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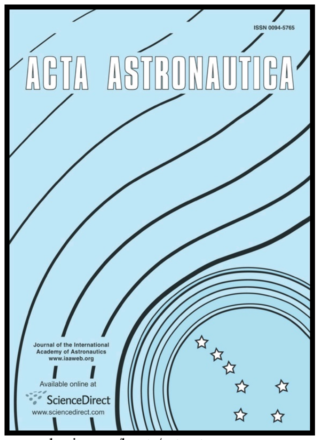

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Experimental evaluation of a Dielectric Elastomer robotic arm for space applications

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Abstract

A growing interest within the space community focuses on robotics due to the large number of possible applications in many mission scenarios. On-Orbit Servicing (OOS) is arguably the most appealing implementation of space automatic systems. In several cases, OOS requires the capture of orbital objects, which is a complex and risky operation that can be successfully performed by robotic manipulators. Soft robotics, in particular, seems to be suitable for such applications given its intrinsic compliance to the operative environment. Devices based on Dielectric Elastomers (DE) can be employed for the manufacturing of soft robotic systems and showed promising performances. The introduction of DEs to orbital systems would represent a breakthrough in space technologies. In addition, space conditions could further advantage DE robotics, given the reduced environmental loads experienced and the longer times for operations. Nevertheless, Dielectric Elastomer Actuators (DEA) are a low-TRL (Technology Readiness Level) technology that needs to prove its maturity and suitability to space implementation. In this work, the performances of a redundant manipulator based on DEAs are presented in terms of numerical and experimental results. A 4-DoF planar manipulator has been tested in a gravity-compensated setup. The system is composed by two double-cone actuators mounted in series, each of them providing actuation of two DoF. The end-effector is an optical marker whose position is detected by a vision system. The system has a total of four joint DoF and operates in the xy horizontal plane; only the x and y positions of the end-effector are controlled. Two degrees of redundancy are obtained and exploited for the optimization of joint torques to avoid the saturation of actuators. Numerical simulations have been conducted to predict the system behaviour. The laboratory facility emulates the zero-gravity orbital environment by means of a suspending cable. Detailed experimental results are presented and exploited for the validation of control algorithm and numerical models.

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