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SPACE SYSTEMS SYMPOSIUM (D1)
Enabling Technologies for Space Systems (2)

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DIELECTRIC ELASTOMER SPACE MANIPULATOR: DESIGN AND TESTING

Abstract

Soft robotics is a promising field and its application to space mechanisms could represent a breakthrough in space technologies by enabling new operative scenarios (e.g. soft manipulators, capture systems). Electro Active Polymers (EAP) and Dielectric Elastomers (DE) have been under deep study for a number of years and have shown several advantages that could be of key importance for space applications. For example, On Orbit Servicing operations requires the capture of space vehicles, which is a complex operation with a lot of uncertain parameters. Soft robotics is intrinsically compliant to the operative scenario, thus being tolerant to partially unpredictable situations. Ground based DE robotic systems are under development and show promising results, although they have to compete with well-established industrial manipulators. Differently, space conditions could advantage DE robotics considerably, given the reduced environmental loads experienced and the longer times for operations. Nevertheless, EAPs and, in particular, DEs are a young technology that need to prove its maturity and suitability for space implementation. In this work, the design and laboratory testing of a redundant manipulator based on Dielectric Elastomer Actuators (DEA) is presented in terms of numerical and experimental results. The prototype of a 4-DoF space manipulator is manufactured and tested in a simulated zero-gravity environment. Two double-cone actuators are mounted in series; each of them guarantees actuation along two DoF. The end-effector is an optical marker whose position is detected by a vision system that closes the control loop. The system has a total of four joint DoFs and operates in a bi-dimensional (i.e. X-Y horizontal plane) workspace where only the X and Y positions of the end-effector are controlled. This configuration leads to two degrees of redundancy, that can be exploited for optimization of joint torques and/or avoid saturation of actuators. A robust control system is implemented in order to effectively operate the system despite of strong non-linearities and difficult modelling of DEs. A numerical simulation campaign has been conducted and the results are discussed. A laboratory facility has been developed to emulate the zero-gravity orbital environment by means of a flexible suspending system. Preliminary experimental results are exploited for the validation of the control algorithm and numerical models.