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Space Structures III Design, Development and Verification (Orbital infrastructure for in orbit service & manufacturing, Robotic and Mechatronic systems, including their Mechanical/Thermal/ Fluidic Systems) (3)

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SOFT ROBOTICS FOR SPACE APPLICATIONS

Abstract

The exploration of increasingly extreme and isolated environments in space drives the need for new and innovative robotic solutions. Soft robotics has emerged as one such paradigm that may provide solutions to some of space explorations most challenging problems. Unstructured, high risk and extreme conditions all challenge our current models and expose limitations in our current robotic methods. A soft robot's ability to deform to its environment enables these systems to more gracefully deal with uncertainty compared to their rigid counterparts. This allows soft robotic structures to more safely perform complex interactions with high value assets. Soft contact, interactions with soft robotic systems, has numerous benefits in these scenarios. Soft contact can increase the contact time, reducing the force and softening interactions between systems. Human-Robot interactions in space are one such scenario where soft contact may be beneficial. Robotic partners with an emphasis on inherent safety may prove vital to humanities return to the moon and beyond. Interactions with exotic terrain may also benefit from soft contact and novel locomotion methods only available to soft systems. Inspired by underwater invertebrates, soft locomotion leverages buoyancy, enabling unique movement in an environment analogous to the reduced and microgravity environments present in space. We present a summary of our research into soft robotics for space applications, outline our design methodology and demonstrate prototype soft robotic systems performing simulated scenarios in analogue space conditions. Traditional soft systems encounter unique challenges in space where extreme environmental conditions can cause embrittlement and performance degradation due to their material composition, limiting their available flexibility or softness. Our design methodology prioritise morphology over material selection, designing soft structures out of traditionally non-rigid materials. Allowing space compatible materials to be used in place of traditional flexible materials that cannot withstand the extreme environmental conditions in space. We have developed soft robotic platforms for locomotion in lunar and asteroid environments, demonstrated in Earth analogues. Additionally, we present a class of configurable soft manipulators for use in a wide range of space environments. Finally, we demonstrate prototype soft robotic systems performing successful precision manipulation and movement in mission analogues for satellite grappling and servicing in extreme cryogenic environments, -196^oC. Our work highlights the transformative potential of soft robotic systems in overcoming current and future challenges in space exploration, enabling safer, more robust and efficient missions.