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# CAPTURE, EJECTION AND HANDLING OF SPACE PAYLOADS, USING ROBOTIC SYSTEMS WITH SUPER-FLEXIBLE MANIPULATOR ARMS

**Abstract**

More challenging missions in space are generating a need for more non-traditional manipulators to perform more complex tasks. It is believed that the mechanical, "catapult" type systems, may offer numerous advantages over the conventional "rigid" robotic manipulators due to being re-usable, more simple, economically efficient and reliable.

The difficulty, however, in practical use of these systems is in their modelling and control, as the super-flexible robotic manipulators, subject to large elastic deformations and undergoing large rotations and translations, represent highly non-linear systems, requiring special methods of the analysis, design and control.

In this paper we present a new platform for the dynamic modelling and adaptive control of these systems, based on the co-rotational finite element method. Using this methodology, we first model various designs of the super-elastic robotic manipulators, including a single-manipulator single-arm super-elastic catapult and multiple two-arm cooperative super-elastic robotic manipulators. Then we consider various practical scenarios of the payload ejection and capture. In particular, we present and analyse in details a scenario of the ejection of the spacecraft with a catapult super-flexible robotic system, which enables to achieve not only desired ejection velocity of the payload, but also its required spin. We demonstrate high efficiency of this "frisbee" payload transfer. As in the case of traditional "frisbee" the super-elastic robotic systems are capable of launching payloads extremely precisely and far distances with only the smallest amount of energy put into the throw. Using the co-rotational finite element methodology, we also perform analysis of the gentle handling of the payloads, using a system of cooperative robotic systems with super-elastic manipulator arms. We complement our feasibility analysis with the method of control of the undesirable vibrations during the operations of the robotic systems and their re-bounce.