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System Creates 'Robotic Life'--Automatically

By Curt Suplee
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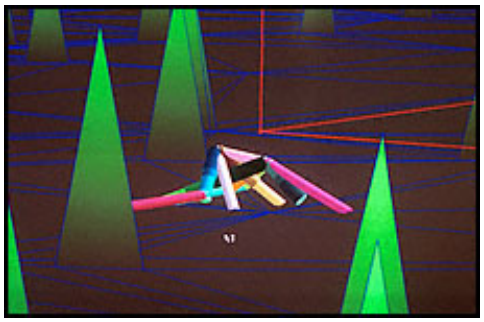
Scientists in the burgeoning field of artificial life have reached a major milestone, creating a computerized system that automatically creates, evolves, improves and finally builds a variety of simple mobile creatures without any significant human intervention.



A virtual robot called "Complex 1" is displayed Tuesday by a computer program at Brandeis University's Dynamical and Evolutionary Machine Organization lab. (Julia Malakie - AP)

The "robotic life forms" that sprang into being at Brandeis University are a few inches long, comprise a dozen or two-dozen plastic parts and have rudimentary nervous systems made of wire. They do only one trick--crudely shoving themselves, inchworm-like, along a horizontal surface using miniature motors.

-----Brandeis University-----
• The Golem Project

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By the standards of even the cheapest automated toys, that may not seem like much. But the creatures described in today's issue of the journal Nature were not constructed, planned, designed or even imagined by people. Every step--except for a couple of trivial hardware connections--was done by computer. Their advent, Brandeis researchers Jordan B. Pollack and Hod Lipson say, marks "the first time robots have been robotically designed and robotically fabricated."

In effect, their existence tests the ability of man-made systems to mimic one of the most fundamental processes in nature: evolution through classic Darwinian, survival-of-the-fittest selection.

The researchers wrote a computer program that would do three things. First, it would produce a variety of body plans entirely from scratch, just as the physical configurations of real plants and animals did over hundreds of millions of years.

Second, it would evaluate those plans and decide which was most capable of actually moving in the real world. Finally, it would order a plastic fabricating machine to make a physical example of each of the best designs.

Among the "fittest" specimens--that is, those that could move the farthest in a given space of time--were a pyramidal creature they called the tetra, as well as the "arrow," the "snake" and the "crab." The entire process took a matter of hours.

At the outset, the designs evolved as "virtual" objects inside a software program. In that state, they were no more or less physically real than a cartoon on a computer screen. Much as life on Earth presumably started with little more than a warm puddle and some organic chemicals, the Brandeis evolution program started as a blank slate. The only instructions were to start building virtual creatures by adding

a bar, a wire, a motor or a ball-and-socket joint--all chosen completely at random.

This system resembles the natural process of evolution, in which mutations arise spontaneously for no predetermined reason and cause changes in various parts of a plant or animal. Most are useless; but some make the organism better adapted. Similarly, most of the Brandeis creatures were immobile or inept. But a few were capable of motion.

Each "generation" of creatures gained one more mutation. After as many as 600 generations, the software then evaluated the scores of wildly dissimilar body designs that had evolved. It chose the best designs by employing the laws of physics and the rules governing mass, momentum, lever action, friction and the like.

At last, the program transferred the most successful body plans electronically to an automated machine that makes objects by building them up from very thin coats of plastic.

The only thing Pollack and Lipson did by hand was attach the actuators where the program specified and transfer the computer-evolved "nervous system" into a small electronic module.

Within a few minutes of taking shape, the creatures began to creep across a tabletop.

The achievement, according to Rodney Brooks, head of MIT's Artificial Intelligence Lab, is "a long-awaited and necessary step toward the ultimate dream of self-evolving machines."

In natural evolution, organisms succeed over time if they are best adapted to their environment, and thus more able to feed and reproduce than their competitors. The Brandeis crawlers evolved in a software environment that rewarded only one fitness trait--the ability to move along a flat plane. But changing the definition of fitness could easily produce entirely different sorts of creatures.

And that, the researchers believe, may open a new sector of the world economy. "We see the possibility of an industry, within five or 10 years, that would produce computer-aided design and manufacturing of mechanisms for very specific purposes," Pollack said.

Just as the beak of a finch develops a particular shape over time to match the kind of food it finds in its surroundings, customized gizmos could be "evolved" to behave optimally in very specific locations. "For example, we could go in with a laser range finder and measure all the dimensions of your home," Pollack said. "Then the system creates a robot specifically to vacuum your den or clean the snow off your particular house."

As a working concept, virtual evolution is about 25 years old, dating from landmark work by John H. Holland of the University of Michigan. Among other insights, it involves the recognition that nature does not devise specific solutions to individual problems--for example, how to live best on the bottom of the Chesapeake Bay--and yet arrives at particular species of oysters or crabs so exquisitely suited to their surroundings that it almost seems as if they were designed for the job. Of course, they are not. Instead, over time, mutations provide a plethora of different alternative organisms and natural selection winnows out the fittest.

Perhaps, researchers theorized, those same superb capabilities could be modeled in computer software. So instead of straining to determine the perfect solution to a tough problem such as the most efficient airline routes among 15 different cities, a programmer would design software that generated "mutations" producing thousands of slightly different flight patterns. Then another part of the program would evaluate each of them and select those that took the least time and fuel to

reach all 15 cities.

In 1994, artificial life pioneer Karl Sims, now of GenArts Inc., applied artificial evolution to the generation of virtual creatures in which both "brains" and "bodies" evolved together. These entities, however, could "live" only in a computer.

Pollack, Lipson and others from Brandeis in Waltham, Mass., extended the idea to creatures that could be built automatically and function in the real world.

Eventually, the scientists will increase the complexity of their creatures to handle uneven terrain and other real-world complications. There is no danger, Pollack said, that the process can get out of hand, creating autonomous rogue robots. "This isn't some out-of-control 'Terminator,' " he said.

Sooner or later, the researchers write in Nature, "to realize artificial life, full autonomy must be attained. . . . Only then can we expect synthetic creatures to sustain their own evolution."