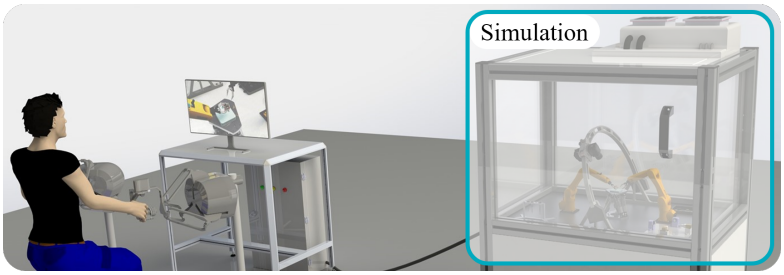
University of Basel
Department of Biomedical Engineering

BIROMED-Lab
Medical Robotics and Mechatronics

Semester Project:
Conception, Implementation, and Evaluation of a Virtual Simulation Environment for a Teleoperation User Console

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 a robotic assembly station with a visual or visuo-haptic 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 (**a**).

Task description: On the user side, we have realized a first prototype of a haptic input handle with grasping force feedback tailored to the highly specific needs of our application, conceptually similar to examples found in the latest commercial systems (**b**). As the assembly side still remains under development, a virtual rendering thereof would be of great benefit to evaluate and refine both hardware and control of the user side at the current stage [2]. Your task will be to devise and implement a simulation framework enabling the rendering of the assembly side in a virtual reality (VR) environment and to interface the framework with our haptic hardware. The thesis will be concluded by demonstrating functionality of your framework through a small user study revolving around said hardware.



(a) The proposed micro-assembly system - the assembly side (right) is to be simulated for evaluation of the user side (left)

(b) Commercial haptic input device with grasping force feedback [3]

Work packages:

- Review the relevant literature on kinematic and dynamic simulations for robotics, and extract the key concepts
- Detail the requirements for your simulation framework based on the given micro-assembly concept
- Implement a basic simulation framework in a VR environment, interface it with the existing haptic user console
- Extend your framework to include the more complex components and properties of the assembly side
- Evaluate usability and performance of your framework in a realistic scenario with the haptic user console

Benefits:

- Gain practical experience with design and implementation of virtual reality applications
- 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 robotics, mechanical engineering, computer science, or a closely related field
- Knowledge of kinematics, dynamics, and programming (C++)
- Prior experience with programming of VR applications is a plus, but not strictly required

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

[2] E. Rohmer et al. "V-REP: a Versatile and Scalable Robot Simulation Framework." *Proc. IEEE Int. Conf. Intelligent Robots and Systems (IROS)*, Tokyo, Japan, pp. 1321-1326, Nov. 2013. doi.org/10.1109/IROS.2013.6696520

[3] Force Dimension. *lambda.7.* (2020). Accessed: Dec. 23, 2020. [Online]. Available: forcedimension.com/products/lambda

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