Paper ID: 63617
student

19th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Post Mission Disposal and Space Debris Removal 1 - SEM (5)

Author: Dr. Federico Basana
University of Padova - DII, Italy, federico.basana@phd.unipd.it

Dr. Francesco Branz
University of Padova - DII, Italy, francesco.branz@unipd.it

A SIMULATION TOOL FOR ROBOTIC ACTIVE DEBRIS REMOVAL WITH MINIMUM REACTION SPACE MANIPULATOR

Abstract

Robotic In-Orbit Servicing (IOS) has been identified as a key technology for Active Debris Removal (ADR). However, the capture of large, non-cooperative objects with a robotic arm is a highly challenging task since an accurate and robust performance is required to the system. Although many enabling technologies have been developed in the past decade and some demonstration missions have been conducted, robotic IOS for ADR is still an open problem.

Spacecraft mounted manipulators need to be carefully manoeuvred not only to successfully grasp the target, but also to maintain the satellite attitude, since its loss may have a negative impact both on the solar array efficiency and on the telecommunication system. This has brought to the development of several minimum reaction control strategies which permit to reach the desired End-Effector (EE) pose while minimizing the dynamic disturbances transferred to the spacecraft by the robotic arm.

This paper presents the development of a software in the MATLAB/Simulink environment capable of simulating the dynamics of a satellite equipped with a 7-DOF robotic arm during the target capture phase. Two different zero-reaction strategies have been implemented: the solution of a Least Squares problem with Equality constraints (LSE) and the Minimization of the local Kinematic Energy (MKE). The goals of this paper are (1) to provide the guidelines to implement a software which may promote further studies (2) to compare two different minimum reaction control strategies.

The manipulator is implemented by using Simscape Multibody (which also permits to import the geometry from CAD) and joint actuators are modelled as Brushless DC motors controlled by PID controllers. The base reaction torques are considered as disturbances to the spacecraft attitude which is Nadir-pointing by default, controlled by means of quaternion feedback and Linear-Quadratic-Regulator (LQR), and maintained by three Reaction Wheels (RW). The precise orbit propagation is obtained by taking into consideration gravity perturbations such as non-spherical gravity potential (EGM2008 model) and atmospheric drag. Furthermore, a realistic visual representation of the scenario is provided through Simulink 3D Animation.

By employing the software, the user can compare the two different strategies (LSE and MKE) with the classic Inverse Kinematics (IK) solution. In this paper a linear EE trajectory is imposed and the performances of the three methods are compared. Furthermore, the experimental results confirmed that LSE and MKE methods are to be preferred since they minimize the control torque that the Attitude Control System (ACS) must provide.