University of Stuttgart

Institute for Nonlinear Mechanics

Term paper
Bachelor's thesis
Master's thesis

Parameter Identification and Dynamic Control of a Tendon-Driven Mechanism

Topic Areas:	Continuum Robotics, Control Engineering
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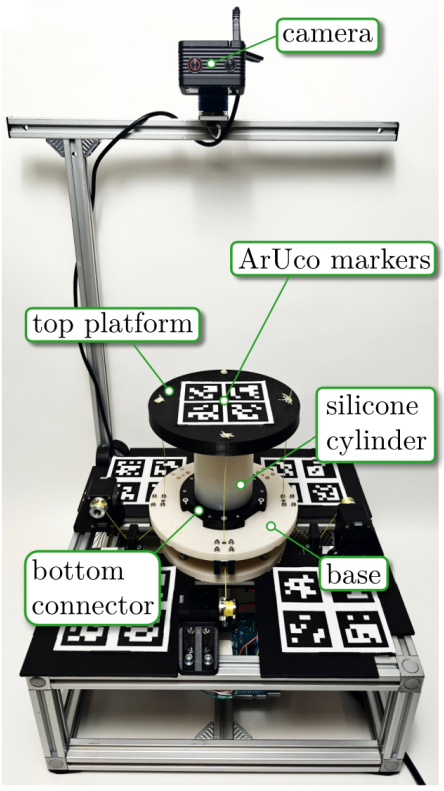
Responsible Professor:	Prof. Remco Leine
Prerequisites/Prior Knowledge:	knowledge in mechanics, control theory, and python programming

Continuum robots (CRs), inspired by soft-bodied organisms such as octopuses, are increasingly being applied in minimally invasive surgery, search and rescue operations, as well as in-space inspection and maintenance. Their high flexibility and dexterity enable safe interaction in complex environments. However, these advantages come at the cost of strong nonlinearities and complex dynamic behavior, which make accurate modeling and control particularly challenging.



Tendon-driven continuum mechanism

At our institute, continuum robot models based on Cosserat rod theory have already been validated under static conditions. While these models provide a solid foundation, extending them to dynamic scenarios introduces significant challenges, including damping effects, actuation dynamics, and real-time computability. To fully exploit the capabilities of CRs, it is therefore essential to develop control strategies that can handle their nonlinear and distributed nature.
This thesis focuses on the design of dynamic controllers for a tendon-driven continuum mechanism. The specific objectives are:

- Experimental identification of dynamic parameters (damping) of the system
- Design of a baseline controller (e.g., PID) using linearization techniques [1]
- Development of advanced model-based control approaches (e.g., inverse dynamics, nonlinear control) [2]
- Implementation and validation of the controllers on the physical system
- Performance evaluation under different operating conditions

The overall goals of this project will be adjusted based on the thesis type.

References

[1] K. Wu et al., *FEM-based gain-scheduling control of a soft trunk robot*, 2021.

[2] C. Alessi et al., *Rod models in continuum and soft robot control: A review*, 2026.