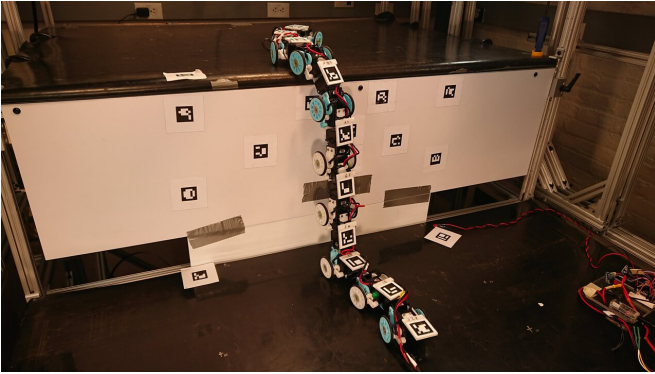


Snakes help engineers design search and rescue robots

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Johns Hopkins University's Terradynamics Lab created this snake robot to mimic its animal counterpart. Credit: JHU/Will Kirk

Snakes live in diverse environments ranging from unbearably hot deserts to lush tropical forests, where they slither up trees, rocks and shrubbery every day. By studying how these serpents move, Johns Hopkins engineers have created a snake robot that can nimbly and stably climb large steps.

The team's new findings, published in *Journal of Experimental Biology* and *Royal Society Open Science*, advance the creation of search and rescue robots that can successfully navigate treacherous terrain.

"We look to these creepy creatures for movement inspiration because they're already so adept at stably scaling obstacles in their day-to-day lives. Hopefully our robot can learn how to bob and weave across surfaces just like snakes," says Chen Li, an assistant professor of mechanical engineering at The Johns Hopkins University and the papers' senior author.

Previous studies had mainly observed snake movements on [flat surfaces](#), but rarely in 3-D terrain except for on trees, says Li, and don't

account for real-life large obstacles such as rubble and debris that search and [rescue robots](#) would have to climb over.

Li's team first studied how the variable kingsnake, a snake that can commonly be found living in both deserts and pine-oak forests, climbed steps in Li's Terradynamics Lab. Li's lab melds the fields of robotics, biology and physics together to study [animal movements](#) for tips and tricks to build more versatile robots.

"These snakes have to regularly travel across boulders and fallen trees; they're the masters of movement and there's much we can learn from them," says Li.

Li and his team ran a series of experiments, changing step height and the steps' surface friction to observe just how the snakes contorted their bodies in response to these barriers.

They found that snakes partitioned their bodies into three sections: their front and rear body wriggled back and forth on the horizontal steps like a wave while their middle body section remained stiff, hovering just so, to bridge the large step. The wriggling portions, they noticed, provided stability to keep the snake from tipping over.

As the snakes got closer and onto the step, the three body sections traveled down each body segment. As more and more of the snake reached the step, its front body section would get longer and its rear section would get shorter while the middle body section remained roughly the same length, suspended vertically above the two steps.

If the steps got taller and more slippery, the snakes would move more slowly and wriggle their front and rear body less to maintain stability.

After analyzing their videos and noting how snakes climbed steps in the lab, Qiyuan Fu, a graduate

student in Li's lab, created a robot to mimic the animals' movements.

At first, the robot snake had difficulty staying stable on large steps and often wobbled and flipped over or got stuck on the steps. To address these issues, the researchers inserted a suspension system (like that in your car) into each body segment so it could compress against the surface when needed. After this, the snake robot was less wobbly, more stable and climbed steps as high as 38% of its body length with a nearly 100% success rate.

Compared to snake robots from other studies, Li's snake robot was speedier and more stable than all but one, and even came close to mimicking the actual [snake](#)'s speed. One downside of the added [body](#) suspension system, however, was the [robot](#) used more electricity.

"The animal is still far more superior, but these results are promising for the field of robots that can travel across large obstacles," adds Li.

Next, the team will test and improve the [snake robot](#) for even more complex 3-D terrain with more unstructured large obstacles.

More information: Robotic modeling of snake traversing large, smooth obstacles reveals stability benefits of body compliance, *Royal Society Open Science*, royalsocietypublishing.org/doi/10.1098/rsos.191192

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