INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team alea

Advanced Learning Evolutionary Algorithms

Bordeaux - Sud-Ouest

Theme : Stochastic Methods and Models

Activity Report

2010

Table of contents

1. Team

Research Scientists
Pierre Del Moral [Team leader, Research Director (DR) INRIA, HdR]
François Caron [Research Associate (CR) INRIA]

Faculty Members
Pierrick Legrand [University Bordeaux 2]
Bernard Bercu [University Bordeaux 1, since July 2010, HdR]

External Collaborators
Arnaud Doucet [University of British Columbia]
Josselin Garnier [University Paris 7]
Pierre Minvielle [CEA]

Technical Staff
Frédéric Proia [Development Engineer]
Adrien Todeschini [Development Engineer]

PhD Students
Michele Pace [INRIA]
Aurélie Le Cain [CEA]
François Giraud [CEA]
Hu Peng [Bourse Ministère Enseignement supérieur et Recherche]
Arijit Das [INRIA, until November 2010]
Philippe Fraysse [Bourse ENS Cachan]
Paul Lemaître [CIFRE EDF]

Post-Doctoral Fellows
Ming Lei [ANR Prevassemble]
Shulan Hu [ARC EPS]
Alexandru-Adrian Tantar [INRIA + Région Aquitaine, until March 2010]
Emilia Tantar [INRIA, until September 2010]

Visiting Scientist
Luke Bornn [University of British Columbia, March-June 2010]

Administrative Assistant
Marie-Christine Echegoyen [Team Assistant]

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, spike sorting, 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.

3. Scientific Foundations

3.1. Description

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 [42], [41]. 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 [43], [44].

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. [39] 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 [40] for solving smoothing problems and more generally Feynman-Kac semigroups on path spaces, see also [38], [39], 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 through a series of four recently selected ANR research projects and one INRIA-INRA joint research project.

Three application domains are directly related to evolutionary computing, particle filtering and Bayesian inference are currently investigated by our team project, two of them are 2008's ANR research projects :

1. **Multi-target tracking**. Multi-target tracking deals with the task of estimating the states of a set of moving targets 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. We are running this research project with the DCNS-SIS division in Toulon.
2. **Forecasting and Data assimilation :** This new application domain concerns the application of the particle filter technology and more general sequential Monte Carlo methods to data assimilation problems arising in forecasting. The ALEA team project is involved in the `ANR 2008 selected project PREVASSEMBLE` with Météo France Toulouse, the INRIA Rennes and the LMD in Paris.
3. **Virtual prairie:** This application domain of evolutionary computing is concerned with the design of ecological systems, mixed-species models and prairial ecosystems. For more details, we refer the reader to the web site of the `Virtual Prairie project` The ALEA project is a partner of the 2008 ANR SYSCOM project named MODECOL.

Three other application domains are directly related to rare event analysis using particle stochastic simulations techniques. These projects are currently investigated by our team project, two of them are 2008's ANR research projects :

1. **Watermarking of digital contents:**

   The terminology watermarking refers to a set of techniques for imbedding/hiding information in a digital audio or video file, such that the change is not noticed, and very hard to remove. In order to be used in an application, a watermarking technique must be reliable. Protection false alarms and failures of traceability codes are practically not achievable without using rare event analysis. This application domain area of particle rare event technology is the subject of joint ANR 2007 research project with the IRISA-INRIA in Rennes and the LIS INPG in Grenoble.

2. **Epidemic propagations analysis:**

   This project aims at developing stochastic mathematical models for the spread of transmissible infectious diseases, together with dedicated statistical methodologies, with the intent to deliver efficient diagnostic/prediction tools for epidemiologists. This application domain area of particle rare event technology is the subject of joint ANR 2008 research project with Telecom Paristech, the Laboratoire Paul Painlevé in Lille 1 and the University of Paris 5 (cf. `Programme Systèmes Complexes et Modélisation Mathématique, list of 2008 selected projects`).

3. **Statistical eco-microbiology predictions:**

   This project aims at developing stochastic models and algorithms for the analysis of bacteriology ecosystems, especially in food safety. The objective is to predict and control critical risk of proliferations. This is the subject of joint research project with the INRA of Paris and Montpellier (Appel d'Offre INRIA-INRA 2008 : Systèmes Complexes).

5. New Results

5.1. Analysis of PhD filters for Multitarget Tracking

We provide several contributions in the theoretical and numerical analysis of PhD Filters for multitarget tracking.

In [29], we consider the problem of estimating a latent point process, given the realization of another point process on abstract measurable state spaces. First, we establish an expression of the conditional distribution of a latent Poisson point process given the observation process when the transformation from the latent process to the observed process includes displacement, thinning and augmentation with extra points. We present an original analysis based on a self-contained random measure theoretic approach combined with reversed Markov kernel techniques. This simplifies and complements previous derivations. Second, we show how to extend our analysis to the more complicated case where the latent point process is associated to triangular array sequences, yielding what seems to be the first results of this type for this class of spatial point processes.

In [30], we design a mean field and interacting particle interpretation of a class of spatial branching intensity models with spontaneous births arising in multiple-target tracking problems. In contrast to traditional Feynman-Kac type particle models, the transitions of these interacting particle systems depend on the current particle approximation of the total mass process. In the first part, we analyze the stability properties and the long time behavior of these spatial branching intensity distribution flows. We study the asymptotic behavior of total mass processes and we provide a series of weak Lipschitz type functional contraction inequalities. In the second part, we study the convergence of the mean field particle approximations of these models. Under some appropriate stability conditions on the exploration transitions, we derive uni- form and non asymptotic estimates as well as a sub-gaussian concentration inequality and a functional central limit theorem.

In [5], we analyse the exponential stability properties of a class of measure-valued equations arising in nonlinear multi-target filtering problems. We also prove the uniform convergence properties w.r.t. the time parameter of a rather general class of stochastic filtering algorithms, including sequential Monte Carlo type models and mean field particle interpretation models. We illustrate these results in the context of the Bernoulli and the Probability Hypothesis Density filter, yielding what seems to be the first results of this kind in this subject.

Finally, in two conference papers [20], [19], we compare numerically several implementations of PhD filters for multitarget on complex and realistic scenarios.

5.2. Snell envelope

In [33], we analyze the Snell envelope with path dependent multiplicative optimality criteria. Especially for this case, we propose a variation of the Snell envelope backward recursion which allows to extend some classical approxima- tion schemes to the multiplicatively path dependent case. In this framework, we propose an importance sampling particle approximation scheme based on a specific change of measure, designed to concentrate the computational effort in regions pointed out by the criteria. This new algorithm is theoritically studied. We provide non asymptotic convergence estimates and prove that the resulting estimator is high biased.

IN [34], we analyze the robustness properties of the Snell envelope backward evolution equation for discrete time models. We provide a general robustness lemma, and we apply this result to a series of approximation methods, including cut-off type approximations, Euler discretization schemes, interpolation models, quantization tree models, and the Stochastic Mesh method of Broadie-Glasserman. In each situation, we provide non asymptotic convergence estimates, including Lp-mean error bounds and exponential concentration inequalities. In particular, this analysis allows us to recover existing convergence results for the quantization tree method and to improve significantly the rates of convergence obtained for the Stochastic Mesh estimator of Broadie-Glasserman. In the final part of the article, we propose a genealogical tree based algorithm based on a mean field approximation of the reference Markov process in terms of a neutral type genetic model. In contrast to Broadie-Glasserman Monte Carlo models, the computational cost of this new stochastic particle approximation is linear in the number of sampled points.

5.3. Genetic Programming/Genetic Algorithms

The first paper [21] presents a Genetic Programming (GP) approach to synthesize estimators for the pointwise Hölder exponent in 2D signals. It is known that irregularities and singularities are the most salient and informative parts of a signal. Hence, explicitly measuring these variations can be important in various domains of signal processing. The pointwise Hölder exponent provides a characterization of these types of features. However, current methods for estimation cannot be considered to be optimal in any sense. Therefore, the goal of this work is to automatically synthesize operators that provide an estimation for the Hölderian regularity in a 2D signal. This goal is posed as an optimization problem in which we attempt to minimize the error between a prescribed regularity and the estimated regularity given by an image operator. The search for optimal estimators is then carried out using a GP algorithm. Experiments confirm that the GP-operators produce a good estimation of the Hölder exponent in images of multifractional Brownian motions. In fact, the evolved estimators significantly outperform a traditional method by as much as one order of magnitude. These results provide further empirical evidence that GP can solve difficult problems of applied mathematics.

Local image features can provide the basis for robust and invariant recognition of objects and scenes. Therefore, compact and distinctive representations of local shape and appearance has become invaluable in modern computer vision. In this work [22],we study a local descriptor based on the Hölder exponent, a measure of signal regularity. The proposal is to find an optimal number of dimensions for the descriptor using a genetic algorithm (GA). To guide the GA search, fitness is computed based on the performance of the descriptor when applied to standard region matching problems. This criterion is quantified using the F-Measure, derived from recall and precision analysis. Results show that it is possible to reduce the size of the canonical Hölder descriptor without degrading the quality of its performance. In fact, the best descriptor found through the GA search is nearly 70% smaller and achieves similar performance on standard tests.

5.4. Sequential Monte Carlo Methods for Option Pricing

In [13], we provide a review and development of sequential Monte Carlo (SMC) methods for option pricing. SMC are a class of Monte Carlo-based algorithms, that are designed to approximate expectations w.r.t a sequence of related probability measures. These approaches have been used, successfully, for a wide class of applications in engineering, statistics, physics and operations research. SMC methods are highly suited to many option pricing problems and sensitivity/Greek calculations due to the nature of the sequential simulation. However, it is seldom the case that such ideas are explicitly used in the option pricing literature. This article provides an up-to date review of SMC methods, which are appropriate for option pricing. In addition, it is illustrated how a number of existing approaches for option pricing can be enhanced via SMC. Specifically, when pricing the arithmetic Asian option w.r.t a complex stochastic volatility model, it is shown that SMC methods provide additional strategies to improve estimation.

5.5. Bayesian methods

5.5.1. Bayesian clustering of decomposable graphs

In [28], we propose a class of prior distributions on decomposable graphs, allowing for improved modeling flexibility. While existing methods solely penalize the number of edges, the proposed work empowers practitioners to control clustering, level of separation, and other features of the graph. Emphasis is placed on a particular prior distribution which derives its motivation from the class of product partition models; the properties of this prior relative to existing priors is examined through theory and simulation. We then demonstrate the use of graphical models in the field of agriculture, showing how the proposed prior distribution alleviates the inflexibility of previous approaches in properly modeling the interactions between the yield of different crop varieties.

5.5.2. A Hierarchical Bayesian Framework for Constructing Sparsity-inducing Priors

Variable selection techniques have become increasingly popular amongst statisticians due to an increased number of regression and classification applications involving high-dimensional data where we expect some predictors to be unimportant. In this context, Bayesian variable selection techniques involving Markov chain Monte Carlo exploration of the posterior distribution over models can be prohibitively computationally expensive and so there has been attention paid to quasi-Bayesian approaches such as maximum a posteriori (MAP) estimation using priors that induce sparsity in such estimates. We focus on this latter approach in [37], expanding on the hierarchies proposed to date to provide a Bayesian interpretation and generalization of state-of-the-art penalized optimization approaches and providing simultaneously a natural way to include prior information about parameters within this framework. We give examples of how to use this hierarchy to compute MAP estimates for linear and logistic regression as well as sparse precision-matrix estimates in Gaussian graphical models. In addition, an adaptive group lasso method is derived using the framework.

5.5.3. Efficient Bayesian Inference for Bradley-Terry models

The Bradley-Terry model is a popular approach to describe probabilities of the possible outcomes when elements of a set are repeatedly compared with one another in pairs. It has found many applications including animal behaviour, chess ranking and multiclass classification. Numerous extensions of the basic model have also been proposed in the literature including models with ties, multiple comparisons, group comparisons and random graphs. From a computational point of view, Hunter (2004) has proposed efficient iterative MM (minorization-maximization) algorithms to perform maximum likelihood estimation for these generalized Bradley-Terry models whereas Bayesian inference is typically performed using MCMC (Markov chain Monte Carlo) algorithms based on tailored Metropolis-Hastings (M-H) proposals. We show in [32] that these MM algorithms can be reinterpreted as special instances of Expectation-Maximization (EM) algorithms associated to suitable sets of latent variables and propose some original extensions. These latent variables allow us to derive simple Gibbs samplers for Bayesian inference. We demonstrate experimentally the efficiency of these algorithms on a variety of applications.

6. Contracts and Grants with Industry

6.1. Contract with EDF Clamart

The objective of this two-year contract (140kE, 2009-2011) between the teams ALEA and CQFD and EDF - ICAME, is to develop algorithms for the recursive prediction of the electricity consumption [27], [26].

6.2. Contract with EDF OSIRIS

The objective of this contract is to develop particle algorithms for financial mathematics.

6.3. Contract with IFREMER

The objective of this contract is to develop particle algorithms for risk analysis and propagation of uncertainties [31].

6.4. Contract with CEA

The objective of this contract is to propose algorithms for the estimation of uncertainties in laser experiments.

7. Other Grants and Activities

7.1. Regional Initiatives

In 2010, the project PSI (Psychology and sounds interactions), headed by P. Legrand received a grant by the region Aquitaine for a PhD thesis on “Dimension reduction in supervised learning. Application to the study of brain activity".

7.2. National Initiatives

7.2.1. ANR

7.2.1.1. ANR PREVASSEMBLE

This new application domain concerns the application of the particle filter technology and more general sequential Monte Carlo methods to data assimilation problems arising in forecasting. The ALEA team project is involved in the `ANR 2008 selected project PREVASSEMBLE` with Météo France Toulouse, the INRIA Rennes and the LMD in Paris.

7.2.1.2. ANR MODECOL

This application domain of evolutionary computing is concerned with the design of ecological systems, mixed-species models and prairial ecosystems. For more details, we refer the reader to the web site of the `Virtual Prairie project` The ALEA project is a partner of the 2008 ANR SYSCOM project named MODECOL.

7.2.1.3. ANR Nebbiano

The terminology watermarking refers to a set of techniques for imbedding/hiding information in a digital audio or video file, such that the change is not noticed, and very hard to remove. In order to be used in an application, a watermarking technique must be reliable. Protection false alarms and failures of traceability codes are practically not achievable without using rare event analysis. This application domain area of particle rare event technology is the subject of joint ANR 2007 research project with the IRISA-INRIA in Rennes and the LIS INPG in Grenoble.

7.2.1.4. ANR Viroscopy

This project aims at developing stochastic mathematical models for the spread of transmissible infectious diseases, together with dedicated statistical methodologies, with the intent to deliver efficient diagnostic/prediction tools for epidemiologists. This application domain area of particle rare event technology is the subject of joint ANR 2008 research project with Telcom Paristech, the Laboratoire Paul Painlevé in Lille 1 and the University of Paris 5 (cf. `Programme Systèmes Complexes et Modélisation Mathématique, list of 2008 selected projects`).

7.2.1.5. ANR Propagation

To combat dramatic event such as happened in Bombay last year (coming from the sea, a terrorist commando killed more than 200 peoples in Bombay city), authorities are decided to deploy efficient sea surveillance system to protect coastal zone including sensitive infrastructures often in vicinity of important cities.

Regulation on frequencies allocation and on coastal constructions is strong constraint to be taken into account to install technical capabilities to permanently survey vulnerable littoral zones. For example, new active sensor shall be frequencies compatible within numerous existing ones in inhabited region. In this context to perform coastal surveillance, attractive solution is to deploy passive sensors networks because:

- Not necessarily compatible within existing active sensors network.
- Provide large possibilities to install the passive sensors, because, it is not needed to be on the shoreline, but can be deployed inside the territory. Such as facility offers more potential sites and then, to optimise the deployment for optimal coverage of the sensitive zone.
- Is totally undetectable by external technical means in hand of structured criminal organisations.

For these objectives, the PROPAGATION project will study, develop and experiment a demonstrator to carry out maritime traffic picture from a set of passive sensors: passive radar, AIS and optronic cameras deployed over a coastal site. This is a joint ANR project with DCNS, Thalès, Ecomer and Exavision, accepted in 2009.

7.2.2. ARC INRIA

7.2.2.1. ARC EPS

This project aims at developing stochastic models and algorithms for the analysis of bacteriology ecosystems, especially in food safety. The objective is to predict and control critical risk of proliferations. This is the subject of joint research project with the INRA of Paris and Montpellier, the University of Bretagne and ENV Alford.

7.2.2.2. ARC M2A3PC

The spread of a pathogen within a strongly anthropized perennial vegetal cover depends on many parameters acting at contrasted spatio-temporal scales. This is of paramount importance for vine and apple trees and their airborne obligated parasites (powdery and downy mildew, scab) which strongly rely on the susceptibility and status of their hosts. Both crop systems require from 17 to 20 fungicide treatments per year. Sustainable crop management goes through a better understanding of the dynamics of these epidemic diseases at various spatio-temporal scales. With this in mind we aimed at developing a plant-pathogen methodology at several spatio-temporal scales. Dedicated teams from INRIA, INRA, CIRAD and CNRS research institutes joined together to form a task force with well-known abilities on :

- the overall dynamics of vine and apple tree systems studied at the desired spatio-temporal scales, in biology, epidemiology and agronomy at the plant and lanscape scales.
- modelling and 3D vizualisation of perenial plant growth coupled to development of pathogens,
- mathematical modelling and numerical simulations of epidemic diseases propagation within a growing host population, including spatial spread of pathogens at different scales.

7.2.3. Organization of conferences

B. Bercu and P. Del Moral were in the organizing committee of the Journées MAS in Bordeaux (September 2010, 300 participants).

P. Legrand was in the organizing committee of the Conference on Computational and Mathematical Population Dynamics in Bordeaux (June 2010, 300 participants).

7.3. International Initiatives

E. Tantar, A. Tantar and P. Del Moral organized an international workshop on Rare Events Simulation in Bordeaux (40 participants).

P. Hu and P. Del Moral organized an international workshop on numerical methods in finance in Bordeaux (35 participants).

E. Tantar, A. Tantar, P. Legrand and P. Del Moral organized an international workshop on Evolutionary Algorithms in Bordeaux (35 participants).

7.4. Exterior research visitors

The following researchers visited the Team ALEA during 2010: Luke Bornn (UBC), Amarjit Budhiraja (Chapel Hill), Dan Crisan (Imperial College), Persi Diaconis (Stanford), Arnaud Doucet (UBC), Susan Holmes (Stanford), Thomas G. Kurtz (Wisconsin U.), Laurent Miclo (CNRS), Emmanuel Rio (U. Versailles), Sylvain Rubenthaler (U. Nice), Oliver Schütze (Cinvestav), Sumeetpal S. Singh (U. Cambridge), Leonardo Trujillo (Cicese), Alexandre Veretennikov (U. Leeds), B.N. Vo (U. of Western Australia).

8. Dissemination

8.1. Animation of the scientific community

B. Bercu is responsible of the thematic group MAS (Modélisation Aléatoire et Statistique) at SMAI.

B. Bercu is an assistant director of the Institut de Mathématiques de Bordeaux (IMB). He is also a member of the IMB council and the UFR council of the University of Bordeaux.

B. Bercu is the director of the applied mathematic department at the University of Bordeaux.

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

F. Caron is in the Senior Program Committee of the international conference AISTATS 2011.

P. Legrand is a member of the UFR council of the University of Bordeaux.

8.2. Teaching

P. Del Moral gives two courses in the Master MIMSE on Stochastic Algorithms.

F. Caron gives one course in the Master MIMSE on Unsupervised Learning.

P. Legrand is teaching the following courses (248 hours)

- Analyse Licence 1 SDV : 32H
- Mathématiques générales Licence 1 SCIMS : 72H
- Informatique pour les mathématiques Licence 1 SCIMS : 72H
- Complément d'algèbre Licence 2 SCIMS : 72H

B. Bercu gives two courses in the Master MIMSE on Probability and Time Series Analysis.

9. Bibliography

Publications of the year

Articles in International Peer-Reviewed Journal

[1] B. Bercu, L. Coutin, N. Savy. *Sharp large deviations for the fractional Ornstein-Uhlenbeck process*, in "Teoriya Veroyatnostei i ee Primeneniya", 2010, vol. 55, n° 4, p. 1-39, http://hal.inria.fr/hal-00386239/en.

[2] B. Bercu, I. Nourdin, M. Taqqu. *Almost sure central limit theorems on the Wiener space*, in "Stochastic Processes an their Applications", 2010, vol. 120, p. 1607-1628, http://hal.inria.fr/hal-00375290/en.

[3] B. Bercu, V. Vazquez. *A new concept of strong controllability via the Schur complement in adaptive tracking*, in "Automatica", 2010, vol. 46, p. 1799-1805, http://hal.inria.fr/hal-00386247/en.

[4] B. Bercu, V. Vazquez. *On the usefulness of persistent excitation in ARX adaptive tracking*, in "International Journal of Control", 2010, vol. 83, p. 1145-1154, http://hal.inria.fr/hal-00386177/en.

[5] F. Caron, P. Del Moral, M. Pace, B.-N. Vo. *On the Stability and the Approximation of Branching Distribution Flows, with Applications to Nonlinear Multiple Target Filtering*, in "Stochastic Analysis and Applications", 2010, to appear, http://hal.inria.fr/inria-00516507/en.

[6] P. Del Moral. *Fundamentals of stochastic filtering, by Alan Bain and Dan Crisan, Stochastic Modelling and Applied Probability, 60, Springer, New York, 2009, xiv+390 pp., ISBN 978-0-387-76895-3*, in "BULLETIN (New Series) OF THE AMERICAN MATHEMATICAL SOCIETY", Oct 2010, http://hal.inria.fr/inria-00533435/en.

[7] P. Del Moral, A. Doucet, A. Brockwell. *Sequentially interacting Markov chain Monte Carlo*, in "The Annals of Statistics", 2010, to appear, http://hal.inria.fr/inria-00533436/en.

[8] P. Del Moral, A. Doucet. *A new class of interacting Markov chain Monte Carlo methods*, in "Comptes Rendus Mathematique", 2010, vol. 348, n° 1-2, p. 79-83 [*DOI :* 10.1016/j.crma.2009.11.006], http://hal.inria.fr/inria-00537141/en.

[9] P. Del Moral, A. Doucet. *Interacting Markov Chain Monte Carlo Methods For Solving Nonlinear Measure-Valued Equations*, in "The Annals of Applied Probability", 2010, vol. 20, n° 2, p. 593-639, http://hal.inria.fr/inria-00227508/en.

[10] P. Del Moral, A. Doucet, A. Jasra, C. Andrieu. *On nonlinear Markov chain Monte Carlo via Self-interacting approximations.*, in "Bernoulli", 2010, to appear, http://hal.inria.fr/inria-00533437/en.

[11] P. Del Moral, A. Doucet, A. Jasra. *On Adaptive Resampling Procedures for Sequential Monte Carlo Methods*, in "Bernoulli", 2010, 47, to appear, http://hal.inria.fr/inria-00332436/en.

[12] P. Del Moral, A. Doucet, S. Singh. *A Backward Particle Interpretation of Feynman-Kac Formulae*, in "Mathematical Modelling and Numerical Analysis", 2010, vol. 44, n° 5, p. 947-975 [*DOI :* 10.1051/m2an/2010048], http://hal.inria.fr/inria-00410165/en.

[13] P. DEL MORAL, A. JASRA. *Sequential Monte Carlo Methods for Option Pricing*, in "Stochastic Analysis and Applications", 2010, to appear, http://hal.inria.fr/inria-00533433/en.

[14] P. DEL MORAL, H. NICOLAS G.. *An Introduction to probabilistic methods, with applications.*, in "ESAIM: M2AN", Aug 2010, vol. 44, p. 805 - 829 [*DOI :* 10.1051/M2AN/2010043], http://hal.inria.fr/inria-00533434/en.

[15] P. DEL MORAL, E. RIO. *Concentration Inequalities for Mean Field Particle Models*, in "The Annals of Applied Probability", 2010, to appear, http://hal.inria.fr/inria-00375134/en.

[16] P. DEL MORAL, S. RUBENTHALER, N. CHOPIN. *Stability of Feynman-Kac formulae with path-dependent potentials*, in "Stochastic Processes and their Applications", 2010, to appear, http://hal.inria.fr/inria-00533438/en.

International Peer-Reviewed Conference/Proceedings

[17] P. DEL MORAL, C. BAEHR, M. LEI. *Analysis of Approximated PCRLBs for Nonlinear Dynamics Using Different Moments of State Estimate.*, in "The 8th IEEE International Conference on Control & Automation (ICCA2010)", Chine to be held in Xiamen, IEEE, Jun 2010, http://hal.inria.fr/inria-00533432/en.

[18] P. DEL MORAL, C. BAEHR, M. LEI. *Fisher Information Matrix-based Nonlinear System Conversion for State Estimation.*, in "The 8th IEEE International Conference on Control & Automation (ICCA2010)", Chine Xiamen, IEEE, Jun 2010, p. 837 - 841 [*DOI :* 10.1109/ICCA.2010.5524066], http://hal.inria.fr/inria-00533431/en.

[19] M. PACE, P. DEL MORAL, F. CARON. *Comparison of implementations of Gaussian Mixture PHD filters*, in "International Conference on Information Fusion", Royaume-Uni Edinburgh, Jul 2010, http://hal.inria.fr/inria-00531099/en.

[20] M. PACE. *Comparison of PHD based filters for the tracking of 3D aerial and naval scenarios*, in "IEEE Radar Conference", États-Unis Washington, 2010 [*DOI :* 10.1109/RADAR.2010.5494574], http://hal.inria.fr/inria-00535931/en.

[21] L. TRUJILLO, P. LEGRAND, J. LÉVY-VÉHEL. *The estimation of Hölderian regularity using Genetic Programming*, in "GECCO 2010", États-Unis Portland Oregon, 2010, vol. ISBN 978-1-4503-0072-8, p. 861-868, http://hal.inria.fr/inria-00534453/en.

[22] L. TRUJILLO, P. LEGRAND, G. OLAGUE, C. PÉREZ. *Optimization of the Hölder Image Descriptor using a Genetic Algorithm*, in "GECCO 2010", États-Unis Portland Oregon, 2010, vol. ISBN 978-1-4503-0072-8, p. 1147-1154, http://hal.inria.fr/inria-00534457/en.

Workshops without Proceedings

[23] J.-B. BURIE, A. CALONNEC, M. CHARRON, P. LEGRAND. *Modeling and simulated a fungal disease epidemic over a heterogeneous plot*, in "CMPD 3", France Bordeaux, 2010, http://hal.inria.fr/inria-00534465/en.

Scientific Books (or Scientific Book chapters)

[24] P. DEL MORAL, F. PATRAS. *Interacting path systems for credit portfolio risk analysis*, in "Recent advancements in the theory and practice of credit derivatives", D. BRIGO, T. BIELECKI, F. PATRAS (editors), Bloomberg Press, 2010, page : to appear, http://hal.inria.fr/inria-00537891/en.

[25] P. DEL MORAL, F. PATRAS, S. RUBENTHALER. *A Mean field theory of nonlinear filtering*, in "The Oxford Handbook of Nonlinear Filtering", D. CRISAN, B. L. ROZOVSKII (editors), Oxford Handbooks in Mathematics, Oxford University Press, 2010, p. 1-39, http://hal.inria.fr/inria-00537331/en.

Research Reports

[26] B. BERCU, F. CARON, A. DAS, F. PROÏA. *Méthodes d'estimation récursive pour la prévision de la consommation d'électricité. Lot 3: La prévision de courbes de charge par estimation fonctionnelle non paramétrique*, INRIA, 2010, n° 2010-EDF-03, http://hal.inria.fr/inria-00537172/en.

[27] B. BERCU, F. CARON, F. PROÏA. *Méthodes d'estimation récursive pour la prévision de la consommation d'électricité. Lot 2 : La prévision de courbes de charge par séries chronologiques linéaires*, INRIA, 2010, n° 2010-EDF-02b, http://hal.inria.fr/inria-00537170/en.

[28] L. BORNN, F. CARON. *Bayesian clustering of decomposable graphs*, INRIA, May 2010, n° arXiv:1005.5081, http://hal.inria.fr/inria-00487168/en.

[29] F. CARON, P. DEL MORAL, A. DOUCET, M. PACE. *On the Conditional Distributions of Spatial Point Processes*, INRIA, Mar 2010, n° RR-7232, http://hal.inria.fr/inria-00464127/en.

[30] F. CARON, P. DEL MORAL, A. DOUCET, M. PACE. *Particle approximations of a class of branching distribution flows arising in multi-target tracking*, INRIA, Mar 2010, n° RR-7233, http://hal.inria.fr/inria-00464130/en.

[31] F. CARON, P. DEL MORAL, A.-A. TANTAR, E. TANTAR. *Simulation particulaire, Dimensionnement en conditions extrêmes*, INRIA, 2010, n° 2010-IFREMER-01, http://hal.inria.fr/inria-00537171/en.

[32] F. CARON, A. DOUCET. *Efficient Bayesian Inference for Generalized Bradley-Terry Models*, INRIA, Nov 2010, n° RR-7445, http://hal.inria.fr/inria-00533638/en.

[33] P. DEL MORAL, P. HU, N. OUDJANE. *Snell envelope with path dependent multiplicative optimality criteria*, INRIA, Aug 2010, n° RR-7360, http://hal.inria.fr/inria-00507794/en.

[34] P. DEL MORAL, P. HU, N. OUDJANE, B. RÉMILLARD. *On the Robustness of the Snell envelope*, INRIA, May 2010, n° RR-7303, http://hal.inria.fr/inria-00487103/en.

[35] P. DEL MORAL, P. HU, D. WENG. *Méthodes de Monte Carlo pour le pricing d'options américaines. Lot 1.*, INRIA, 2010, http://hal.inria.fr/inria-00537173/en.

[36] P. DEL MORAL, F. PATRAS. *Interacting path systems for credit portfolios risk analysis*, INRIA, Feb 2010, n° RR-7196, http://hal.inria.fr/inria-00454005/en.

[37] A. LEE, F. CARON, A. DOUCET, C. HOLMES. *A Hierarchical Bayesian Framework for Constructing Sparsity-inducing Priors*, University of Oxford, Sep 2010, n° arXiv:1009.1914, http://hal.inria.fr/inria-00518430/en.

References in notes

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

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

[40] 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, p. 1166-1198.

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

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

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

[44] 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.