA the most modern equipment in robotics (compliant industrial arm, humanoid robots, mobile robots), in cognitive sciences and neurosciences (movement capture systems, brain-computer interface, eye trackers...), as well as software and hardware updates for the "smart apartment" experimental set-up of the Inria PAL (personally assistance living) project and for the OpenViBE software in the Inria BCI-LIFT (brain-computer interface) project. By the end of 2017, this equipment will be installed in the dedicated Creativ'Lab CPS-Robotics area of the LORIA. This will allow pooling of scientific knowledge and resources, and it will increase the national and international visibility of our activities.

❸ Life of the department

The scientific animation of the department will increase through the arrival of the equipment for the SCIARAT platform in 2016 and the Creativ'Lab in 2017. Sharing the equipments of the Creativ'Lab will decompartmentalise the department's teams and activities. The department 5 will continue to manage the "IPAC" ("Image, Perception, Action et Cognition") transversal seminar series which involves LORIA Departments 1, 4, and 5. Internal departmental seminars will be more regular (minimum twice a year), and the existing "PhD students' day" will be adapted to allow more time for presentations. In terms of education, Department 5 will be very involved in the new Master program called "Apprentissage, Vision et Robotique" that will start in 2018 and also continues to be involved in the Master program in cognitive sciences. The newly arrived assistant professors and researchers will participate in this training, particularly in the artificial intelligence and robotics components. In terms of scientific mediation, Department 5 is highly active thanks to its platforms, and it will continue to participate more in local or national mediation activities (festivals of science, radio interviews, newspapers ...).

4 SWOT

	Positive	Negative
Intern	**Strengths:**	**Weaknesses:**
	- INRIA environment - Theoretical approaches and their validation on experimental platforms - Teams working on related areas - Attractiveness of experimental platforms to students (Master, PhD)	- High cost of experimental platforms - Lack of human resources to maintain these platforms - not enough CNRS researchers
Extern	**Opportunities:**	**Threats:**
	- Proximity of other UL labs, especially in Health-Biology-Signal, Neurosciences, cognitives sciences (CRAN, CHRU, InterPsy, PERSEUS...) - Good funding opportunities due to INRIA and UL/CNRS environment	- Difficulty to get EU projects - Randomness of ANR programs - Robotics and e-education is not enough supported by ANR - Duplication of administrative work (e.g. evaluations) due to INRIA and university/CNRS environment

Team projects

5 Team BISCUIT

Team composition

Name	Position	Employer	Other
Bernard Girau (Head)	Professor	UL	
Yann Bonniface	Assistant Professor	UL	
Alain Dutech	CR	Inria	HDR
Jéréemy Fix	Assistant Professor	Centrale-supélec	
Hervé Frezza-Buet	Assistant Professor	Centrale-supélec	HDR

Project

As mentioned in the Cortex report, our team has seen strong evolutions in the recent years, with the creation of the Neurosys (2013) and Mnemosyne (2012) teams. The Cortex team has now reached its end, and the perspectives of the team now lie in the creation of a new team, BISCUIT, an acronym for Bio-Inspired, Situated, Cellular and Unconventional Information Technologies, together with a researcher of the previous Maia team, and two researchers of Centrale-Supélec. This new team mainly results from the evolution of the “Embodied-embedded systems” axis of the Cortex team, with a focus on neuro-cellular models.

Considering the nervous systems of animals, including humans, as the only information processing systems now capable of producing cognition, intelligence, consciousness (as weakly formalised can be these notions), we intend to examine these systems in terms of computational systems. This approach means to study this evolution-based natural technology, with a focus on complex issues such as massively

distributed fine-grain computing, constraints of spatial computing on slow and low-frequency technologies, energy efficiency and area consumption. Perhaps more fundamentally, such natural computing often relies on generic modules that can spontaneously adapt to behavioral demands, on modularity with massively and intrusively interconnected modules that are not centrally coordinated, and where the dynamic and non-linear aspects are at the heart of every piece of calculation.

The object of the BISCUIT team is to better identify and help develop this computing approach, radically different from the standard Von Neumann paradigm. We also want to understand what it teaches in terms of hardware implementation, and to evaluate how suitable it is for controlling situated, autonomous and adaptive systems. To reach these goals, our working principle is to embody the computing systems we study in physical systems that constantly interact with their environment. We thus start from a dynamic problem, where the coupling to the environment is performed through continuous streams of input-outputs, instead of trying to apply generic modules that are designed previously and independently from each other. Our approach is based on the idea that a specific kind of computing can emerge from the coupling of the system with its environment.

This research will be carried out through three complementary research axes. The first one will focus on the definition and study of neuro-cellular, decentralised and spatialised computational models. The second one will focus on self-organization and emergence so as to enable the specialization and modularization of our computing units. The third one intends to define a new kind of sequential decision through driven self-organization.

National and international positioning:

Several national and international teams work on topics close to the Biscuit team research interests, though we did not identify teams with a really shared goal and approach. INRIA project team Cairn studies reconfigurable computing architectures and the associated algorithms with the aim of designing efficient, robust and low-power computing devices. INRIA project team Dreampal focuses on massively parallel reconfigurable architectures.Works on reconfigurable architectures inspired by neural systems can be found in the LEAT laboratory. The Neurocybernétique team of laboratory ETIS mixes neurosciences, robotics and computer science through the definition of computational models of cerebral structures applied to robot control. Several INRIA project teams study the brain functionning by means of mathematical and computational approaches, such as Mnemosyne and Neuromathcomp. More globally, the research fields of Biscuit meet the subjects of GDR SOC/SIP, GDR Biocomp and GDR Robotique (especially GT4 and GT8), as well as GDR ISIS through the NeuroSTIC workshop. On the international level, a lot of teams study neuromorphic engineering solutions, through representative projects (SpiNNaker, Neurogrid, FACETs), while chip manufacturers build large scale brain-inspired systems (IBM TrueNorth, Qualcomm Zeroth). More generally, this quest for unconventional computing solutions has already reached outstanding technological achievements, and while these systems are primarily designed to simulate biology, their development is still limited by the lack of a computing framework, for which the Biscuit team intends to contribute.

6 Team CAPSID

Team composition

Name	Position	Employer	Other
David Ritchie (Head)	DR	INRIA	
Sabeur Aridhi	Assistant Professor	UL	
Marie-Dominique Devignes	CR	CNRS	HDR
Bernard Maigret	DR	CNRS	Emeritus

Project

Many of the processes within living organisms can be studied and understood in terms of biochemical interactions between large macromolecules such as DNA, RNA, and proteins. Studying such interactions at the three-dimensional (3D) level is a crucial aspect of understanding complex biological systems. Indeed, over 107,000 3D macromolecular structures are now available in public databases. These 3D structures define an immense combinatorial space of 3D interactions and present fascinating challenges for biologists and computer scientists alike.

The overall aim of the Capsid team is to develop algorithms and software to help study biological systems and phenomena from a structural point of view. In particular, the team aims to develop algorithms which can facilitate and improve the 3D modeling of large multi-component biomolecular machines. This project will be carried out along two complementary axes, namely (i) accelerated high-throughput computational modeling and (ii)knowledge extraction from databases of 3D shapes and interactions. While the team's principal research activity is algorithm and software development, the team will also tackle "real-world" biological problems through collaborations with local teams from the University of Lorraine and Nancy Hospital, and with other research teams from Inria, INRA, INSERM, and CNRS and international universities.

The team will evolve and expand through the recruitement of at least one full-time researcher (Inria or CNRS) and at least one university lecturer ("Maître de Conference"). It is envisaged that a permanent research engineer will be recruited (perhaps in conjunction with the CyberBioSanté axis) to manage and support the team's bioinformatics platform. The team already has good local, regional, and national links and collaborations. The team will develop these collaborations through joint funding opportunities with colleagues from the LORIA's Department 5 and CyberBioSanté axis, and the University of Lorraine at regional ("Grand Est"), national (e.g. ANR), and international (e.g. ERC) levels. International collaborations will be developed through initiatives such as the "Associate Teams" (Inria), "Projets International de Coopération scientifique" (CNRS) as well as"Innovative Training Network" (ERC). The team's main teaching activity is through research training of PhD students. The team will also continue to contribute to undergraduate and masters-level teaching at the University of Lorraine, and PhD-level international summer schools. The team will transfer its expertise and technologies to non-expert bio-medical researchers, and it will develop collaborations with regional and national biotechnology companies.

National and international positioning:

The team is a research node of the Institut Français de Bioinformatique (IFB), with a particular focus on structural bioinformatics. The team will contribute to research and knowledge through a greater participation in learned societies and international conferences (e.g. GGMM, ECCB, ISMB, ...). The ultimate aim of the team is to become known world-wide as a centre of expertise in the computational modeling of protein structures and interactions.

7 Team KIWI

Team composition

Name	Position	Employer	Other
Anne Boyer (Head)	Professor	UL	
Dominique Benmouffek	Assistant Professor	UL	
Geoffray Bonnin	Assistant Professor	UL	
Armelle Brun	Assistant Professor	UL	
Sylvain Castagnos	Assistant Professor	UL	
Audrey Knauf	Assistant Professor	UL	
Samuel Nowakowski	Assistant Professor	UL	HDR
Azim Roussanaly	Assistant Professor	UL	
Sahbi Sidhom	Assistant Professor	UL	

Project

The KIWI team is involved in works about user modelling and recommender systems, based on automatic analysis of digital traces, statistical approaches and human factors inclusion.

KIWI has a strong interest in data modelling, with two main goals: mining information or inferring/predicting information. Data can be of two types: matrix data, where there is no order and sequential data, where the order is of the highest importance. Data is mainly preference or behaviour data. The literature has mostly focused on the mining of information that is frequent, representative, etc. on the entire dataset, through standard statistical methods. Recently, we initiated several works about modelling rare events, rare information. In a nutshell, it means elements in data that cannot be discovered through standard statistics-based approaches. Mining such information is original and highly informative. KIWI plans to pursue these works. In matrix data, we will focus on the identification of specific input data (instances): those that significantly differ from the others, but that are not outliers (grey sheep users); at the opposite those that are representative of the data set (they may be used as a summary of the dataset, as leaders, etc.) through dedicated statistical methods. We will specifically focus on modelling what makes the difference between two instances (the literature only focuses on what is common between two instances). Likewise, we plan to work on sequential or temporal data, focusing on the emergence of elements or phenomenon, or in the case of behaviour or preference data, on anticipator users i.e. users showing preferences or behaviours before the others (as well as their « followers »). We will also focus on the identification of factors that trigger this emergence. Temporal mining and confidence indicators will be at the core of these works.

Predictive modelling aims at building statistical models in order to predict future events. For instance, one can try to predict the effort required to complete various possible next educational tasks for a student, and then adapt the recommendations accordingly. A number of factors make predictive modelling particularly challenging: the noise in the available usage data from which the statistical models are trained, the sparsity of these datasets, the quality of the metadata if any, etc. KIWI has done extensive research in that domain. For example, in the field of Web Usage Modelling, KIWI has proposed a new sequential model inspired from the literature of Statistical Language Modelling and has adapted the concept of skipping to the specific constraints of Web browsing. We also designed in music listening a new model exploiting artist similarities. Our future research will study the particular case of e-learning, whose specific constraints make it particularly challenging. In particular, concepts of prerequisites or misconceptions play a major role and are very difficult to take into account.

Recommender systems have to maximise a user satisfaction function: they collect traces of interaction and seek to infer a reliable and relevant user model from the observations. Most of existing systems have

focused on estimating user preferences and sought to minimise the empirical risk, thus equating the precision and the user satisfaction. More recently, many studies advocate a more comprehensive evaluation framework in which the user satisfaction integrates the acceptance and adoption rates of the system, and its ease of use and usefulness. In this context, it has been shown that there are strong correlations between some human factors such as the need for diversity, confidence, trust, memory of users, context, ... and the satisfaction. Our recent work consisted firstly in identifying human factors to be taken into account and, secondly, in incorporating these new dimensions while processing traces in user model and/or while computing recommendations, so as to improve system performance. Much of our works revolve around the need for diversity. Despite progresses, many limitations remain. First, some factors explaining the behaviour of users and their decision-making are still missing in current models (social influence mood and emotion, discovery, ...). This is mainly due to the fact that their identification is time consuming. It requires isolating these factors and building dedicated user studies. Second, current systems are not able to provide good sequences of recommendations (sequences of items in a specific order may depend on prerequisites, progressiveness, context, time constraints, etc.). We will focus on (1) identifying and automatically inferring the interesting features of the user model and its environment, even though interaction data are massive, noisy, uncertain and/or incomplete, (2) intertwining more finely the user modelling and recommendation in a real time process taking into account the multi-factorial user dynamics over time, (3) establishing a more formal and unified framework to evaluate the systems through an holistic view of users. We will rely on deep learning and data mining techniques so as to build high-level abstraction models from interaction data. We will develop new sequence mining models to provide tailored path recommendations (path of the learner in e-education, path in a physical environment, ...). Finally, we will evaluate the systems by considering the user satisfaction as a problem of aggregation, of multi-criteria optimization or as a multilinear regression problem in a high dimensional space, to jointly integrate all the factors involved in the decision making process, rather than individually as it is the case at the moment.

Nowadays, mobile devices and telecommunication networks allow to get recommendations in almost any context, e.g., personalised music radios in the bus, places and travel destinations on a trip, etc. Moving towards more ubiquitous recommendations means that the context in which these recommendations are being made gets an increasing importance. Interestingly, wearable technologies simultaneously provide a good solution to get information about the context of the users. Perhaps one of the most successful examples is the set of sensor watches of Fitbit that allows receiving detailed physiological information about the user. Other examples include eye-tracking devices, ring sensors, facial recognition from camera, etc. These technologies induce a lot of new challenges, including collecting and merging data from different sources, managing the resulting massive information and the corresponding noise. KIWI has started to address some of these challenges by focusing on the particular case of eye-tracking devices. The goal of that research was to build a model of the human memory based on gaze information. The resulting model would then serve as a provider of a potentially important human factor to take into account when computing recommendations.

Our work is applied to various application fields such as e-health (with a focus on autism), recommendations of paths in museum or playlist in music applications. KIWI aims at promoting a new research theme about digital humanities. It could be viewed as a way to propose a synthetic vision of all the research activities of KIWI. “Digital and education” is our main application domain, as it puts into light several scientific points we want to solve: 1) model all the learners to provide personalised services or recommendations of highest quality to everyone? This aspect is strongly related to the grey sheeps modelling question. 2) provide a sequence of recommendations, knowing the pedagogical objective, most of the time a mid-term goal, when many actors act. It is related to the evaluation of sequences of recommendations according to a specific objective, and to the management of uncertainty in our models. 3) to design real time and privacy compliant algorithms able to deal with huge amount of personal data and dynamic flow of heterogeneous data? The privacy constraint impacts the development of our models and

requires a collaborative work with specialist of ethical and legal issues. The question of dynamic flow is related to big data technologies and we intend to develop our work on mining flows of data, but applied to a broader variety of data types. 4) explore new data types as localisation or gaze to have a better knowledge of the user's behaviour. 5) detect and take into account the context of the learner? We have to capture elements of context and to detect evolution in the context, as we started to do it on music applications. 6) learning analytics is an emerging field we want to explore, in the continuation of the research done in the PIA Pericles project, and within the PIA e-FRAN project. We plan to develop them both for transversal analytics and for adaptive learning, in collaboration with MULTISPEECH and SYNALP. It supposes to tackle the problem of small data to do predictive and prescriptive modelling. 7) detection of emergence in data flow is a major issue. We plan to deep this activity, especially in the field of jobs, to determine if a new skill is required for a specific job, or if a competence has evolved or simply a new name, mining jobs offer. This point is related to the question of emergence prediction. 8) KIWI just started a to work on process mining, and more specifically on process involved in e-education. Based on process mining coupled to recommendations technics and traces modelling, we aim at designing algorithms able to help learners in their learning trajectories.

National and international positioning:

As mentioned, KIWI is involved in several communities (learning analytics, recommender systems, user modelling) with the specificity of tracking grey sheep users and mining flow of data, always with a deep concern on privacy and ethics. The French Learning Analytics community is under construction (ANR Hubble, e-fran METAL, ...), and KIWI intends to have an active role in this field. KIWI interacts with the international community (European LACE project, Solar, ...), for example and has been selected to realised a synthesis on Learning Analytics for the ICDE international association

8 Team LARSEN

Team composition

name	Position	Employer	Other
François Charpillet (Head)	Researcher DR	Inria	
Olivier Buffet	CR	INRIA	
Amine Boumaza	Assistant Professor	UL	
Karim Bouyarmane	Assistant Professor	UL	
Francis Colas	CR	Inria	
Serena Ivaldi	CR	Inria	
Jean-Baptiste Mouret	CR	Inria (on secondment)	HDR
Vincent Thomas	Assistant Professor	UL	

Project

Our general goal is to move robots outside of the research laboratories and manufacturing industries: current robots are far from being the fully autonomous, reliable, and interactive robots that could co-exist with us in our society and run for days, weeks, or months. While there is undoubtedly progress to be made on the hardware side, robotics platforms are quickly maturing and we believe the main challenges to achieve our goal are now on the software side. We want our software to be able to run on low-cost mobile robots that are not equipped with high-performance (high-cost) sensors or actuators, so that our techniques can realistically be deployed and evaluated in real settings, such as in service and assistive

robotic applications. We envision that these robots will be able to cooperate with each other but also with intelligent spaces or apartments which can be seen as robots spread in the environments. Like robots, intelligent spaces are equipped with sensors that make them sensitive to human needs, habits, gestures, etc. and actuators to be adaptive and responsive to environment changes and human needs. These intelligent spaces can give robots improved skills, with less expensive sensors and actuators enlarging their human perception field of view, making them able to behave more intelligently, with better awareness of people evolving in their environment. As robots and intelligent spaces share common characteristics, we will use, for the sake of simplicity, the term robot for both mobile robots and intelligent spaces.

Among the particular issues we want to address, we aim at designing robots having the ability to handle dynamic environment and unforeseen situations; cope with physical damages; take decisions under uncertainty, autonomously, and in collaboration with other agents (human, robots, connected devices); interact physically and socially with humans; collaborate with each other; exploit the multitude of sensors measurements from their surrounding; enhance their acceptability and usability by end-users without robotics background.

All these abilities can be summarised by the following two objectives:
(1) *lifelong autonomy*: continuously perform tasks while adapting to sudden or gradual changes in both the environment and the morphology of the robot;
(2) *natural interaction with robotics systems*: interact with both other robots and humans for long periods of time, taking into account that people and robots learn from each other when they live together.

These objectives have in common the requirements of online computation, learning, and decision-making. Our main constraints derive from our willingness to work as much as possible with actual robots, and not only in simulation: (1) real robots have to react quickly and take decisions online, (2) real robots are subject to uncertainties both in their own functioning with their sensors and actuators, but also due to the environment that is not fully known, and (3) real robots are rarely alone and they need to integrate their behavior with other robots, sensors and actuators in the environment and with humans. To this end, the tools we will use and develop in this project are mainly in the fields of *robotics*, *stochastic optimization*, and *Bayesian modeling*. Despite their different roots, these fields interact and intersect more and more. We expect this trend to increase in the future. For instance, robot learning is more and more based on direct policy search algorithms, which are actually stochastic optimization algorithms (e.g., evolutionary algorithms, gradient-based search, etc.) that are tailored for robotics; stochastic optimization rely more and more on Bayesian modeling, may it be to model the function to optimise, like in Bayesian optimization , or in the algorithms itself, like in Estimation of Distribution Algorithms ; robot learning also historically benefits from Bayesian modeling to provide state estimations, which are required to compute embedded rewards , and reasoning abilities ; in addition, robot learning provides new challenges and applications to Bayesian modeling and stochastic optimization.

National and International Positioning

Positioning at Inria The team would like to join the Inria robotics program with which strong links have been established since 2010 through the IPL PAL. Larsen team will be complementary within this program and will bring new skills, by putting online learning and decision making at the heart of its research project with the clear objective to address, in a new way, open issues in robotics such as “lifelong autonomy” and “natural robot interaction”. Our program will also be quite original at Inria considering the robotic platform we will develop. A complete positioning with other Inria teams belonging to the PAL program is currently difficult as most of the teams closed to Larsen are currently under reorganization: Hephaistos (Sophia), Chroma (Grenoble), Pervasive Interaction (Grenoble), Lagadic (Rennes, Sophia).

There are also some connections with the Flowers and Stars teams.

The ongoing scientific collaborations at the national are with :

- *National*: UPMC (ISIR, S. Doncieux, N. Bredeche, M. Chetouani), Paris 8 (E. Zibetti), Inria/Ensta FLOWERS (David Filliat), Citi-Inria Lyon (Olivier Simonin, Jilles Dibangoye), Inria PAL (David Daney), Inria Stars (François Bremont), Cristal Lille (Maan Badaoui);
- *European:* TU Darmstadt (Jan Peters), IIT (Francesco Nori, Giorgio Metta), University of Birmingham (Mike Mistry), Josef Stefan Institute (Jan Babic), Czech Technical University in Prague, Czech Republic (Jan Faigl);
- *International*: University of Wyoming (Jeff Clune), University of Massachusetts at Amherst (Shlomo Zilberstein).

9 Team NEUROSYS

Team composition

Name	Position	Employer	Other
Laurent Bougrain (Head)	Assistant Professor	UL	HDR expected in 2017
Laure Burhy	Assistant Professor	UL	
Patrick Hénaff	Professor	UL	
Abderrahman Iggidr	CR	INRIA	HDR
Dominique Martinez	CR	CNRS	

Project

The team aims at understanding the dynamics of neural systems on multiple scales and develops methods to invent monitoring and control devices. The approach is inspired by systems neuroscience, which relates microscopic modifications in neural systems to macroscopic changes in behavior. The team employs this systems neuroscience approach and develop models and data analysis tools in order to bridge the gap between microscopic and mesoscopic, and mesoscopic and macroscopic/behavior activity. In the future, simulated networks inspired by biological neurons will be intensively investigated to compensate motor deficiencies in humans, devices and robots. Learning mechanisms including consolidation during sleep and anesthesia will be contribute to the study.

Opportunities of Transfert exist to improve monitoring during general anesthesia. to build a electronic nose and detect drugs or chemical hazardous products have also some interest for the industry. In the future, rehabilitation devices for motor disabilities (strokes, Parkinson's disease) will be targeted applications. Potential industrial partners are Mensia tech and Brainwaves (for Brain-Computer interfaces), Philips and medtronic (for anesthesia and sleep).

The team is strongly involved in local, regional and national Dissemination/Education events, especially during the annual brain week and will increase his participation in the organization of this event which generate press articles, tv and radio interviews, conferences... We are also building a regional scientific network on neuroscience. Team members are teaching machine learning, robotic control, brain signal analysis in various master classes.

National and international positioning:

The team of **Boris Gutkin** at the ENS Paris seem to have less interest for advanced data analysis techniques. The team of **Alain Destexhe** at CNRS Gif-sur-Yvette in Paris has less interest to build bridge with EEG. The team of **Klaus-Robert Mueller** at the Technical University in Berlin ,the team of **Gernot**

R. Mueller-Putz at the Institute for Knowledge Discovery and Laboratory of Brain-Computer Interfaces, Graz University of Technology and the team of **Jose del R. Millan** do not make links with the microscopic level.

Report integrators: Éric Domenjoud (Team ADAGIo) and Philippe Dosch (Team QGAR). Report designed under Linux using Emacs, and formated thanks to XeLaTeX.