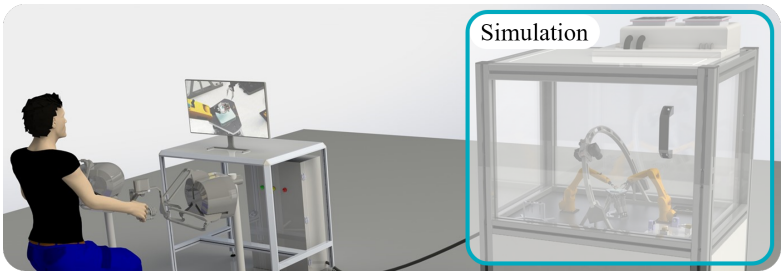
University of Basel
Department of Biomedical Engineering

BIROMED-Lab
Medical Robotics and Mechatronics

Master Thesis:
Development and Evaluation of a Virtual Simulation Environment for a Visuo-Haptic User Console

Context: In the scope of an ongoing research project, we are currently developing a teleoperated micro-assembly system to assemble mechatronic prototype devices (**a**). This system combines a robotic assembly station with a visuo-haptic user interface, providing haptic feedback to the user for a more intuitive interaction [1]. 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 [2], a virtual simulation thereof would be of great benefit to evaluate and refine both hardware and control of the user side at the current stage.

Task description: A basic simulation framework of the proposed micro-assembly system shall be developed. We will start with a purely kinematic simulation of the robots, neglecting any dynamic effects. For visualizing the assembly robots on a head-mounted display (HMD), a virtual scene comprising them needs to be created. The given haptic hardware needs to be integrated into the framework, such that it can be used to control the robots. Interaction forces between the robots shall be computed according to some simple models, such as a spring-damper model. Finally, a small user study shall be conducted to assess how well different models and model parameters perform, and whether this performance is sufficient for the simulation to be used during future user console development.



(a) The proposed micro-assembly system - the assembly side (right) is to be simulated for evaluation and development 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 kinematic simulation and visualization of the micro-assembly system
- Interface your framework with the existing visuo-haptic user console
- Evaluate different force interaction models and model parameters in a small user study

Benefits:

- Gain practical experience with design and implementation of kinematic simulations and VR applications
- Learn to use state-of-the-art haptic input devices
- Work in an academic environment with a strong focus on application-driven, hands-on engineering

Requirements:

- Solid background in computer science, robotics, or a closely related field
- Knowledge of programming (C++, ideally C#) and basic kinematics
- 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] C. Duverney et al. "Development and Evaluation of a Force-Sensitive Flexure-Based Microgripper Concept." *Proc. New Trends in Medical and Service Robotics (MESROB)*, Basel, Switzerland, Forthcoming 2021.

[3] Force Dimension. *lambda.7.* (2020). Accessed: Aug. 12, 2021. [Online]. Available: forcedimension.com/products/lambda

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