MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Microgravity Sciences Onboard the International Space Station and Beyond - Part 2 (7)

Author: Dr. Silvio Cocuzza
CISAS – "G. Colombo" Center of Studies and Activities for Space, University of Padova, Italy, silvio.cocuzza@unipd.it

CAPTURE OF A NON-COOPERATIVE SPACECRAFT INSIDE THE ZERO REACTION WORKSPACE OF A SPACE MANIPULATOR

Abstract

The capture of non-cooperative tumbling objects with unknown dynamic parameters is a priority task for near future space activities. This key technology can be used in several space robotic missions such as in refuelling, repairing, servicing satellites, or for the removal of space debris. In this operative scenarios, the motion of the manipulator should be planned in such a way that the robot end-effector and the satellite grasping point arrive at the rendezvous with the same velocity and that the interception occurs within the Zero Reaction Workspace of the manipulator. In this way, the momentum transfer between the target and the robot can be minimized and the capture can occur without affecting the attitude of the base spacecraft, thus allowing to maintain the communication link with the ground station and to reduce the Attitude Control System fuel consumption. This paper proposes a novel capturing method based on motion estimation for the autonomous retrieval of a non-cooperative tumbling satellite inside the Zero Reaction Workspace of a space manipulator. The robot end-effector trajectory is planned in such a way that a soft impact with approximately zero relative velocity between the end-effector and the target satellite contact points is foreseen and in the meantime minimizing the reactions transferred to the base spacecraft during the manipulator manoeuvre. In the case that the base spacecraft does not approach the target properly before the capture manoeuvre, the end-effector could fail to capture the target satellite due to an excessive target – end-effector relative velocity or due to a target trajectory that has a too small intersection with the manipulator workspace. In particular, in this work the limit conditions are studied for the capture to successfully occur inside the Zero Reaction Workspace of the manipulator. Several operative scenarios are analyzed with different trajectory, velocity and spin of the target satellite with respect to the base satellite. The presented concepts are demonstrated by means of simulated tests in microgravity environment of a real robot prototype previously tested in microgravity in an ESA Parabolic Flight campaign and then extensively tested in an on ground simulated microgravity test facility.