2018-00627 - PHD position FLUMINANCE group: «Group theory approach for the characterization and learning of large-scale oceanic dynamical systems»

Contract type: Public service fixed-term contract  
Level of qualifications required: Graduate degree or equivalent  
Fonction: PhD Position

About the research centre or Inria department

Inria, the French National Institute for computer science and applied mathematics, promotes “scientific excellence for technology transfer and society”. Graduates from the world’s top universities, Inria's 2,700 employees rise to the challenges of digital sciences. With its open, agile model, Inria is able to explore original approaches with its partners in industry and academia and provide an efficient response to the multidisciplinary and application challenges of the digital transformation. Inria is the source of many innovations that add value and create jobs.

Team presentation

The FLUMINANCE research group is dedicated to the study of methods for the measurement, the analysis or the control of fluid flows from image sequences. The group aims at providing on the one hand image sequence methods devoted to the analysis and description of fluid flows and in the other hand physically consistent models and operational tools to extract meaningful features characterizing or describing the observed flow and enabling decisions or action. Such a twofold goal is of major interest for the inspection, the analysis and the monitoring of complex fluid flows, but also for control purpose of specific flows involved in industrial problems.

Context

General description

We seek a candidate for a PhD position within the Fluminance team, (INRIA Rennes, France). This study at the cross section between Applied Mathematics, statistical learning theory and Physical Oceanography. We will investigate the use of group theory techniques together with reproducible kernel Hilbert space theory for the characterization of dynamical systems from observations (see section « Detailed subject » for more information).

Environment

The candidate will work in the Fluminance team located in Rennes. The team is part of INRIA (www.inria.fr), which is one of the leading research center in Computer Sciences in France. Fluminance is as well affiliated to the Mathematics research institute of the Rennes I University (IRMAR). This PhD thesis will be led within a strong a strong collaboration with Imperial College and Ifremer. The main research activities of Fluminance focus on the study of turbulent flows from image data sequences, which encompasses many issues for the analysis of experimental and geophysical flows. We refer the candidates to the team’s website for more information:

http://www.irisa.fr/fluminance/indexFluminance.html

Regular travel foreseen for this post:

The PhD will actively participate to a research collaboration with the Ifremer institute (french oceanic research institute) and the mathematics department of Imperial College. The travel and sojourn expenses will be fully covered.

Assignment

General Information

- **Theme/Domain**: Earth, Environmental and Energy Sciences  
  - Scientific computing (BAP E)
- **Town/city**: Rennes  
- **Inria Center**: CRI Rennes - Bretagne Atlantique
- **Starting date**: 2018-10-01
- **Duration of contract**: 3 years
- **Deadline to apply**: 2018-05-05

Contacts

- **Inria Team**: FLUMINANCE  
- **Recruiter**: Memin Etienne / etienne.memin@inria.fr

Conditions for application

Thank you to send us these documents by applying online:

- updated CV
- cover letter
- letters of recommendation eventually
- degree transcripts

More informations: etienne.memin@inria.fr

Defence Security:

This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST). Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy:

As part of its diversity policy, all Inria positions are accessible to people with disabilities.

Warning: you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.
Main activities

Detailed subject

The precise characterization of geophysical phenomena is becoming a crucial need in many aspects of our everyday life as it may strongly impact many environmental and economical fields. We may think, among others, to applications related to climate studies, oceanographic analysis or weather forecasting which are of paramount importance for the study of global warming, the tracking of polluting sheets or the prediction of catastrophic events. Unfortunately, the laws ruling such geophysical processes depend on state variables evolving in huge dimensional spaces with a strong scale coupling in space and time. The range of these interactions is so large that only large-scale representations of the system of interest can be simulated. In the other hand, one may have access nowadays to series of finely resolved data sequences depicting the footprint of the small-scale flow action.

The goal of this PhD will be to explore the constitution of large-scale representations of flow dynamics from a spectral representation of the infinitesimal generator of Frobenious-Perron and Koopman operators driving the dynamical system's measure and observables respectively [7]. To devise affordable techniques for such a spectral representation of infinite dimensional operators, we will embed these operators onto a family of reproducible kernel Hilbert spaces [1,2,4] driven by the dynamics. This embedding onto a manifold of smooth functions should allow us to characterize several meaningful mathematical properties of the resulting operator semi-groups authorizing to apply classical finite dimensional numerical methods for their spectral analysis and estimation. Those spectral representations will then be used to infer and study fast data assimilation techniques to couple the dynamical system to high resolution data. They also open routes to estimate efficiently the leading Lyapunov exponents associated to the underlying dynamics or to infer meaningful ergodic properties. The characterization of the spectrum of these operators has recently raised a huge interest in the fluid mechanics community [10,12,13]. However, the techniques proposed so far use implicitly strong questionable finite dimensional assumptions. They furthermore rely only on sequence of data. In this work, will use the data as well, but also a (possibly imperfect) representation of the dynamics.

In a second time, we will study the extension of this deterministic setting to a stochastic representation of the dynamics as recently proposed in [5] and [11]. As a matter of fact, in order to incorporate inherent uncertainties or errors and to better represent the effect of the neglected scales, there is a growing interest to set up random representations for those flows [5,9,11]. The modelling and the handling along time of uncertainties are crucial for instance for ensemble forecasting and data assimilation issues. In this study, we propose to stick to a recent derivation [11] that naturally emerges from a decomposition of the flow velocity field into a differentiable drift component and a time uncorrelated uncertainty random term. This framework has shown to enable the derivation of meaningful dynamical random oceanic models with results greatly improved when compared to deterministic simulations [3].

The resulting models open very exciting mathematical questions on those modified equations for which little is known. The characterization of the spectrum associated to random infinitesimal generator of the corresponding Frobenius-Perron and Koopman operators as well as ergodic properties should allow us to extend the data assimilation context tackled in the first part of this thesis beyond the Gaussian coupling strategies, which constitute indeed the Achile's heel of the usual data assimilation procedures based either on optimal control strategies [8] or on ensemble filtering techniques [5]. The mathematical study of the corresponding stochastic systems is also of major interest in order to exhibit their asymptotic properties or to derive stable discrete schemes for their numerical simulation.

Bibliography:

2. Berlinet and C. Thomas-Agnan. Reproducible kernel Hilbert spaces in Probability and


Skills
The candidate should have a solid background in applied mathematics. She/he must have a good knowledge of Matlab or Python, and C/C++. He/She must have a PhD related to applied mathematics or computational physics.

Benefits package
- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Sports facilities

Remuneration
Monthly gross salary : 1982 euros