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Controlled locomotion of robots driven by a vibrating surface[1]

PAUL UMBANHOWAR, KEVIN M. LYNCH, Northwestern University — Robots typically derive their powers of movement from onboard actuators and power sources, but other scenarios are possible where the external environment provides part or all of the necessary forcing and control. I will discuss details of a system where the robots are just planar solid objects and the requisite driving forces originate from frictional sliding-interactions with a periodically oscillated and nominally horizontal surface. For the robots to move, the temporal symmetry of the frictional forces must be broken, which is achieved here by modulating the normal force using vertical acceleration of the surface. Independent of the initial conditions and vibration waveform, a sliding locomotor reaches a unique velocity limit cycle at a given position. Its resulting motion can be described in terms of velocity fields which specify the robots cycle-averaged velocity as a function of position. Velocity fields with non-zero spatial divergence can be generated by combining translational and rotational surface motions; this allows the simultaneous and open-loop collection, dispersal, and transport of multiple robots. Fields and field sequences can simultaneously move multiple robots between arbitrary positions and, potentially, along arbitrary trajectories.

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