Reinforcement Learning Based Kinematic Controller and Proportional-Integrative-Derivative Based Dynamic Controller for Soft Robots

Mazumder, Anirudh (School: Texas Academy of Mathematics and Science)

Soft robotics has immense potential to transform fields like healthcare and exploration due to the superior adaptability of soft robots compared to traditional rigid robots. Their inherently flexible nature enables soft robots to navigate diverse environments and spaces effectively. However, controlling soft robots also presents significant challenges due to their lack of joints and rigidity. This research aimed to develop an advanced kinematic controller using Reinforcement Learning (RL) to direct the movement of a continuum-arm soft robot within an unknown environment. The hypothesis was that an RL-based controller could effectively guide the continuum arm to accurately reach target destinations by learning from feedback on its performance. The study successfully implemented an RL control algorithm to maneuver the continuum arm and achieve end-effector positioning within 0.0001 meters of the specified target position. The outcome proved the hypothesis. This research also sought to create an even more advanced controller that could dictate where a continuum-arm soft robot would go in an unknown environment and where its mobility was affected by external forces. The hypothesis was that a dynamic controller utilizing a Proportional-Integral-Derivative (PID) control strategy could accurately navigate the continuum arm to the target location even amid outside pressures and disturbances. A PID controller was implemented to control a continuum arm affected by external pressures in an unknown environment to test the hypothesis. The results showed that the end-effector position of the continuum arm powered by the dynamic controller was 3.09 ×10^(-6) meters from the target end-effector position, proving the second hypothesis.

Awards Won:

The University of Texas at Dallas: Scholarship awards of $5,000 per year, renewable for up to four years