SPACE SYSTEMS SYMPOSIUM (D1)
Innovative and Visionary Space Systems Concepts (1)

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SMART AND LIGHTWEIGHT ROBOTIC CAPTURING SYSTEM OF NON-COOPERATIVE SPACECRAFTS

Abstract

Space robotics is expected to play an increasingly important role in the near future space activity. In particular, the autonomous capture of unknown non-cooperative targets in orbit is recognized as one the key technologies to be developed. Moreover, the removal of space debris from orbit has become impelling because they seriously threaten existing and future space missions due to their rapidly increasing number. In this paper, innovative robotic capturing systems are developed and compared, taking advantage of some novel concepts recently introduced in the field of smart and inflatable materials and in the field of industrial gripper technology, which in this work have been further developed for the challenging task of the capture of non-cooperative objects in space. The first investigated concept is based on long inflatable fingers, which are rolled during launch and are inflated and then actuated for the grasp using Electroactive Polymers (EAP) actuators or with smart preloaded springs that are released when the target is in the system working area. This concept, which has been never investigated in literature, has the advantage of the very small mass and volume requirements and of a low overall system cost, which makes it possible its extensive use for space debris removal using small chaser satellites. Another advantage of the proposed concept is that most of the mechanical energy required for the capture is stored inside the system before the launch. A similar concept has been investigated using foldable small-section CFRP beams instead of the inflatable beams, which make it possible to obtain an even lighter and self-deployable system. Finally, a concept using foldable multi-degrees-of-freedom fingers actuated by means of a tendon driven mechanism has been investigated, which has the advantage of actuating the whole system with one single actuator, and of being an underactuated compliant system which can easily adapt to different shapes of the captured object. Several test cases are analyzed and demonstrated with software simulations with different trajectory, relative velocity, spin, shape and dimensions of the target satellite in order to simulate real space robotic capture scenarios. The proposed concepts are then compared in terms of performance and weight and volume requirements, and a prototype has been developed and on-ground tested in a simulated microgravity facility for the concept validation of the best performing system.