Our results reveal that lightweight robots can achieve high locomotor performance on granular media by exploiting fluid properties of the granular material. This locomotion mode is distinct from previously observed low frequency yielding walking strategy, and provides a better understanding of fundamental locomotive modes for a broad class of granular substrates. The lightweight robot platform enables detailed examination of legged locomotion, and provides likely the best model to date of a robot running on granular media. In addition, the integrated simulation tool we developed can be used to systematically test the effect of both locomotor and substrate properties on locomotor performance, which can guide the design, control and power consumption estimates for high-performing multi-terrain robot platforms.

Finally, we note that while experiment and simulation allow detailed investigation of mechanics of movement on granular media, a complementary approach is needed, that of low order dynamical models that can be used to gain insight into the critical mechanics of dynamical running. In our future work, we will investigate if a dynamic force law that describes the hydrodynamic-like forces during high speed leg intrusions can be obtained from measurements in DEM simulation. We posit that a generalized locomotion model similar to the Spring-Loaded Inverted Pendulum (SLIP) [26] can be developed based on the force law, and can extend our current study to more generalized conditions. This generalized model will shed light on the locomotor dynamics of legged animals and robots on granular media, as well as guide development for analytically tractable low order models.

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