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LINE-OF-SIGHT CONTROL USING DOUBLE-GIMBAL CONTROL MOMENT GYROSCOPE FOR TETHERED SATELLITE EQUIPPED WITH TETHER-NET FOR DEBRIS CAPTURE

Abstract

Tether-nets, which can be used for active debris removal, have attracted much attention because of their robustness of debris capture in the presence of some error in the estimation of debris motion. Debris capture using a tether-net can be divided into four phases: ejection, deployment, capture, and de-orbit. For tether net deployment and debris capture, the lamped-parameter model has been used. For debris de-orbit, the flexible connection method, in which debris and the spacecraft are tethered, has been studied. In the de-orbit phase, the center of the tether-net and the spacecraft are tethered. The dynamics of the tether-net and spacecraft are equivalent to those for a tethered satellite system, which is a system of multiple satellites connected by a tether. When a tether-net is mounted on the sub-satellite of the tethered satellite to capture debris, the position of the debris is estimated using optical sensors. The ejection direction of the tether-net must be kept toward the debris after the sub-satellite equipped with the tether-net approaches the debris. This is important because the position of the sub-satellite constantly changes due to orbital and tether motion. In addition, the distance from the tether-net to the debris and the line-of-sight error toward the debris greatly affect debris capture. In this study, it is assumed that the relative position of the debris is estimated by the main satellite of the tethered satellite system and that the librational motion of the tether generates a disturbance torque on the sub-satellite. Under these assumptions, the line-of-sight of the sub-satellite is controlled to direct the tether-net ejection toward the debris using a double-gimbal control moment gyroscope and the generalized singularity-robust method is used to avoid control moment gyroscope singularities. In this study, two scenarios were considered, namely one where line-of-sight control of the sub-satellite is performed from the initial time and one where it is performed when the tether is well deployed and the sub-satellite is sufficiently close to the debris. The results of numerical simulations show that the tether-net ejection direction was sufficiently directed toward the debris, and that the offset between the center of the tether-net and the center of the debris was sufficiently small to successfully capture the debris.