University of Stuttgart

Institute for Nonlinear Mechanics

Term paper
Bachelor's thesis
Master's thesis

Damping Identification of a Tendon-Driven Continuum Robot

Topic Areas:	Continuum Robotics, System Identification
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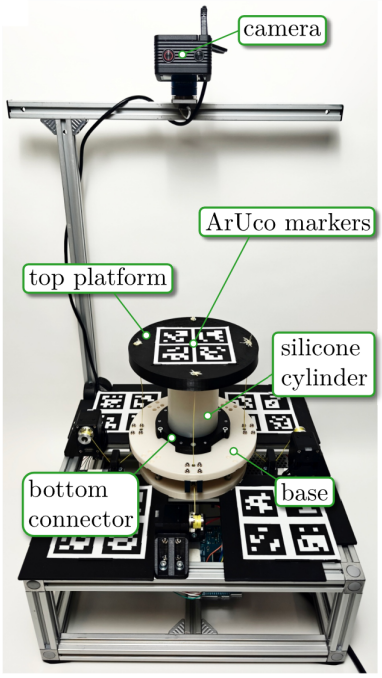
Responsible Professor:	Prof. Remco Leine
Prerequisites/Prior Knowledge:	knowledge in mechanics, dynamics and vibrations, and python programming

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 robot

At our institute, a discrete Cosserat rod model [1] has been validated under static conditions, and a dynamic controller for the robot has been designed in a previous thesis. Accurate dynamic simulation and control, however, require a reliable damping model. Damping is commonly described by a viscoelastic (Kelvin–Voigt) law [2], whose coefficients have to be identified experimentally [3]. This thesis focuses on the experimental identification of the damping parameters of the tendon-driven robot. The specific objectives are:

- Extension of the Cosserat rod model by a suitable damping model
- Design of identification experiments (e.g., free vibration decay, step and harmonic excitation)
- Identification of the damping parameters by fitting simulation to measurement data
- Validation on independent data and, optionally, within the existing controller

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

References

[1] T. Dai et al., "A mixed discrete Cosserat rod formulation," *Proceedings in Applied Mathematics and Mechanics*, vol. 26, no. 4, e70269, 2026.

[2] J. Till et al., "Real-time dynamics of soft and continuum robots based on Cosserat rod models," *The International Journal of Robotics Research*, vol. 38, no. 6, pp. 723–746, 2019.

[3] C. Muhmann et al., "Toward dynamic control of tendon-driven continuum robots using Clarke transform," in *Proc. IEEE/RSJ Int. Conf. Intell. Robots Syst. (IROS)*, 2025.