76th International Astronautical Congress 2025

Paper ID: 98442

23rd IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations - 23rd IAA SYMPOSIUM ON SPACE DEBRIS (IP)

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AN INTELLIGENT GUIDANCE AND CONTROL ALGORITHM FOR CUBESAT-BASED AUTONOMOUS ACTIVE DEBRIS REMOVAL MISSION

Abstract

The increasing orbital debris population poses a growing threat to operational satellites in Low Earth Orbit and to future space endeavours. Nonetheless, previous efforts have focused on the elimination of larger debris objects, and recently has attention been paid to the risk posed by smaller particles (¡ 10 cm). As such, this paper suggests a CubeSat solution to complement the ongoing STRATHcube mission. The suggested CubeSat would operate in cooperation with the STRATHcube mission, which identified debris (by STRATHcube) will be removed by the suggested CubeSat. Stability and accuracy in manoeuvring during the stage of capturing and transporting the debris is however one of the biggest challenges in such a mission. An integrated guidance, navigation, and control (GNC) system for a 3U CubeSat is introduced for this mission. The system uses optical sensors and image processing for precise object tracking also a LQR controller is used for the approach and docking then a PID controller for the stabilization of the satellite after capture. Additionally, microscale thrusters and aerodynamic drag modulation are utilized for controlled trajectory adjustments and minimize the chances of collision while ensuring a soft landing in lower orbits. Beyond the technical aspects, this work highlights the economic viability and scalability of deploying autonomous CubeSat swarms for large-scale debris mitigation. The cost-effective and modular nature of CubeSats allows for scalable deployment in future ADR missions, reducing reliance on expensive conventional satellite systems. Simulation results validate the effectiveness of the proposed approach, demonstrating the CubeSat's capability to precisely locate, capture, and stabilize debris under dynamic space conditions. This work contributes to the advancement of autonomous, modular, and cost-efficient solutions for active debris removal, addressing the long-term sustainability challenges in space operations.