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OPTIMAL MANOEUVRING OF A FLEXIBLE SPACE MANIPULATOR WITH RESPECT TO A CLASS OF OBJECTIVES

Abstract

Space graspers are complex systems, formed by robotic arms accommodated on an orbiting platform. Opposite to terrestrial systems, the orbital and attitude dynamics are strongly coupled, therefore when the robot’s base floats in space, any movement of its links produces a reaction of the base, and a consequent variation of the end-effector position.

A number of manoeuvring strategies with respect to a common mission task, as the grasping of a target body, are analysed, according to different optimal criteria.

The first class of operative interest is reactionless manoeuvres, characterized by the fact that the motion of the manipulator does not perturb the floating platform on which it is mounted. Thus, induced torques that could affect base attitude dynamics is avoided. Another interesting scenario is represented by the minimum time manoeuvre. In this case, however, large elastic displacements should be expected, possibly leading to an inaccurate positioning of the end-effector. In order to take into account the flexible behaviours of the links, a further design strategy, accomplished with minimum vibration amplitude at the end-effector, is implemented. If the base is highly flexible as well, the need can arise to minimize the oscillations induced in the base. Finally, the same mission can be performed with the only objective to minimize consumption.

Performance of the different strategies is analysed in terms of control effort, trajectory errors, flexible response of the manipulator, computational costs. A comparison with results obtained by using conventional spline trajectories can be also carried out.

In order to fulfil the required manoeuvres, an accurate model considering all the forces acting on the space robot has to be written. A fully nonlinear model is used to describe the dynamics, based on a multibody approach. The model includes the orbital motion, the gravity gradient and the aerodynamic effects, as well as flexibility of the links. The elastic response of the links depends also on the manoeuvres, together with elastic properties and geometrical characteristics. Some of the above mentioned manoeuvres greatly excite the elastic vibrations, while some others reduce it at minimum. In any case, additional sensors and actuators are needed to damp these oscillations out. Optimal placements of piezoelectric devices (functioning as sensors and actuators) will be therefore also suggested.