Compliant Force Sensor-less Capture of an Object in Orbit

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Abstract

Space robots have been proposed to perform several tasks in-orbit such as repairing, refueling, and assembly. All those activities require the robot to interact with external objects in a safe and compliance form to avoid high impact forces that may damage the robot's components or the object to manipulate. Impedance controllers have demonstrated to be a suitable approach to perform similar tasks in ground. Therefore, implementing and analyzing impedance-based techniques in space is also worthy of study. Not only that, but also, methods that can reduce the number of components, weight and complexity should be considered. This paper proposes the use of the disturbance observer for the design of an impedance controller to perform a safe capture of a target satellite by a space robot. First, the observer aids in the determination of the contact force between the servicer and the target. Later, once the almost perfect match between the actual and estimated contact force is demonstrated, the estimated force is used as input for an impedance controller with trajectory tracking. The advantages of estimating the contact force instead of measuring it are also discussed in the document. The design of the impedance control is performed such that the capturing process is compliant and safe, and thus it can help to advance towards an autonomous capture of space objects. A simulation experiment was set up to evaluate the performance of the proposed method. The results demonstrate that the contact force is bounded and behaves smoothly in a spring-mass-damper-like manner, imposing a stable contact between the robot's end-effector and the servicer's capturing spot.

Index Terms

Space Robot, Compliant Capture, Impedance Control.

I. Introduction

Several on-orbit tasks will be significantly benefited by robotic technology, for example, structures assembly, space debris removal, among others. Some theoretical and experimental studies have been proposed to address relevant scenarios. However, autonomous capture of a malfunctioning object in orbit is still in experimental phases with cooperative targets in both outer space [1] and in-ground [2] laboratories. A significant challenge is found during the contact phase, where big forces

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