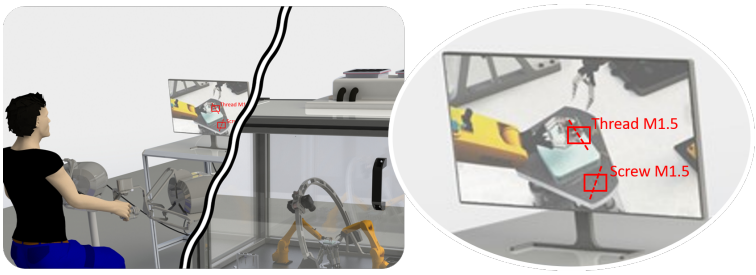
University of Basel
Department of Biomedical Engineering

BIROMED-Lab
Medical Robotics and Mechatronics

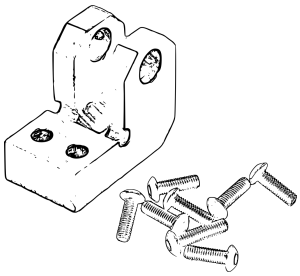
Master Thesis:
Development and Evaluation of a Visual Feature Recognition Framework for a Robotic Assembly System

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 e□ort has been put into the engineering of flexible, versatile micro-assembly systems, which can be used for the assembly of a wide range of di□erent micro-systems [1]. Such micro-assembly systems typically combine a robotic assembly station including a camera system with a visual or visuo-haptic user interface to control and monitor the assembly process. 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: The camera feed provided to the user to monitor the assembly process can additionally be used to automatically recognize, measure, and track specific features of mechanical and electronic assembly parts such as threads, holes, or solder pads [2, 3]. This information can then be supplied to the user for instance as an overlay on top of the camera feed, or it can be used to automate certain assembly steps through visual servoing. Your task will be to devise and implement a first visual feature recognition framework utilizing basic edge detection (b) to identify elemental geometries, to then extend this framework towards more complex features encountered in the given micro-assembly application, and to supply the generated information to the user in an intuitive way. The thesis will be concluded by demonstrating functionality of your framework through a realistic test scenario.



(a) The proposed micro-assembly system, including a conceptual GUI overlay highlighting identified screws and threads



(b) Basic edge detection applied to a set of mechanical parts

Work packages:

- Review the relevant literature on visual feature recognition, and extract the key concepts
- Detail the requirements for your feature recognition framework based on the given micro-assembly concept
- Implement a first framework for recognition of basic features, interface it with the existing automation hardware
- Extend your framework to identify and measure more complex features, and to increase robustness
- Evaluate usability and performance of your framework in a realistic scenario

Benefits:

- Gain practical experience with design and implementation of machine vision applications
- Learn to use a state-of-the-art PLC (programmable logic controller) system (TwinCAT 3, Beckho□)
- 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 machine vision basics and programming (C++)
- Prior experience with programming of machine vision 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] B. Babic et al. "A Review of Automated Feature Recognition with Rule-Based Pattern Recognition." *Computers in Industry*, vol. 59, pp. 321-337, Feb. 2008. doi.org/10.1016/j.compind.2007.09.001

[3] W. Osten and N. Reingand. *Optical Imaging and Metrology.* Weinheim, DE: Wiley-VCH, 2012. doi.org/10.1002/9783527648443

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