PhD Position at INRIA, Rennes, France:

« Uncertainty-Aware Reduced-Order Modeling »

Our Offer

We offer a 3 year PhD position within the research center INRIA in Rennes, France. The research will address the derivation of methodologies for reduced-order modeling by data assimilation. The PhD student will investigate probabilistic approximations of large dynamical systems in the presence of uncertainties on the system trajectories, due to their incomplete observations (typically image data captured by satellite). See more details in the "Scientific Context" section. The post-doctoral fellow is expected to start between September 2016 and January 2017**.** The gross monthly salary is 1,958€ the first two years and 2,059€ the third year.

Your Working Environment

You will join the *ASPI* team (http://www.irisa.fr/aspi/index-en.html) in the INRIA research center in Rennes, France. INRIA (http://www.inria.fr/en/) is the French National Institute for computer science and applied mathematics. Its goal is to promote "scientific excellence for technology transfer and society". INRIA has currently 2,700 employees graduated from the world's top universities working in its labs. The ASPI team is an INRIA research group whose goals are the design, the theoretical analysis and the implementation of interacting Monte-Carlo methods.

Your Skills and Profile

You have solid knowledge in applied mathematics, and specifically in probability theory, statistical analysis, machine learning techniques and constrained optimization. You have good skills in Matlab and C/C++. You have good command of English as working language. Study experiences out of France are an asset.

Scientific Context

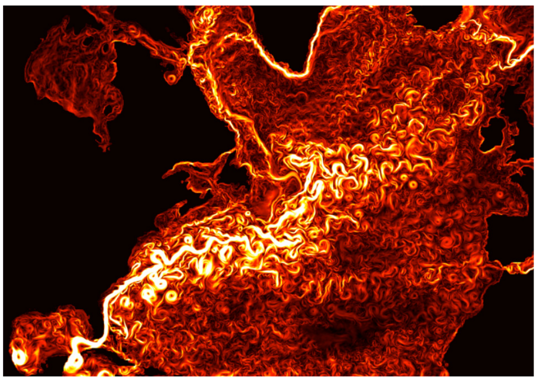

Fig.1: Gulf stream's distribution of cinematic energy.

Model reduction consists in approximating a high-dimensional system (*e.g.*, the evolution of the cinematic energy distribution of the Gulf stream, illustrated in Fig.1) by some model driven by a few degrees of freedom. Model reduction has become very popular in the last decades because it enables to cope with systems whose complexity would be intractable otherwise. The high-dimensional system is simplified by constraining its state to belong to some low-dimensional sub-space. The choice of this sub-space should be made so that it allows for a good approximation of a set of system states. Many techniques have been proposed in the literature to identify such subspaces: reduced basis [1], POD [2], etc.

Because reduced-order models are only approximations of their high-dimensional counterparts, they are only expected to reproduce properly the behaviour of the latter in some particular regimes (for example, for some initial conditions or parameter values). The knowledge of such regimes is thus often used (sometimes explicitly but most often implicitly) in the construction of reduced-order models. Unfortunately, in some situations, the set of states to be reproduced by the reduced model is not given explicitly but only observed through some partial and noisy observations. As an example, one can think of meteorological applications, where the scientists are interested in reproducing ocean currents. In such setups, the initial conditions defining the trajectories of the high-dimensional system are rarely known. However, we have at our disposal a large number of satellite images capturing the evolution of variables (*e.g.*, surface temperature, height or salinity) related indirectly to these currents, as illustrated in Fig.2. These images thus provide noisy and partial observations of the currents of interest, see *e.g.*, [3].

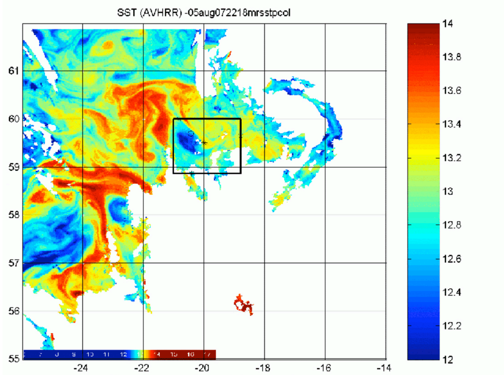

Fig.2: Example of image of sea surface temperature captured by satellite.

You will be in charge of providing solutions to this type of problem. Following recent work in the domain, see [4,5,6], your job will be concerned with the construction, the theoretical analysis and the application to practical setups of reduced-order models using a surrogate prior to model the unknown uncertainties. In particular, based on the theory of interacting Monte-Carlo methods [7] and on the properties of relative entropy [8], you will design reduced-order models based on particle approximations and analyze the influence of the surrogate on the error committed by the reduced-order model.

[1] A. Quarteroni, G. Rozza, and A. Manzoni. Certified reduced basis approximation for parametrized partial differential equations and applications. Journal of Mathematics in Industry, 1(1):1–49, Dec. 2011

[2] A. Antoulas, “Approximation of Large-Scale Dynamical Systems”. Advances in Design and Control, SIAM 2005.

[3] P. Héas, F. Lavancier, S. Kadri Harouna. “Self-similar prior and wavelet bases for hidden incompressible turbulent motion”. SIAM Journal on Imaging Sciences, Volume 7, Issue 2, pp. 1171-1209, 2014.

[4] Y. Maday, A.T. Patera, J.D. Penn, M. Yano, “A Parameterized-Background Data-Weak Approach to Variational Data Assimilation: Formulation, Analysis and Application to Acoustics”. International J. Numer. Meth. Engineering 102:933–965, 2015.

[5] P. Binev, A. Cohen, W. Dahmen,. R. DeVore, G. Petrova, and P. Wojtaszczyk, “Data Assimilation in Reduced Modeling”. ArXiv, June 2015.

[6] Y. Traonmilin, and R. Gribonval, “Stable recovery of low-dimensional cones in Hilbert spaces: One RIP to rule them all”. Arxiv , october 2015

[7] P. Del Moral “Feynman-Kac formulae: genealogical and interacting particle systems with applications”, Series: Probability & Applications Springer Verlag, 2004.

[8] P. Dupuis and R. S. Ellis. “A Weak Convergence Approach to the Theory of Large Deviations” Wiley Series in Probability and Statistics. John Wiley& Sons, New York, 1997

Interested in the Job?

Please send your candidature (a resume, reference letters and detailed marks for the different courses you have followed) to

Dr. Patrick Héas, (http://people.rennes.inria.fr/Patrick.Heas/)
Dr. Cédric Herzet, (http://people.rennes.inria.fr/Cedric.Herzet/Cedric.Herzet/)
Pr. Francois Le Gland, (http://www.irisa.fr/aspi/legland/)
INRIA Rennes-Bretagne Atlantique

e-mail : patrick.heas@inria.fr, cedric.herzet@inria.fr, francois.le_gland@inria.fr