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

**A propos du centre ou de la direction fonctionnelle**

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 in 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.

**Contexte et atouts du poste**

**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.

**Informations générales**

- **Thème/Domaine**: Sciences de la planète, de l’environnement et de l’énergie
  Calcul Scientifique (BAP E)
- **Ville**: Rennes
- **Centre Inria**: CRI Rennes - Bretagne Atlantique
- **Date de prise de fonction souhaitée**: 01-10-2018
- **Durée de contrat**: 3 ans
- **Date limite pour postuler**: 05-05-2018

**Contacts**

- **Equipe Inria**: FLUMINANCE
- **Recruteur**: Memin Etienne / etienne.memin@inria.fr

**Conditions pour postuler**

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

**Sécurité défense**

Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d’établissement, après avis ministériel favorable, tel que défini dans l’arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l’annulation du recrutement.

**Politique de recrutement**

Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.

**Attention**

Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d’autres canaux n’est pas
Contact
Applicants must send their candidature (resume and letter of motivation) to
Etienne Mémin
Fluminance team
INRIA Rennes-Bretagne Atlantique
email: etienne.memin@inria.fr

Principales activités

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 Frobenius-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, we 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 Achilles' 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:


**Compétences**

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.

**Avantages sociaux**

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

**Rémunération**

Monthly gross salary : 1982 euros