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Building a better robot

Daniel McCabe | Visit Martin Buehler's lab and you'll meet all sorts of characters.

Scout II hops past student engineers Don Campbell and Martin de Lasa and mechanical engineering professor Martin Buehler
PHOTO: Owen Egan

There's Scout II, who'll bounce your way with the kind of enthusiasm dog-owners prize in their mutts. Or the insect-like RHex, whose whirring, whipping legs seem to send out the message: "Don't get in my way."

When you watch them in action, you could swear that Scout II and RHex have distinct personalities, but they don't. They're marvels of metal, motors and wiring, the latest creations of Buehler and his collaborators at McGill's Ambulatory Robotics Lab. The lab is drawing a lot of attention these days in the world of robotics as the race to build a resilent, affordable walking robot heats up.

"There has been 30 years of intense research in the field and it hasn't produced much that has real-world applications," says Buehler. Oh sure, there have been some noteworthy creations ? everybody has seen footage of the Sony robot dogs, for instance.

But such robots cost a bundle ? $4,000 each. They exist as toys for the rich and not much else. "Even for commercial applications, the few systems that are successful are so expensive almost no one would buy them," comments Buehler.

Buehler's goal is to create high-performing walking robots that are reasonably priced. His robots are capable of fairly complex activities, but their operating systems require few motors and the materials required for building the machines can, for the most part, be bought off the shelves of a well-stocked hardware store.

So far, legged robots have been eclipsed in the real world by robots that move about on the sorts of

articulated treads you see on tanks. Such robots are used for a variety of purposes ? everything from delivering office mail to inspecting possible bombs.

Buehler admits these machines have come a long way. "They're pretty good at handling rough terrain." But he is adamant that a walking robot, if properly built, would fare better ? it could handle a staircase far more easily, for instance.

"As a field, we need to get our robots into [real-world] applications," says Buehler of legged robot experts. "To do that, our robots have to be much more reliable, and much simpler to build."

Buehler became intensely interested in legged locomotion while doing a post-doc with Marc Raibert, a pioneer of legged robots at MIT, shortly before joining McGill in the early '90s. His first project at the University was the creation of one-legged hopping robots ? ARL Monopods I and II. "I was focusing on fundamental control issues," says Buehler. His research pattern was established. Simple control systems, high performance and cost effectiveness became hallmarks of his team's approach to building mobile robots.

Buehler secured funding from the Natural Sciences and Engineering Research Council to take his work a step further with the Scout robots.

Scouts I and II operate on four legs each. Buehler says one of the keys to creating multi-legged robots is to ensure that the legs "work in harmony. Each pair of legs is thought of as a virtual leg."

Buehler's goal with Scout was simply to "advance the state of the craft." What he and his team accomplished was to prove that inexpensive robots can produce, in Buehler's words, "eye-popping performance."

Scout II is designed to handle a standard-sized staircase and carry a payload. It can perform a 90-degree turn in a few steps. Simulations indicate that Scout II can attain a speed of 5.4 km/h on flat ground. Considering that the robot was built with standard components and features only four motors, Scout II's performance has been impressive. And Buehler believes Scout II can be improved upon.

Buehler's principal goal with the Scout robots was to figure out how to design a fairly simple control system for a fairly sophisticated robot. While other robotics experts built machines with far more complicated legs ? believing this was the key to performance ? Buehler's focus was on the control system that underpinned everything the robot did.

As Buehler and his team went about perfecting Scout,

a new challenge emerged.

Attending a conference with University of Michigan robotics expert Dan Koditschek ? Buehler's PhD supervisor ? the two discussed the work of University of California, Berkeley, biologist Robert Full, an authority on how legged insects and animals get around.

In particular, Full's research on cockroach mobility captured their imagination. Full hailed the bugs for their ability to plow through all sorts of rough terrain. Full's video of a roach in action, shown at the conference, sparked Buehler's thinking for his next robot.

In terms of stabilizing mobility, the roaches' secret is their sprawled posture. "The centre of gravity is very low," notes Buehler. A cockroach can contend with uneven surfaces because its centre of mass is always distributed over three of its six legs ? it rarely topples off balance.

"That very night, I wrote the simple simulation of a robot that was the precursor to RHex," says Buehler.

RHex has been a joint McGill/University of Michigan project involving Buehler and Koditschek's teams, and Full has been enlisted as an advisor for his insights into biomechanics. Buehler indicates that RHex isn't the first robot to look to the world of nature for a model. "The mistake that's made sometimes is to model [the robot] too closely on an organism." In their own way, animals and insects are too sophisticated to duplicate with mechanical means.

RHex is a robot that looks to nature for some guidance, but relies on mechanically feasible methods to get the job done.

RHex can handle most obstacles by rotating its six legs in a full circle ? the legs are mounted on hip joints that rotate a full 360 degrees. It moves at half a meter a second and should soon be able to jump over a ditch as wide as its body length.

RHex quickly earned the funding support of an impressed Defense Advanced Research Projects Agency (DARPA), a branch of the US military. "It's the fastest-running legged platform I know of," DARPA's Alan Rudolph recently told Science. And, true to Buehler's philosophy, RHex's design emphasizes inexpensive elements.

RHex recently proved itself at DARPA's own testing grounds ? handling a variety of rough terrains. The robot accompanies Buehler and his students on weekly off-trail hikes in and around Montreal.

So when will Buehler's robots pass his own litmus test

and venture out into the real world?

He has already been in touch with toy manufacturers. Buehler believes legged robots won't be the stuff of science fiction for much longer.

He envisions legged robots venturing into buildings as police agents, to scout around for armed suspects. Or acting as companions for the elderly, reminding them to take their medications. Or gently sauntering into delicate old-growth forests where tracked vehicles would do too much damage.

"At theme parks, animatronics are already very big. The logical next step would be freely roaming little robots, interacting with people, selling ice cream. A robot small enough that it could bump into a kid without hurting him and tough enough that it could bang into a big guy and still keep running."

So don't be surprised one day if, while you're at a theme park, Scout or RHex walks up to you to ask if you would like some cotton candy while you wait for your turn on the rollercoaster.

To see RHex in action, visit ai.eecs.umich.edu/RHex/RHex0movies.html or visit the

Ambulatory Robotics Lab
Buehler and some of his collaborators will be presenting a paper on RHex and the Scout robots at the International Symposium on Adaptive Motion of Animals and Machines in Montreal next month.

Next: Probing professionals? paycheques

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