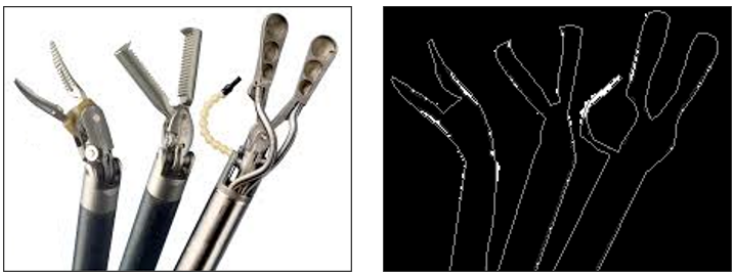
University of Basel
Department of Biomedical Engineering

BIROMED-Lab
Medical Robotics and Mechatronics

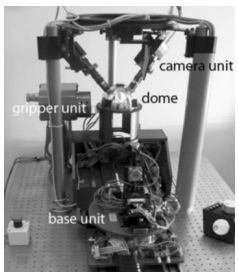
Bachelor Thesis:
Real-Time Visual Feature Recognition and Metrology for Mechanical Micro-Parts

Context: In the last decade, machine vision has been tremendously gaining in importance in various fields, ranging from robotics and autonomous systems to healthcare, agriculture, and consumer electronics. A key aspect enabling this rapid development - particularly for the consumer market - is the massive price drop for optical cameras due to their fast development by the telecommunication industry. One fundamental and recurring task in machine vision applications is the detection of edges in an image [1]; two examples of standard edge detectors can be seen in **(a)**. This information can then further be utilized for various purposes, for instance geometric feature recognition [2] or metrology [3]. One of the applications that can largely benefit from such algorithms is robot-assisted micro-assembly, where a robotic system is used to assist the user in assembling mechanical micro-parts into a functional micro-device. Although considerable effort has been put into the engineering of such systems in the last few decades, see for instance **(b)**, the integration of smart machine vision algorithms intuitively supporting the user remains a challenge.

Task description: The key task within a micro-assembly process is the precise insertion of mechanical micro-parts into the overall assembly. This also includes the fixation of said parts for instance by the means of miniature screws. Typical problems arising during this task include poor alignment of parts before insertion and undetected manufacturing inaccuracies, both leading to jamming or even damaging of the parts during insertion. To remedy these issues, it can be helpful to provide the user with visual cues about the exact location and orientation of holes and threads, and about inaccuracies in the part geometry. Your task will be to develop a system that obtains these information from an optical camera by using appropriate machine vision algorithms, and to display them to the user in real-time.



(a) Examples of standard edge detectors [1]



(b) Ex. of a micro-assembly system [4]

Work packages:

- Review the relevant body of literature on visual feature recognition and metrology, and extract the key concepts and features
- Assess available algorithms for real-time edge detection, geometric feature recognition, and metrology
- Select and implement the algorithms best suiting the given requirements
- Test and evaluate your system w.r.t. the given requirements in a realistic scenario

Benefits:

- Gain experience with state-of-the-art computer vision algorithms, particularly in the context of robotics
- Learn to use a modern real-time PLC (programmable logic controller) system
- Work in an academic environment with a strong focus on application-driven, hands-on engineering

Requirements:

- Solid background in robotics, computer science, or a closely related field
- Ideally, practical programming experience
- Ideally, practical experience with computer vision

References:

[1] H. Spontón and J. Cardelino. "A Review of Classic Edge Detectors." *Image Processing On Line*, vol. 5, pp. 90-123, Jun. 2015.
[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.
[3] W. Osten and N. Reingand. *Optical Imaging and Metrology.* Weinheim, DE: Wiley-VCH, 2012.
[4] M. Probst et al. "A Microassembly System for the Flexible Assembly of Hybrid Robotic Mems Devices." *Int. J. of Optomechatronics*, vol. 3, no. 2, pp. 69-90, May 2009.

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