Robotics and Autonomous Systems Thesis Defense

Design and Modelling Multi-Stable Origami Structures for Adaptive Applications

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Abstract

Origami, the Japanese art of paper folding, has come a long way from its traditional roots. It's now being used in modern engineering and design. In this thesis, I explored multi-stable origami structures. These structures can hold multiple stable shapes, which could have a big impact on various technologies. I aim to break down the complex ideas behind these structures and explain their potential applications in a way that's easy to understand.

In this research, I looked at the history of origami and recent developments in computational design to create and study multi-stable origami structures. I used computer tools like parametric modeling software and finite element analysis to come up with new origami designs. These tools helped me create, improve, and test these designs with a level of accuracy and speed that hadn't been possible before.

The process begins with the formulation of design principles rooted in the fundamental geometry and mechanics of origami. Leveraging mathematical algorithms and optimization techniques, diverse sets of origami crease patterns are generated, each tailored to exhibit specific multi-stable behaviors. Through iterative refinement and simulation-driven design, optimal solutions are identified, leading to the realization of intricate origami morphologies that defy traditional design constraints.

Furthermore, the technological implications of multi-stable origami structures are explored across a spectrum of applications. In robotics, these structures serve as foundational building blocks for reconfigurable mechanisms capable of adapting to dynamic environments and tasks. In aerospace engineering, they enable the development of lightweight, deployable structures for space exploration and satellite deployment. In architecture, they inspire innovative approaches to adaptive building envelopes and kinetic facades, enhancing sustainability and user experience.

In summary, this thesis presents a comprehensive exploration of multi-stable origami structures, from their generation through computational design methodologies to their application across diverse technological domains. By pushing the boundaries of traditional design paradigms and embracing the synergy between art, science, and technology, this research opens new frontiers for innovation and creativity in the realm of origami-inspired engineering.

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