nature news

Published online 9 February 2009 | Nature | doi:10.1038/news.2009.84
Corrected online: 10 February 2009

News

Robot copes with shifting sands

Moving over challenging terrain requires a change of gait.

Philip Ball

Walking over loose sand is hard work, even for robots. But a team of US researchers has shown that an insect-like robot can make quicker progress in sand by using a different gait from that used on hard ground[1].

All the same, the team finds that the top speed of their six-legged 'SandBot' is at best only half that it can achieve on a hard surface. And the researchers say that it will be difficult to make a robot go any faster until more is known about the properties of grainy materials, which are simultaneously solid-like and liquid-like.

The work is "an important first step toward a better understanding of the mechanics behind this type of locomotion", says Al Rizzi, lead scientist of the robotics company Boston Dynamics, who helped to pioneer many-legged robots.

Robots find sand tough going.

Chen Li et al.

Robots that walk can be more stable, manoeuvrable and versatile than those that use wheels or tracks when crossing ground that is uneven, granular or strewn with obstacles. So far, the vehicles used to explore hard-to-access or dangerous environments, such as NASA's Mars rovers Spirit and Opportunity and the US Army's Packbot, have generally been wheeled.

But future generations of robotic explorers are likely to have legs. "The ability to step over small obstacles can make off-road locomotion with legs much more effective and efficient than wheels or tracks," says Rizzi. Already a **scorpion-like robot** is being evaluated at NASA's Ames Research Center in Moffett Field, California, for planetary exploration.

Gently does it

Not much is known about the mechanics of walking across sandy or grainy materials. It clearly poses problems in nature: on sand, the desert-dwelling zebra-tailed lizard (*Callisaurus draconoides*) moves at only three-quarters of the speed it manages over hard rock.

Daniel Goldman of the Georgia Institute of Technology in Atlanta and his co-workers found that their 2.3-kilogram SandBot did even worse, unless it changed its strategy.

The SandBot has six legs, each of which curves into a part-circle and can rotate independently. On hard surfaces the robot, about the size of a human foot, moves by rotating the legs in 'tripods', three at a time: two on one side and one on the other. This gait is inspired by how insects walk and involves a moment of 'double stance', when both tripods are simultaneously in contact with the ground.

Using this gait, the robot has a top speed of about two body lengths (around 60 centimetres) per second on hard ground. But on a bed of particulates — in this case, poppy seeds — it manages just 2 centimetres per second.

The researchers found that the robot could **vastly speed up** by changing its walking motion such that each rotating leg accelerates less sharply as it enters the poppy seed bed. "This allows the limb to come into the material more gently, reducing penetration depth," says Goldman. Then, once the grains beneath the leg have compacted enough to stop it sinking further, the semicircular leg rotates around its centre (which is different from the point of attachment to the axle), so that it slides within the cavity it has dug and pushes the robot forward.

Swim for it

The effectiveness of this strategy depends on both the rotation frequency of the legs — crudely, how many strides the SandBot makes per second — and on how densely packed the grains are. If the packing is very loose, a walking robot struggles for purchase and begins instead to '**swim**' — the legs push forward against the flowing grains, as a swimmer's arms do against water. This makes for slow going — but under these circumstances walking barely works at all.

Walking on sand can also be ineffective if the feet rotate too fast — as the robot ends up just

thrashing around. One of the most striking findings, however, was that in this quick-stepping case there can be a very sudden switch from feeble thrashing to fast walking as the sand gets more densely packed. Changes in the packing fraction — the ratio of grain volume to air volume — of just 1% can make the difference between rapid motion and near-immobility.

That, the researchers say, makes legged locomotion in sand very precarious. But Goldman doesn't see the results as discouraging. "Even with very simple feet, the robot can make good progress once parameters are adjusted appropriately," he says.

"Now that we have a reasonable model for the SandBot locomotion, we can begin to explore other designs for feet, limbs and electronic control," Goldman adds. What's more, the work hints at how animals cope with the problem. "Our model is helping us understand our observations of lizards, crabs and insects running on sand," he says.

CORRECTED: *An earlier version of this article incorrectly stated that on sand the zebra-tailed lizard only moves at a quarter of the speed it manages over rock.*

References

1. Li, C., Umbanhowar, P. B., Komsuoglu, H., Koditschek, D. E. & Goldman, D. I. *Proc. Natl Acad. Sci. USA* Advanced online publication doi:10.1073/pnas.0809095106 (2009).

Comments

Reader comments are usually moderated after posting. If you find something offensive or inappropriate, you can speed this process by clicking 'Report this comment' (or, if that doesn't work for you, email redesign@nature.com). For more controversial topics, we reserve the right to moderate before comments are published.

Add your own comment

You can be as critical or controversial as you like, but please don't get personal or offensive, and do keep it brief. Remember this is for feedback and discussion - not for publishing papers, press releases or advertisements, for example. If you ramble on in an annoying way too often, we may remove your posting privileges.

You need to be registered with Nature to leave a comment. Please log in or register as a new user. You will be re-directed back to this page.

Log in / register

Nature ISSN 0028-0836 EISSN 1476-4687