SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Systems and Infrastructures to Implement Future Building Blocks in Space Exploration and Development (2)

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DESIGN GUIDELINES FOR A SPACE MANIPULATOR FOR DEBRIS REMOVAL

Abstract

One of the most important tasks that the space community will have to face in the next years is the robotic on-orbit operation, in order to perform servicing, repairing or de-orbiting of existing satellites. In particular, many research studies have been focused on removing significant debris objects from their orbit. Space missions involving nets, harpoons or glues are only some options studied and analyzed by the scientific and industrial community, even if the debris removal mission by means of robotic manipulators seems to be the solution with the longest space experience. This paper will show which are the main drivers for the design of a space manipulator aimed to debris removal. At the scope, the different phases of a debris removal mission are considered, starting from the parking orbits where the chaser spacecraft waits for the call-on duty, encompassing target approach, the grasping and finally the dismissal of the captured objects. The requirements of each phase, in terms of required relative navigation sensors accuracy, manipulators' joint control torques and thrusters force will be analyzed. It will be shown that the number of robotic arms, the number of joints of each arm, and the torque level that each joint motor should supply are determined mainly by two phases: the grasping phase and the de-orbit phase. During grasping, in fact, the tumbling target must be tracked with a large degree of robustness with respect to the nominal relative configuration. At the scope, a redundant manipulator must be designed, so that its workspace can be as large as possible. On the other hand, increasing the degrees of freedom of a robotic arm means higher realization costs: a trade-off will be therefore outlined, describing a reasonable solution. The number of arms depends instead from the final de-orbit phase, in which the powerful apogee motor of the chaser satellite is ignited, in order to change the composite system (chaser + target) orbit. The thrust, applied on the chaser, is transferred to the target by means of the robotic arms: it will be demonstrated that a single robotic arm could be not sufficient to withstand the high solicitations acting during this phase. Also the joint torques required to keep the robotic arm into position are very high, and the joint motor torques must be designed following the maximum values recorded in this phase.