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SPACE DEBRIS SYMPOSIUM (A6)
Space Debris Removal Technologies (5)

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A BIOMIMETIC APPROACH FOR ACTIVE DEBRIS REMOVAL

Abstract

Currently one of the most pressing problems in space is the increasing population of space debris. To clear the debris, many active debris removal methods have been proposed. The biomimetic capture method proposed here is inspired by the predation behavior of the frog and the setae on the gecko toe, which use a quickly ejected projectile to adhere and capture the debris. The most obvious advantage of this method is that the task can be performed on standard GEO satellite platforms with little modifications, which implies a great reduction on the total cost. The capture payload includes a projectile and a tether. The projectile consists of a structural unit, an absorption unit and a six-DOF damper. The structural unit is the load-bearing structure of the projectile and the connection between the projectile and the tether. It is formed into an arcuate shape with the six-DOF damper in the center which dissipates the impact energy between the projectile and the target. The back of the structural unit is connected to the tether through a self-lubricating spherical hinge and a buffer spring. At the fore end of the structural unit is the absorption unit. The surface of the unit is coated with a layer of biomimetic gecko micro dry adhesive arrays. Between the absorption unit and the six-DOF damper is an elastic structure which enable the surface of the absorption unit to be reshaped according to the fluctuation of the impact point and thus large steady adhesion force can be provided. According to the size of normal GEO satellites, a 100-meter tether is enough for safe grapple. However, for this length of tether, when the target is tumbling, it will bring enormous dynamical uncertainties to the grapple system. Besides, the tangle of the tether is also a serious problem endangering the chaser. However, if the impact location and the tether orientation are chosen properly, the tension of the tether can be used as a control force to stabilize the tumbling target. This kind of control strategy is also discussed and tested in this paper. The paper is divided into five parts. A brief mission analysis is introduced first, followed by the major design architectures of the release mechanism and the capture payload. The third part presents the detailed control strategies for the tethered complex. The fourth part gives the feasibility analysis of the proposed capture concept. Part five concludes the paper.