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# DESIGN OF CUBESAT-BASED ROBOTIC TENTACLES FOR THE CAPTURE AND REMOVAL OF HIGH-PRIORITY DEBRIS OBJECTS IN LEO

**Abstract**

Recent space activity has pushed the issue of space debris accumulation in the low Earth orbit (LEO) to the frontlines of space sustainability inquiries. Research on space debris identified at least five debris objects, ranked high in priority for removal, to ensure stable LEO operation for satellites. CubeSats equipped with capturing mechanism offer a novel platform for active debris removal (ADR) missions at a fraction of mass, power, and cost when compared to utilizing the conventional satellite platform. However, the list of high-priority debris exhibits significant geometrical and material diversity, placing many of them beyond the capabilities of the mechanisms proposed in the literature. In this paper, we propose a unique ADR CubeSat design by integrating a novel robotic tentacles payload for performing efficient and stable capturing and removal of debris of various shapes and sizes.

This work demonstrates the feasibility and adaptability of the proposed design compared to those designs reported in the literature subject to the same category. First, we study the shapes and sizes of high-priority debris targets and evaluate their conformance with designs presented in the literature. Second, we investigate the inadequacies and incompatibilities of the current designs and propose a new adaptable and dexterous design based on robotic tentacles that can overcome those identified deficiencies. Third, to assess the adequacy and compatibility of the proposed design and mechanism, we simulate the gripping performance using Computer-Aided Design (CAD) simulations of the capture process on real representative debris targets. We analyze contact locations, areas, and types through CAD simulations. Four, we perform numerical simulations of the deorbit phase of a mission, i.e., lowering the orbital altitude of the debris via continuous low-thruster maneuver, while accounting for orbital disturbances and performance parameters of the state-of-the-art CubeSat propulsion systems. To demonstrate the efficacy of the proposed design, we study a deorbit scenario for the CubeSat-debris pair.

The preliminary analysis through CAD simulations shows that all contacts between the robot and the target were plane-on-plane, which, unlike point-to-plane, is a stable contact. They also have a larger contact area, indicating a more secure grasp against possible disturbances by providing a greater distribution of contact loads, hence reducing the risk of damage or generating new debris. Furthermore, additional numerical simulations also show that the proposed design can significantly reduce the number of high-priority debris.

The final manuscript will include detailed analysis and simulation results.