MATERIALS AND STRUCTURES SYMPOSIUM (C2)
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Author: Mr. Benjamin Jenett
Massachusetts Institute of Technology (MIT), United States

DIGITAL CONSTRUCTION SYSTEM FOR SCALABLE SPACE INFRASTRUCTURE

Abstract

Achieving large scale space structures is an ongoing challenge with no clear solution. These structures are desirable for many reasons. Be it aperture for communication antennas and space telescopes, or square area for energy collection, larger scale enables higher performance for a variety of missions. Currently, these structures are achieved as deployables or with on orbit construction. Deployable structures are limited to the mass and volume constraints of a single launch vehicle. On-orbit construction promises the bypassing of launch loads, and incremental erection of structures larger than those achievable in a single launch. However, limitations in human and robotic approaches hinder extensive large-scale on-orbit construction.

A recent approach to constructing large space structures is the use of modular, reconfigurable lattice elements known as digital materials. Reversibly-assembled digital cellular materials consist of a 3D framework that is decomposed into identical building blocks, which are assembled to form continuous materials/systems with many desirable traits, including repairability, reconfigurability, and tunable high-performing mechanical properties, as shown in prior art.

Digital lattice structures differ from generalized on-orbit construction in their degree of modularity and periodicity, lending them to simplified robotic construction. Rather than complex robots with multiple degrees of freedom to perform several tasks, we divide tasks between robots, and design these task-specific robots relative to their function and their structured environment. Prior art includes robots for inspection and assembly.

We propose a construction system based on modular assembly using simplified robots to achieve scalable space structures. We meet design criteria for large truss structures at a lower areal density than traditional monolithic structural elements. We achieve a range of structural properties through spatial distribution and hierarchical construction, extending high performance characteristics of length-limited deployables to scales orders of magnitude larger than the state of the art. Parallelized, distributed robotic construction provides high throughput and strategies for material distribution and supply center location.

Analytical descriptions of hierarchical structures allow for optimization of properties including mass, stiffness, and failure modes, which can be validated with simplified numerical models of high part count digital lattice structures. Large scale robotic construction simulations characterize the performance of distributed versus centralized approaches.

This scalable construction system enables new missions: MW solar energy production, 100m telescopes for exoplanet imaging, and Km scale structures for habitats and long term transport. Scalable construction will create a new space infrastructure which overcomes the constraints of launch vehicle payloads, shifting from bleeding to leading edge.