Postdoctoral Fellowship

AI-Driven Soft Object Robotics

Context

Unlike the handling of rigid bodies, which relies on well-understood kinematic and dynamic modeling, the robotic manipulation of soft objects remains a major challenge because it requires simulating continuous shape changes. This capability is essential for diverse industrial applications, ranging from the delicate conditioning of agro-food products to the precise positioning of rubber sheets and strips during tire manufacturing. Predicting such deformations necessitates solving complex Partial Differential Equations (PDEs) derived from the fundamental principles of continuum mechanics. Traditional numerical methods, such as the finite element method, are not relevant in this context because of the extensive numerical efforts associated with them.

This project investigates alternative solution strategies to solve these PDE, specifically deep learning PDE solvers, such as Physics-Informed Neural Networks (PINNs) [1], Deep Galerkin Methods (DGM, see e.g. [2, 3]). They consist of a dedicated technology with specific architectures, loss functions, *etc*. Their training, which demands significant numerical effort, can be done on a high-performance computing facility or on a workstation, eliminating the need for the robot to execute these computations. Once trained, the network can be used in real time because it requires reduced computational power. This is fully compatible with real-time control and the method remains applicable on the robot's typically less powerful hardware.

The work will consider modeling soft objects governed by non-linear elasticity. This involves investigating a range of non-linear problems, from 1D slender structures undergoing large elastic deformations to complex 3D hyperelastic geometries.

Profile

Candidate with experience using deep learning, with a background in either mechanical engineering, continuum mechanics or numerical methods.

Knowledge of French is not a prerequisite for this position, though it would be helpful for navigating daily life in France.

Application

Expressions of interest must be sent by May 28th to Pierre Beaurepaire (pierre.beaurepaire@sigma-clermont.fr) and Chedli Bouzgarrou (belhassen-chedli.bouzgarrou@sigma-clermont.fr).

If you are interested in pursuing this project, please send your CV and a short motivation letter (maximum 1 page) detailing your research area, motivation for the project, project ideas, and other relevant information.

About the university and the unit

The Université Clermont Auvergne (UCA) is a higher education institution located in Clermont-Ferrand, France. It offers a wide range of programs across various academic fields, from fundamental sciences to humanities and social sciences, as well as law, economics, engineering, and health sciences. UCA is home to approximately 38,000 students and 1,300 academic staff.

The postdoctoral fellow will be hosted at the Institut Pascal, an institute of engineering and applied science, working with the Mechanics, Materials, and Structures team. The team includes about 50 permanent staff and 50 non-permanent members (PhD students, post-docs, etc.). A 3,200 square-meter experimental facility is available and might be used for experimental validation of the methods developed during the project.

References

[1] Raissi, M., Perdikaris, P., & Karniadakis, G. E. (2019). Physics-informed neural networks: A deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations. Journal of Computational Physics, 378, 686–707.
[2] Blechschmidt, J., & Ernst, O. G. (2021). Three ways to solve partial differential equations with neural networks — A review.
[3] Lye, K. W., Sun, C., Li, Z., & Yin, C. (2024). Deep Learning for Solving Partial Differential Equations: A Review of Literature.