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Author: Ms. Kristina Andreyeva
Viterbi School of Engineering, USC, United States

Ms. Haley Topper
Viterbi School of Engineering, USC, United States
Mr. Pierson Lintala
Viterbi School of Engineering, USC, United States
Mr. Tristan Griffith
Viterbi School of Engineering, USC, United States
Prof. David Barnhart
University of Southern California, United States

FEASIBILITY OF MULTI-AXIAL GECKO GRIPPING FOR ACTIVE DEBRIS REMOVAL

Abstract

With the ever-growing amount of space debris in Low Earth Orbit (LEO), there is an increasing demand for Active Debris Removal (ADR) operations. One of the key technologies for ADR which has not yet reached a mature technological level is that of the grasping mechanism and specific method of contact. A gripper for ADR should be versatile enough to grab a wide variety of sizes and shapes of debris, while also being robust enough to handle the highly variable inertial properties. To address this problem, a highly underactuated gecko adhesive based gripper (REACCH) that was created by the University of Southern California's Space Engineering Research Center (USC SERC) and NASA's Jet Propulsion Laboratory (NASA/JPL) as a possible tool for ADR showcased gecko adhesion as the mechanical contact method. The gripper consists of a central body with pairs of opposing tentacles extending from it, where the inside of the tentacles are lined with gecko adhesive material pads that selectively engage and disengage by applying a shear force. This enables the REACCH mechanism to grasp, manipulate, and release objects, which is promising for objects with various geometric surfaces.

The feasibility of using such a gripper has been investigated by performing materials testing on the load-sharing behavior and failure behavior of the gecko pads on both flat and curved surfaces. To validate the mechanism of shear transfer, a series of static tests were conducted to understand the load-sharing behavior of multiple gecko pads connected in series and in parallel. Additional testing was done to study the pad re-engagement behavior after initial failure, substantiating the mechanical contact design of a gripper with multiple gecko pads connected in series. For dynamic testing, two cylindrical test fixtures were created with diameters of 0.8 meters and 2.4 meters, representing geometries of the most frequently encountered defunct rocket bodies. The target test fixtures and the REACCH prototype were tested on the air bearing table to simulate a variety of docking scenarios, including the stationary targets, sliding without rotating, and rotating in place.

The first part of this paper will discuss the architecture of applying gecko adhesive based tiles to a robotic gripper and show experimental setups for the material testing. The second part will focus on the extrapolating the results into potential new designs and how this adhesive methodology can apply to other feasible robotic geometries for real on-orbit ADR scenarios.