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Surveys
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MONITOR

A bug's life for robots

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Creepie-crawlie robots are learning to venture where wheeled machines stumble and humans fear to tread

Roachmobile on the march

THE invention of the wheel was revolutionary, greatly enhancing mankind's mobility. But wheeled vehicles have their limitations. Certain landscapes and activities—eg, climbing a tree, or walking on rocks—do not lend themselves to being explored by means of a rolling machine. Here, animals such as geckos, snakes, cockroaches and crabs have a distinct advantage. For example, roaches can move 50 times their length in a second. On a human scale, that translates into 300kph (200mph). Thanks to advances in engineering and prototyping, a new generation of biologically inspired robots is beginning to crawl all over the place. Cockroaches are the inspiration for some of the most ambitious.

At the forefront of this interdisciplinary field is Robert Full, professor of integrative biology at the University of California, Berkeley. Dr Full cheerfully admits that some of his real-life critters can be disgusting, but they offer valuable insights into how to conquer challenging terrain. In his Poly-PEDAL Laboratory at Berkeley, Dr Full conducts locomotion studies by putting living specimens on treadmills and recording their movements with high-speed cameras. His research has led to designs for a number of robots, including a wall-climbing creature called Mecho-Gecko and a six-legged robot called RHex that scurries on land like a cockroach and will soon swim under water like a crab. One day, Dr Full and his cohorts believe that such machines will go where humans fear to tread—on toxic-waste sites, into the battlefield and even on planets. No surprise that the Defence Advanced Research Projects Agency, NASA and the Office of Naval Research sponsor much of the research.

According to Martin Buehler of the Centre for Intelligent Machines at McGill University in Montreal, the usefulness of wheeled robots has reached its peak. Research into many-legged robots, however, is still in its infancy, and the potential pay-off from them could be huge. The main focus is on creatures with four or more legs. There is a big advantage here: multiple limbs make a robot more stable and reliable. Also, the leg design can be a lot simpler, explains Dr Buehler, who has been working on machines such as RHex for years. Two-legged robots, by comparison, are more difficult to design—not surprising when you consider that early tetrapods preceded the first bipeds by some 80m years.

Likewise, it has taken engineers years to start duplicating the principles of animal locomotion, as well as emulating the complexity of some of the materials found in nature. These days, parts are first modelled on a computer, then produced by a rapid prototyping process. This allows electronic parts needed for actuation to be encased in polymer shells, and whole limbs to be built out of materials with stiffnesses ranging from soft to hard, similar to muscle and bone.

With insights from Dr Full's cockroaches, a Stanford team has gone from a creature called “Sprawl”, which could barely walk, to a more mobile “Minisprawl”, advancing to a quite agile “Sprawlita”, and now to batches of “Sprawlettes”—all within four years. As the names suggest, the robots feature slightly angled, springy legs. Although the current version is none too smart, its simple, flexible design successfully mimics a cockroach's mobility. Half the size of a shoebox, it can scamper at a rate of five times its own body-length per second. The focus is now on enhancing locomotion by adding more sensors, such as antennae, to help the robots to manoeuvre around obstacles or to follow walls.

So far, only wheeled robots have been used in disaster areas, such as the World Trade Centre in New York. That could change within a few years. Researchers at Carnegie Mellon's Robotics Institute are working on an artificial serpent, originally conceived at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California. With five joints, each with two degrees of freedom, the snake-like prototype would be able to thread through fragile, collapsed structures—as if it were performing minimally invasive orthoscopic surgery. Meanwhile, JPL has moved on to develop tiny worm robots, hopping robofrogs and spider-bots—with the aim of using them on other planets in place of wheeled robots that could get stuck.

The spider-bot, one of JPL's most recent creations, features only six legs, although in other respects it bears a striking resemblance to the natural eight-legged arachnid—and even fits in the palm of a hand. The idea is to make small, cheap and low-powered robots that can communicate wirelessly while manoeuvring through rugged terrain. Hundreds of spider-bots could then be dumped in one place and left to co-ordinate the exploration of a given area. If individual spider-bots got lost or stuck, the rest could still complete the survey between them. One spider-bot has already conquered MarsYard, JPL's simulated Martian landscape. JPL is now working on the next generation, experimenting with different types and numbers of legs. Now, that is something nature does not do in a hurry.

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Professor Robert Full's Poly-PEDAL Laboratory at Berkeley details some of its creepy projects. Stanford details its “Sprawl” robotic family. See also McGill's Centre for Intelligent Machines and Carnegie Mellon's Robotics Institute.