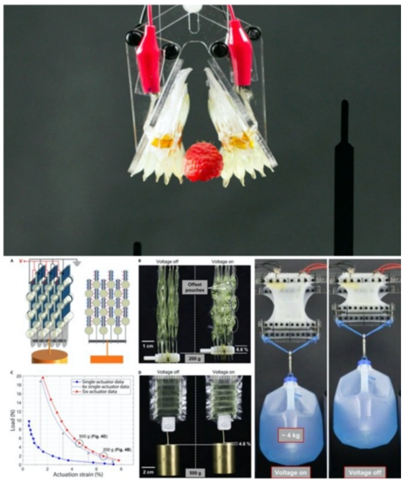
Design and modeling of a soft robot based on Hydraulically Amplified Self-healing ELectrostatic (HASEL) actuators

Context

Due to the recent technological progresses in material sciences, soft robots based on active materials have raised a particular attention over the last decades. Soft robots can provide high compliances and adaptability similar to what can be found in the nature. Different soft active materials have been studied over the last decades such as shape memory alloys (SMAs) [1] or ionic polymer metal composites (IPMC) [2]. However, for different reasons (limited deformation, low bandwidth, fatigue, etc.), their application is limited in soft robotics [3]. Compared with the previous mentioned materials, soft actuators based on HASEL muscles (cf Figure), gained a significant attention from the community due to their high electromechanical efficiency and rapid response. Different HASEL based soft robots have been proposed in the literature like robotic manipulators, terrestrial robots and fast soft robots [4]. Their modeling and control remain a challenging task as these robots are characterized by nonlinear behaviors and distributed parameters phenomena.



Work plan

The **main objective** of this master internship is to design a soft robotic architecture based on HASEL soft actuators and provide a reliable mathematical modeling. HASEL exhibit highly nonlinear behavior and flexibility on account of large deformation and electromechanical coupling. To deal with the multi physical phenomena and nonlinearities involved in HASEL actuators, the port Hamiltonian framework will be investigated during the internship. The port Hamiltonian formulation is particularly well-adapted for the modeling and the control of nonlinear multi-physical systems [8] such as electro-mechanical systems. It is based on the principle of conservation of energy and exhibits the system's passivity properties and provides a clear physical interpretation of control design strategies.

Internship time schedule

The internship starts from March 2021 and end on July 2021, the time planning of the internship is following:

1. The intern will first have to do a solid literature review on HASEL based soft actuators and energy-based port Hamiltonian formulations with the help of the project team.
2. The modeling of the HASEL soft actuator will be investigated using the port Hamiltonian framework (a simple HASEL actuator will be available for the experimental identification and model validation).
3. The intern needs to design a simple architecture for the soft robotic based on the HASEL actuator.

Implementation and supervision team

This master internship will take place in the AS2M department of FEMTO-ST institute in Besançon and be supervised by Dr. Yongxin Wu (MACS team), Prof. Yann Le Gorrec (MACS team) and Dr. Kanty Rabenorosoa (Micro and Nano Robotics team).

Application

The following candidate profiles is expected for this internship: Automatic control, mechatronics, Robotics, etc. The candidate can send his CV and cover letter by email to Dr. Yongxin Wu yongxin.wu@femto-st.fr. The application of the internship will be closed at the end of November 2020.

Bibliography

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[3] U. Gupta, L. Qin, Y. Wang, H. Godaba, J. Zhu, Soft robots based on dielectric elastomer actuators: A review, Smart Mater. Struct. Vol. 28, no. 10, Sep, 2019.

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