Modeling, fabrication and control of dynamically tunable dry adhesion system for robotic micromanipulation

Advisory board: Wissem HAOUAS, Kanty RABENOROSOA, Michaël GAUTHIER

FEMTO-ST Institute (AS2M department), Université Bourgogne Franche Comté, proposes a 3-year PhD position in robotic micromanipulation. The starting date for the position is September 2022.

1 Context and Objective

Precision manipulation and assembly of micro-objects is one of the most challenging steps in micromanufacturing. Indeed, the interaction between tweezers and a micro-object is highly disturbed by specific physical effects predominant in microscale such adhesion [ACC+13]. The design of microgrippers requires to take into account these specificities during the design of both the structure of the gripper and its controller. Several ways have been explored in robotic micromanipulation [BG20] and one of the remaining challenges is to find active principles to actively control the adhesion during the manipulation tasks.

2 Scientific content

The chosen approach in this project consists of developing new grippers able to control the adhesion forces between the gripper tips and the manipulated object by acting actively on the tips of the gripper. One of the essential elements in this project is the control of the adhesion force to break the contact between two objects, which is called the pull-off force. The first objective requires studying and modeling the interactions between the gripper fingers and micro-objects of various shapes and typical sizes between 1μm and 200μm. We will rely on a rich literature to model and simulate the adhesion forces at microscale to then define the best design of the effector [CA96] [JKR71] [DMT75]. Models of interaction between micro-objects and gripper fingers are required for the development of reliable micromanipulation strategies and will be developed in this thesis. The second objective concerns the development of methods to optimize the geometry design of the microstructures of the gripper (see Fig. 1). In this part, we will focus on the development of a generic methodology allowing the integration of optimization criteria to design optimal shapes of these microstructures considering the manufacturing constraints and the mechanical characteristics of the manipulated object. The third objective consists in controlling the adhesion forces between gripper fingers and micro-object, one approach consists of using a dynamically tunable system.

3 Profile

We are looking for a highly motivated, creative, and ambitious student with a good command of English (written and spoken), who can work well in a team as well as independently and quickly acquire knowledge in new topics. The ideal candidate must fulfill ate least 3 of the following requirements:

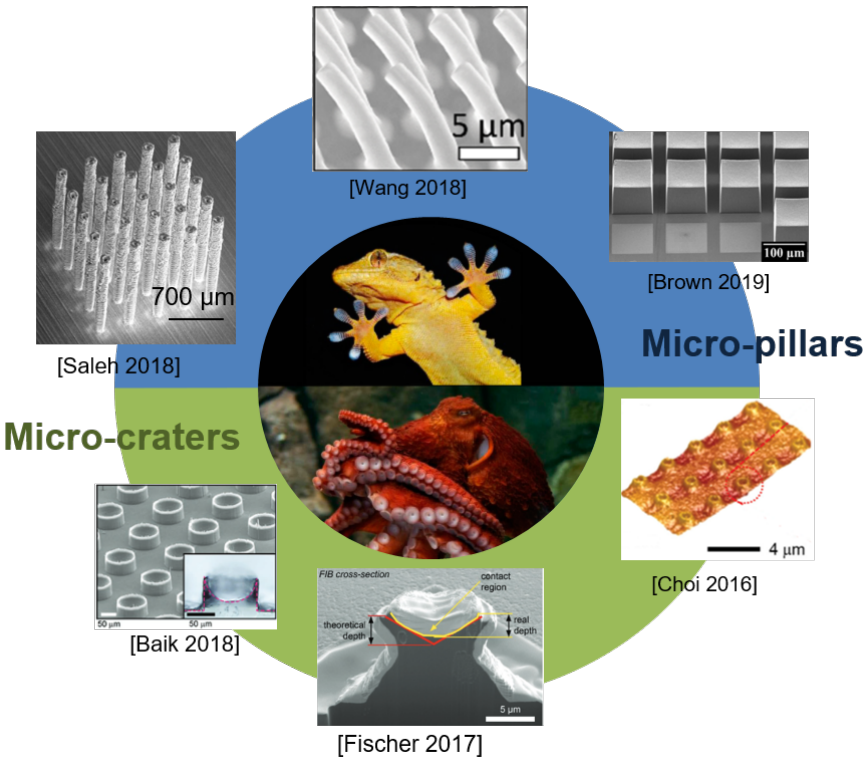

Figure 1: Examples of micro-craters and micro-pillars developed in the literature [WHR+20]

- Successfully completed scientific university degree (Master, Diploma or equivalent) in Robotics, Materials Science, Materials Engineering, Mechanical Engineering or other closely-related discipline with outstanding results,
- Experience in material characterization, including optical and electron microscopy, mechanical properties of materials,
- Excellent knowledge and experience in robotics and manipulation,
- Experience in additive manufacturing of materials,
- Familiar with Matlab, Python, C++, CAD softwares and Finite Element Methods
- Experience in composing academic writing pieces (manuscripts, reviews, etc.)
- Innovative and entrepreneurial mindset

4 Additional information

FEMTO-ST is a rich environment for innovation within robotics and automation which has a strong know-how in microrobotics and micromechatronics including compliant micro-robots. We study next-generation robots that use compliance as part of their intelligence to adapt to complex tasks.

5 Scientific contact

Please send your Curriculum Vitae (CV), a covering letter including research statement and the last year marks to Wissem Haouas wissem.haouas@femto-st.fr.

References

[ACC+13] Joël Agnus, Nicolas Chaillet, Cédric Clévy, Sounkalo Dembélé, Michaël Gauthier, Yassine Haddab, Guillaume Laurent, Philippe Lutz, Nadine Piat, Kanty Rabenorosoa, et al. Robotic microassembly and micromanipulation at femto-st. *Journal of Micro-Bio Robotics*, 8(2):91–106, 2013.

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