Novel robot design for collective transport of soft matter in complex environments

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Collective robot construction has generally been restricted to rigid materials and structured environments. We seek to discover principles by which active collectives can manipulate and operate within soft matter. This will expand the scope of swarm construction behaviors and develop hypotheses for how complex habitats emerge in biological collectives, like ants and termites. To this end, we have developed a scalable legged robophysical model (length = 24 cm, width and height = 16 cm) that can traverse 5 cm tall obstacles and move at 12 cm/s. The robot operates within a dark arena (length = 1.8 m, width = 1.2 m) where light cues dictate different behaviors based on color and intensity. We task the robot to remove portions of material from a mound located at an excavation site. The robot then transports the acquired material to a deposition site one meter away. Staples, which can form structures such as walls, slopes, and arches via geometric entanglement, are used as a model cohesive soft material. A single agent can transport ~10% of the overall staple mound over 4 hours and create multiple piles at the deposition site. By constructing a collective made of such robots, we will observe and discover behaviors that lead to effective emergent collective structure formation.