

Simulation-based Shaping of Deformable Objects in Collaborative Robotic Applications

PhD position starting as early as September 2026 - Duration: 36 months
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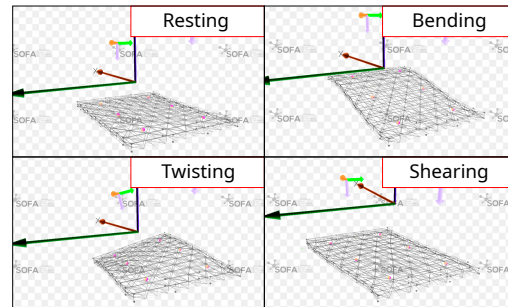
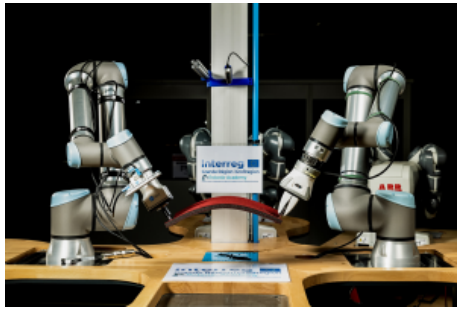


Figure 1: Two UR10e robot arms are shaping a piece of red foam. The foam's deformation is driven by an interactive finite element simulation.

Scientific context

Deformable objects are ubiquitous in industrial and household applications. However, it is still difficult for robot manipulators to handle them properly. The robots are generally not aware of the deformation physics at play, so they cannot control the shape or ensure the object's integrity at all times. This limitation gave rise to the field of deformable object manipulation, which seeks to improve the robot's ability to manipulate soft objects [1, 2]. Some promising solutions consist in leveraging fast mechanical simulations as an internal model for a motion controller [3]. This strategy was also adopted in robotized medical surgery for instance [4].

However, object deformation control problems are underactuated, thus tricky to solve. Conversely, geometrical and mechanical characteristics of the manipulated object can only be so precisely known, meaning the controller meets unavoidable modeling errors. We address these gaps in the ANR Mandolin project, carried out by a multidisciplinary team of experts. In particular, the Control team of the LCFC lab (EA4485, Université de Lorraine) will work on advanced simulation-based control.

Objectives

The scientific challenges we are faced with are:

- Formulate control algorithms that take advantage of the interactive simulation, to improve the controller's performance;
- Perform online deformation state estimation and controller adaptation, to mitigate the mismatch between simulated and perceived quantities;
- Define collaboration modalities in the shaping task, to investigate multi-robot and human-robot applications.

To answer these challenges, the candidate will propose control algorithms drawing from control theory, perception, and mechanical simulation. They will implement their methods in the ROS2-Assist simulation environment, then transfer them to a setup comprised of two UR10e robot arms and a motion capture system, in realistic shaping scenarios they will help define.



Your profile

Candidates should have a Master's degree (M2 or equivalent) with research experience in the field of robotics, mechatronics, or mechanical engineering. We seek the following skills:

- **Languages:** written and spoken English, scientific writing. Spoken French is a plus.
- **Robotics:** kinematics, motion planning, motion control.
- **Control:** linear systems, Lyapunov synthesis, adaptive control.
- **Mechanics:** solid dynamics, continuum mechanics, finite element modeling.
- **Tools:** programming in C++ and/or Python, knowledge in ROS2.
- Knowledge in computer vision or artificial intelligence is a plus.
- **Soft skills:** will to learn, autonomy, palatability for project-oriented organization.

Details

- Duration of 36 months, ideally starting in September or October 2026.
- Monthly gross salary about 2300 euro.
- Office and experimental setup located at the LCFC lab, Metz, France, in the ENIM building.
- Opportunities for mobility at the ICube lab (Strasbourg, France) throughout the PhD.

About our lab

The PhD is a part of the activities of the Control team of the LCFC, where we are interested in robotic systems design and robotization of manufacturing processes. You will integrate a human-scaled work environment, boasting ambitious projects and state-of-the-art experimental platforms.

How to apply

Send before April 17, 2026 your application as an email to adrien.koessler@univ-lorraine.fr, with the title "Mandolin PhD application". You must provide:

- Your CV (1 page max);
- A cover letter (1 page max), **mentioning two referees** and their contacts (eg. your Master's and your internship's supervisor);
- The transcript of your master's grades (at least the **last 3 semesters**).

References

- [1] Jose Sanchez, Juan-Antonio Corrales, Belhassen-Chedli Bouzgarrou, and Youcef Mezouar. Robotic manipulation and sensing of deformable objects in domestic and industrial applications: a survey. *The International Journal of Robotics Research*, 37(7):688–716, June 2018. ISSN 0278-3649, 1741-3176. doi: 10.1177/0278364918779698. URL <http://journals.sagepub.com/doi/10.1177/0278364918779698>.
- [2] Jihong Zhu, Andrea Cherubini, Claire Dune, David Navarro-Alarcon, Farshid Alambeigi, Dmitry Berenson, Fanny Ficuciello, Kensuke Harada, Jens Kober, Xiang Li, Jia Pan, Wenzhen Yuan, and Michael Gienger. Challenges and Outlook in Robotic Manipulation of Deformable Objects. *IEEE Robotics and Automation Magazine*, 29(3):67–77, 2022. URL <http://arxiv.org/abs/2105.01767>. arXiv:2105.01767 [cs].
- [3] A. Koessler, N. Roca Filella, B.C. Bouzgarrou, L. Lequievre, and J.-A. Corrales Ramon. An efficient approach to closed-loop shape control of deformable objects using finite element models. In *2021 IEEE International Conference on Robotics and Automation (ICRA)*, pages 1637–1643, Xi'an, China, May 2021. IEEE. ISBN 978-1-72819-077-8. doi: 10.1109/ICRA48506.2021.9560919. URL <https://ieeexplore.ieee.org/document/9560919/>.
- [4] Paul Baksic, Hadrien Courtecuisse, Christian Duriez, and Bernard Bayle. Robotic needle insertion in moving soft tissues using constraint-based inverse Finite Element simulation. In *2020 IEEE International Conference on Robotics and Automation (ICRA)*, pages 2407–2413, Paris, France, May 2020. IEEE. ISBN 978-1-72817-395-5. doi: 10.1109/ICRA40945.2020.9197515. URL <https://ieeexplore.ieee.org/document/9197515/>.