Snakes and snake robots traversing large, smooth obstacles

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Snakes can bend their elongate body to stably traverse complex 3-D terrain such as rubble, rocks, and felled trees. Despite this, most previous studies of terrestrial snake locomotion focused on that on flat surfaces using inherently stable planar or near-planar gaits. To begin to understand how snakes traverse large, smooth obstacles lacking anchor points for stability, we studied how the generalist variable kingsnake (*Lampropeltis mexicana*) traverses a large step (Gart, Mitchel, Li, 2019, *J. Exp. Biol.*). The snake's anterior and posterior body sections oscillated laterally to generate propulsion, while the middle section cantilevered to bridge the height difference. As the animal progressed forward, each body segment transitioned from lateral oscillation to cantilevering and then back to lateral oscillation. In addition, this gait was qualitatively preserved as step height and surface friction varied, with minor changes to adapt to terrain variation. Remarkably, the snake maintained perfect stability during traversal even on a challenging low friction, high step. We developed a snake robot as a physical model to further understand stability principles (Fu & Li, 2020, *Roy. Soc. Open Sci.*). Using a similar gait, the robot traversed a step as high as a third of its body length rapidly, but traversal probability diminished as step became higher due to increasing roll instability from oscillating body sections losing ground contact. Adding body compliance improved the robot's ground contact, reduced its roll instability, and increased its traversal probability for high steps, while allowing it to maintain high traversal speed surpassing most previous snake robots.

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