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A Leader-Follower Kinematic-Based Control System for a Cable-Driven Hyper-Redundant Manipulator

Authors : Abolfazl Zaraki, Yoshikatsu Hayashi, Harry Thorpe, Vincent Strong, Gisle-Andre Larsen, William Holderbaum

Abstract : Thanks to the high maneuverability of the cable-driven hyper-redundant manipulators (HRMs), this class of robots has shown a superior capability in highly confined and unstructured space applications. Although the large number of degrees of freedom (DOF) of HRMs enhances the motion flexibility and the robot's reachability range, it highly increases the complexity of the kinematic configuration which makes the kinematic control problem very challenging or even impossible to solve. This paper presents our current progress achieved on the development of a kinematic-based leader-follower control system which is designed to control not only the robot's body posture but also to control the trajectory of the robot's movement in a semi-autonomous manner (the human operator is retained in the robot's control loop). To obtain the forward kinematic model, the coordinate frames are established by the classical Denavit–Hartenburg (D-H) convention for a hyper-redundant serial manipulator which has a controlled cables-driven mechanism. To solve the inverse kinematics of the robot, unlike the conventional methods, a leader-follower mechanism, based on the sequential inverse kinematic, is followed. Using this mechanism, the inverse kinematic problem is solved for all sequential joints starting from the head joint to the base joint of the robot. To verify the kinematic design and simulate the robot motion, the MATLAB robotic toolbox is used. The simulation result demonstrated the promising capability of the proposed leader-follower control system in controlling the robot motion and trajectory in our confined space application.

Keywords : hyper-redundant robots, kinematic analysis, semi-autonomous control, serial manipulators
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