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Characterization of undulatory locomotion in granular media ZHIWEI PENG, The University of British Columbia, ON SHUN PAK, Santa Clara University, GWYNN ELFRING, The University of British Columbia — Undulatory locomotion is ubiquitous in nature, from the swimming of flagellated microorganisms in biological fluids, to the slithering of snakes on land, or the locomotion of sandfish lizards in sand. Analysis of locomotion in granular materials is relatively less developed compared with fluids partially due to a lack of validated force models but a recently proposed resistive force theory (RFT) in granular media has been shown useful in studying the locomotion of a sand-swimming lizard. Here we employ this model to investigate the swimming characteristics of an undulating slender filament of both finite and infinite length. For infinite swimmers, similar to results in viscous fluids, the sawtooth waveform is found to be optimal for propulsion speed at a given power consumption. We also compare the swimming characteristics of sinusoidal and sawtooth swimmers with swimming in viscous fluids. More complex swimming dynamics emerge when the assumption of an infinite swimmer is removed. In particular, we characterize the effects of drifting and pitching in terms of propulsion speed and efficiency for a finite sinusoidal swimmer. The results complement our understanding of undulatory locomotion and provide insights into the effective design of locomotive systems in granular media.

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