Building better high-speed robots with the help of cockroaches

December 4 2013

Love them or hate them, cockroaches are notoriously good escape artists and can flee at astonishing speeds. However, this speed can make it difficult to sense the world around them: 'When animals move slowly they rely mostly on their nervous system for accomplishing tasks, but as the animals are pushed to more extreme performances they face potential constraints in their nervous system, for example sensory conduction delays', explains Jean-Michel Mongeau, a researcher from the University of California, Berkeley, USA. Mongeau goes on to suggest that in the face of these problems, using a system reliant on mechanical changes that can occur rapidly, rather than relying solely on the nervous system, might be advantageous during high-speed manoeuvres. With the help of his advisor, Robert Full, Mongeau decided to investigate potential mechanical systems and has published his findings in *The Journal of Experimental Biology*.

Mongeau began by placing blind cockroaches into an arena under the watchful lens of two high-speed cameras. With a gentle prod, the cockroaches were then sent scurrying along a wall with a 30–60 deg bend mid-way. On a smooth acrylic wall the cockroaches' antennas often projected straight out in front of them as they tracked the wall, but this changed on a wooden wall: 'When the wall becomes rougher, which you could think of as more ecologically relevant for this animal, the antenna would bend backwards almost all of the time, in a sort of inverted J-shape', recalls Mongeau. But how does this benefit the cockroaches in their high-speed dashes? Measuring the body-to-wall distance, Mongeau found that bending the tip of the antenna caused the cockroaches to orientate themselves further away from the wall, preventing them from crashing into it, unlike their friends with straight antennas.

'After these findings, we became interested in understanding the mechanism behind the antenna changing shape', says Mongeau. 'We hypothesised that very tiny tactile hairs on the antenna would potentially be able to engage with, and stick to, [a rough] surface, and when that is coupled with forward motion this would be sufficient to make the antenna flip.' To test this, the team decided to remove these little hairs; however, it turned out that giving the antennae a haircut was more difficult than they first thought: 'The first thing I tried to do was use tiny forceps to pluck the hairs out, but that turned out to be impossible because these hairs are very robust and they're embedded within the exoskeleton.' But eventually Mongeau's perseverance paid off: 'After going through several rounds of trial and error, or mostly error, I decided to try a laser system that burns these little hairs at the tip.' And sure enough, without their hairs the antennae rarely bent backwards, even as they were dragged along a wall.

As the ultimate aim of Mongeau's study was to help design better robots, as currently most robots also have difficulties processing information at high speeds, he turned to an artificial antenna created by their collaborator Alican Demir, in Noah Cowan's lab at Johns Hopkins University, USA. By mimicking the cockroach's hairs, the team could get the robotic antenna to bend in a similar manner. However, it turns out that if you even slightly change the orientation of the hairs, so they are facing opposite directions on either side of the antenna, it can cause the antenna to fully curl over to form an inverted C, meaning that the antenna is no longer projecting in front of the robot, which isn't much use. So it seems that cockroaches have already worked out a good design for an antenna, and studies such as Mongeau's might help us make better high-speed robots.

More information: jeb.biologists.org/content/216/24/4530.abstract

Provided by The Company of Biologists