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# INERTIA ESTIMATION OF TUMBLING SPACE DEBRIS VIA TENTATIVE CONTACTS BEFORE CAPTURING


## Abstract

Capturing and stabilizing a tumbling debris is one of the main challenges in space debris removing missions. A relatively precise estimation of mass and moment of inertia of the space debris can avoid the risk that the chaser satellite fails to stabilize the tumbling debris with large angular momentum after capturing. In this paper, a novel method is proposed to estimate the inertial characteristics of a tumbling debris using a manipulator fixed on the chaser satellite before capturing.

The proposed method focuses on the tumbling space debris with a relatively large mass and a spin rate more than 10 deg/s. In the estimating process, the end effector of the manipulator is supposed to contact several times with the target debris, applying slight impact forces on it. The magnitudes and directions of impact forces are obtained by measuring the reactive forces on the base of the chaser satellite. Then by observing the changes of velocity (both linear and angular) of the tumbling debris before and after contacting, one can calculate the values of mass and moments of inertia of the debris. The main innovations of this paper have three aspects: 1) a robotic active compliance control procedure is applied to restrict the magnitudes of impact forces so as to avoid damaging the manipulator. 2) A frequency-domain analysis method is proposed to estimate the changes of angular momentum of the tumbling debris before and after contacting, which increases accuracy and robustness of estimation of moments of inertia. And 3) the coordinated control of base attitude and arms of space manipulator is studied to avoid the debris impacting on the chaser satellite except the end effector of the manipulator.

In addition, the proposed tentative contact method can not only estimate the mass and moments of inertia of tumbling debris, but also lower the spin rate of the tumbling debris. Simulation results suggest that the estimation errors of moments of inertia are reduced to less than 1% after five contacts, while the spin rate is reduced by 40% on average.