PHYSICAL MATH SEMINAR

Multi-legged matter transport:
A framework for locomotion on noisy landscapes

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ABSTRACT:

While the transport of matter by wheeled vehicles or legged robots can be guaranteed in engineered landscapes like roads or rails, locomotion prediction in complex environments like collapsed buildings or crop fields remains challenging. Inspired by principles of information transmission which allow signals to be reliably transmitted over noisy channels, we develop a “matter transport" framework demonstrating that non-inertial locomotion can be provably generated over “noisy" rugose landscapes (heterogeneities on the scale of locomotor dimensions). Experiments confirm that sufficient spatial redundancy in the form of serially-connected legged robots leads to reliable transport on such terrain without requiring sensing and control.

Despite robustness, locomotors with excessively redundant legs are often practically unfavored because of limited efficiency and applicability. Analogous to signal transmission, we further improve locomotion efficiency by properly coordinating (coding) the redundant legs. The challenges of such coding partially lie on the high dimensionality associated with the additional legs and the emergent importance of inter-leg centralized coordination. Specifically, we need a top-down approach to analyze the central coordination among the additional legs, and further design how it should adapt to different environments. We use geometric mechanics, a mathematical framework for studying locomotion in various systems, for motion planning in multi-legged robots operating in complex environments. As a result, open-loop operation on multi-legged robots achieves remarkable performance on terrains with different types and levels of complexity. Additionally, analogies from communication theory coupled to advances in coding for error detection/correction further improve the locomotion efficiency and robustness via centralized adaptation (using simple contact sensors to estimate environmental uncertainty). This research contributes to the field of legged robot locomotion, providing new possibilities for designing effective and adaptable robots for challenging environments.

TUESDAY, OCTOBER 31, 2023
2:30 PM – 3:30 PM
Building 2, Room 449

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