Soft Robotics for Space Applications

Embracing Flexibility for Extreme Environments

Soft robotic systems can perform safe interactions with high values assets. In a space environment these interactions are plentiful; interactions with human operators, plant life and objects of scientific or archaeological significance. A soft robot's ability to deform and comply to its environment enables these systems to more gracefully deal with uncertainty compared to their rigid counterparts.

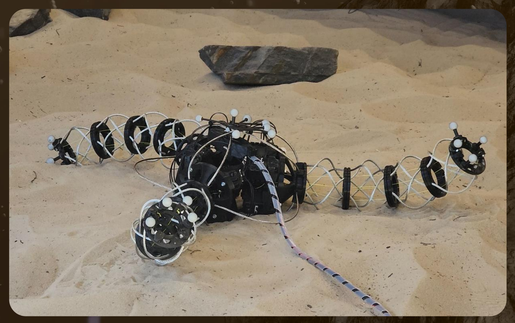
Environmental Challenges

Soft robots encounter unique challenges where extreme environmental conditions in space can limit the available compliance. This prevents traditional soft robotics constructed from elastomers or resins being used. Harsh environmental conditions such as cryogenic and super-heated temperatures, as well as radiation, all have significant effects on the elastomeric materials that soft robots are most commonly composed from.

Design Philosophy

Our soft robotic design philosophy prioritizes structural morphology over material selection to achieve compliance with traditionally non-soft materials. This approach overcomes the limitations of traditional soft materials in space environments, such as reductions to flexibility in extreme temperatures and radiation degradation.

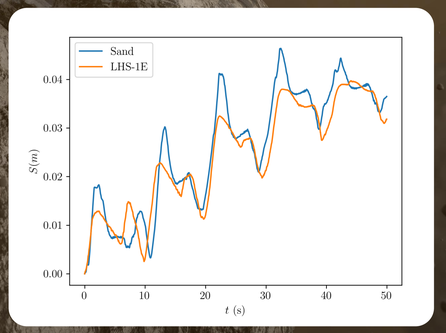
Embracing a modular design philosophy, we construct families of metallic soft robots specifically designed for space environments. Soft legged locomotion, and manipulation with these legged systems are of particular interest.



A soft robotic triped undergoing locomotion testing in sand, above and Space Resource Technologies LHS-1E lunar regolith simulant, below.

Testing Methodologies

Using a piecewise approach, we can capture information from real world environmental testing for sets of conditions and use simulation techniques to model cross-coupling behaviors. Temperature and atmospheric conditions for ranges of target environments are replicated using thermal vacuum, heated furnaces and liquid nitrogen. Analogue terrains are constructed in our Extra-Terrestrial Environmental Simulation Lab (Exterres) where locomotion evaluations can be performed against a variety of surface and simulant types.



Comparison of tripedal platform's crawling gait in sand vs LHS-1E regolith.

Validation of system behaviour in extreme environment analogues (LN2 −196°C).

Soft robotics presents a promising solution for inherent safety in collaborative domains present in space environments. Experimental trials have validated that our soft robotic structures maintain flexibility and operation at cryogenic temperatures, an important step to enable soft robotic usage in extreme environments.

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W. Foster-Hall, D. J. Harvey, and R. Akmeliawati, "Soft Robotics for Space Applications: Towards a Family of Locomotion Platforms" 7th IEEE RAS International Conference on Soft Robotics (ROBOSOFT 2024).

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