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Project-Team tao

Machine Learning and Optimisation

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Theme : Optimization, Learning and Statistical Methods

Activity Report

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2. Overall Objectives

2.1. Introduction

Data Mining (DM), acknowledged to be one of the main ten challenges of the 21st century[1], aims at building (partial) phenomenological models from the massive amounts of data produced in scientific labs, industrial plants, banks, hospitals or supermarkets. Machine Learning (ML) likewise aims at modeling the complex systems underlying the available data; the main difference between DM and ML disciplines is the emphasis put on the acquisition, storage and management of large-scale data.

DM and ML problems can be set as optimization problems, thus leading to two possible approaches. Note that this alternative has been characterized by H. Simon (1982) as follows. *In complex real-world situations, optimization becomes approximate optimization since the description of the real-world is radically simplified until reduced to a degree of complication that the decision maker can handle. Satisficing seeks simplification in a somewhat different direction, retaining more of the detail of the real-world situation, but settling for a satisfactory, rather than approximate-best, decision.*

The first approach is to simplify the learning problem to make it tractable by standard statistical or optimization methods. The alternative approach is to preserve as much as possible the genuine complexity of the goals (yielding "interesting" models, accounting for prior knowledge): more flexible optimization approaches are therefore required, such as those offered by Evolutionary Computation.

Symmetrically, optimization techniques are increasingly used in all scientific and technological fields, from optimum design to risk assessment. Evolutionary Computation (EC) techniques, mimicking the Darwinian paradigm of natural evolution, are stochastic population-based dynamical systems that are now widely known for their robustness and flexibility, handling complex search spaces (e.g. mixed, structured, constrained representations) and non-standard optimization goals (e.g. multi-modal, multi-objective, context-sensitive), beyond the reach of standard optimization methods.

The price to pay for such properties of robustness and flexibility is twofold. On one hand, EC is tuned, mostly by trials and errors, using quite a few parameters. On the other hand, EC generates massive amounts of intermediate solutions. It is suggested that the principled exploitation of preliminary runs and intermediate solutions, through Machine Learning and Data Mining techniques, can offer sound ways of adjusting the parameters and finding shortcuts in the trajectories in the search space of the dynamical system.

2.2. Context and overall goal of the project

The overall goals of the project are to model, to predict, to understand, and to control physical or artificial systems. The central claim is that Learning and Optimization approaches must be used, adapted and integrated in a seamless framework, in order to bridge the gap between the system under study on the one hand, and the expert's goal as to the ideal state/functionality of the system on the other hand.

[1] MIT Technological Review, fev. 2001.

Specifically, our research context involves the following assumptions:

1. The systems under study range from large-scale engineering systems to physical or chemical phenomenons, including robotics and games. Such systems, sometimes referred to as *complex systems*, can hardly be modeled based on first principles due to their size, their heterogeneity and the incomplete information aspects involved in their behavior.
2. Such systems can be observed; indeed selecting the relevant observations and providing a reasonably appropriate description thereof is part of the problem to be solved. A further assumption is that these observations are sufficient to build a reasonably accurate model of the system under study.
3. The available expertise is sufficient to assess the system state, and any modification thereof, with respect to the desired states/functionalities. The assessment function is usually not a well-behaved function (differentiable, convex, defined on a continuous domain, etc), barring the use of standard optimization approaches and making Evolutionary Computation a better suited alternative.

In this context, the objectives of TAO are threefold:

1. using Evolutionary Computation (EC) and more generally Stochastic Optimization to support Machine Learning (ML);
2. using Statistical Machine Learning to support Evolutionary Computation;
3. investigating integrated ML/EC approaches on diversified and real-world applications.

2.3. Highlights

- Best paper award for [25] in the ES-EP track at the ACM-GECCO 2010.
- Work on Evolutionary AI Planning (see Section 6.2) was accepted at ICAPS 2010 [44], and later awarded the *Silver Medal* at ACM-GECCO 2010 Humies Award (awarding best Human-Competitive results obtained by means of Evolutionary Computation).
- Several members of the team have been awarded the ChessBase Award 2009 for the biggest contribution to computer-games. This important award (which was previously given to famous works such as the solving of checkers) mentions the wins both in 19x19 Go and in 9x9 Go (see http://chessprogramming.wikispaces.com/ICGA#BestPublicationAwards for more).
- Work on emergence of global organization in a complex system, from a minimal model of local decision-making process, based on a reservoir of spiking neurons, was accepted as oral presentation at a Workshop at NIPS 2010 [59].

3. Scientific Foundations

3.1. Scientific Foundations

3.1.1. Introduction

This section describes Tao's main research directions, first presented during Tao's evaluation in November 2007. Four strategic issues had been identified at the crossroad of Machine Learning and Evolutionary Computation:

Where	What is the search space and how to search it. *Representations, Navigation Operators and Trade-offs.*
What	What is the goal and how to assess the solutions. *Optimal Decision under Uncertainty.*
How.1	How to bridge the gap between algorithms and computing architectures ? *Hardware-aware software and Autonomic Computing.*
How.2	How to bridge the gap between algorithms and users? *Crossing the chasm*

Six Special Interest Groups (SIGs) have been defined in TAO, investigating the above complementary issues from different perspectives. The comparatively small size of Tao SIGs enables in-depth and lively discussions; the fact that all TAO members belong to several SIGs, on the basis of their personal interests, enforces the strong and informal collaboration of the groups, and the fast information dissemination.

3.1.2. Representations and Properties

The choice of the solution space is known to be the crux of both Machine Learning (model selection) and Evolutionary Computation (genotypic-phenotypic mapping).

The first research theme in TAO thus concerns the definition of an adequate representation, or search space $\mathcal{H}$, together with that of adequate navigation operators. $\mathcal{H}$ and its navigation operators must enforce flexible trade-offs between expressiveness and compacity on the one hand, and stability and versatility on the other hand.

Expressiveness/compacity trade-off (static property): $\mathcal{H}$ should simultaneously include sufficiently complex solutions – i.e. good-enough solutions for the problem at hand – and offer a short description for these solutions, thus making it feasible to find them.

Stability/versatility trade-off (dynamic property): while most modifications of a given solution in $\mathcal{H}$ should only marginally modify its behavior (stability), some modifications should lead to radically different behaviors (versatility). Both properties are required for efficient optimization in complex search spaces; stability, also referred to as "strong causality principle" [132] is needed for optimization to do better than random walk; versatility potentially speeds up optimization through creating short-cuts in the search space.

This research direction is investigated in:

- the Complex System SIG (section 6.2) focusing on developmental representations for Design and sequential representations for Temporal Planning;
- the Large and Deep Networks SIG (section 6.6) considering deep or stochastic Neural Network Topologies;
- the Continuous Optimization SIG (section 6.4), concerned with adaptive representations.

3.1.3. Optimal Decision Under Uncertainty

Benefiting from the MoGo expertise, TAO investigates several extensions of the Multi-Armed Bandit (MAB) framework and the Monte-Carlo tree search. Some main issues raised by optimal decision under uncertainty are the following:

- Regret minimization and any-time behavior.
  The any-time issue is tightly related to the scalability of Optimal Decision under Uncertainty; typically, MAB was found better suited than standard Reinforcement Learning to large-scale problems as its criterion (the regret minimization) is more amenable to fast approximations.
- Dynamic environments (non stationary reward functions).
  The dynamic environment issue, first investigated in TAO through the On-line Trading of Exploration vs Exploitation Challenge[2], is relevant to e.g. on-line parameter tuning (see section 6.3).
- Use of side information / Multi-variate MAB
  The use of side information by MAB is meant to exploit prior knowledge and/or complementary information about the reward. Typically in MoGo, the end of the game can be described at different levels of precision (e.g., win/lose, difference in the number of stones); estimating the local reward estimate depending on the available side information aims at a better robustness.
- Bounded rationality.

[2] The OTEE Challenge, funded by Touch Clarity Ltd and organized by the PASCAL Network of Excellence, models the selection of news to be displayed by a Web site as a multi-armed bandit, where the user's interests are prone to sudden changes; the OTEE Challenge was won by the TAO team in 2006.

The bounded rationality issue actually regards two settings. The first one considers a number of options which is large relatively to the time horizon, meaning that only a sample of the possible actions can be considered in the imparted time. The second one deals with a finite *unknown* horizon, as is the case for the Feature Selection problem.

- Multi-objective optimization.
  Many applications actually involve antagonistic criteria; for instance autonomous robot controllers might simultaneously want to explore the robot environment, while preserving the robot integrity. The challenge raised by Multi-objective MAB is to find the "Pareto-front" policies for a moderately increased computational cost compared to the standard mono-objective approach.

This research direction is chiefly investigated by the Optimal Decision Making SIG (section 6.5), in interaction with the Complex System and the Crossing the Chasm SIGs (sections 6.2 and 6.3).

3.1.4. Hardware-Software Bridges

Historically, the apparition of parallel architectures only marginally affected the art of programing; the main focus has been on how to rewrite sequential algorithms to make them parallelism-compliant. The use of distributed architectures however calls for a radically different programming style/computational thinking, seamlessly integrating:

- computation: aggregating the local information available with any information provided by other nodes;
- communication: building abstractions of the local node state, to be transmitted to other nodes;
- assessment: modeling other nodes in order to modulate the exploitation (respectively, the abstraction) of the received (resp. emitted) information.

Message passing algorithms such as Page Rank or Affinity Propagation [127] are prototypical examples of distributed algorithms. The analysis is shifted from the static properties (termination and computational complexity) to the dynamic properties (convergence and approximation) of the algorithms, after the guiding principles of complex systems.
Symmetrically, modern computing systems are increasingly viewed as complex systems of their own, due to their ever increasing resources and computational load. The huge need of scalable administration tools, supporting grid monitoring and maintenance of the job running process, paved the way toward Autonomic Computing [129]. Autonomic Computing (AC) Systems are meant to feature self-configuring, self-healing, self-protecting and self-optimizing skills [133]. A key milestone for Autonomic Computing is to provide the system with a phenomenological model of itself (self-aware system), built from the system logs using Machine Learning and Data Mining.

This research direction is investigated in the Complex System SIG (section 6.2) and in the Autonomic Computing SIG (section 6.1).

3.1.5. Crossing the chasm

This fourth strategic priority, inspired by Moore's book [131], is motivated by the fact that many outstandingly efficient algorithms never make it out of research labs. One reason for it is the difference between editor's and programmer's view of algorithms. In the perspective of software editors, an algorithm is best viewed as a single "Go" button. The programmer's perspective is radically different: as he/she sees that various functionalities can be ented on the same algorithmic core, the number of options steadily increases (with the consequence that users usually master less than 10% of the available functionalities). Independently, the programmer gradually acquires some idea of the flexibility needed to handle different application domains; this flexibility is most usually achieved through defining parameters and tuning them. Parameter tuning thus becomes a barrier to the efficient use of new algorithms.

This research direction is chiefly investigated by the Crossing the Chasm SIG (section 6.3) and also by the Continuous Optimization SIG (section 6.4).

4. Application Domains

4.1. Application Domains

Since its creation, TAO mainstream applications regard Numerical Engineering, Autonomous Robotics, and Control and Games. Two new fields of applications, due to the arrival of Cécile Germain (Pr UPS, 2005), Philippe Caillou (MdC, 2005), Balazs Kégl (CR CNRS LAL, 2006) and Cyril Furtlehner (CR INRIA, 2007) have been considered: Autonomic Computing and Complex Systems.

Numerical Engineering still is a major source of applications. The successful OMD (Optimization Multi-Disciplinaire) RNTL/ANR project is being resumed by OMD2, started in July 2009. Collaborations with IFP and PSA automobile industry respectively led to Zyed Bouzarkouna's and Mouadh Yagoubi's PhD CIFRE. TAO leads the Work Package "Optimization" in the System@atic CSDL project, responsible for both fundamental research on surrogate models in multi-objective optimization and the setup of a software platform, that lead to Ilya Loshchilov's PhD work. A collaboration with CEA DM2S was conducted as a Digiteo project and lead to Philippe Rolet's PhD on simplified models.

Autonomous Software Robotics is rooted in our participation to the SYMBRION European IP and SyDiN-MaLaS (ANR-JST, coll. University of Kyushu). On this topic, Jean-Marc Montanier started his PhD in Sept. 2009; Vladimir Skortsov did his Post-doc from Sept. 2009 to Sept. 2010; Weijia Wang and Riad Akrour started their PhDs in Sept. 2010. See Section 6.2.

Our activity in **Control and Games** is chiefly visible through Mogo, already mentioned in the Highlights. Another application regards Brain Computer Interfaces: the Digiteo project *Digibrain* (coll. with CEA List and Neurospin), with Cedric Gouy-Pailler's postdoc from October 2009 to October 2010.

Applications related to **Autonomic Computing** became an important part of TAO activities, led by Cécile Germain and Balázs Kégl in tight collaboration with the Laboratoire de l'Accélérateur Linéaire (section 6.1). Xiangliang Zhang has defended her PhD in Julyl 2010 on *Data Streaming of the EGEE grid* [7]; Julien Perez has defend his PhD in September 2010 on *Model-free scheduling policies* [5].

Last but not least, applications related to **Social Systems** are led by Philippe Caillou and Cyril Furtlehner, respectively investigating multi-agent models for labor market, and road traffic models (ANR project TRAV-ESTI, coordinated by C. Furtlehner, started in 2009).

5. Software

5.1. MoGo

Participants: Olivier Teytaud [correspondent], Hassen Doghmen, Jean-Baptiste Hoock, Arpad Rimmel, Julien Perez.

MoGo (55000 lines of code in C++) is currently one of the best Computer-Go programs worldwide (including advanced options as multithreading and now message-passing parallel version). Only the binary code is released, with hundreds of downloads http://www.lri.fr/~gelly/MoGo_Download.htm. Many computer-go programmers discuss their experiments with MoGo on the computer-go mailing-list. MoGo has also been used in several demonstrations (invited games in Taiwan, Sciences En Fête in France, games in Clermont-Ferrand, Rennes, Toulouse, games in the US Open of Go, tournoi de Paris, Jeju's Island computer-Go competition, Taipei's invited games; we are invited for games against professional players in December 09 in Cadiz, Spain).

5.2. Covariance Matrix Adaptation Evolution Strategy

Participant: Nikolaus Hansen [correspondent].

The Covariance Matrix Adaptation Evolution Strategy (CMA-ES) is one of the most powerful continuous domain evolutionary algorithms. The CMA-ES is considered state-of-the-art in continuous domain evolutionary computation[3] and has been shown to be highly competitive on different problem classes. The algorithm is widely used in research and industry as witnessed by hundreds of published applications. We provide source code for the CMA-ES in C, Java, Matlab, Octave, Python, and Scilab including the latest variants of the algorithm.

Links: http://www.lri.fr/~hansen/cmaes_inmatlab.html

5.3. COmparing Continuous Optimizers

Participants: Nikolaus Hansen [correspondent], Raymond Ros, Anne Auger, Marc Schoenauer.

COCO (COmparing Continuous Optimizers) is a platform for systematic and sound comparisons of real-parameter global optimizers. COCO provides benchmark function testbeds (noiseless and noisy) and tools for processing and visualizing data generated by one or several optimizers. The code for processing experiments is provided in Matlab and C. The post-processing code is provided in Python. The code has been improved and used for the GECCO 2009 and 2010 workshops on “Black Box Optimization Benchmarking” (BBOB) (see Section 6.4), and will serve as a basis for the test platform in the CSDL project.

Link: http://coco.gforge.inria.fr/doku.php

5.4. OpenDP

Participant: Olivier Teytaud [correspondent].

Abstract: OpenDP is an open source code for stochastic dynamic programming [128] combining time-decomposition (as in standard dynamic programming), learning, and derivative-free optimization. Its modular design was meant to easily integrate existing source codes: OpenBeagle (with the help of Christian Gagné), EO (with the help of Damien Tessier), CoinDFO, Opt++, and many others, for optimization; the Torch library and the Weka library and some others for learning. It also includes various derandomized algorithms (for robust optimization and sampling) as well as time-pca and robotic-mapping. OpenDP has been experimented on a large set of benchmark problems (available in the environment), allowing for an extensive comparison of function-values approximators and derivative-free optimization algorithms with a small number of iterations.

The merit of the OpenDP platform is twofold. On the one hand, the use of the above well-known algorithms is new in the DP framework. On the other hand, the literature did not provide nor allow a principled and systematic comparison of algorithms on a comprehensive benchmark suite. Our thorough experimentations inspired further theoretical work about the learning criteria in dynamic environments, motivated by the shortcomings of cross-validation in this framework (e.g. the σ^2 parameter in Gaussian SVM chosen by cross-validation is usually too small in the DP context).
http://sourceforge.net/projects/opendp

New: The OpenDP platform has found a second life as it is included in the Mash project. The European Mash project includes many universities in Europe and will provide freely its source code; OpenDP is therefore far from dying.

5.5. GridObservatory

Participants: Michèle Sebag, Cécile Germain-Renaud [correspondent], Tamas Elteto, Xiangliang Zhang, Julien Perez.

The Grid Observatory software suite collects and publishes traces of EGEE grid (Enabling Grid for E-sciencE) usage. With the release and extensions of its portal, the Grid Observatory has made a database of grid usage traces available to the wider computer science community. These data are stored on the grid, and made accessible through a web portal without the need of grid credentials. More than 100 users are currently registered.

[3] H.-G. Beyer (2007). Evolution Strategies, *Scholarpedia*, page 1965.

Portal site: http://www.grid-observatory.org

6. New Results

6.1. Autonomous Computing

Participants: Cécile Germain-Renaud, Michèle Sebag, Balázs Kégl, Tamas Elteto, Xiangliang Zhang, Julien Perez, Yusik Kim, Julien Nauroy.

Autonomous Comping seeks for various self properties.

Self-configuration [19], [5] proposes a model-free resource provisioning strategy supporting both responsiveness, as provided by elastic Clouds, in the Infrastructure as a Service (IaaS) paradigm, and organized resource sharing, as provided by grids. Provisioning is modeled as a continuous action-state space, multi-objective reinforcement learning (RL) problem; simple utility functions capture the high level goals of users, administrators, and shareholders. The RL model includes an approximation of the continuous value function through an Echo State Network. Experimental validation on a real data-set from the EGEE grid shows that introducing a moderate level of elasticity is key to enable self-optimization.

Self-awareness In order for an autonomic system to continuously infer knowledge from its monitoring (the so-called MAPE-K, Monitor-Analyze-Plan-Execute-Knowledge) loop, the likely non-stationarity must be taken into account, thus a focus on the associated detection of ruptures or regime. This detection is critical to create parsimonious and exploitable models of grid workloads [63].

Self-protection In this on-line context, the detection of ruptures has to comply with real-time constraints. While a-priori parameter (here the threshold in the Page-Hinkley test) setting may be sufficient for some practical tasks [71], a more principled approach formalizes the adaptation of the parameter as an optimization problem [100], [7].

Visualization Visualization of the dynamics of the complex networks associated with e-science and applications can give insights for integrating the models developed in each of the previous studies. In collaboration with the GraphDice project of the AVIZ team (INRIA-Saclay), a visualization tool is developed [79].

6.2. Complex Systems

Participants: Jacques Bibaï, Nicolas Bredèche, Matthias Brendel, Cyril Furtlehner, Anne Auger, Philippe Caillou, Jean-Marc Montanier, Hélène Paugam-Moisy, Marc Schoenauer, Michèle Sebag, Maxim Samsonov.

Evolutionary AI Planning: Divide And Evolve (DAE) [134] is an evolutionary planning algorithm: A planning problem is sequentially sliced into hopefully simpler problems that are handled by a classical planner, and evolution optimizes the slicing. In 2010, the DESCARWIN ANR project started, and Jacques Bibaï defended his PhD [1]. Main results in 2010 include the validation of the use of the sub-optimal planner YAHSP rather than the optimal CPT [45], a thorough comparison with state-of-the-art competitors at ICAPS2010 [44], and the improved results obtained by off-line tuning of the parameters [43]. DAE was awarded the Silver Medal at ACM-GECCO Humies Awards 2010.

Distributed Autonomous Robotics: Within the Symbrion project, we are concerned with a fixed-size population of autonomous robot-agents facing unknown, possibly changing, environments.
• One of our goals is to design an embodied self-adaptation algorithm that can adapt to some implicit pressure from the environment. An initial step is to provide adaptation and increase of performance in the long run at the level of a single robotic agent [130], or a population of robotic agents. The main results obtained in 2010 include parameter analysis of the $(1+1)$-on-line for single robot self-adaptation [110] and the design of a new algorithm for on-line distributed optimization of behaviors in swarms of autonomous agents [50].

• Another issue in autonomous robotics is that of designing an implicit fitness, in order to provide the robots with intrinsic motivation and perform latent learning when no task is defined. Two approaches based on Information Theory have been proposed, implementing some *Curiosity*, i.e., incentives for the robot to explore its sensori-motor space [62].

Statistical Physics Perspective Basic tools from statistical physics (scaling, mean-field techniques and associated distributed algorithms, exactly-solvable models) and probability have been used to model and optimize complex systems, either standalone or combined with MABS approaches. Results are
• a scaling analysis of the "affinity propagation" algorithm and a related renormalization-based method able to find the true number of clusters in a dataset under some well defined conditions [17].
• In the context of the ANR TRAVESTI project we propose methods for doing a spatial and temporal analysis of traffic states on large scale networks and how this relates to the encoding of traffic patterns into belief propagation fixed points, which we use for traffic reconstruction and prediction [68].
• a work in progress concerns the design of exactly solvable models relevant to the understanding of the fundamental diagram of traffic flow in the ANR Travesti context [124], [106].
• the design of a message passing algorithm for sampling the Pareto Front of a bi-objective 3-SAT optimization problem has been set up in the STREP Gennetec context [121], [104].

Multi-agent and games • Samuel Thiriot joined the team as Post-doc in September on the InnovNation project. Its goal is to design, analyze and simulate with a multi-agent system a serious game of innovation emergence in a social network (in collaboration with ParaSchool and BlueNove).
• To understand multi-agent simulation logs, a tool to generate new simulations and automatically analyze the results and provide statistically valid test values was designed [57], [56].
• Lastly, Multi-agent systems were used to study decentralized coalition formation and restructuration protocol in a multi-objective framework. A proof of principle of the approach, delivering Pareto optimal solutions in a small-size class-scheduling problem has been proposed in collaboration with Université Lyon-1 and Université Paris Dauphine [11].

6.3. Crossing the Chasm

Participants: Alejandro Arbelaez, Anne Auger, Djalel Benbouzid, Robert Busa-Fekete, Alvaro Fialho, Nikolaus Hansen, Balázs Kégl, Marc Schoenauer, Michèle Sebag.

Adaptive Operator Selection (AOS): within the Microsoft-INRIA joint lab, Alvaro Fialho completed his PhD [2]. New algorithms based on Multi-Armed Bandits (MAB) have been proposed: The Sliding MAB has been introduced, and thoroughly compared with previous MAB-based AOS [15]; the best-performing AOS to-date removes the dependency on fitness values and leans toward comparison-based AOS [67] using as a reward the Area Under the Curve, that is popular in Machine Learning; the paradigm has also been validated in a different context, namely that of Differential Evolution for Continuous Optimization [66], [65]. A book chapter, written with our colleagues from Angers, surveys the AOS domain (though written after our latest propositions) [111].

Adaptive Constraint Programming: Previous work on Automatic Heuristic Selection [126] has been applied to the problem of Protein Structure Prediction [22]. Furthermore, a new procedure to take advantage of idle time between optimization to learn from previously tackled instances has been proposed [24].

Improved AdaBoost: We showed how to accelerate AdaBoost using MABs [54] and applied the technique for ranking [55]. This algorithm was ranked 5th in the 2010 Yahoo Ranking Challenge.

Adaptive Encoding: All work pertaining to Continuous Optimization (see following Section 6.4) and dealing with CMA-ES variants also belongs to this theme, from the derivation of new algorithms [52], [25], [76], [75], [74] to the development of new applications [119].

6.4. Continuous Optimization

Participants: Anne Auger, Dimo Brockhoff, Zyed Bouzarkouna, Nikolaus Hansen, Ilya Loshchilov, Mohamed Jebalia, Raymond Ros, Marc Schoenauer, Olivier Teytaud, Fabien Teytaud.

Distributed optimization: Within the OMD2 project we have studied the convergence rate scaling of ESs in the parallel setting as well as the optimal choice of parents and weights for recombination [78]. Application of CMA-ES parallelized for calibration of traffic simulation has been carried out [119]. A simple and effective modification of the self-adaptive evolutionary algorithm for the highly parallel case has been proposed [96]: the selection pressure is modified in a principled way to tackle the highly parallel case. Theoretical work has been achieved on the ultimate limits of the parallelization of Evolutionary Algorithms, including simple and efficient modifications of existing algorithms [97].

New algorithms: With the motivation of designing new robust local search algorithms, we have proposed to use derandomization by mirroring combined with a smart selection mechanism called sequential selection [52]. Implementation of the different mechanisms have been made within CMA-ES and benchmarked intensively showing the improvement brought by both mechanisms [31], [32], [33], [34], [35], [36], [37], [38], [39], [29], [30]. A thorough theoretical studies where we prove lower bounds and quantify convergence rates has been carried out [40], [113]. *Active CMA* has been revisited and combined with the (1+1)-ES [25] and with weighted recombination [76], [75], [74].

Benchmarking: The benchmarking platform COCO has been further developed and extensively used (see e.g. previous point). Restart variants of CMA-ES [92], [93], [91] and NEWUOA [91], [94], [95] have been benchmarked. Results from 31 algorithms in 2009 have been compared [73].

Optimization with meta-models and surrogate: A modification enhancing CMA-ES with local meta-models has been proposed in [48] and applied to the well-placement problem [49]. A new algorithm coupling CMA-ES with a surrogate computed with support vector machine has been proposed [81]. We proposed a mixture cross-entropy optimizer and used it for merit function optimization in a Gaussian-process surrogate optimization framework [41].

Multi-objective optimization: Theoretical foundations of hypervolume based search algorithms for bi-objective problems have been published in [8]. Extension to three objective problems has been carried out [28]. Surrogate for multi-objective algorithms have been proposed [82], [105], [80]. A simple but effective improvement for step-size adaptation in MO-CMA-ES has been found [99].

6.5. Optimal Decision Making

Participants: Olivier Teytaud, Philippe Rolet, Michèle Sebag, Romaric Gaudel, Cyril Furtlehner, Jean-Baptiste Hoock, Fabien Teytaud, Arpad Rimmel, Julien Perez.

- [21]: paper in Computational Intelligence Magazine around the various tools for introducing learning into Monte-Carlo Tree Search - the paper also recalls that humans are by far stronger than computers, in particular for some well known families of situations.
- [20]: survey and a few new results around computer-Go in IEEE Transactions on Computational Intelligence and Artificial Intelligence in Games.
- [90]: complexity bounds on parallel (batch) active learning. Whereas traditional active learning analysis focuses on one example generated per iteration, we here consider λ examples generated simultaneously.
- [16]: fundamental work on the convergence rates of evolutionary algorithms. Very general results, extending many published results. This work is based on the use of the branching factor techniques.
- [77]: application of bandits to genetic programming. The resulting algorithm is provably, within a given (user-defined) confidence, consistent from a regression testing point of view.

- [86]: including learning in the Monte-Carlo part of Monte-Carlo Tree Search. Whereas many works focus on learning the patterns for biasing the tree search, we learn the so-called “playout” part.
- [88]: theoretical analysis of noisy optimization. Mainly theoretical, but the bandit part can be used for real algorithms: we propose essentially (i) a derandomization of the mutations (necessary for avoiding some bad cases) (ii) a selection step in which not all individuals are ranked (iii) the use of a Bernstein race for ranking individuals. The results are mathematically proved.
- [61] collaboration with Univ. Lille and the Inria Sequel team around noisy optimization; extends the previous work and discusses the surprising fact that the best convergence rates are reached by algorithm which sample far from the optimum.
- [47]: simple and effective application of bandit algorithms with simple regret for tuning Monte-Carlo Tree Search methods. In spite of its simplicity the approach, based on Bernstein races, is efficient and improves a highly optimized algorithm.
- [69]: simple and effective application of matrix games for building stochastic opening books. The technique combines several deterministic opening books into one stochastic opening book with optimal (worst case) performance against these deterministic opening books.
- [87]: use of Rapid-Action Value Estimates in the Monte-Carlo part of Monte-Carlo Tree Search methods. Whereas Rapid-Action Value Estimates are a widely known revolution for the tree part, we here apply it the playout part.
- [98]: use of decisive and anti-decisive moves in Monte-Carlo Tree Search. We prove complexity upper bounds on the cost of this modification and get good results on the Havannah game, a classical challenge in games.
- [46]: analysis of the “plateau” in the scalability of Monte-Carlo Tree Search methods, including some examples of simple things that the human brain performs easily and that computers don’t solve. Includes the comparison of the various parallelizations of Monte-Carlo Tree Search.
- [70]: feature selection is set as a Reinformcement Learning problem, and UCT is modified to tackle unknown horizon and huge branching factor.

6.6. Large and Deep Networks

Participants: Ludovic Arnold, Pierre Allegraud, Sylvain Chevallier, Cédric Gouy-Pailler, Anthony Mouraud, Hélène Paugam-Moisy, Sébastien Rebecchi, Michèle Sebag.

Optimization of deep network architectures An unsupervised and layer-wise method, based on the criterion of reconstruction error, has been successfully applied to the selection of minimal size for efficient learning in successive hidden layers of RBM deep networks. The method holds for stacked auto-associators. The dependency between the model selection task and the training effort has been investigated [101], [26].

Simulation of large spiking neuron networks The DAMNED simulator is a “Distributed And Multi-threaded Neural Event-Driven” development framework suitable for modeling dynamic interactions between large spiking neuron networks. An hypothesis made in neuroscience on the network architecture for controlling saccadic eye movements has been tested through time, thanks to DAMNED [84].

Dynamic organization at a large network scale From a minimal model of decision-making process, based on two spiking neurons, at the node level, a macroscale organization emerges through time in a large sparse network modeling an ant colony. The model reproduces the different regimes of synchronization observed by biologists for the division of labor in real insect societies [103], [59].

Sébastien Rebecchi and Sylvain Chevallier joined the team as post-docs in September on the ASAP ANR project. Their role is to investigate on new tracks (e.g. sparse coding and compressed sensing) for improving learning in deep networks.

7. Contracts and Grants with Industry

7.1. Contracts and Grants with Industry

Contracts managed by INRIA

- **OMD2** – 2009-2012 (131 kEur).*Optimisation Multi-Disciplinaire Distribuée*, ANR *programme COSINUS* Coordinator Maryan Sidorkiewicz, RENAULT Technocentre;
  Participants: Anne Auger, Marc Schoenauer, Olivier Teytaud, Mohamed Jebalia.
- **SyDiNMaLaS** – 2009-2011 (158 kEur).*Integrating Symbolic Discovery with Numerical Machine Learning for Autonomous Swarm Control*, ANR *programme BLANC* Coordinator Michèle Sebag, CNRS;
  Participants: Marc Schoenauer, Vladimir Skvortsov.
- **TRAVESTI** – 2009-2011 (206 kEur).*Estimation du volume de Trafic par Interface Spatio-temporelle*, ANR *programme SYSCOMM 2008* Coordinator Cyril Furtlehner, INRIA;
  Participants: Anne Auger, Dimo Brockhoff, Maxim Samsonov.
- **ASAP** – 2009-2012 (178 kEur).*Apprentissage Statistique par une Architecture Profonde*, ANR *programme DEFIS 2009* Coordinator Alain Rakotomamonjy, LITIS, Université de Rouen, France;
  Participants: Sylvain Chevallier, Hélène Paugam-Moisy, Sébastien Rebecchi, Michèle Sebag.
- **IOMCA** 2010-2012 (264 kEur). Including Ontologies in Monte-Carlo Tree Search and Applications, ANR international project coordinated by O. Teytaud (Tao, INRIA).
  Participants: Adrien Couëtoux.
- **EXPLORA** 2010-2012 (289 kEur, to be shared with Inria Lille). EXPLOitation pour l'Allocation efficace de Ressources. Applications l'optimisation. ANR Project coordinated by R. Munos (INRIA Lille).
  Participants: David Auger, Olivier Teytaud.
- **DESCARWIN** 2010-2012 (201 kEur). Coordinateur P. Savéant, Thalès.
  Participants: Jacques Bibaï, Marc Schoenauer.
- **SIMINOLE** 2010–2014 (1043k, 250k for TAO). Large-scale simulation-based probabilistic inference, optimization, and discriminative learning with applications in experimental physics, ANR project, Coordinator B. Kégl (CNRS LAL).
  Participants: Balázs Kégl, Rémi Bardenet, Nikolaus Hansen, Michèle Sebag, Cécile Germain, Robert Busa-Fekete, Djalel Benbouzid
- **Thalès** – 2007-2010 (15 k Eur). *Evolutionary Temporal Planning*, side-contract to Jacques Bibaï's CIFRE Ph.D.;
  Participants: Jacques Bibaï, Marc Schoenauer.
- **IFP** – 2008-2011 (24 kEur). *Optimisation de puits non-conventionnels: type, position et trajectoire*, side-contract to Zyed Bouzarkouna's CIFRE Ph.D.;
  Participants: Anne Auger, Zyed Bouzarkouna, Marc Schoenauer.
- **PSA** – 2009-2012 (45 kEur). , side-contract to Mouadh Yagoubi's CIFRE Ph.D.;
  Participants: Marc Schoenauer, Mouadh Yagoubi.
- **DIGIBRAIN**– 2007-2011 (13 kEur). DIGITEO grant Coordinator Jean-Denis Muller CEA LIST, France
  Participants: Marc Schoenauer.
- **CSDL**– 2009-2012 (290 kEur). FUI System@tic (Région Ile de France grant). *Complex System Design Lab*

Participants: Anne Auger, Nikolaus Hansen, Ilya Loshchilov, Raymond Ros, Marc Schoenauer.

- **INNOV NATION**– 2009-2011 (69 kEur). Fonds de Compétitivité des Entreprises. *Simulation multi-agent de diffusion et d'évolution d'idées dans un réseau social dynamique (application à un serious game).*
  Participants: Philippe Caillou, Samuel Thiriot .
- **JASMIN**– 2010-2012 (205 kEur). DRIRE *programme FEDER.*
  Participants: CADLM, Intercim, TAO (Michèle Sebag) .
- **Adaptive Combinatorial Search** – 2008-2011 (110 kEur), project of the INRIA-Microsoft joint lab, co-headed with Youssef Hamadi (Microsoft Research Cambridge).
  Participants: Alejandro Arbelaez, Anne Auger, Alvaro Fialho, Nikolaus Hansen, Marc Schoenauer, Michèle Sebag.
- **SYMBRION** – 2008-2013 (420 kEur). *Symbiotic Evolutionary Robot Organisms*, European Integrated Project (IP) coordinated by University Stuttgart.
  Participants: Riad Akrour, Nicolas Bredèche, Jean-Marc Montanier, Marc Schoenauer, Michèle Sebag and Weijia Wang.
- **MASH** 2010-2012 (2309 kEur, 431 kEur for this partner). Massive sets of heuristics for Machine Learning. European project (small or medium scale focused research project) coordinated by François Fleuret (IDIAP).
  Participants: Jean-Baptiste Hoock, Nataliya Sokolovska, Olivier Teytaud

Contracts managed by CNRS or Paris-Sud University

- **PASCAL2**, Network of Excellence, 2008-2013 (34 kE in 2008, 70 kE in 2009). Coordinator John Shawe-Taylor, University of Southampton. M. Sebag is manager of the Challenge Programme.
- **EGEE-III** FP7 Infrastructure - 2008-2010 (30 kEur) Participants: Cécile Germain, Michèle Sebag, Xiangliang Zhang, Julien Perez.
- **EGI** FP7 Infrastructure - 2010-2013 (48 kEur) Participants: Cécile Germain, Michèle Sebag, Julien Nauroy
- **Grid Observatory** DIGITEO grant 2008-2010 (80 kEur). Coordinator Cécile Germain Participants: Michèle Sebag, Balázs Kégl, Tamas Elteto.
- **Grille Paris-Sud** MRM (Moyens de Recherche MutualisÃ©s) 2010-2011 (23KE). Coordinator Balázs Kégl Participants: Cécile Germain, Michèle Sebag, Xiangliang Zhang, Julien Perez,Julien Nauroy.
- **NeuroLog** RNTL 2007-2010 (30 kEur) Participants: Cécile Germain.
- **DIGIBRAIN**– 2007-2011(48 kEur). DIGITEO grant, coordinator Jean-Denis Muller CEA LIST, France
  Participants: Cédric Gouy-Pailler, Michèle Sebag.
- **MSAA - DIGITEO** – 2007-2010 (95 kEur). DIGITEO grant *Modèles Simplifiés et Apprentissages Actifs* Coordinator Michèle Sebag, CNRS
  Participants: Philippe Rolet.
- **MetaModel** – 2008-2011 (150 kEur). Advanced methodologies for modeling interdependent systems - applications in experimental physics, ANR "jeune chercheur" grant, coordinator Balázs Kégl
  Participants: Michèle Sebag, Cécile Germain, Robert Busa-Fekete

8. Other Grants and Activities

8.1. International actions

8.1.1. Organization of conferences and scientific events

- Cécile Germain-Renaud, *Computer Science session at the 5th EGEE User Forum*, Uppsala, April 2010.
- Cécile Germain-Renaud, *Monitoring the Infrastructure session at the 1st EGI Technical Forum*, Amsterdam, September 2010.
- Cécile Germain-Renaud *2nd Grids Meet Autonomic Computing Workshop (GMAC'10)*, at the 7th IEEE International Conference on Autonomic Computing. Proceedings published by ACM. Web site: http://gmac2010.lri.fr/index.php/GMAC_2010
- Anne Auger, Nikolaus Hansen, Raymond Ros *BBOB Black-Box Optimization Benchmarking* workshop at the ACM GECCO Genetic and Evolutionary Computation Conference 2010
- Marc Schoenauer, co-organization of PPSN Workshop *Self-tuning, self-configuring and self-generating search heuristics (Self* 2010)* (with G. Ochoa, Nottingham U.).

8.1.2. Management positions in scientific organizations

- ACM SIGEVO (Special Interest Group on Evolutionary Computation (was the International Society on Genetic and Evolutionary Algorithms before 2006): Marc Schoenauer, Executive Board Member since 2000.

8.2. European actions

8.2.1. Organization of conferences and scientific events

- Anne Auger, Dimo Brockhoff, Nikolaus Hansen, Olivier Teytaud, *4th workshop on "Theory of randomized search heuristics"*, March 2010;
- Anne Auger, *Dagstuhl Seminar "Theory of Evolutionary Computation"*, co-organizer, 2010;

8.2.2. Management positions in scientific organizations

- Parallel Problem Solving from Nature: Marc Schoenauer, Member of Steering Committee, (since 1998)
- Pattern Analysis, Statistical Learning and Computational Modelling NoE: Michèle Sebag, Member of Steering Committee (PASCAL 2004-2008; PASCAL2, 2008-)
- THRaSH, *Theory of Randomized Search Heuristics workshop*: Anne Auger, member of Steering Committee
- EGEE, Enabling Grids for E-SciencE : Cécile Germain-Renaud is a member of the NA4 steering committee, and head of the *Grid Observatory* cluster (2008-2010)

8.2.3. Collaborations with joint publications

- with Max Plack Institute, Algorithms and Complexity dept., one edited book [112].
- with two universities in Taiwan (Tainan and Hualien) [21] (other publications submitted) regarding Monte-Carlo Tree Search methods (O. Teytaud).
- with Dirk Arnold, Dalhousie University, Canada [25], [52]
- with the *Optimization of Adaptive Systems* group (leader Christian Igel) of the Ruhr University Bochum [99].

- with Computational Intelligence Group at Vrei Universität Amsterdam [51], [109].
- with BRL at Univ. of West England (joint publication, under final revision for publication in 2011)
- with ETH Zürich, System Optimization Group [8], [28], [27].
- with China University of Geosciences [72], [64].
- with Memorial University, St John's, Canada [85].
- with the "Boostr" company on games; one submitted paper on Upper Confidence Trees with Partial Observations (O. Teytaud).

8.3. National actions

8.3.1. Organization of conferences and scientific events

- Cécile Germain-Renaud, *Colloque Interfaces Recherche en grilles et Grilles de production* http://graal.ens-lyon.fr/~desprez/FILES/ProdRech.html, co-Chair, 2009
- Nicolas Bredèche, *Journée thématique JET*, Co-organizer, 2010 (and 2011).

8.3.2. Management positions in scientific organizations

- INRIA Saclay
  - Anne Auger, membre de la Commission de Suivi des Doctorants (2010).
  - Marc Schoenauer, président de la Commission Scientifique (2008-2010), now délégué scientifique du CRI Saclay (since Nov. 2010).
  - Michèle Sebag, membre de la Commission Actions de Développement Technologique (2009-).
  - Olivier Teytaud, représentant CUMI (2008-).
- CNRS
  - Michèle Sebag, Membre nommé du Comité Scientifique (since Oct. 2010).
- Université Paris-Sud
  - Nicolas Bredèche, membre du Conseil de Laboratoire du LRI, UMR 8623 (2004-); membre de la Commission de Spécialistes du Département d'Informatique (2003-2010).
  - Philippe Caillou, coordinateur de formation continue à l'IUT de Sceaux (2009-)
  - Cécile Germain-Renaud, membre (élue) du Conseil de l'UFR de Sciences(2007-)
  - Michèle Sebag, membre du Conseil du Laboratoire de Recherche en Informatique (2004-); membre de la Commission de Spécialistes du Département d'Informatique (2003-2008).

8.3.3. Management positions in scientific societies

- Association Française pour l'Intelligence Artificielle: Michèle Sebag, president, (2004-2010), Marc Schoenauer, member of Executive Committee.
- Association Evolution Artificielle: Marc Schoenauer, founding president and member of Executive Committee (1994-2002), now member of Advisory Committee. Anne Auger and Nicolas Bredèche, members of Executive Commitee (2008-).

8.3.4. Collaborations with joint publications

- With the AVIZ (INRIA-Saclay) team, [79].
- with L2S (Laboratoire des Signaux et Systèmes) [63].
- with LAL (Laboratoire de l'Accélérateur Linéaire) [19].

- With EADS-Astrium [107], [60].
- with LNC (Laboratoire de Neurobiologie de la Cognition), Marseille [84].
- with NeuroMathComp (INRIA Sophia) et Cortex (INRIA Nancy) [12].
- with Université d'Angers, *Metaheuristics, Optimization and Applications* group [111].
- with MOAIS (INRIA Rhone-Alpes) and the Paral team at LRI (Orsay), about parallelization of MCTS [46].
- with Univ. Lille & Sequel (Inria Lille-Nord Europe) around noisy optimization [61].
- With ISIR, UPMC (co-edition of a Springer book publication related to past Evoderob2009 workshop - to be published in 2011).

8.4. Honors

8.4.1. Prizes and Awards

- Mogo, developed by the team with collaborations in Taiwan, won the gold medal in 9x9, in 13x13 and in 19x19 Go in the TAAI computer-Go competition. Several members of the team were also given the ChessBase award (see highlights). MoGo is still the only program which won with handicap 7 against a top professional player.
- Jacques Bibaï and Marc Schoenauer, together with Pierre Savéant and Vincent Vidal: Silver Medal at the ACM-GECCO 2010 Humies Award (Human-Competitive Results using Evolutionary Computation), for their work on Satisfycing AI Planning.
- Best paper award for [25] in the ES-EP track at the ACM-GECCO 2010.

8.4.2. Keynote Addresses – International

- Nikolaus Hansen, invited talk at the PPSN Workshop *Self-tuning, self-configuring and self- generating search heuristics (Self* 2010).*
- Michèle Sebag, *22th International Conference on Tools with Artificial Intelligence* (ICTAI 2010): Self-driven rewards for an autonomous robot: An information theoretic approach.
- Michèle Sebag, *Second International Conference of Soft Computing and Pattern Recognition* (SoCPaR 2010): SpikeAnts: A Spiking Neuron Net modelling the Division of Labor in an Ant Colony.
- Michèle Sebag, *PlanLearn*, Planning to Learn Workshop at ECAI, Lisboa (August 2010).
- Olivier Teytaud, *TAAI 2010* (Taiwan): invited talk: Monte-Carlo Tree Search, applications to Computer-Go and Beyond. (November 2010)
- Olivier Teytaud, invited talk in the *National Center for High-Performance Computing*, Taiwan: Artificial Intelligence and Optimization with Parallelism. (November 2010)
- Olivier Teytaud, invited talk in the *MCTS workshop 2010 of the "AI and Games" network*, London.

8.4.3. Keynote Addresses – France

- Anne Auger, Workshop on Advanced Methods and Perspective in Nonlinear Optimization and Control, Toulouse February 2010.

9. Dissemination

9.1. Animation of the scientific community

9.1.1. Editorial boards

- ECJ, *Evolutionary Computation*, MIT Press: M. Schoenauer (Editor in Chief, 2002-2009, now Editorial Board), A. Auger (Editorial Board, elected in 2009), N. Hansen (Editorial Board, elected in 2009)
- GPEM, *Genetic Programming and Evolvable Machines*, Springer: M. Schoenauer and M. Sebag (Associate Editors, 2000-)
- MLJ, *Machine Learning Journal*, Springer: M. Sebag (Editorial Board, 2002-2008)
- ASOC, *Applied Soft Computing*, Elsevier: M. Schoenauer (Editorial Board, 2000-)
- *Natural Computing Series*, Springer Verlag: M. Schoenauer (Editorial Board)
- JoGC, *Journal of Grid Computing*, special issue EGEE applications and supporting grid technologies, 8:2, 2010: C. Germain

9.1.2. Chair in Organizing Committees

- ECML/PKDD, *European Conference on Machine Learning / Practice of Knowledge Discovery in Databases*, Europe: M. Sebag, Area Chair (2008), Program co-Chair (2010)
- KDD, *Knowledge Discovery from Databases*: M. Sebag, Area Chair (2008, 2009)
- ICML, *International Conference on Machine Learning*: M. Sebag, area Chair (2008, 2009),
- ACML, *Asian Conference on Machine Learning*: M. Sebag, area Chair (2009),
- GMAC,*Grids Meet Autonomic Computing Workshop*: C. Germain-Renaud, Chair (2009, 2010).

9.1.3. Program Committee Member (international events)

- ACM-GECCO, *Genetic and Evolutionary Computation COnference*, USA: A. Auger (2006-), N. Bredèche (2006-), N. Hansen (2003-), M. Schoenauer (1999-), M. Sebag (2009-)
- ACS (Autonomic Computational Science) Workshop in conjunction with IEEE/ACM Grid2010: C. Germain (2010)
- CCGRID IEEE/ACM (Cloud, Cluster and Grid Computing): C. Germain (2009-)
- EGEE UF, *EGEE User Forum*: C. Germain (2007-2010)
- EGI TF, *EGI Technical Forum*: C. Germain (2010)
- EvoStar, *Series of Conferences and Workshops in Evolutionary Computation*: M. Schoenauer (1998-), N. Bredèche (2006-), N. Hansen (2008-), A. Auger (2008-), M. Sebag (2009-)
- ESANN, *European Symposium on Artificial Neural Networks*: H.Paugam-Moisy (1994-)
- FOGA, *Foundations of Genetic Algorithms*: A. Auger (2004-), M. Schoenauer (1996-)
- IEEE-CEC, *Congress on Evolutionary Computation*: A. Auger (2006-), N. Hansen (2005-), M. Schoenauer (1999-), O. Teytaud (2005-)
- ICML, *International Conference on Machine Learning*: M. Schoenauer(2010)
- IJCNN, *IEEE-INNS International Joint Conference on Neural Networks*: H.Paugam-Moisy (2006-)
- ILP, *Inductive Logic Programming*: M. Sebag (2003-)
- LION (Learning and Intelligent Optimization: M. Schoenauer (2006-), O. Teytaud (2009)
- NIPS, *Neural Information Processing Systems*: M. Sebag (2008-), O. Teytaud (2009)
- NPC, *IFIP Network and Parallel Computing*: C. Germain (2007-)
- PPSN, *Parallel Problem Solving from Nature*: A. Auger (2008-), N. Hansen (2004-), M. Schoenauer (1994-), M. Sebag (1996-), O. Teytaud (2008-).
- SAB, *International Conference on Simulation of Adaptive Behavior*: N. Bredèche (2010)

9.1.4. Program Committee Member (national events)

- NeuroComp, *Conférence plénière française de Neurosciences Computationnelles*: H. Paugam-Moisy (2006-2009)
- CAp, *Conférence d'Apprentissage*: H. Paugam-Moisy (2010), M. Sebag (1999-), O. Teytaud (2005-)
- RFIA, *Reconnaissance des Formes et Intelligence Artificielle*: M. Sebag, comité éditorial (2004-)

9.1.5. Evaluation committees and invited expertise

- European Commission (FP7 projects), EU: M. Schoenauer (STREP PERPLEXUS).
- ERC Starting Grants: Marc Schoenauer.
- Research projects for Région des Pays de la Loire: Marc Schoenauer.
- Commission de sélection *Problématiques informatiques intégrant l'aléatoire* at Rennes 1 University (Professorship).

9.1.6. Other evaluation activities

- Reviewer for PhD dissertations: Cécile Germain (1), Hélène Paugam-Moisy (2), Marc Schoenauer (1); Michèle Sebag (3), Olivier Teytaud (2);
- Reviewer for Habilitation: Marc Schoenauer (1), Michèle Sebag (1);
- Member of the PhD/HDR jurys: Nicolas Bredèche (1), Cécile Germain-Renaud (1), Nikolaus Hansen (1), Hélène Paugam-Moisy (3), Marc Schoenauer (4), Michèle Sebag (4).

9.1.7. Popularisation of research results

- Mogo's successes were also reported in many newspapers, in Europe, United States and Asia (see http://www.lri.fr/~teytaud/mogo.html).
- Sciences en Fête 2010 at LRI: Olivier Teytaud (Computer Go) and Nicolas Bredèche, Jean-Marc Montanier (Learning Robots).

9.1.8. Summer schools, tutorials, invited seminars

- Anne Auger and Nikolaus Hansen, ACM GECCO Conference tutorial, Portland, USA, July 2010.
- Anne Auger, Evolution Artificielle Summer School, Advanced tutorial, Calais, June 2010.
- Marc Schoenauer, Evolution Artificielle Summer School, Introductory Tutorial, Calais, June 2010.
- Cécile Germain, panelist at ACS (Autonomic Computational Science), October 2010
- Nicolas Bredèche, Journée IA embarquée, Univ. Cergy-Pontoise, June 2010.
- Nicolas Bredèche, Seminaire LISIC, Univ. du Littoral, Calais, October 2010.
- Nicolas Bredèche, Seminaire iPAC, LORIA, Nancy, October 2010.
- Nicolas Bredèche, SMA team seminar, LIP6, June 2010.
- Nicolas Bredèche, Journée Franco-Taiwainaise de l'IA, LRI, July 2010.

9.2. Teaching

9.2.1. Defended habilitations

- Nikolaus Hansen, 19/2/2010, Université Paris-Sud, Ecole Doctorale Informatique

9.2.2. Defended doctorates

- Xiangliang Zhang, 28/07/2010, co-supervisors Michèle Sebag and Cécile Germain-Renaud

- Julien Perez, 17/9/2010, Université Paris-Sud, co-supervisors Cécile Germain-Renaud and Balázs Kégl
- Jacques Bibaï, 8/10/2010, Université Paris-Sud, co-supervisors Pierre Savéant and Marc Schoenauer
- Romaric Gaudel, 14/10/2010, Université Paris-Sud, co-supervisors Antoine Cornuèjols and Michèle Sebag
- Alvaro Fialho, 22/12/2010, Université Paris-Sud, co-supervisors Marc Schoenauer and Michèle Sebag
- Philippe Rolet, 22/10/2010, Université Paris-Sud, co-supervisors Michèle Sebag and Olivier Teytaud

9.2.3. Graduate Courses

- Master 2 Recherche (U. Paris-Sud), Statistical Machine Learning and Optimization - basic course (24 h + 24h hands-on experiments): Michèle Sebag, Pierre Allegraud, Anne Auger (with François Yvon, LIMSI).
- Master 2 Recherche (U. Paris-Sud), Advanced Machine Learning and Optimization (24 h): Michèle Sebag, Balazs Kégl, Anne Auger.
- Master 2 Recherche (U.Paris-Sud), Systèmes multi-agents : Philippe Caillou (18h).
- Master 2 Recherche (U.Paris-Sud), Robots et Agents Autonomes : Nicolas Bredèche (12h).

9.2.4. Undergraduate course

- Anne Auger: Ecole Centrale Paris, cours “Contrôle avancé” (part: Genetic Algorithms), (12h).
- Nicolas Bredèche: ”Vie Artificielle”, Université Paris-Sud, Licence 2 (50h)
- Nicolas Bredèche: ”Robotique Autonome”, Polytech 5eme année, formation continue (16h)
- Nicolas Bredèche: ”Intelligence Artificielle”, Polytech 4eme année (15h)
- Nicolas Bredèche: ”IA et Jeux Vidéos”, Polytech 5eme année (17h)

9.2.5. Other research-related teaching activities

At *Ecole Polytechnique*:

- Majeure “SEISM” (Engineering Science, Grégoire Allaire): one lesson (amphi) on Evolutionary Topological Optimum Design, Marc Schoenauer;
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