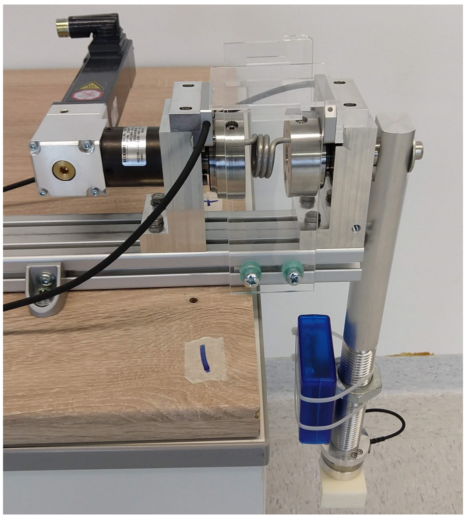
University of Basel
Department of Biomedical Engineering

BIROMED-Lab
Medical Robotics and Mechatronics

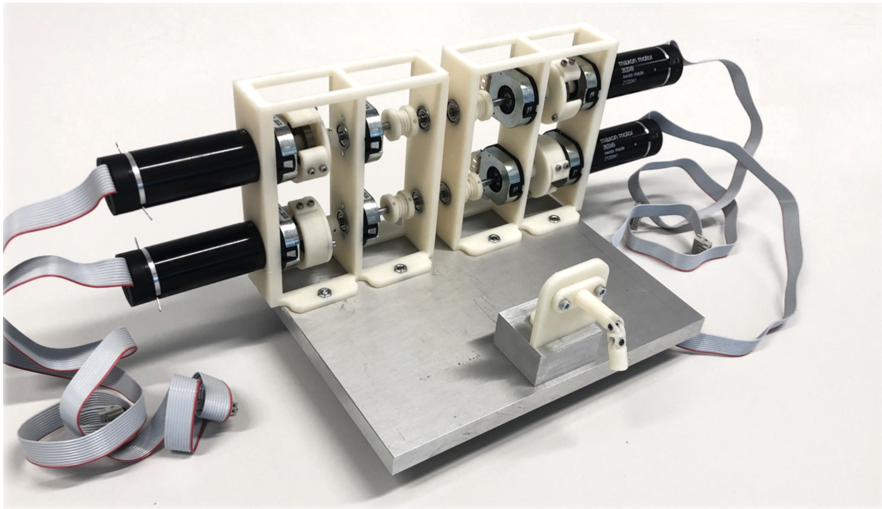
Semester/Bachelor/Master Thesis: Comparing cascaded controller architectures for reactive series elastic actuators

Context: Series elastic actuators (SEA) allow safer interaction compared to rigid actuators when used in robots for physical human-robot interaction tasks. Although SEA are widely used in legged robots, they are still not prevalent in the medical domain. One of the reasons is that the control of SEA joints is difficult as it depends on the spring characteristics, load model, controller design and more. At the BIROMED-Lab we have developed two SEA joints intended to be used in medical applications that can be controlled for different scales of motion: macro-sea (Figure 1a) for use in macro-robots and milli-sea (Figure 1b) that is cable driven for endoscope joints.

Task description: Your task would be to understand the effect of different control architectures and their hyper-parameters (for example, control rates for different feedback loops) on these 1-DoF SEAs. You will have to design cascaded control architectures with position and force control at the low-level for the hardware setup(s) that make it *safer* for interaction. You will implement the controllers, experimentally evaluate and compare their performance.



(a) Macro-sea



(b) Milli-sea

Figure 1: The two SEA prototypes we have at the BIROMED-Lab.

Workpackages:

1. Building on the previous work, do literature survey to identify existing controller architectures as well as performance and safety evaluation criteria.
2. If necessary, design springs with required stiffness for the macro-sea joint.
3. Design control architectures that can be implemented on hardware (using TwinCAT3 environment).
4. Identify experimental protocols to quantify performance and safety of the controller for interaction tasks.
5. Experimentally evaluate the different controllers and assess their performance.

Benefits:

1. Gain experience working with state-of-the-art industrial hardware (TwinCAT3 and Beckhoff Automation).
2. Learn and understand control theory by applying it in a practical setting.
3. Work in an open-minded and friendly team in an academic environment.

Student:
Start: February 2022
Duration: 6 months
https://biromed.dbe.unibas.ch

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