ALEA : Advanced Learning Evolutionary Algorithms

Team Presentation

*Joint team with the IMB (CNRS and university Bordeaux 1 et 2).*

The recent technological advances together with the fast development of probability theory have lead to new generations of sophisticated evolutionary type and interacting stochastic processes for analyzing more and more realistic models arising in engineering and computer sciences. To name a few, bootstrap filters, genetic and tabu searches, quantum Monte Carlo walkers, level splitting branching processes, subsets methods, and many others. These biology-inspired 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 or physical discussion that clarifies the applicability of these models. Our project consists in studying their mathematical foundations, their different application areas, the design of new methodologies, as well as their computer implementation. Our project is not a single application-driven project, but it is oriented towards concrete applications with important potential industrial transfers on two central problems in advanced stochastic engineering ; namely, Bayesian inference and rare event simulation, and more particularly unsupervised learning, multi-target tracking, data assimilation, uncertainty propagation, epidemic and micro-biology predictions.

Research Themes

Our research project is centered on three central problems in advanced stochastic engineering

- Bayesian inference
- rare event simulation
- Global optimization

and more particularly

- Unsupervised learning
- Nonlinear filtering and multi-target tracking
- Data assimilation and forecasting
- Calibration and uncertainty propagation.
- Financial mathematics (option pricing, sensitivity calculation and risk analysis)
- Epidemiology and 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 classes of biology inspired stochastic algorithms:

- Branching and interacting particle systems
- Dynamic population models
- Reinforced random walks and self interacting processes
- Random tree based search models
- Sequential Monte Carlo methodology

**International and industrial relations**

International collaborations:

- Dan Crisan and Ajay Jasra (Imperial Collage of London)
- Bruno Rémillard (HEC Montreal)
- S. S. Singh (Cambridge Univ.)
- B.N. Vo (Perth Univ.)
- Arnaud Doucet (Univ. of Oxford)
- Andreas Greven (Erlangen Univ.)
- Li-Ming Wu (Clermont Ferrand Univ., Wuhan Univ. & Chine Academy of Sciences)
- Pierre Tarres and Chris Holmes (Oxford University)
- Persi Diaconis and Susan Holmes (University of Stanford)

**Industrial collaborations**

- DCNS : PhD filters and Sequential Monte Carlo methods for multi-target tracking
- EDF R & D : Prediction of electricity consumption, American option pricing, Industrial risk
management.
- CEA : Stochastic optimization, filtering.
- DASSAULT : parameter estimation, particle filters.

Scientific leader

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