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Shape-assisted body reorientation enhances trafficability through cluttered terrain CHEN LI, ANDREW PULLIN, DUNCAN HALDANE, RONALD FEARING, ROBERT FULL, University of California, Berkeley — Many birds and fishes have slender, streamlined bodies that reduce fluid dynamic drag and allow fast and efficient locomotion. Similarly, numerous terrestrial animals run through cluttered terrain where 3-D, multi-component obstacles like grass, bushes, trees, walls, doors, and pillars also resist motion, but it is unknown whether their body shape plays a major role. Here, we challenged discoid cockroaches that possess a rounded, thin, nearly ellipsoidal body to run through tall, narrowly spaced, grass-like beams. The animals primarily rolled their body to the side to maneuver through the obstacle gaps. Reduction of body roundness by artificial shells inhibited this side roll maneuver, resulting in a lower traversal probability and a longer traversal time (P <0.001, ANOVA). Inspired by this discovery, we added a cockroach-like, rounded exoskeleton shell to a legged robot of a nearly cuboidal body. The rounded shell enabled the robot to use passive side rolling to maneuver through beams. To explain the mechanism, we developed a simple physics model to construct an energy landscape of the body-terrain interaction, which allowed estimation of body forces and torques exerted by the beams. Our model revealed that, by passive interaction with the terrain, a rounded body (ellipsoid) rolled more easily than an angular body (cuboid) to access energy valleys between energy barriers caused by obstacles. Our study is the first to demonstrate that a terradynamically "streamlined" shape can reduce terrain resistance and enhance trafficability by assisting body reorientation.

Chen Li
University of California, Berkeley

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