DATA-DRIVEN MODELLING SMART FLUIDS FOR SHOCK CONTROL IN PROSTHETIC MEDICINE

Area(s) of Knowledge:

- Physical Sciences, Mathematics and Engineering

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Research group/Research project website
http://www.lacan.upc.edu
https://www.lacan.upc.edu/Credible

Group of disciplines:

PHYSICAL SCIENCES, MATHEMATICS AND ENGINEERING

Theoretical and Applied Mathematics, Computer Sciences
Civil and Construction Engineering, Energy, Nuclear Energy and Renewable Energy Engineering
Telecommunications, Electronics, Robotics, Biomedical Engineering, Automation Engineering, ICT
Industrial Engineering, Mechanical Engineering, Metallurgy, Materials, Nanotechnology, Aeronautical, Naval and Aerospace Engineering

Research project/Research group description (màx. 2.000caràcters)

Mechanical shocks represent one of the major causes of damage in engineered structures. Due to the unavoidable and generally unpredictable nature of these phenomena, the development of control devices able to absorb shock waves is crucial.

This project aims to investigate the use of magnetorheological (MR) fluids for vibration control in prosthetic legs, in particular MR dampers to absorb the shock experienced by patients when running, jumping or walking on heterogeneous soil. MR fluids are a type of smart fluids characterized by a non-magnetic carrier in which magnetic microparticles are suspended. The application of a magnetic field is responsible for these particles to form strings that increase the viscosity of the fluid. Thus, their mechanical response spans from a viscous fluid to a viscoelastic solid.

Mathematical modelling and numerical simulation of magnetorheological fluids still represent a challenge for the engineering community. In this context, multiscale modelling based on a machine learning and data-driven rationale will be investigated to provide an accurate description of the coupled physical phenomena involving both the carrier and the microparticles. Special emphasis will be given to the development of high-fidelity discretization methods able to capture the complex flow features of MR fluids and their magnetic response.

Moreover, the ability to provide a real-time response of MR fluids under different scenarios is a critical aspect to efficiently design a control device. This relies on an explicit parametric solution of the governing equations. Nonetheless, the computational complexity of finite element solutions rapidly becomes unaffordable when several parameters are introduced in the model under analysis. To overcome this *curse of dimensionality*, reduced order models will be investigated to construct explicit parametric solutions of flow and magnetic problems and to devise a vibration control strategy based on surrogate models.

<u>Job position description</u> (màx. 2.000 caràcters)

This interdisciplinary project lies at the interface of two research fields: mathematical modelling and computational engineering, with application to biomedical problems.
The PhD thesis will be developed within the **Credible high-fidelity data-driven models** group of **Laboratori de Càlcul Numèric** (LaCàN) at **Universitat Politècnica de Catalunya**. This research group is active on different topics related to the development of innovative numerical methods in computational mechanics and computational fluid dynamics and their application to industrial problems. The candidate will integrate a very dynamic research team of recognized experts under the supervision of Prof. A. Huerta and Dr. M. Giacomini. He/she will have access to state-of-the-art research and computing facilities. He/she is expected to develop high-quality research in applied mathematics and computational engineering applied to the thriving field of biomedical engineering, to attend advanced training courses, to present the obtained results in international conferences and to contribute to the writing of technical reports and scientific articles for high-impact international journals.

Requirements:

- Strong undergraduate and MS degree (or equivalent) record in mathematics, engineering or related discipline.
- Good written and oral communication skills in English.
- Good knowledge of numerical methods for the approximation of partial differential equations (in particular, the finite element method).
- Knowledge of computational fluid dynamics, computational electromagnetics and reduced order models is not compulsory but will be considered an advantage.
- Advanced programming skills (Matlab and/or Fortran).
- Curiosity and commitment to develop high-quality research.
- Hard-working and enthusiastic attitude towards research and innovation.
- Flexibility and ability to work in an interdisciplinary team.