Paper ID: 6379
student

SPACE SYSTEMS SYMPOSIUM (D1)
Enabling Technologies for Space Systems (2)

Author: Mr. Benoit Larouche
York University, Canada, blarouch@yorku.ca

Dr. George.Z.H. Zhu
York University, Canada, gzhu@yorku.ca

DESIGN OF CAPTURE OPERATIONS FOR NON-COOPERATIVE TARGETS EMPLOYING AN AUTONOMOUS ROBOTIC MANIPULATOR

Abstract

On-orbit servicing (OOS) of failed or failing spacecrafts using satellite robots is not only feasible, but also believed to be necessary for the future of space exploration as missions are becoming more complex and expensive. One of the most important phases of OOS is the initial capture of the target satellite because it involves contact between the two spacecrafts and typically requires a timely cooperation of the control systems on both satellites, which is impossible for a tumbling (non-cooperative) satellite. In this phase, the chase satellite's robotic arm approaches the free-floating target satellite and grasps it. During the contact between the end-effector and grasping point, there is risk that the target and the robot may be pushed away from each other or the end-effecter/target may be damaged by the contact force, if it is not properly controlled.

Previous efforts in this field have focused on 2D and 3D contact mechanics of rigid bodies and the related control strategies to minimize the contact force with grossly simplified assumptions. These include (1) zero external applied force; (2) contact duration is instantaneous; (3) generalized coordinates remain unchanged during contact; (4) contact occurs at a point rather than a time-varying area. Later, some of the above assumptions are abandoned and the finite element method has been adopted to model the local flexibility of contact area. However, all of these approaches face complications from their simplifications and cannot perform autonomous capture operations while minimizing dynamics of the captured satellite.

To address the above limitations, this paper will closely examine the design of the capture operation of a non-cooperative target employing a custom robotic manipulator (RM), vision system, force sensors, and adaptable evaluative target. We will present the development of the RM and vision system and proceed to develop the capture operation that will involve the dynamic control of the arm, path planning and predictive motion planning as well as contact dynamics. The goal of the capture operation is to grasp a flexible beam target simulate and minimize stresses and strains while bringing their relative motion to a halt. The system will employ foreknowledge of the target's shape and grasping point as well as generic mechanical properties in order to achieve the task autonomously and safely.