SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Novel Concepts and Technologies to Enable Future Building Blocks in Space Exploration and Development (3)

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REACTIONLESS CAPTURE OF A TUMBLING TARGET WITH A SPACE MANIPULATOR

Abstract

Space robotics is expected to play an increasingly important role in the near future space activity. In particular, the autonomous capture of an unknown tumbling target in orbit is recognized as one the key technologies, which can be applied to several space missions, such as servicing, inspection, maintenance, construction of satellites and large space structures, and for the removal of space debris from orbit. In the capturing operation, an accurate robot trajectory control should be used in order to minimize the impact force at the time of capture. Indeed, the impact force could damage either the manipulator or the target, cause an undesired spacecraft attitude destabilization, or cause the target to be pushed away. Therefore, the robot trajectory has to be computed in such a way that the relative velocity between the robot end-effector and the target at the time of capture is very small. Moreover, the spacecraft attitude deviation should be minimized during trajectory execution in order to maintain the communication link with the ground station. In this paper, a novel control strategy for the capture of a non-cooperative tumbling target is proposed, in which a recently developed least-squares-based reaction control method is used to control the reactions transferred to the base spacecraft during the manoeuvre. In particular, Kalman filtering techniques are used in order to predict the relative motion end-effector – target and the robot is guided in such a way that the relative velocity between the two contact points is near to zero at the planned impact time. Several test cases are analyzed and demonstrated with software simulations with different relative initial velocity and spin of the target with respect to the robot end-effector in order to simulate real space robotic operations scenarios.