PhD Position in Credible data-driven models: “Adaptive parameterisation in Markov chain Monte Carlo methods” (VAC-2021-37)

Title of the PhD project: Adaptive parameterisation in Markov chain Monte Carlo methods

INTRODUCTION:

The International Centre for Numerical Methods in Engineering (CIMNE, www.cimne.com) is a research centre, created in 1987 by consortium between the Catalan Government and the Universitat Politècnica de Catalunya (UPC-BarcelonaTech), devoted to the development and application of numerical methods to a wide range of areas in engineering. CIMNE has been selected as a Severo Ochoa Centre of Excellence for the period 2019-2023, the highest level of recognition of excellence and leadership awarded to a research centre in Spain.

POSITION DETAILS

Number of vacancies: 1
Category: PhD (PHD2)
Location: Barcelona
Yearly salary (gross): 17.563,14 EUR
Working hours: Full time
Duration: 3 years
Starting date: No later than Sept 2021

FUNCTIONS TO BE DEVELOPED BY THE APPLICANT

CIMNE is looking for a **PhD Researcher** to be part of the Research and Technical Development (RTD) Group on Credible data-driven models.

The functions assigned to the candidate will be:

- Complete a PhD on Civil Engineering or Applied Mathematics at Universitat Politècnica de Catalunya – Barcelona Tech. The candidate is expected to complete the PhD thesis in a maximum of three years.
- Collaborate with various research groups within CIMNE and worldwide, namely Macquarie university in Sydney, Australia.
- To publish a minimum of two papers in JCR journals during the PhD period, author and co-author articles in high-impact international journals.
- Carry out quality research, training and management.
- Participate on the dissemination and outreach activities associated with the project.

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- Participate in international conferences presenting her/his work.

DESCRIPTION OF THE PHD PROJECT:

During the last 20 years the Solid Earth community pursues massive data-driven simulations and joint inversions for the physical state of the Earth's interior with unprecedented complexity and resolution. Traditional inversion techniques applied to the problem of characterising the thermal and compositional structure of the upper mantle are not well suited to deal with the nonlinearity of the problem. Probabilistic inversions, on the other hand, offer a powerful formalism to cope with these difficulties. The parameterisation usually used in geophysical inversions is based on very fine structured grids, where the properties of each cell is considered independent. This simple parameter space is chosen as the structures to be recovered include sharp contrasts, discontinuities and complex spatial shapes. Although, the grid based parameterisation in three dimensional domains produce an enormous number of parameters to determine, exceeding 500.000 unknowns in practical cases. Several drawbacks arise: first, solving an inverse problem to determine 500.000 parameters is computationally exhausting. Second, this kind of parameterisation reduces the sensitivity of each parameter while the grid is refined and, therefore, increases the difficulty of the inversion. In this thesis we want to explore model reduction techniques that seek low-dimensional representations of parameters. The goal is producing an adaptive parameterisation effectively reducing the number of parameters. This is expected to accelerate the probabilistic inversion algorithm and facilitate efficient sampling in the reduced parameter space. The result will be a tractable procedure for the solution of statistical inverse problems involving partial differential equations with high-dimensional parametric input spaces.

References

- Previous work within the group:

Ortega O., S. Zlotnik J.C. Afonso and P. Díez, “Fast Stokes flow simulations for geophysicalgeodynamic inverse problems and sensitivity analyses based on reduced order modeling”, Journal of Geophysical Research: Solid Earth, Vol. 125, 1–25, doi:10.1029/2019JB018314, 2020.

Manassero M.C., J.C. Afonso, F. Zyserman and S. Zlotnik, “A reduced order approach for probabilistic inversions of 3-D magnetotelluric data I: general formulation”, Geophysical Journal International, Vol. 223, Issue 3, pags. 1837–1863, doi:10.1093/gji/ggaa415, 2020

- Other relevant references:

Lieberman C., K. Willcox And O. Ghattas, Parameter And State Model Reduction For Large-Scale Statistical Inverse Problems. SIAM J. Sci. Comput. Vol. 32, No. 5, pp. 2523–2542, 2010.

Constantine P.G., C. Kent and Tan Bui-Thanh, Accelerating Markov Chain Monte Carlo with Active Subspaces, SIAM J. Sci. Comput., 38(5), A2779–A2805, 2016.

REQUIREMENTS

1. To have a strong undergraduate and MSc degree (or equivalent) in Engineering, Mathematics, Physics or a related field and a good level of English.
2. To have an enthusiastic attitude to conduct research, being hard-worker and critic.
3. To demonstrate knowledge of some programming languages such as Matlab, c, Julia, Python…
4. To have some experience with Finite Element analysis

EVALUATION OF CANDIDATES

The requirements and merits will be evaluated with a maximum mark of 100 points. Such maximum mark will be obtained by adding up the points obtained in the following items:

- Academic record (60%)
- Previous research and academic experience in the field of the position (20%)
- Programming skills (10%)
- Language skills (10%)

HOW TO APPLY

Candidates must complete the "Application Form" form on our website, indicating the reference of the vacancy and attaching the following documents **in English**:

- Curriculum vitae
- A motivation letter
- Academic transcripts from all Undergraduate and MSc degrees
- Name and institutional contact information of two possible referees

The deadline for registration to the offer ends on 31st May, 2021 at 12 noon.

The shortlisted candidates may be called for an interview. They may also be required to provide further supporting documentation.

CIMNE is an equal opportunity employer committed to diversity and inclusion. We are pleased to consider all qualified applicants for employment without regard to race, colour, religion, sex, sexual orientation, gender identity, national origin, age, disability or any other basis protected by applicable state or local law. CIMNE has been awarded the HRS4R label.