Augmenting a Custom Haptic Input Device Handle with Force Feedback for Intuitive Grasping

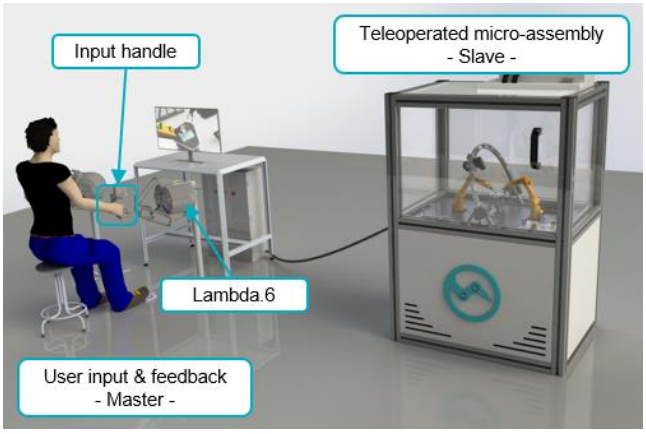

Figure 1: Representation of the future intended teleoperated micro-assembly station (Picture: C. Duverney)

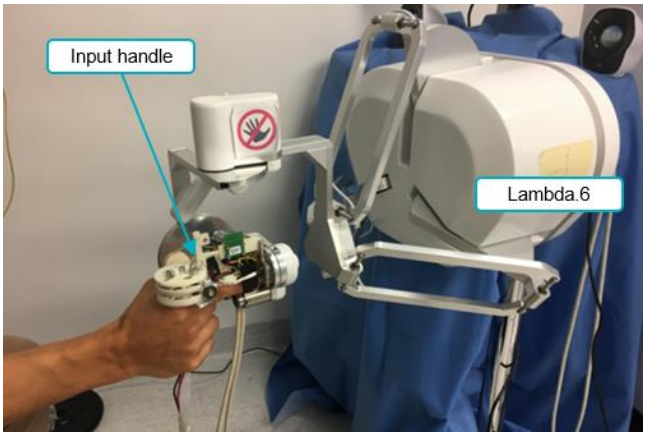

Figure 2: Prototype input handle with grasping DoF attached to the 6 DoF Force Dimension lambda.6 haptic device (Picture: C. Duverney)

Master Thesis by Nicolás Candia (Eidgenössische Technische Hochschule Zürich – ETHZ) at BIROMED-Lab.

There is a trend towards miniaturization and automation in several domains. One of them is the MIRACLE project, that aims at developing robotic endoscopic devices for minimally invasive surgery. Here, to develop prototypes, components with dimensions in the millimeter and even micrometer range need to be assembled. Human-controlled, teleoperated robotic micro-assembly stations with haptic interfaces are a way to tackle this challenge (1). Due to the lack of a convenient input handle, this master thesis pursued the goal of extending the six degrees of freedom (DoFs) of a commercial force-reflecting interface with a seventh grasping DoF for an intuitive force feedback control of a robotic gripper, including input channels to operate system settings and tool selections. During the development process, the needs of the target application as well as affected human movement and sensing capabilities were investigated. The resulting system requirements allowed to identify system features and possible solutions, and their evaluation to define the desired system. An extensive mechanical and electronic design process yielded a first prototype input handle. It combines an index-finger controlled, force-reflecting grasping DoF with a torque-reflecting scroll wheel, for the control of rotational tools as well as settings, tactile feedback channels, and inputs for menu navigation. The handle can be easily modified to fit different hand sizes and offers the possibility to connect further components to increase the number of input and output channels. A first evaluation study demonstrated the well-functioning of all prototype features and their usability and revealed potential for improvements. The developed prototype offers a good platform for further experimental evaluations to investigate different input and feedback channels for an intuitive teleoperated micro-assembly, and to improve the handle's ergonomics.

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Supervision:
Cédric Duverney
cedric.duverney@unibas.ch

Esther Zoller
esther.zoller@unibas.ch

Prof. Dr. Georg Rauter
BIROMED-Lab
georg.rauter@unibas.ch

Prof. Dr. Robert Riener
SMS-Lab, ETH Zürich
robert.riener@hest.ethz.ch

References:
(1) A. Bolopion and S. Régnier. “A Review of Haptic Feedback Teleoperation Systems for Micromanipulation and Microassembly.” *IEEE Trans. Automation Sc. and Eng.*, vol. 10, no. 3, pp. 496-502, Jul. 2013. doi.org/10.1109/TASE.2013.2245122