4b. Comparison between hybrid PDE-ROM with linear PDE vs hybrid PDE-ROM with nonlinear PDE

4a. Comparison between full ROM and hybrid PDE-ROM.

4. Benchmarking:
   - method (LS, ANN, etc) and problem inversion. On data subset 2: validation and error estimate
   - developed in two steps. On data subset 1: model reduction and learning. selection of the learning formulation allowing to couple MOR and data assimilation (LS, ANN, etc). The process will then be
   - MOR phase with the assimilation of reference (numerical or experimental) data, and thus on the
   - the space to depend (at least) on time. Other challenges are related to the coupling of the nonlinear
   - in an appropriate reduced space. This RHS is a result of the large-scale PDE computations, requiring
   - the near shore region. These represent a small-scale correction for short waves. The long
   - nonlinear and dispersive. The most efficient models are based on appropriate two-dimensional (large
   - wave component can be computed very efficiently solving the hyperbolic shallow water system. The
   - required in the near shore region. These represent a small-scale correction for short waves. The long
   - computation of the dispersive small scales requires at each time step the inversion of a nonlinear
   - elliptic system. The CPU time over-head w.r.t. shallow water computations can go up to one order of
   - the physics relevant to the engineering applications while remaining computationally affordable in an operational context;
   - efficient adaptive discretizations allowing to optimize the computational effort, while providing a sharp and accurate resolution of the physics;
   - a certification step quantifying the uncertainty in engineering outputs due to all modelling choices, both physical, and mathematical (continuous and discrete)

To develop a robust and accurate model means to be able to quantify and control the effects of the choices made in each of the above steps. The development of robust models tailored to the applications mention above is the objective of CARDAMOM.

Contexte et atouts du poste

In this project we will explore an alternative approach for the accurate modeling of free surface waves. The focus is on the near-shore area in which waves are highly energetic, and their dynamics nonlinear and dispersive. The most efficient models are based on appropriate two-dimensional (large scale) asymptotic approximations, accounting for full nonlinearity, and for weakly dispersive effects required in the near shore region. These represent a small-scale correction for short waves. The long wave component can be computed very efficiently solving the hyperbolic shallow water system. The computation of the dispersive small scales requires at each time step the inversion of a nonlinear elliptic system. The CPU time over-head w.r.t. shallow water computations can go up to one order of magnitude. To mitigate this we consider a hybrid size-specific (fixed topology) PDE-ROM approach replacing the computation of the small scales with an approximate model. The approximate model can be achieved through reduced order models or statistical learning models. This work will be done in collaboration with BRGM and Rivages Pro-tech (SUEZ), providing data for assimilation and validation, with Prof. R. Abgrall (U. Zurich) on aspects related to numerical methods, and with the MEMPHIS Team on ROMs.

Mission confiée

The work will proceed by steps of increasing complexity: starting with one dimensional linearized dispersive PDEs (Boussinesq system), and then moving to the 2D nonlinear system with weakly nonlinear dispersive effects, 2D systems (linear and then weakly nonlinear), up to the fully nonlinear equations (Serre-Green-Naghdi).

The main challenges will be related to the choice of the representation of the RHS in the elliptic PDE in an appropriate reduced space. This RHS is a result of the large-scale PDE computations, requiring the space to depend (at least) on time. Other challenges are related to the coupling of the nonlinear MOR phase with the assimilation of reference (numerical or experimental) data, and thus on the choice of the learning/problem inversion technique.

Another important issue will be to be able to control and estimate the error in approximation for the small scales.

At each step the main developments will be the following:

1. Decomposition of the full problem: hyperbolic system plus a source obtained from a time independent elliptic system
2. ROM for the elliptic system: study of the most appropriate formulation especially w.r.t. data compression (choice of the basis) and the representation on different (variable) parameters
3. Learning phase (site-specific). The first step will be the selection of the most appropriate formulation allowing to couple MOR and data assimilation (LS, ANN, etc). The process will then be developed in two steps. On data subset 1: model reduction and learning: selection of the learning method (LS, ANN, etc) and problem inversion. On data subset 2: validation and error estimate
4. Benchmarking:

A propos du centre ou de la direction fonctionnelle

From PDEs to certified computational models: this is the motto of CARDAMOM. We aim at providing a robust model development methodology, as well as a quantitative approach to model certification, allowing to assess the robustness of the model w.r.t. each of its components (equations, numerical methods, etc), and to assess the variability of the outputs w.r.t. random variations of the data.

We will achieve this objective working toward a unified set of tools for the engineering analysis of complex flows involving moving fronts. Examples of such flows be found in civil, industrial, and aerospace engineering, industrial hazards (explosions), free surface hydraulics (coastal hydrodynamics, floods, etc), energy conversion facilities (gas-vapour, liquid-vapour systems, wave energy conversion, etc.), space-reacting (chemically reacting fronts, ablating walls, rarefied/continuous flows), wing de anti-icing systems (ice-air flow), etc.

Simulating, optimising, and controlling these systems in a robust manner is far from being a simple task, especially in a real life. There is still a large number of open scientific challenges. These are related to the intrinsic nature of these flows necessitating:

- an appropriate PDE formulation taking into account the physics relevant to the engineering applications while remaining computationally affordable in an operational context;
- efficient adaptive discretizations allowing to optimize the computational effort, while providing a sharp and accurate resolution of the physics;
- a certification step quantifying the uncertainty in engineering outputs due to all modelling choices, both physical, and mathematical (continuous and discrete)

To develop a robust and accurate model means to be able to quantify and control the effects of the choices made in each of the above steps. The development of robust models tailored to the applications mention above is the objective of CARDAMOM.

À propos d’Inria

Inria, l’instutional national de recherche dédié aux sciences du numérique, promeut l’excellence scientifique et le transfert pour avoir le plus grand impact. Il emploie 2400 personnes. Ses 200 équipes-projets agiles, en général communes avec des pôles universitaires académiques, impliquent plus de 3000 scientifiques pour relever les défis des sciences informatiques et mathématiques, souvent à l’interface d’autres disciplines. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 160 start-up. L’institut s’efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l’économie.

L’essentiel pour réussir

Essential qualities in order to fulfill this assignment are feeling at ease in an environment of scientific dynamics and wanting to learn and listen.

Consignes pour postuler

Thank you to send:

- CV
- Cover letter
- Support letters (mandatory)
- List of publication

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.

Informations générales

- Thème/Domaine : Schémas et simulations numériques
- Ville : Toulouse
- Centre Inria : CRI Bordeaux - Sud-Ouest
- Date de prise de fonction souhaitée : 2019-10-01
- Durée de contrat : 1 an
- Date limite pour postuler : 2019-03-31
- Site web : Inria.fr
- Recruteur : ricchiuto Mario / mario.ricchiuto@inria.fr

Attention: Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.
**Principales activités**

The main developments will be the following:

1. Decomposition of the full problem: hyperbolic system plus a source obtained from a time independent elliptic system

2. ROM for the elliptic system: study of the most appropriate formulation especially w.r.t. data compression (choice of the basis) and the representation on different (variable) parameters

3. Learning phase (site-specific). The first step will be the selection of the most appropriate formulation allowing to couple MOR and data assimilation (LS, ANN, etc). The process will then be developed in two steps. On data subset 1: model reduction and learning, selection of the learning method (LS, ANN, etc) and problem inversion. On data subset 2: validation and error estimate


4a. Comparison between full ROM and hybrid PDE-ROM.

4b. Comparison between hybrid PDE-ROM with linear PDE vs hybrid PDE-ROM with nonlinear PDE system

**Compétences**

Candidates are expected to have a strong background in numerical methods for PDEs. Some background on machine learning methods and inverse problems is also required as well as good programming skills.

**Avantages**

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking (after 6 months of employment) and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

**Rémunération**

2653€ / month (before tax)