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Project-Team CORTEX

Neuromimetic Intelligence

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THEME COG

Activity Report

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1. Team

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2. Overall Objectives

2.1. Overall Objectives

The goal of our research is to study the properties and capacities of distributed, numerical and adaptive automated information processing and to show that this kind of processing may allow to build "intelligent" systems, i.e. able to extract knowledge from data and to manipulate that knowledge to solve problems. More precisely, these studies rely on the elaboration and analysis of neuromimetic connectionist models (*cf.* § 3.1), developed along two sources of inspiration, computational neuroscience and machine learning.

Both sources of inspiration are studied together because they are interested in better understanding how such distributed models can learn internal representations, and manipulate knowledge and both propose complementary approaches allowing cross-fertilization. Machine learning proposes connectionist numerical models for information processing in a statistical framework, to extract knowledge from data (*cf.* § 3.2). Computational neuroscience proposes distributed theoretical models and elementary mechanisms that aim at explaining how the human or animal nervous system processes information at various levels, from neuronal mechanisms (*cf.* § 3.4) to behaviour (*cf.* § 3.3).

Complementarily to our multidisciplinary domains of inspiration, our research is applied in domains like data and signal interpretation, intelligent sensors, robotics, and computer-aided decision. More generally, our models are dedicated to monitoring complex, multimodal processes, perceiving and acting on their environment (*cf.* § 4.1).

These models are firstly implemented on classical computers, but other architectures are also explored, namely parallel machines, autonomous robots, and more generally specialized circuits for embedded systems, as suggested by our applications (*cf.* § 3.5).

Accordingly, four topics of research are currently carried out. (i) In computational neuroscience, at a behavioral level, we are developing models of cerebral neuronal structures (*cf.* § 6.1), to allow the navigation of autonomous robots. (ii) In computational neuroscience, at the neuronal level, we are modeling spiking neurons (*cf.* § 6.2), seen as dynamic systems with temporal behavior, allowing synchronization within populations of neurons. (iii) From a more statistical point of view, we are studying how classical continuous neuronal models can be adapted to database and signal interpretation, for knowledge extraction (*cf.* § 6.3). (iv) From a more technological point of view, all the above-mentioned models are adapted to allow implementations on dedicated architectures (*cf.* § 6.4).

3. Scientific Foundations

3.1. Connectionism

Keywords: *artificial neural network*, *connectionism*, *multi-layer perceptron*, *perceptron*, *self-organizing map*.

Connectionism can be defined as the study of graphs of simple interconnected units, performing elementary numerical computations, derived from their input and internal parameters. In particular, neuro-inspired connectionism is interested in artificial neural networks, like perceptrons or self-organizing maps. These models have been thoroughly studied in the domain of machine learning for their properties of learning and approximation and their links with other statistical tools.

Artificial neural networks have been successfully applied to a variety of tasks (pattern matching, prediction, control) in a variety of domains (signal processing, industrial processes, medicine). Beyond computing statistics on databases from such domains, one can also wonder about using such capabilities on databases including an important temporal dimension and on more cognitive tasks like interpretation and knowledge extraction. Both characteristics are not classical properties of artificial neural networks, but are fundamental from an expertise point of view. Current research aims at extending their capabilities to these tasks (*cf.* § 3.2).

Other connectionist approaches aim at going back to the basis of connectionism and look for a tighter inspiration from neuroscience. The inspiration can be local and look for more realistic models of neuronal functioning and particularly of its dynamical aspect (*cf.* § 3.4). It can be global with the goal of implementing tasks related to the modeling of integrated behavior (*cf.* § 3.3). Both biologically inspired approaches are refered to as computational neuroscience. They are multidisciplinary and aim at a better understanding of brain function (biological aspect) and of neuronal computation, seen as a new paradigm of computation (computer science aspect).

Another important issue in connectionism is to take benefit from the parallel distributed nature of its computation and to develop implementations that exploit those characteristics. As such implementations lead to cope with the real nature of neural computation, they may improve the performance of algorithms and be embedded in electronic devices (*cf.* § 3.5).

3.2. Intelligent information processing

Keywords: *data analysis*, *knowledge extraction*, *neuro-symbolic integration*, *pre-processing*, *visualization*.

Artificial neural networks are information processing systems that can be widely applied to data mining. They have a lot of capabilities for analyzing and pre-processing data, as well as visualizing and extracting knowledge. These capabilities can be developed through unsupervised and supervised networks or by combining them to obtain data analysis and forecasting models close to the ones performed by statistical methods but with other interesting properties.

To improve the performance of such information processing systems, several approaches can be followed depending of the prior knowledge available. Indeed, depending on additional labels (class or continuous value) which can be used (or available) on none of the patterns, on a subset of the patterns or on all of them, unsupervised or supervised learning can be sequentially performed. When there is no prior knowledge on the problem to be solved, knowledge extraction may use an unsupervised neural network as a front-end for forecasting applications or extracting rules. Because of its synthesis capabilities, an unsupervised neural network can be used both for limiting the computation complexity and for extracting the most significant knowledge. Moreover, knowledge extraction is facilitated as soon as multi-viewpoint unsupervised neural network model is used. This kind of methods also allows using in a second step additional information when it is available for optimizing a forecasting problem. However, for a forecasting problem where all patterns are labelled, classical networks using supervised learning can be successfully improved by finding the minimal architecture using pruning algorithms. The pruning methods consist in removing, during learning, the connections or neurons, or both, that have the least influence on the system's performance. Reducing the complexity of the networks prevents overtraining and allows easier implementation and knowledge extraction (variable selection, rule extraction). In any case, combining several models into a committee helps to improve the quality of the knowledge extracted or the forecasting and the proposed methods must be efficient for typical real-world in our domain, dealing with large amount of noisy and temporal data. Both topics are recently developed in the project.

Whenever they can be associated to such information processing techniques, new visualization techniques represent high added value as soon as their original processing results are mostly represented in high dimensional space.

3.3. Computational neuroscience: behavioral approach

Keywords: *behavioral model*, *computational neuroscience*, *cortical column*, *cortical model*, *population of neurons*.

With regards to the progress that has been made in anatomy, neurobiology, physiology, imaging, and behavioral studies, computational neuroscience offers a unique interdisciplinary cooperation between experimental and clinical neuroscientists, physicists, mathematicians and computer scientists. It combines experiments with data analysis and computer simulation on the basis of strong theoretical concepts and aims at understanding mechanisms that underlie neural processes such as perception, action, learning, memory or cognition. Today, computational models are able to offer new approaches of the complex relations between the structural and the functional level of the brain thanks to realistic models. Furthermore, these computational models and methods have strong implications for other sciences (e.g. psychology, biology) and applications (e.g. robots, cognitive prosthesis) as well.

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

The main cognitive tasks we are currently interested in are related to the autonomous navigation of a robot in an unknown environment (perception, sensorimotor coordination, planning). The corresponding neuronal structures we are modeling are part of the cortex (perceptive, associative, frontal maps) and the limbic system (hippocampus, amygdala, basal ganglia). Corresponding models of these neuronal structures are defined at the level of the population of neurons and functioning and learning rules are built from neuroscience data to emulate the corresponding information processing (filtering in perceptive maps, multimodal association in associative maps, temporal organization of behavior in frontal maps, episodic memory in hippocampus, emotional conditioning in amygdala, selection of action in basal ganglia). Our goal is to iteratively refine these models, implement them on autonomous robots and make them cooperate and exchange information, toward a completely adaptive, integrated and autonomous behavior.

3.4. Computational neuroscience: spiking neurons

Keywords: *computational neuroscience*, *neural code*, *olfaction*, *spiking neurons*, *synchronization of activity*.

Computational neuroscience is also interested in having more precise and realistic models of the neuron and especially of its dynamics. Compartmental models describe the neuron through various compartments (axon, synapse, cellular body) and coupled differential equations. Such models describe the activity of real neurons to a high degree of accuracy. However, because of their complexity, these models are difficult to understand and to analyze. For this reason our work focuses on the use of simplified models, i.e. simple phenomenological models of spiking neurons, that try to capture the dynamic behavior of the neuron in leaky integrators that explain how spikes can be emitted through time from input integration.

These models are interesting for several reasons. From a neuroscience point of view, they allow a better understanding of neuronal functioning. Indeed, although it is well known that real neurons communicate with spikes, i.e. a short electrical pulse also called action potential, the precise nature of the neural code is a topic of intense debate. The firing-rate coding hypothesis stating that the firing frequency of a neuron estimated by temporal averaging encodes information is now challenged by a number of recent studies showing that precise spike timing is a significant element in neural encoding. In particular, stimulus-induced synchronization and oscillatory patterning of spike trains have been experimentally observed in perceptive systems like in vision or olfaction. Moreover, synchronization of neural activities seems to play a role in olfactory perception; for example, when the synchronization is pharmacologically abolished, honeybees do not discriminate anymore between similar odors.

From a computer science point of view, we investigate the spatio-temporal dynamics of simplified models of spiking networks using both mathematical analysis and numerical simulations. Therefore, we have to define (i) a tractable mathematical analysis with methods coming from the theory of nonlinear dynamical systems and (ii) an efficient computing scheme with either event-driven or time-driven simulation engines. These models can also be applied to difficult coding tasks for machine perception like vision and olfaction, and can help to understand how sensory information is encoded and processed by biological neural networks.

3.5. Connectionist parallelism

Keywords: *FPGA*, *connectionism*, *digital circuits*, *parallelism*.

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

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

Our approach claims that the parallelism of connectionist models makes them able to deal with strong implementation and application constraints. This claim is based on both theoretical and practical properties of neural networks. It is related to a very fine parallelism grain that fits parallel hardware devices, as well as to the emergence of very large reconfigurable systems that become able to handle both adaptability and massive parallelism of neural networks. More particularly, digital reconfigurable circuits (e.g. FPGA, Field Programmable Gate Arrays) stand as the most suitable and flexible device for fully parallel implementations of neural models, according to numerous recent studies in the connectionist community. We carry out various arithmetical and topological studies that are required by the implementation of several neural models onto FPGAs, as well as the definition of hardware-targetted neural models of parallel computation.

4. Application Domains

4.1. Overview

Keywords: *database interpretation*, *multidisciplinary applications*, *perception/action interaction*, *robotics*, *signal interpretation*.

Our connectionist models are applied to two kinds of tasks. From a machine learning point of view, the idea is to combine the statistical exploration of databases with knowledge extraction from these databases. From a computational neuroscience point of view, we are interested in modeling various aspects of intelligent behavior. Domains of application are thus very wide since they include domains where databases have to be structured and interpreted and domains where perception-action loops have to be elaborated from the exploration of an unknown world.

Beyond the good performances of the neuronal paradigm on these tasks, these applications are also interesting for several reasons. From an expertise point of view, they allow to extract knowledge from databases including geographical and geological data (*cf.* § 7.2), industrial data (*cf.* § 7.3), bibliographical data (*cf.* § 7.3) or EEG signals (*cf.* § 7.3).

From a technological point of view, they allow to define a methodology for using artificial neural networks (*cf.* § 5.2) and they can lead to hardware implementation (*cf.* § 5.5). From a multidisciplinary point of view, they lead to projects (*cf.* § 7.2 and § 7.3) including partners from different domains and working together for a better understanding of the brain (neuroscientists, ethologists, physicians).

5. Software

5.1. Spiking neural networks simulation

Keywords: *event-driven simulator*, *spiking neurons*.

Participant: Dominique Martinez.

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 using either (i) an event-driven approach or (ii) a time-driven approach. They are respectively more dedicated to the simulation of integrate-and-fire neurons or Hodgkin-Huxley neurons.

- The event-driven simulation engine was developed in C++ by O. Rochel during his PhD thesis. It allows to achieve good performance in the simulation phase while maintaining a high level of flexibility and programmability in the modeling phase. A large class of spiking neurons can be used ranging from standard leaky integrate-and-fire neurons to more abstract neurons, e.g. defined as complex finite state machines.
- The time-driven simulator engine called SIRENE was written in C and developed for the simulation of a model of the antennal lobe, the first structure of the insect olfactory system. This simulator engine can simulate any type of spiking neural network and is indeed more dedicated to the simulation of biologically detailed models of neurons —such as conductance-based neurons— and synapses. Its high flexibility allows the user to implement easily any type of neuronal or synaptic model and use the appropriate numerical integration routine (e.g. Runge-Kutta at given order). In the context of an application to large networks (*cf.* § 7.2), we have developed a graphical interface to visualize the spikes and the evolution of our networks.

5.2. Implementation of computational neuroscience mechanisms

Keywords: *computational neuroscience*.

Participants: Nicolas Rougier, Thomas Girod, Jérémy Fix.

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. However, there exist two major differences. The first difference lies in the distributed nature of computation that does not allow to implement "regular" neural networks which require non local functions. For example, perceptron, multi layer perceptron, Kohonen maps or Hopfield networks all require at some point a global function and then, cannot be implemented using D.A.N.A. The second difference lies in the asynchronous nature of computations: units are evaluated in random order and updated immediately. From a conceptual point of view, the computational paradigm supporting the library is grounded on the notion of a unit that is essentially a potential that can vary along time under the influence of other units and learning. Those units are organized into layers, maps and network: a network is made of one to several map, a map is made of one to several layer and a layer is made of a set of several units. Each unit can be linked to any other unit (included itself) using a weighted link. D.A.N.A library offers a set of core classes needed to design and run such networks. However, what is actually computed by a unit or what is learned is far beyond the scope of the library. User is in charge of implementing a unit derived class that actually does something useful for his own purposes.

5.3. Decision-making platform

Keywords: *decision-making*.

Participants: Laurent Bougrain, Nizar Kerkeni, Marie Tonnelier.

GINNet (Graphical Interface for Neural Networks) is a decision-aid platform written in Java, intended to make neural network teaching, use and evaluation easier, by offering various parametrizations and several data pre-treatments. GINNet is based upon a local library for dynamic neural network developments called DynNet. DynNet (Dynamic Networks) is an object-oriented library, written in Java and containing base elements to build neural networks with dynamic architecture such as Optimal Cell Damage and Growing Neural Gas. Classical models are also already available (multi-layer Perceptron, Kohonen self-organizing maps, ...). Variable selection methods and aggregation methods (bagging, boosting, arcing) are implemented too.

The characteristics of GINNet are the following: Portable (100% Java), accessible (model creation in few clicks), complete platform (data importation and pre-treatments, parametrization of every models, result and performance visualization). The characteristics of DynNet are the following: Portable (100% Java), extensible (generic), independent from GINNet, persistent (results are saved in HML), rich (several models are already implemented), documented.

This platform is composed of several parts:

1. Data manipulation: Selection (variables, patterns), descriptive analysis (stat., PCA..), detection of missing, redundant data.
2. Corpus manipulation: Variable recoding, permutation, splitting (learning, validation, test sets).
3. Supervised networks: Simple and multi-layer perceptron.
4. Competitive networks: Kohonen maps, Neural Gas, Growing Neural Gas.
5. Metalearning: Arcing, bagging, boosting.
6. Results: Error curves, confusion matrix, confidence interval.

DynNet and GINNet are free softwares, registrated to the APP and distributed under CeCILL license, Java 1.4 compatible (http://ginnet.gforge.inria.fr). GINNet is available as an applet. For further information, see http://gforge.inria.fr/projects/ginnet (news, documentations, forums, bug tracking, feature requests, new releases...)

5.4. MicroNOMAD-MultiSOM

Keywords: *documentary database*, *knowledge discovery*.

Participant: Jean-Charles Lamirel.

The MicroNOMAD-MultiSOM software mainly focuses on the automatic extraction and organization of knowledge that is embedded in documentary databases. The basic principle of this software is to provide users with interactive and interconnected cartographies of knowledge materializing several different syntheses of the content of a given documentary database. The underlying model of the MicroNOMAD-MultiSOM software represents an extension of Kohonen's SOM model to a multi-maps (i.e. multi-viewpoints) context. Due to the flexibility of this extension, the resulting maps can both play the role of elaborated browsing tools, data mining tools, as well as tools for assisting users in querying the documentary database. The model allows users to exploit dynamic exchange between the multiple viewpoints for highlighting correlations between the different views on the same data. It also permits the use of partial or incomplete descriptions of the data and accepts simultaneous representations of the same data with regard to different media.

The MicroNOMAD-MultiSOM software has been used on different operational applications of data mining. The versions 1 and 2 of this software have been patented by INRIA. The version 3 offers numerous extensions for analyzing non structured data as well as numerous functions for the automation of analysis.

5.5. Neural network synthesis on FPGA

Keywords: *FPGA*, *digital circuits*, *parallelism*.

Participant: Bernard Girau.

To date the majority of neural network implementations have been in software. Despite their generally recognised performances, the high cost of developing ASICs (Application Specific Integrated Circuits) has meant that only a small number of hardware neural-computing devices has gone beyond the research-prototype stage in the past. With the appearance of large, dense, highly parallel FPGA circuits, it has now become possible to realize large-scale neural networks in hardware, with the flexibility and low cost of software implementations.

Though easier than ASIC development, implementations on FPGAs still require a significant amount of work, especially for connectionists who are not very familiar with such tools as the VHDL language, synthesis tools, etc. Therefore, we have initiated a software project that aims at developing a generic methodology to fully automatically specify, parametrize and implement neural networks according to various application and technological constraints (e.g. area of targeted FPGAs, required precision, etc).

This work has led to a software platform that handles both FPGA boards and neural implementations. Multilayer neural networks and graphically designed networks of neurons are automatically "compiled" onto FPGA by this tool. Communications between the FPGA, the host and the memory slots are also taken into account. The GUI provides facilities for test benches and results generation. The software fully implements a functional chain from the creation of a network to the visualisation of results produced in the board [26]. Current efforts focus on the optimization of the partial use of the different levels of neural parallelism.

5.6. EEG acquisition module

Keywords: *Brain-Computer Interface*, *EEG*.

Participant: Laurent Bougrain.

In the domain of Brain-Computer Interface (BCI), we developed an acquisition module to interface the BCI2000 plateform that we recently acquired to an EEG amplifier by TMSi including a graphical interface to check the impedance of each electrode. This module allows to send data collected from our experiments to this well-known platform. This module has been sent to the BCI2000 community. We aim to compare our algorithms with the ones developed by the other community members.

6. New Results

6.1. Behavioral computational neuroscience

Participants: Frédéric Alexandre, Yann Boniface, Laurent Bougrain, Jérémy Fix, Hervé Frezza-Buet, Bernard Girau, Thomas Girod, Nicolas Rougier, Thomas Voegtlin, Thierry Viéville, Axel Hutt, Mauricio Cerda.

The works reported this year represent extensions of previous works that are mostly concerned with modeling several parts of the visual path in the cortex, from the most elementary to the most integrated (motion detection, attention and active vision, anticipation) and also with the better understanding of the computational paradigms we use to model populations of neurons. We have tried to extend their use and relate them to a solid mathematical formalism. We have also explored ways to reconciliate models using the frequency rate code at the level of the population of neurons, with our spiking models.

6.1.1. Motion detection

Visual perception of motion is a major challenge in machine perception research, since it constitutes an important parameter in a wide variety of tasks such as path-finding, estimation of time to collision, perception of gestures, movement control, etc.

We have developed a bio-inspired neural architecture to detect, extract and segment the direction and speed components of the optical flow within sequences of images. The structure of this model derives directly from the course of the optical flow in the human brain. It begins in the retina and receives various treatments at every stages of its magnocellular pathway through the thalamus and the cortex. Our model mostly handles the properties of three cortical areas called V1, MT (middle temporal), and MST (middle superior temporal): the MT area detects patterns of movement, while spatio-temporal integration is made at the local level by V1 and at the global level by both MT and MST.

We have mainly focused on two fundamental problems in the treatment of a sequence of images. Firstly, the computation of their optical flow (a three-stage process: pre-processing based on filters, extraction of elementary characteristics and integration into a 2D optical flow), and secondly, the extraction of several moving objects in a scene. Our model massively uses bio-inspired inhibitory/excitatory mechanisms that induce local competitions between antagonistic movements so as to make coherent moving areas appear. This work faces many concrete difficulties, such as specular effects, shadowing, texturing, occlusion and aperture problems. Moreover, the complexity of this task must be dealt with within the implementation constraint of real-time processing.

Recent works have focused on three improvements of our initial model.

- Introduction of feedback interactions within the neural layer that extracts the optical flow. This represents the iso-surround inhibition effect that some works consider as responsible for some “pop-out” effects, reducing the noise in the locally extracted motions.
- Adaptation to the bio-inspired principles of a retina-centered vision, through the use of a log-polar transform of the surrounding visual field. This approach intends to improve the quality of motion detection within a central area (with a constant computational load), without “forgetting” the surround.
- Extension to the local extraction of the FOE (focus of expansion). This work is a first step towards the extraction of egomotion in a sequence of images.

6.1.2. Attention and active vision

In the domain of robotic, modeling perceptive and executive attention is a critical feature given the limited computational power available on mobile devices. More specifically, it allows to recruit the vast majority of available resources for processing of a given location of the considered space (either perceptive or motor) in order to process it finely while the remaining resources are allocated for a broader processing of the remaining space. We have been exploring the perceptive attentional paradigm in for the visual space.

Based on our previous work concerning the Continuum Neural Field Theory (CNFT), we proposed in [2] a model whose principle relies on producing a prediction of the location of previously attended stimuli, thanks to the parameters of an impeding eye movement, which is combined with the perceptual input after the saccade is performed. More specifically, we have proposed to connect homogeneous assemblies of units to build a memory circuit. We have extended this model in [15] to take into account the eye movements while performing a visual search task, by adding a mechanism that predicts the consequences of these saccades on the visual perception, showing that disrupting this mechanism drastically impairs the performances of the system.

More recently, we explored further these ideas in [3], [16] and designed a model where the visual input is processed in parallel in different maps, extracting basic features. This distributed representation of the visual input feeds two pathways, a spatial non-feature specific one and a feature roughly non-spatial one. The main purpose of the first is to spatially select a location of interest to memorize that a given location has been attended to and to anticipate the consequences of an eye movement on this memory if the movement is triggered. A key point of the model is the use of feedback projections of the selected location biasing this distributed representation toward the features of the stimulus at the attended location. The feature specific pathway then combines this representation with a target template that might be a complex combination of basic features and is also projected via feedback connections to the feature maps. The resulting activities in the feature processing maps are then propagated to the decision area so as to provide it with the necessary clues to decide which behavior to adopt.

6.1.3. Self-organizing receptive fields using a variational approach.

Self organizing-maps, as e.g. introduced by Kohonen, are artificial neural networks characterized by competitive learning of the processing elements. They thus can be used for the pattern analysis of input signal. Here we consider, as a working example, the self-organization of visual receptive fields, as it occurs in V1 and study to which extend using a variational approach may help specifying such a mechanism.

The goal of the study is thus humble in the sense that we simply would like to explore at a technical level, the advantages and limits of the variational specification in this case. This formulation includes non-linear formulation of self-organizing maps as proposed by Fort and Pages, while unusual non-linear profiles allowing edge preserving smoothing, via non-linear diffusion are introduced. This criterion also acts as a convergence function (à la Lyapounov) of the underlying dynamical system.

The assumption is that they contribute to regularize the learning process. As such, they likely speed-up the convergence. They however constraint the solution to be taken in a more restrictive space of smoother functions. Experimental results are going to confront these assumptions to the ground truth.

A step ahead, the “arg max” rule itself is implemented by a winner-take-all mechanism, given an initial condition, the formulation leading to a local distributed implementation and guaranties the convergence towards a local minimum of the criterion.

A theoretical result predicts a stable interaction through feed-backs between these two layers and an experimental verification has been proposed.

6.1.4. From spikes to frequency

The Continuum Neural Field Theory as it has been introduced in the above sections is mainly concerned with the functional modeling of neural structures at the level of the population. At the level of a single neuron, the model that is used is a mean frequency model where the electrical activity of a neuron is approximated by a single potential. However, there also exist several spiking neuron models that represent both a finer and more accurate model of a real biological neuron. In the framework of the CNFT, they allow to bypass the inherent time discretization implicitely brought by mean frequency models. This section presents the work that has been engaged in this direction and tries to bridge the gap between these two different levels of description.

Based on previous works, we developed a model of visual attention using spiking neurons with several objectives:

- A ’fine grain’ validation, closer to our biological inspiration, from numerical models, with spiking communication between neurons.
- A study of the dynamics and properties of the CNFT at continuous time.
- A study and a validation of the functional properties of a temporal coding of the CNFT.
- The study and the design of the emergence of functional properties from populations of networks of spiking neurons.
- The study, definition and representation of the concept of a network activity within a population of spiking neurons.

Those studies allowed in a first time to design a model that is able to reproduce functional properties and dynamics of the numerical and ’discrete time’ equivalent network. But, beyond the scope of the Continuum Neural Field Theory, these works underline the necessity to thoroughly study the temporal coding of the information flow and to study the dynamic of such functional spiking neurons networks. The next step in this work is then to study the learning of the emergence of functional properties with a temporally coding neural network, using for example learning methods such as the STDP (Spike-Timing Dependent Plasticity).

Reciprocally, spiking neurons have also applications in the behavioral domain. We have developed a robotic search application with spiking neurons.

Like many other insects, a female moth releases a specific blend of odours - a pheromone - to signal her presence to a male. The pheromone plume is not a smooth, continuous cloud, but consists of intermittent, wind-blown patches of odour separated by wide voids. The probability of encountering one of these patches decays exponentially with the distance from their source. Under these circumstances, finding the pheromone source cannot be accomplished simply by ’chemotaxis’ - climbing a chemical concentration gradient. With such scanty information, how do moths successfully locate their mates over distances of hundreds of metres? Artificial ethology or experimentation with animal-like robots can help our understanding to such behavioural questions [6]. We have built an olfactory robot to locate odour sources in a turbulent environment. Our work with the robot has been to test hypotheses of chemo-orientation depending on the nature of the available sensory information (isolated odour patches or smoother concentration field).

6.2. Spiking neurons

Participants: Maxime Ambard, Yann Boniface, Dominique Martinez, Noelia Montejo-Cervera, Thomas Voegtlin.

Our research in fine grain computational neuroscience (*cf.* § 3.4) is performed at different structural scales: the cellular, the circuit and the systems levels. We investigate how information is processed at these different levels and we aim at elucidating the link from cellular functions to cognitive functions.

6.2.1. Time Coding using Neuronal Response Properties

The temporal coding hypothesis states that neuronal information is encoded in the precise timing of action potentials sent by neurons. In realistic neuron models, the timing of an output spike depends on the timing of input synaptic currents, in a way that is classically described by the Phase Response Curve.

We have developed a new theory of time coding, that exploits dynamic response properties in order to perform computations. This theory takes advantage of the fact that the effect of synaptic currents depends on the internal state of the post-synaptic neuron. This has implications for temporal coding: an action potential that arrives on a synapse has an implicit meaning, that depends on the position of the postsynaptic neuron on the firing cycle.

We have shown that it is possible to train artificial neural networks using this principle [9]. For that, we developed biologically plausible learning rules, that are based on Spike Timing Dependent Plasticity (STDP). More precisely, we investigated how STDP can be used to achieve minimization of an error criterion, using two possible mechanisms :

- Spike prediction : Neurons learn to spike at desired times. Hence, the underlying algorithms are supervised. This work is being pursued in collaboration with Samuel McKennoch and Linda Bushnell, from the Department of Electrical Engineering of the Washington University in Seattle. (1 paper submitted).
- Phase cancellation : Neurons receive an external input (excitation) and a prediction of the input (inhibition). Synaptic efficacies are optimized so that the neurons of a population learn to spike synchronously, even though their external input taken alone would have the effect of desynchronizing them. Resynchronization is performed through inhibition; in this sense, the inhibitory cells learn to cancel the phase of excitatory cells. This results in a completely unsupervised learning algorithm. (1 paper in preparation)

6.2.2. Neural synchronization and network oscillation

Neural synchronization and network oscillation are very often observed in recorded brain activity. They seem to play an important role in the coding of sensory information by providing a *clock* or temporal frame of reference for the encoding neurons. In the hippocampus of rats for example, place cells exhibit phase-dependent firing activity relative to the EEG theta oscillation. In the olfactory system, projection neurons are phase-locked to the network oscillation.

Several experimental and modeling studies have shown that inhibitory feedback shapes oscillatory synchronization. These studies however have focused on macroscopic network properties, such as the emergence of oscillations and global synchronization, and did not consider the fact that some neurons exhibit phase-locked activity while others do not. How does the received inhibition affect the probability of individual neurons to be phase-locked to the simultaneously recorded field potential? We have developed several models to understand the role of inhibition in early olfactory systems.

Local field potentials recorded in the rat olfactory bulb exhibit oscillations with a frequency that changes from one band to another. Network models of inhibitory coupled neurons fail to explain how oscillations may be generated in different frequency bands. We have studied the effect of synchronous versus asynchronous inhibition in a simplified model of the olfactory bulb. We observed that frequency and synchronization are reduced when release is asynchronous; the standard deviation of activity bursts increases linearly, while their period increases in a sublinear way. A mathematical analysis supports these observations. Therefore, not only the time constant of the inhibition, but also its mode of release could play an important role in setting up the oscillatory frequency. The switch from gamma to beta frequencies might result from a change from asynchronous to synchronous release caused by feedback from the olfactory cortex.

GABAergic inhibition via local interneurons plays a role in enhancing spike timing precision in principal cells, since it tends to eliminate the influence of initial conditions. However, both the number and the timing of inhibitory synaptic events may be variable across repeated trials. How does this variability affect the spike timing precision in principal neurons? We have derived an analytical expression for the spike output jitter as a function of the variability of the received inhibition. This study predicts that variable inhibition is especially tolerated as the number of inhibitory cells is large and the decay time constant of the GABAergic synapse is small. Unlike fast inhibition, slow inhibition is not robust to a variability in the number of received inhibitory events. This suggests that synchronization or desynchronization depends on the relative amount of received fast and slow inhibition [23]. We conclude that fast inhibition acts in concert with slow inhibition to reformat the glomerular input into odor-specific synchronized neural assemblies.

6.2.3. Numerical simulation of spiking neurons

Two strategies have been used for the simulation of integrate-and-fire neural networks: time-stepping methods that approximate the membrane voltage of neurons on a discretized time and event-driven schemes where the timings of spikes are calculated exactly (*cf.* § 5.1). The numerical simulation of spiking neural networks requires particular attention. On the one hand, time-stepping methods are generic but they hardly reproduce accurately the short-time scale fluctuations of spiking neurons and need specific treatments to avoid the errors associated with the discontinuities of integrate-and-fire models. On the other hand, event-driven methods are exact but restricted to a limited class of models, although we have extended event driven schemes to a class of nonlinear integrate-and-fire models. We have recently proposed a new simulation scheme (voltage-stepping) that combines the advantages of the two approaches and consists of a discretization of the voltage state-space. The numerical simulation is reduced to a local event-driven method that induces an implicit activity-dependent time-stepping scheme: long time-steps are used when the neuron is slowly varying whereas small time-steps are used in periods of intense activity. Our method accurately approximates the neuronal dynamics and we show analytically that such a scheme leads to an high-order algorithm.

6.3. Data exploitation and interpretation

Participants: Frédéric Alexandre, Laurent Bougrain, Randa Kassab, Nizar Kerkeni, Jean-Charles Lamirel, Marie Tonnelier.

This research aims at adapting classical models of connectionism (*cf.* § 3.1) to extend their use to data interpretation and knowledge extraction (*cf.* § 3.2). This year, our activities concerned information analysis and interpretation and the design of numerical distributed and adaptive algorithms in interaction with biology and medical science.

6.3.1. Information analysis and interpretation

Novelty detection for adaptive filtering and one-class classification: We have implemented this year an original approach to information analysis and filtering inspired by the novelty detection theory. The approach has an analytical capacity for better understanding data's category description. It provides a new way of looking at said description in terms of precise, broad, and contradictory profile?contributing criteria. These criteria go on to estimate the relative importance that can be attached to precision and recall. The filtering threshold is then adjusted taking into account this knowledge about user's need. Experimental results on the standard Reuters-21578 collection prove that the approach clearly outperform the existing approaches, like SVM, for the one-class classification problem. It also highlights its potential usefulness in the information filtering domain, for adapting the filtering results according to the knowledge acquired about user's need.

Automatic cluster labeling and clustering summarization: This year, we have presented a new approach combining original hypertree construction techniques for multidimensional clustering results visualization with novel cluster labeling techniques based on the use of cluster contents evaluation criteria, like the F-measure on cluster properties. We have illustrated that the scope of the proposed techniques can be extended from single cluster labeling to labeling of hierarchical structures, like hypertrees. Finally, using specific evaluation criteria, we have shown the better efficiency of the proposed methods, as compared to usual labeling methods, both for single cluster labeling and for hierarchical labeling. The experimental context is a bibliographic database of 2127 PASCAL references related to the geological domain.

Clustering validation: Cluster validation is commonly used to determine the correct number of clusters in a data set. Despite the success of distance-based validity indexes, their efficacy decreases rapidly when dealing with high-dimensional data. We have introduced this year a feature-based cluster validation criterion which can cope with said situation. In contrast to distance-based methods, our criterion evaluates similarity in terms of shared relevant features between data. The overall clustering quality is evaluated by a weighted combination of within and between cluster correlation coefficients, which enables choosing an appropriate number of clusters according to the purpose of clustering. Furthermore, obtained criteria can be used to prune out unreliable clusters which have no correlated features and thus no specific description of their content. Extensive experiments on the Reuters-21578 collection are conducted to show the effectiveness of our validation criterion.

Highlighting inherent dataset structures through learning summarization: Whenever there are combined with hebbian learning, competitive neural models, like the neural gas (NG) model, can be used to highlight the basic topology that is inherent to a given dataset. However, such a method tends to generate structural redundancies. We have recently set up a multilevel link summarization method which is based on a combination of link age thresholding and link dependency analysis. The method enables to identify referent cluster or nodes of different level of generality, both to better understand the overall structure inherent to a given dataset and to identify its potential substructures, or local data distributions. The first results obtained on synthetic distribution mixtures and on known dataset structures have proven the accuracy of the proposed method.

Time comparison of clustering results: The Multi Viewpoint Data Analysis (MVDA) paradigm we have recently set up has main advantage to be usable to analyze the information issued from different kinds of data as well as from different kinds of descriptions of the same data and to be especially efficient on high dimensional and sparse data. Comparison of views has proven to be efficient for solving yet unsolved data analysis problems involving posterior hybridization between multiple results. We have recently proven that this latter mechanism can also represent a sound basis in the framework of incremental clustering for discriminating between analyses related to different time periods. For this, we have analyzed the yearly evolution of the research topics in the experimental context of a bibliographic database of 6544 PASCAL references covering 3 years of publication in the geological domain.

Semi-supervised classification: Semi-supervised classification represents a useful approach whenever the size of the dataset to be classified is too large to include only labeled data. Thus, we investigate this year the utility of Tabu Search (TS) Meta-heuristics for semi-supervised image classification tasks. The proposed heuristic solves the integer programming Transductive Support Vector Machine (MIP-TSVM) formulation. Preliminary results, with a linear kernel show that our TS implementation can effectively find optimal global solutions for TSVM with relatively large problem dimensions and is competitive, in terms of generalization performance, with Transductive SVMlight on LIBSVM benchmarks

6.3.2. Distributed algorithms for biology and medical science

Modeling of the treatment of the lexical access and comparison with EEG data: Starting from neurophysiological observations, we defined and implemented in collaboration with the speech project-team at INRIA, a representation of the semantic level in the connexionnist model TRACE by Mc Clelland in order to be able to model the effects of semantic priming during the lexical access [rapport de master d'Enrique Sidhoum]. More precisely, we were interested in some evoked potentials which represents the cognitive processes related to the understanding of a word. Indeed, some works support the assumption of a top-down interaction between the semantic level and the phonetic level starting from the existence of N200, evoked potentials known to represent a reaction at the phonetic level, and of N400 which express processes of a semantic nature. This assumption was used as a basis for implementation of the semantic priming model. We also drew up an EEG protocol with an aim of confirming our assumption. Quantity of data collected until now does not allow us to conclude on this aspect from work. However, comparable results of experiments (carried out in English language) seem to confirm neverthemless our assumption.

Dysorthography at dyslexic subjects: from cognitive processes to writing assistance: The dyslexia-dysorthography is a frequent and serious pathology. It was recognized officially in France very recently in its criterion of specificity and raise of a cognitive handicap. Current remedies are very limited in the field of writing; on the one hand because cognitive mechanisms of the dysorthography are less known than those of the dyslexia, on the other hand because axes of rehabilitation seem more centered on compensatory strategies that on the mobilization of functional cognitive processes. In collaboration with the speech project-team at INRIA we are builting a project where three objectives are distinguished: (i) The creation of a database of handwritten and typewriting including dynamics of the line acquired using a tablet PC, open to the researchers and clinicians. (ii) Analysis of these data taking into account knowledge of the complex act to read-write. (iii) The use of these data for diagnoses and therapeutic remedies and teaching.

Automatic recognition of temporal graphic elements in sleep EEG: In neurophysiology, electroencephalogram (EEG) is a major material for studies in various fields among which we can mention sleep disorders diagnosis and sleep vigilance analysis. The clinical study of this physiological signal is first based on the visual recognition of a set of specific information of two types: waves, characterized by their frequential spectrum, and graphic elements caracterized by their temporal morphology. According to our past sutidies in spatio-temporal models [24], [18], we presented an approach of automatic recognition of graphic elements of the EEG which is based to a measure of temporal similarity to prototypes of graphic elements [22]. Measurement is done using Dynamic Time Warping (DTW). The goal of this recognition is to reenforce the spectral analysis that we exploited in other works to study their influence on the performances of our system of automatic sleep scoring based on EEG.

Brain computer-interface: In collaboration with supélec Metz, we are studing how to exceed the current obstacles of brain-computer interfaces developing algorithms to allow their use in a context of home care. Indeed, the association of the specific techniques that we develop, of our experiment and of immersive rooms included in our laboratory owes us to allow to improve the utilisability of this new means of communication. More precisely, it is about to develop a whole data processing sequence able of to allow a person evolving/moving in residence to interact with various elements of its daily newspaper only with to start from electro-encéphalographiques observations allowing to detect a mental task specifically dependent on a particular order or a reaction to one visual or auditive stimulus also specific to one order. Two conditions of use will be more particularly studied: displacement and the distance.

6.4. Hardware implementations

Participant: Bernard Girau.

Three main axes appear in our study of connectionist parallelism in conjunction with reconfigurable digital hardware : new hardware-adapted frameworks of neural computation, dedicated embeddable implementations, and automatic neural synthesis on FPGAs.

Many neural implementations on FPGAs handle simplified neural computations. Furthermore, many efficient implementation methods (on ASICs, neuro-computers, etc) have to limit themselves to few well-fitted neural architectures. An upstream work is preferable: neural computation paradigms may be defined to counterbalance the main implementation problems, and the use of such paradigms naturally leads to neural models that are more tolerant of hardware constraints. In this domain, our main contribution is the definition and application of the FPNA paradigm (Field Programmable Neural Array) : this hardware-adapted framework of neural computation leads to powerful neural architectures that are easy to map onto FPGAs, by means of a simplified topology and an original data exchange scheme. This work is now mature and current studies intend to include it in the technological solutions that will be handled by our automatic neural synthesis tool (*cf.* § 5.5).

In the field of dedicated embeddable neural implementations, we use our expertise in both neural networks and FPGAs so as to propose efficient implementations of applied neural networks on FPGAs. Recent works in this axis have mainly focused on implementations of spiking neural networks for image segmentation [4]. The main principle of this work is to massively use interlaced pipelined local loops. We use a similar principle in a collaboration with the MAIA team about the FPGA implementation of distributed harmonic control for dynamic trajectory planning [17].

The third axis is the development of a generic synthesis tool to fully automatically specify, parametrize and implement neural networks on FPGAs [26]. This work has been detailed in § 5.5.

7. Other Grants and Activities

7.1. Regional initiatives

7.1.1. Collaboration with INIST

Participants: Randa Kassab, Jean-Charles Lamirel.

The goal of this collaboration is to propose neural models for the creation of easily interpretable representations issued from very big documentary databases. The main characteristic of this problem is the sparseness of the description space (large set of descriptors, but only a small number of descriptors associated to each document. We are more specifically studying pre-processing, neural clustering, visualization and novelty detection techniques that can be applied on this specific kind of data.

7.1.2. Action Incremental Classification of the CPER

Participants: Randa Kassab, Jean-Charles Lamirel.

The project represents a challenging project in the domain of data analysis. It aims at setting up new methods for highlighting emerging topics in a permanent upcoming flow of textual data. Many international scope applications are planed in such various domains as science evaluation, web analysis and technological survey. The project takes benefit of the exhaustive experience of the CORTEX team in the domains of adaptive and flexible clustering models, novelty detection, model evaluation and highly multidimensional and sparse data management.

7.1.3. Action Modeling, Simulation and Interaction of the CPER

Participants: Frédéric Alexandre, Hervé Frezza-Buet, Nicolas Rougier.

In the framework of the Contrat de Plan État Région, we are contributing to the project Modeling, Simulation and Interaction, whose goal is to study massive cellular computations in an interactive framework.

7.2. National initiatives

7.2.1. DGE Ministry grant COMAC "Optimized multitechnique control of aeronautic composite structures"

Participant: Laurent Bougrain.

The goal of this three-years project is to develop a powerful system of control on site, in production and in exploitation, of aeronautical pieces made of composite. It takes up the challenge of the precise, fast and local inspection on composite pieces of aeronautical structures new or in service by using techniques of non-destructive control more effective and faster to increase the lifespans of the structures of planes. This project requires a decision-making system including fast methods of diagnostic based on several optical technics as non-destructive control.

7.2.2. Ministry Grant Systèmes Complexes pour les Sciences Humaines et Sociales

Participant: Arnaud Tonnelier.

Our studies in theoretical neuroscience address the dynamics at the cellular and network level. In order to investigate the related cognitive functions, we are interested in modeling the psychological processes and revealing the underlying neural substrate. The fundamental question of space and time dependencies is studied using a mathematical model. In this multidisciplinary project, in collaboration with M.D. Giraudo (MCF, UMR Mouvement et Perception) and V. Kostrubiec (MCF, Adaptation percepto-motrice et Apprentissage, Toulouse), we study in the model (i) the accuracy of the reponse and (ii) the dynamical properties of the variability observed over trials.

7.2.3. Action de Recherche Coopérative RDNR

Participants: Dominique Martinez, Arnaud Tonnelier.

This project focuses on network dynamics and non-smooth systems. We investigate the dynamical properties of networks coming from the modeling of spiking neural networks. We are mainly interested in the numerical simulations from non-smooth systems viewpoint (event driven, time stepping and hybrid computation methods). The theoretical part of this project is devoted to the understanding of emergent properties of these networks (synchronization, oscillations, traveling waves). (More information on the Web Page :
http://www.inrialpes.fr/bipop/people/tonnelier/ArcRDNR.html)

7.2.4. Convention with the Museum of La Villette

Participant: Jean-Charles Lamirel.

This project deals with intelligent access to the collections of the museum, with the interest to multiply user's views on these collections and also to lead historians and administrators to discover unexpected links between the objects exposed in the collections. The central idea we apply for that goal is the coupling of two different classification methods for visualizing the collection of objects, for constructing viewpoints on these objects, for constructing object subsets with variable level of granularity, and lastly for highlighting correlation between some of the properties of the objects. This approach represents a collaboration between the Cortex team and the Orpailleur team who deals with the Galois lattice classification technique.

7.2.5. ANR project PHEROSYS

Participants: Dominique Martinez, Noelia Montejo-Cervera.

This new collaborative project in systems Biology (ANR-BBSRC SysBio) with INRA (Paris, FR) and the University of Sussex (UK) will explore olfactory coding in the insect pheromone pathway through models and experiments

7.2.6. ANR project MAPS

Participants: Frédéric Alexandre, Yann Boniface, Nicolas Rougier.

This new collaborative project with INCM (Marseille), UMR Perception and Movement (Marseille) and LIRIS (Lyon) aims at re-examining the relationship between structure and function in the brain, taking into account the topological (spatial aspects) and hodological (connectivity) constraints of the neuronal substrate. We think that those constraints are fundamental for the understanding of integrative processes, from the perception level to the motor level and the initiation of coordinated actions.

7.2.7. Project of the CNRS NeuroInformatics program

Participants: Dominique Martinez, Noelia Montejo-Cervera.

The new project "Olfactory coding" from the CNRS program "Neuroinformatics" with the CNRS UMR5020 (Lyon) will explore the role of oscillation and synchronization in olfactory coding.

7.3. European initiatives

7.3.1. NoE GOSPEL

Participants: Maxime Ambard, Dominique Martinez.

GOSPEL (General Olfaction and Sensing Projects on a European Level) is a Network of Excellence (NoE) under funding of the European Commission in the 6th framework programme.

The aim of GOSPEL is to structure the European research in the field of Artificial Olfaction with the declared goal of establishing Europe as a world leader in this field. The leadership shouldn't be limited just to the scientific understanding, as it happened many times in the past, but expand into the technological development and commercial exploitation.

More information is available at http://www.gospel-network.org.

7.3.2. FP7-ICT project NEUROCHEM

Participants: Dominique Martinez, Noelia Montejo-Cervera.

This new european project will explore biologically inspired computation for chemical sensing, in collaboration with the University of Barcelona, the royal institute of technology (Sweden), INRA (Paris), the university of Manchester, the university Pompeu Fabra (Spain), CNR-IMM (Italy) and the university of Leicester.

7.4. International cooperation

7.4.1. INRIA Associate Team BIOSENS

Participant: Dominique Martinez.

BIOSENS is a collaboration between the Cortex team at INRIA and the Smart Sensory Integrated Systems lab from the Hong Kong University of Science and Technology. The objective of BIOSENS is to develop biologically inspired sensory processing for artificial vision and olfaction.

7.4.2. Common project with Mexico

Participant: Bernard Girau.

We are working with the Computer science department of the INAOEP (national institute of astrophysics, optics and electronics of Puebla, Mexico) on massively distributed connectionist models for embedded image processing, within a Conacyt project led by M. Arias-Estrada, entitled “Hardware/Software Platform for Massive Parallel Applications using Reconfigurable Computing” (Conacyt project num. 59474).

7.4.3. Common project with Tunisia

Participants: Laurent Bougrain, Bernard Girau, Nizar Kerkeni.

We are working with the faculty of medicine in Monastir on physiological signal interpretation (EEG, EMG, EOG). Following our works about the discrimination of vigilance states and of the different stages of sleep, we now focus on embedded connectionist processings of physiological signals, through an INRIA STIC-Tunisia project (num. 07/01). This project mostly focuses on the problem of modeling the partial use of the different nested levels of neural parallelism. The main expected application is the automatic optimization of these levels of parallelism within our generic tool for neural synthesis on FPGAs (see § 5.5).

7.4.4. Joint venture INRIA-NSC Taiwan and NIEHS USA

Participant: Jean-Charles Lamirel.

The goal of the IGAP-AREX project is to propose a federating framework for the processing of the data provided by the DNA microarrays. It is based on sharing of know-how between two research teams and on the integration of existing tools and original methodologies within the framework of a new data analysis paradigm, namely that of the multi-view data analysis. The main experimentation field of the suggested approach is genomics. One of the long term goals of the IGAP-AREX project is to produce an integrated bioinformatics platform for gene function screen/annotation. Several important points will be dealt with at the time of the collaboration planned in the project, in particular that of the techniques of visualization of the results of analyses performed on complex data, via the installation of a multi-view hyperbolic visualization method. The temporal data processing will be also taken into account, through development of an original method of incremental clustering. Lastly, a parallel objective of the partners will be generating a scientific synergy in the field covered by the project, via the common organization of high level scientific workshops.

7.4.5. Joint venture with Dalian university and NISTAD institute (India)

Participant: Jean-Charles Lamirel.

The domains of application of this project are the scientometrics and the webometrics domains. It consists in setting up and supervising a new research team at the University of Technology of Dalian (DUT), China and at the National Institute of Science, Technology and Development Studies (NISTAD), India, in these domains. The collaboration includes high level teaching, research exchange and PhD student research project management. On the Cortex side, the focus is put on the use of the recent research results of the team in the domains of unsupervised clustering, knowledge extraction and hyperbolic visualization. Teaching sessions and workshops have been achieved during the year 2007 in parallel with the initiation of student research projects. This joint venture also includes a complementary collaboration with the department of Social Sciences of the Humboldt University of Berlin and with the Steunpunt Statistieken department of the Catholic University of Leuwen.

8. Dissemination

8.1. Leadership within the scientific community

- Responsible for the axis “Modeling, Interaction Simulation”, of the CPER with the Lorraine Region (F. Alexandre).
- Head of the Network Grand-Est for Cognitive Science (F. Alexandre)
- Member of the scientific committe of the Neuroinformatic CNRS program (F. Alexandre)
- Guest Editors of a special issue of the Journal of Physiology, Paris about Neurocomputing (F. Alexandre, T. Viéville).
- Board member of the international journal "Collnet Journal of Scientometrics and Information Management", Taru publications, New Delhi, Inde; Board member of the national journal "AMETIST" related to Information Science Technologies, INIST publications, Nancy (J.-C. Lamirel)
- Reviewing for journals: IEEE TNN and NCA (Neural Computing and Applications) (B. Girau); Collnet Int. J. , Neural Networks Int. J. (J.-C. Lamirel).
- Member of program committee: CAP’07, NeuroComp07 (F. Alexandre)
- Expertise for the European Commission (FP7; ICT) (F. Alexandre)
- Expertise for several programs of the ANR (F. Alexandre)

- invited talks: Coordinacion de Ciencias Computacionales, Instituto Nacional de Astrofisica, Optica y Electronica, Puebla (Mexique), 18/04/2007 (B. Girau). « Towards a Memory-Prediction Model of Speech Processing » 26-28 November 2007, Leuven, Belgium, sponsored by the European Science Foundation (ESF) and the Dutch Research Council (NWO) (N. Rougier); « Conceptual Neuroscience » 16-18 April2007, first workshop meeting from the Institute Para Limes, 2007, chaired by Professor Jean-Pierre Changeux (N. Rougier); « Computational Neurocience for Humanoïd robotics » 1st symposium « Frontiers of Science » French-Japanese organised by "Ministère des Affaires Etrangères", "Ministère de l'Education Nationale, de l'Enseignement Supérieur et de la Recherche" "Centre National de la Recherche Scientifique" (CNRS) and "Japanese Society for the Promotion of Science" (JSPS), January 2007, Shonan Village Center, Kanagawa, Japan (N. Rougier). Managerial Economics, Strategy and Innovation Workshops, Katholiek Universiteit (KU) Leuwen, Leuwen, Belgia; NISTAD Silver Jubilee Workshop on Data Gathering, Processing and Measurement of Science and Technology in the 21th Century, New Delhi, India (J.-C. Lamirel)

8.2. Teaching

- Courses given at different levels (DEA, DESS, IUT, Licence-Maîtrise) in computer science in Nancy and Strasbourg by most team members;
- Member of PhD defense committees (F. Alexandre, B. Girau, D. Martinez, J.C. Lamirel, N. Rougier, A. Tonnelier);
- Co-supervision of PhD in Tunisia and Algeria (J.-C. Lamirel, F. Alexandre).

8.3. Miscellaneous

- Coordination activity for the design of a web site for the French community in Computational Neuroscience (T. Viéville) (http://www.neurocomp.fr)

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