DISCOVER

On Newsstands Now
The Top 100 Science Stories of 2006
A special report on the m...
More Features

Special Offer! SUBSCRIBE NOW!
go

HOME / MIND & BRAIN / MEDICINE / SPACE / TECHNOLOGY / ANCIENT LIFE / ENVIRONMENT / CURRENT ISSUE / ARCHIVES / MY DISCOVER

powered by Google

Members/Subscribers Log In

Photo of the day

inside THE CURRENT ISSUE

The Top 13 Medicine Stories of 2006
The Top 13 Space Stories of 2006
The Top 12 Biology Stories of 2006
More Features

online EXCLUSIVES

DiscoBlog: Don't Focus on Porn
Horganism: Explaining Extreme Altruism
Blinded by Science: The Real Reason We Can't Find bin Laden
The Top 3 Science Policy Stories of 2006
The Discover Interview: Marvin Minsky

top 5 ARTICLES

The Top 12 Biology Stories of 2006
Can Coal Come Clean?
20 Things You Didn't Know About... Aliens
The Top 13 Space Stories of 2006
The Top 6 Mind & Brain Stories of 2006

newsletter OFFERS

Mind & Brain
Medicine
Space
Technology
Ancient Life

Discover Magazine → Issues → sep-00 → features → Biobots

Biobots

Can man mimic organic life-forms with machinery? Take a look . . .

By Peter Menzel and Faith D'Aluisio

DISCOVER Vol. 21 No. 09 | September 2000

Officially, Mark Tilden is a robotics physicist at Los Alamos National Laboratory in New Mexico, but he is principally interested in what he calls biomorphic robots. They are made from transistors, motors, sensors, and anything else he cares to throw in, with many parts salvaged from cast-off cameras and video-cassette recorders. He endows his machines with what he calls "nervous networks," which function much like the neurons in animal nervous systems.

Unlike conventional robots, which are usually based on digital technology, Tilden's nervous-network machines are based on analog technology using continuously changing waves, rather than ones and zeroes. Instead of writing elaborate programs to make his robots walk, he designs circuits that automatically seek a desired state. Motion is usually the result.

When his robots encounter obstacles, they frantically try to get back on track, sending out a blizzard of almost random impulses until they manage to scramble past the obstruction. The results are startling: Tilden's devices can skitter over almost any terrain.

Given the contrast between the fluid motions of his inexpensive machines and the stiff, clumsy behavior of many more-costly robots, it is little wonder that the bombastic Tilden enjoys the role of vocal skeptic about the digital world and professes enjoyment of the drubbing he sometimes gets. "I don't use computers except to comb the nits out of my beard," he says.

That's an exaggeration. Tilden returns e-mail with unnerving speed. At the same time, he's serious about advocating analog. "As soon as a device has to interact with complex worlds— like a forest, or a field, or a human— then digital hits the complexity barrier, where a small behavioral improvement can cost thousands of man-hours. We're already seeing this with computers, and they just have to sit on a desk. If laptops did have to move and work in the real world, the complexity required would continually demand precise, predictive updates. This just isn't easy to do in the language of digital logic. They're too fragile to take risks as living things do.

"Even worse, it may not be necessary. Nature uses analog answers, but we can't build those. I believe there's another way, ideal for robots themselves. That's why I'm exploring analog devices to see if there might be other solutions to making a machine think it's alive."

Tilden is always wary of what he calls "Wizard of Oz" demonstrations: " 'Pay no attention to that graduate student behind the curtainÑI am the great and powerful roboticist of Oz.' If you see a machine with a whacking great big cable or antenna coming off it going to a supercomputer run by various grad students, then you are looking at a Wizard of Oz demonstration. If it repeats a behavior pattern, then you've got a puppeteer on tape. There are over 10,000 special-effects masters on the planet right now. But if you count the number of people who are really researching robots, who are trying to go beyond fiction, the total is small compared to the people who are making Jim Henson machines that run [using] human control."

And that is partly because people don't accept robots easily. "We built de-mining robots, grass cutters. We built everything," Tilden says. "Self-contained, solar-powered, automatic devices that don't require any programming and in many cases don't even require batteries. You just have to put them in the dishwasher every now and then. But they didn't sell! They crawled off the shelves when we tried to market them, no pun intended. The fact is, people have media-enforced expectations of robots. They demand robot characters.

"Take a look at all the major artificial characters that you think you know. You'll find out that they're all human characterizations: Robby the Robot fr*om Forbidden Planet, Commander Data [from* Star Trek, the Next Generation]. The fact is, people want a character that essentially is a metal embodiment of a human personality. You have to start building things that fall in with people's expectations— that a robot is a faultless Commander Data, wearing an apron, who pushes a broom and fetches you a beer. It is not some sort of machine that roams around the hall or cleans under your couch, even if that's what the robots are best at.

"In 1982 I tried to build a digital home robot butler and found that it looks really nice on *The Jetsons,* but it's the last thing you want in your environment. Why? How can you program a robot not to eat the book that you were reading last night? Or to leave your loose laundry alone?

"The funniest thing was when I walked into the kitchen and there's my robot sucking up the cat kibble, and the cat is looking at me as if to say, 'Get this thing out of my face!' What was awful was finding out that even in a single bachelor apartment I could not come up with all of the sub-routines necessary to make this thing useful. Also, I kept tripping over the damn thing.

"Trip over your dog or cat in the night and they're soft, they'll heal. You trip over your robot, you swear like a trooper, and you're in for a $5,000 repair the next day. Imagine if your laptop decided to walk around your house. My conclusion is that having a robot to make your bed would be like getting a Sherman tank to mow your lawn."

Road RHex

With its decal eyes, fake plastic antennae, and mouse-pad feet, RHex 0 isn't much to look at. But the conceptual underpinnings of this six-legged robot are a potential blockbuster for robotics.In 1998, Martin Buehler, a McGill University roboticist, was captivated by biologist Robert J. Full's video of cockroaches navigating a bumpy surface. In ultra-slow-motion, Full revealed that the creatures were constantly stumbling and bumping into obstructions. Nonetheless, they continued to run swiftly, suffering little loss in performance.With Full's encouragement, Buehler decided to borrow the principles of cockroach design to create a walking robot. According to his longtime mentor, Dan Koditschek of the University of Michigan, Buehler roughed out the design by sticking "paper clips into an eraser— a conceptual eraser— and said, 'We can build this.'" RHex the roach-bot is now a full-blown collaboration among Buehler, Koditschek, Full, and Michigan graduate student Ulu? Saranli.Buehler cautions that RHex is just an early prototype. But even in its crude, unfinished state, the squat-bodied, autonomous machine is wicked fast. Set in motion, RHex moves so quickly that its legs are hard to see, much like the cockroach's legs in Full's video.What's next for RHex? Maybe a RHex 1 that hops and runs and does more eye-popping demos. Buehler says: "RHex 2 will have articulated legs, with just the knee, to be able to get better mobility. Right now the mobility is somewhat limited— it can't go under cars, because it has to rotate its legs around. After that, RHex 3 would have even more actuation per leg — with a hip and a knee— so it would look more like a cockroach."

Claw and Order

Joseph Ayers, head of Northeastern University's Marine Research Laboratory, has been researching lobster locomotion for more than 20 years. Based on Ayers's studies, staff researcher Jan Witting is building a robotic lobster that will capture the behavior of a real lobster. Unlike many biomimetics researchers, Ayers is trying to come close to duplicating the principles of a living creature mechanically. On the other hand, the project has enough potential that it is funded by the Defense Advance Research Projects Agency. Although its eight legs are in place and working, the battery-operated machine shown below lacks the tail and claws that will stabilize it underwater. Real lobsters are buoyant and almost float along the ocean floor, with their claws and tail extended in a triangular shape that maximizes their stability. Ayers has since added stabilizers at the front and rear. Some biologists who work with roboticists want to reproduce accurately every part of an animal, but Ayers says: "To me, the big picture is the major organizational or governing rules by which you operate the thing. Others are very focused on their robot behaving exactly the same way as the animal. I want to say which details are important and focus on the governing principles."What's important in the lobsters, he says, is "their ability to go and find something on the bottom of the ocean. If they want to go out and find trap bait, they can get through anything. It's that kind of performance capability we want to capture. And energetically, they are very efficient."Ultimately, he says, "the goal is to build robots that are autonomous. That's the Holy Grail as far as I'm concerned— autonomy."

Crab Dip

Sidling along the edge of a reservoir outside Boston, Ariel the crab-robot moves with a slow, steady sideways gait. It is designed to scuttle from the shore through the surf to search for mines on the ocean floor. Ariel was funded by the Defense Advanced Research Projects Agency and built by iRobot, a company founded by Massachusetts

Institute of Technology robot guru Rodney Brooks. Inspired by research on crabs at Robert Full's lab at Berkeley, Ariel takes advantage of the animal's stability— and improves on it. Unlike real crabs, which must struggle to right themselves if a wave flips them on their backs, the robot simply reorients itself and keeps walking with its body upside down. Housed in a waterproof cavity, Ariel's electronics feature self-adaptable software— if one of the six legs fails, the programming realizes it and adjusts to a five-legged gait. Fleets of these bottom crawlers communicating with one another could thoroughly sweep an area.The machine has a compass and a tilt-and-roll sensor sticking out at each end, far away from interference caused by the magnets in Ariel's motors. "For dealing with real-world situations, coming up from the hardware and sensors is very much how animals do it," says Ed Williams, the technician in charge of Ariel. "By having a very small controller and really bringing [in] that mindset, we can do things that are fairly successful and fairly tight, in cheap packages."Williams supervises Ariel's excursions with great anxiety— the machine still gets stuck when it encounters big rocks. "Robots can't do much now," he says, "but airplanes couldn't do much in 1910."

See gecko-inspired robots in action

Web Resources:

At the *Robo sapiens* Web site, you can learn more about Peter Menzel and Faith D'Aluisio's upcoming book: robosapiens.mit.edu.
For more information about the robots (and their creators) featured in this book excerpt, consult the following Web sites:
For more of Mark Tilden's robots and information about how to start making robots like his, see www.beam-online.com.
RHex: See ai.eecs.umich.edu/RHex.
"Design, Modeling and Preliminary Control of a Compliant Hexapod Robot," Ulu? Saranli, Martin Buehler, and Daniel E. Koditschek, Proceedings of the 2000 International Conference on Robotics and Automation; see www.ieee.org for proceedings.Ariel: www.isr.com/research/ ariel.html.
Lobster robot: www.dac.neu.edu/msc/ burp.html.
Robo-Geckos: For more about the actual reptiles, see www.lclark.edu/~autumn/private/u38j47a0t, which features images of gecko foot hairs and other details. For more research on different gecko characteristics, see www.lclark.edu/~autumn/ dept/index.html and polypedal.berkeley.edu. For information about the geckos' robot counterparts, see polypedal.berkeley.edu/Bioinspire/ Robotics.html and www.isr.com/ research/gecko.html.
"Biologists and Engineers Create a New Generation of Robots That Imitate Life," Gary Taubes, *Science,* April 7, 2000; www.sciencemag.org.