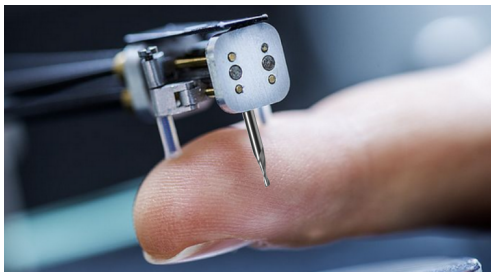
University of Basel
Department of Biomedical Engineering

BIROMED-Lab
Medical Robotics and Mechatronics

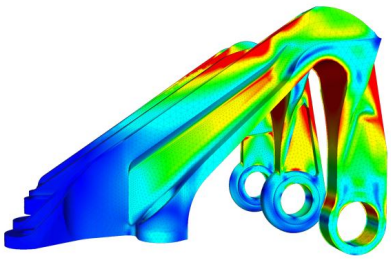
Internship:
Structural Analysis of a Miniature Parallel Robot for Precise Milling in Surgery

Context: Surgical procedures are increasingly often being performed using minimally invasive approaches instead of the traditional open methods. While this new path offers substantial benefits such as faster patient recovery, it also necessitates the development of novel, specialized devices and technologies. In the scope of a larger research project addressing these needs, a miniature parallel robot for precise laser-ablation of bone in surgical applications has been developed (**a**). Currently, it is being investigated whether this robot might also be used for high-precision surgical milling by replacing its laser by an appropriate milling tool. The advantages of relying on robotic systems instead of manual approaches in the context of surgical milling have been identified a rather long time ago [1]. However, using the novel miniature parallel robot for such procedures would render them more precise, and less invasive.

Task description: One of the main challenges arising when retooling the miniature parallel robot initially designed towards laser-ablation for milling processes is the occurrence of reaction forces between the milling tool and the bone. These forces influence the entire structure of the robot and might lead to undesired motions thereof, which in turn might breed uncontrolled milling of surrounding portions of the bone. The reaction forces must hence carefully be accounted for in the robot design. To this end, your task will be to first identify the key metrics and parameters relevant for bone milling applications. In a second phase, using this data, you will then perform a structural analysis of the miniature parallel robot using FEM (see an example in **b**) to identify key weaknesses in its current design, and draw conclusions on potential design optimizations towards surgical milling applications.



(a) Parallel robot for surgical milling, based on [2]



(b) Ex. of a structural analysis using FEM [3]

Work packages:

- Review the relevant body of literature on surgical milling, and extract the key metrics and parameters
- Assess different FEM software packages towards their applicability for the given task, and select the optimal one
- Define system model, boundary conditions, and all required parameters for the FEM model
- Perform a structural analysis of the miniature robot using the FEM model, and draw conclusions on its design and possible optimizations thereof

Benefits:

- Gain experience with state-of-the-art FEM packages, particularly in the context of robotics
- Work in an academic environment with a strong focus on application-driven, hands-on engineering

Requirements:

- Solid background in computational science, mechanical engineering, or a closely related field
- Ideally, practical experience in mechanical design
- Ideally, practical experience with finite element methods

References:

[1] M. Engelhardt et al., "Manual vs. robotic milling parameters for development of a new robotic system in cranial surgery," *Int. Congress Series*, vol. 1268, pp. 533-538, Jun. 2004.

[2] M. Eugster et al., "A Parallel Robotic Mechanism for the Stabilization and Guidance of an Endoscope Tip in Laser Osteotomy," in *2018 IEEE/RSJ Int. Conf. on Intelligent Robots and Systems (IROS)*, 2018, pp. 1306-1311.

[3] G. Giraldo. *Structural Analysis Software Without a Large Investment in Hardware.* (2020). Accessed: Feb. 10, 2020. [Online]. Available: https://www.simscale.com/blog/2017/10/structural-analysis-software/

Student: Lina Aribi
Start: March 2020
Duration: 6 months

Supervision:
Manuela Eugster (manuela.eugster@unibas.ch)
Cédric Duverney (cedric.duverney@unibas.ch)

https://biromed.dbe.unibas.ch

Professor: Prof. Dr. Georg Rauter