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Author: Dr. Pierpaolo Palmieri
Politecnico di Torino, Italy

Mr. Matteo Gaidano
Politecnico di Torino, Italy
Dr. Matteo Melchiorre
Politecnico di Torino, Italy
Ms. Laura Salamina
Politecnico di Torino, Italy
Mr. Davide Sorli
Politecnico di Torino, Italy
Mr. Mario Troise
Politecnico di Torino, Italy
Prof. Stefano Mauro
Politecnico di Torino, Italy

A DEPLOYABLE AND RETRACTABLE INFLATABLE LINK FOR A SPACE ROBOTIC MANIPULATOR

Abstract

This paper presents the development of IDRA, an Inflatable and Deployable Robotic Arm for space applications. IDRA allows significant volume savings, a critical factor in space missions, and offers a workspace expansion beyond the capabilities of conventional space robotic manipulators. Moreover, its compact nature during launch offers efficient cargo space utilization, which can lead to reduced launch costs. The robot has a hybrid structure made of inflatable links and rigid electric-actuated joints. Therefore, when links are deployed, the robot has the same mode of operation of a traditional one, controlled through standard visual servoing algorithms. The ability to deploy and retract allows to occupy volume only when needed, reducing the exposure to space debris impacts and extreme conditions.

IDRA can be employed in satellites with high economic value for inspection, maintenance and servicing activities to extend their operational life, contributing to the mitigation of space debris issue. In-orbit servicing, assembly and manufacturing (ISAM) is a growing trend in the space industry and new innovative, economic and sustainable systems are required to improve the sustainability of the sector. The robotic system could be deployed only when necessary and, when stored, would have little impact on the overall volume of the satellites. Nevertheless, IDRA could be employed as an on-board manipulator: the possibility to fold back the robot in its package allows to optimize the restricted room available in spacecrafts.

This paper focuses on the advancements in the design, analysis and verification of the inflatable link mechanism, the key component that enables the efficient deployment and retraction of the robot. The design of the inflatable link mechanism addresses key challenges in space missions: weight efficiency, compactness at launch, and resilience in the harsh space environment. Aramid fibers are selected as material for the structural layer, optimizing launch mass, and ensuring strength and stability. The link is designed to maintain structural integrity and operational precision of the robotic manipulator when inflated, conserving a cylindrical shape. A series of tests are performed to validate the inflatable link and

the controllability, repeatability and stability of the deployment and retraction phase. A two-dimensional version of the robotic system is tested in microgravity conditions by using air bearings on epoxy resin floor. Results validate the deployable and retractable inflatable link. Next steps regard the test of the inflatable links under extreme conditions, such as high and low temperature and vacuum.