Abstract Submitted
for the MAR16 Meeting of
The American Physical Society

Jammed granular cones affect frictional resistive forces at the onset of intrusion[1] JEFFREY AGUILAR, School of Mechanical Engineering, Georgia Institute of Technology, DANIEL GOLDMAN, School of Physics, Georgia Institute of Technology — Characterizing the functional form of granular resistive forces has allowed for analysis of the locomotion of animals and robots on and within dry granular media. Resistive force theory (RFT) has been an effective tool in predicting these forces for various locomotive gaits within the "frictional fluid" regime, where intrusions are sufficiently slow such that granular inertial effects are negligible. These forces have been typically described by a linear dependence to submersion depth. However, recent experiments on robotic jumping [Aguilar & Goldman, Nature Physics, 2015] have revealed the importance of considering the nonlinear effects at the onset of intrusion to accurately predict robot kinematics. Particle image velocimetry (PIV) analysis of sidewall grain flow during foot intrusion reveals a jammed granular cone that develops beneath the foot at the onset of intrusion. A geometric model of cone development combined with empirical RFT forces on angled conical surfaces was able to predict the non-linear force trajectory vs. depth for experimental intrusions of various foot sizes, suggesting that intruders experience non-linear frictional forces according to the shape of the granular jamming fronts that form at the onset of movement.

[1]This work was supported by NSF Physics of Living Systems, Burroughs Wellcome Fund, and the Army Research Office

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Date submitted: 05 Nov 2015 Electronic form version 1.4