IN PARTNERSHIP WITH:
CNRS

Université Paris-Sud (Paris 11)

Activity Report 2016

Project-Team TAO

Machine Learning and Optimisation

IN COLLABORATION WITH: Laboratoire de recherche en informatique (LRI)

RESEARCH CENTER
Saclay - Île-de-France

THEME
Optimization, machine learning and statistical methods

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Project-Team TAO

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Other Research Topics and Application Domains: 0.0 - empty

Creation of the Project-Team: 2004 November 04, end of the Project-Team: 2016 December 31

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Cyril Furtlehner [Inria, Researcher]
Gregory Grefenstette [Inria, Advanced Research position, until Oct 2016]
Nikolaus Hansen [Inria, Senior Researcher, until Dec. 2016, HDR]
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2. Overall Objectives

2.1. Presentation

TAO main research domains, defined at the birth of the team in 2003, have slowly evolved since then. As TAO has now reached the 12-years lifetime limit of all Inria teams, it will die at the end of 2016 and most TAO researchers will together propose a new team with renewed research themes. This Section is thus meant as a historical remain of the late TAO team.
Data Mining (DM), acknowledged to be one of the main ten challenges of the 21st century [1], aims at building (partial) phenomenological models from the massive amounts of data produced in scientific labs, industrial plants, banks, hospitals or supermarkets. Machine Learning (ML) likewise aims at modeling the complex systems underlying the available data; the main difference between DM and ML disciplines is the emphasis put on the acquisition, storage and management of large-scale data.

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

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

[1] MIT Technological Review, feb. 2001.

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

Specifically, our research context is based on the following assumptions:

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

In this context, the objectives of TAO are threefold:

1. Investigating how specific prior knowledge and requirements can be accommodated in Machine Learning thanks to evolutionary computation (EC) and more generally Stochastic Optimization;
2. Investigating how statistical Machine Learning can be used to interpret, study and enhance evolutionary computation;
3. Facing diversified and real-world applications, requiring and suggesting new integrated ML/EC approaches.

3. Research Program

3.1. The Five Pillars of TAO

This Section describes TAO main research directions at the crossroad of Machine Learning and Evolutionary Computation. Since 2008, TAO has been structured in several special interest groups (SIGs) to enable the agile investigation of long-term or emerging theoretical and applicative issues. 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.

The first two SIGs consolidate the key TAO scientific pillars, while the others evolve and adapt to new topics.

The **Stochastic Continuous Optimization** SIG (OPT-SIG) takes advantage of the fact that TAO is acknowledged the best French research group and one of the top international groups in evolutionary computation from a theoretical and algorithmic standpoint. A main priority on the OPT-SIG research agenda is to provide theoretical and algorithmic guarantees for the current world state-of-the-art continuous stochastic optimizer, CMA-ES, ranging from convergence analysis to a rigorous benchmarking methodology. Incidentally, the benchmark platform COCO has been acknowledged since 2009 as "the" international continuous optimization benchmark, and its extension is at the core of the ANR projects NumBBO and NumBBO2. Another priority is to address the current limitations of CMA-ES in terms of high-dimensional or expensive optimization and constraint handling (respectively Ouassim Ait El Hara's and Asma Atamna's PhDs). Note that most members of this SIG have moved to the recently created Inria team RANDOPT by December 2016.

The **Optimal Decision Making under Uncertainty** SIG (UCT-SIG) benefits from the MoGo expertise and its past and present world records in the domain of computer-Go, establishing the international visibility of TAO in sequential decision making. Since 2010, UCT-SIG resolutely moves to address the problems of **energy management** from a fundamental and applied perspective. On the one hand, energy management offers a host of challenging issues, ranging from long-horizon policy optimization to the combinatorial nature of the search space, from the modeling of prior knowledge to non-stationary environment to name a few. On the other hand, the energy management issue can hardly be tackled in a pure academic perspective: tight collaborations with industrial partners are needed to access the true operational constraints. Such international and national collaborations have been started by Olivier Teytaud during his three stays (1 year, 6 months, 6 months) in Taiwan, and witnessed by the FP7 STREP Citines, the ADEME Post contract, and the METIS I-lab with SME Artelys. Note that Olivier Teytaud has left TAO for Google-Zurich on June 6., 2016. The project is continuing in collaboration with RTE under the leadership of Isabelle Guyon and Marc Schoenauer, making connections with Data Science.

The **Data Science** SIG (DS-SIG) includes the activities conducted or started within the CDS and ISN Lidexes in Saclay. On the one hand, it replaces and extends the former *Distributed systems* SIG, that was devoted to the modeling and optimization of (large scale) distributed systems, and itself was extending the goals of the original *Autonomic Computing* SIG, initiated by Cécile Germain-Renaud and investigating the use of statistical Machine Learning for large scale computational architectures (from data acquisition – the Grid Observatory in the European Grid Initiative – to grid management and fault detection). Under the application pressure from natural and social sciences (ranging from High Energy Physics to computational social sciences), this SIG has evolved. A major result of this theme has been the creation 3 years ago of the Paris-Saclay Center for Data Science, co-chaired by Balázs Kégl, and the organization of the Higgs-ML challenge (http://higgsml.lal.in2p3.fr/), most popular challenge ever on the Kaggle platform. Another large scale data challenge sponsored by Microsoft with USD 60000 in prizes on the theme of Automatic Machine Learning (AutoML) in 2015/2016 was crowned by success: the winners developed a new tool called AutoSKlearn as a wrapper to the scikit-learn library, an open source project lead by Inria team Parietal.

On the other hand, several activities around Computational Social Sciences involving Gregory Grefenstette, Cécile Germain-Renaud, Michèle Sebag, Philippe Caillou, Isabelle Guyon and Paola Tubaro, have widely extended previous work around the modeling of multi-agent systems and the exploitation of simulation results in the SimTools RNSC network frame. A research direction involves adding semantics to underspecified collections of societal information: in an historical perspective (as in the new TAO H2020 project, EHRI-II on holocaust archives, or in the Gregorius project on church history) or an individual perspective (as in the ongoing Personal Semantics project). Another research direction, developed within the Paris-Saclay Institute for Digital Society (ISN Lidex), examines societal questions (frictional unemployment, Th. Schmitt's PhD, or quality of life at work, O. Goudet's post-doc, or scientific institution activities, F. Louistisserand's engineer stint on Cartolabe) in a data-driven perspective. The key challenge here is to use learning algorithms to find structure and extract knowledge from poorly structured or unstructured information, and to provide intelligible results and/or means to interact with the user. Novel approaches involving causal modeling are under exploration.

The **Designing Criteria** SIG (CRI-SIG) focuses on the design of learning and optimization criteria. It elaborates on the lessons learned from the former *Complex Systems* SIG, showing that the key issue in challenging applications often is to design the objective itself. Such targeted criteria are pervasive in the study and building of autonomous cognitive systems, ranging from intrinsic rewards in robotics to the notion of saliency in vision and image understanding, and that of automatic algorithm selection and parameterization. The desired criteria can also result from fundamental requirements, such as scale invariance in a statistical physics perspective, and guide the algorithmic design. Additionally, the criteria can also be domain-driven and reflect the expert priors concerning the structure of the sought solution (e.g., spatio-temporal consistency); the challenge is to formulate such criteria in a mixed non convex/non differentiable objective function, nevertheless amenable to tractable optimization.

The **Deep Learning and Information Theory** SIG (DEEP-SIG) originated from some extensions of the work done in the *Distributed Systems* SIG that have been developped in the context of the TIMCO FUI project (started end 2012 and just ended); the challenge was not only to port ML algorithms on massively distributed architectures, but to see how these architectures can inspire new ML criteria and methodologies. The coincidence of this project with the arrival of Yann Ollivier in TAO gradualy led this work toward Deep Networks. Other research themes of this SIG are concerned with studying various theoretical and practical aspects of deep learning, providing information-theoretic perspectives on the design and optimization of deep learning models, such as using the Fisher information matrix to optimize the parameters, or using minimum description length criteria to choose the right model structure (topology of the neural graph, addition or removal of parameters...) and to provide regularization and model selection. This activity has also branched out into exploring various applications of Deep Learning. Isabelle Guyon has been involved in applications in computer vision, including the study of personality traits in video data and the verification of fingerprints. Energy Management (Section 4.1), Computational Social Sciences (Section 4.2), and anomaly detection are now also steered toward using Deep Networks for different variants of representation learning.

4. Application Domains

4.1. Energy Management

Energy management, our prioritary application field, involves sequential decision making with:

- stochastic uncertainties (typically weather);
- both high scale combinatorial problems (as induced by nuclear power plants) and non-linear effects;
- high dimension (including hundreds of hydroelectric stocks);
- multiple time scales:
  - minutes (dispatching, ensuring the stability of the grid), essentially beyond the scope of our work, but introducing constraints for our time scales;
  - days (unit commitment, taking care of compromises between various power plants);
  - years, for evaluating marginal costs of long term stocks (typically hydroelectric stocks);
  - decades, for investments.

Significant challenges also include:

- spatial distribution of problems; due to capacity limits we can not consider a power grid like Europe + North Africa as a single “production = demand” constraint; with extra connections we can equilibrate excess production by renewables for remote areas, but not in an unlimited manner.
- other uncertainties, which might be modelized by adversarial or stochastic frameworks (e.g. technological breakthroughs, decisions about ecological penalization).

We have had several related projects in the past, many of them together with the SME Artelys, working on optimization in general, and in particular on energy management. In particular, we had with them an Inria ILAB (Metis, ended in end 2014), and are currently working on POST, an ADEME BIA project about investments in power systems that will end in July 2017. Another project has been submitted to ADEME about the optimization of the local grids (at the city level) depending on the demand and the prediction of the market prices.
In 2016, we started to work with RTE, the company that is managing the global electric network in France. They fund Benjamin Donnot's CIFRE PhD thesis about learning the parries to prevent the loss off security of the network in case of material failures or unexpected consumption peaks. This collaboration had several follow-up, including the organization of a large scale challenge funded by the EU http://see4c.eu/, which will be endowed with 2 million euros in prizes (Isabelle Guyon co-organizer). The participants will be asked to predict the power flow on the entire French territory over several years. This challenge will eventually be followed by a challenge in reinforcement learning (RL), in the context of the PhD thesis of Lisheng Sun who just started working on the problem of RL and Automatic Machine Learning (reducing to the largest possible extend thuman intervention in reinforcement learning). Another direction being explored are uses of causal models to improve explainability of predictive models in decision support systems (Inria-funded post-doc Berna Batu). This should allow making more intelligible suggestions of corrective actions to operators to bring network operations back to safety when incidents or stress occur.

Technical challenges: Our work with Artelys focuses on the combination of reinforcement learning tools, with their anytime behavior and asymptotic guarantees, with existing fast approximate algorithms. Our goal is to extend the state of the art by taking into account non-linearities which are often neglected in power systems due to the huge computational cost. We study various modelling errors, such as biases due to finite samples, linearization, and we propose corrections. The work with RTE involves modeling the network itself from archives, because the numerical simulation is both too expensive and not robust, and modeling the client demand in order to be able to predict possible outlier consumptions.

Related Activities:

- Joint team with Taiwan, namely the Indema associate team.
- Organization of various forums and meetings around Energy Management

4.2. Computational Social Sciences

Several projects related to research in social science and humanities and/or research transfer have started in 2015 and continued in 2016:

- Personal semantics (Gregory Grefenstette). In the current digital world, individuals generate increasing amount of personal data. Our work involves discovering semantic axes for organizing and exploiting this data for personal use.
- Gregorius (Cécile Germain & Gregory Grefenstette). An application of semantic structuring and automatic enrichment of existing digital humanities archives.
- Cartolabe (Ph. Caillou, Jean-Daniel Fekete - AVIZ, Gregory Grefenstette, Michèle Sebag). The Cartolabe project applies machine learning techniques to provide a visual, global and dynamic representation of scientific activities from large scale data (HAL at the moment).
- AmiQap (Philippe Caillou, Isabelle Guyon, Michèle Sebag, Paola Tubaro). The multivariate analysis of government questionaire data relative to the quality of life at work, in relation with the socio-economical indicators of firms, aims at investigating the relationship between quality of life and economic performances (conditionally to the activity sector). This will be the topic of the Divyan Kalainathan's PhD, with emphasis on learning causal effect with novel causal discovery algorithms, in collaboration with post-doctoral student Olivier Goudet and researchers at Facebook AI research.

- Collaborative Hiring (Philippe Caillou, Michèle Sebag). Thomas Schmitt's PhD, started in 2014, aims at matching job offers and resumes viewed as a collaborative filtering problem. An alternative approach based on Deep Networks has been started by François Gonard within his IRT PhD.
- Within the U. Paris-Saclay Nutriperso IRS (Philippe Caillou, Flora Jay, Michèle Sebag), we start investigating the relationships between health, diets and socio-demographic features, with the ultimate goal of emitting individual recommendations toward a more healthy diet, such that these recommendations are acceptable.
- Foodtech (Paola Tubaro, Philippe Caillou, Odalric Maillard). An application of agent-based modelling and machine learning to the study of labor conditions in digital platforms. Focus is on online services and mobile applications for food production, delivery, and consumption.
- Sharing Networks (Paola Tubaro). Mapping the "collaborative economy" of internet platforms through social network data and analysis.
- IODS (Wikidata for Science).

Significant challenges include some Big Data problems:

- learning interpretable clusters from bottom-up treatment of heterogeneous textual and quantitative data
- aligning bottom-up clusters with existing manually created top-down structures
- building a unified system integrating the "dire d'experts".
- merging heterogeneous data from different sources.
- moving from predictive to causal discovery algorithms, in line with state-of-the-art research on causality.

Partners:

- Amiqap is funded by the ISN Lidex, with Mines-Telecom SES, RITM (Univ. Paris Sud) and La Fabrique de l'Industrie as partners.
- The collaborative hiring study is funded by the ISN Lidex, in cooperation with J.P. Nadal from EHESS.
- Cartolabe is funded by Inria, in collaboration between TAO and AVIZ.

4.3. High Energy Physics (HEP)

This is joint work with The Laboratoire de l'Accelerateur Lineaire (LAL) https://www.lal.in2p3.fr and the ATLAS and CMS collaborations at CERN. Our principal collaborators at LAL are David Rousseau and Balazs Kegl. The project started in 2015 with the organization of a large world-wide challenge in machine learning that attracted nearly 2000 participants. The theme of the challenge was to improve the statistical significance of the discovery of the Higgs Boson in a particular decay channel, using machine learning. The outcome of the challenge impacted very importantly the methodology used by HEP researchers, introducing new ways of conducting cross-validation to avoid over-fitting and state-of-the-art learning machines, such as XGboost and deep neural networks. The setting of the challenge was purposely simplified to attract easily participants with no prior knowledge of physics. Following the success of the challenge, we decided to dig deeper and re-introduce into the problem more difficulties, including systematic noise.

1. **SystML.** (Cécile Germain, Isabelle Guyon, Michèle Sebag, Victor Estrade, Arthur Pesah): Preliminary explorations were conducted by an intern from ENSTA (Arthur Pesah) and Victor Estrade as an M2 intern. Victor Estrade started in September 2016 his PhD on this subject. The SystML project aims at tackling this problem from 3 angles:
   - calibrating simulators better;
   - using machine learning to train post-hoc correctors of systematic noise;
   - tolerating systematic noise by computing more accurately their effect on the statistical power of tests.

Exploratory work was performed by Arthur Pesah and Victor Estrade to align the distributions generated by simulators and real data using Siamese networks and adversarial learning. Although good results were obtained on toy data and bioinformatics data, disappointing results were obtained on HEP data. Victor Estrade is now turning to another technique: tangent propagation. This method allows training neural networks, which are robust to "noise" in given directions of feature space.

2. **TrackML.** (Isabelle Guyon): A new challenge is in preparation with LAL and the ATLAS and CMS collaborations. The instantaneous luminosity of the Large Hadron Collider at CERN is expected to increase so that the amount of parasitic collisions can reach a level of 200 interaction per bunch crossing, almost a factor of 10 w.r.t the current luminosity. In addition, the experiments plan a 10-fold increase of the readout rate. This will be a challenge for the ATLAS and CMS experiments, in particular for the tracking, which will be performed with a new all Silicon tracker in both experiments. In terms of software, the increased combinatorial complexity will have to be dealt with within flat budget at best. To reach out to Computer Science specialists, a Tracking Machine Learning challenge (TrackML) is being set up for 2017, building on the experience of the successful Higgs Boson Machine Learning challenge in 2015. The problem setting is to provide participants with coordinates of "hits" that are excitations of detectors along particle trajectories. The goal of the challenge is to devise fast software to "connect the dots" and guess particle trajectories. TAO contributes preparing the challenge platform using Codalab and preparing the challenge protocol and baseline methods.

5. Highlights of the Year

5.1. Highlights of the Year

- Yann Ollivier was invited to contribute to Yann LeCun's official series of talks on Deep Learning at College de France.
- Isabelle Guyon was program chair of the NIPS 2016 conference (in 2017 she will be general chair).
- The TAO team was selected by Microsoft to become the community lead of the competition plaform Codalab. We received a $20 000 Azure for research grant.
- Paola Tubaro co-organized the Second European Social Networks (EUSN) Conference, a major interdisciplinary event for the international research community interested in social networks. Jean-Daniel Fekete (AVIZ) was keynote speaker, and some TAO members contributed papers.

6. New Software and Platforms

6.1. CMA-ES

Covariance Matrix Adaptation Evolution Strategy
KEYWORDS: Numerical optimization - Black-box optimization - Stochastic optimization
SCIENTIFIC DESCRIPTION

The CMA-ES is considered as state-of-the-art in evolutionary computation and has been adopted as one of the standard tools for continuous optimisation in many (probably hundreds of) research labs and industrial environments around the world. The CMA-ES is typically applied to unconstrained or bounded constraint optimization problems, and search space dimensions between three and a hundred. The method should be applied, if derivative based methods, e.g. quasi-Newton BFGS or conjugate gradient, (supposedly) fail due to a rugged search landscape (e.g. discontinuities, sharp bends or ridges, noise, local optima, outliers). If second order derivative based methods are successful, they are usually faster than the CMA-ES: on purely convex-quadratic functions, f(x)=xTHx, BFGS (Matlabs function fminunc) is typically faster by a factor of about ten (in terms of number of objective function evaluations needed to reach a target function value, assuming that gradients are not available). On the most simple quadratic function f(x)=‖x‖2=xTx BFGS is faster by a factor of about 30.

FUNCTIONAL DESCRIPTION

The CMA-ES is an evolutionary algorithm for difficult non-linear non-convex black-box optimisation problems in continuous domain.

- Participants: Nikolaus Hansen and Emmanuel Benazera
- Contact: Nikolaus Hansen
- URL: https://www.lri.fr/~hansen/cmaesintro.html

6.2. COCO

COmparing Continuous Optimizers
KEYWORDS: Benchmarking - Numerical optimization - Black-box optimization - Stochastic optimization
SCIENTIFIC DESCRIPTION

COmparing Continuous Optimisers (COCO) [61] is a tool for benchmarking algorithms for black-box optimisation. COCO facilitates systematic experimentation in the field of continuous optimization. COCO provides: (1) an experimental framework for testing the algorithms, (2) post-processing facilities for generating publication quality figures and tables, (3) LaTeX templates of articles which present the figures and tables in a single document.

The COCO software is composed of two parts: (i) an interface available in different programming languages (C/C++, Java, Matlab/Octave, Python) which allows to run and log experiments on a suite of test functions. Several testbeds are provided. (ii) a Python tool for generating figures and tables that can be browsed in `html` or used in LaTeX templates.
FUNCTIONAL DESCRIPTION

The COCO platform provides the functionality to automatically benchmark optimization algorithms for bounded or unbounded, (yet) unconstrained optimization problems in continuous domains. Benchmarking is a vital part of algorithm engineering and a necessary path to recommend algorithms for practical applications. The COCO platform releases algorithm developers and practitioners alike from (re-)writing test functions, logging, and plotting facilities by providing an easy-to-handle interface in several programming languages. The COCO platform has been developed since 2007 and has been used extensively within the "Blackbox Optimization Benchmarking (BBOB)" workshop series since 2009. Overall, 140+ algorithms and algorithm variants by contributors from all over the world have been benchmarked with the platform so far and all data is publicly available for the research community. A new test suite of bi-objective problems [70] has been used for the BBOB-2016 workshop at GECCO.

- Participants: Dimo Brockhoff, Arnaud Liefooghe, Thanh-Do Tran, Nikolaus Hansen, Anne Auger, Marc Schoenauer, Ouassim Ait Elhara, Asma Atamna, Tea Tusar and Dejan Tusar
- Partners: Université technique de Dortmund - Université technique de Prague
- Contact: Dimo Brockhoff
- URL: https://github.com/numbbo/coco

6.3. Cartolabe

FUNCTIONAL DESCRIPTION

The goal of Cartolabe is to build a visual map representing the scientific activity of an institution/university/domain from published articles and reports. Using the HAL Database and building upon the AnHALytics processing chain, Cartolabe provides the user with a map of the thematics, authors and articles and their dynamics along time. ML techniques are used for dimensionality reduction, cluster and topics identification; visualisation techniques are used for a scalable 2D representation of the results.

- Participants: Felix Louistisserand, Philippe Caillou, Michèle Sebag, Jean-Daniel Fekete (AVIZ)
- Partners: AVIZ (Inria)
- Contact: Philippe Caillou
- URL: https://cartolabe.lri.fr

6.4. METIS

KEYWORDS: Optimization - Energy
FUNCTIONAL DESCRIPTION

Many works in Energy Optimization, in particular in the case of high-scale sequential decision making, are based on one software per application, because optimizing the software eventually implies losing generality. Our goal is to develop with Artelys a platform, METIS, which can be used for several applications. In 2012 we interfaced existing codes in Artelys and codes developed in the TAO team, experiments have been performed and test cases have been designed. A main further work is the introduction of generic tools for stochastic dynamic programming into the platform, for comparison and hybridization with other tools from the UCT-SIG.

- Participants: Olivier Teytaud, Jeremie Decock, Jean-Joseph Christophe, Vincent Berthier, Marie Liesse Cauwet and Sandra Cecilia Astete Morales
- Partner: Artelys
- Contact: Olivier Teytaud
- URL: https://www.lri.fr/~teytaud/metis.html

6.5. io.datascience

FUNCTIONAL DESCRIPTION

This Data as a Service (DaaS) platform is developed in the context of the Center for Data Science and the TIMCO project. Its overall goals is to exploit the advances in semantic web techniques for efficient sharing and usage of scientific data [36], [69]. A related specific software is the Tester for Triplestore (TFT) software suite, which benchmarks the compliance of sparql databases wrt the RDF standard and publishes the results through the SparqlScore service. The io.datascience platform has been selected for presentation at numerous venues, see section 10.3 for details.

- Contact: Cécile Germain
- URL: https://io.datascience-paris-saclay.fr/

6.6. CodaLab

KEYWORDS Benchmarking, competitions.

FUNCTIONAL DESCRIPTION

Challenges in machine learning and data science are competitions running over several weeks or months to resolve problems using provided datasets or simulated environments. Challenges can be thought of as crowdsourcing, benchmarking, and communication tools. They have been used for decades to test and compare competing solutions in machine learning in a fair and controlled way, to eliminate “inventor-evaluator" bias, and to stimulate the scientific community while promoting reproducible science.

Codalab Competitions (http://competitions.codalab.org) is a project that was started by Microsoft Research in 2013 in which Isabelle Guyon has taken an active part, to promote the use of challenges in Machine Learning and Data Science. The TAO team has been selected to take over the project under Isabelle Guyon’s leadership. The transfer has been successfully completed in the fall 2016. New features are being implemented, including developing a Wizard http://staging.chalab.eu/.

With already over 50 public competitions (including this year the Data Science Game, a student Olympiad co-organized by our PhD. student Benjamin Donnot http://www.datasciencegame.com/, the AutoML challenge http://automl.chalearn.org/ [37] and a new contest in the LAP challenge series http://chalearnlap.cvc.uab.es/ [42], co-organized by Isabelle Guyon), Codalab is taking momentum in medical imaging, computer vision, time series prediction, text mining, and other applications. TAO is going to continue expanding Codalab to accommodate new needs. For example, two competitions in preparation – TrackML competition (in High Energy Physics) [68] and the See.4C competition (spatio-temporal time series in collaboration with RTE) [43] – will require code submission, permitting to benchmark methods in a controlled environment. We are re-designing the backend of CodaLab to allow organizers to add more servers to satisfy on-the-fly demands of new competitions. Other features coming soon will be the possibility of interacting with a data generating model (rather than analyzing "canned" data), which enables the organization of reinforcement learning competitions and the possibility of organizing "coopetitions" (a mix of competition and collaboration). Other existing challenge platforms are too restrictive to simulate collaboration between participants and implement "coopetitions". Our starting PhD. student Lisheng Sun designed and implemented a first prototype of coopetition "Beat AutoSKLearn", which was run at the NIPS Challenges in Machine Learning workshop (CiML 2016 http://ciml.chalearn.org/).

- Contact: Isabelle Guyon
- URL: http://competitions.codalab.org

7. New Results

7.1. Optimal Decision Making under Uncertainty

The Tao UCT-SIG is working mainly on mathematical programming tools useful for power systems. In particular, we advocate a data science approach, in order to reduce the model error - which is much more critical than the optimization error, in most cases. Real data are the best way for handling uncertainties. Our main results in 2016 are as follows:

Noisy optimization In the context of stochastic uncertainties, noisy optimization handles the model error by simulation-based optimization. Our results include:

- It has been conjectured that gradient approximation by finite differences (hence, not a comparison-based method) is necessary for reaching such a simple regret of O(1/N). We answer this conjecture in the negative [27], providing a comparison-based algorithm as good as gradient methods, i.e. reaching O(1/N) - under the condition, however, that the noise is Gaussian.
- The concept of Regret is widely used in the bandit literature for assessing the performance of an algorithm. The same concept is also used in the framework of optimization algorithms, sometimes under other names or without a specific name. Experimental results on the noisy sphere function show that the approximation of Simple Regret, termed Approximate Simple Regret, used in some optimization testbeds, fails to estimate the Simple Regret convergence rate, and propose a new approximation of Simple Regret, the Robust Simple Regret [22].

Capacity Expansion Planning The optimization of capacities in large scale power systems is a stochastic problem, because the need for storage and connections (i.e. exchange capacities) varies a lot from one week/season to another. It is usually tackled through sample average approximation, i.e. assuming that the system which is optimal on average over the last 40 years (corrected for climate change) is also approximately optimal in general. However, in many cases, data are high-dimensional; the sample complexity, i.e. the amount of data necessary for a relevant optimization of capacities, increases linearly with the number of parameters and can be scarcely available at the relevant scale. This leads to an underestimation of capacities. We suggested the use of bias correction in capacity estimation, and investigated the importance of the bias phenomenon, and the efficiency of both standard and original bias correction tools [49].

Multi-armed bandits We studied the problem of sequential decision making in the context of multi-armed bandits. We provided:

- An algorithm to handle a non-stationary formulation of the stochastic multi-armed bandit where the rewards are not assumed to be identically distributed, that achieves both a competitive regret and sampling complexity against a best sequence of arms. See [57].
- An algorithm to handle the task of recommending items (actions) to users sequentially interacting with a recommender system. Users are modeled as latent mixtures of C many representative user classes, where each class specifies a mean reward profile across actions. Both the user features (mixture distribution over classes) and the item features (mean reward vector per class) are unknown a priori. The user identity is the only contextual information available to the learner while interacting. This induces a low-rank structure on the matrix of expected rewards from recommending item a to user b. The problem reduces to the well-known linear bandit when either user-or item-side features are perfectly known. In the setting where each user, with its stochastically sampled taste profile, interacts only for a small number of sessions, we develop a bandit algorithm for the two-sided uncertainty. It combines the Robust Tensor Power Method with the OFUL linear bandit algorithm. We provide the first rigorous regret analysis of this combination. See [59].

Confidence intervals for streaming data We consider, in a generic streaming regression setting, the problem of building a confidence interval (and distribution) on the next observation based on past observed data. The observations may have arbitrary dependency on the past observations and come from some external filtering process making the number of observations itself a random stopping time. In this challenging context, we provide confidence intervals based on self-normalized vector-valued martingale techniques, applied to the estimation of the mean and of the variance. See [65].

Forecasting tool for Hydraulic networks We studied a problem of prediction in the context of the monitoring of an hydraulic network by the French company Prolog-ingenierie. The problem is to predict the value of some specific sensor in the next thirty minutes from the activity of the network (values of all other sensors) in the recent past. We designed a simple tool for that purpose, based on a random forests. The tool has been tested on data generated from the activity recorded on the Parisian hydraulic network in 2010, 2011 and 2013.

7.2. Continuous Optimization

Markov Chain Analysis of Evolution Strategies The theory of Markov chains with discrete time and continuous state space turns out to be very useful to analyze the convergence of adaptive evolution strategies, including simplified versions of the state-of-the art CMA-ES. Exploiting invariance properties of the objective function and of a wide variety of comparison-based optimisation algorithms, we have developed a general methodology to prove global linear convergence [4]. The constructed Markov chains also show the connection between comparison-based adaptive stochastic algorithms and Markov chain Monte Carlo algorithms. Furthermore, we have continued to work on new theoretical tools that exploit deterministic control models to prove the irreducibility and T-chain property of general Markov chains. These tools promise to trivialise some stability proofs of the Markov chains we are interested in to analyse.

Large-scale Optimisation Algorithms We have been working on (improved) variants of CMA-ES with more favorable scaling properties with the dimension. While computing and using the natural gradient in appropriate subspaces turned out to be considerably more difficult than expected, we explored variants that restrict the covariance via projection, so-called VkD-CMA-ES [21]. We derived a computationally efficient way to update the restricted covariance matrix, where the richness of the model is controlled by the integer parameter k. This parameter provides a smooth transition between the case where only diagonal elements are subject to changes and changes of the full covariance matrix. In the latter case, the update is equivalent with the original CMA-ES. In order to get rid of the control parameter we propose an adaptation of k which turns out to be surprisingly efficient [20].

Analysis of Lagrangian based Constraints Handling in Evolution Strategies We have addressed the question of linear convergence of evolution strategies on constrained optimisation problems with one linear constraint. Based on previous works, we consider an adaptive augmented Lagrangian approach for the simple (1+1)-ES [23] and for the CMA-ES [24]. By design both algorithms derive from a framework with an underlying homogenous Markov chain which paves the way to prove linear convergence on a comparatively large class of functions. For the time being, stability of the Markov chain, associated with linear convergence, has been shown empirically on convex-quadratic and ill-conditioned functions.

Benchmarking of continuous optimizers We have been pursuing our efforts towards improving the standards in benchmarking of continuous optimisers [61], [62], [60]. Three new testbeds have been developed and implemented. (i) A bi-objective testbed [70] where also a corresponding performance assessment procedure has been advised [58]. In this context, a new version of MO-CMA-ES has been developed and benchmarked [39] on this testbed. (ii) A large-scale testbed, as a straight forward extension of the standard tested. The extension is based on a general methodology we have developed to construct non-trivial but scalable test functions [19]. (iii) a constrained testbed (unpublished).

7.3. Data Science

High Energy Physics The focus of the period has been to expand the collaboration with the High Energy Physics experiments started with the success of the 2014 HiggsML challenge [18] to new issues. The subject of V. Estrade Phd is to advance domain adaptation methods in the specific context of uncertainty quantification and calibration. So far, transfer learning has been addressed only with classical, additive and differentiable objective functions as performance criteria. However, learning to discover, exemplified by HEP, relies on more global and difficult criteria, related to the Area Under Roc Curve (AUC) and Neymann-Pearson learning. CERN funds another PhD (A. Pol), on anomaly detection. Another promising theme has emerged with the ongoing organization of a Tracking Challenge (TrackML) [52], [68], which focuses on extreme scaling of ML image processing.

Personal Semantics Our algorithm for inducing a taxonomy from a set of domain terms, that was placed first in the international Taxonomy Induction task, part of the SemEval 2015 conference in Denver, has been improved by the development of a robust technique for discovering the domain vocabulary for a new topic using a directed crawler we created. We have created hundreds of taxonomy for personal themes (hobbies, illnesses) that can be integrated into our Personal Semantics platform PTraces, and have deployed and evaluated the taxonomies. We also have introduced newer machine learning methods, such as Latent Dirichlet Allocation, for better recognition of domain vocabularies [51], [67].

Distributed system observation The work on distributed system automated analaysis and description has been persued thru the continued development of the GAMA multi-agent framework https://github.com/gama-platform/gama/wiki. The simulation framework has been applied to the study of a new protocol for MOOC management [6]. Philippe Caillou is associated to the young researcher ANR ACTEUR, coordinated by Patrick Taillandier (IDEES, Rouen university). With this project, the BDI cognitive agent model has been improved both in term of flexibility and ease of use for the non expert modeler [46].

Computational social sciences Thomas Schmitt's PhD focuses on the matching of job offers and applicant CVs. An informal collaboration with the Qapa agency (FUI proposal underway) gave us access to the 2012-2016 logs of their activity (CVs, job announcements and application clicks). This wealth of data delivered some unexpected findings, e.g., as to the differences between people's practice (the clicks) and their say (the documents). In [44], with Philippe Caillou and Michèle Sebag, a deep NN system MAJORE (MAtching JObs and REsumes) was proposed, trained to match the metric properties extracted from the collaborative filtering matrix, and address the cold start problem. A further research perspective, in collaboration with J.-P. Nadal from EHESS, is to build an observatory of the job demand dynamics.

The Cartolabe project, started in Feb. 2016 (F. Louistisserand's engineer stint), applies machine learning techniques to build an interpretable representation from vast amounts of scientific articles. The goal is to use raw textual data, and the results of the pre-processing chain achieved by ANHALYTICS, to define a topology on authors, scientific themes, and teams, and enforce its 2D projection in a semantically admissible way. The collaboration with AVIZ is key to enable the scalable and navigable exploitation of this map. The perspective for 2017 is to build a visual interrogation of the map (locating all author names relevant to a given request) and to display the temporal evolution of the research activities.
Amiqap studies the relation between quality of life at work and company performance, using both survey data on individual workers (collected by DARES, the statistical service of the French Ministry of labor, in 2013) and administrative data on companies provided by SECAFI, a union body. The study is run by a team within TAO (Philippe Caillou, Isabelle Guyon, Michèle Sebag and Paola Tubaro, plus post-doctoral researcher Olivier Goudet and intern Diviyan Kalainathan) in collaboration with Mines ParisTech social science and economics (SES) department, the RITM economics research center (Univ. Paris Sud) and the think-tank La Fabrique de l'Industrie. In its first stage, the exploratory analysis delivered some unexpected results, e.g. as to the existence of a "industry worker cluster", or the non-monotonous relationship between autonomy, salary and subjective satisfaction. A summary of these findings has been released online on the website of La Fabrique de l'Industrie, as a complement to their book on the same topic (published in October 2016). The exploratory analysis of the SECAFI data (yet unpublished) complements the above and shows how workers' satisfaction correlates with companies' financial and social performance indicators, though with marked differences across industries. The key question regards the nature of this relationship: cause, effect or due to a confounder feature (the industrial sector). Further research (Diviyan Kalainathan's PhD, O. Goudet post-doc) will focus on the use and extension of causal modelling algorithms on this issue; these perspectives attract quite some interest from the ministry (DARES) and big industrial players, willing to assess the relevance of their HR policies.

7.4. Designing criteria

Algorithm selection and configuration Two PhD theses are related to the former *Crossing the Chasm* SIG: Nacim Belkhir (CIFRE PhD with Thalès) is working on Per Instance Algorithm Configuration (PIAC) in the context of continuous optimization. He has worked on the use of surrogate models for feature computation in case of expensive objective functions [26] and has validated his work with Differential Evolution applied to BBOB testnehc [25]. Defence planned for March 2017.

François Gonard's PhD is dedicated to optimization algorithm selection. The original application domain was that of expensive car industry simulations (within the IRT-ROM project). The lack of real test cases made him investigate some combinatorial optimization setting, for which there exist public datasets. François obtained a "Honorable mention from the jury" for his submission to the ICON Challenge (http://iconchallenge.insight-centre.org/), for its original approach coupling a pre-scheduler and an algorithm selector [34]. Defence is planned for November 2017.

The work done during Mustafa Misir's post-doc stint (ERCIM 2013-2014), regarding the formalization and tackling of the algorithm selection problem in terms of a collaborative filtering problem, was finally published [15].

A statistical physics perspective Our activity on probabilistic model design is progressively moving from static explicit interactions to dynamical ones and to latent variable models, taking inspiration from latent feature representations provided by deep learning techniques. Concerning explicit pairwise interactions models like in [14] initially motivated by traffic applications, a systematic treatment of loop corrections based on a minimal cycle basis [11] has led us to propose: (i) a fast and large scale generalized belief propagation method (GCBP) with more robust convergence properties than bare belief propagation (ii) an inverse approximate MRF with linear scaling of the computational time, compliant with GCBP (iii) a new sampling method based on extracting random sub-graph of tree-width 2 on which GCBP can provide exact marginals. More generally considering effect of problematic i.e. frustrated cycles open the possibility for new criteria in model design. In particular we have started to bridge this work with the analysis of multi-layer restricted Boltzmann machines (RBM). Remarkably these possess a planar dual representation and we are expecting the density of frustrated

cycles nodes to play a key role when characterizing an RBM learned from structured data by contrast with purely random instances. Additionally we have identify some properties of the data themeselves that have to be taken into consideration when learning static [9] or dynamical [8] Ising models.

Artificial Immune Systems Within the E-Lucid project with Thalès TERESIS, around anomaly detection in network trafic, a first approach has been developed using Artificial Immune System (AIS) and the concept of Voronoi representation. A first proof of concept was a poster at the GECCO conference [66], before a complete paper was published at the PPSN conference [41]. Note that this work on anomaly detection is ongoing using Deep Learning. AIS are also the basis of Chaouki Boufenar's PhD work (visiting TAO from U. Oran, Algérie), with a first work on arabic characters recognition [5].

7.5. Deep Learning and Information Theory

Neural networks for computer vision We continued working on the topic of large-scale image segmentation with multiple object detection. The application target is the analysis of high-resolution multispectral satellite images covering the Earth. Challenges are numerous: finding good features to distinguish objects, obtaining fine-resolution segmentations, while dealing with badly-registered groundtruth, keeping a scalable complexity, while avoiding boundary effects when tiling a big image into small ones, which are processed independently and merged back together. We propose to move to fully convolutional neural networks [40] to avoid artifacts from patch-based approaches. We show the benefits of training first on imprecise groundtruth, which is available in large amounts, and then refining on precise but scarce groundtruth [13]. To further refine the segmentation, as convolutional networks tend to produce blurry outputs, we use recurrent neural networks to learn the partial differential equation (PDE) which would sharpen the segmentations, i.e. an iterative process taking into account the edges in the original image to locate precisely their boundaries and to sharpen them [63]. Finally, to benefit simultaneously from information at various resolutions, we design a new, more suitable architecture [64].

We also started to work on medical image classification, in the long-term goal of automatic diagnosis, in collaboration with the Necker Hospital and the Inria start-up Therapixel, and on image labelling and representation, with the database editor company Armadillo, through the Adamme project (cf Section 9.2.1).

In collaboration with the University of Barcelona, we organize a series of challenges in video analysis of human behavior (ChaLearn Looking at People series). Looking at People (LAP) is an area of research that deals with the problem of automatically recognizing people in images, detecting and describing body parts, inferring their spatial configuration, performing action/gesture recognition from still images or image sequences, often including multi-modal data. Any scenario where the visual or multi-modal analysis of people takes a key role is of interest to us within the field of Looking at People. We have been leaders in organizing challenges in this area since 2013 [10], [12], [31], organizing events sponsored by DARPA, NSF, Microsoft, Google, Facebook, NVIDIA, and others. In 2016 we organized follow up competitions on gesture recognition [48] and face aging [32] to advance the state-of-the-art in areas we had previously explored. We also organized two rounds of a completely new recognition on personality trait evaluation from short video clips [42], [29]. The purpose of this study is to evaluate whether human first impression judgements are consistent and reproducible. Such research could lead to device coaching curricula to help job applicants present themselved better and hiring managers to overcome unsubstantiated negative biases. The winners of the challenge used Deep Learning methods. The third place winners teamed up with the organizers to put together a demonstration system, which was shown at the NIPS conference(https://nips.cc/Conferences/2016/Schedule?showEvent=6314). Work performed in collaboration with UC Berkeley on fingerprint verification using Deep Learning was also presented in this demonstration.

Natural Gradients for Deep Learning Deep learning is now established as a state-of-the-art technology for performing different tasks such as image or sequence processing. Nevertheless, much of the computational burden is spent on tuning the hyper-parameters. On-going work, started during the TIMCO project, is proposing, in the framework of Riemannian gradient descents, invariant algorithms for training neural networks that effectively reduce the number of arbitrary choices, e.g., affine transformations of the activation functions or shuffling of the inputs. Moreover, the Riemannian gradient descent algorithms perform as well as the state-of-the-art optimizers for neural networks, and are even faster for training complex models. The proposed approach is based on Amari's theory of information geometry and consists in practical and well-grounded approximations for computing the Fisher metric. The scope of this framework, going beyond Deep Learning, encompasses any class of statistical models. This year's contribution is a new, simple framework (both theoretical and practical) that allowed us to release a simpler implementation of these techniques in Torch (one of the main deep learning libraries in use) and demonstrate good performance on real data. We have also started to explore criteria from information geometry criteria for automating the construction and selection of network architectures themselves, a major problem given the current trend towards highly complex, hand-built model architectures (P. Wolinski's PhD).

Training dynamical systems online without backtracking with application to recurrent neural networks. The standard way to train recurrent neural networks and other systems that exhibit a temporal dynamical behavior involves "backpropagation through time", which as the name indicates goes backward in time and is unrealistic. Last year we proposed an algorithm to learn the parameters of a dynamical system in an online, memoryless setting, thus scalable and requiring no backpropagation through time, in a way guaranteed to be unbiased. This year we started to provide full convergence proofs for this algorithm (the first of their kind). Moreover Corentin Tallec (PhD) proposed a considerably simpler version of the algorithm keeping the same key mathematical properties, which now allows for a simple "black-box" implementation on top of any existing recurrent network model.

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Contracts with Industry

Thales Research & Technology 2014-2017 (30 kEuros), related to Nacim Belkhir's CIFRE PhD
Coordinator: Marc Schoenauer
Participants: Johann Dréo, Pierre Savéant, Nacim Belkhir

Orange 2013-2016 (30 kEuros), related to Robin Allesiardo's CIFRE PhD
Coordinator: Michèle Sebag
Participants: Raphael Feraud, Robin Allesiardo

Réseau Transport d'Electricité 2015-2018 (30 kEuros), related to Benjamin Donnot's CIFRE PhD
Coordinator: Olivier Teytaud (until May 2016), now Isabelle Guyon and Marc Schoenauer
Participants: Benjamin Donnot, Antoine Marot

9. Partnerships and Cooperations

9.1. Regional Initiatives

PGMO NUMBBER 2016-2018 (60 kEuros)
Coordinator: FMJH(Fondation mathématiques Jacques Hadamard - Paris Saclay) & Anne Auger
Participants: Anne Auger, Nikolaus Hansen

9.2. National Initiatives

ROM *Model Reduction and Multiphysics Optimization* 2014-2016 (50 Keuros)
Coordinator: IRT System X
Participants: Marc Schoenauer, Michèle Sebag, François Gonard (PhD)

MAJORE *A Collaborative Filtering Approach to Matching Job Openings and Job Seekers*, 2013-2016 (105 kEuros)
Thomas Schmitt's PhD (funded by ISN).
Participants: Philippe Caillou, Michèle Sebag, Thomas Schmitt (PhD)

AutoML *An empirical approach to Machine Learning* 2014-2017 (104 kEuros)
Sourava Mishra's PhD
Participants: Michèle Sebag, Balazs Kégl, Sourava Mishra

ReMODeL *Rewarded Multimodal Online Deep Learning* 2015-2016 (31,5 kEuros)
This project lies at the junction of reinforcement learning, deep learning, computational neuroscience and developmental robotic fields. It is closely related to the transversal DIGITEO robotic theme, Roboteo.
Participants: Michèle Sebag, Mathieu Lefort, Alexander Gepperth

AMIQAP 2015-2016 (12 months of Postdoctoral fellow). Project funded by ISN
Participants: Philippe Caillou, Olivier Goudet, Isabelle Guyon, Michèle Sebag, Paola Tubaro, Diviyan Kalavanathan (2016 intern, 2017 PhD)

NUMBBO 2012-2017 (290kEuros for TAO). Analysis, Improvement and Evaluation of Numerical Blackbox Optimizers, ANR project, Coordinator Anne Auger, Inria. Other partners: Dolphin, Inria Lille, Ecole des Mines de Saint-Etienne, TU Dortmund
Participants: Anne Auger, Nikolaus Hansen, Marc Schoenauer, Ouassim Ait ElHara

ACTEUR 2014-2018 (236kEuros). Cognitive agent development for urban simulations, ANR project, Coordinator P. Taillandier (IDEES, Univ Rouen).

Participant: Philippe Caillou

9.2.1. Other

POST 2014-2017 (1,220 MEuros, including 500 kEuros for a 'private' cluster). Platform for the optimization and simulation of trans-continental grids
ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie)
Coordinator: ARTELYS
Participants: Olivier Teytaud, Marie-Liesse Cauwet, Jérémie Decock, Sandra Cecilia Astete Morales, David L. Saint-Pierre, J. Decock

E-LUCID 2014-2017 (194 kEuros)
Coordinator: Thales Communications & Security S.A.S
Participants: Marc Schoenauer, Cyril Furtlehner

PIA ADAMME 2015-2018 (258 kEuros)
Coordinator: Bull SAS
Participants: Marc Schoenauer, Yann Ollivier, Gaetan Marceau Caron, Guillaume Charpiat, Cécile Germain-Renaud, Michèle Sebag

CNES contract 2015-2017 (70 kEuros)
Coordinator: Manuel Grizonnet (CNES) & Yuliya Tarabalka (Inria Sophia-Antipolis, Titane team)
Participant: Guillaume Charpiat

ESA Tender 2016-2017 (52 kEuros)
Coordinator: Oana Togt (TNO) & Marc Schoenauer
Participant: Marc Schoenauer

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

EHRI-II 2015-2019 (7 969 kEuros). European Holcaust Research Infrastructure, H2020, Coordinator NIOD, Amsterdam. Digital Humanities.
Participants: Gregory Grefenstette

See.4C 2016-2017 (2 700 kEuros). SpatiotEmporal ForEcasting: Coopetition to meet Current Cross-modal Challenges
Participants: Isabelle Guyon

9.3.2. Collaborations with Major European Organizations

MLSpaceWeather 2015-2019. Coupling physics-based simulations with Artificial Intelligence.
Coordinator: CWI
Participants: Michèle Sebag, Aurélien Decelle, Cyril Furtlehner.

ESA tender 2015-2016, through collaboration with TNO (see Section 9.2.1).

9.4. International Initiatives

9.4.1. CIADM

Title: Computational intelligence and Decision making

International Partner (Institution - Laboratory - Researcher):

NUTN (Taiwan) - Multimedia Informatics Lab - Chang-Shing Lee

Start year: 2015

See also: http://www.lri.fr/~teytaud/indema.html

The associate team works on computation intelligence for decision making, with different application fields for the various partners: - power systems (Tao) - eLearning (Oase) - games (Ailab)

9.4.2. S3-BBO

Title: Threefold Scalability in Any-objective Black-Box Optimization

International Partner (Institution - Laboratory - Researcher):

Shinshu (Japan) - Tanaka-Hernan-Akimoto Laboratory - Hernan Aguirre

Start year: 2015

See also: http://francejapan.gforge.inria.fr/doku.php?id=associateteam

This associate team brings together researchers from the TAO and Dolphin Inria teams with researchers from Shinshu university in Japan. Additionally, researchers from the University of Calais are external collaborators to the team. The common interest is on black-box single and multi-objective optimization with complementary expertises ranging from theoretical and fundamental aspects over algorithm design to solving industrial applications. The work that we want to pursue in the context of the associate team is focused on black-box optimization of problems with a large number of decision variables and one or several functions to evaluate solutions, employing distributed and parallel computing resources. The objective is to theoretically derive, analyze, design, and develop scalable black-box stochastic algorithms including evolutionary algorithms for large-scale optimization considering three different axes of scalability: (i) decision space, (ii) objective space, and (iii) availability of distributed and parallel computing resources.

We foresee that the associate team will make easier the collaboration already existing through a proposal funded by Japan and open-up a long term fruitful collaboration between Inria and Shinshu university. The collaboration will be through exchanging researchers and Ph.D. students and co-organization of workshops.

9.4.3. Informal International Partners

Marc Schoenauer partner of the ARC-DP (Australian Research Council Discovery Project) *bio-inspired computing methods for dynamically changing environments*. Coordinator: University of Adelaide (Frank Neumann), 5 years from Nov. 2015, 400 k$-AUS. Visit to Adelaide planned in Feb. 2017.

Isabelle Guyon partner of UC Berkeley *Fingerprint verification with deep siamese neural networks using ultratonic sensor data.* Co-advisor of a master student (Baiyu Chen). Partners: Alyosha Efros, Bernhard Boser.

9.4.4. Participation in Other International Programs

9.4.4.1. Indo-French Center of Applied Mathematics

Contextual multi-armed bandits with hidden structure

Title: Contextual multi-armed bandits with hidden structure

International Partner (Institution - Laboratory - Researcher):

IISc Bangalore (India) - ___ECE___ - Aditya Gopalan

Duration: 12 months - April 2017

Start year: April 2016

See also: ___URL???___

Recent advances in Multi-Armed Bandit (MAB) theory have yielded key insights into, and driven the design of applications in, sequential decision making in stochastic dynamical systems. Notable among these are recommender systems, which have benefited greatly from the study of contextual MABs incorporating user-specific information (the context) into the decision problem from a rigorous theoretical standpoint. In the proposed initiative, the key features of (a) sequential interaction between a learner and the users, and (b) a relatively small number of interactions per user with the system, motivate the goal of efficiently exploiting the underlying collective structure of users. The state-of-the-art lacks a wellgrounded strategy with provably near-optimal guarantees for general, low-rank user structure. Combining expertise in the foundations of MAB theory together with recent advances in spectral methods and low-rank matrix completion, we target the first provably near-optimal sequential low-rank MAB

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Edgar Galvan Lopez University College Dublin, April 2015 - December 2016, funded by the ELEVATE Fellowship, the Irish Research Council's Career Development Fellowship co-funded by Marie Curie Actions.

9.5.1.1. Internships

Borja Seijo Universidade da Coruña, Galicia, Spain, October-November 2016, self-funded. Worked on missing data under the supervision of Isabelle Guyon.

Tomas Lungenstrass , June 2016 - June 2017, self-funded. Worked on magnetic storm prediction under A. Decelle's, C. Furtlehner's and M. Sebag's supervision.

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events Organisation

10.1.1.1. General Chair, Scientific Chair

Isabelle Guyon, Program Chair of NIPS 2016

10.1.1.2. Member of the Organizing Committees

- Anne Auger, co-organizer of the GECCO workshop on Black Box Optimization Benchmarking.
- Cécile Germain, Scientific Committee, DataScience@HEP 2016
- Nikolaus Hansen, co-organizer of the GECCO workshop on Black Box Optimization Benchmarking.
- Marc Schoenauer, Steering Committee, Parallel Problem Solving from Nature (PPSN); Steering Committee, Learning and Intelligent OptimizatioN (LION).
- Michele Sebag, President of Steering Committee, Eur. Conf. on Machine Learning and Principles and Practice of Knowledge Discovery in Databases (ECML-PKDD).
- Isabelle Guyon, co-organizer of two NIPS workshops (Challenges in Machine Learning and Spatio-temporal time series), co-organizer of AutoML workshop at ICML, co-organizer of LAP challenge workshops (ECCV, ICPR).
- Paola Tubaro, co-organizer of the Second European Social Networks (EUSN) Conference.

10.1.1.3. Member of Conference Program Committees

All TAO members are members of the Program Committees of the main conferences in the fields of Machine Learning, Evolutionary Computation, and Information Processing.

10.1.1.4. Reviewer

All TAO member review papers for the most prestigious journals in the fields of Machine Learning and Evolutionary Computation.

10.1.2. Journal

10.1.2.1. Member of the Editorial Boards

- Anne Auger, member of Editorial Board, *Evolutionary Computation Journal*, MIT Press.
- Gregory Grefenstette, member of Editorial Board, *Journal of Natural Language Engineering*, Cambridge University Press.
- Isabelle Guyon, action editor, *Journal of Machine Learning Research* (JMLR).
- Isabelle Guyon, series editor, *Microtome book series Challenges in Machine Learning* (CiML).
- Nikolaus Hansen, member of Editorial Board, *Evolutionary Computation Journal*, MIT Press.
- Marc Schoenauer, member of Advisory Board, *Evolutionary Computation Journal*, MIT Press; member of Editorial Board, *Genetic Programming and Evolutionary Machines*, Springer Verlag; action editor, *Journal of Machine Learning Research*(JMLR).
- Michèle Sebag: Editorial Board, Machine Learning, Springer Verlag.
- Olivier Teytaud, action editor, *Journal of Machine Learning Research* (JMLR).
- Paola Tubaro, member of Associate Editorial Board, *Sociology*, Sage; member of Editorial Board, *Revue Française de Sociologie*, Presses de Sciences Po.

10.1.2.2. Reviewer - Reviewing Activities

All members of the team reviewed numerous articles for international conferences and journals.

10.1.3. Invited Talks

- Isabelle Guyon. 17 Oct. ENS SMILE seminars. Network Reconstruction: the Contribution of Challenges in Machine Learning.
- Michele Sebag, 21 Jan., Deep Learning, IHP
- Michele Sebag, 24 Mar., Nutrition personnalisée et alimentation sur mesure, AgroParisTech.
- Michele Sebag, 12 Oct., Deep Learning and Artificial Intelligence, Franco-Japanese Symposium. Tokyo
- Paola Tubaro. 8 Mar. University of Insubria (Italy) economics department seminar. Investigating peer effects and performance similarity in organizational networks: a longitudinal study.
- Paola Tubaro. 15 Mar. EHESS seminar. Sociabilité et soutien social dans les communautés en ligne autour des troubles de l'alimentation.
- Paola Tubaro. 2 Nov. UQAM (Montréal), Seminar of the health communication research center (ComSante). Le phénomène 'pro ana' : Troubles alimentaires et réseaux sociaux.
- Paola Tubaro. 8 Nov. Université Laval (Québec), Seminar of the CELAT research center. Le phénomène 'pro ana' : Troubles alimentaires et réseaux sociaux.

10.1.4. Leadership within the scientific community

- Isabelle Guyon, President and co-founder of ChaLearn, a non-for-profit organization dedicated to the organization of challenge. http://chalearn.org
- Marc Schoenauer, elected Chair of ACM-SIGEVO (Special Interest Group on Evolutionary Computation), July 2015 (2-years term).
- Marc Schoenauer, founding President of SPECIES (Society for the Promotion of Evolutionary Computation In Europe and Surroundings), that organizes the yearly series of conferences *EvoStar*.
- Michèle Sebag, elected Chair of Steering Committee, ECML-PKDD; head of the Research Committee of Labex Digicosme.
- Paola Tubaro, convenor of the Social Network Analysis Group of British Sociological Association.

10.1.5. Scientific expertise

- Cécile Germain, evaluator for the H2020 calls: *ICT-2015 Topic ICT-16 – Big Data - research*
- Gregory Grefenstette, evaluator for FU21, Cap Digital, Digiteo (IASI) review board
- Gregory Grefenstette, project reviewer for the H2020 (SemCare): *Information and Communication Technologies ICT*
- Michele Sebag, evaluator for the Swedish Foundation for Strategic Research
- Michele Sebag, member of hiring jury for U. Nancy
- Paola Tubaro, evaluator for ANR, SNSF (Swiss National Science Foundation), and National Science Center (Poland).

10.1.6. Research administration

- Philippe Caillou, elected member of the Scientific Council and Academic Council.
- Cécile Germain, elected member of the U-PSUD Scientific Council and of its board. University officer for scientific computing. Deputy head of the computer science departement, in charge of research, member of the Board of the Lidex *Center for Data Science*.
- Marc Schoenauer, *Délégué Scientifique* (aka VP-Research) for the Inria Saclay Île-de-France branch until June 2016; co-chair (with Sylvain Arlot) of the *Maths-STIC* program of the Labex of Mathematics Hadamard (LMH).
- Michele Sebag, deputy director of LRI, CNRS UMR 8623; elected member of the Research Council of Univ. Paris-Saclay; member of the STIC department council; member of the Board of the Lidexes *Institut de la Société Numérique* and *Center for Data Science*.

- Paola Tubaro, member of the steering team, MSH Paris-Saclay, axis 1 "Power of algorithms".

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

Licence : Philippe Caillou, Computer Science for students in Accounting and Management, 192h, L1, IUT Sceaux, Univ. Paris Sud.

Licence : Aurélien Decelle, Computer Architecture, 60h, L2, Univ. Paris-Sud.

Licence : Aurélien Decelle, Machine Learning and Artificial Life, 55h, L2, Univ. Paris-Sud.

Licence : Aurélien Decelle, Computer Architecture, 41h, L3, Univ. Paris-Sud.

Licence and Polytech : Cécile Germain, Computer Architecture

Licence : Isabelle Guyon, Project: Creation of mini-challenges, M2, Univ. Paris-Sud.

Master : Anne Auger, Optimisation, 12h, M2 Recherche, U. Paris-sud.

Master : Guillaume Charpiat et Gaétan Marceau, Advanced Machine Learning, 34h, M2 Recherche, Centrale-Supélec.

Master : Aurélien Decelle, Machine Learning, 27h, M1, Univ. Paris-Sud.

Master : Aurélien Decelle, Information theory, 39h, M1, Univ. Paris-Sud.

Master : Cécile Germain, Parallel Programming

Master : Isabelle Guyon, Project: Resolution of mini-challenges (created by M2 students), L2, Univ. Paris-Sud.

Master : Odalric-Ambrym Maillard, Machine Learning, 6h, M2 Recherche, Univ. Paris-Sud

Master : Yann Ollivier, Deep learning, 4h, M2 Recherche, Telecom/Polytech.

Master : Michèle Sebag, Machine Learning, 12h; Deep Learning, 6h; Reinforcement Learning, 6h; M2 Recherche, U. Paris-sud.

Master : Paola Tubaro, Sociology of social networks, 24h, M2, EHESS/ENS/ENSAE.

Master : Paola Tubaro, Digital platforms, online socialization and new economic models, 6h, M2, Arts et Métiers ParisTech (ENSAM).

Doctorate: Paola Tubaro, Research Methods, 9h, University of Insubria, Italy.

10.2.2. Supervision

PhD: Jérémy BENSADON, *Applications of Information Theory to Statistical Learning*, Univ. Paris-Saclay, 02/02/2016, Yann Ollivier.

PhD: Marie-Liesse CAUWET, *Artificial intelligence with uncertainties, application to power systems*, Univ. Paris-Saclay, 30/9/2016, Olivier Teytaud.

PhD: Sandra ASTETE-MORALES, *Noisy optimization, with applications to power systems*, Univ. Paris-Saclay, 5/10/2016, Olivier Teytaud.

PhD: Robin ALLESIARDIO, *Multi-armed Bandits on non Stationary Data Streams*, Univ. Paris-Saclay, 19/10/2016, Raphaël Féraud (Orange Labs) and Michèle Sebag.

PhD in progress: Ouassim AIT ELHARA, *Large-scale optimization and Evolution Strategies*, 1/09/2012, Anne Auger and Nikolaus Hansen.

PhD in progress: Asma ATAMNA, *Evolution Strategies and Constrained Optimization*, 1/10/2013, Anne Auger and Nikolaus Hansen.

PhD in progress: Nacim BELKHIR, *On-line parameter tuning*, 1/5/2014, Marc Schoenauer and Johann Dréo (Thalès), CIFRE Thalès.

PhD in progress: Vincent BERTHIER, *Large scale parallel optimization, with application to power systems*, 1/09/2013, Michèle Sebag et Olivier Teytaud.

PhD in progress: Mehdi CHERTI *Learning to discover: supervised discrimination and unsupervised representation learning with applications in particle physics.* 01/10/2014, Balazs Kegl and Cécile Germain.

PhD in progress : Benjamin DONNOT, *Optimisation et méthodes d'apprentissage pour une conduite robuste et efficace du réseau électrique par anticipation sur base de parades topologiques.*, 1/09/2015, Isabelle Guyon and Marc Schoenauer

PhD in progress : Guillaume DOQUET, *ML Algorithm Selection and Domain Adaptation*, 1/09/2015, Michele Sebag

PhD in progress: Victor ESTRADE *Robust domain-adversarial learning, with applications to High Energy Physics,* 01/10/2016, Cécile Germain and Isabelle Guyon.

PhD in progress: François GONARD, *Automatic optimization algorithm selection and configuration*, 1/10/2014, Marc Schoenauer and Michèle Sebag, thèse IRT SystemX.

PhD in progress : Hoang M. LUONG, *Squaring the Circle in Modelling Corporate Governance, Market Structure and Innovation: A Tobin's Q Approach to R&D Investment when Network Effects Are Present*, 01/09/2014, (with M. Ugur and S. Gorgoni, at the University of Greenwich, London, UK).

PhD in progress : Emmanuel MAGGIORI, *Large-Scale Remote Sensing Image Classification*, 1/1/2015, Guillaume Charpiat (with Yuliya Tarabalka and Pierre Alliez, Inria Sophia-Antipolis)

PhD in progress: Pierre-Yves MASSÉ, *Gradient Methods for Statistical Learning*, 1/10/2014, Yann Ollivier

PhD in progress: Sourava MISHRA, *AutoML: An empirical approach to Machine Learning*, 1/10/2014, Balazs Kégl and Michèle Sebag

PhD in progress : Anna PIAZZA, *Inter-Organisational Relationships and Organisational Performance: Network Analysis Applications to a Health Care System*, 01/09/2014, Paola Tubaro (with F. Pallotti and A. Lomi, at the University of Greenwich, London, UK).

PhD in progress: Adrian POL *Machine Learning Anomaly Detection, with application to CMS Data Quality Monitoring,* 01/10/2016, Cécile Germain.

PhD in progress: Karima RAFES *Gestion et sécurité des données personnelles dans le web des objets*. 01/10/2014, Serge Abiteboul and Cécile Germain.

PhD in progress : Yasaman SARABI, *Network Analysis of Private Water Companies, Challenges Collaboration and Competition*, 15/03/2012, Paola Tubaro (at the University of Greenwich, London, UK).

PhD in progress: Thomas SCHMITT, *A Collaborative Filtering Approach to Matching Job Openings and Job Seekers*, 1/11/2014, Philippe Caillou and Michèle Sebag and Jean-Pierre Nadal (EHESS)

PhD in progress : Lisheng SUN, *Apprentissage Automatique: Vers une analyse de données automatisé*, 1/10/2016, Isabelle Guyon and Michèle Sebag

PhD in progress : Corentin TALLEC, *Reinforcement Learning and Recurrent Neural Networks: dynamical approaches*, 1/10/2016, Yann Ollivier

PhD in progress : Pierre WOLINSKI, *Learning the Architecture of Neural Networks*, 1/9/2016, Guillaume Charpiat and Yann Ollivier

10.2.3. Juries

Marc Schoenauer, PhD jury of Jonathan GUERRA (ISAE, Toulouse), External reviewer of HDR of David Gianazza (IRIT, Toulouse).

Cyril Furtlehner, PhD jury of Christophe Schülke (Université Paris Diderot).

Isabelle Guyon, PhD jury of Mathieu Bouyrie (AgroPariTech), November 29, 2016. Restauration d'images de noyaux cellulaires en microscopie 3D par l'introduction de connaissance a priori.

Guillaume Charpiat, PhD jury of Thomas Bonis (Inria Saclay); jury for the SIF best PhD prize (Gilles Kahn).

Nikolaus Hansen, PhD jury of Oswin Krause (University of Copenhagen), January 8, 2016. External reviewer.

Michele Sebag, HdR jury of Matthieu Geist (U. Lille); PhD Jury Jiaxin Kou (Royal Holloway, London); PhD Phong N'guyen (U. Geneve).

10.3. Popularization

- **Yann Ollivier** coordinated, with IHP, numerous activitives for the centenary of Claude Shannon, including a public exhibition at the Musee des Arts et Metiers, a cycle of public conferences, a contest for teachers on the best IT class project, and a workshop on the current state of information theory.
- **Yann Ollivier**, co-organizes the European Union Contest for Young Scientists (science fair for high school students from 30+ countries organized by the European Commission).
- **Aurélien Decelle**, participation to "la fête de la science" animating a presentation of arduino to high school students and families at Inria Turing.
- **Paola Tubaro**, invited talk on "Online social networks and eating disorders", ACT eating disorders association, Nîmes, 5 Feb.; invited talk on "Are we all digital laborers?", Autonomy salon of urban mobility, Paris, 8 Oct.; public interview, "L'économie peut-elle être collaborative? Rencontre avec la sociologue et chercheure Paola Tubaro", Montréal, 2 Nov.; panelist at the round table "Big data, que fait-on de nos données?", organized at Museum of civilization, Québec, 3 Nov.; co-animator, workshop on big data in the "International science and society forum" for high school students, Québec, 4-6 Nov.; panelist at the round table "L'économie peut-elle être vraiment collaborative ET sociale et solidaire?", Ministry of the Economy, Paris, 13 Dec.
- **Paola Tubaro**, training on the digital society and its effects on labor and the economy, for union leaders (CGT, 27 Apr., CFDT, 23 Jun).
- **Paola Tubaro**, radio interviews and panels: Radio France Inter, Radio France Culture, ICI Radio Canada, Aligre.fm. Book reviews and mentions in the media: Le Monde, Rue89/L'Obs, Mashable/France24, Slate.fr, Journal International de Médecine, The Conversation.
- **io.datascience** notable presentations at: CNRS-Inria day *data4ist : exploration et analyse des sources de données pour la recherche et ses environnements* (May 2016) ; Futur en Seine 2016 (Juin 2016) ; DGESIP/MiPNES seminar *Normes et échanges de données : où en est-on ?* (September 2016).

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Publications of the year

Doctoral Dissertations and Habilitation Theses

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[2] J. BENSADON. *Applications of Information Theory to Machine Learning*, Université Paris-Saclay, February 2016, https://tel.archives-ouvertes.fr/tel-01297163

[3] M.-L. CAUWET. *Uncertainties in Optimization*, Université Paris Sud - Orsay, September 2016, https://hal.archives-ouvertes.fr/tel-01422274

Articles in International Peer-Reviewed Journals

[4] A. AUGER, N. HANSEN. *Linear Convergence of Comparison-based Step-size Adaptive Randomized Search via Stability of Markov Chains*, in "SIAM Journal on Optimization", June 2016, https://hal.inria.fr/hal-00877160

[5] C. BOUFENAR, M. BATOUCHE, M. SCHOENAUER. *An Artificial Immune System for Offline Isolated Handwritten Arabic Character Recognition*, in "Evolving Systems", 2016, pp. 1-17 [*DOI :* 10.1007/s12530-016-9169-1], https://hal.inria.fr/hal-01394841

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Invited Conferences

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International Conferences with Proceedings

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