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COORDINATED CONTROL OF A SPACE MANIPULATOR TESTED ON A FREE FLOATING PLATFORM

Abstract

A large interest is currently being raised by space missions designed for refurbishing end-of-life satellites, assembling large modular space structures, and de-orbiting space debris. These tasks call for a new kind of space manipulators, that are characterized by a mass and inertia ratio between the robotic arm and the hosting platform that is much larger than previous cases, such as Canadarm and Canadarm2.

A peculiarity of this new generation of space robots is the strong interaction between the arm motion and the platform dynamics. The usual approach for the guidance of such systems is to decouple the platform and the arm maneuvers, which are supposed to happen sequentially, mainly because of safety concerns. Conversely, in this work the platform and the manipulator are considered as a single multibody system subject to a coordinated control, with the goal of approaching and grasping a target spacecraft. The two opposite risks of an unbalanced coordinated control are to completely extend the arm before the target is within its actual reach (singular configuration), or to approach the target with a very limited usage of the arm (high collision risk between chaser and target platforms).

According to the proposed approach, an optimal path planning is performed, which minimizes the mission duration and the required propellant, while avoiding these undesired behaviors. At the scope, the Reaction-Null algorithm is used to map the points that the end effector can reach by means of the arm motion with limited reactions on the platform. The guidance algorithm considers the target position within this map together with the chaser kinematic state, for performing a gain scheduling finalized to a balanced contribution of the platform and arm motion. The result is a coordinated maneuver in which the end effector moves thanks to the a platform motion, predominant in a first phase, and to the arm motion, predominant when the Reaction-Null workspace is reached. In this way the collision avoidance and attitude over-control issues are automatically considered, without the need of splitting the mission in independent (and overall sub-optimal) segments.

The guidance and control algorithms are first simulated by means of a multibody code, and successively tested in the lab by means of a free floating platform equipped with a robotic arm, moving frictionless on a flat granite table thanks to air bearings and on-off thrusters. Both coordinated guidance and more classic two-stages maneuvers will be tested, compared and discussed.