Termites Inspire Paper Pusher

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Scientists at the world's leading research establishments are tapping millions of years of evolutionary dynamics to help them build the next generation of electronics, components and materials.

By copying the way termites make independent decisions to achieve a common goal such as building a nest, Palo Alto Research Center scientists are building a device with thousands of air jets that can act independently to move paper through a copier or printer.

Termites are not very complex creatures, but if a stick needs to be moved, they get the job done. They perform tasks based on just a few simple rules, but work together to solve the problem. In effect, they create a distributed computer. PARC wants to do the same by rewriting those simple rules into a few lines of code and distributing them among a bunch of digital devices.

Such biologically inspired science is all the rage among the research community. Biomimetics takes ideas from nature and implements them in other areas. PARC, IBM Research, Bell Labs and many others are using biomimetic techniques to create the next generation of software, bioengineered devices and materials.

For example, IBM Research in Zurich is lithographically printing proteins onto plastics to create biochips that can recognize or bind with a particular substance such as anthrax. At Bell Labs, researchers are studying how shells are grown. Shells tend to be stronger, lighter and of course cheaper than their synthetic equivalents. "Synthetic shell-like materials might be useful for housing consumer electronics, such as cellular phones and PDAs," said Elsa Reichmanis, materials research director at Bell Labs.

On one level, PARC's AirJet paper mover (PDF) is simply a reinvention of the paper-feeding mechanism in today's copiers. It looks like a board with air

jets. However, the air jets and sensors can be manufactured on a printed circuit board, making them far less costly to produce. They contain no moving or mechanical parts, so they're cheaper to maintain, and they are more effective because the machine does not need to make physical contact with the paper.

The printed circuit boards contain 144 sets of four jets pointing in different directions and 32,000 optical sensors and microcontrollers. The system is designed so that circuit boards can be bolted together. PARC's David Biegelsen and fellow scientist Andy Berlin designed the system.

Here's the rub: The data from the sensors together with the instructions for the jets is too much information for a single microprocessor to handle effectively.

"Termite colonies do not have one king giving each termite specific instructions on how to build a nest," said Biegelsen. "They are able to act as individuals but work together to achieve their aim."

Similarly, the sensors are designed to determine whether there is a sheet of paper above. If there is, they activate the air jets. Each air jet can make independent decisions, but they can also all act together. Also, one jet can take control to shut the system down if there is a jam.

Not surprisingly, the thinking behind the paper mover has made its way into other PARC projects, such as robotics.

"The big observation in biology is that you have very separate local programs that have certain emergent properties, but they are hard to reproduce in science," said Biegelsen.