PhD POSITION IN "APPLIED MATHEMATICS: MACHINE LEARNING AND DATA SCIENCE" AT THE ICMAT FOR THE INPhINIT PROGRAMME

Job Position title: **PhD in Applied Mathematics: Machine Learning and Data Science**

Research project/ group description

ICMAT RESEARCH GROUP C: APPLIED MATHEMATICS

This research group works with mathematical foundations and models needed to deal with new societal challenges, with a focus on Data Science, Machine Learning and Quantum Technologies.

The main research lines may be grouped into the following general directions:

- **Mathematics of Quantum Information Theory:** Quantum technologies are one of the most promising technologies for the near future. They exploit quantum effects to develop new techniques in cryptography, metrology, material science, pharmacology, etc., which have the potential to go far beyond the current state of the art. Some of the mathematical problems are related to condense matter and many body systems, quantum control, foundational aspects of quantum mechanics and the theory of operator algebras.
- **Machine Learning and Data Science:** Machine learning and Data Science are disciplines at the core of many current significant societal developments. Embedded in the disciplines of Statistics, Probability, Optimization and Algebra, with strong support from Computer Science developments, this line focuses on providing efficient Bayesian approaches to the treatment of large scale inference and prediction problems and methods through adversarial risk analysis and adversarial machine learning. Moreover, it also emphasizes dealing with complex applied problems mainly in the areas of security and cybersecurity, with the aid of its DataLab.
- **Mathematical Modelling and Simulation:** This covers a wide spectrum ranging from the multidisciplinary mathematical approach to the problems, with emphasis in numerical computation, to the promotion of applications in engineering, biology, physics and earth sciences. Research include topics such as microfluidics modelling and technological applications, geophysical fluid dynamics, etc.

The group is formed by the following faculty members:

M.A. Fontelos, A. Ibort, F. Lledó, C. Palazuelos, D. Pérez, C. Rascón, D. Ríos, I. Villanueva.

Job position description

The focus is on the mathematical foundations of machine learning (ML), data science (DS) and artificial intelligence (AI) with the aim to achieve two main goals. First, mathematics may provide tools to improve our understanding the mechanisms that make AI techniques so efficient in the tasks of classification, recognition, etc. as well as systematize our knowledge around them. Secondly, based on this better knowledge, explore the ways to improve existing methods and create new ones. Indeed, ML, DS and AI

entail novel mathematical challenges that promise to have real applied impact in future technology and society. Among them, it is crucial to develop Bayesian learning methods that scale to massive data sets: current approaches based on variational Bayes methods tend to be biased; current Markov chain Monte Carlo methods are not fast enough for many applications. Their hybridation could lead to powerful new solutions. The security and robustification of (ML) algorithms against adversarial attacks demands also novel concepts and computational methods, beyond simplified approaches based on standard game theoretic concepts, so as to increase our trust in deployed systems. Applications motivating these areas of research include the development of autonomous driving systems as well as of autonomous defensive systems.

The PhD candidate will be appointed a supervisor among the faculty members of the Group, with whom regular meetings will be held. He/she will be expected to participate in the group activities including seminars and conferences, interacting with visitors and international colleagues. ICMAT will also provide counselling to help the PhD candidate develop a successful research career.

Research Group Contact: D. Ríos (david.rios@icmat.es)

Research Group website:

ICMAT RESEARCH GROUP C: APPLIED MATHEMATICS: https://www.icmat.es/researchers/groups/group-c/

Links to the INPhINIT 2021 Incoming Open Call:

Programme description: https://fundacionlacaixa.org/en/educacion-becas/becas-la-caixa/doctorado-inphinit/descripcion-del-programa

Application website: https://candidate.lacaixafellowships.org/login

Programme rules here.

PhD position finder: https://hosts.lacaixafellowships.org/finder