IN PARTNERSHIP WITH:
CNRS

Université de Bordeaux

Activity Report 2013

Project-Team ALEA

Advanced Learning Evolutionary Algorithms

IN COLLABORATION WITH: Institut de Mathématiques de Bordeaux (IMB)

RESEARCH CENTER
Bordeaux - Sud-Ouest

THEME
Stochastic approaches

Table of contents

Project-Team ALEA

Keywords: Statistical Methods, Machine Learning, Stochastic Methods, Optimization, Inverse Problem

Creation of the Team: 2009 March 01*, updated into Project-Team:* 2010 January 01.

1. Members

Research Scientists
Pierre Del Moral [Team leader, Inria, Senior Researcher, until Dec 2013, HdR]
François Caron [Oxford University, Researcher, HdR]

Faculty Members
Bernard Bercu [Univ. Bordeaux I, Professor, HdR]
Pierrick Legrand [Univ. Bordeaux II, Associate Professor]
Adrien Richou [Univ. Bordeaux I, Associate Professor]

External Collaborators
Arnaud Doucet [Oxford University, Professor]
Pierre Minvielle [CEA, from Jan 2013 until Dec 2013]

PhD Students
Nicolas Antunes [CNRS]
Vassili Blandin [Univ. Bordeaux I]
Philippe Fraysse [Univ. Bordeaux I, until Aug 2013]
Paul Lemaître [EDF, granted by CIFRE, until Oct 2013]
Frédéric Proia [Inria, until Aug 2013]
Adrien Todeschini [Inria, granted by EDF]
Christelle Vergé [CNES]

Post-Doctoral Fellow
Alexander Lundervold [Inria, from May 2013]

Visiting Scientists
José Blanchet [Colombia University, from Jun 2013 until Jul 2013]
François Giraud [Min. de l'Education Nationale, until Oct 2013]
Andreas Greven [Erlangen University, until Mar 2013]

Administrative Assistant
Nicolas Jahier [Inria]

Other
Mo Dick Wong [Inria, Internship, from Jun 2013 until Aug 2013]

2. Overall Objectives

2.1. Overall Objectives

In recent years, a new generation of numerical algorithms have begun to spread through the scientific community. Surprisingly enough, up to a few exceptions, many of these modern ideas do not really come from physics, but from biology and ethology. In a growing number of scientific disciplines, the researchers are now interpreting real world processes and engineering type systems less like purely deterministic and crude clockwork mechanisms, but much more like random and sophisticated biology inspired processes. This new generation of engineering models is based on stochastic ideas and natural principles like : chance, randomness, interactions, reinforcement strategies, exploration rules, biology-inspired adaptation and selection transitions, learning, reproduction, birth and death, ancestral lines and historical processes, genealogical tree evolutions, as well as self-organization principles, and many others.

These biology-inspired stochastic algorithms are often presented as natural heuristic simulation schemes without any mathematical foundations, nor a single performance analysis ensuring their convergence, nor even a single theoretical discussion that clarifies the applicability of these models. An important aspect of our project is to create a concrete bridge between pure and applied probability, statistics, biology, stochastic engineering and computer sciences. This fundamental bridging effort is probably one of the most important key to turn real nature's processes into engineering devices and stochastic algorithms, by learning what can be abstracted, copied or adapted. In the reverse angle, we can mention that these abstracted models adapting nature mechanisms and biological capabilities also provides a better understanding of the real processes.

By essence, *the team-project is not a single application-driven research project* . The reasons are three-fold. Firstly, the same stochastic algorithm is very often used in a variety of application areas. On the other hand every application domain area offers a series of different perspectives that can be used to improve the design and the performances of the algorithms. Last but not least, concrete industrial applications, as well as most of concrete problems arising in biology, physics and chemistry, require a specific attention. In general, we do not use a single class of stochastic algorithm but a broader set of stochastic search algorithms that incorporates facets of nature inspired strategies.

Our research project is centered on two central problems in advanced stochastic engineering: *Bayesian inference and rare event simulation* and more particularly *unsupervised learning, multi-target tracking, data assimilation and forecasting, as well as infection spreads inference.* These important and natural research directions have emerged as logical parts of the team project combined with interdisciplinary approaches well-represented at Bordeaux university campus.

The fundamental and the theoretical aspects of our research project are essentially concerned with the stochastic analysis of the following three classes of biology inspired stochastic algorithms: *branching and interacting particle systems, reinforced random walks and self-interacting processes, random tree based models.* One of our prospective research project is to apply the Bayesian learning methodology and the recent particle filter technology to the design of a new generation of interactive `evolutionary computation` and `stochastic art composition` models.

2.2. Highlights of the Year

- Pierrick Legrand was finalist of the Humies award (Human-Competitive Results Produced by Genetic and Evolutionary Computation) for his work on "Evolving estimators of the pointwise Holder exponent with Genetic Programming" at Genetic and Evolutionary Computation Conference (GECCO) July 6-10, 2013 In Amsterdam. The jugging committee was:
  - Erik Goodman
  - Una-May O'Reilly
  - Wolfgang Banzhaf
  - Darrell Whitley
  - Lee Spector

  The regularity of a signal can be numerically expressed using Holder exponents, which characterize the singular structures a signal contains. In particular, within the domains of image processing and image understanding, regularity-based analysis can be used to describe local image shape and appearance. However, estimating the Holder exponent is not a trivial task, and current methods tend to be computationally slow and complex. This work presents an approach to automatically synthesize estimators of the pointwise Holder exponent for digital images. This task is formulated as an optimization problem and Genetic Programming (GP) is used to search for operators that can approximate a traditional estimator, the oscillations method. Experimental results show that GP can generate estimators that achieve a low error and a high correlation with the ground truth estimation. Furthermore, most of the GP estimators are faster than traditional approaches, in some cases their runtime is orders of magnitude smaller. This result allowed us to implement a real-time estimation of the Holder exponent on a live video signal, the first such implementation in current literature.

Moreover, the evolved estimators are used to generate local descriptors of salient image regions, a task for which a stable and robust matching is achieved, comparable with state-of-the-art methods. In conclusion, the evolved estimators produced by GP could help expand the application domain of Holder regularity within the fields of image analysis and signal processing.

- The IRSES FP7 Marie Curie project ACOBSEC presented by the team ALEA was accepted.

  Over the last decade, Human-Computer Interaction (HCI) has grown and matured as a field. Gone are the days when only a mouse and keyboard could be used to interact with a computer. The most ambitious of such interfaces are Brain-Computer Interaction (BCI) systems. The goal in BCI is to allow a person to interact with an artificial system using only brain activity. The most common approach towards BCI is to analyse, categorize and interpret Electroencephalography (EEG) signals, in such a way that they alter the state of a computer. The objective of the present project is to study the development of computer systems for the automatic analysis and classification of mental states of vigilance; i.e., a person's state of alertness. Such a task is relevant to diverse domains, where a person is expected or required to be in a particular state. However, this problem is by no means a trivial one. In fact, EEG signals are known to be highly noisy, irregular and tend to vary significantly from person to person, making the development of general techniques a very difficult scientific endeavour.
  List of Beneficiaries
  - Beneficiary 1 (coordinator) Institut National de Recherche en Informatique et Automatique Inria France
  - Beneficiary 2 Universite Victor Segalen Bordeaux II UB2 France
  - Beneficiary 3 Instituto de Engenharia de Sistemas e Computadores, Investigacao e Desenvolvimento em Lisboa INESC-ID Portugal
  - Beneficiary 4 Universidad de Extremadura UNEX Spain
  - Partner 5 Instituto Tecnologico de Tijuana ITT Mexico
  - Partner 6 Centro de Investigacion Cientifica y educacion Superior de Ensenada, Baja California CICESE Mexico

3. Research Program

3.1. Research Program

This idea of analyzing nature systems and transferring the underlying principles into stochastic algorithms and technical implementations is one of the central component of the ALEA team project. Adapting nature mechanisms and biological capabilities clearly provides a better understanding of the real processes, and it also improves the performance and the power of engineers devices. Our project is centered on both the understanding of biological processes in terms of mathematical, physical and chemical models, and on the other hand, on the use of these biology inspired stochastic algorithms to solve complex engineering problems.

There is a huge series of virtual interfaces, robotic devices, numerical schemes and stochastic algorithms which were invented mimicking biological processes or simulating natural mechanisms. The terminology *"mimicking or simulating"* doesn't really mean to find an exact copy of natural processes, but *to elaborate the mathematical principles so that they can be abstracted from the original biological or physical model.* In our context, the whole series of evolutionary type principles discussed in previous sections can be abstracted into only three different and natural classes of stochastic algorithms, depending on the nature of the biology-inspired interaction mechanism used in the stochastic evolution model. These three stochastic search models are listed below :

1) *Branching and interacting particle systems (birth and death chains, spatial branching processes, mean-field interaction between generations):*

The first generation of adaptive branching-selection algorithms is very often built on the same genetic type paradigm: When exploring a state space with many particles, we duplicate better fitted individuals at the expense of light particles with poor fitness die. From a computational point of view, we generate a large number of random problem solvers. Each one is then rated according to a fitness or performance function defined by the developer. Mimicking natural selection, an evolutionary algorithm selects the best solvers in each generation and breeds them.

2) *Reinforced random walks and self-interacting chains (reinforced learning strategies, interaction processes with respect to the occupation measure of the past visited sites):*

This type of reinforcement is observed frequently in nature and society, where "beneficial" interactions with the past history tend to be repeated. A new class of historical mean field type interpretation models of reinforced processes were developed by the team project leader in a pair of articles [32], [31]. Self interaction gives the opportunity to build new stochastic search algorithms with the ability to, in a sense, re-initialized their exploration from the past, re-starting from some better fitted initial value already met in the past [33], [34].

3) *Random tree based stochastic exploration models (coalescent and genealogical tree search explorations techniques on path space):*

The last generation of stochastic random tree models is concerned with biology-inspired algorithms on paths and excursions spaces. These genealogical adaptive search algorithms coincide with genetic type particle models in excursion spaces. They have been applied with success in generating the excursion distributions of Markov processes evolving in critical and rare event regimes, as well as in path estimation and related smoothing problems arising in advanced signal processing (cf. [29] and references therein). We underline the fact that the complete mathematical analysis of these random tree models, including their long time behavior, their propagations of chaos properties, as well as their combinatorial structures are far from being completed. This class of genealogical tree based models has been introduced in [30] for solving smoothing problems and more generally Feynman-Kac semigroups on path spaces, see also [28], [29], and references therein.

4. Application Domains

4.1. Application Domains

This short section is only concerned with the list of concrete application domains developed by our team project on Bayesian inference and unsupervised learning, nonlinear filtering and rare event analysis. Most of these application areas result from fruitful collaborations with other national institutes or industries.

Three application domains are directly related to evolutionary computing, particle filtering and Bayesian inference. They are currently investigated by our team project:

1. **Multi-object tracking**. Multi-object tracking deals with the task of estimating the states of a set of moving objects from a set of measurements obtained sequentially. These measurements may either arise from one of the targets or from clutter and the measurement-to-target association is generally unknown. This problem can then be recast as a dynamic clustering one where the clusters are the clutter and the different targets. The targets actually move in time, some targets may appear/disappear over time and the number of targets is generally unknown and time-varying. The ALEA team has been involved in the ANR project Propagation with DCNS, Thalés and Exavision.
2. **Finance**. The Team ALEA is interested in the design and analysis of new advanced particle methods for option pricing, partial observation problems, and sensitivity measures computation. An international workshop has been jointly organized by ALEA and CMAP (Polytechnique) on this topic in October 2012 (organizers: E. Gobet, P. Del Moral, P. Hu).
3. **Epidemiology**. Our team is interested in the development and analysis of particle mean field models for the calibration and uncertainty propagations in complex kinetic population models. The ALEA team is involved in an interdisciplinary exploratory research project with Laboratory Ecologie & Evolution, and co-organized an international workshop on this topic in 2011.

5. Software and Platforms

5.1. BiiPS software

BiiPS is a general software, developped by Adrien Todeschini, for Bayesian inference with interacting particle systems, a.k.a. sequential Monte Carlo (SMC) methods. It aims at popularizing the use of these methods to non-statistician researchers and students, thanks to its automated “black box" inference engine.

It borrows from the BUGS/JAGS software, widely used in Bayesian statistics, the statistical modeling with graphical models and the language associated with their descriptions.

Unlike MCMC methods used by BUGS/JAGS, SMC methods are more adapted to dynamic problems (tracking, signal filtering, etc).

A beta version of the software can be downloaded from the website of the BiiPS project. This software has been presented at the international workshop BayesComp in Kyoto, the international conference ISBA in Tokyo, the conference on Premières Rencontres R in Bordeaux, and the international workshop on efficient simulation in finance in Paris.

Adrien Todeschini participated to a session focused on Recent Developments in Software for MCMC (and SMC) (MCMSki IV, Fifth IMS-ISBA joint meeting MCMSki IV, Chamonix Mont-Blanc, France).

This invited panel features four leading researchers working on software development for Bayesian computation. Each panelist will highlight their particular software, including its history, development, and relative strengths and weaknesses. Looking forward, panelists will discuss and debate the future of Bayesian computation and software development, including challenges, opportunities and bottlenecks. Emphasis throughout will be on simplifying and automating the implementation of Monte Carlo methods, with an eye towards scalability to larger and more complex models and data.

6. New Results

6.1. Sparsity-Promoting Bayesian Dynamic Linear Models

Sparsity-promoting priors have become increasingly popular over recent years due to an increased number of regression and classification applications involving a large number of predictors. In time series applications where observations are collected over time, it is often unrealistic to assume that the underlying sparsity pattern is fixed. We propose an original class of flexible Bayesian linear models for dynamic sparsity modelling. The proposed class of models expands upon the existing Bayesian literature on sparse regression using generalized multivariate hyperbolic distributions. The properties of the models are explored through both analytic results and simulation studies. We demonstrate the model on a financial application where it is shown that it accurately represents the patterns seen in the analysis of stock and derivative data, and is able to detect major events by filtering an artificial portfolio of assets.

6.2. Evolutionnary algorithms and genetic programming

The regularity of a signal can be numerically expressed using Hölder exponents, which characterize the singular structures a signal contains. In particular, within the domains of image processing and image understanding, regularity-based analysis can be used to describe local image shape and appearance. However, estimating the Hölder exponent is not a trivial task, and current methods tend to be computationally slow and complex. This work presents an approach to automatically synthesize estimators of the pointwise Hölder exponent for digital images. This task is formulated as an optimization problem and Genetic Programming (GP) is used to search for operators that can approximate a traditional estimator, the oscillations method. Experimental results show that GP can generate estimators that achieve a low error and a high correlation with the ground truth estimation. Furthermore, most of the GP estimators are faster than traditional approaches,

in some cases their runtime is orders of magnitude smaller. This result allowed us to implement a real-time estimation of the Hölder exponent on a live video signal, the first such implementation in current literature. Moreover, the evolved estimators are used to generate local descriptors of salient image regions, a task for which a stable and robust matching is achieved, comparable with state-of-the-art methods. In conclusion, the evolved estimators produced by GP could help expand the application domain of Hölder regularity within the fields of image analysis and signal processing.

One of the main open problems within Genetic Programming (GP) is to meaningfully characterize the difficulty (or hardness) of a problem. The general goal is to develop predictive tools that can allow us to identify how difficult a problem is for a GP system to solve. On this topic, we identify and compare two main approaches that address this question. We denote the first group of methods as Evolvability Indicators (EI), which are measures that attempt to capture how amendable the fitness landscape is to a GP search. The best examples of current EIs are the Fitness Distance Correlation (FDC) and the Negative Slope Coefficient (NSC). The second, more recent, group of methods are what we call Predictors of Expected Performance (PEP), which are predictive models that take as input a set of descriptive attributes of a particular problem and produce as output the expected performance of a GP system. The experimental work presented here compares an EI, the NSC, and a PEP model for a GP system applied to data classification. Results suggest that the EI fails at measuring problem difficulty expressed by the performance of the GP classifiers, an unexpected result. On the other hand, the PEP models show a very high correlation with the actual performance of the GP system. It appears that while an EI can correctly estimate the difficulty of a given search, as shown by previous research on this topic, it does not necessarily capture the difficulty of the underlying problem that GP is intended to solve. Conversely, while the PEP models treat the GP system as a computational black-box, they can still provide accurate performance predictions.

Another research area is to predict the alertness of an individual by analyzing the brain activity through electroencephalographic data (EEG) captured with 58 electrodes. Alertness is characterized here as a binary variable that can be in a "normal" or "relaxed" state. We collected data from 44 subjects before and after a relaxation practice, giving a total of 88 records. After a pre-processing step and data validation, we analyzed each record and discriminate the alertness states using our proposed "slope criterion". Afterwards, several common methods for supervised classification (k nearest neighbors, decision trees (CART), random forests, PLS and discriminant sparse PLS) were applied as predictors for the state of alertness of each subject. The proposed "slope criterion" was further refined using a genetic algorithm to select the most important EEG electrodes in terms of classification accuracy. Results shown that the proposed strategy derives accurate predictive models of alertness.

6.3. Moderate Deviations for Mean Field Particle Models

Our team is interested with moderate deviation principles of a general class of mean field type interacting particle models. We discuss functional moderate deviations of the occupation measures for both the strong - topology on the space of finite and bounded measures as well as for the corresponding stochastic processes on some class of functions equipped with the uniform topology. Our approach is based on an original semigroup analysis combined with stochastic perturbation techniques and projective limit large deviation methods.

6.4. Bifurcating autoregressive processes

We investigate the asymptotic behavior of the least squares estimator of the unknown parameters of random coefficient bifurcating autoregressive processes. Under suitable assumptions on inherited and environmental effects, we establish the almost sure convergence of our estimates. In addition, we also prove a quadratic strong law and central limit theorems. Our approach mainly relies on asymptotic results for vector-valued martingales together with the well-known Rademacher-Menchov theorem.

We study also the asymptotic behavior of the weighted least square estimators of the unknown parameters of random coefficient bifurcating autoregressive processes. Under suitable assumptions on the immigration and the inheritance, we establish the almost sure convergence of our estimators, as well as a quadratic strong law and central limit theorems. Our study mostly relies on limit theorems for vector-valued martingales.

Finally, we study the asymptotic behavior of the weighted least squares estimators of the unknown parameters of bifurcating integer-valued autoregressive processes. Under suitable assumptions on the immigration, we establish the almost sure convergence of our estimators, together with the quadratic strong law and central limit theorems. All our investigation relies on asymptotic results for vector-valued martingales.

6.5. Durbin-Watson statistic and first order autoregressive processes

We investigate moderate deviations for the Durbin-Watson statistic associated with the stable first-order autoregressive process where the driven noise is also given by a first-order autoregressive process. We first establish a moderate deviation principle for both the least squares estimator of the unknown parameter of the autoregressive process as well as for the serial correlation estimator associated with the driven noise. It enables us to provide a moderate deviation principle for the Durbin-Watson statistic in the easy case where the driven noise is normally distributed and in the more general case where the driven noise satisfies a less restrictive Chen-Ledoux type condition.

We investigate the asymptotic behavior of the Durbin-Watson statistic for the general stable $p-$order autoregressive process when the driven noise is given by a first-order autoregressive process. We establish the almost sure convergence and the asymptotic normality for both the least squares estimator of the unknown vector parameter of the autoregressive process as well as for the serial correlation estimator associated with the driven noise. In addition, the almost sure rates of convergence of our estimates are also provided. Then, we prove the almost sure convergence and the asymptotic normality for the Durbin-Watson statistic. Finally, we propose a new bilateral statistical procedure for testing the presence of a significative first-order residual autocorrelation and we also explain how our procedure performs better than the commonly used Box-Pierce and Ljung-Box statistical tests for white noise applied to the stable autoregressive process, even on small-sized samples.

In a recent paper (to appear hal-00677600), we investigate the asymptotic behavior of the maximum Likelihood estimators of the unknown parameters of positive recurrent Ornstein-Uhlenbeck processes driven by Ornstein-Uhlenbeck processes.

6.6. Ornstein-Uhlenbeck process with shift

We investigate the large deviation properties of the maximum likelihood estimators for the Ornstein-Uhlenbeck process with shift. We estimate simultaneously the drift and shift parameters. On the one hand, we establish a large deviation principle for the maximum likelihood estimates of the drift and shift parameters. Surprisingly, we find that the drift estimator shares the same large deviation principle as the one previously established for the Ornstein-Uhlenbeck process without shift. Sharp large deviation principles are also provided. On the other hand, we show that the maximum likelihood estimator of the shift parameter satisfies a large deviation principle with a very unusual implicit rate function.

6.7. Markovian superquadratic BSDEs

In [Stochastc Process. Appl., 122(9):3173-3208], the author proved the existence and the uniqueness of solutions to Markovian superquadratic BSDEs with an unbounded terminal condition when the generator and the terminal condition are locally Lipschitz. In [8], we prove that the existence result remains true for these BSDEs when the regularity assumptions on the generator and/or the terminal condition are weakened.

6.8. Non-Asymptotic Analysis of Adaptive and Annealed Feynman-Kac Particle Models

Sequential and Quantum Monte Carlo methods, as well as genetic type search algorithms can be interpreted as a mean field and interacting particle approximations of Feynman-Kac models in distribution spaces. The performance of these population Monte Carlo algorithms is strongly related to the stability properties of nonlinear Feynman-Kac semigroups. We analyze these models in terms of Dobrushin ergodic coefficients of the reference Markov transitions and the oscillations of the potential functions. Sufficient conditions for

uniform concentration inequalities w.r.t. time are expressed explicitly in terms of these two quantities. We provide an original perturbation analysis that applies to annealed and adaptive FK models, yielding what seems to be the first results of this kind for these type of models. Special attention is devoted to the particular case of Boltzmann-Gibbs measures' sampling. In this context, we design an explicit way of tuning the number of Markov Chain Monte Carlo iterations with temperature schedule. We also propose and analyze an alternative interacting particle method based on an adaptive strategy to define the temperature increments.

6.9. A Robbins-Monro procedure for a class of models of deformation

We are interested with the statistical analysis of several data sets associated with shape invariant models with different translation, height and scaling parameters. We propose to estimate these parameters together with the common shape function. Our approach extends the recent work of Bercu and Fraysse to multivariate shape invariant models. We propose a very efficient Robbins-Monro procedure for the estimation of the translation parameters and we use these estimates in order to evaluate scale parameters. The main pattern is estimated by a weighted Nadaraya-Watson estimator. We provide almost sure convergence and asymptotic normality for all estimators. Finally, we illustrate the convergence of our estimation procedure on simulated data as well as on real ECG data.

6.10. Individual load curves intraday forecasting

A dynamic coupled modelling is investigated to take temperature into account in the individual energy consumption forecasting. The objective is both to avoid the inherent complexity of exhaustive SARIMAX models and to take advantage of the usual linear relation between energy consumption and temperature for thermosensitive customers. We first recall some issues related to individual load curves forecasting. Then, we propose and study the properties of a dynamic coupled modelling taking temperature into account as an exogenous contribution and its application to the intraday prediction of energy consumption. Finally, these theoretical results are illustrated on a real individual load curve. The authors discuss the relevance of such an approach and anticipate that it could form a substantial alternative to the commonly used methods for energy consumption forecasting of individual customers.

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

Contract with Astrium/EADS. The aim of this contract, in collaboration with the EPI AYIN, is to develop automatic object tracking algorithms on a sequence of images taken from a geostationary satellite. P. Del Moral cosupervises with J. Zerubia the PhD thesis of Paula Craciun on this subject.

Contract with CNES

The goal of this contract is to predict the trajectories of space debris around the earth. It is necessary to provide a new methodology since traditional methods such as Kalman filtering do not work satisfactory.

7.2. Bilateral Grants with Industry

- EDF (phd F. Proia)

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR BNPSI: Bayesian NonParametric methods for Signal and Image processing

Statistical methods have become more and more popular in signal and image processing over the past decades. These methods have been able to tackle various applications such as speech recognition, object tracking, image segmentation or restoration, classification, clustering, etc. We propose here to investigate the use of Bayesian nonparametric methods in statistical signal and image processing. Similarly to Bayesian parametric methods, this set of methods is concerned with the elicitation of prior and computation of posterior distributions, but now on infinite-dimensional parameter spaces. Although these methods have become very popular in statistics and machine learning over the last 15 years, their potential is largely underexploited in signal and image processing. The aim of the overall project, which gathers researchers in applied probabilities, statistics, machine learning and signal and image processing, is to develop a new framework for the statistical signal and image processing communities. Based on results from statistics and machine learning we aim at defining new models, methods and algorithms for statistical signal and image processing. Applications to hyperspectral image analysis, image segmentation, GPS localization, image restoration or space-time tomographic reconstruction will allow various concrete illustrations of the theoretical advances and validation on real data coming from realistic contexts.

8.2. European Initiatives

8.2.1. FP7 Projects

8.2.1.1. ACOBSEC

Type: PEOPLE

Instrument: International Research Staff Exchange Scheme

Objectif: NC

Duration: November 2013 - October 2016

Coordinator: Pierrick Legrand

Partner:

Inria contact: Pierrick Legrand

Abstract: Over the last decade, Human-Computer Interaction (HCI) has grown and matured as a field. Gone are the days when only a mouse and keyboard could be used to interact with a computer. The most ambitious of such interfaces are Brain-Computer Interaction (BCI) systems. The goal in BCI is to allow a person to interact with an artificial system using only brain activity. The most common approach towards BCI is to analyse, categorize and interpret Electroencephalography (EEG) signals, in such a way that they alter the state of a computer. The objective of the present project is to study the development of computer systems for the automatic analysis and classification of mental states of vigilance; i.e., a person's state of alertness. Such a task is relevant to diverse domains, where a person is expected or required to be in a particular state. However, this problem is by no means a trivial one. In fact, EEG signals are known to be highly noisy, irregular and tend to vary significantly from person to person, making the development of general techniques a very difficult scientific endeavor.
List of Beneficiaries

- Beneficiary 1 (coordinator) Institut National de Recherche en Informatique et Automatique Inria France
- Beneficiary 2 Universite Victor Segalen Bordeaux II UB2 France
- Beneficiary 3 Instituto de Engenharia de Sistemas e Computadores, Investigacao e Desenvolvimento em Lisboa INESC-ID Portugal

- Beneficiary 4 Universidad de Extremadura UNEX Spain
- Partner 5 Instituto Tecnologico de Tijuana ITT Mexico
- Partner 6 Centro de Investigacion Cientifica y educacion Superior de Ensenada, Baja California CICESE Mexico

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Declared Inria International Partners

- Institut Technologique de Tijuana. TREE-LAB: www.tree-lab.org Tijuana, BC, Mexico

8.4. International Research Visitors

8.4.1. Visits of International Scientists

The following researchers visited the Team ALEA during 2013: J. Blanchet (Colombia University), A. Doucet (Univ. Oxford), A. Greaven (Univ. Erlangen).

8.4.2. Visits to International Teams

Pierre Del Moral: new South Wales university, Sydney.

9. Dissemination

9.1. Scientific Animation

9.1.1. Editorial Board

P. Del Moral is currently associate editor/editor for the following journals

- Associate editor : Applied Mathematics and Optimization, since 2009.
- Associate editor Revista de Matematica: Teoria y Aplicaciones, since 2009.
- Associate editor : Stochastic Analysis and Applications, since 2001.

P. Legrand is currently associate editor/editor for the following publications

- EA artificial evolution, LNCS volume, Springer (biennal).

9.1.2. Responsibilities

B. Bercu is an assistant director of the Institut de Mathématiques de Bordeaux (IMB). He is a member of the CNU section 26.

B. Bercu is co-responsible of the specialty "Modélisation Statistique et Stochastique" of the Master MIMSE.

P. Legrand is a member of “bureau de l’association Evolution artificielle".

P. Legrand is in charge of the learning management system MOODLE of the UFR sciences et modélisation (University of Bordeaux II).

9.1.3. Organization of Conferences

- International Conference Evolve 2013: P. Legrand, P. Del Moral (with A.A. Tantar, E. Tantar, P. Bouvry, O. Schütze)
- International conference EA 2013: P. Legrand (general chair)

9.1.4. Reviewing

- Journals: Annals of Statistics, IEEE TPAMI, Journal of the Royal Statistical Society B, Computational Statistics and Data Analysis, Statistics and Computing, Journal de la Société Francaise de Statistiques, Signal Processing.
- Conferences: UAI, NIPS, ICML, AISTATS, GECCO, CEC, EA

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

Licence :

- B. Bercu, Mathématiques générales, Analyse et Algèbre SVE, 36h, L1, University of Bordeaux, France
- P. Legrand, Espaces Euclidiens, 54h, L2, University of Bordeaux, France
- P. Legrand, Traitement du Signal, 18h, L3, University of Bordeaux, France
- P. Legrand, Informatique pour les mathématiques, 36h, L1, University of Bordeaux, France
- P. Legrand, Algèbre, 72h, L1, University of Bordeaux, France
- P. Legrand, Technologies de l'information, de la communication pour l'éducation, 42h, University of Bordeaux, France
- A. Richou, Probabilités et statistiques, 32h, L3, University of Bordeaux, France
- A. Richou, Probabilités et statistiques, 32h, L1, University of Bordeaux, France

Master :

- A. Richou, Probabilité, 32h, M1, University of Bordeaux, France
- B. Bercu, Séries chronologiques, 48h, M2, University of Bordeaux, France
- B. Bercu, Processus aléatoires à temps discret, 30h, M1, University of Bordeaux, France
- B. Bercu, Probabilités, 30h, L3, University of Bordeaux, France
- F. Caron, Bayesian Methods, 33h, M2, University Bordeaux II, France
- F. Caron, Statistical Methods in Robotics, 25h, M2, IPB, France
- F. Caron, Advanced estimation tools in signal and image processing, 30h, M2, University Bordeaux I, France
- P. Legrand, Traitement du signal, 15h, M2, IPB, France

Other:

- P. Del Moral, Professeur chargé de cours (1/3 temps), Monte Carlo methods and Stochastic models, and introduction to probability calculus, Ecole Polytechnique, France.
- P. Del Moral, Mean field particle simulation for Monte Carlo integration, 10h, Lectures INLN-CNRS of the University of Nice Sophia Antipolis.
- P. Legrand, Course on Matlab, 42H

9.2.2. Supervision

PhD:

- François Giraud, Méthodes particulaires adaptatives pour l'estimation non linéaire, may 2013, P. Del Moral
- Vassili Blandin, Processus autorégressifs à bifurcation, june 2013, B. Bercu
- Frédéric Proia, Processus autorégressifs stables, nov. 2013, B. Bercu, P. Del Moral
- Philippe Fraysse, Algorithmes stochastiques pour la régression semi-paramétrique, july 2013, B. Bercu
- Laurent Vézard, Réduction de dimension en apprentissage supervisé. Application à l'étude de l'activité cérébrale, dec 2013, M. Chavent, F. Faita, P. Legrand

PhD in progress:

- Paul Lemaitre, Analyse de sensibilité et analyse de risques, Sept. 2010, P. Del Moral
- Nicolas Antunès, Etude du modèle GARP pour la prédiction de niches écologiques, Sept. 2011, P. Del Moral and P. Legrand
- Antoine Campi, Filtrage particulaire de fluides turbulents, 2012, P. Del Moral
- Christelle Vergé, Méthodes particulaires pour la propagation d'incertitudes dans des codes numériques, 2012, P. Del Moral
- Paula Craciun, Méthodes de filtrage multi-objets en analyse d'image, 2012, P. Del Moral
- Emigdio Zeta Flores, Genetic Programming and EEG.
- Marie Du Roy de Chaumaray, Grandes déviations pour des processus de diffusion, 2013, B. Bercu, A. Richou

9.2.3. Juries

- Raphael Coudret, P. Legrand
- Zoe Siegrist, P. Legrand
- Xiequan Fan, B. Bercu
- Francois Portier, B. Bercu

10. Bibliography

Publications of the year

Doctoral Dissertations and Habilitation Theses

[1] P. FRAYSSE. , *Estimation récursive dans certains modèles de déformation*, Université Sciences et Technologies - Bordeaux I, July 2013, http://hal.inria.fr/tel-00844393

Articles in International Peer-Reviewed Journals

[2] B. BERCU, T. MONG NGOC NGUYEN, J. SARACCO. *On the asymptotic behavior of the Nadaraya-Watson estimator associated with the recursive SIR method*, in "Statistics", 2014, http://hal.inria.fr/hal-00673832

[3] B. BERCU, B. PORTIER, V. VAZQUEZ. *On the asymptotic behavior of the Durbin-Watson statistic for ARX processes in adaptive tracking*, in "International Journal of Adaptive Control and Signal Processing", 2013, vol. 27, pp. 1-25 [*DOI :* 10.1002/ACS.2424], http://hal.inria.fr/hal-00915951

[4] B. BERCU, F. PROIA. *A sharp analysis on the asymptotic behavior of the Durbin-Watson statistic for the first-order autoregressive process*, in "ESAIM: Probability and Statistics", 2013, vol. 17, pp. 500-530 [*DOI :* 10.1051/PS/2012005], http://hal.inria.fr/hal-00642634

[5] B. BERCU, F. PROÏA, N. SAVY. *On Ornstein-Uhlenbeck driven by Ornstein-Uhlenbeck processes*, in "Statistics and Probability Letters", 2014, vol. 85, pp. 36-44 [*DOI :* 10.1016/J.SPL.2013.11.002], http://hal.inria.fr/hal-00915963

[6] V. BITSEKI PENDA, H. DJELLOUT, L. DUMAZ, F. MERLEVÈDE, F. PROÏA. *Moderate deviations of functional of Markov Processes*, in "ESAIM: Proceedings", January 2014, vol. 44, 214 p. , http://hal.inria.fr/hal-00872322

[7] L. BORNN, P. E. JACOB, P. DEL MORAL, A. DOUCET. *An Adaptive Interacting Wang-Landau Algorithm for Automatic Density Exploration*, in "Journal of Computational and Graphical Statistics", 2013, vol. 22, n^{o} 3 [*DOI :* 10.1080/10618600.2012.723569], http://hal.inria.fr/hal-00932238

[8] F. MASIERO, A. RICHOU. *A note on the existence of solutions to Markovian superquadratic BSDEs with an unbounded terminal condition*, in "Electronic Journal of Probability", April 2013, vol. 18, n^{o} 50, pp. 1-15 [*DOI :* 10.1214/EJP.V18-2124], http://hal.inria.fr/hal-00713123

[9] M. PACE, P. DEL MORAL. *Mean-Field PHD Filters Based on Generalized Feynman-Kac Flow*, in "IEEE Journal of Selected Topics in Signal Processing", 2013, vol. 7, n^{o} 3 [*DOI :* 10.1109/JSTSP.2013.2250909], http://hal.inria.fr/hal-00932284

[10] C. VERGÉ, J. MORIO, P. DEL MORAL. *An island particle Markov chain Monte Carlo algorithm for safety analysis*, in "Structural Safety", June 2013, http://hal.inria.fr/hal-00834987

[11] M. ZGHAL, L. MEVEL, P. DEL MORAL. *Modal parameter estimation using interacting Kalman filter*, in "Mechanical Systems and Signal Processing", March 2013 [*DOI :* 10.1016/J.YMSSP.2013.01.012], http://hal.inria.fr/hal-00824108

International Conferences with Proceedings

[12] A.-A. TANTAR, A. Q. NGUYEN, P. BOUVRY, B. DORRONSORO, E.-G. TALBI. *Computational intelligence for cloud management: current trends and opportunities*, in "Proceedings of the IEEE Congress on Evolutionary Computation (CEC), part of World Conference in Computational Intelligence (WCCI)", Cancun, Mexico, June 2013, http://hal.inria.fr/hal-00837568

[13] L. VEZARD, P. LEGRAND, M. CHAVENT, F. FAITA-AINSEBA, L. TRUJILLO. *Detecting mental states of alertness with genetic algorithm variable selection*, in "IEEE Congress on Evolutionary Computation (CEC) 2013", CANCUN, Mexico, June 2013, pp. 1247 - 1254, http://hal.inria.fr/hal-00939851

Scientific Books (or Scientific Book chapters)

[14] P. DEL MORAL. , *Mean field simulation for Monte Carlo integration*, Monographs on Statistics & Applied Probability, Chapman&Hall, June 2013, 626 p. , http://hal.inria.fr/hal-00932211

[15] P. DEL MORAL, E. TANTAR, A.-A. TANTAR. *On the foundations and the applications of evolutionary computing*, in "Evolve : A bridge between Probability, Set Oriented Numerics and Evolutionary Computation", E. TANTAR, A. TANTAR, P. BOUVRY, P. D. MORAL, P. LEGRAND, C. COELLO, O. SCHUTZE (editors), Springer, 2013, pp. 3-89, http://hal.inria.fr/hal-00756117

[16] O. SCHUTZE, C. COELLO, A.-A. TANTAR, E. TANTAR, P. BOUVRY, P. DEL MORAL, P. LEGRAND. , *Evolve - A bridge between probability, set oriented numerics and evolutionary computation II*, Advances in Intelligent Systems and Computing, Springer, 2013, vol. 175, 508 p. , http://hal.inria.fr/hal-00756101

[17] E. TANTAR, A.-A. TANTAR, P. BOUVRY, P. DEL MORAL, P. LEGRAND, C. COELLO, O. SCHUTZE. , *Evolve : A bridge between probability, set oriented numerics and evolutionary computation*, Studies in Computational Intelligence, Springer, 2013, vol. 447, 414 p. , http://hal.inria.fr/hal-00641466

[18] L. VEZARD, P. LEGRAND, M. CHAVENT, F. FAITA-AINSEBA, J. CLAUZEL, L. TRUJILLO. *Classification of EEG signals by evolutionary algorithm*, in "Advances in Knowledge Discovery and Management Volume 4", F. GUILLET, B. PINAUD, G. VENTURINI, D. ZIGHED (editors), Studies in Computational Intelligence, Springer, 2014, vol. 527, http://hal.inria.fr/hal-00939850

[19] L. VEZARD, P. LEGRAND, M. CHAVENT, F. FAITA-AINSEBA, J. CLAUZEL. *Classification of EEG signals by evolutionary algorithm*, in "Advances in Knowledge Discovery and Management", F. GUILLET, B. PINAUD, G. VENTURINI, D. ZIGHED (editors), Studies in Computational Intelligence, Springer International Publishing, 2014, vol. 527, pp. 133-153 [*DOI :* 10.1007/978-3-319-02999-3_8], http://hal.inria.fr/hal-00926830

Other Publications

[20] B. BERCU, A. RICHOU. , *Large deviations for the Ornstein-Uhlenbeck process with shift*, December 2013, http://hal.inria.fr/hal-00915936

[21] J.-F. CHASSAGNEUX, A. RICHOU. , *Numerical simulation of quadratic BSDEs*, 2013, 49 p. , http://hal.inria.fr/hal-00854612

[22] P. DEL MORAL, J. TUGAUT. , *Uniform propagation of chaos for a class of nonlinear diffusions*, 2013, 25 p. , http://hal.inria.fr/hal-00798813

[23] F. DELBAEN, Y. HU, A. RICHOU. , *On the uniqueness of solutions to quadratic BSDEs with convex generators and unbounded terminal conditions: the critical case*, March 2013, http://hal.inria.fr/hal-00802330

[24] F. GIRAUD, P. MINVIELLE, P. DEL MORAL. , *Advanced Interacting Sequential Monte Carlo Sampling for Inverse Scattering*, 2013, http://hal.inria.fr/hal-00779847

[25] F. MASIERO, A. RICHOU. , *HJB equations in infinite dimension with locally Lipschitz Hamiltonian and unbounded terminal condition*, December 2013, http://hal.inria.fr/hal-00915046

[26] H. MUNTHE-KAAS, A. LUNDERVOLD. , *On post-Lie algebras, Lie–Butcher series and moving frames*, June 2013, http://hal.inria.fr/hal-00835061

[27] C. VERGÉ, C. DUBARRY, P. DEL MORAL, E. MOULINES. , *On parallel implementation of Sequential Monte Carlo methods: the island particle model*, 2013, http://hal.inria.fr/hal-00932282

References in notes

[28] N. BARTOLI, P. DEL MORAL. , *Simulation and Stochastic Algorithms (An introduction with applications)*, Cépaduès Editions, 2001

[29] P. DEL MORAL. , *Feynman-Kac formulae. Genealogical and interacting particle systems, with applications*, Springer Verlag New York, Series: Probability and its Applications, 2004

[30] P. DEL MORAL, L. MICLO. *Genealogies and Increasing Propagations of Chaos for Feynman-Kac and Genetic Models*, in "Annals of Applied Probability", 2001, vol. 11, n^{o} 4, pp. 1166-1198

[31] P. DEL MORAL, L. MICLO. *On convergence of chains with time empirical self-interactions*, in "Proc. Royal Soc. Lond. A.", 2003, vol. 460, pp. 325–346

[32] P. DEL MORAL, L. MICLO. *Self Interacting Markov chains*, in "Stochastic Analysis and Applications", 2006, vol. 24, n^{o} 3, pp. 615–660

[33] A. JASRA, C. ANDRIEU, A. DOUCET, P. DEL MORAL. , *Non-Linear Markov chain Monte Carlo via Self Interacting Approximations*, 2007, Univ. Bristol Preprints

[34] A. JASRA, C. ANDRIEU, A. DOUCET, P. DEL MORAL. *A Note on Convergence of the Equi-energy Sampler*, in "Journal Stochastic Analysis and its Applications", 2008