

Sequential Bayesian Inference Methods for Complex Dynamical Systems

Institution: IMT Lille Douai & CRIStAL Laboratory UMR CNRS 9189
Advisors: François Septier, Víctor Elvira
Contact: francois.septier@imt-lille-douai.fr, victor.elvira@imt-lille-douai.fr

Subject

Many problems in different scientific domains can be described through statistical models that relate the sequential observed data to a hidden process through some unobserved parameters. In the Bayesian framework, the probabilistic estimation of the unknowns is represented by the posterior distribution of these parameters. However in most of the realistic models, the posterior is intractable and must be approximated. Importance Sampling (IS)-based algorithms are Monte Carlo methods that have shown a satisfactory performance in many problems of Bayesian inference [1].

In this thesis, we will study IS-based methods for probabilistic inference in complex non-linear high-dimensional systems. More specifically, we will propose novel adaptation schemes in order to overcome current limitations of more traditional IS-based techniques in such a challenging context [2]. Extension to sequential learning problems such as in [3] will also be studied. Many applications can be benefited from the development of these methodologies. In particular, the proposed Monte-Carlo techniques could be applied to two challenging problems: 1) indoor localization and 2) spatial and/or temporal field reconstruction [4] such as pollution level [5], electromagnetic radiation, etc.

Candidate profile

We are looking for **two** motivated and talented PhD students with

- background in signal processing, statistics or applied mathematics
- strong mathematical skills
- experience in programming, preferably in Matlab and/or Python.

Details

Two fully funded PhD position are available from September/October 2018 at IMT Lille Douai and in the SIGMA Team [\[link\]](#), of the CNRS laboratory CRIStAL. Both institutions are located in the scientific campus of Villeneuve d’ascq (Lille). Earlier start date can be also considered.

During the thesis, the students will have the opportunity to collaborate with internationally renowned researchers from institutions such as Stony Brook University-New York (USA), Universidad Carlos III-Madrid (Spain), Institute of Statistical Mathematics-Tokyo (Japan), etc.

The PhD students will enjoy an international and creative environment where research seminars and reading groups take place very often. Moreover, with 36% of the population aged under 25, Lille is a vibrant, young and dynamic city. Lille lies in the heart of the triangle that links three of Europe’s main metropolises: London (80 min), Paris (60 min), and Brussels (35 min).

The student will be supervised during this three-year contract by:

- Víctor Elvira [\[link\]](#): victor.elvira@imt-lille-douai.fr
- François Septier [\[link\]](#): francois.septier@imt-lille-douai.fr

The candidates are requested to send us a CV and a motivation letter to apply for this position.

References

- [1] C. P. Robert and G. Casella, *Monte Carlo Statistical Methods*. Springer, 2004.
- [2] L. Martino, V. Elvira, D. Luengo, and J. Corander, “Layered adaptive importance sampling,” *Stat. Comput.*, vol. 27, no. 3, pp. 599–623, May 2017.
- [3] V. Elvira, J. Miguez, and P. M. Djuric, “Adapting the Number of Particles in Sequential Monte Carlo Methods Through an Online Scheme for Convergence Assessment,” *IEEE Trans. Sig. Proc.*, vol. 65, no. 7, pp. 1781–1794, 2017.
- [4] I. Nevat, G. W. Peters, F. Septier, and T. Matsui, “Estimation of Spatially Correlated Random Fields in Heterogeneous Wireless Sensor Networks,” *IEEE Trans. Sig. Proc.*, vol. 63, no. 10, pp. 2597–2609, May 2015.
- [5] H. Rajaona, F. Septier, P. Armand, Y. Delignon, C. Olry, A. Albergel, and J. Moussafir, “An adaptive Bayesian inference algorithm to estimate the parameters of a hazardous atmospheric release,” *Atm. Environ.*, vol. 122, pp. 748–762, Dec. 2015.