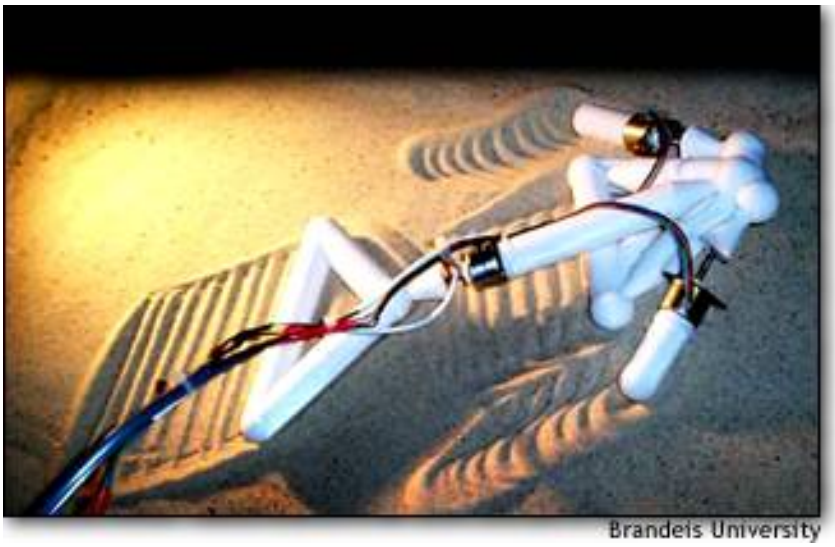
A revolution in robotic evolution



A computer-designed and automatically built "arrow" robot crawls through the sand. Its symmetric shape arose after hundreds of generations' worth of simulated evolution.

Watch a simulated "arrow" robot crawl through cyberspace - and then morph into the real thing crawling on a carpet.

By Alan Boyle
MSNBC

Aug. 30 — In what's being hailed as a first step to bridge the gap between the cyber-world and the real world, researchers programmed a computer to sift through hundreds of generations' worth of virtual progeny — then actually construct the contraptions that proved best able to crawl. What's more, they're offering a screensaver program that allows you to do it, too.

COMPLETE STORY

MSNBC
Alan Boyle
SCIENCE EDITOR

THE EXPERIMENT represents an advance in the field known as “artificial life” — the study of whether machines, working with a minimal set of components, can figure out how to build better and better machines.

“We have demonstrated for the first time a robotic bootstrap, where automatically designed electromechanical systems have been manufactured robotically,” Hod Lipson and Jordan Pollack of Brandeis University reported.

As described in Thursday’s issue of the journal Nature, Lipson and Pollack programmed a computer to put a population of simple robots through an evolutionary process: The computer tested each “generation” to see which primitive robots could crawl the farthest, then made refinements in the design.

In the course of 300 to 600 generations, some of the robot species went extinct, while others converged toward optimal (if sometimes weird) designs. When the selection was winnowed down to a handful of the fittest survivors, the computer carved them from a block of plastic, using a 3-D printer.

This tetrahedron robot performed in reality almost exactly as predicted during the computer simulation that produced it. The robot moves by "ratcheting" itself across the floor. Click on the image for details from Brandeis.

The 3-D printer, also known as a plotter or milling machine, could create the complete robot, joints and all, within its 8-by-8-by-12-inch parameters. All the humans had to do was snap in the motors and hook the robots up to their electronic “brain,” which evolved along with the physical parts in the simulation.

Of course, humans set the rules of the game at every stage. “We constrained the universe that can be simulated,” Pollack said.

Nevertheless, Pollack said his biggest surprise was finding out that the contraptions actually worked. “By October, the first

robot was fabricated, and it worked right away," he said.

"The other surprising thing was that the robots discovered symmetry," he said. There was no rule in the program that the robots had to have the mirror-image look found in most living things, but the simulation program discovered for itself that balanced designs tended to crawl more efficiently.

This ratcheting robot may look ungainly, but it really, really works. Like the other robots, it was designed and built by a computer with minimal human intervention. Click on the image for details from Brandeis University.

"The 'breast stroke on the ground' motion was done without any human intervention at all," Pollack said.

Pollack said another key point was that the robots' hardware and artificial-neuron software evolved together: "What you have in a real animal is a sequence of iterations where the body and the brain have small changes that can't survive without the other, and we've captured that in a simulation."

He said more progress has been made since the submission of the research paper, which describes the first six months of work on a five-year effort partially supported by the Pentagon's Defense Advanced Research Projects Agency.

REAL ARTIFICIAL LIFE

Even though it's just the beginning, the work at Brandeis has gotten glowing reviews. The experiment represented "a first step toward bridging the gap between computer models and physical reality," Rodney Brooks of the Artificial Intelligence Lab at the Massachusetts Institute of Technology wrote in a commentary also published by Nature. Most other efforts in the field of artificial life have focused on computer simulations rather than the evolution of real-life robots.

Even in the Brandeis experiment, there was no feedback from the real world to the virtual evolutionary process. "At best, this system is like a virus that uses other more complex machines (which in this case are not life forms themselves) to carry out reproduction," Brooks said.

Pollack said closing the feedback loop would be one of the natural next steps.

Self-replicating robots would be a boon to the exploration and exploitation of extreme environments. As far back as the 1960s, NASA investigated the

Robots in space

In a four-part series, Space.com and MSNBC focus on the role of robots in space exploration:

possibility of seeding the moon with a self-reproducing factory, Brooks noted, and similar schemes involving robot factories have been proposed for Mars missions.

Another study in this week's Nature looked at how efficiently swarms of small mechanical "antbots" could locate simulated food items and bring them back to a central nest.

"Groups of robots using ant-inspired algorithms of decentralized control techniques foraged more efficiently and maintained higher levels of group activity than single robots," the University of Lausanne researchers reported. "But the benefits of group living decreased in larger groups, most probably because of interference during foraging."

The bottom line was that "group dynamics of swarms of robots may follow rules similar to those governing social insects," said the study's authors, Michael Krieger, Jean-Bernard Billeter and Laurent Keller.

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ROBOTS RUN AMOK?

All this may sound like the setting for a science-fiction plot — the kind in which self-replicating robots eventually run amok — and Lipson and Pollack are already working hard to downplay those kinds of descriptions of their work.

"It's not the dreaded 'robots making themselves,'" he told MSNBC.com.

At another point during the interview, he said, "The robots that we're building now are really like bacteria. We're trying to get to insects in a couple of years. It's not like a humanoid is going to walk out of our fabrication plant."

The name of the simulation program itself — Genetically Organized Lifelike Electro Mechanics, or GOLEM for short — provides some perspective, Pollack said. In Jewish legends, a golem is an image or form that is given life through a magical formula. In the legends, the creator usually loses control of the creation.

"Golems are sort of a warning about hubris, about taking God's power into your own hands, and we pay a little bit of attention to that," Pollack said.

Fun with robots

MSNBC Interactive

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- Click on Kismet's robotic range of emotions
- From Brandeis University: Download Golem@Home
- Watch a robot walk on two legs

With that cautionary note, Lipson and Pollack are making a screensaver version of the simulation program, dubbed Golem@Home, available via their Web site. A standalone version of the simulator, called LiveTruss, is also available. Both programs simulate the evolution of the kinds of robots involved in the Brandeis experiment, and the screensaver has the added twist that robot prototypes can be traded back and forth over the Internet.

To create a Golem robot from the simulation, you'll need access to a 3-D printer — and don't expect a magical formula that works instantly. It took up to 22 hours for the computer to carve out the crawlers described in the Nature paper.

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