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LISA-ODISEE: A CUBESAT COMPATIBLE AND HYPER-REDUNDANT ROBOT FOR IN-ORBIT INSPECTION, SERVICING AND ASSEMBLY

Abstract

The current application of robotic systems in space exploration is primarily limited to planetary surface operations and assisting with extravehicular activities. However, with the rapid increase in the number of satellites in orbit and the concurrent push for sustainable space activities, there is a significant demand for On-Orbit Inspection and Servicing capabilities such as maintenance, repair, and Active Debris Removal. Especially the Low Earth Orbit (LEO) is of interest in this regard. An autonomous low cost robotic system capable of repairing satellites or de-orbiting space debris addresses this challenge. Developing a cost-effective satellite servicing system for LEO requires the robotic system to be compatible with industry standards like CubeSats. The design and control of such systems pose significant challenges, particularly in terms of adaptability, dexterity, and flexibility in unstructured environments.

This paper explores the development of hyper-redundant robotic manipulators tailored for servicing and assembly tasks in space. A primary focus is placed on optimizing kinematic architectures to maximize workspace efficiency while minimizing mass and stowage volume, a critical parameter for deployment on small satellites. A key innovation is the development of a fully integrated drive system that combines high-torque density actuators with embedded power electronics directly within the robotic modules. This novel approach eliminates external wiring, significantly enhances packing efficiency, and results in fully self-contained robotic segments. The complete robotic manipulator is small enough to fit into the volume of a 1U CubeSat. A passive thermal control system integrated into the structure reduces the thermal load of the electrical system without adding significant mass to the modules. The paper concludes with a description of laboratory tests conducted in preparation of a future in-orbit demonstration.