Manipulating the Micro-World - Design and Fabrication of a Small-Scale Force-Sensitive Gripping Device

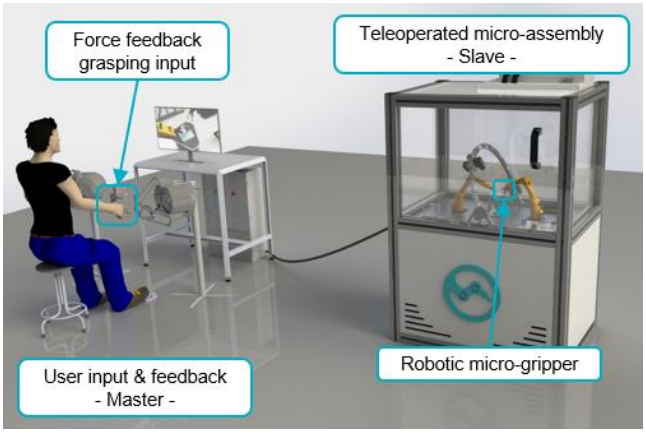

Figure 1: Representation of the future intended teleoperated micro-assembly station (Picture C. Duverney)

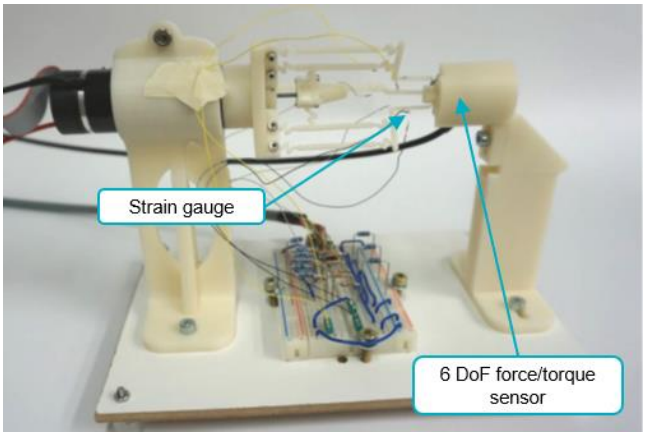

Figure 2: Prototype robotic micro-gipper with three strain gauges for grasping force measurement mounted in a test bench with a 6 DoF force/torque sensor for strain gauge calibration and performance evaluation (Picture: C. Duverney)

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The trend towards increased miniaturization of devices has been driving developments in various sectors of industry in the past decades such as telecommunication, medical technology, or even watchmaking. Assembling such miniature devices remains a challenge to this day, especially in the case of unique prototypes which cannot be assembled by pre-programmed, high-performance production lines. One way to address this issue is to rely on a teleoperated micro-assembly system. These typically include one or several micro-grippers on the slave slide which are controlled by a suitable input device on the master side (1). To increase the intuitiveness of the assembly process for the user and reduce the risk of damaging the fragile micro-parts, the micro-grippers may be fit with force-sensing capabilities, which allow the grasping forces to be fed back to the user for instance by means of a haptic grasping input handle. A lack of suitable force-sensitive micro-grippers motivates the developments carried out in this thesis. After careful analysis of the given system requirements, various micro-gripper concepts have been designed and evaluated. A first prototype of the most promising structure has then been manufactured. It relies on a flexure-based mechanism to largely reduce mechanical play, which represents one of the predominant issues when handling micro-parts. The flexure-based structure further allows for straightforward and cost-efficient force-sensing by means of strain gauges directly affixed to the gripper tips. A test stand including a high-precision 6 degrees of freedom (DoFs) force/torque sensor has been built to calibrate and evaluate the micro-gripper. A series of experiments demonstrated functionality of the proposed concept. Next steps will include miniaturization and precise characterization of the micro-gripper.

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References:
(1) J. Cecil et al. “A Review of Gripping and Manipulation Techniques for Micro-Assembly Applications.” *Int. J. of ProductionResearch*, vol. 43, no. 4, pp. 819-828, Feb. 2005. doi.org/10.1080/00207540512331311813