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Soft Mechatronic Actuators: Advances in Design, Modeling, and Motion Control

organized by

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Call for Papers

Soft actuators are emerging as key enabling technologies for the next generation of mechatronic systems. Thanks to their compliance, flexibility, and lightweight construction, they offer unique opportunities to develop artificial muscle-like actuators for applications where conventional electromagnetic drives reach their limits, such as wearable and assistive devices, medical robots, adaptive grippers, and safe human-machine interfaces. A wide range of soft actuator technologies is currently under development, ranging from fluid-driven artificial muscles (pneumatic and hydraulic) to smart material-based actuators (e.g., dielectric elastomers, electrohydraulic actuators, shape memory alloys), up to compliant motor-driven structures based on series-elastic and tendon-driven architectures. Despite remarkable progress in materials and fabrication, transforming these actuators into reliable and high-performance mechatronic components remains challenging. Their behavior is typically affected by strong nonlinearities, hysteresis, viscoelasticity, rate dependence, and multiphysical coupling, which complicate their design, modeling, and control. Although their intrinsic softness and multifunctionality enable new concepts such as self-sensing and embedded proprioception, these remain largely unexploited.
This special session aims to bring together researchers from materials, robotics, and control communities to discuss recent advances in the design, modeling, and control of soft actuators and artificial muscles. The organizers are active in the Motion Control community, with expertise spanning design, modeling, and motion control of various soft actuator technologies. Contributions addressing physics-based and data-driven

modeling, self-sensing and state estimation, motion control, learning-based methods, and system integration are particularly welcome, as well as experimental validations and applications that demonstrate the potential of soft actuation technologies in compliant mechatronic and robotic systems.

Topics of the Session include, but are not limited to:

- o Smart material-based actuators and artificial muscles
- o Fluid-driven soft actuators and artificial muscles
- o Tendon-driven and series-elastic actuators
- o Design, fabrication, and characterization of soft actuators
- o Modeling and identification of soft actuators
- o State estimation and self-sensing for soft actuators
- o Motion, force, and stiffness control of soft actuators
- o Learning-based and data-driven methods for soft actuators
- o Applications of soft actuators in soft mechatronics and robotics