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PATH PLANNING ALGORITHM FOR OBSTACLE AVOIDANCE OF MULTI-ARM SPACE WALKING ROBOT

Abstract

Space robot is playing an important role in the space activities, such as satellite maintenance, on-orbit assembly, and onboard robotic assistant. A multi-arm robotic system is capable of replacing astronauts to perform dangerous and complex tasks in space. Among the related theoretical issues in designing the operation of the multi-arm robotic system, the trajectory of each arm should be first determined. This paper focuses on the path planning of a triple-arm space robot, in which the obstacle avoidance is particularly considered. The robotic system comprises a platform and three robotic arms, two of which are utilized for walking, and the third one is used for on-orbit operating. Each manipulator consists of seven rigid links serially connected by revolute joints. Since the manipulator is kinematically redundant for the six-dimensional tasks in space, it is possible to adjust the manipulator's configuration to avoid collisioins without changing the location and orientation of the end-effector in the Cartesian space. The approach of path planning is composed of two building blocks. To keep away from the obstacles, the trajectories of the manipulator end-effectors in the Cartesian space are firstly planned with respect to the particular geometry of the workcell with polynomial interpolation method. Then, based on the kinematics of manipulator, a Moore-Penrose pseudoinverse solution of the joint trajectories is calculated to describe the path of the manipulators. Although the end-effectors are ensured to bypass the obstacle as planned, the other links of the manipulator may crash the obstacle at this time. Collision detection is developed to estimate the security during the operation. A distance calculation algorithm is presented to detect the collision between the robot and other objects in the workspace. In case of undesirable collision, a constrained optimization method is further executed. With the collision avoidance constraints, the originally planned configurations of the manipulators are optimized to prevent the links from obstacles under the same boundary conditions. Numerical results illustrate the maneuver process of the triple-arm space walking robot, where the first two manipulators capture the surface of a space station in sequence and perform alternating walking motion; the 3rd manipulator finally captures the desired point on the space station and makes preparation for the subsequent operations. In particular, the optimized path is

devoid of any collision so that the security is guaranteed all along the walking process, namely verifying the efficiency of the approach.