Harn SIMON

Morphology-Guided Locomotion: How Heterogeneous Joint Stiffness Enables Low-Redundancy Control through Morphological Computation

Insect legs possess multiple degrees of freedom, enabling movement across complex terrains. However, during routine foraging on familiar paths, simpler leg motions are often sufficient. In these cases, simple three-dimensional trajectories generate functional propulsion, resulting in energy efficiency and reducing transport cost while maintaining effective velocity and travel distance. From this observation, simple and periodic command signals eliminate redundant locomotion responses to environmental perturbations. In contrast, natural leg joints and links exhibit a degree of compliance that enables the structure to passively adapt to terrain and trajectory variations without the need for continuous control signal modulation. As a roboticist, my research question is how heterogeneous joint stiffness in compliant structures can improve the efficiency of constrained command signals by minimizing redundancy through morphological computation. Motivated by the idea that mechanical properties can serve as computational elements, I integrated compliant structures into rigid robot legs to compare locomotion efficiency. Preliminary results showed that our team’s double spiral structure improved the performance of a small quadruped robot across varied terrains, even with simple trajectory inputs