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Design and Experimental Validation of a Novel Hybrid Continuum Robot with Enhanced Dexterity and Manipulability in Confined Space

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Abstract—Existing continuum robots still lack the necessary dexterity and manipulability to inspect and operate in confined space with multiple obstacles. In this paper, we propose a novel hybrid continuum robot (HCR) with enhanced dexterity and manipulability. The proposed 9-degree-of-freedom robot can fit in confined space with multiple obstacles by changing the length of its inner hybrid-structure section and outer flexible section. A rotatable inner hybrid-structure section and an additional distal wrist enable rotation motion and sharp bending at the distal end of the HCR, which enhances its dexterity and manipulability. Besides, we develop a detachable, lightweight (2.5 kg), and compact (41 cm×15 cm×6 cm) actuation system for the HCR. It can be easily integrated with existing commercial robot arms to adjust the pose of the HCR's base, which further enlarges its workspace. In order to demonstrate the HCR's obstacle avoidance capability in confined space, a path-planning method is proposed. Simulation results show the dexterity and manipulability of the HCR enhanced by 98 % and 3804 times compared with an existing concentric flexible robot in a confined space with one obstacle. Experiments validate the feasibility of the HCR and its path-planning method.

Index Terms—Continuum robot, flexible robot, surgical robotics.

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