IN PARTNERSHIP WITH:
CNRS
Université de Lorraine

Activity Report 2018

Project-Team NEUROSYS

Analysis and modeling of neural systems by a system neuroscience approach

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

RESEARCH CENTER
Nancy - Grand Est

THEME
Computational Neuroscience and Medicine

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Project-Team NEUROSYS

Creation of the Team: 2013 January 01, updated into Project-Team: 2015 July 01

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B2.8. - Sports, performance, motor skills

1. Team, Visitors, External Collaborators

Research Scientist

Axel Hutt [Inria, Senior Researcher, secondment at Deutscher Wetterdienst, HDR]

Faculty Members

Laurent Bougrain [Team leader, Univ Lorraine, Associate Professor]
Laure Buhry [Univ Lorraine, Associate Professor]

PhD Students

Amélie Aussel [Univ Lorraine]
Oleksii Avilov [Univ Lorraine & Kiev Polytechnic Institute, from June 2018]
Nathalie Azevedo Carvalho [Inria, from Nov 2018]
Sébastien Rimbert [Inria]

Interns

Nathalie Azevedo Carvalho [Univ Lorraine, from Apr 2018 until Sep 2018]
Magali Jay [Ecole normale supérieure de Rennes, from May 2018 until Jul 2018]
Pierre Riff [Inria, from Mar 2018 until Aug 2018]
Sooraj Sivakumar [IIT Madras, until Mar 2018]

Administrative Assistants

Antoinette Courrier [CNRS]
Annick Jacquot [CNRS, from Jul 2018]
Hélène Cavallini [Inria]

Visiting Scientists

Rahaf Al-Chwa [Univ Lorraine, until Jan 2018]
Pierre Riff [Univ Lorraine, from Sep 2018 until Oct 2018]
Emel Demircan [Univ South California, from Jun 2018 until Jul 2018]
Takeshi Nishida [Univ Kyutech, from Jun 2018 until Jul 2018]
Radu Ranta [Univ Lorraine, HDR]
Patrick Hénaff [Univ Lorraine, Professor, HDR]
Dominique Martinez [CNRS, Senior Researcher, HDR]
Abderrahman Iggidr [Inria, Researcher, HDR]

2. Overall Objectives

2.1. General Objectives

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 develops 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 anesthesia.

3. Research Program

3.1. Main Objectives

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.

After extracting models for different description levels, they are typically applied to obtain simulated activity which is supposed to reconstruct features in experimental data. Although this approach appears straightforward, it presents various difficulties. Usually the models involve a large set of unknown parameters which determine the dynamical properties of the models. To optimally reconstruct experimental features, it is necessary to formulate an inverse problem to extract optimally such model parameters from the experimental data. Typically this is a rather difficult problem due to the low signal-to-noise ratio in experimental brain signals. Moreover, the identification of signal features to be reconstructed by the model is not obvious in most applications. Consequently an extended analysis of the experimental data is necessary to identify the interesting data features. It is important to combine such a data analysis step with the parameter extraction procedure to achieve optimal results. Such a procedure depends on the properties of the experimental data and hence has to be developed for each application separately. Machine learning approaches that attempt to mimic the brain and its cognitive processes had a lot of success in classification problems during the last decade. These hierarchical and iterative approaches use non-linear functions, which imitate neural cell responses, to communicate messages between neighboring layers. In our team, we work towards developing polysomnography-specific classifiers that might help in linking the features of particular interest for building systems for sleep signal classification with sleep mechanisms, with the accent on memory consolidation during the Rapid Eye Movement (REM) sleep phase.

3.2. Challenges

Models implementation and analysis techniques achieved promises to be able to construct novel data monitors. This construction involves additional challenges and requires contact with realistic environments. By virtue of the specific applications of the research, the close contact to hospitals and medical enterprises shall be established in a longer term in order to (i) gain deeper insight into the specific application of the devices and (ii) build specific devices in accordance to the actual need. Collaborations with local and national hospitals and the pharmaceutical industry already exist.

3.3. Research Directions

- 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 theoretical neural population activity to be compared 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 behavior 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 powerful 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.

4. Application Domains

4.1. Medical applications

Our research directions are motivated by applications with a high healthcare or social impact. They are developed in collaboration with medical partners, neuroscientists and psychologists. Almost all of our applications can be seen as neural interfaces which require analysis and modeling of sensorimotor rhythms.

4.1.1. Per-operative awareness during general anesthesia

Collaborators: Univ. Hospital of Nancy-Brabois/dept. Anesthesia & Resuscitation
During general anesthesia, brain oscillations change according to the anesthetic drug concentration. Nowadays, 0.2 to 1.3% of patients regain consciousness during surgery and suffer from post-traumatic disorders. Despite the absence of subject movements due to curare, an electroencephalographic analysis of sensorimotor rhythms can help to detect an intention of movement. Within a clinical protocol, we are working on a brain-computer interface adapted to the detection of intraoperative awareness.

4.1.2. Recovery after stroke

Collaborators: Regional Institute of Physical Medicine and Rehabilitation/Center for Physical Medicine and Rehabilitation (Lay St Christophe), Univ. of Lorraine/PErSEUs.
Stroke is the main cause of acquired disability in adults. Neurosys aims at recovering limb control by improving the kinesthetic motor imagery (KMI) generation of post-stroke patients. We propose to design a KMI-based EEG neural interface which integrates complementary modalities of interactions such as tangible and haptic ones to stimulate the sensorimotor loop. This solution would provide a more engaging and compelling stroke rehabilitation training program based on KMI production.

4.1.3. Modeling Parkinson's disease

Collaborators: Center for Systems Biomedicine (Luxembourg), Institute of Neurodegenerative Diseases (Bordeaux), Human Performance & Robotics laboratory (California State Univ., Long Beach).
Effective treatment of Parkinson's disease should be based on a realistic model of the disease. We are currently developing a neuronal model based on Hodgkin-Huxley neurons reproducing to a certain extent the pathological synchronization observed in basal ganglia in Parkinsonian rats. Moreover, our mesoscopic models of plastic CPG neural circuitries involved in rhythmic movements will allow us to reproduce incoherent coordination of limbs observed on humans affected by Parkinson's diseases like frozen gait, crouch gait. Our long-term objective is to understand how oscillatory activity in the basal ganglia affects motor control in spinal structures.

5. Highlights of the Year

5.1. Highlights of the Year

5.1.1. Awards

BEST POSTER AWARD
Amélie Aussel, Laure Burhy and colleagues obtained the Best student poster award at the 27th Annual Computational Neuroscience Meeting CNS*2018 (Seattle, US) [7].

FEATURED ARTICLE
The journal article by L. Bougrain and colleagues, *A review of classification algorithms for EEG-based brain–computer interfaces: a 10 year update, has been identified as a Featured article i.e. a recent article of high-interest across the entire IOP content (containing more than 70 science journal titles including Journal of Neural Engineering) [4].*

6. New Software and Platforms

6.1. OpenVIBE

KEYWORDS: Neurosciences - Interaction - Virtual reality - Health - Real time - Neurofeedback - Brain-Computer Interface - EEG - 3D interaction
FUNCTIONAL DESCRIPTION: OpenViBE is a free and open-source software platform devoted to the design, test and use of Brain-Computer Interfaces (BCI). The platform consists of a set of software modules that can be integrated easily and efficiently to design BCI applications. The key features of OpenViBE software are its modularity, its high-performance, its portability, its multiple-users facilities and its connection with high-end/VR displays. The designer 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 is available on the Inria Forge under the terms of the AGPL licence, and it was officially released in June 2009. Since then, the OpenViBE software has already been downloaded more than 60000 times, and it is used by numerous laboratories, projects, or individuals worldwide. More information, downloads, tutorials, videos, documentations are available on the OpenViBE website.

- Participants: Cédric Riou, Thierry Gaugry, Anatole Lécuyer, Fabien Lotte, Jussi Tapio Lindgren, Laurent Bougrain, Maureen Clerc and Théodore Papadopoulo
- Partners: INSERM - GIPSA-Lab
- Contact: Anatole Lécuyer
- URL: http://openvibe.inria.fr

6.2. Platforms

6.2.1. EEG experimental room

A room at Inria Nancy - Grand Est is dedicated to electroencephalographic recordings. An umbrella agreement and several additional experiment descriptions have been approved by the Inria Operational Legal and Ethical Risk Assessment Committee (COERLE). A new 64 channels Biosemi EEG amplifier has been added this year to be able to record two experimental campaign in parallel (Regional initiative *Contrat de Projet État Région (CPER) IT2MP* see section 8.1). Specific experimentation have been done in interaction with Pepper, a semi-humanoid robot.

7. New Results

7.1. From the microscopic to the mesoscopic scale

Participants: Laure Buhry, Axel Hutt Amélie Aussel, Nathalie Azevedo Carvalho.
In collaboration with Radu Ranta (univ. Lorraine), Dominique Martinez (CNRS), Abderrahman Iggidr (Inria), Patrick Hénaff (univ. Lorraine), Beate Knauer and Motoharu Yoshida (Ruhr university) and LieJune Shiau (university of Houston)

Figure 1. Electroencephalographic Experimental room at Inria Nancy-Grand Est

7.1.1. Memory & sleep

We proposed a detailed anatomical and mathematical model of the hippocampal formation for the generation of sharp-wave ripples and theta-nested gamma oscillations [1], [7]. Indeed, the mechanisms underlying the broad variety of oscillatory rhythms measured in the hippocampus during the sleep-wake cycle are not yet fully understood. We proposed a computational model of the hippocampal formation based on a realistic topology and synaptic connectivity, and we analyzed the effect of different changes on the network, namely the variation of synaptic conductances, the variations of the CAN channel conductance and the variation of inputs. By using a detailed simulation of intracerebral recordings, we showed that this model is able to reproduce both the theta-nested gamma oscillations that are seen in awake brains and the sharp-wave ripple complexes measured during slow-wave sleep. The results of our simulations support the idea that the functional connectivity of the hippocampus, modulated by the sleep-wake variations in Acetylcholine concentration, is a key factor in controlling its rhythms. A presentation of this work received a best poster award at the 27th annual Computational Neuroscience Meeting, CNS'2018.

7.1.2. Parkinson's network

Using a Hodgkin and Huxley's model, we modeled pathological oscillations of Parkinson's disease in basal ganglia. Our hypothesis was that the pathological oscillations are generated by a MSN-GPeA-FSN circuit and then transferred to the STN by the GPeP. The normal state is represented by neurons of the MSN emitting at a frequency of $\sim 1Hz$ and the parkinsonian state is represented by MSN neurons that emit at a frequency of $\sim 15Hz$. Our results correspond to the experimental results of the rat. In the normal state, there is no visible synchronization, whereas in the parkinsonian state pathological synchronizations are formed at the level of the circuit. There is even a rhythm that is created, that is to say, the neurons of MSN emit first then those of the FSN and then those of the GPeA and so on. We performed large-scale simulations of 1.5 million neurons in the basal ganglia in rats using the Grid5000 (parallel computation platform).

7.2. From the Mesoscopic to the Macroscopic Scale

Participants: Laurent Bougrain, Axel Hutt, Sébastien Rimbert, Oleksii Avilov, Rahaf Al-Chwa.
In collaboration with Stéphanie Fleck (Univ. Lorraine) and Patrick Hénaff (univ. Lorraine)

7.2.1. Motor system

In collaboration with Stéphanie Fleck (Univ. Lorraine)

Kinesthetic motor imagery (KMI) tasks induce brain oscillations over specific regions of the primary motor cortex within the contralateral hemisphere of the body part involved in the process. This activity can be measured through the analysis of electroencephalographic (EEG) recordings and is particularly interesting for Brain-Computer Interface (BCI) applications.

7.2.1.1. Electroencephalographic modulations during an open- or closed-eyes motor task

There is fundamental knowledge that during the resting state cerebral activity recorded by electroencephalography (EEG) is strongly modulated by the eyes-closed condition compared to the eyes-open condition, especially in the occipital lobe. However, little research has demonstrated the influence of the eyes-closed condition on the motor cortex, particularly during a self-paced movement. This prompted the question: How does the motor cortex activity change between the eyes-closed and eyes-open conditions? To answer this question, we recorded EEG signals from 15 voluntary healthy subjects who performed a simple motor task (i.e., a voluntary isometric flexion of the right-hand index) under two conditions: eyes-closed and eyes-open. Our results confirmed strong modulation in the mu rhythm (7–13 Hz) with a large event-related desynchronisation. However, no significant differences have been observed in the beta band (15–30 Hz). Furthermore, evidence suggests that the eyes-closed condition influences the behaviour of subjects [5]. Our study gives greater insight into the motor cortex and could also be useful to improve brain-computer interface (BCI) based on motor imagery.

7.2.1.2. Can a Subjective Questionnaire be used as a Brain-Computer Interface performance Predictor?

Predicting a subject's ability to use a Brain Computer Interface (BCI) is one of the major issues in the BCI domain. Relevant applications of forecasting BCI performance include: the ability to adapt the BCI to the needs and expectations of the user; assessing the efficiency of BCI use in stroke rehabilitation; and finally, homogenizing a research population. A limited number of recent studies have proposed the use of subjective questionnaires, such as, the Motor Imagery Questionnaire Revised-Second Edition (MIQ-RS). However, further research is necessary to confirm the effectiveness of this type of subjective questionnaire as a BCI performance estimation tool. In this study we aim to answer the following questions: can the MIQ-RS be used to estimate the performance of an MI-based BCI? If not, can we identify different markers that could be used as performance estimators? To answer these questions, we recorded EEG signals from 35 voluntary healthy subjects during BCI use. The subjects previously had completed the MIQ-RS questionnaire. We conducted an offline analysis to assess the correlation between the questionnaire scores related to Kinesthetic and Motor imagery tasks and the performances of four classification methods. Our results show no significant correlation between BCI performance and the MIQ-RS scores. However, we reveal that BCI performance is correlated to habits and frequency of practicing manual activities [15] (accepted in Front. Hum. Neurosci. | doi: 10.3389/fnhum.2018.00529).

7.2.1.3. Median nerve stimulation based BCI: a new approach to detect intraoperative awareness during general anesthesia

Hundreds of millions of general anesthesia are performed each year on patients all over the world. Among these patients, 0.1-0.2% are victims of Accidental Awareness during General Anesthesia (AAGA), i.e. an unexpected awakening of the patient during a surgical procedure under general anesthesia. This terrifying experience may be very traumatic for the patient and should be avoided by the anesthesiologists. Out of all the techniques used to prevent these awakenings, there is currently no solution based on the EEG signal to detect this phenomenon efficiently. Since the first reflex for a patient during an AAGA is to move, a passive BCI based on the intention of movement is conceivable. However, the challenge of using such BCI is that the intention to move from the waking patient is not initiated by a trigger that could be used to guide a classifier. We proposed a solution based on Median Nerve Stimulation (MNS), which causes specific modulations in the motor cortex and can be altered by an intention of movement. We showed that MNS may provide a foundation for an innovative BCI that would allow the detection of an AAGA [17].

8. Partnerships and Cooperations

8.1. Regional Initiatives

Within the *Contrat de Projet 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*) observing electroencephalographic activity of humans during motor tasks.

8.2. National Initiatives

8.2.1. Inria project-Lab BCI-LIFT 2015-2018 (Brain-Computer Interfaces: Learning, Interaction, Feedback, Training)

Project leader: Maureen Clerc
Partners: 7 Inria project-teams (Aramis, Athena, Demar, Hybrid, Mjolnir, Neurosys, Potioc), univ. Rouen, Dycog team at Centre de Recherche en Neurosciences de Lyon.

BCI-LIFT is a research initiative to reach a next generation of non-invasive Brain-Computer Interfaces (BCI), more specifically BCI that are easier to appropriate, more efficient, and suit a larger number of people. With this concern of usability as our driving objective, we build non-invasive systems that benefit from advanced signal processing and machine learning methods, from smart interface design, and where the user immediately receives supportive feedback. What drives this project is the concern that a substantial proportion of human participants is currently categorized "BCI-illiterate" because of their apparent inability to communicate through BCI. Through this project we aim at making it easier for people to learn to use BCI, by implementing appropriate machine learning methods and developing user training scenarios.

8.2.2. Projet CNRS PEPS S2IH INS2I 2018 : MoveYouMind (Design and evaluation of a visual neurofeedback based on specific corticomotor areas using source localization for enhancing motor imagery)

Project leader: Laurent Bougrain
Partners: Neurosys, Cognitive and Systems Neurosciences (univ. Lorraine/CRAN), Perseus (univ. Lorraine)
This project aims at improving the functional recovery protocols of hemiplegic stroke patients by increasing the precision of the identification of the brain areas involved in a kinesthetic motor task of the upper limbs. The brain areas engaged during this rehabilitation task will be detected by specific source localization methods based on the signals obtained by an electroencephalographic acquisition system with variable geometry, which will inform and therefore guide the patient (and the nursing staff) during the functional rehabilitation by indicating to her/him if the activity which she/he produces is in the right motor area. The project aims to design and evaluate a visual neurofeedback based on active cortical areas within an existing brain-computer interface.

8.2.3. Projet CNRS PEPS S2IH INS2I 2018 : HDCHS (From Human-Human Handshaking to Human-Robot Handshaking)

Project leader: Patrick Hénaff
Partners: Neurosys, Perseus (univ. Lorraine), Cerco

This project interfaces robotics, neuroscience and experimental psychology. It is part of on-going research initiated at LORIA on the understanding of physical and cognitive phenomena that appear while two persons handshake, in order to reproduce them with a humanoid robot naturally interacting with a human. This act is studied because is a multimodal physical and social interaction, socially common but complex from a neuroscience and robotics point of view, because it involves physical, psychological and sensorimotor couplings which differ, depending on the social context. This project proposes novel handshaking experiments aiming at understanding the physical and psychological synchronization phenomena (coupling, locking, rhythmicity), best known as the « Human Dynamic Clamp » (HDC) paradigm, in order to propose models in adequation with the bio-inspired controllers developed at LORIA for the control of humanoid robots.

8.3. International Initiatives

8.3.1. Informal International Partners

- We hosted Takeshi Nishida (Kuytech, Japan) for five months and Sozo Inoue (Kuytech, Japan) for one week to prepare a collaboration on neurosciences and robotics. Laurent Bougrain visited Takeshi Nishida, Kiyohisa Natsume and Toshimasa Yamazaki in Kyutech. Asako Watanabe, a master student from Kuytech, will come for 3 weeks in the team in January 2019 to work on EEG markers of a motor task.
- We collaborate with Anton Popov (Kiev Polytechnic Institute, Ukraine) on feature extraction of brain signal and deep learning (L. Bougrain). Oleksii Avilov is a Ph.D student under a joint supervision arrangement between Kiev Polytechnic Institute and university of Lorraine.
- We also collaborate with Emel Demircan (Univ South California) to use EMG-informed Computed Muscle Control for dynamic simulations of movement available in OpenSim [1]. She stayed 3 weeks in Neurosys this year.
- We also collaborate with 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).

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Takeshi Nishida, Ass. Prof, Kuytech, Japan, 5 weeks (Jun.-Jul. 2018)
- Emel Demircan, Ass. Prof, Univ South California, USA, 3 weeks (Jun.-Jul. 2018)
- Sozo Inoue, Full Prof, Kuytech, Japan, 1 week (dec. 2018)

8.4.1.1. Internships

- Sooraj Sivakumar, Student, IIT Madras, India (Jan-Mar 2018)

9. Dissemination

9.1. Promoting Scientific Activities

Laurent Bougrain is a member of the Board of Directors of the scientific society CORTICO for the promotion of Brain-Computer Interfaces in France.

Laurent Bougrain is a member of the steering committee of the research network in neuroscience of the university of Lorraine.

Laure Buhry is an elected member of the "Pôle Scientifique AM2I" council of university of Lorraine.

Sébastien Rimbert is an elected member of the doctoral school IAEM of university of Lorraine.

9.1.1. Scientific Events Organisation

9.1.1.1. General Chair, Scientific Chair

- Laurent Bougrain is a member of the organization committee of the scientific days of the research network in neuroscience of the university of Lorraine, June 14th 2018 (topic: learning and memory) & December 18th 2018 (topic: motor system).

9.1.1.2. Member of the Organizing Committees

- Laure Buhry is a member of the organization committee of the IPAC seminar (Image, Perception, Action et Cognition).

9.1.2. Scientific Events Selection

9.1.2.1. Member of the Conference Program Committees

Laurent Bougrain is a member of the program committee of the IEEE conference on System, Man and Cybernetics.

[1] https://opensim.stanford.edu/

9.1.3. Invited Talks

- Laurent Bougrain, Brain-Computer Interfaces, Oct. 4th 2018, Yamazaki Lab, Kuytech, Japan
- Laurent Bougrain, Brain-Computer Interfaces, Oct. 5th 2018, Natsume Lab, Kuytech, Japan
- Laurent Bougrain, Neuronal effect therapeutic hypnosis and anesthesia on the movement intention, scientific days of the research network in neuroscience of the university of Lorraine, Dec. 18th 2018 (topic: motor system).

9.1.4. Leadership within the Scientific Community

Laurent Bougrain is a member of the Board of Directors of the scientific society CORTICO for the promotion of Brain-Computer Interfaces in France.

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

Engineering school: L. Bougrain, Brain-Computer Interfaces, 4.5h, 3rd year, Supelec, France

Engineering school: L. Bougrain, Artificial Intelligence, 61h, 3rd year, Telecom Nancy, France

Engineering school: A. Aussel, Python, Ecole des Mines, Nancy, France

Master: L. Buhry, Algorithms for Articifial Inteligence, 31h, Master of cognitive science, 1st year, University of Lorraine, France

Master: L. Buhry, Fondamental Artificial Intelligence and data mining, 18h, Master of cognitive science,1st year1, University of Lorraine, France

Master: L. Buhry, Formalisms for representation and reasoning, 25h, Master of cognitive science,1st year1, University of Lorraine, France

Master: L. Buhry, Memory and Machine Learning, 38h, Master of cognitive science, 1st year, University of Lorraine, France

Master: L. Buhry, Computationnal Neurosciences, 25h, Master of cognitive science, 2nd year/SCMN, University of Lorraine, France

Master: L. Bougrain, Learning and reasoning in the uncertain, 32h, Master of computer science, 2nd year, University of Lorraine, France

Master: S. Rimbert, Brain-Computer Interface, 17h, Master of cognitive sciences, 2nd year, University of Lorraine, France

Master: A. Aussel, Computational Neuroscience, Master of cognitive sciences, 2nd year, University of Lorraine, France

Licence: S. Rimbert, Introduction to Neurosciences, 15h, Licence of cognitive sciences, 1st year, University of Lorraine, France

Licence: L. Buhry, Programmation Python, 37h, level L1 MIASHS, University of Lorraine, France

Licence: L. Buhry Probability and statisticss, 30h, level L1 MIASHS, University of Lorraine, France

Licence: L. Buhry, Artificial Intelligence and problem solvinges, 25h, level L3 MIASHS, University of Lorraine, France

Licence: L. Bougrain, programming on mobile devices, 17h, Licence of computer science, 3rd year, University of Lorraine, France

9.2.2. Supervision

PhD in progress: Amélie Aussel, Extraction of electrophysiological markers and mathematical modelling of the epileptic hippocampus, October 1st 2016, Laure Buhry and Radu Ranta (CRAN).

PhD in progress: Sébastien Rimbert, Study of the dynamic of cerebral motor patterns during general anesthesia, January 1st 2016, Axel Hutt and Laurent Bougrain.

PhD in progress: Oleksii Avilov, methods for on-line detection of neural rythm changes in the motor system: application to brain-computer interfaces, June 1st 2018, Patrick Hénaff, Laurent Bougrain and Anton Popov (Kiev polytechnic institute).

PhD in progress: Nathalie Azevedo Carvalho, a biologically plausible computer model of pathological neuronal oscillations observed in Parkinson's disease, November 1st 2018, Dominique Martinez and Laure Buhry.

9.2.3. Juries

Ph.D. thesis jury: Louis Korczowski, Methods for multi-subject electroencephalography and application to brain-computer interfaces, university Grenoble-Alpes, October 17th 2018, L. Bougrain (member)

9.3. Popularization

Neurosys' activities. Artificial Intelligence, IoT and robotics for health,association ATD quart-monde, June 10th 2018 (L. Bougrain)

10. Bibliography

Publications of the year

Articles in International Peer-Reviewed Journals

[1] A. AUSSEL, L. BUHRY, L. TYVAERT, R. RANTA. *A detailed anatomical and mathematical model of the hippocampal formation for the generation of sharp-wave ripples and theta-nested gamma oscillations*, in "Journal of Computational Neuroscience", December 2018, vol. 45, n^{o} 3, 207 p. [*DOI :* 10.1007/S10827-018-0704-X], https://hal.archives-ouvertes.fr/hal-01917285

[2] D. BICHARA, A. IGGIDR. *Multi-patch and multi-group epidemic models: A new framework*, in "Journal of Mathematical Biology", 2018, vol. 77, n^{o} 1, pp. 107-134, https://arxiv.org/abs/1703.04554 [*DOI :* 10.1007/S00285-017-1191-9], https://hal.inria.fr/hal-01490764

[3] M. JOUAITI, L. CARON, P. HENAFF. *Hebbian Plasticity in CPG Controllers Facilitates Self-Synchronization for Human-Robot Handshaking*, in "Frontiers in Neurorobotics", June 2018, vol. 12, pp. 1-15 [*DOI :* 10.3389/FNBOT.2018.00029], https://hal.archives-ouvertes.fr/hal-01811316

[4] F. LOTTE, L. BOUGRAIN, A. CICHOCKI, M. CLERC, M. CONGEDO, A. RAKOTOMAMONJY, F. YGER. *A Review of Classification Algorithms for EEG-based Brain-Computer Interfaces: A 10-year Update*, in "Journal of Neural Engineering", April 2018, 55 p. [*DOI :* 10.1088/1741-2552/AAB2F2], https://hal.inria.fr/hal-01846433

[5] S. RIMBERT, R. AL-CHWA, M. ZAEPFFEL, L. BOUGRAIN. *Electroencephalographic modulations during an open- or closed-eyes motor task*, in "PeerJ", 2018, vol. 6, pp. 1-18 [*DOI :* 10.7717/PEERJ.4492], https://hal.inria.fr/hal-01736600

[6] A. D. SHACHYKOV, P. HENAFF, O. P. SHULYAK. *Neuro-musculoskeletal simulator of rhythmic movements of human hip joint*, in "Bulletin of National Technical University of Ukraine "KPI". Series Instrument Making", June 2018, vol. 55(1), pp. 118-125 [*DOI :* 10.20535/1970.55(1).2018.135832], https://hal.archives-ouvertes.fr/hal-01798576

International Conferences with Proceedings

[7] A. AUSSEL, R. RANTA, L. BUHRY, L. TYVAERT, P. HENAFF. *A detailed model of the hippocampal formation for the generation of sharp-wave ripples and theta-nested gamma oscillations*, in "27th Annual Computational Neuroscience Meeting, CNS*2018", Seatle, WA, United States, July 2018, https://hal.archives-ouvertes.fr/hal-01843023

[8] M. JOUAITI, P. HENAFF. *CPG-based Controllers can Generate Both Discrete and Rhythmic Movements*, in "IROS 2018 - IEEE/RSJ International Conference on Intelligent Robots and Systems", Madrid, Spain, October 2018, https://hal.archives-ouvertes.fr/hal-01837189

[9] M. JOUAITI, P. HENAFF. *CPG-based Controllers can Trigger the Emergence of Social Synchrony in Human-Robot Interactions*, in "ARSO 2018 - IEEE International Workshop on Advanced Robotics and its Social Impacts", Genoa, Italy, September 2018, https://hal.archives-ouvertes.fr/hal-01825464

[10] B. MENGES, M. SARREY, P. HENAFF. *Implementation, risk assessment and safety human/robot interaction of collaborative robot UR10*, in "SIAS 2018 - 9th International Conference on Safety of Industrial Automated Systems", Nancy, France, October 2018, https://hal.archives-ouvertes.fr/hal-01842999

[11] B. MENGES, M. SARREY, P. HENAFF. *Integration of collaborative robot in a hard steel industrial environment*, in "CASE 2018 - 14th IEEE International Conference on Automation Science and Engineering", munich, Germany, August 2018, https://hal.archives-ouvertes.fr/hal-01843017

Conferences without Proceedings

[12] P. AKSONENKO, V. AVRUTOV, Y. F. LAZAREV, P. HENAFF, L. CIARLETTA. *Expanded Algorithm for Inertial Navigation*, in "SAI 2018 - IEEE Computing Conference", londres, United Kingdom, July 2018, https://hal.archives-ouvertes.fr/hal-01843047

[13] O. AVILOV, A. POPOV, V. I. TIMOFEYEV, L. BOUGRAIN, P. HENAFF. *Combined imaginary movements classification using binary classifiers in brain-computer interfaces*, in "XVII International scientific and technical conference “Physical processes and fields of technical and biological objects”", Kremenchuk, Ukraine, November 2018, https://hal.archives-ouvertes.fr/hal-01928217

[14] P. GRANJON, A. DUTECH, P. HENAFF. *Guido and Am I Robot?, case study of two robotic artworks operating in public spaces*, in "ICLI 2018 - International Conference on Live Interfaces", Porto, Portugal, June 2018, https://hal.archives-ouvertes.fr/hal-01843041

[15] S. RIMBERT, N. GAYRAUD, M. CLERC, S. FLECK, L. BOUGRAIN. *Can the MIQ-RS questionnaire be used to estimate the performance of a MI-based BCI?*, in "2018 Seventh International BCI Meeting", Pacific Grove, United States, May 2018, https://hal.archives-ouvertes.fr/hal-01889864

Scientific Books (or Scientific Book chapters)

[16] A. D. SHACHYKOV, P. HENAFF, O. P. SHULYAK (editors). *Simulation of rhythmic movements of the human hip joint at the neuronal and muscular-skeletal level*, National Technical University of Ukraine "Kyiv Polytechnic Institute", May 2018, https://hal.archives-ouvertes.fr/hal-01798555

Other Publications

[17] P. RIFF. *Study of the EEG Responses of a Median Nerve Stimulation of the forearm for a better monitoring during general anesthesia*, Université de Lorraine (Nancy), September 2018, https://hal.inria.fr/hal-01889015