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Lift-off performance of a jumping robot on hard and soft ground

JEFFREY AGUILAR, ALEX LESOV, KURT WIESENFELD, DANIEL GOLDMAN, Georgia Tech — We study lift-off during jumping on hard ground and granular media in a simple robot composed of a linear actuator in series with a spring. On hard ground, the robot jumps from a metallic base. On granular media (GM) composed of 0.3 mm glass particles, a circular foot is attached to the spring and an air-fluidized bed sets the initial volume fraction, ϕ. The actuator frequency and phase are systematically varied to find optimal performance. On both substrates, optimal jump height does not occur at the robot's resonant frequency f_0. Two distinct jumping modes emerge: a simple jump which is optimal above f_0 is achievable with a squat maneuver, and a "stutter" jump which is optimal below f_0 is generated with a counter-movement. For hard ground, both modes exhibit similar performance. On closely packed GM ($\phi = 0.62$), the simple jump becomes the favored mode. On loosely packed GM ($\phi = 0.58$), jump height performance is significantly reduced due to greater yielding in the material. A dynamical model reveals how optimal lift-off results from non-resonant transient dynamics.

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