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Space Structures II Development and Verification (Orbital deployable and dimensionally stable structures, including mechanical and robotic systems and subsystems) (2)

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CO-DESIGN ROBOTS AND STRUCTURES FRAMEWORK FOR AUTOMATED CONSTRUCTION OF MODULAR SPACE PLATFORMS

Abstract

Large-scale space structures have taken center stage as the future of space exploration, paving the way for ambitious endeavors like sprawling solar power stations, intricate telescopes, and giant space stations. This program lies not in manual assembly, but in empowering space robots to autonomously build these structures using plans provided by dedicated on-orbit assembly planning algorithms.

In this paper, we describe an approach to large-scale space structure assembly frameworks, keeping in mind the many benefits associated with the use of autonomous crawling mobile robots.

Our research describes a model of a large scale deployable structure, and its physical constraints, and a corresponding assembly approach. Initially, all building elements (beams and nodes) are stored in the payload fairing. These will be deployed one by one to form the structure on which the robots themselves will evolve until the final configuration is reached. The proposed concept considers a structure made up of truss beams with standard interfaces at their ends and attachment nodes, also equipped with standard interfaces, supporting a payload such as a solar panel or a deployable antenna. This concept can be easily extended to three dimensions. Assembly is performed by crawling robots, which are systems that adhere to or grip the structure and move around it. We therefore carefully co-design the robots and the satellite to ensure manageable dynamics.

We represent the assembling problem as an automated planning instance, where several structural constraints dictate the actions available for execution, and their application is constrained in time to avoid introducing dynamic forces that compromise stability and pointing accuracy. The automated planner algorithm provides the steps to achieve the final, deployed structure, while ensuring that the structural constraints and center of mass variation bounds are not violated during plan execution.

We have implemented a prototypical version of the planner that provides an assembly plan, i.e. a sequence of actions to move the elements from the payload fairing to the deployed structure.

This model and its associated tools help to illustrate the feasibility of the approach and the benefits of having AI tools for autonomous assembly robots in space.