Forceful manual manipulation with millirobot ensembles on unreliable substrates

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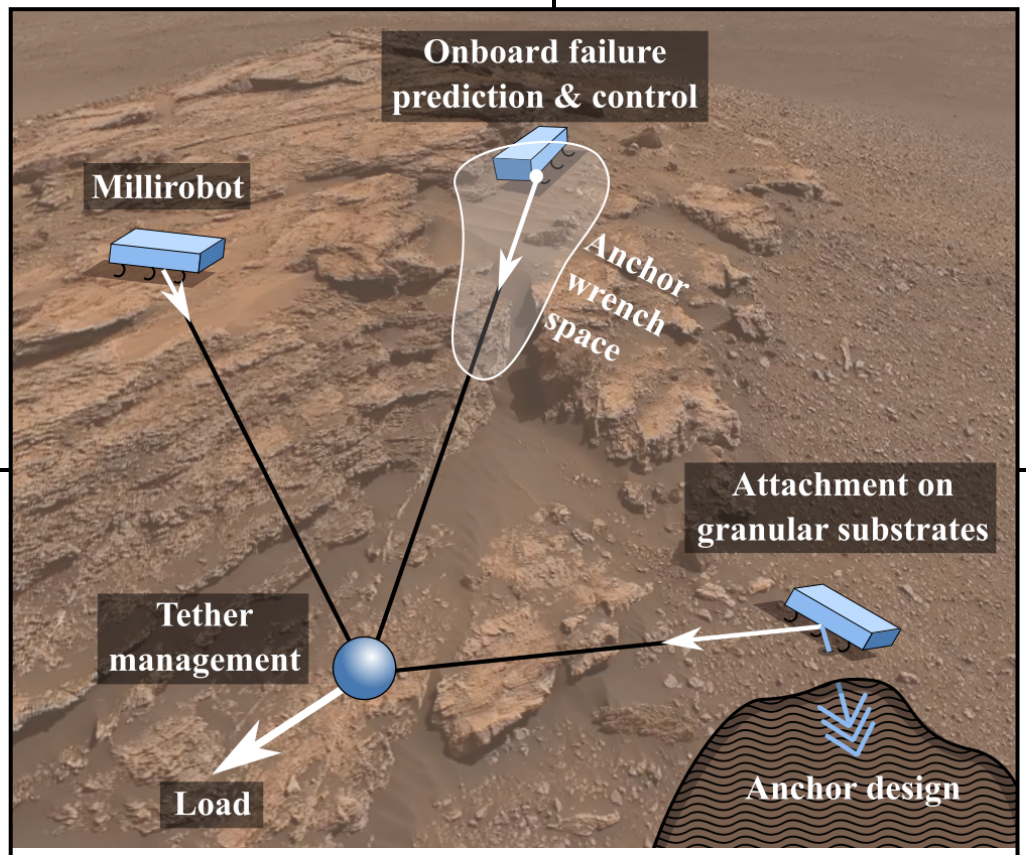
Research Objectives

Objective: To achieve forceful manipulation when each agent is limited by ground reaction forces on varied granular substrates dominated by silt, sand and rock. **State of the art**: Robot attachment typically assumes rigid, reliable surfaces, not variable granular media.



A system of millirobots with anchors and onboard sensors achieves forceful tasks together, even on sandy or crumbling substrates.

Innovation: New ability to perform more rapid and reliable maneuvers robustly, via onboard anchoring, contact sensing, and coordinated action centralization.

The project **starts at TRL 1-2**, with basic principles of granular media forces observed, and will **finish with TRL 3** by demonstrations with mock lab setups.

Approach

Mechanics modeling and controlled laboratory experiments will be used to:

Aim 1: develop and validate a model for anchor forces in granular media typical to the surface of Mars.

Aim 2: create sensitive, light-weight anchor mechanisms, and realization methods, for secure attachment.

Aim 3: generate a framework for multi-agent load-sharing control during large-scale manipulations.

Potential Impact

Mobile robots that can anchor to produce large manipulation forces enable new maneuvers at size and force scales beyond typical platforms today. If successful, this work enables agents to perform on new substrates, such as sand a shale, which are common on Mars. Novel estimation and control methods will help machines robustly perform manipulation in tandem for tasks like moving large payloads. The design and modelling tools developed will expand what we understand about interacting with granular media, which may influence applications like future rover and excavation tasks.