INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team tao

Thème Apprentissage et Optimisation

Saclay - Île-de-France

Theme : Optimization, Learning and Statistical Methods

Activity Report

2009

Table of contents

TAO (Thème Apprentissage et Optimisation) is a joint project inside PCRI, including researchers from INRIA and the LRI team I & A – Inférence et Apprentissage (CNRS and University of Paris Sud), located in Orsay.

1. Team

Research Scientist

Marc Schoenauer [Team co-leader, DR INRIA, HdR]
Michèle Sebag [Team co-leader, DR CNRS, HdR]
Anne Auger [CR INRIA]
Cyril Furtlehner [CR INRIA]
Nikolaus Hansen [CR INRIA since September 2009]
Yann Ollivier [CR CNRS, visitor until August 2010]
Olivier Teytaud [CR INRIA]

Faculty Member

Nicolas Bredèche [MDC Université Paris Sud, délégation INRIA from Sept. 2008, HdR]
Philippe Caillou [MDC Université Paris Sud]
Cécile Germain-Renaud [Professeur Université Paris Sud, HdR]
Hélène Paugam-Moisy [Professor, Université Lyon 2, délégation INRIA from Sept. 2008, HdR]

Technical Staff

Hassen Doghmen [Since october 2009]
Philippe Gauron [Since March 2009]
Miguel Nicolau [Until December 2009]

PhD Student

Alejandro Arbelaez [Started September 2008]
Rémi Bardenet [Started September 2009]
Jacques Bibaï [CIFRE Thalès, started September 2007]
Zyed Bouzarkouna [CIFRE IFP, started December 2008]
Pierre Delarboulas [Started October 2009]
Alexandre Devert [Defended May 2009]
Alvaro Fialho [Started September 2008]
Romaric Gaudel [Sxtarted September 2006]
Cédric Hartland [Defended November 2009]
Jean-Baptiste Hoock [Started November 2009]
Fei Jiang [TAO-ALCHEMY, defended December 2009]
Ilya Loshchilov [Started September 2009]
Jean-Marc Montanier [Started October 2009]
Julien Perez [started October 2006]
Arpad Rimmel [Defended December 2009]
Philippe Rolet [Started September 2008]
Raymond Ros [Defended December 2009]
Fabien Teytaud [Started September 2008]
Xiangliang Zhang [Started September 2006]
Mouadh Yagoubi [CIFRE PSA, started February 2009]

Post-Doctoral Fellow

Dimo Brockhoff [Since June 2009]
Luis Da Costa [Until October 2009]
Davide Fichera [Until November 2009]
Tamas Elteto [Since October 2008]
Cédric Gouy-Pailler [Since October 2008]
Joan Herisson [April-August 2009]

Mohamed Jebalia [Since October 2009]
Maxim Samsonov [Since April 2009]
Vladimir Skvortsov [Since September 2009]

Administrative Assistant

Marie-Carol Lopes [Tao/In Situ]

Other

Antoine Cornuéjols [professor INA-PG, Paris, HdR]
Balász Kégl [CR CNRS, LAL]

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 modelling 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 Optimisation 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 modelled based on first principles due to their size, their heterogeneity and the incomplete information aspects involved in their behaviour.
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 optimisation 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 Optimisation 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

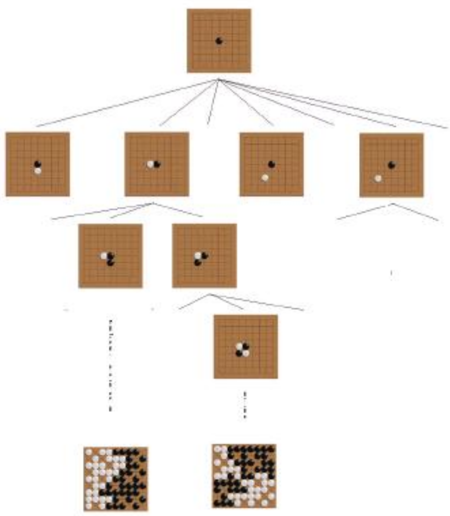

Figure 1. Tree-structured Multi-armed Bandits, the MoGo algorithm

One major breakthrough of TAO regarding optimal control in uncertain environments was illustrated by the MoGo program, first ever Computer-Go program to win a professional human player (more in section 6.5). This achievement, acknowledged to be a “notable success of AI” by *The Economist* (jan. 2007) is based on original tree-structured extensions of Multi-Armed Bandit algorithms (Fig. 1). Its parallelization was undertaken in collaboration with the Parall team and Bull; collaborations with Microsoft started in 2008, and a branch of MoGo has been developped jointly with the National University of Tainan (NUTN, Taiwan). Notably, the approach involves little specific domain knowledge; it directly tackles optimal policy learning under uncertain/incomplete information.

Recent developments of MoGo include the use of patterns (off-line learning) and the on-line exploitation of information gathered through the search, referred to as RAVE. The combined use of patterns and RAVE pioneered by TAO is now widely used in the litterature. Among the applications of the general MoGo principles are the optimization of the mathematical Spiral library (coll. CMU).

This work has been widely disseminated to the general public: IA-Go Challenge in Paris in March; Gold medal Olympiads 2008, first ever win against a pro in 9x9 Go in 2007, first ever win against a pro in 9x9 Go in 2008 without blitz, first ever win against a pro in 19x19 Go with handicap 9 in 2008. Three more world successes (still at the top of the state of the art as of Nov. 2009) have been featured by TAO in 2009, win against i) a top professional player with handicap 7 (Tainan 2009); ii) a professional player with handicap 6 (Tainan 2009); and iii) a top professional player as black in 9x9 Go[2] (Taipei 2009).

Other fundamental results regard:

- advancing the **theory of stochastic optimization**, based on the adaptation of statistical learning theory tools to evolutionary optimization. Specifically, Monte Carlo Markov Chains were used for proving the convergence of Evolution Strategies (ES) and analysing their convergence rate. Other results regard the optimization of computationally expensive functions or the use of quasi-random algorithms. The robustness of ES compared to standard, Newton-based approaches in convex settings *with high condition number* has been demonstrated experimentally.
- investigating **design-oriented representations**, enforcing stability, compacity, and versatility in the framework of EC-based applications in Numerical Engineering. Various search spaces have been considered, ranging from developmental representations to Echo State Networks. Architectural applications in collaboration with EZCT, opened promising avenues for research (exhibitions at the Beaubourg Museum of Modern Art; primed contribution to the Seroussi contest, Fig. 2).
- pioneering **ML-based Autonomic Computing**, a major field of applications for both learning and optimization. This research theme benefitted from the arrival and expertise of Cécile Germain in 2005 (Pr. UPS) and Balász Kégl in 2007 (CR1 CNRS), strengthening the link between LRI and Laboratoire de l'Accélérateur Linéaire. Within EGEE[3], a Grid Observatory (http://www.grid-observatory.org/) was launched to gather and edit traces of grid activity, supporting the behavioural modelling of the grid and ultimately aimed at its self-management.
- investigating **Automatic parameter tuning**, in the framework of the joint lab Microsoft-INRIA. This goal has been tackled through two applications, respectively on-line tuning of evolutionary parameters (best paper award LION 2009) and on-line heuristics selection in Constraint Programming.

During the year 2009, TAO has confirmed its position as a key research group in Evolutionary Computation (invited talks at 8th ISEA in June 2009, at GECCO 2009, at 3rd Workshop TRSH; Editor in Chief of MIT Press *Evolutionary Computation* journal; Best Paper Awards at LION'09 conference in January, at EvoBIO'09 in April, and in the Continuous Optimization track at ACM-GECCO in July; as well as in Machine Learning (steering committee of PASCAL and PASCAL-2 NoEs, 2003-2013; chair of ECML/PKDD 2010). It has expanded its activities to Data Mining (invited talk at IEEE Forum on DM 2008) and Complex Systems (chair of ANR SYSCOMM Evaluation Committee; invited talk at Eur. Conf. on Complex Systems 2009). TAO activities have also been recognized as a source of applicative breakthroughs (OMD RNTL; MoGo; coll. with EZCT nominated for Seroussi contest). Following earlier recommendations, TAO 's robotics activities are now supported by an active collaboration with hardware roboticists (SYMBRION IP), witnessed by the organization of two robotics events (collocated workshops at IROS and ECML/PKDD 2009).

[2] With the standard komi 7.5, 9x9 Go is more difficult for the black; this result is the first win ever in such a situation.

[3] The *Enabling Grid for E-SciencE* infrastructure project, spanning 2004-2010 (FP6 and FP7).

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 expressivity and compacity on the one hand, and stability and versatility on the other hand.

Expressivity/compacity tradeoff (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 tradeoff (dynamic property): while most modifications of a given solution in $\mathcal{H}$ should only marginally modify its behaviour (stability), some modifications should lead to radically different behaviours (versatility). Both properties are required for efficient optimization in complex search spaces; stability, also referred to as "strong causality principle"[4] 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) focussing 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.

[4] I. Rechenberg: *Evolutionstrategie: Optimierung Technisher Systeme nach Prinzipien des Biologischen Evolution*. Fromman-Hozlboog Verlag, Stuttgart, 1973.

3.1.3. Optimal Decision Under Uncertainty

Benefitting 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 behaviour.
  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 Online Trading of Exploration vs Exploitation Challenge[5], is relevant to e.g. online 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.
  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: modelling 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[6] 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.

[5]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.

[6]Frey, B., Dueck, D.: Clustering by passing messages between data points. In: Science. Volume 315. (2007) 972–976.

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[7]. Autonomic Computing (AC) Systems are meant to feature self-configuring, self-healing, self-protecting and self-optimizing skills[8]. 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[9], 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 Kgl (CR CNRS LAL, 2006) and Cyril Furtlehner (CR INRIA, 2007) have been considered: Autonomic Computing and Complex Systems.

Numerical Engineering still is a main source of applications. The successful OMD (Optimisation 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 and Mouadh Yagoubi 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. A collaboration with CEA DM2S started as a Digiteo project (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). Cedric Hartland defended his PhD [3] in November 2009 on *Robust Robotic behavior Optimization*; Nicolas Bredèche defended his HdR [1] in December 2009 on *Evolutionary Design of Embodied Agents*. In September 2009, Jean-Marc Montanier and Pierre Delarboulas started their PhD, and Vladimir Skortsov started his Post-doc on this topic.

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 starting in October 2009.

[7] J. O. Kephart and D. M. Chess, "The vision of autonomic computing," *Computer*, vol. 36, pp. 41–50, 2003.

[8] I. Rish, M. Brodie, and S. M. et al, "Adaptive diagnosis in distributed dystems," *IEEE Transactions on Neural Networks (special issue on Adaptive Learning Systems in Communication Networks)*, vol. 16, pp. 1088–1109, 2005.

[9] Moore, G.A.: Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customer. Collins Business Essentials (1991).

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 will defend her PhD in April 2010 on *Data Streaming of the EGEE grid*; Julien Perez will defend his PhD in June 2010 on *Model-free scheduling policies*.

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[10] and has been shown to be highly competitive on different problem classes. The algorithm is widely used in research and industry as witnessed by more than a hundred 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 Optimisers) is a platform for systematic and sound comparisons of real-parameter global optimisers. 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 workshop "Black Box Optimization Benchmarking" (BBOB-2009) (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. GUIDE: A graphical interface for Evolutionary Algorithms

Participants: Marc Schoenauer [correspondent], Luis Da Costa.

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

Abstract: GUIDE is a graphical user interface for easy Evolutionary Algorithm design and coding. It allows the user to describe its genome (the structure that will evolve) graphically, using containers (e.g. tuples, vectors, lists, ...) and elementary types (booleans, integers, real numbers and permutations). All representation-dependent operators (initialization, crossover and mutation) are then automatically defined with default values, built bottom-up from the elementary types, or can be specified by the user. Developing a prototype for a new search space involving complex structures has now become a matter of minutes.

GUIDE was programmed in JAVA by James Manley during the 6 months of his DESS stage in 2004. It is a follow-up of a previous tool developed in collaboration with Pierre Collet in the DREAM FP5 STREP project (http://www.dcs.napier.ac.uk/~benp/dream/dream.htm).
GUIDE has been chosen as the evolutionary basis for the EvoTest FP6 STREP project: testing a given program means feeding it with data of a specific structure. In this context, the goal of EvoTest is to automatically evolve test data, relying on an automatic code generator that only requires a description of the structure of the data to evolve – and this is precisely what GUIDE is doing.

After the complete redesign of the graphical interface in 2008, and the use of Velocity Template to generate the code, allowing a complete independence of the application w.r.t. the target library, the main advance in 2009 has been the addition of a Racing procedure for (off-line) automatic parameter tuning. GUIDE is available on the INRIA GForge as an Open Source software (http://guide.gforge.inria.fr/).

5.5. Simbad Autonomous and Evolutionary Robotics Simulator

Participant: Nicolas Bredèche [correspondent].

Abstract: Simbad is an open source Java 3D robot simulator for scientific and educational purposes (Authors: Louis Hugues and Nicolas Bredèche). Simbad embeds two stand-alone additional packages: (1) a Neural Network library (PicoNode) and (2) an Artificial Evolution Engine (PicoEvo). The Simbad package is targeted towards Autonomous Robotics and Evolutionary Robotics for research and education. The packages may be combined or used alone. In the scope of Research in Evolutionary Robotics, the Simbad package package supports fast algorithm prototyping based on a comprehensive and easy-to-extend library. Simbad controllers can be transferred to real robots through easily-written interfaces (Khepera interface is available). The open-source nature of the project combined with easy-to-understand code makes it a good choice for teaching Autonomous and Evolutionary Robotics. Simbad is used in several AI and robotics courses: IFIPS engineering school (4th and 5th year) ; Master 1 at Université Paris-Sud ; Modex at Ecole Polytechnique.
http://simbad.sourceforge.net/

5.6. Django

Participant: Michèle Sebag [correspondent].

Abstract: Django is an algorithm of theta-subsumption of Datalog clauses, written in C by Jerome Maloberti and freely available under the GNU Public License. This algorithm is an exact one, with a gain of two or three orders of magnitude in computational cost over other theta-subsumption algorithms. Django uses Constraint Satisfaction techniques such as Arc-Consistency, Forward-Checking and M.A.C. (Maintaining Arc-Consistency) and heuristics based on the First Fail Principle.

Django has been widely used and cited in the literature (coll. with the Yokohama University, Japan, U. of Tufts in Arizona, USA, U. of Bari, Italy).

http://tao.lri.fr/tiki-index.php?page=Django.

5.7. OpenDP

Participant: Olivier Teytaud [correspondent].

Abstract: OpenDP is an open source code for stochastic dynamic programming[11] 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 litterature 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

5.8. 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. 77 users are currently registered. The Grid Observatory portal is part of the more comprehensive *Grid Observatory project* presented in section 6.1.

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.

The Autonomous Computing SIG focuses on autonomic grids, identified as a promising field of TAO applications since 2006 in the context of EGEE[12]. Our implication in EGEE resulted in the *Grid Observatory* project. Supported by EGEE, DIGITEO and CNRS, concerned with digital assets curation *for* the grid, the Grid Observatory establishes long-term repositories of grid traces for current and future references, that will ultimately support the deployment of advanced management tools.

6.1.1. Grid models

A first line of research concerns the exploratory analysis (clustering) of the job queries submitted to the grid. For traceability reasons, the examplar-based Affinity Propagation (AP) approach was chosen; AP has been extended to StrAP, featuring a quasi-linear complexity and dealing with non-stationary distributions [105]. A new result concerns the self-tuning of the change detection test involved in StrAP, through the optimization of the BIC criterion [82]; this result will be extended to handle on-line process segmentation, an issue widely relevant to grid modeling since the stationarity hypothesis is clearly unrealistic. Another result concerns the large-scale assessment of StrAP on recent and extensive datasets [84].

[11] Sylvain Gelly and Olivier Teytaud. Opendp: a free reinforcement learning toolbox for discrete time control problems. In *NIPS Workshop on Machine Learning Open Source Software*, 2006.

[12] Enabling Grids for E-Science in Europe, infrastructure project (2001-2003), (2003-2007), (2008-2010).

Another line of research aims at generative and interpretable models of the grid workload. First results based on the principled use of the MDL criterion [101] establish that consistent grid workload models can be discovered from the empirical data; the model space of piecewise linear time series provides a satisfactory trade-off between accuracy and stability. Additionally, a bootstrapping strategy building more accurate models from limited samples is presented.

6.1.2. Model-Free Scheduling Policy

The huge computational needs of e-science can either be supported by grid architectures (enabling hardware and software sharing) or cloud computing (enabling dynamic resource provisioning, aka elastic computing). Large (scientific) collaborations critically depend on organized resource sharing, governing the responsiveness of the system and *in fine* its everyday use.

A model-free resource provisioning strategy supporting both above scenarii has been devised, implemented and validated by [67]. The provisioning objective is formalized as a continuous action-state space, multi-objective reinforcement learning problem, modeling the high level goals of users, administrators, and shareholders through simple utility functions.

On the e-science application side, a grid-enabled study in collaboration with INSERM U525 (*Génétique épidémiologique et moléculaire des pathologies cardiovasculaires*) has resulted in identifying the SLC22A3-LPAL2-LPA gene cluster as a strong susceptibility locus for coronary artery disease; this result has been published by Nature Genetics [20]. The collaboration is resumed using the StrAP algorithm.

6.2. Complex Systems

Participants: Jacques Bibaï, Nicolas Bredèche, Cyril Furtlehner, Anne Auger, Philippe Caillou, Alexandre Devert, Jean-Marc Montanier, Marc Schoenauer, Michèle Sebag, Maxim Samsonov.

6.2.1. Developmental Representations for Evolutionary Design

Developmental representations provide a powerful framework for the automatic design of complex structures. In this setup, referred to as artificial ontogeny, global effects are reached through local interactions of elements (or cells), with some guarantees about the scalability and robustness of the solution structures. Proofs of principle of the approach, concerning the design of bridges or multi-robot cooperation, have been given in Alexandre Devert's PhD (defended in May 2009), including the evolutionary optimization of Echo State Networks using new fitness objectives and the design of a specific stopping criterion. This stopping criterion not only yields significant computational savings; it also provides design solutions which are outstandingly robust w.r.t. environmental perturbations. A prototypical application, the design of a truss structure, features a single cell template used all over the structure, flexibly achieving different behaviours depending on the local environment, and resulting in a low-dimensional search space.

6.2.2. Self-Adaptive and Swarm Robotics

In the European Symbrion IP (2008-2012 – http://www.symbrion.eu/), TAO's role is to provide the robotic swarm with learning and evolution facilities, meeting the constraints of *in-situ* and *on-board* design. During his 3-month visit at the Vrije Universiteit, Amsterdam, Nicolas Bredèche investigated the on-board evolution of autonomous robots [40], [62]. Position papers regarding the self-organization of robotic swarms have been published [35], [57] and Jean-Marc Montanier started his PhD in Sept. 2009 on this topic. Interestingly, the Complex Systems and the Large and Deep Networks SIGs strongly interact to investigate the computational properties of e.g., Echo State Networks from different and complementary perspectives. The good properties of ESNs to achieve autonomous robotic control for non-markovian tasks, e.g. related to the Tolman maze, have been shown in Cedric Hartland's PhD, defended in Nov. 2009 [56], [88].

6.2.3. Data Mining and Information Theory for Autonomous Robotics

In collaboration with the University of Kyushu, the joint SyDiNMaLaS ANR-JST proposal concerns the principled use of the robotic logs to devise and debug a robotic controller (2008-2011). A first step along this line investigates the on-board evolutionary optimization of the controller entropy, computed from its trajectory [87] and Pierre Delarboulas started his PhD in Sept. 2009 on this topic.

TAO's involvement in Robotics has been made visible through the co-organization of workshops collocated with the mainstream robotic IROS conference [50] (in collaboration with ISIR, Paris 6) and the European conference on Machine Learning and Data Mining (in collaboration with U. of Kyushu).

A mailing list on Evolutionary Robotics ("evoderob", managed by N. Bredeche, S. Doncieux and J.B. Mouret) involve most researchers from the ER community. This activity has been widely disseminated [111], *Fête de la science*.

6.2.4. Social Systems Modelling

Multi-agent systems have been investigated to simulate, understand and optimize complex systems, and more specifically social systems. Multi-agent based simulation (MABS) provides a fast prototyping framework for modelling agent behavior, interaction rules and scenarii, while enabling the multi-scale observation of the system.

Our 2008 study regarding the French Academic Labor Market was resumed to account for the University learning behaviour [43], showing that e.g. good but not top-ranked universities learn to lower their expectations to compensate for the market saturation. Another complex, thrust-based market is the Rungis wholesale market; a thorough model thereof was proposed in collaboration with University of Coimbra and AUDENCIA school of management [42]; the thrust impact on the maximization of both the profit and the exchange volume has been highlighted and confronted to empirical observations [91].

Independently, new models of cognitive agents relying on polychronous networks and Memory Evolutive System have been proposed in collaboration with University of Sao Paolo [63]).

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 [9].

6.2.5. A 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.

Data streaming for Autonomic Computing (section 6.1) has been identified as a promising field of applications; the message passing Affinity Propagation algorithm has been extended using on-line aggregation and hierarchical processing of the data stream [82]; the scaling analysis based on a renormalization-based approach yields an almost costless way of finding the "true" number of clusters in the data [105].

Another message-passing approach has been investigated to model road traffic in the context of the ANR Travesti project, aimed at learning an approximate Markov Random Field based on generalized Bethe free energy approximations, in collaboration with the Imara INRIA project. In [13] we have obtained a surrogate solution which can efficiently encode a supperposition of patterns in the form of Belief-Propagation fixed points; this solution provably asymptotically behaves like an unsupervised Hopfield model. 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; independently, the design of a message passing algorithm for sampling the Pareto Front of a multi-objective combinatorial optimization problem has been considered in the STREP Gennetec context.

6.2.6. Sequential Representation for Temporal Planning

On-going collaboration with Thalès (Jacques Bibaï's CIFRE PhD; DESCARWIN ANR project, accepted in 2009) is concerned with formalizing, validating and improving the Divide-and-Evolve (DAE) approach to Temporal Planning. Within IPC'08 (International Planning Competition), DAE was found to fail on 50% of the problem instances, while matching or improving the best known results on the other instances [37]. Based on the analysis of those results, several improvements of DAE have been designed. Among the most promising ones are the use of heuristic bounds on the earliest possible time where an atom can become true

[86], the tuning of the (many) algorithm parameters through a racing procedure [38], and the combination with different (non-optimal) embedded planners, that seems to paradoxically improve the results a lot [39].

6.3. Crossing the Chasm

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

Many forefront techniques in both Machine Learning and Stochastic Search have been very successful in solving difficult real-world problems. However, their application to either newly encountered problems or new instances of known problems, remains a challenge for experienced researchers of the field – and even more so for scientists or engineers from other areas. No theory- or practice-based guidance is provided to make these techniques crossing the chasm[13]. The difficulties faced by the users concern the selection of some appropriate algorithm in a portfolio, or the tuning of algorithm parameters, and the lack of a robust selection methodology. Moreover, state-of-the-art approaches for real-world problems tend to represent bespoke problem-specific methods which are expensive to develop and maintain.

The "Crossing the Chasm" research theme is structured around the joint MSR-INRIA project *Automatic Parameter Tuning* in collaboration with Youssef Hamadi from Microsoft Research Cambridge (A. Fialho and A. Arbelaez' PhDs) the EvoTest STREP project, where TAO is in charge of automatic generation of the Evolutionary Engine, and the ANR Metamodel project.

A longer-term goal relevant to all abovementioned projects concerns the design of order parameters accurately reflecting the problem instances at hand. Such order parameters or meta-descriptors would enable systematic experiments, supporting the identification of the appropriate algorithms/parameters conditionally to the order parameter values, as shown in relational learning[14] or SAT[15] domains.

6.3.1. Adaptive Operator Selection

Alvaro Fialho's PhD focuses on Online Parameter Tuning, specifically on selecting the different variation operators in Evolutionary Algorithms. The proposed approach is inspired from Multi-Armed Bandit algorithms (where each operator is viewed as an arm), and it additionally involves a statistical change detection test to deal with the non-stationary context of evolution. Another contribution is based on the use of extreme values as opposed to average ones to compute the operator reward: in quite a few design contexts, rare events are acknowledged to be more consequential than average ones. This approach has been validated in 2008 on the OneMax problem, where the "ground truth" is known; new extensions in 2009 concern:

- the validation of Extreme-values based reward on the k-path and Royal Road problems [51], [52];
- the hybridation of the above ideas with the population diversity criterion, in collaboration with the Université of Angers [61];
- a sliding-window extension of the Exploration vs Exploitation scheme underlying the MAB algorithm [11].

6.3.2. Learning Heuristics Choice in Constraint Programming

Alejandro Arbelaez' PhD focuses on the Online Selection of Heuristics for Constraint Programming. The idea is to use the idle computer time to explore the search space, thus gathering new resolution paths. Each such path is labelled after its overall computational cost, and the whole set of paths (training set) is exploited by supervised learning algorithms to discriminate the best heuristics depending on the current state of the search (described after static and dynamic order parameters, e.g. domain sizes and constraint "hardness") [23].

[13] Moore, G.A.: Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customer. Collins Business Essentials (1991).

[14] M. Botta and A. Giordana and L. Saitta and M. Sebag. Relational Learning as Search in a Critical Region. Journal of Machine Learning Research, 2003, pp 431–463

[15] F.Hutter, Y.Hamadi, H.H.Hoos, and K.Leyton-Brown. Performance Prediction and Automated Tuning of Randomized and Parametric Algorithms, CP'2006.

6.3.3. Bandit-Based Boosting

The goal of this project is to apply multi-armed bandits (MABs) to accelerate AdaBoost. AdaBoost constructs a strong classifier in a stepwise fashion by selecting simple base classifiers and using their weighted "vote" to determine the final classification. We model this stepwise base classifier selection as a sequential decision problem, and optimize it with MABs. Each arm represents a subset of the base classifier set. The MAB gradually learns the "utility" of the subsets, and selects one of the subsets in each iteration. AdaBoost then searches only this subset instead of optimizing the base classifier over the whole space. We investigate the feasibility of both adversarial and stochastic bandits. Since the boosting setup is inherently adversarial, we can prove weak-to-strong learning boosting theorems only in this framework. On the other hand, stochastic bandits such as UCB and UCT are more versatile and they can exploit existing structure in the weak classifier space, and make bandit-based optimization more efficient in case of trees or products [58]. Our experiments on benchmark data sets suggests that AdaBoost can be accelerated by an order of magnitude using MABs without significant loss of performance. This computational improvement made it possible to be competitive in a large scale ML task, the KDD 2009 cup [41].

6.4. Continuous Optimization

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

Research in continuous optimization at TAO is centered on stochastic search algorithms, most often population-based and derivative-free. The stress is put on theoretical and algorithmic aspects, as well as on the comparative assessment of diverse, (stochastic and deterministic search methods. One key feature of stochastic optimization algorithms regards the online adaptation of the algorithm parameters, at the intersection of Continuous Optimization and Crossing the Chasm SIGs. The study focuses on the so-called Covariance Matrix Adaptation Evolution Strategy (CMA-ES) algorithm that adapts the covariance matrix of the Gaussian mutation of an Evolution Strategy.

6.4.1. Performance assessment

In the last decades, quite a few bio-inspired algorithms have been proposed to handle continuous optimization problems; in the meanwhile gradient-based quasi-Newton algorithms, pattern search algorithms and more recently Derivative-Free-Optimization algorithms have been proposed, with provable convergence guarantees under some (more or less) restrictive conditions. We have conducted comparisons of several bio-inspired algorithms (CMA-ES, Particle Swarm Optimization (PSO), Differential Evolution (DE)) with the deterministic derivative-free BFGS and NEWUOA algorithms [21], [32], [6], addressing the known shortcomings of the litterature (few optimizers are usually tested within a single paper; different papers commonly use different experimental settings, hampering the results comparability, and comparisons are often biased to certain types of problems, e.g. Evolutionary Algorithms (EAs) have long been tested mostly on separable problems).

For these reasons we have organized a workshop on Black Box Optimization Benchmarking (BBOB) http://coco.gforge.inria.fr/doku.php?id=bbob-2009 at the ACM Genetic and Evolutionary Computation Conference (GECCO 2009). Participants have been provided with (1) the implementation of a well-motivated noise-less [109], [102] and noisy [110], [103] benchmark function testbed, (2) the experimental set-up [107], (3) the implementation of the testbeds in Matlab and C, including generation of data output, (4) post-processing tools in Python for the presentation of the results in graphs and tables [107].

We have used the BBOB-2009 set-up for benchmarking various evolutionary algorithms [26], [25], [30], [31], [53], [54], [72], [73], [64] as well as derivative-free optimizers [55], [76], [77] and BFGS [74], [75] also in comparison to pure Monte-Carlo search [34], [33]. The analysis of the results from the workshop (about 50 benchmarking data sets) is ongoing.

6.4.2. Optimization in presence of uncertainties

Evolutionary algorithms (EAs) are known to be robust in presence of uncertainties, i.e when the objective function is noisy (for example, the function can be the result of an experiment in a lab where the outcome might fluctuate with the temperature). Robustness of EAs in terms of convergence and convergence rates have been theoretically investigated in [16]. Moreover, deficiency of formulating noisy optimization problems in terms of minimization of expectation for multiplicative noise models have been pointed out [16]. Part of this work was done in the context of the ANR/RNTL OMD project. In the context of Steffen Finck's visit (until end of 2008, in collaboration with Voralberg, Austria) we have been investigating the Simultaneous Perturbation Stochastic Approximation (SPSA) algorithm designed for optimization of noisy objective functions and the related method Evolutionary Gradient Search (EGS). A multi-start version of CMA-ES (BIPOP-CMA-ES) has been shown superior results on the BBOB-2009 noisy testbed [54]. Complexity lower and bounds have been shown in [71] for noisy optimization with variance decreasing to 0. Finally, a new algorithm for measuring and handling uncertainty in rank-based search algorithms has been proposed [15] and applied to CMA-ES for online optimization of controllers. The case of structured spaces has also been considered, with the publication of the first penalization rule provably avoiding the "bloat" effect [22].

6.4.3. Covariance Matrix Adaptation Evolution Strategy (CMA-ES)

In [19] a method for an efficient covariance matrix update is proposed. The update is quadratic in the dimension and can therefore be applied in each iteration step without changing the asymptotic time complexity of the algorithm. In Raymond Ros' PhD (defended in Dec. 2009) variants of CMA-ES with a reduced number of internal parameters (block diagonal matrices) are presented and investigated [6]. In [97] the principle design ideas of the CMA-ES algorithm and its key properties, like invariance, are explicated. In [95] an object oriented approach to the implementation of optimization algorithms is proposed and among others the implementation of CMA-ES is presented in this framework.

6.4.4. Multi-Objective optimization

Multi-objective (MO) optimization (or vector optimization) consists in optimizing simultaneously two or more conflicting objective functions. Recent MO algorithms are based on selecting a set of solutions maximizing the volume defined by this set and a given reference point called hypervolume. The spread of optimal set of points on the Pareto front and the influence of the reference point have been investigated [29], [7]. Efficient methods for computing the hypervolume while setting the decision maker preferences have been proposed [28], [27]. Based on previous work on Covariance Matrix Adaptation for MO[16], a recombination scheme for the strategy parameters in the MO-CMA-ES has been recently developed [81]. Furthermore, within the GENNETEC project, MO-CMAES was applied to the identification of the parameters of an ODE-based model for a Genetic Regulatory Network [49]. This work has obtained the Best Paper award at the EvoBIO'09 conference. A book chapter on the theory of multi-objective algorithms has been written [94]. Ilya Loschilov's PhD started in Sept. 2009 within the CSDL project, aimed at learning and exploiting a model of the Pareto front for the multi-objective optimization of expensive functions; note that this work will be immediately relevant to Mouadh Yagoubi's PhD (CIFRE PSA).

6.4.5. Complexity bounds and parallel optimization

The non-validity of the No-Free-Lunch Theorem in continuous optimization and the design of optimal continuous optimization algorithms has been investigated [8].

[12] provided a complete and general set of bounds extending the state of the art for several variants of evolutionary algorithms. This has shown in particular the large gap between complexity (upper and lower) bounds and experimental results. The case of parallel executions has been analysed, showing that most evolutionary algorithms are in fact poorly parameterized for the parallel case [79]. The convergence rate has been improved with respect to the state of the art by a factor which goes to infinity with the number of

[16] C. Igel, N. Hansen, and S. Roth. Covariance matrix adaptation for multi-objective optimization. *Evolutionary Computation*, 15(1):1–28, 2007.

processors. [80] also considered the risk of premature convergence in Estimation of Distribution Algorithms, a very important family of algorithms. A simple one-line modification is proposed, with proved asymptotic properties when the population size (often related to the number of processors) is large.

6.4.6. On the efficiency of derandomization

It is now known that the technique of quasi-random mutations, developped in 2008, can also be applied in other algorithms as well [45].

On the other hand, the team applied evolutionary algorithms for optimizing the discrepancy of a point set; this is a joint work with the Laval University at Quebec [48] that obtained the Best Paper Award in the "Real World Application" track at ACM-GECCO conference.

6.4.7. Calibration for traffic simulation and for well placement

In the context of the ANR Travesti project coordinated by Cyril Furtlehner, we are investigating the calibration of mesoscopic car traffic simulators. As simulator, we use the METROPOLIS software, an agent-based traffic simulator developed by Fabrice Marchal (formerly at Laboratoire d'Economie des Transports in Lyon). In particular, we study the influence of several parameters of the simulator such as vehicle length and origin and destination of the cars on the traffic prediction with respect to the fit with simulated data (expected to be real world dynamic data from traveling cars in the future). The optimization itself is noisy and is therefore carried out with a noise-handling version of CMA-ES (work in progress by Dimo Brockhoff in collaboration with Anne Auger and Fabrice Marchal). The problem of the placement of petrol wells to maximize the productivity of each well is investigated in the PhD thesis of Zyed Bouzarkouna (Cifre IFP). CMA-ES coupled with meta-models is used for that purpose, the objective function taking several minutes to evaluate.

6.4.8. And beyond

Beyond continuous optimization our fundamental research is well integrated into the "Theory of randomized search heuristics" dealing with theory of optimization algorithms for discrete and continuous search spaces as witnessed by the book "Theory of randomized search heuristics–Foundations and Recent Developments" [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.

This SIG is devoted to all aspects of Artificial Intelligence related to sequential settings, specifically sequential decision under uncertainty and sequential learning. World successes in computed-Go have been made visible through scientific and vulgarization papers (section 6.5.1). Other applications unrelated to the Game of Go have been realized and published (section 6.5.2).

6.5.1. Sequential Decision Under Uncertainty Applied To Games

The game of Go, a 2000 year-old Asian game most important to China, Korea, Taiwan, and Japan, proves to be much more difficult for computers than chess (note that humans cannot win any longer against computers at the game of chess, unless the machine plays with a handicap).

Among the recent progresses in this game, we designed a (grid-based computed) set of openings, using a Monte-Carlo Tree Search strategy [24]. Several learning modes (offline, online and transient learning) were combined [17]. The role of exploration has been carefully analyzed [44], showing that in many cases this role should remain very moderate (its weight in UCT-like implementations should be close to 0), except perhaps when the exploration term involves the use of patterns or other aspects than the number of simulations. The role of offline learning is key to the beginning of the learning curve (first visit to a node), while online learning governs the asymptotic regime of the process; the role of transient learning is to manage the transition between the offline and online learning regimes. This multi-level learning approach is an original contribution to the field of Go.



Figure 2. Left: The Huygens computer. Middle: games in Taiwan, handshake between Olivier Teytaud and Prof. Dong (taiwanese high-rank amateur). Right: Interactive table.

As mentioned in the highlights, MoGo and its branch MoGoTW (joint work with the national university of Tainan [59]) remain the world leading programs in computer-Go[17] and our results have been widely acknowledged[18]. The generality of the MoGo principles has been mentioned earlier on; actually, very similar techniques can be applied to other games, in particular Havannah, a game designed for challenging computers [78]. Furthermore, in collaboration with the SPIRAL team at Carnegie Mellon University (Pittsburg, USA), the same princpiles have been successfully applied to the on-line choice of the components of the SPIRAL library [47], [5]. It was shown that frugality in bandits is crucial for Monte-Carlo Tree Search applications, explaining why exploration constants are null in most strong computer-Go programs [36].

6.5.2. Other Bandit-based Applications

The MoGo ideas were applied in three more fields: active learning, “optimal” optimization and feature selection. Philippe Rolet’s PhD (Digiteo grant, coll. with CEA DM2S) formalizes active learning as a reinforcement learning problem, and proposes a one-player game approach to approximate the (intractable) optimal strategy thereof. This approach features an any-time behaviour, asymptotically delivering the optimal strategy for instance selection with respect to the expectation of the generalization error conditionally to the number of queries allowed. The convergence speed has been experimentally shown to be satisfactory [69], [89], see below.

Along similar lines, the feasability of optimal optimization has been investigated using UCT algorithms; the goal likewise is to find the optimum of a function with a minimum number of queries, minimizing the loss expectation [8], [70]. While this algorithm is computationally very expensive, it features an optimal query strategy for a given prior on the function space.

Lastly, Romaric Gaudel’s PhD (ENS grant) formalizes feature selection as a reinforcement learning problem, aimed at minimizing the expectation of the generalization error; the optimal (intractable) strategy is approximated again using an extended version of UCT, dealing with a finite *unknown* number of options [92].

Interestingly, all above approaches combine the same ingredients beyond the MoGo expertise:

- Each problem is formalized as a Partially Observable Markov Decision Process (POMDP), where the optimal strategy is the solution of an (intractable) reinforcement learning problem;
- An any-time approximation of this strategy is obtained using UCT, using diverse extensions in order to deal with continuous spaces and a finite *unknown* horizon;
- The Monte-Carlo search within UCT relies on billiard algorithms, generating conditional distributions depending on the priors, with good scalability with respect to the dimension of the search space.

[17] First and only win as black in 9x9 Go against a top professional player; first and only win with H7 against a top professional player; first and only win with H6 against a professional player.

[18] The communications of the ACM, vol. 51, Nb. 10, (10/08), page 13, published the first ever won against a professional player in 19x19, as well as several newspapers http://www.lri.fr/~teytaud/mogo.html.

6.6. Large and Deep Networks

Participants: Hélène Paugam-Moisy, Nicolas Bredèche, Alexandre Devert, Fei Jiang, Cédric Hartland, Miguel Nicolau, Marc Schoenauer, Michèle Sebag.

The Large and Deep Networks (formerly, Reservoir Computing) SIG focuses on stochastic or hierarchical network structures, aimed at generative and/or discriminant modelling.

This research theme, initially included in the Complex Systems SIG, has been boosted by Hlne Paugam-Moisy's arrival at TAO (Pr. Université Lyon-2, dlgation INRIA), the collaboration with INRIA Alchemy (Fei Jiang's PhD) and the GENNETEC Strep project.

6.6.1. Echo State Networks (ESN) and Deep Networks (DN)

ESNs are stochastically specified from the number n of nodes, the density of their connexions, and the highest eigenvalue of the connexion matrix. Beyond these 3 hyper-parameters, an ESN instance is described from its output weights, thus with complexity $\mathcal{O}(n)$. Their excellent expressivity w.r.t. the space of dynamic systems is combined with a frugal search space.

Fei Jiang's PhD (defended in December 2009; coll. Alchemy and TAO) examines the relationships between the structure of the network and its computational properties [4]. He pioneered the Evolutionary Reinforcement Learning of the ESN output weights, using CMA-ES; other results show that evolutionary optimization can be applied to optimize the sparseness of the network while preserving its performance.

Alexandre Devert's PhD (defended in May 2009, already mentioned in the Complex Systems SIG) used ESNs as basic controllers for developmental representations (Continuous Cellular Automata).

Cdric Hartland's PhD (defended in Nov. 2009, already mentioned in the Complex Systems SIG) used ESNs as robotic controllers, investigating their memory capacities [56], [88], [3].

Deep Networks, aimed at the unsupervised and iterative learning of hierarchical structures, are investigated by Ludovic Arnold (PhD starting in Dec. 2009, coll. LIMSI), with preliminary results regarding the generalization behaviour [85].

6.6.2. Genetic Regulatory Network models

Genetic Regulatory Networks (GRNs) have been initially proposed by W. Banzhaf[19] as generative models for networks complying with statistical requirements. TAO has been investigating the evolutionary optimization of GRNs within the GENNETEC Strep,

This work was consolidated in 2009, showing that GRNs are far more evolvable than randomly-generated networks when it comes to generate small-world [66] or scale-free [18] networks. Further work within GENNETEC aims at bridging the gap between the GRN model and the semantic of Genetic Programming. In collaboration with W. Banzhaf, Memorial University of Newfoundland (Canada), preliminary results in Evolutionary Reinforcement Learning using GRNs as computational units have been obtained ([65], to appear).

7. Contracts and Grants with Industry

7.1. Contracts and Grants with Industry

Contracts managed by INRIA

- **OMD-RNTL** – 2005-2009 (71 kEur). *Optimisation Multi-Disciplinaire*, Coordinator Rodolphe Leriche, Ecole des Mines de St Etienne;

[19] W. Banzhaf, Artificial Regulatory Networks and Genetic Programming, in R. Riolo, Ed., *Genetic Programming Theory and Practice 2003*, pp 43–62, Kluwer

Participants: Anne Auger, Nikolaus Hansen, Olivier Teytaud and Marc Schoenauer.

- **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: Hélène Paugam-Moisy, Michèle Sebag.
- **EvoTest** – 2006-2009 (231 kEur). *Evolutionary Testing*, European *Specific Targeted Research Project* from FP6. Coordinator Tanja E.J. Vos, Instituto Tecnolgico de Informtica, Spain;
  Participants: Luis Da Costa, Marc Schoenauer.
- **GENNETEC** – 2006-2009 (379 kEur). *GENetic NETworks: Emergence and Complexity*, European *Specific Targeted Research Project* from FP6. Coordinator Franois Képs, Génople and CNRS, France;
  Participants: Cyril Furtlehner, Miguel Nicolau, Marc Schoenauer.
- **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.
- **France Télécom** – 2008-2009 (37 kEur). *Etude Multi Relational (ou Table) Data Mining (MTDM=MRDM*, Contrat de Recherche Externalisée
  Participants: Michèle Sebag, Marc Schoenauer.
- **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.
- **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: Nicolas Bredèche, Pierre Delarboulas, Jean-Marc Montanier, Marc Schoenauer, Michèle Sebag.

Contracts managed by INRIA starting in 2010

- **IOMCA** 2010-2012 (264 kEur). Including Ontologies in Monte-Carlo Tree Search and Applications, ANR international project coordinated by O. Teytaud (Tao, INRIA).

Participants: Arpad Rimmel.

- **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, Olivier Teytaud
- **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: Olivier Teytaud
- **DESCARWIN** 2010-2012 (201 kEur). Coordinateur P. Savéant, Thalès.
  Participants: Jacques Bibaï, Marc Schoenauer.

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)
- **Grid Observatory** DIGITEO grant 2008-2009 (80 kEur) Participants: Cécile Germain, Michèle Sebag, Balázs Kégl, Tamas Elteto.
- **Observatoire de la Grille** CNRS grant - Projets Exploratoires Pluridisciplinaires(PEPS) 2008-2009 (7 kEur) Participants: Cécile Germain, Michèle Sebag, Balázs Kégl.
- **NeuroLog** RNTL 2007-2009 (10 kEur) Participants: Cécile Germain.
- **DEMAIN** PPF (Interdisciplinary program) of the Ministry of Research 2006-2009 (10KE) Participants: Cécile Germain (coordinator), Michèle Sebag, Xiangliang Zhang, Julien Perez.
- **DIGIBRAIN**– 2007-2011(48 kEur). DIGITEO grant, coordinator Jean-Denis Muller CEA LIST, France
  Participants: Cédric Gouy-Pailler, Michèle Sebag.
- **IST Japon** CNRS grant– 2007-2009 (94 kEur). Coordinator: Nicolas Spyratos (LRI) and Michèle Sebag
  Participant: Michèle Sebag, Cyril Furtlehner.
- **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, *Grid Observatory session at EGEE'09* , 2009
- Cécile Germain-Renaud *Grids Meet Autonomic Computing Workshop (GMAC'09)*, at the 6th IEEE International Conference on Autonomic Computing. Proceedings published by ACM. Web site: http://www.frombarcelona.org/GRIDmeetsAC/
- Anne Auger, Nikolaus Hansen, Raymond Ros, Marc Schoenauer, *BBOB Black-Box Optimization Benchmarking* workshop at the ACM GECCO Genetic and Evolutionary Computation Conference 2009
- Nicolas Bredeche, *IROS workshop on exploring new horizons in Evolutionary Design of Robots*, co-organizer, 2009. web site: http://www.isir.fr/evoderob

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;
- Michèle Sebag, *Large Scale Learning Challenge Workshop, Helsinki*, co-Chair, 2008;
- Michèle Sebag, *2nd Pascal Challenge Workshop, Venice*, Chair, 2006.

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

- Laval University at Quebec: [48] optimizes low-discrepancy sequences using Evolutionary Algorithms.
- CISUC, University of Coimbra, Portugal. Multi-agent systems for Social Modelling [42], [91] (Section 6.2).
- CS Department, University of Sao Paolo, Brazil. Multi-agent systems for Social Modelling [63] (Section 6.2).

- Maastricht University, Dept. of Knowledge Engineering [44]: computer Go (Section 6.5.1).
- SPIRAL team, Carnegie Mellon University, Pittsburg: applications of UCT to the spiral library [47] (Section 6.5.2).
- National University of Tainan (NUTN, Taiwan): computer Go [17] (Section 6.5.1).
- IST Lisboa, within GENNETEC project: 1 month visit of Daniele Muraro at TAO, working on multi-objective system identification for a GRN model (see section 6.4.4) [49].
- ETH Zürich, Switzerland, SOP group headed by Eckart Zitzler [29], [7], [28], [27].
- Vrije Universiteit Amsterdam[40]: self-adaptive autonomous robot.

8.3. National actions

8.3.1. Organization of conferences and scientific events

- Michèle Sebag, *4th Franco-Japanese Workshop, Paris*, co-Chair, 2008.
- Michèle Sebag, *Apprenteo, Machine Learning Group in Digiteo*, Chair, 2006.
- Michel`e Sebag, *Apprentissage: la carte, le territoire et l'horizon*, Chair, 2008
- 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 Bredeche, *Journée thématique JET*, Co-organizer, 2009.

8.3.2. Management positions in scientific organizations

- INRIA Saclay
  - Marc Schoenauer, président de la Commission Scientifique (2008-).
  - Olivier Teytaud, représentant CUMI (2008-).
- Université Paris-Sud
  - Nicolas Bredèche, membre du Conseil du Laboratoire de Recherche en Informatique (2004-); membre de la Commission de Spécialistes du Département d'Informatique (2003-2009).
  - Philippe Caillou, coordinateur de formation continue Ã l'IUT de Sceaux (2009-)
  - Cécile Germain-Renaud, membre (lue) 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).
  - Olivier Teytaud, représentant des B pour le comité d'évaluation du LRI.
- Exercice national de prospective sur les grilles de production
  - Cécile Germain-Renaud, présidente du groupe thématique *Sciences de l'ingénieur et informatique*. Whitepaper: http://www.idgrilles.fr/IMG/pdf/livreBlancecran.pdf

8.3.3. Management positions in scientific societies

- Association Française pour l'Intelligence Artificielle: Michèle Sebag, president, (2004-), 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 Bredeche, members of Executive Commitee (2008-2010).

8.3.4. Collaborations with joint publications

- U. Paris-Sud, LAL (Balázs Kégl, Autonomic Computing; C. Loomis, Grid Computing) [67]
- INSERM U.525 (François Cambien, David Tregouet) on cardiovascular diseases [20].
- GIL, AUDENCIA School of Management, Nantes (Corentin Curchod). Multi-agent systems for Social Modelling [42], [91] (Section 6.2).
- LIESC, University Lyon 1 (Samir Aknine) and LAMSADE, University Paris Dauphine (Suzanne Pinson). Multi-agent systems for optimization [9] (Section 6.2).
- Synthesis of the ACI Masses de Donnes AGIR [96].
- Université d'Angers, Frédéric Saubion and Jorge Maturana, using their idea of diversity-based reward together with the Multi-Armed Bandit based Operator Selection Mechanism [61].
- ISIR, Université Paris 6, with Stephane Doncieux and Jean-Baptiste Mouret [50] on a review paper on challenges in evolutionary design of robots.

8.4. Honors

8.4.1. Prizes and Awards

- Mogo, developed by the team with collaborations in Amsterdam and Taiwan, has been in the past the first ever Go program to win a human professional player in even game (9x9 Go, 5th Dan pro, Amsterdam 2007); a human professional player in non-blitz even game (9x9 Go, 5th Dan pro, Paris 2008); a human professional player in 19x19 Go, handicap 9 (US Open, Portland, 2008). With the first (and only) win as black in 9x9 Go against a top professional player (in Taipei, 2009), the first (and only) win with H7 against a top professional player (in Tainan 2009), and the first (and only) win with H6 against a pro (in Tainan, 2009), MoGo and its branch MoGoTW (joint work with the national university of Tainan [59]) are still the top program in Computer Go.
- Alvaro Fialho and co-authors won the Best Paper Award at LION'09 conference in January 2009 [51].
- Miguel Nicolau, Marc Schoenauer, and their co-authors from the GENNETEC project won the Best Paper Award at the EvoBIO'09 conference in April 2009 [49].
- Olivier Teytaud won with his canadian collaborators the best paper award for track "Real World Application" [48] in Gecco 2009.

8.4.2. Keynote Addresses – International

- Marc Schoenauer, Experimental Comparisons of Derivative Free Optimization Algorithms. SEA, 8^{th} International Symposium on Experimental Algorithms, June 3-6, 2009, Dortmund, Germany.
- Michèle Sebag:
  - *COE Program for Next Generation Information Technology*, Sapporo, 22/01/09, *Toward Autonomic Computational Systems*
  - *ECCS'09*, Warwick, 22/09/2009, *Self Organization and Learning in Cellular Robotics*
  - *NIPS 2009*, Vancouver, 7/12/09, *Pro-Active Challenges*

8.4.3. Keynote Addresses – France

- Marc Schoenauer, *ArchiLab*, Orléans, 19/11/2009 *Les algorithmes évolutionnaires, outils de créativité artificielle ?*

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-), 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)

9.1.2. Chair in Organizing Committees

- LEMIR, *Learning and Mining in Robotics*, Bled: M. Sebagm co-Chair (2009)
-
- ECML/PKDD, *European Conference on Machine Learning / Practice of Knowledge Discovery in Databases*, Europe: M. Sebag, Area Chair (2008)
- 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*, Barcelona: C. Germain-Renaud, Chair.

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)
- EGEE UF, *EGEE User Forum*: C. Germain (2007-)
- EvoStar, *Series of Conferences and Workshops in Evolutionary Computation*: M. Schoenauer (1998-), N. Bredèche (2006-), N. Hansen (2008-), A. Auger (2008-), M. Sebag (2009)
- FOGA, *Foundations of Genetic Algorithms*: A. Auger (2004-), M. Schoenauer (1996-)
- IAMA, *International Conference on Intelligent Agent and Multi-Agent Systems*: P. Caillou (2009-)
- IEEE-CEC, *Congress on Evolutionary Computation*: A. Auger (2006-), N. Hansen (2005-), M. Schoenauer (1999-), M. Sebag (2009), O. Teytaud (2005-)
- ILP, *Inductive Logic Programming*: M. Sebag (2003-)
- ICML, *International Conference on Machine Learning*: O. Teytaud (2009)
- LION (Learning and Intelligent Optimization: M. Schoenauer (2006-), O. Teytaud (2009)
- NIPS, *Neural Information Processing Systems*: M. Sebag (2008-2009), O. Teytaud (2009)
- NPC, *IFIP Network and Parallel Computing*: C. Germain (2007-)

9.1.4. Program Committee Member (national events)

- EA, *Evolution Artificielle* (national conference with international Program Commitee and international audience): A. Auger (2005-), N. Bredèche (2005-), N. Hansen (2007-), M. Nicolau (2009), M. Schoenauer (1994-), M. Sebag (1994-), O. Teytaud (2005-)
- CAp, *Conférence d'Apprentissage*: M. Sebag (1999-), O. Teytaud (2005-)
- RFIA, *Reconnaissance des Formes et Intelligence Artificielle*: M. Sebag, comité éditorial (2004-)
- SFC, *Société Francaise de Classification*: M. Sebag (2009).

9.1.5. Evaluation committees and invited expertise

- European Commission (FP7 projects), EU: M. Schoenauer (STREP PERPLEXUS).

- Irish Science Foundation: Marc Schoenauer, External expert for a 4 years project.
- Swiss Science Fund: Marc Schoenauer.
- ANR SYSCOMM (Complex Systems and Mathematical Modeling): Marc Schoenauer, Président du Comité d'Évaluation.
- AERES: Michèle Sebag, chair of the evaluation committee of UBIA, INRA, Toulouse.

9.1.6. Other evaluation activities

- Reviewer for PhD dissertations: Marc Schoenauer (3, including Adelaide Univ., Australia); Michèle Sebag (3);
- Reviewer for Habilitation: Marc Schoenauer (1, Bochum, Germany), Michèle Sebag (1);
- Member of the PhD jurys:
  - Marc Schoenauer (1),
  - Michèle Sebag (1),
  - Olivier Teytaud (1: Emmanuel Rachelson, 2009)
- Member of the jury for INRIA researcher hiring (2008-2009): Michèle Sebag;
- Reviewer for the programme "Equipes associées INRIA": Anne Auger
- ANR DEFIS: Nicolas Bredeche, reviewer.

9.1.7. Popularisation of research results

- The collection of Chairs, designed within a collaboration between TAO and with the architect consortium ECZT, were exhibited form April 2007 until April 2009 in the permanent Design Collection of Beaubourg, the French National Modern Art Museum (http://www.inria.fr/saclay/resources/computer-culture/a-rt-lgorithm-design-informed-by-mathematics).
- MoGo (computer-go tool) was exhibited
  - Taiwan invited games.
  - Jeju's computer Go event (Korea, 2009).
  - Events in France: Rennes, Toulouse (2009).
  - Cadiz Go tournament, 2009.
  - Taipei's computer Go event, 2009.
  - Alternative party in Finland, 2009.
- Mogo's successes also reported in many newspapers, in Europe, United States and Asia (see http://www.lri.fr/~teytaud/mogo.html).
- Sciences en Fête 2009: Olivier Teytaud in the Lri (Computer Go) and Nicolas Bredeche, Jean-Marc Montanier, Pierre Delarboulas (Learning Robots).
- Popularization around artificial intelligence in 3 schools, Olivier Teytaud (see http://www.lri.fr/~teytaud/sef.pdf).

9.1.8. Summer schools, tutorials, invited seminars

- Anne Auger and Nikolaus Hansen, ACM GECCO Conference tutorial, Montreal, Canada, July 2009.
- Anne Auger and Nikolaus Hansen, TRSH Theory of Randomized Search Heuristics workshop tutorial, Birmingham, UK, October 2009.
- Philippe Caillou, invited talk at ICAS 09 (workshop on Activity in Simulations), Cargese, 2009.

- Anne Auger, JET Summer School, Tutorial, Porquerolles, 2009.
- Nicolas Bredeche, VU Amsterdam, seminar, February 2009.
- Nikolaus Hansen, INRIA Paris-Rocquencourt, Seminar Constraints, November 2009.
- Nikolaus Hansen, Université Paris 6, Seminar Laboratoire d'Analyse Numerique, April 2009.
- Arpad Rimmel, Bandit-based optimization on graphs with application to library performance tuning. Ecole des Mines de Paris, SMILE seminar
- Philippe Rolet, institut Henri Poincaré, "Upper Confidence Trees and Billiards for Optimal Active Learning". SMILE seminar.
- Marc Schoenauer, "Automatic Parameter Tuning", invited tutorial at First ACM Genetic and Evolutionary Summit, Shanghai, June 2009.
- Marc Schoenauer, "Bandit-based Method for Adaptive Operator Selection", Bristol Institute of Technology, University of the West of England, December 2009.
- Marc Schoenauer, École Nationale d'Architecture, Malaquais, Paris, mai 2009, *Les algorithmes évolutionnaires, outils de créativité artificielle ?*
- Michèle Sebag, U. Kyushu, Japan, Avril 2009, *Data Streaming based on Affinity Propagation, Application to Autonomic Computing*.
- Olivier Teytaud, Journées "Algorithmes stochastiques", Dijon 2009 http://math.u-bourgogne.fr/algostoc09/: Fouille Monte-Carlo d'Arbres.
- Olivier Teytaud, Systems and Modeling Research Unit, Leuven University: Monte-Carlo Tree Search for Planing: the Game of Go and beyond.
- Olivier Teytaud, LAIC, Clermont-Ferrand: complexity and parallel complexity with oracles http://www.lri.fr/~teytaud/clermont2009_6.pdf
- Olivier Teytaud, Inria Rocquencourt, "Le modèle et l'algorithme": prise de décision séquentielle dans l'incertain. Application au jeu de Go. Video: http://extranet.paris-rocquencourt.inria.fr/rendez-vous/modele-et-algo/prise-de-decision-sequentielle-dans-l-incertain-application-au-jeu-de-go
- Olivier Teytaud, invited talk (university of Cadiz), December 2009.
- Olivier Teytaud, AHL's research department, Man Group plc, London; invited talk. December 2009. Duplex with delay to the Honk-Kong office of Man Group plc.
- Olivier Teytaud, invited talk at IEEE Fuzz special session for computer-Go, Korea 2009.
- Olivier Teytaud, invited talk at Smai 09 (mini-symposium "Recherche opérationnelle : théorie et application"). http://smai.emath.fr/smai2009/programme_detaille.php

9.2. Enseignement

9.2.1. Defended habilitations

- Nicolas Bredèche, 7/12/2009, Université Paris-Sud.

9.2.2. Defended doctorates

- Alexandre Devert, 21/05/09, Université Paris-Sud, co-supervisors Nicolas Bredèche and Marc Schoenauer.
- Cedric Hartland, 16/11/2009, Universié Paris-Sud, co-supervisors Nicolas Bredèche and Michèle Sebag.
- Fei Jiang, 16/12/09, Université Paris-Sud, co-supervisors Hugues Berry (INRIA ALCHEMY) and Marc Schoenauer.

- Arpad Rimmel, 15/12/09, Université Paris-Sud, co-supervisors Antoine Cornuéjols (Agro ParisTech) and Olivier Teytaud.
- Raymond Ros, 21/12/09, Université Paris-Sud, co-supervisors Nikolaus Hansen and Michéle Sebag.

9.2.3. Graduate Courses

- Master 2 Recherche (U. Paris-Sud), Data Mining and Machine Learning (24 h): Michèle Sebag, Balazs Kégl, Antoine Cornuéjols.
- Master 2 Recherche (U.Paris-Sud), Artificial Evolution and Evolutionary Robotics (24 hours): Anne Auger, Nicolas Bredèche and Marc Schoenauer.
- Master 2 Recherche (U.Paris-Sud), Artificial and Natural Perception : Nicolas Bredèche (6h).
- Master 2 Recherche (U.Paris-Sud), Systèmes multi-agents : Philippe Caillou (6h).
- Master 2, (U. du Liban, Beyrouth), APprentissage et Fouille de Données (20h).

9.2.4. Undergraduate course

- Anne Auger: Ecole Centrale Paris, cours “Contrôle avancé” (part: Genetic Algorithms), (12h).

9.2.5. Other research-related teaching activities

At *Ecole Polytechnique*:

- Project around Computer Go (Epita, 2009): Amine Bourki, Edouard Deneve, Mathieu Coulm, Paul Vayssiere.
- Majeure “SEISM” (Engineering Science, Grégoire Allaire): one lesson (amphi) on Evolutionary Topological Optimum Design, Marc Schoenauer;
- Majeure Combinatorial Optimization (Philippe Baptiste): one lesson (amphi) on Evolutionary Methods for Combinatorial Optimization, Marc Schoenauer;
- *Stages d’option* (internships), Michèle Sebag.

10. Bibliography

Year Publications

Doctoral Dissertations and Habilitation Theses

[1] N. BREDÈCHE. *Contributions to Evolutionary Design of Embodied Agents*, HDR – Habilitation Ã Diriger des Recherches, Université Paris-Sud, December 2009, Ph. D. Thesis.

[2] A. DEVERT. *Building processes optimization: Toward an artificial ontogeny based approach*, Université Paris-Sud, June 2009, Ph. D. Thesis.

[3] C. HARTLAND. *Robust Robotic behavior Optimization*, Université Paris-Sud, Ecold doctorale d’informatique, November 2009, Ph. D. Thesis.

[4] F. JIANG. *Optimisation de la topologie de grands rÃ©seaux de neurones*, UniversitÃ© Paris-Sud, Ecold doctorale d’informatique, December 2009, Ph. D. Thesis.

[5] A. RIMMEL. *Bandit-based optimization on graphs with application to library performance tuning*, UniversitÃ© Paris-Sud, Ecold doctorale d’informatique, December 2009, Ph. D. Thesis.

[6] R. ROS. *Real-Parameter Black-Box Optimisation: Benchmarking and Designing Algorithms*, Université Paris-Sud, Orsay, France, December 2009, Ph. D. Thesis FR .

Articles in International Peer-Reviewed Journal

[7] A. AUGER, J. BADER, D. BROCKHOFF, E. ZITZLER. *Hypervolume-based Multiobjective Optimization: Theoretical Foundations and Practical Implications*, in "Theoretical Computer Science", 2010, submitted.

[8] A. AUGER, O. TEYTAUD. *Continuous Lunches are free plus the design of optimal optimization algorithms.*, in "Algorithmica", 2009.

[9] P. CAILLOU, S. AKNINE, S. PINSON. *Searching Pareto-optimal solutions for the problem of forming and restructuring coalitions in multi-agents systems*, in "Group Decision and Negotiation", vol. 19, 2010, http://hal.archives-ouvertes.fr/inria-00370430/en/.

[10] B. CESSAC, H. PAUGAM-MOISY, T. VIÉVILLE. *Overview of facts and issues about neural coding by spikes*, in "Journal of Physiology Paris", 2009, http://hal.inria.fr/inria-00407915/en/, to appear.

[11] A. FIALHO, L. DA COSTA, M. SCHOENAUER, M. SEBAG. *Analyzing Bandit-based Adaptive Operator Selection Mechanisms*, in "Annals of Mathematics and Artificial Intelligence – Special Issue on Learning and Intelligent Optimization", 2009, submitted.

[12] H. FOURNIER, O. TEYTAUD. *Lower Bounds for Comparison Based Evolution Strategies using VC-dimension and Sign Patterns*, in "Algorithmica", 2010, (accepted with minor revision).

[13] C. FURTLEHNER, J.-M. LASGOUTTES, A. AUGER. *Learning Multiple Belief Propagation Fixed Points for Real Time Inference*, in "J. Phys. A", vol. 389, n^{o} 1, 2010, p. 149–163, http://www-roc.inria.fr/who/Cyril.Furtlehner/physicaA.pdf.

[14] C. GERMAIN-RENAUD, O. RANA. *The Convergence of Clouds, Grids, and Autonomics - GMAC Panel Session report*, in "IEEE Internet Computing", vol. 13, 11 2009, 9, http://hal.inria.fr/inria-00434044/en/FRGB.

[15] N. HANSEN, A. NIEDERBERGER, L. GUZZELLA, P. KOUMOUTSAKOS. *A Method for Handling Uncertainty in Evolutionary Optimization with an Application to Feedback Control of Combustion*, in "IEEE Transactions on Evolutionary Computation", vol. 13, n^{o} 1, 2009, p. 180–197, http://hal.inria.fr/inria-00276216/en/.

[16] M. JEBALIA, A. AUGER, N. HANSEN. *Log linear convergence and divergence of the scale-invariant (1+1)-ES in noisy environments*, in "Algorithmica", 2010, conditionally accepted, http://hal.inria.fr/inria-00433347/en/, conditionally accepted.

[17] C.-S. LEE, M.-H. WANG, G. CHASLOT, J.-B. HOOCK, A. RIMMEL, O. TEYTAUD, S.-R. TSAI, S.-C. HSU, T.-P. HONG. *The Computational Intelligence of MoGo Revealed in Taiwan's Computer Go Tournaments*, in "IEEE Transactions on Computational Intelligence and AI in games", 2009, http://hal.inria.fr/inria-00369786/en/.

[18] M. NICOLAU, M. SCHOENAUER. *On the Evolution of Scale-Free Topologies with a Gene Regulatory Network Model*, in "BioSystems Journal", vol. 98, n^{o} 3, December 2009, p. 137-148, http://dx.doi.org/10.1016/j.biosystems.2009.06.006.

[19] T. SUTTORP, N. HANSEN, C. IGEL. *Efficient Covariance Matrix Update for Variable Metric Evolution Strategies*, in "Machine Learning", vol. 72, n° 2, 2009, p. 167–197.

[20] D. TREGOUET, I. KÖNIG, J. ERDEMANN, A. MUNTEANU, P. BRAUND, A. HALL, A. GROHENNIG, P. LINSEL-NITSCHKE, C. PERRET, M. DESUREMAIN, T. MEITINGER, B. WRIGHT, M. PREUSS, A. BALMFORTH, S. BALL, C. MEISINGER, C. GERMAIN-RENAUD, A. EVANS, D. ARVEILLER, G. LUC, J.-B. RUIDAVETS, C. MORRISON, P. VAN DER HARST, S. SCHREIBER, K. NEUREUTHER, A. SCHÄFER, P. BUGERT, N. EL MOKHTARI, J. SCHREZENMEIR, K. STARK, D. RUBIN, H.-E. WICHMANN, C. HENGSTENBERG, W. OUWEHAND, TRUST CASE CONTROL CONSORTIUM, WELLCOME, CONSORTIUM, CARDIOGENICS, A. ZIEGLER, L. TIRET, J. THOMPSON, F. CAMBIEN, H. SCHUNKERT, N. SAMANI. *Genome-wide haplotype association study identifies the SLC22A3-LPAL2-LPA gene cluster as a risk locus for coronary artery disease*, in "Nature Genetics", vol. 41, 2009, p. 283-285, http://hal.inria.fr/inria-00433429/en/FRGBDENE.

Invited Conferences

[21] A. AUGER, N. HANSEN, J. PEREZ ZERPA, R. ROS, M. SCHOENAUER. *Experimental Comparisons of Derivative Free Optimization Algorithms*, in "8th International Symposium on Experimental Algorithms, Dortmund", J. VAHRENHOLD (editor), LNCS, n° 5526, Springer Verlag, 2009, p. 3-15, http://hal.inria.fr/inria-00397334/en/.

International Peer-Reviewed Conference/Proceedings

[22] M. AMIL, N. BREDÈCHE, C. GAGNÉ, S. GELLY, M. SCHOENAUER, O. TEYTAUD. *A Statistical Learning Perspective of Genetic Programming*, in "Proceedings of EuroGP 09", Springer Veralg, 2009, http://hal.inria.fr/inria-00369782/en/Canada.

[23] A. ARBELAEZ, Y. HAMADI. *Exploiting Weak Dependencies in Tree-based Search*, in "Proceedings of the 24th Annual ACM Symposium on Applied Computing", ACM Press, ACM, 2009, p. 1385-1391, http://hal.inria.fr/inria-00344179/fr/, to appear.

[24] P. AUDOUARD, G. CHASLOT, J.-B. HOOCK, A. RIMMEL, J. PEREZ, O. TEYTAUD. *Grid coevolution for adaptive simulations; application to the building of opening books in the game of Go*, in "EvoGames, Tuebingen Allemagne", Springer Verlag, 2009, http://hal.inria.fr/inria-00369783/en/.

[25] A. AUGER. *Benchmarking the (1+1) evolution strategy with one-fifth success rule on the BBOB-2009 function testbed*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2447-2452.

[26] A. AUGER. *Benchmarking the (1+1)-ES with One-Fifth Success Rule on the BBOB-2009 noisy Function Testbed*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2453-2458.

[27] A. AUGER, J. BADER, D. BROCKHOFF, E. ZITZLER. *Articulating User Preferences in Many-Objective Problems by Sampling the Weighted Hypervolume*, in "Genetic and Evolutionary Computation Conference (GECCO 2009)", G. RAIDL, ETAL (editors), ACM, July 2009, p. 555-562.

[28] A. AUGER, J. BADER, D. BROCKHOFF, E. ZITZLER. *Investigating and Exploiting the Bias of the Weighted Hypervolume to Articulate User Preferences*, in "Genetic and Evolutionary Computation Conference (GECCO 2009)", G. RAIDL, ETAL (editors), ACM, July 2009, p. 563-570.

[29] A. AUGER, J. BADER, D. BROCKHOFF, E. ZITZLER. *Theory of the Hypervolume Indicator: Optimal μ-Distributions and the Choice of the Reference Point*, in "Foundations of Genetic Algorithms (FOGA 2009)", ACM, 2009, p. 87-102.

[30] A. AUGER, N. HANSEN. *Benchmarking the (1+1)-CMA-ES on the BBOB-2009 function testbed*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2459-2466.

[31] A. AUGER, N. HANSEN. *Benchmarking the (1+1)-CMA-ES on the BBOB-2009 noisy testbed*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2467-2472.

[32] A. AUGER, N. HANSEN, J. PEREZ ZERPA, R. ROS, M. SCHOENAUER. *Empirical comparisons of several derivative free optimization algorithms*, in "Acte du 9ème colloque national en calcul des structures", May 2009.

[33] A. AUGER, R. ROS. *Benchmarking the pure random search on the BBOB-2009 noisy testbed*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2485-2490.

[34] A. AUGER, R. ROS. *Benchmarking the pure random search on the BBOB-2009 testbed*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2479-2484.

[35] G. BAELE, N. BREDÈCHE, E. HAASDIJK, S. MAERE, N. MICHIELS, Y. V. DE PEER, T. SCHMICKL, C. SCHWARZER, R. THENIUS. *Open-ended On-board Evolutionary Robotics for Robot Swarms*, in "Proceedings of the IEEE Congress on Evolutionary Computation (IEEE CEC 2009)", 2009.

[36] V. BERTHIER, H. DOGHMEN, O. TEYTAUD. *Consistency Modifi'cations for Automatically Tuned Monte-Carlo Tree Search*, in "Lion4", 2010, http://hal.inria.fr/inria-00437146/en/, To appear.

[37] J. BIBAI, M. SCHOENAUER, P. SAVÉANT. *Divide-And-Evolve Facing State-of-the-art Temporal Planners during the 6th International Planning Competition*, in "9th European Conf. on Evolutionary Computation in Combinatorial Optimization (EvoCOP'09), Tübingen Allemagne", C. COTTA, P. COWLING (editors), LNCS, n° 5482, Springer-Verlag, 2009, p. 133-144, http://hal.inria.fr/inria-00356069/fr/.

[38] J. BIBAI, P. SAVÉANT, M. SCHOENAUER, V. VIDAL. *Learning Divide-and-Evolve Parameter Configurations with Racing*, in "ICAPS 2009 proceedings of the Workshop on Planning and Learning, Thessaloniki Grèce", A. COLES, A. COLES, S. J. CELORRIO, S. F. ARREGUI, T. DE LA ROSA (editors), AAAI press, International Conference on Planning and Scheduling and University of Macedonia, 2009, http://hal.inria.fr/inria-00406626/en/.

[39] J. BIBAI, P. SAVÉANT, M. SCHOENAUER, V. VIDAL. *On the Benefit of Sub-Optimality within the Divide-and-Evolve Scheme*, in "EvoCOP 2010", P. MERZ, P. COWLING (editors), Springer-Verlag, 2010, http://hal.inria.fr/inria-00443984/fr/.

[40] N. BREDÈCHE, E. HAASDIJK, A. EIBEN. *On-line, On-board Evolution of Robot Controllers*, in "Proceedings of the 9th international conference on Artificial Evolution (Evolution Artificielle - EA'09)", 2009 NL .

[41] R. BUSA-FEKETE, B. KÉGL. *Accelerating AdaBoost using UCB*, in "KDDCup 2010 (JMLR workshop and conference proceedings), Paris, France", vol. 7, 2009, p. 111-122.

[42] P. CAILLOU, C. CURCHOD, T. BAPTISTA. *Simulation of the Rungis Wholesale Market: Lessons on the Calibration, Validation and Usage of a Cognitive Agent-Based Simulation*, in "IAT 2009, Milano Italie", vol. 2, IEEE, 09 2009, p. 70-73, http://hal.archives-ouvertes.fr/inria-00429616/en/.

[43] P. CAILLOU, M. SEBAG. *Pride and Prejudice on a Centralized Academic Labor Market*, in "Artificial Economics 09 LNEMS, Valladolid Espagne", LNEMS, Springer, 2009, http://hal.inria.fr/inria-00380541/en/.

[44] G. CHASLOT, C. FITER, J.-B. HOOCK, A. RIMMEL, O. TEYTAUD. *Adding expert knowledge and exploration in Monte-Carlo Tree Search*, in "Advances in Computer Games, Pamplona Espagne", Springer Verlag, 2009, http://hal.inria.fr/inria-00386477/en/.

[45] G. CHASLOT, J.-B. HOOCK, F. TEYTAUD, O. TEYTAUD. *On the huge benefit of quasi-random mutations for multimodal optimization with application to grid-based tuning of neurocontrollers*, in "ESANN, Bruges Belgique", 2009, http://hal.inria.fr/inria-00380125/en/.

[46] L. DA COSTA, M. SCHOENAUER. *Bringing Evolutionary Computation to Industrial Applications with GUIDE*, in "Genetic and Evolutionary Computation Conference (GECCO)", G. RAIDL, ETAL (editors), ACM Press, ACM, 2009, http://hal.inria.fr/inria-00375419/en/.

[47] F. DE MESMAY, A. RIMMEL, Y. VORONENKO, M. PÜSCHEL. *Bandit-Based Optimization on Graphs with Application to Library Performance Tuning*, in "ICML, Montréal Canada", 2009, http://hal.inria.fr/inria-00379523/en/.

[48] F.-M. DE RAINVILLE, C. GAGNÉ, O. TEYTAUD, D. LAURENDEAU. *Optimizing Low-Discrepancy Sequences with an Evolutionary Algorithm*, in "Genetic and Evolutionary Computation Conference (GECCO 2009), Montréal Canada", G. RAIDL, ETAL (editors), ACM Press, 2009, http://hal.inria.fr/inria-00386475/en/Canada.

[49] R. DILÃO, D. MURARO, M. NICOLAU, M. SCHOENAUER. *Validation of a morphogenesis model of Drosophila early development by a multi-objective evolutionary optimization algorithm*, in "European Conference on Evolutionary Computation, Machine Learning and Data Mining in Bioinformatics", C. PIZZUTI, M. D. RITCHIE, M. GIACOBINI (editors), LNCS, n^{o} 5483, Springer Verlag, April 2009, p. 176-190, Best Paper Award.

[50] S. DONCIEUX, J.-B. MOURET, N. BREDÈCHE. *Exploring New Horizons in Evolutionary Design of Robots*, in "CD Proceedings of IROS 2009 Workshop on Exploring new horizons in Evolutionary Design of Robots (Evoderob09)", 2009, p. 5-12.

[51] A. FIALHO, L. D. COSTA, M. SCHOENAUER, M. SEBAG. *Dynamic Multi-Armed Bandits and Extreme Value-based Rewards for Adaptive Operator Selection in Evolutionary Algorithms*, in "LION'09: Proceedings of the 3rd International Conference on Learning and Intelligent OptimizatioN", Springer Verlag, January 2009.

[52] A. FIALHO, M. SCHOENAUER, M. SEBAG. *Analysis of Adaptive Operator Selection Techniques on the Royal Road and Long K-Path Problems*, in "Genetic and Evolutionary Computation Conference (GECCO 2009)", G. RAIDL, ETAL (editors), ACM Press, July 2009, p. 779–786.

[53] N. HANSEN. *Benchmarking a BI-Population CMA-ES on the BBOB-2009 Function Testbed*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2389-2395.

[54] N. HANSEN. *Benchmarking a BI-Population CMA-ES on the BBOB-2009 Noisy Testbed*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2397-2402.

[55] N. HANSEN. *Benchmarking the Nelder-Mead Downhill Simplex Algorithm With Many Local Restarts*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2403-2408.

[56] C. HARTLAND, N. BREDÈCHE, M. SEBAG. *Memory-Enhanced Evolutionary Robotics: The Echo State Network Approach*, in "Proceedings of the IEEE Congress on Evolutionary Computation (IEEE CEC 2009)", 2009.

[57] S. KERNBACH, H. HAMANN, J. STRADNER, R. THENIUS, T. SCHMICKL, A. VAN ROSSUM, M. SEBAG, N. BREDÈCHE, Y. YAO, G. BAELE, Y. V. DE PEER, J. TIMMIS, M. MOHKTAR, A. TYRRELL, A. EIBEN, S. MCKIBBIN, W. LIU, A. F. WINFIELD. *On adaptive self-organization in artificial robot organisms*, in "Proceedings of the First IEEE International Conference on Adaptive and Self-adaptive Systems and Applications (IEEE ADAPTIVE 2009)", 2009.

[58] B. KÉGL, R. BUSA-FEKETE. *Boosting products of base classifiers*, in "International Conference on Machine Learning, Montreal, Canada", vol. 26, 2009, p. 497-504.

[59] C.-S. LEE, M.-H. WANG, T.-P. HONG, G. CHASLOT, J.-B. HOOCK, A. RIMMEL, O. TEYTAUD, Y.-H. KUO. *A Novel Ontology for Computer Go Knowledge Management*, in "IEEE FUZZ, Jeju Corée, République de", 2009, http://hal.inria.fr/inria-00386476/en/.

[60] R. MARTINEZ, H. PAUGAM-MOISY. *Algorithms for structural and dynamical polychronous groups detection*, in "ICANN'2009, International Conference on Artificial Neural Networks Artificial Neural Networks, Limassol Chypre", LNCS, Lecture Notes in Computer Science, vol. 5769, Springer, IEEE - INNS, 2009, p. 75-84, http://hal.inria.fr/inria-00425514/en/.

[61] J. MATURANA, A. FIALHO, F. SAUBION, M. SCHOENAUER, M. SEBAG. *Extreme Compass and Dynamic Multi-Armed Bandits for Adaptive Operator Selection*, in "CEC'09: Proceedings of the IEEE International Conference on Evolutionary Computation", IEEE, May 2009, p. 365–372.

[62] J.-M. MONTANIER, N. BREDÈCHE. *Embedded Evolutionary Robotics: The (1+1)-Restart-Online Adaptation Algorithm*, in "CD Proceedings of IROS 2009 Workshop on Exploring new horizons in Evolutionary Design of Robots (Evoderob09)", 2009, p. 37-43.

[63] J. MONTEIRO, P. CAILLOU, M. NETTO. *An Agent Model Using Polychronous Networks*, in "Colibri, Bento Gonçalves Brésil", 2009, http://hal.inria.fr/inria-00393065/en/.

[64] M. NICOLAU. *Application of a simple binary genetic algorithm to a noiseless testbed benchmark*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, http://hal.inria.fr/inria-00377093/en/.

[65] M. NICOLAU, M. SCHOENAUER, W. BANZHAF. *Evolving Genes to Balance a Pole*, in "13th European Conference on Genetic Programming (EuroGP 2010)", A. I. ESPARCIA, A. ECKART (editors), Springer, 2010.

[66] M. NICOLAU, M. SCHOENAUER. *Evolving Specific Network Statistical Properties using a Gene Regulatory Network Model*, in "Genetic and Evolutionary Computation Conference (GECCO 2009)", G. RAIDL, ETAL (editors), ACM, July 2009, p. 723-730.

[67] J. PEREZ, C. GERMAIN-RENAUD, B. KÉGL, C. LOOMIS. *Responsive Elastic Computing*, in "Workshop Grids Meet Autonomic Computing, associated with International Conference on Autonomic Computing, Barcelone, June 15th-19th", ACM, 2009, p. 55-64, http://hal.inria.fr/inria-00384970/en/.

[68] J. PEREZ, C. GERMAIN-RENAUD, B. KÉGL, C. LOOMIS. *Toward Responsive Grids through Multi Objective Reinforcement Learning*, in "4th EGEE User Forum", 2009.

[69] P. ROLET, M. SEBAG, O. TEYTAUD. *Boosting Active Learning to Optimality: a Tractable Monte-Carlo, Billiard-based Algorithm*, in "ECML, Bled Slovénie", 2009, p. 302-317, http://hal.inria.fr/inria-00433866/en/ .

[70] P. ROLET, M. SEBAG, O. TEYTAUD. *Optimal robust expensive optimization is tractable*, in "Genetic and Evolutionary Computation Conference (GECCO 2009), Montréal Canada", G. RAIDL, ETAL (editors), ACM Press, ACM, 2009, p. 1951-1956, http://hal.inria.fr/inria-00374910/en/, G.: Mathematics of Computing/G.1: NUMERICAL ANALYSIS/G.1.6: Optimization, I.: Computing Methodologies/I.2: ARTIFICIAL INTELLIGENCE/I.2.8: Problem Solving, Control Methods, and Search.

[71] P. ROLET, O. TEYTAUD. *Bandit-based Estimation of Distribution Algorithms for Noisy Optimization: Rigorous Runtime Analysis*, in "Lion4, Venice Italie", 2010, http://hal.inria.fr/inria-00437140/en/, To appear.

[72] R. ROS. *Benchmarking sep-CMA-ES on the BBOB-2009 function testbed*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2435–2440.

[73] R. ROS. *Benchmarking sep-CMA-ES on the BBOB-2009 noisy testbed*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2441–2446.

[74] R. ROS. *Benchmarking the BFGS algorithm on the BBOB-2009 function testbed*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2409–2414.

[75] R. ROS. *Benchmarking the BFGS algorithm on the BBOB-2009 noisy testbed*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2415–2420.

[76] R. ROS. *Benchmarking the NEWUOA on the BBOB-2009 function testbed*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2421–2428.

[77] R. ROS. *Benchmarking the NEWUOA on the BBOB-2009 noisy testbed*, in "Workshop Proceedings of the GECCO Genetic and Evolutionary Computation Conference", G. RAIDL, ETAL (editors), ACM, July 2009, p. 2429–2434.

[78] F. TEYTAUD, O. TEYTAUD. *Creating an Upper-Confidence-Tree program for Havannah*, in "ACG 12, Pamplona Espagne", 2009, http://hal.inria.fr/inria-00380539/en/.

[79] F. TEYTAUD, O. TEYTAUD. *On the parallel speed-up of Estimation of Multivariate Normal Algorithm and Evolution Strategies*, in "EvoNum, Proceedings of EvoStar workshop 2009, Tuebingen Allemagne", vol. EvoNum, Springer Verlag, 2009, http://hal.inria.fr/inria-00369781/en/.

[80] F. TEYTAUD, O. TEYTAUD. *Why one must use reweighting in Estimation Of Distribution Algorithms*, in "Genetic and Evolutionary Computation Conference (GECCO 2009)", G. RAIDL, ETAL (editors), ACM Press, 2009, http://hal.inria.fr/inria-00369780/en/.

[81] T. VOSS, N. HANSEN, C. IGEL. *Recombination for Learning Strategy Parameters in the MO-CMA-ES*, in "Fifth International Conference on Evolutionary Multi-Criterion Optimization (EMO 2009)", Springer-Verlag, 2009, p. 155-168.

[82] X. ZHANG, C. FURTLEHNER, J. PEREZ, C. GERMAIN-RENAUD, M. SEBAG. *Toward Autonomic Grids: Analyzing the Job Flow with Affinity Streaming*, in "15th ACM SIGKDD Conference on Knowledge Discovery and Data Mining (KDD), Paris France", 2009, p. 987-995, http://hal.inria.fr/inria-00393825/en/.

[83] X. ZHANG, C. FURTLEHNER, M. SEBAG, C. GERMAIN-RENAUD. *Grid Monitoring by Online Clustering*, in "4th EGEE User Forum, Catania, Sicily, Italy", 2009.

[84] X. ZHANG, M. SEBAG, C. GERMAIN-RENAUD. *Multi-scale Real-time Grid Monitoring with Job Stream Mining*, in "IEEE International Symposium on Cluster Computing and the Grid (CCGrid 2009), Shanghai China", 2009, p. 420-427, http://hal.inria.fr/inria-00367544/en/, EGEE-III PASCAL.

National Peer-Reviewed Conference/Proceedings

[85] L. ARNOLD, H. PAUGAM-MOISY, M. SEBAG. *Optimisation de la Topologie pour les Réseaux de Neurones Profonds*, in "Proc. RFIA", 2010, to appear.

[86] J. BIBAI, M. SCHOENAUER, P. SAVÉANT. *Construction des sèries d'états dans l'algorithme Divide-and-Evolve*, in "ROADEF09, Livre des rÃ©sumÃ©s, Nancy France", ROADEF'09, 2009, p. 98-99, http://hal.inria.fr/inria-00354272/fr/.

[87] P. DELARBOULAS, M. SEBAG. *Critères non supervisés pour contrôleurs robotiques embarqués*, in "Proc. RFIA", 2010, to appear.

[88] C. HARTLAND, N. BREDÈCHE, M. SEBAG. *Robotique Evolutionnaire et Mémoire*, in "Proceedings of the Conférence francophone sur l'apprentissage automatique (CAp09)", 2009, p. 161–172.

[89] P. ROLET, M. SEBAG, O. TEYTAUD. *Upper Confidence Trees and Billiards for Optimal Active Learning*, in "CAP09, Hammamet, Tunisie", 2009, http://hal.inria.fr/inria-00369787/en/.

Workshops without Proceedings

[90] A. ARBELAEZ, Y. HAMADI, M. SEBAG. *Online Heuristic Selection in Constraint Programing*, in "International Symposium on Combinatorial Search", 2009.

[91] C. CURCHOD, P. CAILLOU, T. BAPTISTA. *Which Buyer-Supplier Strategies on Uncertain Markets? A Multi-Agents Simulation*, in "Strategic Managemtn Society, Washington États-Unis d'Amérique", 2009, http://hal.inria.fr/inria-00380540/en/.

[92] R. GAUDEL, M. SEBAG. *Feature Selection as a one-player game*, in "2nd NIPS Workshop on Optimization for Machine Learning", 2009.

Scientific Books (or Scientific Book chapters)

[93] D. BROCKHOFF. *Many-Objective Optimization and Hypervolume Based Search*, Shaker Verlag, Aachen, Germany, 2009.

[94] D. BROCKHOFF. *Theoretical Aspects of Evolutionary Multiobjective Optimization*, in "Theory of Randomized Search Heuristics: Foundations and Recent Developments", A. AUGER, B. DOERR (editors), World Scientific Publishing, 2010, accepted for publication.

[95] Y. COLETTE, N. HANSEN, G. PUJOL. *Vers une Programmation Orientée Objet des Optimiseurs*, in "Opimisation multidisciplinaire en mécanique 2. Réduction de modèles, robustesse, fiabilité, réalisations logicielles, Paris, London, Chippenham", Méthodes Numériques en Mécanique, vol. 2, chap. 7, Hermes Science, Lavoisier, April 2009, http://hal.archives-ouvertes.fr/hal-00409906/en/.

[96] C. GERMAIN-RENAUD, V. BRETON, P. CLARYSSE, B. DELHAY, Y. GAUDEAU, T. GLATARD, E. JEANNOT, Y. LEGRÉ, J. MONTAGNAT, J.-M. MOUREAUX, A. OSORIO, X. PENNEC, J. SCHAERER, R. TEXIER. *Grid analysis of radiological data*, in "Handbook of Research on Computational Grid Technologies for Life Sciences, Biomedicine and Healthcare", M. CANNATARO (editor), chap. 19, Medical Information Science Reference, 05 2009, ., http://hal.archives-ouvertes.fr/hal-00382594/en/.

[97] N. HANSEN, A. AUGER. *Principled Design of Continuous Stochastic Search in Practice: the CMA Evolution Strategy*, in "Theory and Principled Methods for the Design of Metaheuristics", Y. BORENSTEIN, A. MORAGLIO (editors), Springer, 2010, submitted, submitted.

[98] H. PAUGAM-MOISY, S. M. BOTHE. *Computing with Spiking Neuron Networks*, in "The Handbook of Natural Computing", Springer, 2009, to appear NL .

Books or Proceedings Editing

[99] A. AUGER, B. DOERR (editors). *Theory of Randomized Seach Heuristics–Foundations and Recent Developments*, Theoretical Computer Science, vol. 1, World Scientific, 2010.

Research Reports

[100] D. BROCKHOFF. *Theoretical Aspects of Evolutionary Multiobjective Optimization—A Review*, n^{o} RR-7030, INRIA Saclay—Île-de-France, September 2009, Rapport de Recherche.

[101] T. ELTETO, C. GERMAIN-RENAUD, P. BONDON. *Discovering Linear Models of Grid Workload*, n^o RR-7112, INRIA, 2009, http://hal.inria.fr/inria-00435561/en/, Research Report.

[102] S. FINCK, N. HANSEN, R. ROS, A. AUGER. *Real-Parameter Black-Box Optimization Benchmarking 2009: Presentation of the Noiseless Functions*, n^o 2009/20, Research Center PPE, 2009, Technical report.

[103] S. FINCK, N. HANSEN, R. ROS, A. AUGER. *Real-Parameter Black-Box Optimization Benchmarking 2009: Presentation of the Noisy Functions*, n^o 2009/21, Research Center PPE, 2009, Technical report.

[104] S. FINCK, R. ROS. *Real-Parameter Black-Box Optimization Benchmarking 2009 Software: User Documentation*, n^o RT-0372, INRIA, 2009, http://hal.inria.fr/inria-00433590, Technical reportDEFR.

[105] C. FURTLEHNER, M. SEBAG, X. ZHANG. *Scaling Analysis of the Affinity Propagation Algorithm*, n^o RR-7046, INRIA, 2009, http://hal.inria.fr/inria-00420407/en/, Research Report.

[106] N. HANSEN, A. AUGER, S. FINCK, R. ROS. *Real-Parameter Black-Box Optimization Benchmarking 2009: Experimental Setup*, n^o RR-6828, INRIA, 2009, http://hal.inria.fr/inria-00362649/en/, Technical report.

[107] N. HANSEN, A. AUGER, S. FINCK, R. ROS. *Real-Parameter Black-Box Optimization Benchmarking 2009: Experimental Setup*, n^o RR-6828, INRIA, 2009, http://hal.inria.fr/inria-00362649/en/, Research Report.

[108] N. HANSEN, S. FINCK, R. ROS, A. AUGER. *Real-Parameter Black-Box Optimization Benchmarking 2009: Noiseless Functions Definitions*, n^o RR-6829, INRIA, 2009, http://hal.inria.fr/inria-00362633/en/, Technical report.

[109] N. HANSEN, S. FINCK, R. ROS, A. AUGER. *Real-Parameter Black-Box Optimization Benchmarking 2009: Noiseless Functions Definitions*, n^o RR-6829, INRIA, 2009, http://hal.inria.fr/inria-00362633/en/, Research Report.

[110] N. HANSEN, S. FINCK, R. ROS, A. AUGER. *Real-Parameter Black-Box Optimization Benchmarking 2009: Noisy Functions Definitions*, n^o RR-6869, INRIA, 2009, http://hal.inria.fr/inria-00369466/en, Technical report.

Scientific Popularization

[111] N. BREDÈCHE. *Évolution de robots autonomes et autres créatures artificielles*, in "Les mondes darwiniens, L'évolution de l'évolution", T. HEAMS, P. HUNEMAN, G. LECOINTRE, M. SILBERSTEIN (editors), chap. 31, Editions Syllepse, 2009, p. 747-768.

[112] M. SCHOENAUER. *Les algorithmes évolutionnaires*, in "Les mondes darwiniens, L'évolution de l'évolution", T. HEAMS, P. HUNEMAN, G. LECOINTRE, M. SILBERSTEIN (editors), chap. 31, Editions Syllepse, 2009, p. 731-746.