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AI-BASED AND PERFORMANCE-DRIVEN DESIGN FOR THE OPTIMAL COMBINED TENSEGRITY AND MEMBRANE STRUCTURES FOR LUNAR BASES

Abstract

The aerospace industry, facing high launch costs and restricted rocket tank capacities, is exploring lightweight, deployable tensegrity structures inspired by biological systems. Tensegrity, showcasing a mix of tensile and compressive components from micro-scale spider fibers to macro-scale animal structures, was first conceptualized by Ioganson in 1921 and later refined by Snelson in 1948. This principle offers benefits like lightweight, adjustable stiffness, and morphing capabilities. Applied across various domains from airfoil design to rover innovation and planetary landers, tensegrity holds significant promise for aerospace system design. To address the challenges of establishing sustainable human habitation on other celestial bodies, such as the Moon, this study proposes an innovative, AI (artificial intelligence)-driven, and performance-driven approach for designing lunar bases.

By optimizing the combined tensegrity and membrane structures, the research aims to enhance thermal efficiency and structural integrity, ensuring the bases are suited to the Moon's harsh conditions. Tensegrity offers an optimal balance between material use and structural performance, while membranes provide efficient coverage for large areas with minimal resources. Utilizing AI algorithms, this study rigorously evaluates various design configurations against key performance indicators, including thermal and structural efficiency, material use, and adaptability to the lunar surface. The AI-driven process not only accelerates design exploration but also ensures a level of optimization that is meticulously aligned with the unique demands of lunar base construction. The results show that combining AI with performance-driven design to develop optimal lunar habitats contributes valuable insights for future space exploration and settlement. This research provides valuable guidance toward realizing the goal of human life beyond Earth, offering a beneficial example for designing efficient, resilient, and habitable extraterrestrial structures.