University of Basel
Department of Biomedical Engineering

BIROMED-Lab
Medical Robotics and Mechatronics

Master Thesis:
Switching Tools on the Fly - Design and Fabrication of a Small-Scale Tool Changing System for a Miniature Robot Arm

Context: In the last few decades, miniaturization has been observed to be one of the main driving forces in various sectors of industry. Assembling unique prototypes of such small devices is becoming increasingly challenging; hence, considerable effort has been put into the engineering of flexible, versatile micro-assembly systems, which can be used for the assembly of a wide range of different micro-systems [1]. Such micro-assembly systems typically combine one or several micro-grippers or other tools mounted on miniature robot arms with a camera system, a moveable working platform, and some user interface. In the scope of an ongoing research project, we are currently developing a novel micro-assembly system with largely increased flexibility and intuitiveness.

Task description: Basal tasks in micro-assembly include the precise picking and placing of parts, the insertion of screws, and the soldering of components. Different tools such as micro-grippers, various screwdrivers, and a soldering iron therefore need to be employed during a single assembly process. In order to maintain a streamlined and efficient workflow, we wish to fit the miniature robot arms carrying the tools (**a**) with automatic tool changers (**b**), allowing the system to quickly provide the user with the specific tools currently needed. Your task will be to design, manufacture, and test such a small-scale tool changing system suiting the given micro-assembly application. The key challenges will be to implement both automatic mechanical and electrical coupling in a single, highly miniaturized device, and to seamlessly integrate your prototype with the existing robot arm and micro-grippers.

(a) Miniature 6 axis robot arm used in this project [2]

(b) Example of an industrial miniature tool changer [3]

Work packages:

- Review the relevant body of literature on small-scale tool changing and coupling, and extract the key concepts
- Detail the requirements for your system based on the given micro-assembly application
- Devise, manufacture, assemble, and test your design in a realistic scenario
- Optional: Design, manufacture, and assemble an additional simple tool complementing the existing micro-grippers to extend your tool changer testing scenario

Benefits:

- Gain practical experience with mechanical design, particularly in the context of miniature robotics
- Learn to use a state-of-the-art PLC (programmable logic controller) system (TwinCAT 3, Beckhoff)
- Work in an academic environment with a strong focus on application-driven, hands-on engineering

Requirements:

- Solid background in mechanical engineering or a closely related field
- Knowledge of mechanics, basic electronics, and programming
- Ideally, practical experience with CAD (SolidWorks, Dassault Systèmes)

References:

[1] A. Bolopion and S. Régnier. "A Review of Haptic Feedback Teleoperation Systems for Micromanipulation and Microassembly." *IEEE Trans. on Automation Sc. and Eng.*, vol. 10, no. 3, pp. 496-502, Jul. 2013.

[2] WLKATA Robotics. *WLKATA Mirobot 6 Axis Desktop Robot Arm.* (2019). Accessed: Jul. 1, 2020. [Online]. Available: https://www.wlkata.com/products/wlkata-mirobot-introduction

[3] ATI Industrial Automation. *ATI Tool Changer Products: QC-1.* (2020). Accessed: Jul. 1, 2020. [Online]. Available: https://www.ati-ia.com/products/toolchanger/QC.aspx?ID=QC-1

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