2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
October 25-29, 2020, Las Vegas, NV, USA (Virtual)

IROS 2020 Workshop on "New Advances in Soft Robot Control"

Machine learning controllers for continuum and soft manipulators

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A novel subdomain of continuum manipulators, referred to as soft robotic manipulators, has been rapidly growing in the past decade since roboticists found inspiration from biological organisms such as elephant trunk and octopus arms. This led to the growth of a new range of continuum manipulators made up of soft with the ability to undergo a large deformations. The deformability of the soft material offers compliance, which facilitates safe human–robot interaction in comparison to the rigid counterparts. These desirable characteristics are the fundamental reason behind the rapidly increasing demand in industrial, surgical, and assistive applications.

However, the long-term success for the practical application of these systems is dependent on the development of real-time kinematic and/or dynamic controllers that facilitate fast, reliable, accurate, and energy-efficient control.
This is nontrivial because unlike rigid manipulators, the movement of which can be specified by three translations and three rotations, elastic deformation of soft robotic manipulators results in virtually infinite degrees-of-freedom motions, (bending, extension, contraction, torsion, buckling, etc.). In addition, the material properties exhibit nonlinear characteristics such as compliance and hysteresis that make the model of these manipulators very complex. Machine learning techniques represent a valid approach for the control of these artifacts, since the robot model can be derived from data. The focus is on kinematic and dynamic controllers relying on supervised or reinforcement learning networks, developed and tested on soft and braided-structure continuum manipulators. The results demonstrate the effectiveness of this approach that needs to be further explored to extend its applicability in real world settings and human-robot interaction tasks.