Data-driven Dynamic Modeling of Soft Robots for Agile Trajectory Tracking

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As robotics expands from industrial applications into an increasing number of domains, safety and flexibility are becoming ever more important. Soft robots are the most natural solution to these requirements. Typically made of soft materials such as silicone, soft robots can undergo large deformations and rely on inherent structural compliance. Currently, most soft robots are driven in a quasi-static way to avoid oscillations. However, as new, more agile applications of soft robotics emerge, the need for precise dynamic control methods is increasing. Feedback control for dynamic motion requires precise sensing, whereas feedforward control requires an accurate model of the controlled system.

The main challenge in using feedback control for soft robots is integrating sensors without compromising their softness. Model-based controllers can reduce the number of sensors required. The main challenges in modelling soft robots are their large elastic deformations, unknown material parameters and manufacturing inaccuracies. One solution is data-driven models, which typically require large amounts of training data. In soft robotics, quasi-static controllers are mainly used. However, these controllers neglect dynamics and are insufficient for advanced soft robot applications requiring increasingly faster and more accurate movements. Extending existing data-driven quasi-static control concepts directly to dynamic control is usually impractical due to the large quantity of required training data.

In this study, model-based control of soft robots using data-efficient, data-driven models of soft robot dynamics is investigated and demonstrated through experimentation. Two different beam-shaped, tendon-actuated soft robot arms are used as test systems, one of which is operated underwater. First, spectral submanifold reduction (SSMR) [1] is employed to model the soft robot's dynamics. The derived model is then used to control the robot.

Literatur

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