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ESTIMATION OF INERTIA PARAMETERS FOR ON-ORBIT OBJECT USING A ROBOT ARM

Abstract

Space robots have been used in various on-orbit servicing missions, ranging from recovery to maintenance of the spacecraft. In previous successes, for example the ETS-7 and the Orbital Express Program, these objects' inertial properties were completely known in advance, such as the mass, the center of mass and the inertia tensor. However, there are still many space debris and disabled satellites need to be displaced or repaired with limited knowledge on their inertial properties. As for these non-cooperative objects, we have to estimate their accurate inertia parameters before doing any further operations.

Conventional methods for identifying the inertial properties have been investigated originally on ground objects including vehicles and industrial robots. Most of these methods need to collect data form a series of tests, which can be carried out through pendulum method, vibration method, or even a robot-assisted method. However, all of these experiments strongly rely on the manual work of test planning, equipments setting and operations. Thus, to our knowledge, the issue of identifying inertia properties for non-cooperative on-orbit object has not yet been addressed in detail.

Here we propose a study for estimating the inertia parameters of on-orbit object using a floating space robot, which has a manipulator with multiple degree-of-freedom. This method uses a series of algorithms to estimate inertial properties of the object based on the reaction behaviors of the active robot. In this method, the object has to be captured by the manipulator at first. Then the proposed algorithms could build the object's equivalent rigid body model composed of many regular cube-shape modules in a physical simulator. A group of excitation signals is applied to joints of the robot arm, and the dynamical responses of the active robot are recorded simultaneously. An evolutionary algorithm is then used to search for a proper solution of mass distribution for each cube-shape elements in the simulated model. In the evolutionary search phase, the same excitation is applied to the robot arm in the simulator, and the data from physical tests are treated as the reference, which includes the attitude and position information of active robot along with discrete time steps.

A series of experiments has been conducted to validate this method's feasibility, and a couple of factors for this method have been investigated in those tests as well. The experimental results confirm that our method has both efficiency and robustness.