IAF ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation & Control (1) (5)

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SEMI-PHYSICAL SIMULATION EXPERIMENT ON THE ON-ORBIT CAPTURE OF TUMBLING UNCOOPERATIVE TARGET SPACECRAFT

Abstract

The robotic on-orbit service (OOS) has been a research priority of space technology for decades, because of its widely potential applications, such as satellite on-orbit repairing, refueling and removal of the space debris. The on-orbit capture (OOC) technology plays a key role in robotic OOS. The OOC involves two kinds of spacecraft: chaser (service spacecraft which mounted one or more manipulators) and target. The target spacecraft can be further subdivided into two categories: cooperative spacecraft and uncooperative spacecraft. Despite the rapid development of OOC, it is still immature. In development of new space technology, ground physical, semi-physical and mathematic simulation experiments play essential roles. This paper introduces a semi-physical simulation experiment on the OOC of tumbling uncooperative target. The experiment simulates the whole process of the OOC of a tumbling uncooperative target. It is divided into four phases: 1) Approach: the chaser flies close to the target. 2) Flying-Around: the chaser flies around the target and remains relatively motionless with respect to the target. 3) Capture: the manipulator captures the target. 4) Release: the manipulator releases the target. The experiment is carried out on a novel semi-physical simulation system, whose core equipment is a novel 9 degree-of-freedom (DOF) motion simulator platform. The simulator is composed of two 3-DOF rotating platforms and one 3-DOF translational mechanism. It can simulate the relative translational motion between chaser and target, and the rotational motions of the chaser and target. One main feature of this simulator is that it can simulate continuous rotational motion up to 3600 degrees. A cube box with two solar panels and one engine nozzle is installed on one 3-DOF rotating platform to simulate a tumbling uncooperative target spacecraft. An OOC controller, a sensor called LiDAR and a 7-DOF manipulator are installed on the other 3-DOF rotating platform to simulate the chaser spacecraft. At the end of the manipulator a capture tool is installed, which can grasp the engine nozzle of the target. Furthermore, we also build a high-fidelity dynamics model of the two spacecrafts. By the model, a real-time computer simulator computes the next motions of the two spacecrafts. After that, the 9-DOF motion simulator physically implements the motions. A series of closed-loop simulation experiments are carried out on the semi-physical simulation system. It found out that when the target rotates at speed up to 1 degree/s, the chaser can capture it successfully.