Creating an Origami-Based Soft Robot for use in High Stress Environments

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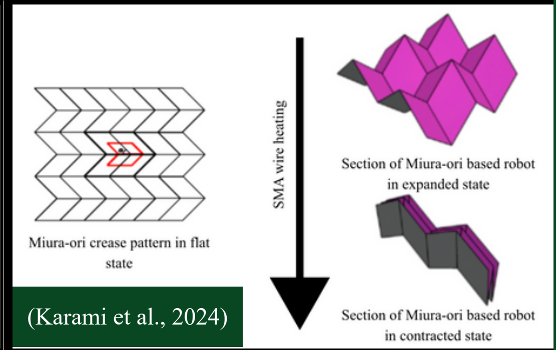
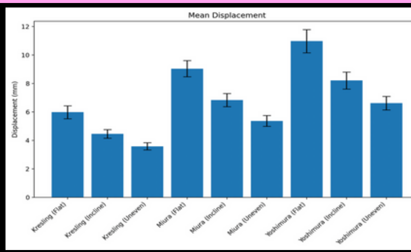
Research Question: How can origami-based folding patterns be used to design a soft robot that adapts its locomotion to uneven terrain?

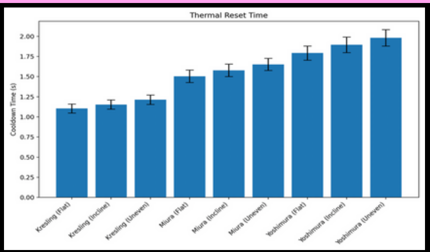
Objective: Design, build, and test an origami-inspired soft robotic platform that converts controlled actuation into directional motion using geometric deformation.

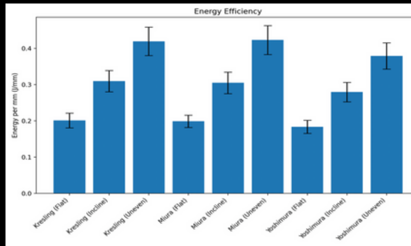


(Karami et al., 2024)

Analysis: Comparison of different fold geometries







Average displacement, energy efficiency, and thermal recovery of three tessellations over 500 simulations and three different terrain types.

A difference in origami geometry results in a change in a lightweight soft robot's energy efficiency, displacement per cycle, and speed.

SIMULATION — Emulate displacement, energy efficiency, and thermal behaviour

SMA INTEGRATION — Integrate SMA wires to create modules with tuneable stiffness and motion profiles.

PHYSICAL PROTOTYPE — Fabricate prototype segments using heat-resistant materials and embed SMA wires.

TESTING — Measure displacement, energy consumption, and thermal cooldown

ANALYSIS — Determine tessellation with the best locomotion, motion, and thermal recovery.

Interpretation

- ANOVA showed significant differences in displacement between tessellations ($p < 0.001$), with Miura producing the greatest average displacement.
- Energy efficiency (J/mm) also differed significantly across designs ($p < 0.001$), with Kresling showing the lowest energy cost per millimeter.
- Cooldown time varied by geometry ($p < 0.001$), with Yoshimura cooling fastest.

Real-world Applications

Applications in search and rescue, medicine delivery, underwater welding, machinery maintenance, and other high-stress environments